Journal of the American Mosquito Control Association, 16(4):313–320, 2000

EVALUATION OF AGNIQUE® MMF IN MAN-MADE PONDS FOR THE CONTROL OF PESTIFEROUS CHIRONOMID MIDGES (DIPTERA: CHIRONOMIDAE)

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ABSTRACT. The efficacy of a monomolecular surface film, Agnique® MMF (a liquid isostearyl alcohol ethoxylate containing 2 oxyethylene groups [ISA-2OE]) in suppressing emergence of adult Chironomidae from man-made earthen ponds was studied. Three replicated rates, 0.23, 0.47, and 0.94 ml/m² (or 0.25, 0.5, and 1.0 gal/acre) of Agnique MMF were applied. Pretreatment and periodic posttreatment samples of adult chironomids were collected by employing submerged metal-cone traps as well as floating traps. Concurrently, water pH, dissolved oxygen, specific conductance, and water temperature were measured. Tanytarsini (>82%), Chironomini (16%), and Tanypodinae (1%) midges were collected during the study period. Midge adult collections in floating traps were not significantly reduced by the 0.23-ml/m² treatment rate, but were significantly reduced (73–93%) for 1–2 wk posttreatment at 0.47 and 0.94 ml/m² of Agnique MMF. The lowest rate significantly reduced midge adult emergence for 1 day posttreatment as measured by metal-cone traps, whereas the 2 higher rates reduced emergence by 78.6–97% for 1 wk posttreatment. Using either trap, the highest rate of Agnique MMF did not produce suppression of adult midges of any greater magnitude or duration than the middle rate. Agnique MMF was not detected by the indicator oil in any treated pond after 7 days posttreatment. Water pH, dissolved oxygen, specific conductance, and water temperature in the ponds were not significantly influenced by Agnique MMF treatments. Analysis of these data supports the possible use of Agnique MMF for chironomid control in areas where the surface film of this material can be maintained for sufficient time to interfere with adult emergence.

KEY WORDS Agnique® MMF, ISA-2OE, monomolecular surface film, Chironomidae, midges, control, man-made ponds

INTRODUCTION

The mosquito control agent Agnique® MMF is a liquid isostearyl alcohol ethoxylate containing 2 oxyethylene groups (ISA-2OE). This product creates a monomolecular organic film over the water surface that alters surface tension and thus interferes and disrupts behavior and normal development of mosquitoes. The same chemistry under the trade name of Arosurf® MSF has been successfully tested in the laboratory and field against a wide variety of mosquito species (Levy et al. 1980, 1981, 1982; Mulla et al. 1983), and against all stages of mosquitoes (Levy et al. 1982). However, the use of monomolecular film for the control of nuisance midges of the dipteran family Chironomidae has not been previously explored. These aquatic midges can cause severe nuisance and substantial economic losses as well as human allergies in many situations worldwide (Ali 1995, Cranston 1995). Reported here is the efficacy of Agnique MMF applied at 3 rates of treatment against chironomid midges in man-made earthen ponds.

MATERIALS AND METHODS

Twelve earthen ponds (each 6 × 4 m containing 0.5-m-deep water) located at the University of Florida's Central Florida Research and Education Center at Sanford were utilized for this study. The ponds were cleaned of vegetation in May 1999 and flooded on June 8, 1999. The water supply to the ponds was from a reclaimed source with the desired level (ca. 0.5 m) in each pond maintained by a toilet float valve. Each pond was fertilized with 1.5 kg of chicken starter mash on the day of flooding to enhance midge oviposition. Within 2 wk of flooding, the ponds supported large natural populations of chironomid midges and some other aquatic invertebrates. The ponds were treated with Agnique MMF on June 22, 1999, at 0.23-, 0.47-, and 0.94-ml/m² (0.25-, 0.5-, and 1.0-gal/acre, respectively) rates of treatment. A randomized complete block design was utilized to treat 3 ponds (replicates) with each rate, whereas 3 untreated ponds served as controls. The required amount of Agnique MMF for a treatment pond was added at 1 spot 5–8 cm above the pond water surface using a 20-ml pipette.

