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POPULATION SURVEY AND CONTROL OF CHIRONOMIDAE (DIPTERA) IN WETLANDS IN NORTHEAST FLORIDA, USA

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ABSTRACT

A qualitative and quantitative population survey of immature and adult Chironomidae was conducted for 1 year in a country club wetlands in northeast Florida, USA. *Glyptotendipes paripes* and *Goeldichironomus carus* were the 2 predominant chironomid species in the wetlands. Adults of these 2 species emerged at nuisance levels from Apr through Jun, and in Aug and Sep. *Polypedilum*, *Cryptochironomus*, Tanytarsini, and Tanypodinae collected in low numbers during the survey were not identified to species. In laboratory bioassays, LC_{90} values of technical grade temephos against *G. paripes* and *G. carus* were 0.01 and 0.009 ppm, respectively. For *s*-methoprene the LC_{90} values were 0.082 and 0.055 ppm, and for *Bacillus thuringiensis* serovariety *israelensis* (*Bti*) 1.056 and 0.467 ppm, respectively. In experimental field plots in the wetlands, 5% AI Skeeter Abate® (temephos) pellets at 0.1 kg AI/ha reduced midge larvae by 52-86% and at 0.2 kg/ha by 74-92% during 4 weeks posttreatment. Sand formulated technical powder of *Bti* at 1,000,000 and 2,000,000 ITU (International Toxic Units) *Bti*/m^2 reduced midge larvae by 47-52% and 82-88%, respectively, during 6 to 20 days posttreatment. STRIKE® pellets (4.25% AI *s*-methoprene) at 0.14 kg AI/ha suppressed a maximum of 80% total chironomid adult emergence at 7 days posttreatment; this IGR at 0.28 kg AI/ha reduced adult emergence up to 92% during 15 days posttreatment. Temephos and *Bti* were more cost-effective and provided midge control for relatively longer period than *s*-methoprene in the field evaluations.

Key Words: nuisance midges, *Glyptotendipes paripes*, *Goeldichironomus carus*, population management, temephos, *Bacillus thuringiensis* serovar. *israelensis*, *s*-methoprene

RESUMEN

Se realizó un monitoreo cualitativo y cuantitativo por 1 año de los inmaduros y adultos de la familia Chironomidae en los humedales de un club en el noreste de la Florida, EEUU. *Glyptotendipes paripes* y *Goeldichironomus carus* fueron las especies de la familia Chironomidae mas predominantes en los humedales. Los adultos de estas especies emergieron en niveles fastidiosos desde el mes de abril hasta junio, y en agosto y septiembre. Los *Polypedilum*, *Cryptochironomus*, Tanytarsini y Tanypodinae recolectados en numeros bajos durante el monitoreo no fueron identificados al nivel de especie. En los bioensayos del laboratorio, el valor CL_{90} de 'temephos' al grado tecnico contra *G. paripes* y *G. carus* fue 0.01 y 0.009 ppm, respectivemente. Los valores de CL_{90} para '*S*-methoprene' fueron 0.082 y 0.055 ppm y para '*Bacillus thuringiensis*' serovariedad *israelensis* (*Bti*) 1.056 y 0.467 ppm, respectivemente. En ensayos de parcelas en el campo en los humedales, pelotillas al 5% de AI Skeeter Abate® (temephos) al 0.1 kg IA/ha reducieron 52-86% de las larvas y al 0.2 kg/ha 74-92% de las larva durante las 4 semanas despues del tratamiento. El polvo tecnico de *Bti* formulado con arena al 1,000,000 y 2,000,000 UTI (Unidades Toxicos Internacionales) *Bti*/m^2 reducieron las larvas de chironomidos por 47-52% y 82-88%, respectivemente, durante los 6 a 20 dias despues del tratamiento. Las pelotillas de STRIKE® (4.25% de IA *S*-methoprene) al 0.14 kg =IA/ha suprimieron la emergencia de los adultos de chironomidos a un maximo de 80% a los 7 dias despues del tratamiento; este RCI (Regulador del Crecimiento de Insectos) aplicado al 0.28 kg IA/ha redujo la emergencia de adultos hasta 92% durante los 15 dias despues del tratamiento. Temephos y *Bti* fueron los mas efectivos en cuanto al costo y controlar los chironomidos por un periodo de tiempo mas largo que *S*-methoprene en las evaluaciones del campo.

