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A JOURNAL OF AGRICULTURAL SCIENCE PUBLISHED BY
THE CALIFORNIA AGRICULTURAL EXPERIMENT STATION

Volume 58 • Number 1 • August 1990

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II. Impact of Diflubenzuron and Triflumuron

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ABSTRACT

An application of triphenyltin hydroxide at 1.16 kg (AI)/ha to rice fields for stem rot (*Sclerotium oryzae* Catt.) control resulted in a significant reduction of 57% of the invertebrate taxa and 67% fewer individuals based on two collecting methods that sampled the nekton, neuston, and benthon. Populations of herbivores, carnivores, and filter feeders were sharply reduced after treatment, and most remained so through the 28th day following application. By day 50 many of the winged species recovered in both numbers and diversity. However, recovery of benthic organisms was slower or not at all for most Crustacea. An initial reduction followed by a strong resurgence was noted for the mosquito *Culex tarsalis* Coq., which was probably due to the significant reduction of five predaceous species.

Two benzoylphenyl ureas, diflubenzuron and triflumuron, were evaluated in California rice fields to determine their ecological impact on populations of nontarget organisms. Modified minnow traps, drag net, and kellen dredge sampling devices were used in the collecting. Nontarget populations were sampled continuously throughout much of the 1985 and 1986 rice growing season. Total collections of nontargets showed only two *Cypris* species of seed shrimp crustaceans were significantly ($P<0.05$) reduced over time due to either chemical. One predaceous water boatman, *Corisella decolor*, showed the opposite pattern in that populations were significantly ($P<0.05$) lower in the control. Significant differences were not observed in species diversity

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INTRODUCTION

EXPERIMENTAL APPLICATIONS of triphenyltin hydroxide (TPTH) sprayed on California rice fields (1974-76), effectively controlled stem rot, a disease of rice caused by the fungus *Sclerotium oryzae* Catt. (Jackson et al. 1977). Therefore, TPTH was considered an alternative to postharvest burning, a cultural control practice currently recommended for this important plant disease. Burning of rice stubble and straw is also very effective in control of stem rot but unfortunately, burning can lead to air pollution.

TPTH is effective on a complex of fungal diseases on a variety of crops and is reported to inhibit feeding of some surface-feeding insects. Its biocidal properties also extend to vertebrates as demonstrated by an acute oral LD50 value for rats ranging from 156 to 345 mg/kg (Meister 1986).

This study originated as a part of an overall study to examine the effects of a TPTH treatment on rice field organisms as a prerequisite to possible registration for stem rot control. The results reported here are limited to the chemical's direct or indirect effects on invertebrates in rice fields as determined by two sampling devices used 7 days before and up to 50 days after treatment.

The 1985-86 study was part of a project to determine the effectiveness of benzoylphenyl ureas (BPUs) in controlling the rice water weevil, *Lissorhoptrus oryzophilus* Kuschel, in California rice fields and to determine if there is an effect on major nontarget organisms found in these fields.

The rice water weevil (RWW) is an economically important pest of rice in the United States (Grigarick 1984). The major concern is larval feeding on rice roots. Currently only conventional insecticides are employed to control or prevent root feeding by this life stage. At present, carbofuran is the only registered insecticide available in California for RWW control. This chemical is applied in a granular formulation to the soil. Recently, the California Department of Food and Agriculture restricted the use of carbofuran for RWW control. Some of these restrictions reduced the amount of chemical allowed and required incorporation of the granules into the soil in certain areas. These restrictions have been implemented primarily because of an increased number of duck kills caused by ingestion of the granules.

[1]Accepted for publication June 19, 1990.

Because of these restrictions and because of carbofuran's highly toxic non-selectivity, there has been increased interest in the possible use of BPUs in controlling the RWW. These chemicals are considered to be chitin synthesis inhibitors and are relatively nontoxic to organisms that are not chitin producers.

For the past several years we have been investigating the use of two BPUs, diflubenzuron (1-(4-chlorophenyl)3-(2,6 difluorobenzoyl) urea) and triflumuron (2-chloro-N-[[[4-(trifluoromethoxy)phenyl]amino]carbonyl]benzamide) for RWW control. Smith et al. (1985) demonstrated that both chemicals have an ovicidal effect on the RWW primarily through ingestion by the mother.

Maximum field oviposition in California occurs during the first 2 weeks after rice emerges through the water (Grigarick, unpublished data). Adult RWW begin to feed and oviposit on rice as soon as plants emerge through the water, thus timing of application for these BPUs is critical. Our field trials (Smith and Grigarick 1988) have demonstrated that significant reduction in RWW immatures is achieved by applying either BPU at 0.28 kilogram (active ingredient) per hectare (kg [AI]/ha) at 4 or 5 days following 50% emergence of rice plants from the water.

Diflubenzuron is currently registered for use in certain parts of the United States for control of mosquito and midge larvae. Because these organisms are found in aquatic habitats, there is concern over what effect diflubenzuron or other BPUs will have on nontarget organisms in these habitats. Several studies have been conducted to analyze possible effects, primarily with diflubenzuron. Some of the different aquatic habitats that have been studied are (1) fresh-water ponds (Ali and Lord 1980; Apperson et al. 1978; Colwell and Schaefer 1981; Miura et al. 1983; Mulla and Darwazeh 1975), (2) recreational lakes (Ali and Mulla 1977, 1978a, 1978b), (3) fresh-water laboratory stream communities (Hansen and Garton 1982a, 1982b; Rodrigues and Kaushik 1986), (4) Louisiana rice fields (Steelman et al. 1975), and (5) Louisiana coastal marsh (Farlow et al. 1978). There have also been investigations on the effect of both BPUs to nontarget organisms in terrestrial agricultural environments (Ables et al. 1977; Broadbent and Pree 1984; Keever et al. 1977). Some studies have also investigated the effect on fresh-water fish (Ellgaard et al. 1979; Nebeker et al. 1983) and birds (Yahner et al. 1985).

The following studies are presented to show contrasting effects of selective and nonselective pesticides.

MATERIALS AND METHODS

These studies were conducted at the Rice Research Experiment Station located at Biggs, California, during the 1977, 1985, and 1986 rice growing seasons. The experimental design for TPTH in 1977 consisted of eight adjoining fields, each having a separate water inflow and outflow. They were approximately 14.5 by 83.3 m in size. The experiment was set up as a randomized complete block design with four blocks, each containing a treated and untreated paddy. The field design for the BPUs in 1985 and 1986 consisted of 12 paddies, each having separate water inflow and outflow and approximately 44.5 by 6.1 m in area (fig. 1). The experiment was set up as a randomized complete block design with three blocks, each block containing four paddies (treatments). Water source for all studies was the Feather River.

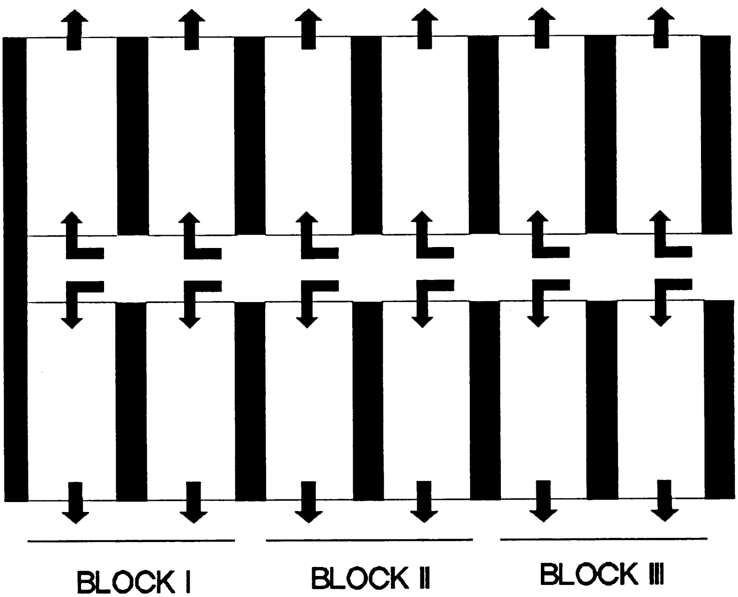

Fig. 1. Diagrammatic representation of the field design for the 1985 and 1986 experiments. Arrows indicate water flow. Dark areas represent levees.

In 1977 a preflood treatment was made to all paddies using bufencarb granules (5G at 1.16 kg [AI]/ha) shortly before flooding to reduce or eliminate the effect of the RWW on rice plant growth. All paddies were flooded to a depth of about 15 cm and seeded by airplane with rice variety 'S6' on May 4. TPTH (W-47.5) was applied to the treatment paddies at a rate of 1.16 kg (AI)/ha by ground application on June 28. Rice growth on this date was at approximate mid-tillering stage (40 days). The spray was applied with a 4.8 m hand-held boom on a compressed-air powered sprayer. Control paddies were not sprayed. Water samples from the drainage end of the four treated paddies and one untreated paddy were taken at intervals from 1 hour to 21 days after treatment. Analyses for TPTH residues in the rice water were obtained from the Thompson Hayward Chemical Company.

All paddies in 1985 and 1986 were flooded to a depth of about 10 cm and seeded at 146 kg/ha seed of rice variety 'M-201.' In 1985, paddies were hand seeded 24 hours after the initial flood with seed presoaked in tap water. In 1986, fields were dry seeded by machine one day before flood. Copper sulfate was applied to all fields at 11.2 kg (AI)/ha for tadpole shrimp (*Triops longicaudatus*) control 1 week following seeding in 1985. This pest is not distributed evenly in all fields, and, since it reduces rice plant stand, it would interfere with the yield evaluations of the BPUs. The effect of the copper sulfate treatment would be primarily on crustaceans present at the time of treatment and secondarily on fauna that would be affected by a temporary delay in algal growth about 3 weeks before sampling started. The BPUs were applied to the paddies with a CO_2-pressurized backpack sprayer utilizing a spray boom that spanned the width of the paddy from levee to levee. In 1985, triflumuron (25% WP) was applied at a rate of 0.28 kg (AI)/ha. Treatments consisted of single application at 4 (June 4) and 7 days (June 7) post mean rice emergence and as a double application at 4 and 10 days (June 4 and 10) post mean rice emergence. Mean rice emergence was determined when about 50% of the rice plants emerged from the continuously flooded paddies. Control paddies were sprayed with water only. In 1986, triflumuron (4F) was applied at 0.28 kg (AI)/ha and at 0.42 kg (AI)/ha. Diflubenzuron (25% WP) was the third treatment and applied at 0.28 kg (AI)/ha. Treatments were applied at 5 days post mean rice emergence (June 7). The control paddies were again sprayed with water only. Water flow for both years was stopped for 7 days following the BPU application.

Two different sampling devices in 1977 and three in 1985 were employed to sample the animal fauna found in the paddies. In 1985 and 1986, a "standard" minnow trap was used. This trap was modified by lining the inside with aluminum window screening (1.6-mm mesh) because the mesh of the minnow trap (6.4 mm) was too large to retain smaller organisms. For each sampling date, three of these modified minnow traps were randomly placed in each paddy. The traps were gently pushed into the mud so that only about 3 cm of air space was present at the top of the trap (this insured that the two entrance holes were well below the water surface). Bait was not used in these traps. The traps were then recovered 24 hours later. The contents of three traps from one paddy were combined in a plastic container, screened through a hand-held net, and placed in a quart mason jar. The jar was filled with 95% EtOH and returned to our laboratory for future processing. This was repeated for each sampling date.