One day before and at intervals of 1, 3, 7, 10, 14, 21, 28, and 35 days posttreatment, a composite of 4 dip (ca. 400 ml water/dip) samples (1 dip sample from near the corner of each pond) was collected using a standard mosquito dip sampler. Two adult emergence samples utilizing 2 submerged metal-cone traps, and 4 adult emergence samples utilizing 4 floating adult traps from each treatment and control pond were also collected on each sampling occasion. The submerged metal-cone trap (0.3-m² base and 40 cm high) was fitted with a 1-liter Mason jar at the top (Ali 1996). The method of overnight metal-cone sampling was previously described by Mulla et al. (1974) and Ali and Lord (1980). During each metal-cone sampling in the treated ponds, the Mason jar was attached to the top of the cone (usually 5–8 cm below water surface) taking extreme caution of least disturbance of

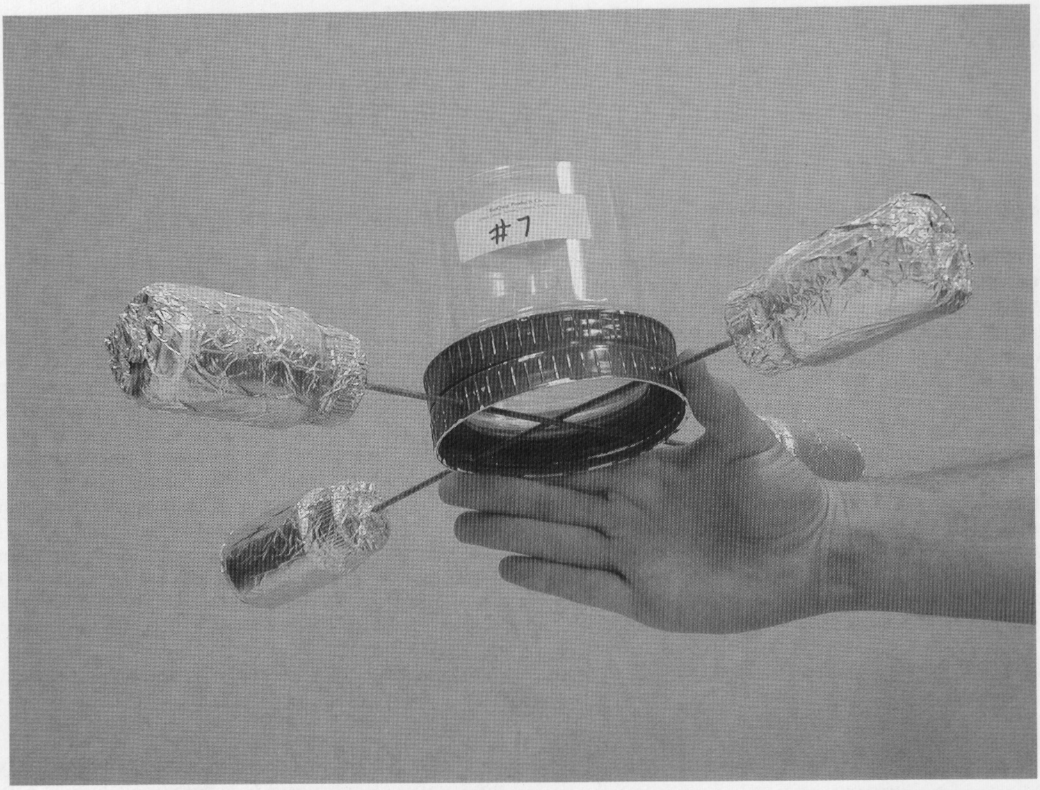

Fig. 1. A floating trap utilized to collect emerging chironomid adults from Agnique® MMF-treated and control ponds.

the water surface, particularly inside the mouth of the inverted jar, to prevent any displacement or loss of Agnique MMF. The floating traps utilized in this study were made from 12-cm-diameter standard mosquito-rearing units with funnel (BioQuip Products, Gardena, CA) but without the base compartment. The trap was provided with 4 permanent floats and all plastic on the trap coming in contact with pond water was completely covered with enamel paint or tin foil (Fig. 1) to avoid any possible repulsion of Agnique MMF by plastic. The floating traps were randomly placed on the water surface in each pond for a period of 24 h on each sampling occasion.

Water collected by the dip samples from each treatment and control pond was utilized in the laboratory to measure pH using a Model 710A pH/ISE meter (Orion Research Co., Boston, MA). Daily maximum and minimum water temperatures in a treated and a control pond were monitored throughout the study using suitable thermometers. Dissolved oxygen (Model 54A meter, Yellow Springs Instruments Co., Yellow Springs, OH) and specific conductance (Model 140 Conductivity–Temperature–Salinity meter, Orion Research) in each treated as well as each control pond were measured on the day of each midge sampling. During the posttreatment period, Agnique MMF indicator oil was tested in each treated pond to detect presence of Agnique MMF.