Adult emergence of chironomid midges can occur at nuisance levels in areas surrounding urban and suburban aquatic habitats (see Ali 1996 for review). At Ponte Vedra Beach, northeast Florida, USA, a "labyrinth" of shallow wetlands developed for residential and recreational purposes, support chironomid populations at nuisance levels for several months each year that interfere with human activities, necessitating control measures. We examined the composition of the midge larval community in these wetlands, as well as the prevalence of adults in adjacent residential and recreational land areas. Laboratory and field evaluations of the organophosphorus larvicide temephos, the insect growth regulator (IGR), *s*-methoprene, and the biological insecticide, *Bacillus thuringiensis* serovar. *israelensis* (*Bti*) for midge control also were conducted. The relative cost of controlling midge larvae with each material was compared.

Materials and Methods

The habitat in northeast Florida (30°11'N, 81°22.5'W) includes a series of man-made shallow lakes (<1-3 m deep, surface area 65 ha) with ca. 19 km of irregular shoreline (Fig. 1). Prior to routine larval and adult sampling, a survey of the entire habitat was conducted for midge fauna by collecting benthic samples with a 15 × 15 cm Ekman dredge from a boat at ca. 0.05-min latitude/longitude intervals. Spatial coordinates were recorded with a Global Positioning System receiver. All benthic samples were washed in the field through a 350-µm pore sieve, and retained material transferred to labeled bottles for transport to the laboratory to identify (Epler 1995) and count the immature (larvae and pupae) Chironomidae. Based on these data which identified areas supporting nuisance or near-nuisance (>100 larvae/m^2) levels of midge larvae, a routine spatio-temporal stratified larval sampling plan was established. This plan facilitated the efficient use of sampling resources (Lobinske et al. 2002). From Jul 2003 to Jul 2004, 45 Ekman dredge samples were collected at monthly basis, processed as above, and the midge larvae identified and counted.

Adult midge populations were assessed based on 9 permanently placed New Jersey (NJ) light traps (Fig. 1). Trap jars were replaced at least weekly and collected chironomids were identified (Weiderholm 1989) and counted.

A procedure similar to that of Ali (1981) was used for laboratory evaluation of technical temephos (90% active ingredient, AI) and the biological insecticide *Bti* (potency: 7,468 International Toxic Units (ITU)/mg) against field-collected larvae of the predominant midge species. The serial dilutions for temephos were made in acetone while those for *Bti* were made in deionized water. Larval mortality in the bioassay cups was noted 24 h (temephos) and 48 h (*Bti*) after treatments and corrected for any mortality in corresponding control cups.

Technical grade *s*-methoprene (96% AI) was tested in small rearing units with continuous air supply (Ali & Lord 1980). Larval and/or pupal