The nekton and neuston for 1977 and 1985 were collected with a 1.27-mm mesh drag net (Turtox dredge net 73-425). This net was set on basal runners so that it passed through the water slightly above the bottom with the upper margin above the water surface. The average water depth was such that approximately 520 liters of water was sampled when the net was pulled 15 m in about 30 seconds. One linear drag of 15 m was taken in each paddy. This type of sampling device could not be used in dense rooted vegetation, so 1 week before routine sampling, rice plants were removed from the paddy to form an open water aisle 15 m long and 0.5 m wide. All drag net samples were confined to these aisles. The contents of the net were placed in plastic bags and returned to a washing facility on the station. The contents were then screened and washed through three brass graded sieves of 5 (4 mm), 20 (0.85 mm), and 40 (0.425 mm) mesh to remove dirt and debris. All organisms were hand removed from the 5- and 20-mesh screens. The entire contents of the 40-mesh screen, along with the hand-removed specimens were placed in a quart mason jar and then filled with 95% EtOH for later processing.

The Kellen dredge (Kellen 1954) was used in 1977 and 1985 to sample the benthon. This device was originally designed to remove mud to a depth of 5 cm. Clement et al. (1977) found that most chironomid midge larvae are limited principally to the soil surface. To eliminate the collection of excessive mud, they modified the dredge by connecting two lateral aluminum flanges, which limited penetration to 2.5 cm. We used this modified version of the Kellen dredge. This device when pushed firmly into the mud removed a 0.023 m^2 sample of soil. For each sampling date two subsamples in 1977 and three subsamples in 1985 were randomly removed from each paddy and combined in a single plastic bag. The sample was then washed and screened as described above.

In the laboratory, the entire samples from both the minnow trap and drag net traps were counted and identified and Kellen dredge collections were frequently subsampled to estimate total numbers. All organisms were identified to genus (except for terrestrial Homoptera) and, if possible, to species. Insects were identified by keys provided in Usinger (1956), Darby (1962), and Merritt and Cummins (1978). All other taxa were identified by keys found in Edmondson (1959) and Pennak (1978). Identification of Kellen dredge samples in 1985 were limited to chironomid larvae because they were the dominant organisms collected.

All data was transformed by $\overline{X} + 0.5^{1/2}$ due to the many zero counts. Statistical differences between treatments for a particular species collected on one sampling date by one sampling device were analyzed by two-way ANOVA. Means were separated by Duncan's (1955) multiple range test. Species diversity was calculated using the Shannon-Weiner Index formula (Shannon and Weaver 1949); $H' = -\Sigma \, pi \log_e p_i$ where p_i is the proportion of the $_i$th species in the total sample. A three-way ANOVA was run using treatments, blocks, and sample dates for each species as the three factors. The grand mean for each treatment regime for the entire sampling period for each species was calculated. Significant differences for the treatment factor from the three-way ANOVA are listed. A two-way ANOVA was run for each sampling device, the two factors consisting of total number of species and the treatment grand means.

RESULTS

A checklist of taxa collected in these studies is given in table 1 (p. 15) along with the table number indicating their incidence, the stage collected, and collection device. A total of 35 families and 58 taxa are represented. By far, the largest proportion of species belongs to the class Insecta with most from the order Coleoptera. Paddies were irrigated with water from the Feather River, which accounts for the presence of the different fish species. Data for species indicated as not included were not analyzed statistically due to the low number of specimens collected.

Part I

Table 2 (p. 18) lists collection dates for the 1977 study, mean number of individuals collected by species from each sampling device and year collected, and tabulations of the grand mean for each species by sampling device. Significance was determined for taxa that appeared in more than 3 of the 11 sample periods. Table 3 (p. 23) gives the grand mean of taxa by sampling device for the 9 days of collections following treatment. Figure 2 presents the results of drag net collections for each collection date by a calculated Shannon-Weiner Diversity Index. The same type of information as in figure 2 is presented in figure 3 for the Kellen dredge collections. Water analyses for TPTH residues are presented in table 4 (p. 23).

The results of the 1977 study with TPTH show an obvious detrimental effect on many invertebrates found in the rice paddies during the sampling period. Significant changes between treated and untreated paddies and possible trends are discussed by groups below.

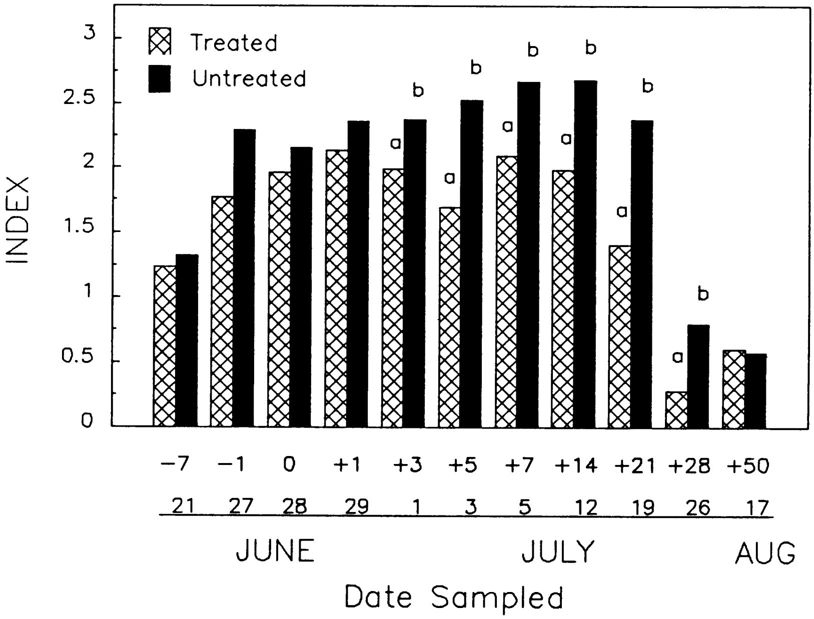

Fig. 2. Shannon-Weiner Diversity Index values calculated from 1977 drag net data. Means in groups of two bars followed by different letters for each date sampled are significantly different ($P<0.05$; Duncan's (1955) multiple range test) for two-way ANOVA. Bars without letters are not significantly different.

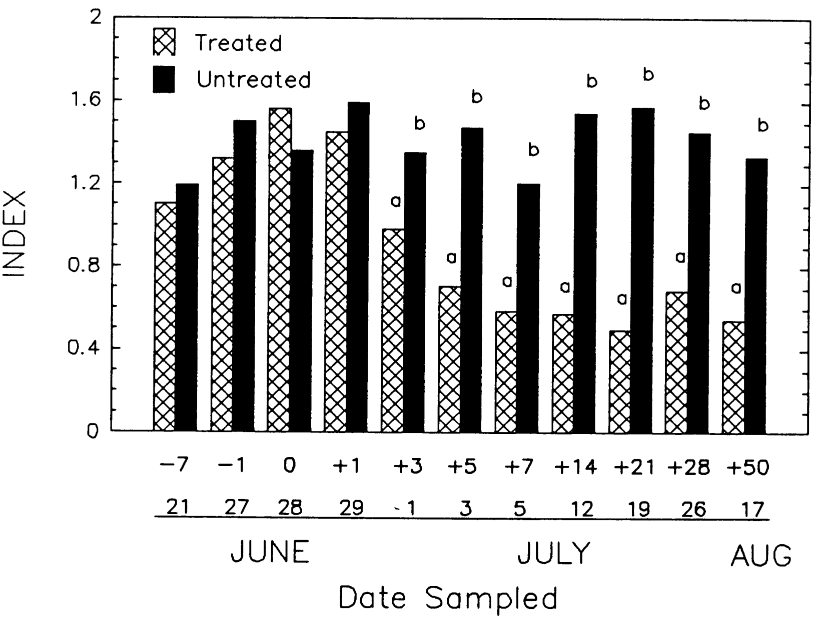

Fig. 3. Shannon-Weiner Diversity Index values calculated from 1977 Kellen dredge data.

Oligochaetes

These worms were collected by both sampling methods (table 2). The largest numbers were found in close association with the soil and were not significantly affected by TPTH in this habitat. The drag net collected fewer oligochaetes, but their presence in this collecting device indicated some moved about in the water or were dislodged from the soil surface by the drag net. No worms were found in drag net collections in the treated paddies after the initial treatment, while the untreated paddies consistently contained them and, on occasion, in significant numbers.

Crustacea

Three species of ostracods (seed shrimp) and one cladoceran (water flea) were present in the rice paddies. All four species were adversely affected by the treatment (table 2). The cladoceran, *Ilyocryptus spinifer*, was not present before treatment and did not become established in the treated paddies, but was found in significant numbers in the untreated paddies. All three species of ostracods were significantly reduced from the untreated by the third day after treatment and were not collected after the fifth or seventh days in the treated paddies. Only *Cypris* sp. showed a slight recovery starting with the 21-day collection. The strong effect of TPTH on crustaceans may be a combination of acute toxicity and elimination of food. These crustaceans are omnivorous scavengers as collectors or grazers of various microorganisms. The Kellen dredge frequently yielded fewer crustaceans than the drag net, depending on species but usually showed their presence earlier. Only the drag net effectively collected *Ilyocryptus spinifer*.

Insects

Most of the species of animals collected in the rice paddies were insects. Not all insects were identified to the species level, but 35 different aquatic taxa were represented. About one-third of these taxa showed a significant reduction in the populations in the treated paddies.

Four species of plant-feeding chironomids showed significantly fewer midge larvae in the treated paddies and the same trend, although not significant, was noted for a fifth species. The decrease in populations was generally noted by the third day after treatment. Recovery of most species began by the 50th day following treatment.

Immature bugs of the water boatman, *Corisella decolor*, were significantly reduced in the treated paddies. The decrease of these bugs, which are collectors of organic plant and animal matter on the bottom, began the third day following treatment and recovery was apparent at the 50th day. Similar trends for the adults were not significant.

Larvae of the mosquito, *Culex tarsalis*, were significantly reduced by the toxic effect of the chemical or the lack of food through the seventh day. The effect was reversed by the 21st day later as significantly more larvae occurred in the treated paddies. This also coincided with the largest populations of the predaceous beetle larvae, *Laccophilus decipiens*, in the untreated paddies and significantly fewer predators in the treated ones.

Five species of predators were significantly reduced in the treated paddies. These included the dragon fly naiad, *Pantala hymenaea*, the velvet water bug, *Merragata hebroides*, and the water beetle larvae, *Laccophilus decipiens*, *Hygrotus* sp. (table 2), and *Tropisternus lateralis*.

The Shannon-Weiner Diversity Index showed greater values for drag net samples than Kellen dredge samples (figs. 2 and 3). The spread of differences between the treated and untreated paddies that were significant were smaller for the drag net than for the Kellen dredge. The indices for treated and untreated paddies for the Kellen dredge collections remained at a relatively constant level after the day of treatment, whereas both the treated and untreated indices for the drag net dropped during the last half of the sampling period. This drop in diversity is probably due in a large part to the large increase in numbers of aphids. No significant difference in the indices for treated and untreated drag net collections was found at 50 days.

The grand mean for total numbers collected by taxa (table 2, p. 18) shows 57% of the taxa, in either the adult or immature stages, were significantly reduced in the treated paddies. This percentage is based on both collecting methods. The grand mean for all taxa by treatment regime and sampling device (table 3, p. 23) showed that 67% fewer individuals were found in the treated paddies with the drag net and 83% fewer individuals in the treated paddies with Kellen dredge. This reflects a strong detrimental effect of the chemical on the nekton, neuston, and benthon, and particularly on the benthic community.

The residues of TPTH found in the water (table 4, p. 23) showed a mean value of 160 parts per billion 1 hour following treatment. Residues dropped significantly to 70 ppb 1 day later and 40 ppb at the third day. The decrease in TPTH was gradual for the next 18 days. This last sample showed a mean value of 10 ppb.