All dip samples, metal-cone emergence samples, and floating adult trap samples were examined in the laboratory to identify immature and/or adult Chironomidae. The pretreatment and periodic posttreatment catches of any immature midges in dip samples collected from treated and control ponds were determined. Similarly, the pretreatment and periodic posttreatment adult emergence data taken in metal cone traps and floating adult traps were separately analyzed for percent reduction of adult emergence (% ER). The following expression proposed by Mulla et al. (1971) was used to calculate % ER values:

$$\% \text{ ER} = 100 - \left(\frac{C_1}{T_1} \times \frac{T_2}{C_2}\right)100,$$

where C_1 is the number of adults in the control ponds before treatment, C_2 is the number of adults in the control ponds after treatment, T_1 is the number of adults in treated ponds before treatment, and T_2 is the number of adults in treated ponds after treatment.

For statistical analysis, individual pond % ER values were calculated using a modification of the above formula. Overall mean pretreatment emergence from the 3 control ponds was used to determine C_1, whereas overall mean (3 ponds) pretreatment emergence for each treatment was used to determine respective T_1 values. For each sample date, % ER values for both floating and cone traps were calculated for each pond, using the overall control mean as C_2 and the individual treated pond mean value for T_2. The treatment mean % ER and statistical variance were determined from the 3 pond % ER values generated for each treatment. These values were also used for further statistical analysis. Calculated pond % ER values < 0 were treated as 0 for determination of the mean % ER.

Statistical analysis of posttreatment % ER at different treatment rates of Agnique MMF was conducted using the computer software InStat V.3.00 for Windows (Graphpad Software, San Diego, CA). Between-treatment differences were analyzed using repeated-measures analysis of variance (ANOVA) with Tukey–Kramer posttests, whereas analysis of differences between sample dates for each treatment was made using 1-way ANOVA with Tukey–Kramer posttests (Neter et al. 1990); pre- and posttreatment dissolved oxygen, water pH, and specific conductance differences were also statistically analyzed (1-way and repeated-measures ANOVA). Interactions between these physicochemical parameters and their influence on midge emergence from treated (different rates) and control ponds were analyzed by linear regression analysis (Neter et al. 1990).

RESULTS AND DISCUSSION

The ponds supported populations of Chironominae (Chironomini and Tanytarsini) and Tanypodinae midges during the study period. Among these midge groups, Tanytarsini remained predominant at pretreatment as well as throughout the posttreatment observation period, forming >82% of the total adult midges collected, whereas Chironomini represented nearly 16% of the total adult midge catches, and Tanypodinae represented nearly 1%.

Mean numbers of total adult midges taken in floating adult traps at pretreatment and during periodic posttreatment samplings in the treated and the control ponds are shown in Table 1. These numbers ranged from 0.5 to 4.1, 0.3 to 4.9, 0.3 to 3.4, and 0.6 to 4.6 adults/trap in ponds treated with 0.23, 0.47, and 0.94 ml/m² Agnique MMF, and in control ponds, respectively. Generally, adult midge emergence during the posttreatment period was suppressed in almost all treated ponds as compared to control ponds and this fact was more evident from the cumulative mean number of total adult Chironomidae occurring per trap in treated ponds compared to control ponds (Table 2). Specifically, significantly ($P < 0.05$) lower numbers of adult midges/trap occurred at the 0.47- and 0.94-ml/m² rates of treatment, although the mean total of 1.7 adults/trap at the 0.23-ml/m² treatment rate also was

Table 1. Numbers of adult Chironomidae[1] captured pretreatment and periodic posttreatment in floating adult traps placed in Agnique® MMF-treated (different rates) ponds,[2] and in control ponds,[2] Aquatic Research Facility, University of Florida, Central Florida Research and Education Center, Sanford, June–July 1999.

Treatment rate (ml/m²)	Mean no. (±SD) total adult Chironomidae captured/trap pre- and posttreatment (days)[3]								
	Pretreatment	1	3	7	10	14	21	28	35
0.23	2.9 ± 4.0 a	4.1 ± 5.9 a	2.4 ± 4.2 a	0.6 ± 0.9 a	1.3 ± 1.6 a	1.5 ± 1.4 a	0.6 ± 0.7 a	0.5 ± 0.8 a	1.3 ± 1.7 a
0.47	4.9 ± 4.2 b	0.7 ± 1.5 a	0.6 ± 1.0 a	0.4 ± 0.8 a	0.6 ± 0.7 a	0.3 ± 0.5 a	0.9 ± 1.0 a	1.3 ± 1.6 a	1.7 ± 1.3 a
0.94	3.4 ± 2.1 b	0.9 ± 2.6 a	0.5 ± 1.2 a	0.3 ± 0.8 a	0.3 ± 0.5 a	0.8 ± 1.0 a	1.3 ± 1.2 a	1.7 ± 2.1 ab	1.8 ± 1.4 ab
Control	3.4 ± 2.7 ab	4.6 ± 2.5 b	4.0 ± 3.8 ab	3.3 ± 3.7 ab	1.5 ± 1.2 ab	3.2 ± 2.7 ab	1.1 ± 1.2 ab	0.6 ± 0.7 a	2.3 ± 3.7 ab

[1] Predominantly Tanytarsini (>82%); others: Chironomini and Tanypodinae.
[2] Water temperature: 26–35°C.
[3] Mean numbers in a row followed by the same letter are not significantly different ($P > 0.05$) when analyzed by 1-way analysis of variance with Tukey–Kramer multiple comparisons posttests.