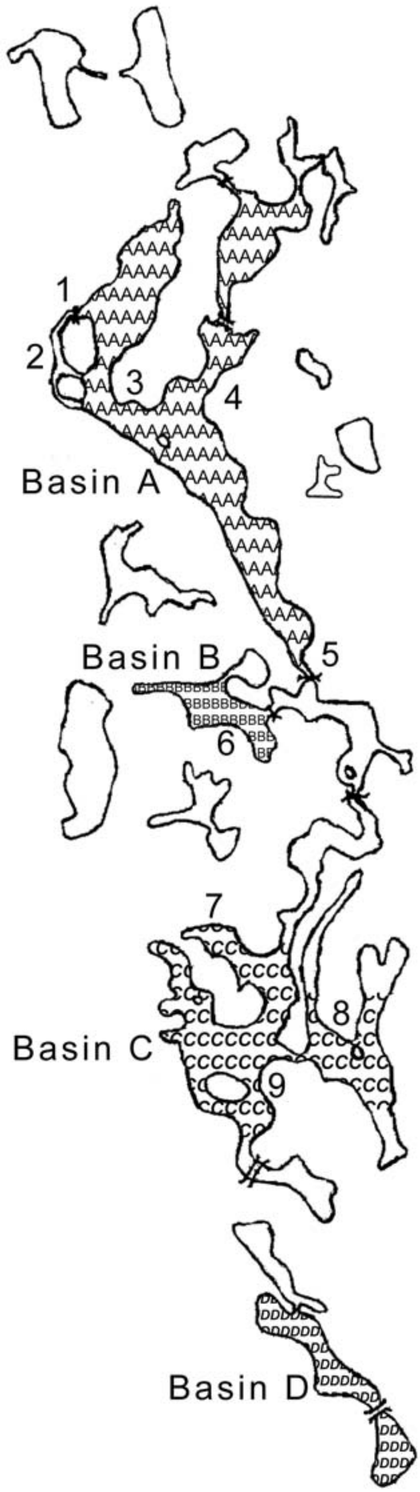

Fig. 1. Map of study wetlands for Chironomidae showing Basins A to D (larval sampling) and location of New Jersey light traps 1 to 9 (adult sampling), Ponte Vedra Beach, Florida, USA.

mortality and adult emergence was assessed daily until all immatures had died or emerged as adults in the controls. Bioassays for all materials were replicated at least 3 times. The corrected mortality data were analyzed by Probit analysis to estimate dose response of larvae of each species to the test materials.

Temephos (5% Skeeter Abate® pellets), *s*-methoprene (4.25% STRIKE® pellets), and *Bti* (VectoBac® technical powder, containing 5,000 ITU/mg) were evaluated for chironomid control in the wetlands. For this, 21 open field plots (each 20 x 5 m) in wetland areas supporting consistent larval densities of >1,000/m^2 were permanently marked by driving a stake in each corner of a plot. Each test material was evaluated at 2 rates in separate evaluations that followed at the termination of the prior field evaluation. Each treatment rate was applied to 3 randomly selected plots (replicates) while 3 plots served as controls, utilizing a total of 9 plots per evaluation. Treatments were made by hand from a boat to ensure uniform distribution. The first evaluation started on 20 Apr 2004, when temephos was applied at 0.1 and 0.2 kg AI/ha. On 2 Jun 2004, *Bti* formulated on sand grains at 1,000,000 and 2,000,000 ITU/m^2 was applied. On 4 Oct 2004, *s*-methoprene was applied at 0.14 and 0.28 kg AI/ha for the final evaluation.

For temephos and *Bti* evaluations, 3 Ekman dredge samples were randomly collected from each plot immediately prior to treatment and at posttreatment d 3, 7, 14, 21, and 28 (temephos), and 2, 6, 13, 20, and 30 d (*Bti*). All benthic samples were washed and processed in the laboratory as above. For evaluation of *s*-methoprene, a single night's adult emergence at pretreatment and at 7, 15, 22, and 29 d posttreatment was sampled utilizing 3 randomly placed 30-cm high (0.25 m^2 base area) metal-cone submerged emergence traps (Ali 1980) per plot; thus 27 total traps were utilized during each sampling. A removable glass jar at the apex of the trap containing the trapped adult chironomids was collected and transported to the laboratory for midge identification and counting. The degree of reduction in posttreatment larvae and adults was calculated according to Mulla et al. (1971).

Results

Two chironomid species, *Glyptotendipes paripes* and *Goeldichironomus carus* predominated in Ponte Vedra Beach wetland and were the primary nuisance in the vicinity. In the preliminary survey of the entire wetland, *G. paripes* formed 99% and *G. carus* <1% of the total chironomid larvae. Midge larvae of the taxa, *Polypedilum*, *Cryptochironomus*, Tanytarsini and Tanypodinae were found in very low numbers and were not identified to species. Spatially, mean midge densities in different basins (Fig. 1) of the wetland varied considerably; Basin A supported the highest (1,714 larvae/m^2) and Basin B the lowest (57 larvae/m^2) densities of midge larvae. Basins C and D, respectively, supported 982 and 344 midge larvae/m^2. The overall mean density of total midge larvae in all basins amounted to 923 larvae/m^2.