Part II

Tables 5 (p. 24), 6 (p. 30), and 7 (p. 32) list collection dates for the 1985 and 1986 studies, mean number of individuals collected by species from each sampling device and year collected, and tabulations of the grand mean for each species by sampling device. Table 8 (p. 34) gives the grand mean of taxa by sampling device for the sample period following each treatment. Figures 4 to 7 present the results of a calculated Shannon-Weiner Diversity Index for each year and sampling device.

Based on the data of table 8, each treatment regime was not significantly different from the controls regardless of the sampling device employed. However, when analyzing data on a species basis, some significant differences were found. The effects of the BPUs on individual species will be discussed below.

Physa sp. Grand mean totals for 1985 and 1986 showed significant differences. In general, a double application or a higher BPU rate caused an increase of the populations over the control. Data from sampling dates over time showed this same trend, but no two-way ANOVA significant differences were found. However, the three-way ANOVA analysis showed significantly different interactions for 1986 on July 2, 17, and August 1.

Cypris sp. No. 1. Grand mean totals showed a significant increase for the control. There was also a significant interaction between the treatments and sampling dates with the controls on June 25 and July 2 and 10 being higher over all remaining data points. Data for four sampling dates showed a significant increase for the control.

Cypris sp. No. 2. Grand mean totals showed a significant increase for the control. Data for four sampling dates showed a significant increase for the control.

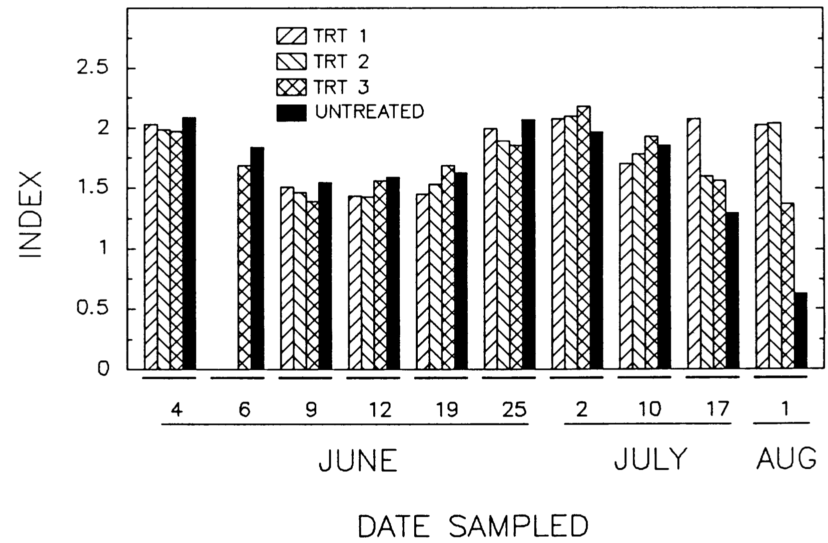

Fig. 4. Shannon-Weiner Diversity Index values calculated from 1985 minnow trap data. TRT 1 = 4 days post mean rice emergence, TRT 2 = 7 days post mean rice emergence, and TRT 3 = 4 and 10 days post mean rice emergence.

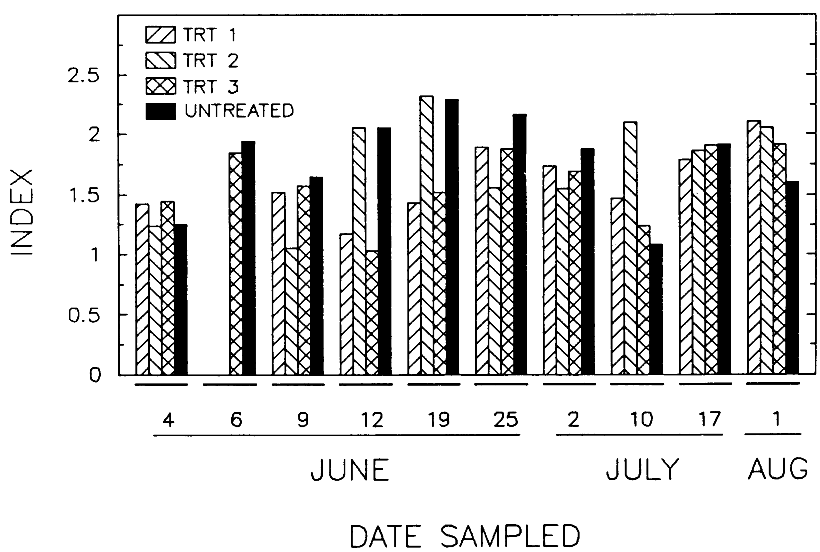

Fig. 5. Shannon-Weiner Diversity Index values calculated from 1985 drag net data.

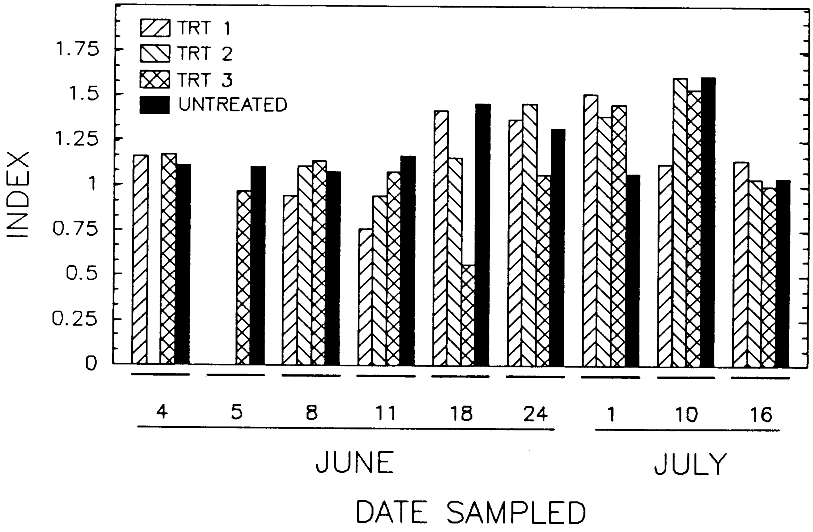

Fig. 6. Shannon-Weiner Diversity Index values calculated from 1985 Kellen dredge data.

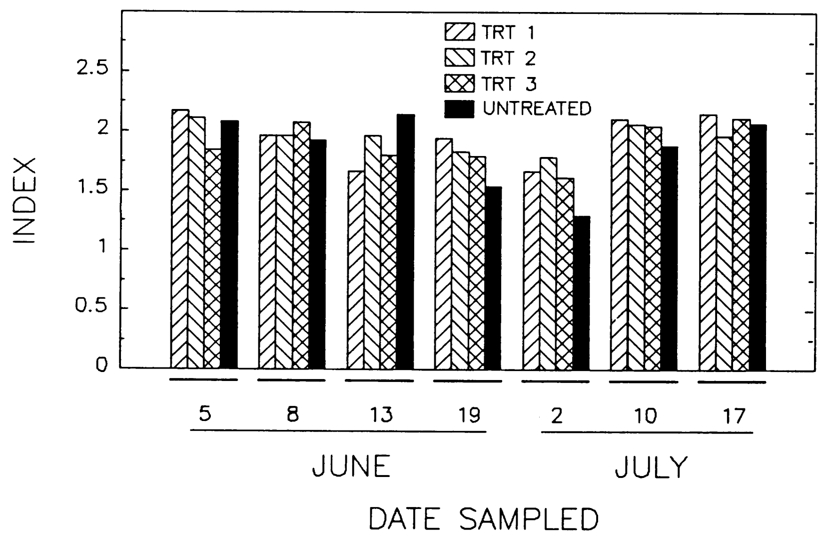

Fig. 7. Shannon-Weiner Diversity Index values calculated from 1986 minnow trap data. TRT 1 = triflumuron at 0.28 kg (AI)/ha, TRT 2 = triflumuron at 0.42 kg (AI)/ha, and TRT 3 = diflubenzuron at 0.28 kg (AI)/ha.

Callibaetis sp. Grand mean totals for the 1985 minnow trap showed a significant decrease for the 4-day postemergence treatment. Data for three sampling dates also showed significant differences, but no population trends over time were seen. In 1986, a significant difference on June 8 was seen. Again, no population trend was evident for any of the treatments.

Notonecta undulata. Drag net data for 1985 showed a significant difference on July 10, but no population trends were seen. The data were significantly different on July 10, 1986.

Corisella decolor. Grand mean totals for 1985 drag net and 1986 minnow trap showed significant reductions in the control. In 1985, minnow trap counts for June 9, 12, and 19 were estimated at 50 each due to the large numbers present and time constraints. A significant difference was found on July 2 and 10. Drag net counts differed significantly on July 2 and 17, and August 1. In 1986, significant reductions in the control were found on June 13 and 19. Totals collected in 1986 were much lower than in 1985. In general, all three data sets showed a trend for less numbers in the controls than all treatment regimes following BPU applications.

Laccophilus decipiens. Grand mean totals for 1986 minnow trap showed that the diflubenzuron and control plots were significantly higher. This was probably due to the sudden increase in numbers collected on June 19. This trend was not evident throughout the remainder of the sampling period. Totals for 1986 were higher than for 1985, but population trends during the growing seasons were similar. Populations peaked on June 10 for all treatments.

Thermonectus basillaris. Grand mean totals for 1986 minnow trap were significantly different, but the pattern was not significantly different for any of the sampling dates. The 1986 counts were almost twice as high as 1985 counts. Population peaks were similar for both years.

Thermonectus sp. (larvae). Grand mean totals for 1985 minnow trap showed significant differences, but none were found for any of the sampling dates, although numbers in the control tended to be higher. In 1986, significant differences were found on June 5, 8, and 13. Populations for both years peaked in mid-June.

Tropisternus lateralis (adults). Grand mean totals for 1985 minnow trap showed significant differences; the control was lower than 4-, 7-, and 10-day postemergence applications. Data for August 1 were significantly different. Data for controls were lower after the last BPU application even though the population throughout the study followed a bell-shaped curve. Drag net data showed no significant differences although controls were lower in July and August. Population peaks in 1985 for minnow trap and drag net counts differed with populations peaking at the end of June for the minnow trap and populations still rising at the end of the survey for the drag net. Populations in 1986 tended to follow a bell-shaped curve.

Tropisternus lateralis (larvae). For drag net data, significant differences were seen on three sampling dates although grand means were not significantly different. Data for controls were higher than treatments for 2 weeks following application, but then the trend reversed with the treatment populations increasing over the control.

Hydrophilus triangularis (adults). Grand mean totals for 1985 minnow trap showed significant differences with the control and the 7-day postemergence treatment being lower. Four of the sampling dates were significantly different showing similarities with the above pattern. In 1986, significant differences were found on June 19. In general, data for the control tended to be lower than the treatments.

Hydrophilus triangularis (larvae). Grand mean totals for 1985 and 1986 minnow trap showed significant differences, with the control data in 1985 being higher. In 1986, significant differences were seen on five sampling dates with numbers in both triflumuron treatments tending to be lower. Population numbers tended to increase in the control up through the end of June then reverse, with treatments tending to be higher than the control late into the season.

Berosus styliferus. Grand mean totals for 1985 minnow trap showed that the 4-day postemergence treatment was significantly higher than the other three treatments. There was also a significant ($P<0.01$) interaction between treatments and sampling date, with triflumuron at 4 days post-mean emergence on June 9 and 12 being significantly higher from all other data points.

Berosus sp. (larvae). Grand mean totals for drag net showed significant differences, and significant differences on June 9 and 19 were found. No population trends among the four treatments were observed.

Procladius culiciformis. Significant differences were found on four sampling dates. Controls tended to be higher than the other three treatments; however, grand mean totals indicated that the control from the double application was significantly higher.