Table 2. Mean total adult Chironomidae[1] captured on 9 sampling occasions (1 pretreatment and 8 posttreatment) in floating adult traps placed in Agnique® MMF-treated (different rates) ponds,[2] and in control ponds,[2] Aquatic Research Facility, University of Florida, Central Florida Research and Education Center, Sanford, June–July 1999.

Treatment rate (ml/m²)	Mean (±SD) total Chironomidae/trap[3]
0.23	1.7 ± 1.2 ab
0.47	1.3 ± 1.4 b
0.94	1.2 ± 1.0 b
Control	2.7 ± 1.4 a

[1] Predominantly Tanytarsini (>82%); others: Chironomini and Tanypodinae.
[2] Water temperature: 26–35°C.
[3] Mean values in the column followed by the same letter are not significantly different ($P > 0.05$) when analyzed by repeated-measures analysis of variance with Tukey–Kramer multiple comparisons posttests.

lower than mean total of 2.7 adults/trap taken in controls.

Further statistical analysis of data from floating adult traps to ascertain posttreatment percent reductions of adult midges and statistical significance of these reductions revealed that the lowest rate of 0.23 ml/m² of Agnique MMF caused 33–80% reductions of adult midge emergence from treated ponds, but these reductions were not significant at the 5% level of probability. However, the 2 higher rates produced statistically significant 73–93% reductions for 1–2 wk posttreatment. The highest rate of treatment did not necessarily produce midge control of higher magnitude or duration (Table 3).

Mean numbers of total adult midges collected pretreatment and periodic posttreatment in submerged metal-cone emergence traps are shown in Table 4. They ranged from 8.8 to 28.4, 3.6 to 56.7, 2.3 to 55.8, and 6.2 to 135.2 adults/trap in ponds treated with 0.23, 0.47, and 0.94 ml/m² of Agnique MMF, and in control ponds, respectively. These numbers of adult midges captured by metal-cone traps, on per trap basis, were much higher than those taken in floating traps (Table 1). This was primarily because of larger size (nearly 24 times larger base) of the former trap. Analysis of data in Table 4 shows some significant ($P < 0.05$) declines in adult captures during 1–7 days posttreatment in treated ponds (all rates), whereas adult emergence from control ponds during the same observation period generally increased when compared to the pretreatment level. Cumulative mean numbers of total adult Chironomidae occurring per cone trap in each treatment compared to the control were consistently lower, although some of these means were not statistically significant because of the large variances between trap captures among treated as well as control ponds (Table 5).

Analysis of mean percent reductions data pertaining to metal-cone emergence traps (Table 6)

Table 3. Posttreatment mean percent reductions of total adult Chironomidae[1] captured in floating adult traps placed in Agnique® MMF-treated (different rates) ponds,[2] Aquatic Research Facility, University of Florida, Central Florida Research and Education Center, Sanford, June–July 1999.

Treatment rate (ml/m²)	Mean (±SD) % reduction posttreatment (days)[3]: Pre-treatment	1	3	7	10	14	21	28	35
0.23	0 ± 0 a	53.9 ± 47.1 a	39.9 ± 34.7 a	79.5 ± 13.4 a	40.7 ± 35.2 a	44.6 ± 33.3 a	39.7 ± 36.9 a	33.3 ± 57.7 a	33.2 ± 47.4 a
0.47	0 ± 0 a	89.8 ± 14.5 c	89.8 ± 9.1 c	91.3 ± 15.2 c	72.8 ± 24.3 c	92.6 ± 3.2 c	40.8 ± 40.7 abc	13.3 ± 23.1 ab	50.0 ± 30.3 abc
0.94	0 ± 0 a	80.0 ± 34.6 bc	87.5 ± 21.5 c	90.0 ± 8.7 c	77.8 ± 19.2 abc	73.7 ± 32.9 abc	2.6 ± 4.4 ab	33.3 ± 57.7 abc	25.0 ± 21.4 abc

[1] Predominantly Tanytarsini (>82%); others: Chironomini and Tanypodinae.
[2] Water temperature: 26–35°C.
[3] Mean values in a row followed by the same letter are not significantly different ($P > 0.05$) when analyzed by 1-way analysis with Tukey–Kramer multiple comparisons posttests.