Monthly mean larval densities (Fig. 2) varied from 152 larvae/m^2 (Aug 2003) to 1,666 larvae/m^2 (May 2004) for *G. paripes*; 20 larvae/m^2 (Jul 2003) to 581 larvae/m^2 (Aug 2003) for *G. carus*; and 363 larvae/m^2 (Nov 2003) to 2,809 larvae/m^2 (May 2004) for total Chironomidae. *Glyptotendipes paripes* and *G. carus*, respectively, formed 56 and 14% of total Chironomidae larvae collected during the study period. The larval maxima for *G. paripes* occurred in Apr-May 2004 and minima in Aug and Nov 2003. The highest density of *G. carus* occurred in Aug 2003 and lowest in Jun 2003 and Jun 2004. It was interesting to note that total chironomid densities (predominately *G. paripes*) during winter (Dec 2003 and Jan and Feb 2004) exceeded 1,200 larvae/m^2.

Glyptotendipes paripes formed 86% and *G. carus* 7% of the total adult chironomids collected during the study period (Fig. 2). The daily mean number of *G. paripes* occurring in NJ traps was highest in Apr 2004 (3,096 adults/trap/day) and lowest in Jan 2004 (<5 adults/trap/day). *Goeldichironomus carus* populations were <1 adult/trap/day in Dec 2003 and Jan 2004, with maxima (363 adults/trap/day) occurring in Apr 2004. In general, peak adult activity was somewhat bimodal, with major peaks occurring during Apr to Jun and relatively smaller peaks from Aug to Nov. There were appreciable numbers of adults in the study area for almost 9 months of the year.

Susceptibility of *G. paripes* and *G. carus* larvae in the laboratory to temephos was very similar; both species were highly susceptible to temephos as indicated by LC_{90} values of 0.01 ppm (*G. paripes*) and 0.009 ppm (*G. carus*) (Table 1). The *Bti* technical powder was twice as effective against *G. carus* (LC_{90} = 0.467 ppm) compared to *G. paripes* (LC_{90} = 1.056 ppm) (Table 1).

The IGR *s*-methoprene was more effective against *G. carus* (LC_{90} = 0.055 ppm) compared to *G. paripes* (LC_{90} = 0.082 ppm) (Table 1). The LC_{90} data indicate that *G. paripes* and *G. carus*, respectively, were 8.2 and 6.1 times more susceptible to temephos compared to *s*-methoprene.

In field tests, temephos at 0.1 kg AI/ha gave appreciable larval control with 38-78% reduction in the population of *G. paripes* and *G. carus*, and 52-86% reduction in the total number of chironomid larvae for 21 d posttreatment. At the application rate of 0.2 kg AI/ha, temephos produced between 58 and 94% reduction in *G. paripes* and *G. carus*, and 74-92% reduction of total midge larvae during 28 d posttreatment (Fig. 3).

Posttreatment larval reduction with *Bti* was lower compared to the temephos treatments. For example, at 2 d posttreatment, only a 12% (low