Tanytarsus n. sp. No. 5. A significant increase in the control on June 11 was found. Populations tended to be higher in the control throughout.

Chironomus attenuatus. A significant difference was found on June 8. No population trends were observed among the four treatments.

Cricotopus bicinctus. A significant difference was found on June 18. No population trends were observed among the four treatments.

Fish (all species). In 1985, the fish were not identified to species. Only total counts of all species were made. In 1986, all fish were identified to species.

Lavinia exilcauda. Grand mean totals for this fresh water fish showed a significant reduction in the control data. This pattern was evident throughout the sampling period.

Hyla regilla. Grand mean totals for 1985 show that the 4-day postemergence treatment was significantly higher than the control although no significant differences were found by sampling date. There was a trend for lower numbers in the control. In 1986, there was a significant difference on July 2.

Shannon-Weiner Diversity Index calculated for both the 1985 and 1986 studies showed no significant differences between the treatment regimes and the control.

DISCUSSION

Part I

TPTH residues of 10 ppb in the water were detectable in three of the four treated paddies at 21 days and in the final residue sample (table 4, p. 23). TPTH water residues analyses taken by Shaefer et al. (1981) at similar time intervals showed similar results to our study through 2 weeks but were lower at about 3 weeks. They found no detectable TPTH in the water at 24 days. Schaefer et al. study also included soil analyses for TPTH in their study. The TPTH rose sharply after treatment to 327 ppb in the soil at 3 days and steadily decreased to 17 ppb at the final 24-day sample.

The drag net and Kellen dredge sampling devices appeared to be adequate to show the impact of TPTH on the invertebrate nontarget fauna. Populations of both herbivores and carnivores and filter feeders were sharply reduced after treatment, and most remained so 28 days later. By the 50th day, many of the winged species were showing recovery in numbers and diversity as indicated by drag net samples. Recovery of benthic organisms, as indicated by the Kellen dredge, was slower or not at all for most Crustacea. The crustacean populations were not sampled the following year, so the effect of TPTH on diapausing eggs is unknown.

Bufencarb as a preplant treatment was necessary to eliminate or minimize yield losses due to the RWW larvae because yield was a major factor in evaluating the efficacy of TPTH on the stem rot organism. The bufencarb would have had its greatest effect on soil-inhabiting organisms, but Kellen dredge samples did not indicate that it was a major factor in reducing many species. The absence of O_2 in flooded soil severely limits most fauna in the bufencarb treated region (RWW larvae being an exception that taps the rice root for O_2).

The study of Schaefer et al. (1981) reports on a single treatment of TPTH on a portion of a single rice paddy. Subsamples of organisms were collected within this paddy by different sampling devices than were used in our study. They also reported a strong detrimental effect upon Crustacea and insect predators. Their collection counts show large differences between treated and untreated samples for some taxa, but it is difficult to determine significance for other taxa because of the lack of statistics. Schaefer et al. also reported a reduction of the mosquito larva, *Culex tarsalis*, by the TPTH treatment and a resurgence after 4 weeks. A strong resurgence of this species was observed in our study at 3 weeks.

On the basis of a broad range of invertebrate populations reduced by TPTH treatments and the potential for resurgence of medically important insects due to a reduction of predators, we do not recommend that TPTH be registered for use in an aquatic habitat such as rice fields.

Part II

The data presented indicate that both BPUs have only a minor impact on the nontarget species analyzed for this study. When conducting a two-way ANOVA analysis of each species between the four treatments for each sampling date, some species on some sampling dates show significant differences. However, no real pattern of population change due to direct or indirect effects of the BPUs is evident. The lack of discernible patterns may be due to the low number of replications (three) in the experimental design and nonuniform dispersal of populations within the paddies. Therefore we believe that much of the scattered significant differences among the four treatments has no real biological meaning.

The only non-insect group that appears to be directly affected by the BPUs is the Ostracoda. Both *Cypris* species show similar effects in that populations in the control plots are much higher than any of the other three treatments during July and August. Some of the sampling dates are significantly different, but those that are not still show the control higher. Grand mean totals for the control are also significantly higher. The other Ostracoda, *Cypricerus* sp., appears not to be affected.

The insect species *Corisella decolor*, a hemipteran, shows affects caused by the BPUs. The trend is interesting in that numbers in the control tend to be lower than the treatment regimes. One explanation may be that BPUs are reducing some predator species not analyzed in this study. Another may be the similarity of feeding habits for corixids and chironomids. Both are phytophagous food gatherers in the aquatic environment. Because some of the chironomid larval populations were reduced in response to the BPU applications, this may have eliminated one or more competitors for food with *C. decolor*. Therefore, food availability may be related to the increased numbers in the BPU paddies and thus the effect is indirect.

By far, BPUs may have the greatest impact on aquatic Coleoptera. Significant differences among the four treatments is scattered and varies among the sampling devices and year collected, but the overall trend is for greater numbers in the control. Grand mean totals show similar results.

The Shannon-Weiner Diversity Index measures both species richness (total number of species) and species evenness. We decided to calculate the index to see if there were changes in the overall nontarget populations that were collected due to the applications of the BPUs to the rice agroecosystem. If significant differences are found, this may show an overall effect on species populations collected in the system.

The index values for both the minnow traps and drag net are similar and remain rather constant throughout the entire seasons. Index numbers for the Kellen dredge are lower, but this is due to fewer total number of species collected and not because of the BPUs. There were no significant differences between the index values for any of the sampling devices.

Grand mean totals for all species by treatment regime and sampling device indicate that the different BPU treatments applied in this study have no overall effect when compared to the controls.

The data presented indicate that either BPU, when applied at the rates and times indicated, has a minimal impact on the species collected and analyzed. Although this study is not exhaustive, species representing several taxa were collected. Based on these results and BPUs relative nontoxicity to nonchitin producing organisms, it appears that BPUs could be incorporated into the Integrated Pest Management (IPM) program for RWW control in California rice fields with minimal harmful effects.

CONCLUSIONS

For Parts I and II

The studies for parts I and II were conducted in different years and fields, using different rice cultivars and management practices (water depth and pesticides). Therefore, this precludes a direct comparison of the two studies other than comparing specific treatments to the respective controls. However, general conclusions can be made. TPTH is obviously a nonselective pesticide, which is detrimental to the rice invertebrate fauna. This characteristic is a direct contradiction to the aims of the IPM program for the rice agroecosystem, which strives to minimize effects on nontarget organisms while providing the grower with an acceptable commodity and profit. BPUs, on the other hand, seem to have a minimal impact on the aquatic fauna studied and would serve as an acceptable strategy for control of the RWW.

TABLE 1. CHECKLIST OF TAXA COLLECTED IN RICE PADDIES AT THE BIGGS RICE RESEARCH EXPERIMENT STATION

CLASS ORDER FAMILY SPECIES	Collection*	Stage†	Incidence‡	Device§
Gastropoda — univalve mollusks				
Basommatophora — fresh-water snails				
Physidae				
Physa sp.	2	A,I	5,6	D,M
Oligochaeta — aquatic earthworms				
Plesiopora				
Naididae				
Chaetogaster sp.	1	A,I	2	D,K
Crustacea — crustaceans				
Notostraca — tadpole shrimps				
Triopsidae				
Triops longicaudatus	2	A,I	NI¶	M
Conchostraca — clam shrimps				
Cyzicidae				
Caenestheriella sp.	2	A,I	NI	D
Ostracoda — seed shrimps				
Cypridae				
Cypricerus sp.	1,2	A;A,I	2,5	D,K
Cypris sp. #1	1,2	A;A,I	2,5	D,K
Cypris sp. #2	2	A,I	5	D
Candona sp.	1	A	2	D,K
Cladocera — water fleas				
Macrothricidae				
Ilyocryptus spinifer	1	A	2	D
Decapoda — crayfish				
Astacidae				
Procambarus clarki	2	A,I	NI	M
Insecta — insects				
Ephemeroptera — mayflies				
Baetidae				
Callibaetis montanus	1	I	2	D
Callibaetis sp.	2	I	5,6	D,M
Caenidae				
Caenis sp.	1	I	NI	K
Odonata — dragonflies and damselflies				
Aeshnidae				
Anax junius	1,2	I	NI	D,M
Libellulidae				
Pantala hymenaea	1	I	2	D
Tarnetrum corruptum	1	I	2	D
Coenagrionidae				
Ischnura cervula	1,2	I	NI	D,M
Homoptera — aphids				
Aphididae	1,2	A,I	2,5	D
Cicidellidae	1	A,I	2	D
Hemiptera — true bugs				
Hebridae				
Merragata hebroides	1,2	A,I	2,5	D

(*Continued on next page.*)

TABLE 1. (*Continued*)

CLASS ORDER FAMILY SPECIES	Collection*	Stage†	Incidence‡	Device§
Notonectidae				
Buenoa scimitra	1	A	2	D
Notonecta undulata	1,2	I;A,I	2,5,6	D,M
Corixidae				
Corisella decolor	1,2	A,I	2,5,6	D,M
Gerridae				
Gerris remegis	1,2	A,I	2,NI	D
Mesoveliidae				
Mesovelia mulsanti	1	A	NI	D
Belostomatidae				
Belostoma flumineum	1,2	I;A,I	NI	D,M
Coleoptera—beetles				
Dytiscidae				
Hygrotus sp.	1,2	A,I;A	2,NI	D,K,M
Laccophilus decipiens	1,2	A,I	2,5,6	D,K,M
Rhantus hoppingi	2	A	5,6	M
Thermonectus basillaris	1,2	A,I;A	2,5,6	D,K,M
Thermonectus sp.	2	I	5,6	D,M
Hydrophilidae				
Berosus styliferus	2	A	5	M
Berosus sp.	1,2	I	NI;5	D
Enochrus diffusus	1,2	A,I;A	2,5	D,M
Hydrophilus triangularis	1,2	I;A,I	NI;5,6	D,M
Tropisternus lateralis	1,2	A,I	2,5,6	D,M
Tropisternus obscurus	2	A	NI	M
Hydraenidae				
Hydraena sp.	1	A	NI	D
Haliplidae				
Haliplus sp.	1	A	NI	D
Curculionidae				
Lissorhoptrus oryzophilus	1,2	A,I;A	2;NI	D,K,M
Diptera—flies				
Culicidae				
Culex tarsalis	1	I	2	D
Ephydridae				
Hydrellia sp.	1	A	2	D
Scatophila sp.	1	A	2	D
Tipulidae				
Limonia sp.	1	I	NI	D
Ceratopogonidae				
Palpomyia sp.	1	I	NI	D
Stratiomyiidae				
Odontomyia sp.	1	I	NI	K
Chironomidae				
Chironomus attenuatus	1,2	I	2,7	D,K
Cricotopus bicinctus	1	I	7	K
Cricotopus sylvestris	1	I	2	D,K
Paralauterborniella spp. complex	2	I	7	K
Procladius culiciformis	1,2	I	2,7	K
Tanytarsus viridiventris	1,2	I	2,7	D,K

(*Continued on next page.*)

TABLE 1. (*Continued*)

CLASS ORDER FAMILY SPECIES	Collection*	Stage†	Incidence‡	Device§
Tanytarsus n. sp. #5	1,2	I	2,7	D,K
Tanytarsus n. sp. #6	1,2	I	2,7	D,K
Arachnida—arachnids				
Araenida—spiders				
Lycosidae				
Pardosa sp.	1	A	2	D
Tetragnathidae				
Tetragnatha sp.	1	A	NI	D
Osteichthyes—bony fish				
Cypriniformes—minnows				
Cyprinidae				
Cyprinus carpio	2	A,I	6	M
Lavinia exilcauda	2	A,I	6	M
Centrarchidae				
Lepomis cyanellus	2	A,I	6	M
Amphibia—amphibians				
Salienta—frogs and toads				
Hylidae				
Hyla regilla	2	A,I	5,6	M

*1 and 2 refer to the collections made in Part I and Part II, respectively.