Table 4. Numbers of adult Chironomidae[1] collected pretreatment and periodic posttreatment in submerged metal-cone emergence traps fitted with Mason jars placed in Agnique® MMF-treated (different rates) ponds,[2] and in control ponds,[2] Aquatic Research Facility, University of Florida, Central Florida Research and Education Center, Sanford, June–July 1999.

Treatment rate (ml/m²)	Mean no. (±SD) total adult Chironomidae/trap pre- and posttreatment (days)[3]								
	Pretreatment	1	3	7	10	14	21	28	35
0.23	21.5 ± 14.6 a	8.8 ± 13.4 a	15.7 ± 15.2 a	28.4 ± 20.0 a	20.5 ± 22.6 a	18.5 ± 12.7 a	9.5 ± 7.6 a	11.5 ± 11.4 a	14.7 ± 10.0 a
0.47	56.7 ± 30.7 a	6.0 ± 9.3 b	3.6 ± 4.3 ab	8.6 ± 10.4 ab	5.8 ± 8.8 b	4.2 ± 3.0 b	10.5 ± 14.3 ab	9.8 ± 5.6 ab	13.0 ± 7.2 ab
0.94	55.8 ± 24.0 a	4.2 ± 8.8 b	2.3 ± 2.9 b	10.2 ± 7.9 ab	6.2 ± 4.8 ab	10.5 ± 11.7 ab	15.5 ± 15.6 ab	23.3 ± 29.4 ab	25.2 ± 27.5 ab
Control	64.2 ± 46.6 ab	135.2 ± 48.8 b	74.8 ± 50.9 ab	63.7 ± 30.4 ab	13.0 ± 9.5 a	29.3 ± 25.3 a	15.2 ± 9.8 a	6.2 ± 4.6 a	21.0 ± 17.1 a

[1] Predominantly Tanytarsini (>82%); others: Chironomini and Tanypodinae.
[2] Water temperature: 26–35°C.
[3] Mean numbers in a row followed by the same letter are not significantly different ($P > 0.05$) when analyzed by 1-way analysis of variance with Tukey–Kramer multiple comparisons posttests.

Table 5. Mean total adult Chironomidae[1] collected on 9 sampling occasions (1 pretreatment and 8 posttreatment) in submerged metal-cone emergence traps fitted with Mason jars placed in Agnique® MMF-treated (different rates) ponds,[2] and in control ponds,[2] Aquatic Research Facility, University of Florida, Central Florida Research and Education Center, Sanford, June–July 1999.

Treatment rate (ml/m²)	Mean (±SD) total adult Chironomidae/trap[3]
0.23	16.6 ± 6.4 ab
0.47	13.1 ± 16.6 a
0.94	17.0 ± 16.6 ab
Control	47.0 ± 41.8 b

[1] Predominantly Tanytarsini (>82%); others: Chironomini and Tanypodinae.
[2] Water temperature: 26–35°C.
[3] Mean values in the column followed by the same letter are not significantly different ($P > 0.05$) when analyzed by repeated-measures analysis of variance with Tukey–Kramer multiple comparisons posttests.

shows a statistically significant ($P < 0.05$) reduction of 83.5% for 1 day posttreatment at the 0.23-ml/m² rate of treatment. At 0.47 ml/m², statistically significant adult midge reductions of 79.3–95% occurred for 1 wk posttreatment, whereas the highest rate of Agnique MMF produced 78.6–97% reductions of adult midges for 1 wk posttreatment. The latter 2 rates resulted in very similar adult suppression in terms of magnitude and duration.

Dip water samples, which were routinely collected to check for presence of any living or dead chironomid larvae, pupae, and/or adults at or near the water surface in treated ponds, were devoid of chironomids (immature or adult) on most sampling occasions except for a couple of occasions when their negligible numbers were taken (data not included).

Agnique MMF indicator oil, a drop of which forms a tight bead on the water surface of a treated area, confirmed presence of Agnique MMF at the surface of all treated ponds 1 day posttreatment. However, at 3 days posttreatment, Agnique MMF was detectable only in 1 pond treated at 0.47 ml/m², but in all ponds treated at 0.94 ml/m². At 7 days posttreatment, a detectable level of Agnique MMF remained only in 1 pond treated at the highest rate; thereafter (10 days posttreatment), Agnique MMF was not detected in any treated pond.