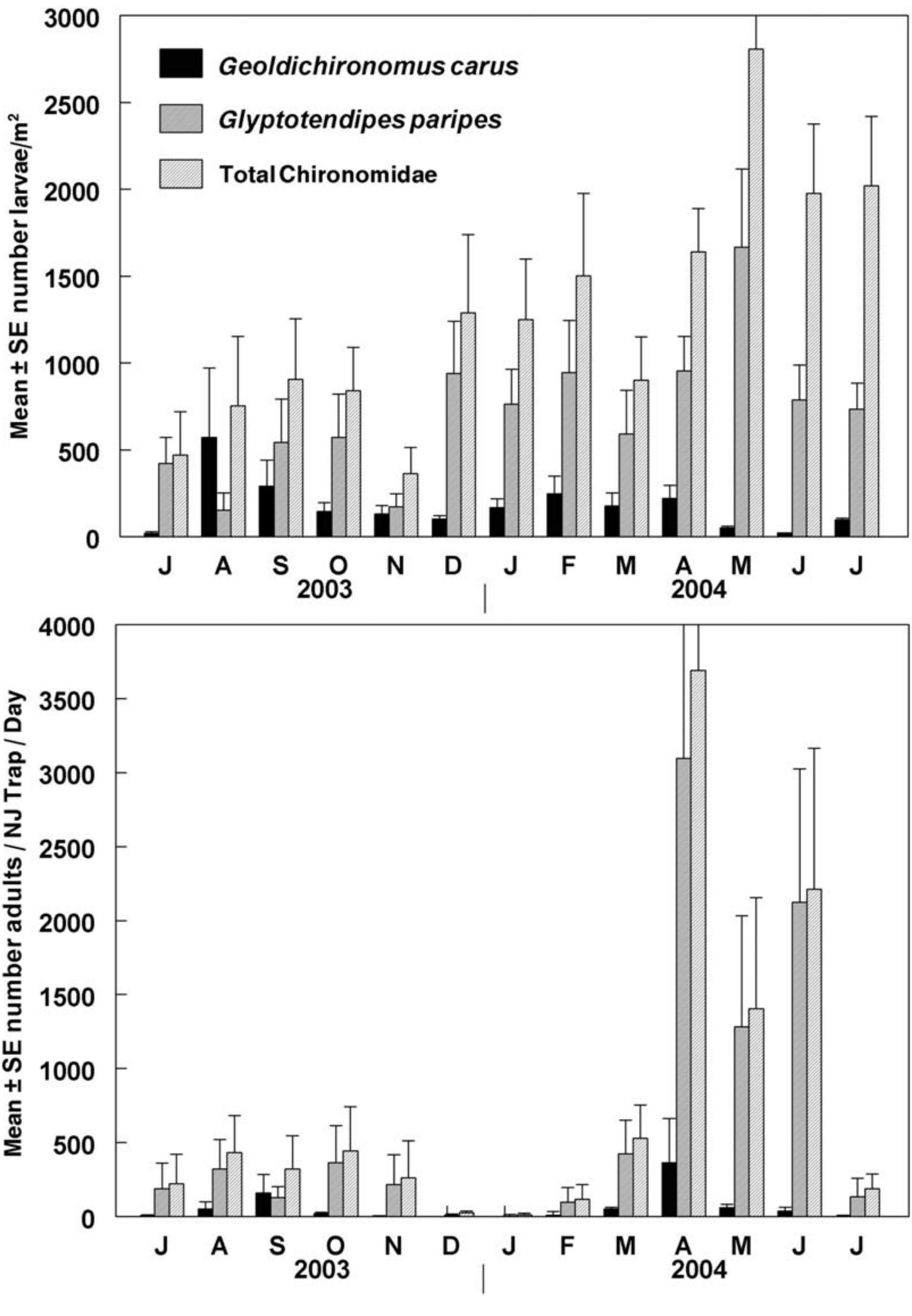

Fig. 2. Monthly mean densities of chironomid larvae prevailing in wetlands and corresponding population trends of adult Chironomidae in 9 New Jersey (NJ) light traps permanently placed around wetlands at the Ponte Vedra Beach, Florida (Jul 2003 to Jul 2004).

