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Effects of Herbicides and Microbial Insecticides on the Insects of Aquatic Plants

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INTRODUCTION

Waterhyacinth (*Eichhornia crassipes*) (Mart.) Solms., waterlettuce (*Pistia stratiotes* L.) and hydrilla (*Hydrilla verticillata* Royle) are currently the three most troublesome aquatic weeds found in Florida. In 1987, a total of 25,197 hectares were controlled with herbicides, at an estimated cost of $8.5 million (Schardt 1987). Introduced biological control agents have been released and are established for waterhyacinth (Perkins 1973, Center and Durden 1981), and programs are currently underway to release and evaluate approved biocontrol agents for waterlettuce (Dray et al. 1990, Thompson and Habeck 1989), and hydrilla (Buckingham 1988, Center 1989). In addition, numerous other native natural enemies of aquatic weeds are present in the environment and cause various levels of feeding damage which stress these target pest plants (Buckingham et al. 1986, Haag et al. 1986, Habeck et al. 1986).

It has been determined that most commonly used herbicides and additives are not harmful to waterhyacinth biocontrol agents (Haag 1986), but similar trials have not

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been conducted with other phytophagous insects feeding on these aquatic weeds. In addition, various microbial pesticides continue to be used in many aquatic habitats to eliminate various species of mosquitoes. The purpose of this study was to evaluate the impacts of selected herbicides and microbial insecticides on native and introduced biocontrol insects of waterlettuce and hydrilla.

MATERIALS AND METHODS

Conditions for laboratory trials varied with the particular plant, insect and pesticide being tested. All treatments and controls included 5 replicates. Choice of either larval or adult insect life history stage was based on the likelihood of contact with the selected pesticides under field conditions. *Neohydronomus affinis* Hustache was collected from rearing colonies in Gainesville or Ft. Lauderdale, FL. For each replicate, 6 adult weevils were put on a single waterlettuce plant which was then placed in a 4.4 l plastic-lined paper carton (17.8 cm diameter) filled with 2 l of tap water. Cartons were fitted with screen-covered lids to prevent escape of insects.

Samea multiplicalis (Guenee) was collected from field sites in Gainesville. Three to 5 healthy waterlettuce leaves were put into a 100 ml plastic cup (8.3 cm diameter) filled with 50 ml of tap water and covered by a screen lid. *S. multiplicalis* was added at a rate of 5 larvae per dish.

Bagous affinis Hustache was taken from USDA colonies in Gainesville. For each replicate, two strands of hydrilla totaling 20 cm length were placed into a 100 ml plastic cup filled with 100 ml tap water. Eight weevils were placed in each cup, which was then covered with a screen lid. *Hydrellia pakistanae* Deonier larvae were taken from USDA colonies in Gainesville. Each 100 ml plastic cup was filled with 50 ml of tap water and provided with three 5 cm strands of hydrilla. Ten larvae were added to each cup and allowed to burrow into the plant leaves before treatments were initiated.

Larvae of the native moths *Parapoynx diminutalis* Snellen and *Synclita obliteralis* (Walker) were collected from field sites in Gainesville. Trials were conducted in 100 ml plastic cups fitted with screen covers. Each cup was filled with 50 ml of tap water, and provided with one of the following insect/host plant combinations: 5 *S. obliteralis* larvae with 1 leaf of *Brasenia schreberi* Gmelin per cup; 5 *P. diminutalis* larvae and 20 cm hydrilla/cup.

Microbial agents were obtained from Jeff Lord at the USDA in Gainesville. A dry powder preparation of the bacterium *Bacillus thuringiensis israelensis* (H-14, US Standard) (Dulmage et al. 1985) was added to the water in the test cups (100 ml) to yield final concentrations equivalent to 10 ppb [10 ug/1] and 20 ppb 20 [20 ug/1], (the LC 90 and 2x LC 90, respectively, for the mosquito *Culex quinquefasciatus*). A dry powder preparation of *Bacillus sphaericus* was added to test cups to yield a final concentration of 2 ppb or 4 ppb, for comparable reasons. The fungus *Laginidium giganticum* was added to each test cup as a 5 mm agar disc which contained sufficient material to give a total final concentration of 1500 zoospores/ml in 100 ml water. The virulence of these three microbial agents was verified at the time of experimental trials by simultaneous application to 5 replicate 100 ml plastic cups provided with 100 ml tap water and 20 *Anopheles freeborni* mosquito larvae. Mosquito mortality always exceeded 95%.