Water physicochemical parameters, pH, dissolved oxygen, specific conductance, and temperature range during the study period are summarized in Table 7. Water in all treated and control ponds was alkaline with pH values during pretreatment and periodic posttreatment observations remaining between 8.13 and 9.70, 8.15 and 9.62, and 8.09 and 9.17 in ponds treated at 0.23, 0.47, and 0.94 ml/m², respectively; in control ponds water pH values fluctuated between 7.99 and 9.43. No significant ($P > 0.05$) posttreatment change of water pH was noted

Table 6. Posttreatment mean percent reductions of total adult Chironomidae[1] collected in submerged metal-cone emergence traps fitted with Mason jars placed in Agnique® MMF-treated (different rates) ponds;[2] Aquatic Research Facility, University of Florida, Central Florida Research and Education Center, Sanford, June–July 1999.

Treatment rate (ml/m²)	Mean (±SD) % reduction posttreatment (days)[3]								
	Pretreatment	1	3	7	10	14	21	28	35
0.23	0.0 ± 0.0 a	83.5 ± 26.8 b	46.8 ± 46.0 ab	22.4 ± 38.8 ab	0.0 ± 0.0 a	11.3 ± 19.6 ab	20.2 ± 35.0 ab	0.0 ± 0.0 a	21.5 ± 37.3 ab
0.47	0.0 ± 0.0 a	95.0 ± 6.6 b	92.7 ± 8.1 b	79.3 ± 23.6 b	59.4 ± 51.9 ab	83.9 ± 9.5 b	44.3 ± 39.1 ab	0.0 ± 0.0 a	30.8 ± 36.0 ab
0.94	0.0 ± 0.0 a	97.0 ± 5.2 b	96.4 ± 2.3 b	78.6 ± 14.1 b	47.5 ± 42.6 ab	58.8 ± 44.9 ab	36.3 ± 43.7 ab	14.7 ± 25.4 ab	33.8 ± 2.8 ab

[1] Predominantly Tanytarsini (>82%); others: Chironomini and Tanypodinae.
[2] Water temperature: 26–35°C.
[3] Mean values in a row followed by the same letter are not significantly different ($P > 0.05$) when analyzed by 1-way analysis of variance with Tukey–Kramer multiple comparisons posttests.

in any of the ponds treated with Agnique MMF. The dissolved oxygen values in all treated ponds (specifically at the highest 2 rates) did not significantly increase or decrease in any treated or control pond, and ranged between 4.0 and 11.4, 4.8 and 9.7, 4.9 and 12.1, and 5.1 and 13.2 ppm in ponds treated at 0.23, 0.47, and 0.94 ml/m², and control ponds, respectively. Interestingly, ponds receiving the highest rate of 0.94 ml/m² Agnique MMF showed a rather gradual increase of dissolved oxygen for up to 10 days posttreatment (Table 7). Specific conductance values ranged between 637 and 703, 652 and 705, 643 and 768, and 680 and 717 μS/cm in ponds treated at 0.23, 0.47, and 0.94 ml/m² of Agnique MMF, and in control ponds, respectively. No significant ($P > 0.05$) change in specific conductance (dissolved solids) in water of any pond treated with Agnique MMF was noted. The water temperature range of 26–35°C during the June 22 to July 28, 1999, study period indicated that adult emergence of chironomids (predominantly Tanytarsini midges) from these shallow study ponds did occur at a water temperature as high as 35°C.

Correlation analysis revealed no significant ($P > 0.05$) relationship(s) between suppression of adult midge emergence from treated ponds with observed changes in water pH, dissolved oxygen, and specific conductance. The same parameters also were not significantly correlated with midge emergence from control ponds. Thus, these parameters in this study had no significant influence on midge emergence in Agnique MMF-treated or control ponds. Regarding the interrelationship(s) among physicochemical parameters, both dissolved oxygen and pH were significantly correlated and their values increased in control as well as treated ponds (e.g., 0.94 ml/m²: $r = 0.70$, $P = 0.036$, $n = 9$). This positive relationship is to be expected because these 2 parameters are interrelated through the fCO_2-HCO_3-CO_3 system.

This study has demonstrated that Agnique MMF could significantly suppress chironomid adult emergence for 1–2 wk posttreatment from small ponds without interfering with the physicochemical balance of selected water parameters studied. A rate of 0.47 ml/m² was as effective as 0.94 ml/m² in terms of magnitude and duration of midge control; the highest rate did not reduce dissolved oxygen in the treated ponds.

Both floating adult traps as well as submerged metal-cone emergence traps were suitable to monitor pre- and posttreatment chironomid adult emergence from shallow habitats, such as the ponds employed in this study. In the future, only 1 type of trap should be used for the type of study undertaken here.