†A and I are the adult and immature stages, respectively.

‡The data for each collection period are given in tables 2, 5, 6, and 7.

§D, K, and M, indicate that the collection device was a drag net, Kellen dredge, or minnow trap, respectively.

¶NI indicates that the data were not included in tables 2, 5, 6, and 7.

TABLE 2. MEAN NUMBERS COLLECTED BY DRAG NET AND KELLEN DREDGE, 1977

Taxa		Date Sampled											
		June				July						Aug	Grand
Treatment Regime		21	27	28	29	1	3	5	12	19	26	17	Mean§
		−7	−1	0	+1	+3	+5	+7	+14	+21	+28	+50¶	
Chaetogaster sp. (A&I)*													
Treated	DN†	3.0	1.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0a‡	0.0	0.0	0.0a
Untreated	DN	0.5	0.0	0.3	12.5	5.0	5.8	2.3	6.0	3.3b	5.5	21.8	7.8b
Treated	KD	145.2	82.0	37.5	57.0	38.0	63.5	143.5	91.5	83.0	59.5	136.8	84.1
Untreated	KD	121.5	68.5	78.0	63.3	58.5	81.5	177.0	143.0	85.0	73.3	131.0	101.6
Cypricercus sp. (A)													
Treated	DN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0a	0.0a	0.0a	0.0a	0.0a
Untreated	DN	0.0	0.0	0.0	0.0	0.0	0.0	0.5	27.5b	114.5b	49.8b	38.3b	28.8b
Treated	KD	4.3	3.8	1.8	5.3	0.3a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.7a
Untreated	KD	4.5	6.3	4.0	8.0	2.3b	4.0b	6.8b	31.0b	63.8b	34.5b	9.0b	19.9b
Cypris sp. (A)													
Treated	DN	5.0	1.5	2.0	4.3	0.0a	0.0a	0.0a	0.0a	0.5a	0.3a	0.5a	0.7a
Untreated	DN	0.5	5.0	12.8	9.0	6.8b	27.0b	27.0b	35.0b	83.0b	44.5b	31.3b	19.9b
Treated	KD	6.0	8.8	8.0	12.0	2.8a	1.0a	0.0a	0.0a	0.3a	1.3a	0.8a	2.3a
Untreated	KD	10.8	10.5	7.5	13.5	11.0b	21.8b	22.8b	73.0b	159.0b	111.8b	48.8b	57.7b
Cadona sp. (A)													
Treated	DN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0a	0.0a	0.0a	0.0a	0.0a
Untreated	DN	0.0	0.0	0.0	0.0	0.0	0.0	18.8	16.3b	22.0b	19.0b	41.5b	14.7b
Treated	KD	0.0	1.5	0.0	3.0	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.4a
Untreated	KD	0.0	3.3	2.0	7.0	4.3b	15.3b	11.0b	29.3b	60.8b	24.0b	17.8b	21.2b
Ilyocryptus spinifer (A)													
Treated	DN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0a	0.0a	0.0a	0.0a	0.0a
Untreated	DN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8b	27.0b	57.0b	56.5b	18.4b
Callibaetis montanus (I)													
Treated	DN	0.0	2.3	0.0	0.0	0.3	0.0	0.0	0.0	0.3	0.3	0.0	0.1a
Untreated	DN	0.3	1.3	0.0	0.3	0.0	0.8	0.5	1.0	0.8	0.8	0.5	0.6b

(*Continued on next page.*)

TABLE 2. (*Continued*)

Taxa		Date Sampled											
		June				July						Aug	Grand
Treatment Regime		21	27	28	29	1	3	5	12	19	26	17	Mean§
		−7	−1	0	+1	+3	+5	+7	+14	+21	+28	+50¶	
Tarnetrum corruptum (I)													
Treated	DN	0.5	1.0	0.0	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.2
Untreated	DN	0.3	1.8	0.8	0.5	1.0	0.0	0.8	0.0	0.3	0.0	0.3	0.4
Pantala hymenaea (I)													
Treated	DN	0.0	4.0	1.5	0.3	0.3	0.3	0.8	0.0a	0.0a	0.0	0.0	0.2a
Untreated	DN	0.0	2.8	1.8	2.0	2.0	0.5	3.8	2.8b	1.5b	0.5	0.5	1.8b
Aphididae (A&I)													
Treated	DN	0.0	0.0	0.5	0.0	1.0	0.5	1.0	13.0	91.5	1408.0	1428.0	367.9
Untreated	DN	1.0	0.8	0.0	0.3	0.0	1.3	1.8	9.3	12.3	2172.0	2615.0	601.5
Cicidellidae (A&I)													
Treated	DN	0.5	0.0	0.5	0.3	0.3	1.3	0.8	3.5	5.0	5.0	47.5a	8.0
Untreated	DN	0.0	0.8	0.0	0.8	1.0	4.0	3.0	5.8	5.8	8.5	3.3b	4.0
Merragata hebroides (A)													
Treated	DN	0.0	0.3	0.0	0.0	0.0	0.8	0.0a	0.0a	2.5	2.5	6.5	1.5a
Untreated	DN	0.3	0.3	0.3	0.5	0.8	1.3	1.5b	4.8b	4.0	3.3	16.5	4.1b
Merragata hebroides (I)													
Treated	DN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.1a
Untreated	DN	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.5	0.8	0.0	6.8	1.1b
Buenoa scimitra (A)													
Treated	DN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Untreated	DN	0.3	0.3	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.1
Notonecta undulata (I)													
Treated	DN	0.0	0.0	0.0	0.3	0.3	0.5	0.5	2.3	2.3	2.0	3.3	1.4
Untreated	DN	0.0	0.0	0.0	0.0	0.5	3.0	3.0	2.3	4.8	9.0	1.5	3.0
Corisella decolor (A)													
Treated	DN	164.3	38.8	10.8	3.0	4.5	6.3	5.5	18.0	16.3	38.8	29.5	15.2
Untreated	DN	98.8	11.5	4.8	4.3	9.0	7.0	7.0	59.8	71.0	71.0	7.5	29.6

(*Continued on next page.*)

TABLE 2. (*Continued*)

Taxa		Date Sampled											
		June				July						Aug	Grand
Treatment Regime		21	27	28	29	1	3	5	12	19	26	17	Mean[§]
		−7	−1	0	+1	+3	+5	+7	+14	+21	+28	+50[¶]	
Corisella decolor (I)													
Treated	DN	22.8	11.8	25.8	11.5	4.8	7.5	0.5a	0.0a	0.0a	3.8a	23.8	6.5a
Untreated	DN	12.8	7.8	8.8	12.8	15.5	18.3	33.8b	13.5b	10.0b	16.3b	7.0	15.9b
Gerris remegis (I)													
Treated	DN	0.0	0.0	0.0	0.0	0.3	0.3	4.5	2.0	2.0	0.8	14.0	3.0
Untreated	DN	0.0	0.0	0.0	0.0	0.0	1.5	4.3	3.8	1.8	1.3	1.5	1.8
Laccophilus decipiens (A)													
Treated	DN	0.5	1.0	2.3	1.8	3.5	1.3	2.5	0.3	1.0	0.0	3.8	1.8
Untreated	DN	1.0	0.5	1.8	0.3	1.5	0.8	1.0	0.8	0.8	0.8	2.0	1.0
Laccophilus decipiens(I)													
Treated	DN	5.0	13.3	19.3	1.3	1.0	0.3	0.3a	0.5a	0.5a	0.3a	8.5	1.6a
Untreated	DN	3.5	7.8	9.0	1.8	3.0	6.8	6.5b	11.0b	9.0b	12.3b	5.3	7.0b
Thermonectus basillaris (A)													
Treated	DN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.1
Untreated	DN	0.0	0.3	0.3	0.0	0.3	0.0	0.3	0.0	0.0	0.0	0.3	0.1
Thermonectus basillaris (I)													
Treated	DN	0.0	2.5	1.3	0.5	0.0	0.0	0.0	0.0	2.5	1.0	3.0	0.9a
Untreated	DN	0.0	1.3	0.8	1.5	2.0	3.8	3.3	2.0	2.5	1.0	1.8	2.2b
Hygrotus sp. (A)													
Treated	DN	0.3	0.3	0.0	0.8	0.0	0.0	0.0	0.0	0.8	0.0	0.3	0.2
Untreated	DN	0.0	0.0	0.5	0.5	0.5	0.0	0.8	0.0	0.3	0.5	1.5	0.5
Hygrotus sp. (I)													
Treated	DN	0.0	1.3	0.3	0.3	0.0	1.0	0.0	0.0	0.0	0.0	0.5	0.2
Untreated	DN	0.0	0.8	0.0	0.0	0.5	0.0	0.8	0.0	0.0	0.8	1.3	0.4
Treated	KD	0.5	0.0	0.5	0.0	0.0	0.0	0.3	0.5	0.0a	0.0	0.0a	0.1a
Untreated	KD	0.3	1.0	2.0	1.3	1.5	2.3	2.8	5.2	3.8b	1.8	5.0b	3.0b

(*Continued on next page.*)

TABLE 2. (*Continued*)

Taxa		Date Sampled											
		June				July						Aug	Grand
Treatment	Regime	21	27	28	29	1	3	5	12	19	26	17	Mean[§]
		−7	−1	0	+1	+3	+5	+7	+14	+21	+28	+50[¶]	
Tropisternus lateralis (A)													
Treated	DN	0.5	1.3	1.0	0.0	0.3a	0.0	0.3	1.0	0.5	1.0	4.8	1.8
Untreated	DN	0.3	1.3	0.3	0.5	2.0b	0.5	1.3	1.0	1.0	0.8	1.0	1.0
Tropisternus lateralis (I)													
Treated	DN	3.3	12.3	7.5	1.3	0.8a	1.3a	0.8a	1.0a	2.5	1.8a	8.3	2.1a
Untreated	DN	3.0	7.0	6.3	3.0	5.5b	3.5b	9.8b	15.0b	9.0	8.0b	9.8	7.9b
Enochrus diffusus (A)													
Treated	DN	0.0	0.0	0.0	0.3	0.0	0.0	0.5	0.5	0.3	0.3	0.0	0.2
Untreated	DN	0.0	0.0	0.0	0.3	0.0	0.3	0.3	0.5	0.3	0.0	0.0	0.2
Lissorhoptrus oryzophilus (A)													
Treated	DN	0.0	1.5	1.5	1.0	0.8	0.3	0.0	0.0	1.0	4.8	5.5	1.7
Untreated	DN	0.3	2.0	2.0	1.5	1.8	0.3	1.3	2.8	0.5	2.5	1.5	1.5
Lissorhoptrus oryzophilus (I)													
Treated	KD	8.3	12.0	19.3	14.5	22.8	23.3a	20.0	28.0	19.8	24.8	36.6	23.7
Untreated	KD	8.5	10.3	20.0	15.0	18.8	33.8b	32.5	41.0	32.8	25.8	36.5	29.5
Culex tarsalis (I)													
Treated	DN	0.3	0.3	0.8	0.0	0.3a	0.5a	0.3a	1.0	8.3a	7.3a	1.3	2.4a
Untreated	DN	0.0	2.0	8.0	0.0	0.5b	5.0b	4.5b	2.8	1.3b	0.5b	2.5	2.1b
Hydrellia sp. (A)													
Treated	DN	0.0	0.0	0.0	0.0	0.3	0.8	1.3	7.5	1.8	0.3	1.0	1.6
Untreated	DN	0.0	0.0	0.0	0.3	0.0	2.8	1.3	4.8	0.8	1.3	2.0	1.7
Scatophila sp. (A)													
Treated	DN	0.0	0.0	0.0	0.0	0.3	0.5	0.8	6.0	1.3	0.0	0.8	1.2
Untreated	DN	0.0	0.0	0.0	0.0	0.0	1.3	0.8	3.8	0.8	0.8	1.0	1.1
Cricoptopus sylvestris (I)													
Treated	DN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5a	0.0a	0.0a	5.8	0.8a
Untreated	DN	0.0	0.0	0.0	0.0	0.0	0.0	15.0	39.3b	30.0b	27.5b	12.3	15.5b
Treated	KD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0a	0.0	0.0	0.0	0.0
Untreated	KD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0b	0.5	0.0	0.0	0.2