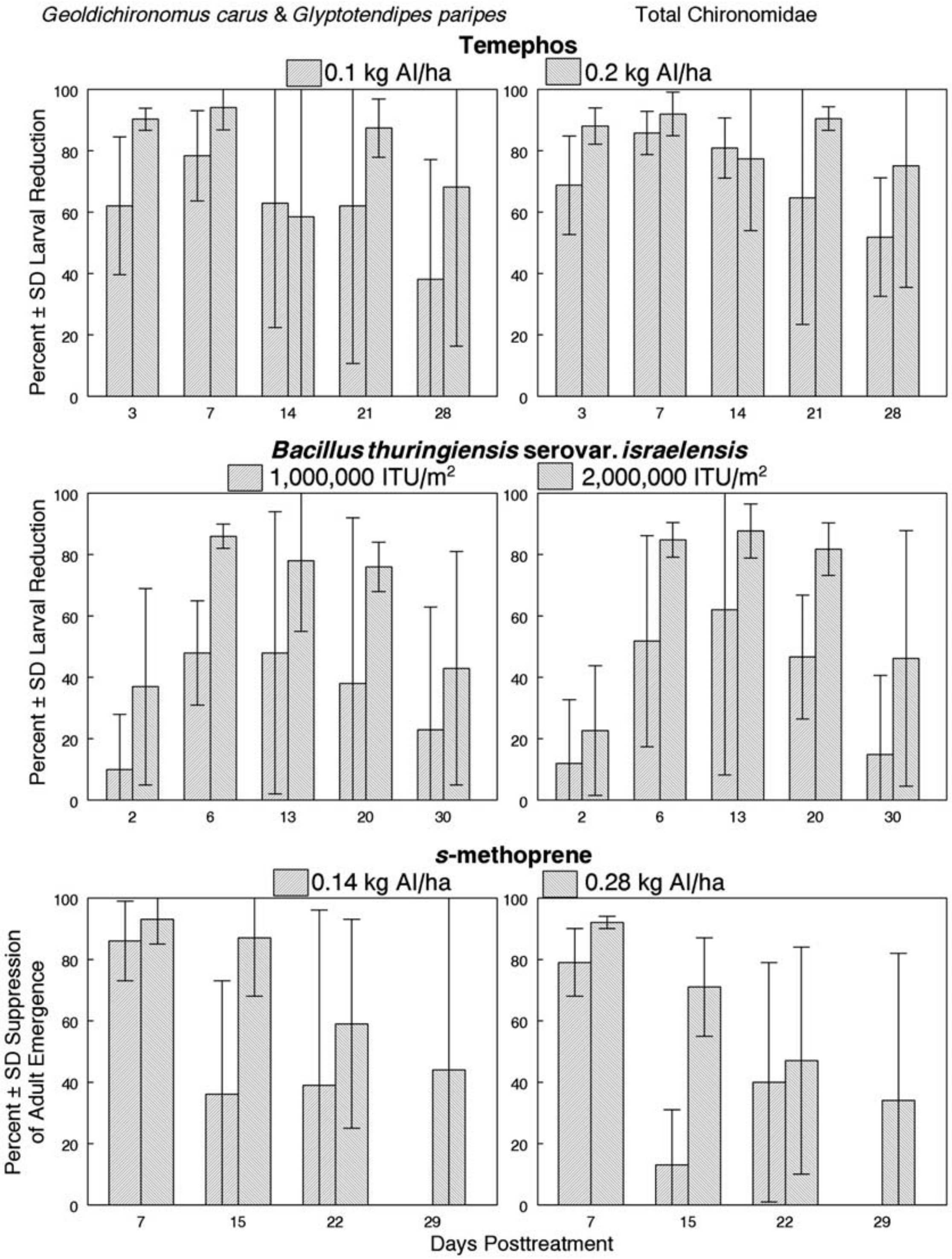

Fig. 3. Percent reduction of chironomid larvae after application of temephos (Skeeter Abate® 5% pellets) utilized at two rates (0.1 and 0.2 kg AI/ha), and a *Bacillus thuringiensis* serovar. *israelensis* powder containing 5,000 ITU/mg, formulated on sand utilized at 2 rates (1,000,000 and 2,000,000 ITU/m²), and percent reduction of chironomid adult emergence after application of *s*-methoprene (STRIKE® 4.25% pellets) at 2 rates (0.14 and 0.28 kg AI/ha) in field plots established in wetlands at the Ponte Vedra Beach, Florida (Apr-Nov 2004).