Collection of dip water samples was not necessary because the chironomid groups encountered were mostly benthic and their dead or living larvae, pupae, or adults were almost absent at or near the water surface treated with Agnique MMF.

Table 7. Values of water physicochemical parameters measured pretreatment and periodic posttreatment in Agnique® MMF-treated (different rates) ponds,[1] and in control ponds,[1] Aquatic Research Facility, University of Florida, Central Florida Research and Education Center, Sanford, June–July 1999.

Treatment rate (ml/m²)	Mean (±SD) pH, dissolved oxygen, and conductivity pretreatment and posttreatment (days)[2]								
	Pretreatment	1	3	7	10	14	21	28	35
					pH				
0.23	8.38 ± 0.35 a	8.13 ± 0.25 a	8.32 ± 0.31 a	8.28 ± 0.14 a	8.70 ± 0.18 a	9.01 ± 0.76 a	9.50 ± 0.32 a	9.70 ± 0.29 a	9.59 ± 0.21 a
0.47	8.33 ± 0.56 a	8.27 ± 0.53 a	8.65 ± 0.67 a	8.15 ± 0.28 a	8.48 ± 0.41 a	8.63 ± 0.81 a	8.96 ± 0.62 a	9.15 ± 0.57 a	9.62 ± 0.27 a
0.94	8.19 ± 0.45 a	8.09 ± 0.28 a	8.38 ± 0.29 a	8.46 ± 0.58 a	9.01 ± 0.58 a	8.80 ± 0.77 a	8.46 ± 0.68 a	8.68 ± 0.46 a	9.17 ± 0.85 a
Control	8.10 ± 0.18 a	7.99 ± 0.25 a	8.37 ± 0.57 a	8.51 ± 0.48 a	9.00 ± 0.83 a	9.05 ± 1.04 a	9.05 ± 1.31 a	9.23 ± 1.25 a	9.43 ± 0.86 a
					Dissolved oxygen (ppm)				
0.23	4.0 ± 1.25 a	5.4 ± 1.81 ab	5.7 ± 1.43 ab	7.2 ± 1.16 ab	9.3 ± 1.00 ab	10.0 ± 3.68 b	11.4 ± 4.74 b	10.5 ± 1.40 b	8.8 ± 2.66 ab
0.47	4.8 ± 1.35 a	7.4 ± 3.83 a	7.5 ± 3.26 a	5.9 ± 2.95 a	9.6 ± 0.72 a	8.6 ± 1.91 a	8.0 ± 1.97 a	9.7 ± 1.50 a	9.6 ± 2.42 a
0.94	4.9 ± 1.42 a	7.0 ± 1.72 a	7.0 ± 2.02 a	10.1 ± 4.03 a	12.1 ± 4.30 a	9.0 ± 1.92 a	6.4 ± 1.47 a	7.0 ± 0.91 a	9.3 ± 4.19 a
Control	5.1 ± 0.47 a	7.4 ± 1.31 a	7.9 ± 0.91 a	10.7 ± 0.50 a	13.2 ± 5.00 a	13.1 ± 5.45 a	8.5 ± 5.70 a	9.9 ± 7.49 a	9.2 ± 4.42 a
					Specific conductance (µS/cm)				
0.23	637 ± 87 a	652 ± 71 a	668 ± 69 a	663 ± 55 a	660 ± 53 a	670 ± 56 a	640 ± 56 a	703 ± 6 a	595 ± 108 a
0.47	660 ± 53 a	662 ± 46 a	672 ± 41 a	667 ± 49 a	667 ± 49 a	670 ± 52 a	665 ± 56 a	705 ± 15 a	652 ± 79 a
0.94	683 ± 64 a	688 ± 68 a	700 ± 53 a	695 ± 45 a	685 ± 41 a	702 ± 93 a	735 ± 152 a	768 ± 132 a	643 ± 53 a
Control	713 ± 25 a	713 ± 33 a	717 ± 29 a	695 ± 23 a	682 ± 28 a	688 ± 35 a	690 ± 30 a	703 ± 95 a	680 ± 75 a

[1] Water temperature: 26–35°C.

[2] Mean value in a row followed by the same letter are not significantly different ($P > 0.05$) when analyzed by 1-way analysis of variance with Tukey–Kramer multiple comparisons posttests.

This study did not evaluate direct (physical) or indirect (chemical) impacts of Agnique MMF on water-surface- (or near-surface-) dwelling invertebrates. However, the posttreatment high values of dissolved oxygen in the water column are encouraging and indicative of minimal adverse effects on fauna present in the water column, specifically zooplankton and nekton (excluding true water-surface-inhabiting invertebrates).