(*Continued on next page.*)

TABLE 2. (*Continued*)

Taxa		Date Sampled											
		June				July						Aug	Grand
Treatment Regime		21	27	28	29	1	3	5	12	19	26	17	Mean§
		−7	−1	0	+1	+3	+5	+7	+14	+21	+28	+50¶	
Chironomus attenuatus (I)													
Treated	DN	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	1.2	0.2a
Untreated	DN	11.5	0.3	0.3	0.3	0.8	2.8	3.3	11.3	9.8	4.0	1.3	4.2b
Treated	KD	0.8	0.8	2.0	1.0	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.2
Untreated	KD	1.8	1.3	0.8	0.8	1.0	0.8	0.5	0.3	0.5	0.0	0.0	0.5
Procladius culiciformis (I)													
Treated	DN	1.8	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.1
Untreated	DN	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.1
Tanytarsus viridiventris (I)													
Treated	DN	71.0	21.5	7.5	3.3	0.5a	0.5	0.0	0.3a	0.3	0.3a	2.8	1.0a
Untreated	DN	33.5	2.5	11.3	1.8	7.8b	11.8	6.0	10.3b	10.0	6.8b	1.2	7.0b
Treated	KD	8.0	4.8	4.3	2.0	0.0	0.0a	0.0	0.0	0.0	0.0	0.0	0.3
Untreated	KD	14.0	3.5	3.0	1.3	0.5	1.3b	3.0	1.3	0.5	0.0	0.0	1.0
Tanytarsus n. sp. #5 (I)													
Treated	DN	36.5	23.3	12.3	2.0	0.3	0.0a	0.0	0.5a	0.0a	0.3a	10.0	1.6a
Untreated	DN	18.3	2.3	16.0	1.8	1.3	8.8b	17.5	56.5b	48.5b	19.5b	7.3	20.2b
Treated	KD	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Untreated	KD	0.3	0.5	0.0	0.3	0.0	0.3	1.3	0.5	1.8	0.0	0.0	0.5
Tanytarsus n. sp. #6 (I)													
Treated	DN	395.3	116.8	32.3	6.0	0.0a	0.0	0.0	0.0	0.0	0.0	0.0	0.8a
Untreated	DN	198.3	22.3	33.5	4.5	3.3b	17.8	4.0	24.3	0.8	4.3	0.0	7.4b
Treated	KD	164.8	33.0	17.0	8.3	1.8	0.3a	0.0a	0.0	0.0	0.0	0.0	1.3a
Untreated	KD	144.8	27.5	15.0	16.0	3.8	3.5b	7.5b	2.3	1.0	0.0	0.0	4.3b
Pardosa sp. (A)													
Treated	DN	0.0	1.5	1.3	1.0	2.3	0.3	1.0	0.3	0.8	1.3	2.5	1.2
Untreated	DN	0.3	1.0	2.0	2.8	1.3	1.0	1.0	0.3	0.8	1.8	1.3	1.3

*Life stage; A = Adult, I = Immature.

†DN = drag net; KD = Kellen dredge.

‡Column means followed by a different letter are significantly different by two-way ANOVA ($P<0.05$; Duncan's (1955) multiple range test).

§Grand mean for total numbers

TABLE 3. GRAND MEAN FOR ALL TAXA
BY TREATMENT REGIME AND SAMPLING DEVICE (TPTH STUDY)

Sampling device	Treatment regime	Grand Mean
Drag Net	Treated	12.2 a*
	Untreated	24.0 b
Kellen Dredge	Treated	2.6 a
	Untreated	12.5 b

*Column means followed by a different letter are significantly different ($P<0.05$; Duncan's (1955) multiple range test).

TABLE 4. ANALYSIS OF TPTH WATER RESIDUES
IN PADDIES AT THE INDICATED COLLECTION PERIODS (1977 STUDY)

Time	Treated paddies				Avg.	Control
Prespray	<10	<10	<10	<10	<10	<10
1 hour	90*	180	220	160	160a†	<10
1 day	60	<10	130	80	70b	<10
3 days	50	20	<10	90	40bc	<10
5 days	<10	50	<10	70	30bc	<10
7 days	20	40	20	30	30bc	<10
14 days	20	10	20	10	20c	<10
21 days	10	10	<10	10	10c	<10

*Residue in parts per billion TPTH.

†Means followed by a different letter are significantly different ($P<0.05$; Duncan's (1955) multiple range test).

TABLE 5. MEAN NUMBERS COLLECTED BY MINNOW TRAP AND DRAG NET, 1985

Taxa Treatment Regime*		Date Sampled June 4	June 6	June 9	June 12	June 19	June 25	July 2	July 10	July 17	Aug 1	Grand† Mean
(Days postemergence)												
Physa sp.												
4	(DN)‡	0.3	.§	0.3	0.0	7.3	15.7	16.3	12.7	23.7	22.0	10.1¶
7	(DN)	0.0	.	0.0	0.0	0.0	0.0	8.7	0.0	0.7	4.3	1.5b
4 & 10	(DN)	0.0	0.0	0.0	0.0	0.3	6.3	14.7	33.0	35.3	33.0	13.6b
Control	(DN)	0.0	0.0	0.0	0.0	0.0	3.3	2.0	0.3	2.0	3.3	1.2a
Cypris sp. #1												
4	(DN)	0.3	.	1.0	0.3	0.0	0.0	0.7a	1.3a	1.3a	8.3a	1.5a
7	(DN)	0.0	.	0.0	1.0	3.7	7.3	2.7a	2.3a	38.7a	39.3ab	10.6a
4 & 10	(DN)	0.0	1.3	1.0	0.7	0.0	0.0	0.0a	1.7a	7.7a	13.7a	2.8a
Control	(DN)	0.0	1.3	1.0	1.7	2.7	21.3	21.3b	136.7b	38.7b	77.3b	33.4b
Cypris sp. #2												
4	(DN)	0.0	.	1.0	0.0	0.0a	0.0a	0.0a	0.3	2.3a	13.7	1.9a
7	(DN)	0.0	.	0.3	0.7	0.0a	0.0a	0.0a	1.7	4.0a	36.3	4.8a
4 & 10	(DN)	0.0	0.0	1.7	0.7	0.0a	0.3a	0.0a	0.3	5.3a	14.3	2.5a
Control	(DN)	0.0	1.0	0.0	0.3	2.3b	1.7b	6.3b	17.3	14.0b	42.3	9.4b
Cypricerus sp.												
4	(DN)	0.0	.	0.0	0.0	0.0	0.0	0.0	0.0	0.3	13.0	1.5
7	(DN)	0.0	.	1.0	0.3	1.3	0.7	0.0	0.3	4.7	7.0	1.7
4 & 10	(DN)	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	2.7	3.3	0.8
Control	(DN)	0.0	0.0	0.3	0.3	3.0	2.3	0.7	2.7	4.0	4.3	2.0
Callibaetis sp.												
4	(MT)	1.0	.	0.0a	0.0a	0.0	1.7	0.0	1.3	0.0a	0.0	0.4a
7	(MT)	2.0	.	4.3b	0.0a	0.0	2.7	12.3	4.0	0.0a	0.0	2.8b
4 & 10	(MT)	0.3	1.0	0.0a	0.0a	0.0	0.3	4.3	4.0	2.3b	0.0	1.2b
Control	(MT)	0.0	1.0	5.3b	2.7b	0.3	5.0	6.0	1.3	0.0a	0.0	2.3b

(*Continued on next page.*)

TABLE 5. (*Continued*)

Taxa Treatment Regime*		Date Sampled June 4	June 6	June 9	June 12	June 19	June 25	July 2	July 10	July 17	Aug 1	Grand† Mean
(Days postemergence)												
Callibaetis sp.												
4	(DN)	1.3	.	1.3	0.0	0.0	4.3	0.0	0.0	0.0	0.3	0.8
7	(DN)	0.0	.	0.0	0.0	0.0	1.3	1.0	0.0	0.0	0.0	0.3
4 & 10	(DN)	0.0	0.3	0.3	0.0	0.0	1.3	0.7	0.0	1.7	0.0	0.4
Control	(DN)	0.0	0.0	1.7	0.3	0.0	9.3	0.0	0.0	0.0	0.0	1.3
Notonecta undulata												
4	(MT)	0.0	.	0.7	0.3	0.7	0.3	0.0	0.7	1.3	1.7	0.6
7	(MT)	0.	0.	0.0	0.0	1.7	1.7	0.3	1.3	1.7	1.0	0.9
4 & 10	(MT)	0.0	0.0	0.0	0.3	1.0	1.0	0.0	0.3	0.7	1.0	0.5
Control	(MT)	0.0	0.0	0.0	0.3	1.7	5.0	1.3	0.7	0.7	0.3	1.1
Notonecta undulata												
4	(DN)	0.0	.	0.0	0.0	0.0	0.0	1.0	0.0a	3.0	1.3	0.6
7	(DN)	0.0	.	0.0	0.0	0.0	0.0	0.7	2.3b	3.3	2.7	1.0
4 & 10	(DN)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0a	2.3	1.7	0.4
Control	(DN)	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.3a	2.0	1.3	0.5
Corisella decolor												
4	(MT)	4.7	.	50.0	50.0	50.0	26.7	13.3a	33.3c	10.0	3.7	26.9
7	(MT)	0.7	.	50.0	50.0	50.0	36.7	26.7b	26.7bc	16.7	1.3	28.8
4 & 10	(MT)	3.0	27.3	40.0	50.0	50.0	23.3	10.0a	11.0ab	20.0	1.0	23.1
Control	(MT)	3.3	26.3	50.0	50.0	50.0	38.3	30.0b	3.3a	5.7	0.0	25.6
Corisella decolor												
4	(DN)	3.0	.	28.7	14.0	5.3	28.0	23.0ab	34.0	50.0b	43.0b	25.4b
7	(DN)	5.3	.	44.0	6.3	4.0	35.7	46.0b	9.0	36.0b	9.7a	21.8b
4 & 10	(DN)	1.7	0.3	23.3	17.0	11.3	16.3	7.0a	14.3	50.0b	25.3ab	18.5ab
Control	(DN)	1.3	1.0	24.7	5.0	8.0	30.3	28.0ab	1.7	7.3a	2.7a	12.1a

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TABLE 5. (*Continued*)