TABLE 1. LABORATORY TOXICITY OF THE ORGANOPHOSPHORUS LARVICIDE TEMEPHOS (90% TECHNICAL MATERIAL), A TECHNICAL POWDER OF THE BIOLOGICAL INSECTICIDE, *BACILLUS THURINGIENSIS* SEROVAR. *ISRAELENSIS* (7,468 INTERNATIONAL TOXIC UNITS [ITU]/MG) AND *s*-METHOPRENE (96% TECHNICAL MATERIAL) TO LATE THIRD/EARLY FOURTH INSTARS OF *GLYPTOTENDIPES PARIPES* AND *GOELDICHIRONOMUS CARUS* COLLECTED FROM WETLANDS AT PONTE VEDRA BEACH, FLORIDA (JUL-OCT 2003).

	Lethal concentration (ppm)						
						Chi square for heterogeneity	
Midge species	LC_{50}	95% CL	LC_{90}	95% CL	Slope	Calculated	Tabular value at 0.05 level
			Temephos[a]				
G. paripes	0.005	0.004-0.005	0.010	0.008-0.012	4.30	6.797	7.815
G. carus	0.005	0.004-0.006	0.009	0.007-0.011	5.17	1.672	7.815
			Bacillus thuringiensis serovar. *israelensis*[b]				
G. paripes	0.175	0.127-0.224	1.056	0.778-1.624	1.64	4.046	11.070
G. carus	0.089	0.059-0.121	0.467	0.335-0.749	1.77	2.040	9.488
			s-Methoprene[c]				
G. paripes	0.022	0.016-0.028	0.082	0.061-0.123	2.23	5.476	7.815
G. carus	0.013	0.010-0.017	0.055	0.040-0.086	2.04	4.551	7.815

[a]Larval mortality checked after 24 h.
[b]Larval mortality checked after 48 h.
[c]Continuously exposed in laboratory aquaria.

rate of application) and a 23% (high rate of application) reduction in numbers of total larvae were noted. However, at 6, 13, and 20 d posttreatment, the low rate of *Bti* gave 38-48% reduction of *G. paripes* and *G. carus* and 47-52% reduction in the total larval chironomid population. The high rate of *Bti* produced 76-86% reduction in *G. carus* and *G. paripes* and 82-88% reduction in total Chironomidae during the 6-20 d posttreatment (Fig. 3).

The low rate of *s*-methoprene application resulted in 80% reduction of adult Chironomidae at 7 d posttreatment, but thereafter this IGR was generally ineffective. At 0.28 kg AI/ha, *s*-methoprene induced 71-92% emergence suppression of adult Chironomidae for up to 15 d posttreatment (Fig. 3).

DISCUSSION

Two species of chironomids, *G. paripes* and *G. carus* vastly predominated the Ponte Vedra Beach wetlands with other chironomid taxa found only in very small numbers. Adults of these species emerged at nuisance levels from Mar to Nov, with large peaks of emergence occurring during Apr to Jun, coinciding with highest larval densities during this period. Larvae of the 2 midge species were susceptible to the larvicides, temephos and *Bti*, and the IGR, *s*-methoprene. In field trials, temephos applied as 5% Skeeter Abate® pellets at 0.2 kg AI/ha gave good control of larvae for up to 28 d; *Bti* at 2,000,000 ITU/m^2 gave control for 20 d; and *s*-methoprene STRIKE® pellets at 0.28 kg AI/ha suppressed significant adult emergence for 15 d posttreatment. Considering the current market price in relation to field control of these chironomids, temephos gave control for the longest period and is 3-4 and 4-5 times more economical than *Bti* and *s*-methoprene, respectively. However, due to the possible development of resistance (Ali & Mulla 1978a), we recommend that *Bti* and *s*-methoprene be used in rotation with temephos as alternate options for midge control as part of a resistance management program. Each control material has a separate mode of action and thus with alternation, the risk of resistance to any one compound will be reduced. Although temephos is environmentally more hazardous than *Bti* and *s*-methoprene, the temephos use rate of 0.2 kg AI/ha would probably have temporary and reversible impact on non-target biota coexisting with chironomids in the aquatic ecosystem, as described by Ali & Mulla (1978b).

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