Hydrilla biocontrol insects were exposed to three herbicides commonly used against this weed. Endothall (dipotassium salt of 7-oxabicyclo [2.2.1] heptane-2,3-dicarboxylic acid; 4.23 lbs active ingredient per gal) was added with a pipette to test cups to give a final concentration of 2 or 4 ppm (0.4 ul or 0.8 ul in 100 ml water). Fluridone (1-methyl-3-phenyl-5-[3- (trifluromethyl) phenyl]-4(1H)-pyridinone; 4 lbs active ingredient per gal) aequous suspension was applied with a handheld sprayer to test cups at rates equivalent to 1.8 l/ha or 3.6 l/ha (4.6 and 9.2 ppm). Diquat dibromide 6,7-dihydropyrido (1,2-a:2',1'-c) pyrazinediium dibromide; 3.73 lbs salt per gal] was combined with chelated copper (copper-ethylene diamine complex; 0.8 lbs metallic copper per gal) and applied to test cups with a handheld sprayer at rates equivalent to the following: 18.9 l/ha diquat (45 ppm) + 37.85 l/ha chelated copper (19 ppm); 37.85 l/ha diquat (90 ppm) + 75.5 l/ha chelated copper (38 ppm).

Mean % mortality in the various treatments was tested for significance using Student's T-test ($p \leq 0.05$) (SAS Institute 1985).

RESULTS AND DISCUSSION

Results of trials with microbial insecticides are presented in Table 1. *B. sphaericus* caused significant mortality of *P. diminutalis* moth larvae (46.7% ± 24.9), whereas *B. t. i.* application resulted in significant mortality of *S. obliteralis* larvae (53.3% ± 9.4). The fungus *Laginidium* did not cause statistically significant mortality of any insect species tested. A recent review of the literature on microbial control of mosquitoes indicates no negative impacts on nontarget organisms, although no aquatic Lepidoptera were included in any of the studies cited (Lacey and Undeen 1986).

TABLE 1. PERCENT MORTALITY OF INSECTS TREATED WITH MICROBIAL INSECTICIDES.

	B. sphaericus		*B. t. i.*		*L. giganticum*	
	2ppb	4ppb	10ppb	20ppb	1500/ml	Control
P. diminutalis (larvae)	–	46.7 ± 24.9[a,b]	–	20.0 ± 28.3	–	6.7 ± 9.4
S. multiplicalis (larvae)	28.0 ± 16.0	32.0 ± 20.4	28.0 ± 20.4	24.0 ± 15.0	12.0 ± 16.0	8.0 ± 9.8
S. obliteralis (larvae)	–	0	–	53.3 ± 9.4[b]	–	0
B. affinis (adults)	7.5 ± 10.0	27.5 ± 12.2	7.5 ± 6.1	2.5 ± 5.0	12.5 ± 7.9	0
N. affinis (adults)	0	10.0 ± 13.3	20.0 ± 19.5	0	–	6.7 ± 9.4
H. pakistanae (larvae)	14.0 ± 10.2	14.0 ± 15.0	–	0	–	6.0 ± 4.9

[a]Values are means ± one standard deviation.
[b]Indicates mortality significantly different from control mortality ($p \leq 0.05$) using Student's T-test.

Results of trials with herbicides are presented below. *Bagous affinis* adults did not experience significant mortality when exposed to low or high concentrations of: diquat dibromide and chelated copper 2.5% ± 5.0, 2.5% ± 5.0, respectively); endothall (2.5% ± 5.0, 0%, respectively); or fluridone (7.5% ± 10.0, 2.5% ± 5.0, respectively). *Hydrellia* fly larvae did suffer significant mortality when treated with: 4 ppm endothall (44.0% ± 13.6); 8 ppm endothall (74.0% ± 12.0); 4.6 ppm fluridone (38.0% ± 13.3); and 9.2 ppm fluridone 96.0% ± 4.9); 90 ppm diquat dibromide + 38 ppm chelated copper (100% ± 0). With the exception of the endothall tests, the herbicides were evaluated at concentrations considerably higher than would normally be used in field operations. The high rate of larval death for *Hydrellia* may be due to loss of habitat following death of hydrilla leaflets and not due to direct toxic effects of the herbicides themselves. If herbicide is applied in an integrated management program against hydrilla, it may be important to avoid those times of the year when fly larvae and pupae are present and vulnerable to habitat loss.

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