Taxa Treatment Regime*		Date Sampled June 4	June 6	June 9	June 12	June 19	June 25	July 2	July 10	July 17	Aug 1	Grand† Mean
(Days postemergence)												
Merragata hebroides												
4	(DN)	0.0	.	0.7	0.3	0.0	1.3	2.7	2.3	21.3	19.0	5.3
7	(DN)	0.3	.	0.3	0.7	3.0	1.7	4.0	7.0	10.0	32.0	6.6
4 & 10	(DN)	0.0	0.3	1.0	0.7	3.3	3.0	5.0	0.7	7.0	10.7	3.5
Control	(DN)	0.0	0.0	0.0	0.7	6.3	6.0	9.0	9.0	10.7	18.0	6.6
Aphididae												
4	(DN)	0.0	.	0.0	0.0	0.0	0.0	1.7	2.7	39.3	69.7	12.6
7	(DN)	0.0	.	0.3	0.0	0.0	0.0	4.3	4.3	48.0	51.0	12.0
4 & 10	(DN)	0.0	0.0	0.0	0.3	0.3	1.0	2.3	6.0	44.7	80.7	15.0
Control	(DN)	0.0	0.3	0.0	1.3	0.7	0.3	2.7	7.0	24.0	77.7	12.7
Laccophilus decipiens												
4	(MT)	7.7	.	12.0	10.3	20.0	11.7	12.7	7.3	4.0	1.7	9.7
7	(MT)	6.0	.	7.7	10.3	21.0	28.0	13.3	6.3	2.0	2.0	10.7
4 & 10	(MT)	14.3	7.3	10.3	18.7	18.3	16.7	8.3	3.7	0.0	0.0	10.0
Control	(MT)	5.3	5.0	9.0	8.7	44.0	17.3	13.0	5.0	2.0	0.3	11.6
Rhantus hoppingi												
4	(MT)	0.0	.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	(MT)	0.3	.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
4 & 10	(MT)	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.1
Control	(MT)	0.0	0.0	0.0	0.0	0.3	0.7	0.3	0.0	0.0	0.0	0.1
Thermonectus basillaris												
4	(MT)	0.7	.	2.0	2.7	4.3	4.0	8.0	2.3	1.7	1.3	3.0
7	(MT)	0.3.	.	0.0	0.7	6.0	11.3	6.3	2.3	1.0	0.3	3.1
4 & 10	(MT)	1.3	0.3	0.3	2.3	5.0	6.7	9.3	2.7	1.0	0.3	3.2
Control	(MT)	0.7	1.3	0.0	4.0	7.7	5.3	7.0	1.7	2.7	0.0	3.2

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TABLE 5. (*Continued*)

Taxa Treatment Regime*		Date Sampled June 4	June 6	June 9	June 12	June 19	June 25	July 2	July 10	July 17	Aug 1	Grand† Mean
(Days postemergence)												
Thermonectus sp. Larvae												
4	(MT)	0.0	.	0.0	0.0	0.7	3.0	1.3	0.3	0.3	0.0	0.6ab
7	(MT)	0.0	.	1.7	1.0	1.0	1.3	2.0	1.7	0.7	0.0	1.0b
4 & 10	(MT)	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.7	0.3	0.0	0.1a
Control	(MT)	0.0	0.0	0.7	2.3	5.3	4.7	0.7	0.0	0.0	0.0	1.5b
Thermonectus sp. Larvae												
4	(DN)	0.3	.	1.0	0.0	0.0	3.7	0.3	0.0	0.3	0.0	0.6
7	(DN)	0.3	.	1.7	1.7	0.7	2.0	1.0	0.0	1.7	0.3	1.0
4 & 10	(DN)	0.3	0.3	1.7	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.4
Control	(DN)	2.0	0.3	4.3	0.7	0.0	9.7	1.3	0.3	0.0	0.0	2.0
Tropisternus lateralis Adults												
4	(DN)	0.3	.	0.0	0.0	0.7	0.7	1.0	1.3	4.7	9.0	2.0
7	(DN)	0.0	.	0.3	0.3	0.3	2.0	0.0	0.0	5.3	3.3	1.3
4 & 10	(DN)	0.0	0.0	0.3	0.7	1.3	1.3	0.7	0.0	1.0	2.0	0.8
Control	(DN)	0.0	0.3	0.3	0.0	3.0	2.3	0.0	0.3	0.3	0.0	0.7
Tropisternus lateralis Adults												
4	(MT)	2.7	.	4.7	7.0	19.7	27.7	25.3	9.7	4.0	6.3b	11.9ab
7	(MT)	3.7	.	4.7	5.0	23.0	45.7	21.3	9.0	7.3	7.3b	14.1b
4 & 10	(MT)	3.3	7.7	6.3	13.3	24.3	34.7	20.7	10.0	5.0	2.0ab	13.3b
Control	(MT)	3.7	7.7	7.7	7.7	14.3	29.7	12.7	4.3	1.3	0.0a	9.0a
Tropisternus lateralis Larvae												
4	(MT)	0.3	.	0.7	0.0	0.0	1.0	0.0	1.7	1.0	0.0	0.5
7	(MT)	0.3	.	0.3	0.7	0.3	0.0	1.3	1.0	0.0	0.0	0.4
4 & 10	(MT)	0.3	1.0	1.0	0.3	0.0	0.0	2.7	0.3	0.3	0.0	0.5
Control	(MT)	0.7	1.3	3.0	0.7	0.7	1.0	0.3	0.0	0.0	0.0	0.7

(*Continued on next page.*)

TABLE 5. (*Continued*)

Taxa Treatment Regime*		Date Sampled June 4	June 6	June 9	June 12	June 19	June 25	July 2	July 10	July 17	Aug 1	Grand† Mean
(Days postemergence)												
Tropisternus lateralis Larvae												
4	(DN)	7.0	.	2.3a	0.7	0.3a	12.0	1.7a	2.0	2.3	5.0	3.7
7	(DN)	2.3	.	4.0ab	1.7	1.3b	11.3	7.3b	3.3	3.0	6.7	4.5
4 & 10	(DN)	3.7	2.0	2.7a	0.0	0.0a	14.0	5.0ab	0.3	5.7	7.3	4.3
Control	(DN)	7.3	1.7	14.0b	4.0	3.0b	7.0	2.0a	2.7	3.0	1.7	5.0
Hydrophilus triangularis Adults												
4	(MT)	5.3	.	8.0b	6.3b	2.3a	3.7	5.0c	1.0	0.0	0.0	3.5b
7	(MT)	5.3	.	1.7a	1.0a	2.0a	3.3	0.7a	0.0	0.0	0.7	1.6a
4 & 10	(MT)	6.0	4.3	2.0a	2.0a	5.3b	2.7	3.0bc	0.3	0.3	0.3	2.4b
Control	(MT)	6.0	3.0	2.0a	0.7a	0.7a	0.3	1.7ab	0.7	0.0	0.0	1.3a
Hydrophilus triangularis Larvae												
4	(MT)	0.3	.	1.3	0.0	0.0	0.7	5.0	0.3	0.3	0.3	0.9a
7	(MT)	0.0	.	1.3	1.0	1.0	1.3	2.3	1.0	0.0	0.0	0.9a
4 & 10	(MT)	3.0	1.3	0.0	2.7	0.7	1.0	2.3	0.0	0.0	0.0	1.1a
Control	(MT)	1.3	2.7	2.7	0.3	2.7	4.0	2.3	0.3	0.0	0.0	1.5b
Berosus styliferus												
4	(MT)	0.0	.	3.7	4.7	0.3	0.3	0.3	0.0	0.3	0.0	1.1b
7	(MT)	0.0	.	1.7	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.4a
4 & 10	(MT)	0.0	0.7	0.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1a
Control	(MT)	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1a
Berosus styliferus												
4	(DN)	0.0	.	8.3	4.7	1.0	0.0	0.0	0.0	0.0	0.0	1.6
7	(DN)	0.0	.	2.0	2.0	0.7	0.0	0.0	0.0	0.0	0.0	0.5
4 & 10	(DN)	0.7	0.3	1.3	0.0	1.3	0.3	0.0	0.0	0.3	0.0	0.4
Control	(DN)	0.0	0.0	2.3	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.3

(*Continued on next page.*)

TABLE 5. (*Continued*)

Taxa Treatment Regime*		Date Sampled June 4	June 6	June 9	June 12	June 19	June 25	July 2	July 10	July 17	Aug 1	Grand† Mean
(Days postemergence)												
Berosus sp. Larvae												
4	(DN)	0.0	.	0.0a	0.0	0.3a	2.3	2.0	1.0	1.7	0.3	0.8ab
7	(DN)	0.0	.	1.7b	2.0	0.3a	2.7	0.7	1.7	1.3	0.0	1.2b
4 & 10	(DN)	0.7	0.0	0.3a	0.0	0.0a	0.3	0.0	0.0	1.0	0.0	0.3a
Control	(DN)	0.0	0.3	0.3a	0.3	3.3b	4.0	0.7	2.3	0.3	0.3	1.3b
Enochrus diffusus												
4	(MT)	3.7	.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
7	(MT)	11.7	.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3
4 & 10	(MT)	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Control	(MT)	6.3	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Fish (All species total)												
4	(MT)	1.7	.	3.3	3.3	1.3	30.3	18.3	36.3	3.0	4.0	11.3
7	(MT)	5.0	.	8.7	7.3	1.3	19.7	9.0	43.7	26.0	3.3	13.8
4 & 10	(MT)	1.7	1.7	6.0	47.7	10.0	8.7	15.0	10.3	12.1	9.3	13.4
Control	(MT)	0.3	2.0	3.7	3.7	1.0	8.3	10.0	14.0	24.0	9.0	8.2
Hyla regilla												
4	(MT)	0.0	.	0.3	0.0	1.7	18.3	15.3	10.7	2.3	1.0	5.5b
7	(MT)	0.0	.	0.0	0.3	0.0	4.0	5.3	4.7	2.7	3.7	2.3ab
4 & 10	(MT)	0.0	0.0	0.0	0.0	1.0	8.7	6.3	4.0	2.7	1.3	2.7ab
Control	(MT)	0.0	0.0	0.0	0.0	0.0	4.7	1.3	1.7	1.0	0.0	1.0a

*Triflumuron at 0.28 kg (AI)/ha. Dates of application are: June 4 for 4 days postemergence, June 7 for 7 days postemergence, and June 4 and 10 for 4 and 10 days postemergence.

†Grand mean for total numbers collected by species for each sampling device throughout the entire sampling period.

‡DN = Drag net, MT = Minnow trap counts.

§Not sampled.

¶Means within a column followed by a different letter are significantly different ($P<0.05$; Duncan's (1955) multiple range test).