No quantitative data exist on the effects of Agnique MMF or Arosurf MSF on chironomid populations for comparison purposes. However, a few previous studies (e.g., Levy et al. 1981, Mulla et al. 1983) reported mortality of adult chironomids in Arosurf-treated habitats at rates comparable to those employed in the present study. In contrast, Takahashi et al. (1984) reported no adverse effects of ISA-2OE on Chironomidae, but those authors were dealing with larval rather than adult chironomids.

The target (Chironomidae) and selected water physicochemical data gathered in the present study, as well as the already-existing safety information data concerning ISA-2OE to a vast majority of aquatic nontarget organisms (Levy et al. 1981, Mulla et al. 1983, Webber and Cochran 1984, Hester et al. 1991, Kenny and Ruber 1993) are clearly supportive of possible use of Agnique MMF for chironomid control. This product should be economically effective where the surface film could be maintained/contained for a period(s) long enough to interfere with the adult midge emergence.

ACKNOWLEDGMENTS

The assistance of Richard Lobinske and Robert Leckel, Jr., during the course of this study is greatly appreciated. Provision of a research grant by Henkel Corporation, Cincinnati, OH, to undertake this study is gratefully acknowledged. This is Florida Agricultural Experiment Station Journal Series R-07407.

REFERENCES CITED

Ali A. 1995. Nuisance, economic impact and possibilities for control. In: Armitage PD, Cranston PS, Pinder LCV, eds. *The Chironomidae: the biology and ecology of non-biting midges* London, United Kingdom: Chapman and Hall. p 339–364.

Ali A. 1996. Pestiferous Chironomidae (Diptera) and their management. In: Rosen D, Bennett FD, Capinera JL, eds. *Pest management in the subtropics: integrated pest management—a Florida perspective* Andover, United Kingdom: Intercept. p 487–513.

Ali A, Lord J. 1980. Experimental insect growth regulators against some nuisance chironomid midges of central Florida. *J Econ Entomol* 73:243–249.

Cranston PS. 1995. Medical significance. In: Armitage PD, Cranston PS, Pinder LCV, eds. *The Chironomidae: the biology and ecology of non-biting midges* London, United Kingdom: Chapman and Hall. p 365–384.

Hester PG, Olson MA, Dukes JC. 1991. Effects of Arosurf® MSF on a variety of aquatic nontarget organisms in the laboratory. *J Am Mosq Control Assoc* 7:48–51.

Kenny EA, Ruber E. 1993. Effects of Arosurf® MSF on micro-Crustacea associated with the cattail mosquito, *Coquillettidia perturbans*. *J Am Mosq Control Assoc* 9: 361–363.

Levy R, Chizzonite JJ, Garrett WD, Miller TW Jr. 1981. Ground and aerial application of a monomolecular organic surface film to control salt-marsh mosquitoes in natural habitats of southwestern Florida. *Mosq News* 41: 291–301.

Levy R, Garrett WD, Chizzonite JJ, Miller TW Jr. 1980. Control of *Culex* spp. mosquitoes in sewage treatment systems of southwestern Florida with monomolecular organic surface films. *Mosq News* 40:27–35.

Levy R, Garrett WD, Chizzonite JJ, Miller TW Jr. 1982. Efficacy of the organic surface film isostearyl alcohol containing two oxyethylene groups for control of *Culex* and *Psorophora* mosquitoes: laboratory and field studies. *Mosq News* 42:1–11.

Mulla MS, Darwazeh HA, Luna LL. 1983. Monolayer films as mosquito control agents and their effects on nontarget organisms. *Mosq News* 43:489–495.

Mulla MS, Norland RL, Fanara DM, Darwazeh HA, McKean DW. 1971. Control of chironomid midges in recreational lakes. *J Econ Entomol* 64:300–307.

Mulla MS, Norland RL, Ikeshoji T, Kramer WL. 1974. Insect growth regulators for the control of aquatic midges. *J Econ Entomol* 67:167–170.

Neter J, Wasserman W, Kutner MH. 1990. *Applied linear statistical models. Regression, analysis of variance, and experimental designs* 3rd ed. Homewood, IL: Richard D. Irwin.

Takahashi RM, Wilder WH, Miura T. 1984. Field evaluations of ISA-2OE for mosquito control and effects on aquatic nontarget arthropods in experimental plots. *Mosq News* 44:363–367.

Webber LA, Cochran DC. 1984. Laboratory observations on some freshwater vertebrates and several saline fishes exposed to a monomolecular organic surface film (ISA-2OE). *Mosq News* 44:363–367.