TABLE 6. MEAN NUMBERS COLLECTED BY MINNOW TRAP, 1986

Taxa Treatment Regime*	Rate kg (AI)/ha	Date Sampled June 5	June 8	June 13	June 19	July 2	July 10	July 17	Grand† Mean
Physa sp.									
Triflumuron	0.28	0.0	0.0	0.0	0.0	0.3	0.3	1.0	0.2a‡
Triflumuron	0.42	0.0	0.0	1.0	1.7	16.7	4.7	3.0	3.9b
Diflubenzuron	0.28	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.1a
Control	.	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.1a
Callibaetis sp.									
Triflumuron	0.28	1.0	1.0a	0.0	0.0	0.0	1.3	1.7	0.7
Triflumuron	0.42	2.3	3.0b	0.3	0.0	0.0	0.3	0.3	0.9
Diflubenzuron	0.28	0.7	1.3a	0.0	0.0	0.0	0.3	0.3	0.4
Control	.	0.7	1.0a	0.7	0.3	0.0	0.0	0.0	0.4
Notonecta undulata									
Triflumuron	0.28	0.3	0.3	0.3	0.3	1.3	0.7a	0.3	0.5
Triflumuron	0.42	0.0	0.0	0.7	0.3	0.0	0.0a	1.0	0.3
Diflubenzuron	0.28	0.0	0.0	1.3	0.3	0.0	0.0a	0.7	0.3
Control	.	0.0	0.0	1.0	0.3	0.0	2.7b	2.0	0.9
Corisella decolor									
Triflumuron	0.28	1.7	4.0	15.3b	12.0b	0.3	1.3	2.3	5.3b
Triflumuron	0.42	1.3	2.3	10.3b	12.3b	2.0	1.0	1.0	4.3b
Diflubenzuron	0.28	2.3	3.7	11.3b	13.3b	0.3	0.7	0.7	4.6b
Control	.	3.0	3.7	4.3a	1.7a	0.3	1.0	0.0	2.0a
Laccophilus decipiens									
Triflumuron	0.28	0.0	3.7	13.0	33.7	32.0	15.7	11.7	15.7a
Triflumuron	0.42	3.0	2.7	16.7	47.7	10.3	3.7	3.0	12.4a
Diflubenzuron	0.28	7.7	9.3	22.3	77.0	35.0	19.7	14.0	26.4b
Control	.	2.7	2.0	22.0	104.0	15.0	21.7	19.3	26.7b
Rhantus hoppingi									
Triflumuron	0.28	0.0	0.0	0.0	4.7	2.0	0.3	1.3	1.2
Triflumuron	0.42	0.0	0.0	0.7	1.7	2.0	1.3	1.0	1.0
Diflubenzuron	0.28	0.0	0.0	0.3	8.0	1.0	3.3	4.0	2.4
Control	.	0.0	0.0	2.0	8.0	4.0	6.7	3.0	3.4
Thermonectus basillaris									
Triflumuron	0.28	0.3	0.0	1.3	7.7	25.3	5.0	7.3	6.7b
Triflumuron	0.42	0.0	0.3	2.0	4.0	4.7	7.7	4.0	3.2a
Diflubenzuron	0.28	0.7	1.3	3.0	17.3	19.3	9.7	9.7	8.7b
Control	.	0.0	0.3	2.0	9.0	8.7	8.3	6.0	4.9ab
Thermonectus sp. Larvae									
Triflumuron	0.28	2.3a	1.0a	0.0a	0.3	1.3	7.0	2.7	2.1
Triflumuron	0.42	2.7a	6.0ab	1.0a	0.3	0.0	2.7	0.3	1.9
Diflubenzuron	0.28	7.0b	7.0ab	0.0a	0.0	1.7	5.7	2.7	3.4
Control	.	4.0ab	13.3b	3.7b	0.7	0.0	0.3	1.7	3.4
Tropisternus lateralis Adults									
Triflumuron	0.28	1.0	3.7	2.0	39.3	65.0	26.3	24.0	23.1
Triflumuron	0.42	3.7	1.3	8.3	22.0	44.0	30.0	16.0	17.9
Diflubenzuron	0.28	0.7	2.3	7.3	19.0	82.3	48.7	37.7	28.3
Control	.	3.3	4.0	4.3	26.3	78.0	31.0	12.3	22.8
Tropisternus lateralis Larvae									
Triflumuron	0.28	1.3	1.3	0.0	0.3	0.3	3.3	2.7	1.3
Triflumuron	0.42	1.0	1.7	0.3	0.0	0.3	4.0	4.7	1.7
Diflubenzuron	0.28	1.0	1.3	0.0	0.7	1.0	4.3	5.7	2.0
Control	.	2.3	2.0	0.7	0.0	0.0	7.0	1.7	2.0

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TABLE 6. (*Continued*)

Taxa Treatment Regime*	Rate kg (AI)/ha	Date Sampled June 5	June 8	June 13	June 19	July 2	July 10	July 17	Grand† Mean
Hydrophilus triangularis Adults									
Triflumuron	0.28	1.3	1.3	2.0	5.3ab	9.3	1.7	1.0	3.1
Triflumuron	0.42	1.0	0.0	1.0	4.3ab	5.3	5.3	3.7	3.0
Diflubenzuron	0.28	0.7	3.0	4.7	7.0b	8.7	1.3	2.0	3.9
Control	.	0.7	2.0	1.3	1.3a	4.3	3.3	2.3	2.2
Hydrophilus triangularis Larvae									
Triflumuron	0.28	1.3	0.3ab	0.0	0.3a	0.0a	6.0ab	4.7b	1.8a
Triflumuron	0.42	0.0	0.0a	0.0	0.7a	0.0a	5.0ab	4.0b	1.4a
Diflubenzuron	0.28	0.7	1.0bc	1.7	0.3a	5.7b	9.7b	4.0b	3.3b
Control	.	1.0	1.3c	4.0	5.7b	1.7ab	1.7a	0.7a	2.3ab
Lavinia exilcauda (Hitch fish)									
Triflumuron	0.28	0.0	14.0	1.7	20.3	1.3	17.7	1.3	8.0b
Triflumuron	0.42	0.0	8.7	2.3	29.0	19.3	4.7	1.0	9.3b
Diflubenzuron	0.28	0.0	0.0	0.7	9.3	5.7	16.3	15.7	6.8b
Control	.	0.0	0.0	0.3	2.7	0.7	0.3	0.3	0.6a
Cyprinus carpio (Carp fish)									
Triflumuron	0.28	0.0	1.7	0.7	0.3	0.0	0.0	0.0	0.4
Triflumuron	0.42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diflubenzuron	0.28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Control	.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lepomis cyanellus (Green sunfish)									
Triflumuron	0.28	0.0	0.0	0.3	5.0	1.0	19.3	10.0	5.1
Triflumuron	0.42	0.0	0.0	1.3	2.3	1.7	6.3	9.3	3.0
Diflubenzuron	0.28	0.0	0.0	0.3	0.7	8.3	8.7	4.0	3.1
Control	.	0.0	0.0	1.0	4.0	0.3	2.3	1.3	1.3
Hyla regilla									
Triflumuron	0.28	0.0	0.7	0.7	2.7	4.0bc	0.0	0.0	1.1
Triflumuron	0.42	0.0	0.0	3.7	5.7	5.3c	0.3	0.7	2.2
Diflubenzuron	0.28	0.0	0.0	0.7	1.7	0.0a	1.3	0.3	0.6
Control	.	1.0	1.3	2.0	5.7	1.0ab	0.3	0.3	1.7

*Treatments were applied June 7.

†Grand mean for total numbers collected by species throughout the entire sampling period.

‡Means within a column followed by a different letter are signifi antly different ($P<0.05$; Duncan's (1955) multiple range test).

TABLE 7. MEAN NUMBERS COLLECTED BY KELLEN DREDGE, 1985

Taxa Treatment Regime*	Date Sampled June 4	June 5	June 8	June 11	June 18	June 24	July 1	July 10	July 16	Grand† Mean
(Days postemergence)										
Procladius culiciformis										
4	3.4	.‡	0.0	0.0	1.9a§	20.6ab	13.0ab	6.9a	8.0	.
7	.	.	4.3	2.9	13.9ab	47.5b	28.6b	9.2ab	12.6	.
4 & 10	4.6	9.8	0.0	0.0	0.0a	2.6a	5.5a	16.7ab	9.0	5.4a
Control	0.0	37.9	5.1	3.2	49.2b	50.2b	36.4b	17.4b	10.7	23.3b
Tanytarsus viridiventris										
4	6.9	.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.
7	.	.	0.0	0.0	0.0	0.0	0.0	3.7	0.0	.
4 & 10	19.3	4.4	0.0	4.1	0.0	0.0	0.0	2.7	0.0	3.4
Control	5.3	7.1	0.0	0.0	0.0	0.0	0.0	14.3	1.6	3.1
Tanytarsus n. sp. #5										
4	104.8	.	25.7	0.0a	7.4	26.1	5.4	36.5	7.4	.
7	.	.	14.5	4.8a	7.7	46.4	22.6	13.8	9.0	.
4 & 10	144.6	78.3	41.7	4.1a	0.0	36.1	15.3	3.6	0.0	36.0
Control	173.1	83.6	21.7	54.3b	22.4	25.5	16.8	43.8	4.3	49.5
Tanytarsus n. sp. #6										
4	238.6	.	74.4	14.1	33.5	24.6	5.7	0.0	0.0	.
7	.	.	54.8	49.0	55.8	32.6	3.1	1.7	0.0	.
4 & 10	172.8	346.9	114.1	31.9	0.0	65.1	3.4	0.0	1.3	81.7
Control	167.0	452.0	64.3	113.3	42.3	26.5	3.1	9.1	0.0	97.5
Chironomus attenuatus										
4	248.2	.	125.6b	29.6	18.9	34.4	3.7	2.2	0.0	.
7	.	.	40.3a	53.7	32.5	42.7	6.2	2.4	0.0	.
4 & 10	180.3	146.2	89.9ab	48.9	14.3	19.0	4.0	12.6	0.0	57.3
Control	52.5	139.2	122.0b	72.5	48.8	19.3	0.0	4.7	0.0	51.0

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TABLE 7. (*Continued*)

Taxa Treatment Regime*	Date Sampled June 4	June 5	June 8	June 11	June 18	June 24	July 1	July 10	July 16	Grand† Mean
(Days postemergence)										
Cricotopus bicinctus										
4	4.8	.	0.0	1.6	0.0a	0.0	0.0	2.2	2.0	.
7	.	.	0.0	0.0	0.0a	3.9	0.0	1.3	0.0	.
4 & 10	0.0	5.6	3.0	2.4	0.0a	0.0	0.0	3.3	1.5	1.8
Control	0.0	0.0	3.6	0.0	9.4b	0.0	0.0	1.2	0.0	1.6
Paralauterborniella spp. complex										
4	0.0	.	0.0	0.0	1.9	0.0	9.4	37.3	20.2	.
7	.	.	0.0	0.0	0.0	0.0	15.3	15.9	21.5	.
4 & 10	0.0	2.7	3.0	0.0	0.0	0.	09.5	18.9	15.5	5.5
Control	5.3	5.1	0.0	3.2	0.0	0.0	11.1	31.8	23.1	8.8

*Triflumuron applied at 0.28 kg (AI)/ha.

†Grand mean for total numbers collected by species throughout the entire sampling period.

‡Not sampled.

§Means within a column followed by a different letter are significantly different ($P<0.05$; Duncan's (1955) multiple range test).

TABLE 8. GRAND MEAN FOR ALL TAXA
BY TREATMENT REGIME AND SAMPLING DEVICE (BPU STUDY)

Sampling device	Treatment regime	Grand Mean*
Minnow trap 1985	4 days postemergence	3.4
	7 days postemergence	3.7
	4 & 10 days postemergence	3.2
	Control	3.0
Drag net 1985	4 days postemergence	3.4
	7 days postemergence	3.3
	4 & 10 days postemergence	3.1
	Control	4.2
Kellen dredge 1985	4 days postemergence	.†
	7 days postemergence	.
	4 & 10 days postemergence	27.3
	Control	33.6
Minnow trap 1986	Triflumuron 0.28 kg (AI)/ha	3.3
	Triflumuron 0.42 kg (AI)/ha	2.9
	Diflubenzuron 0.28 kg (AI)/ha	4.0
	Control	3.2

*No significant difference ($P>0.05$).

†Not calculated.

LITERATURE CITED

ABLES, J. R., S. L. JONES, and M. J. BEE
1977. Effects of diflubenzuron on beneficial arthropods associated with cotton. Southwest Entomol. 2:66-72.

ALI, A., and J. LORD
1980. Impact of experimental insect growth regulators on some nontarget aquatic invertebrates. Mosq. News. 40:564-71.

ALI, A., and M. S. MULLA
1977. The IGR diflubenzuron and organophosphorous insecticides against nuisance midges in man-made residential-recreational lakes. J. Econ. Entomol. 70:571-77.
1978a. Effects of chironomid larvicides and diflubenzuron on nontarget invertebrates in residential-recreational lakes. Environ. Entomol. 7:21-27.
1978b. Impact of the insect growth regulator diflubenzuron on invertebrates in a residential-recreational lake. Arch. Environ. Contamin. Toxicol. 7:483-91.

APPERSON, C. S., C. H. SCHAEFER, A. E. COLWELL, G. H. WERNER, N. L. ANDERSON, E. F. DUPRAS, JR., and D. R. LONGANECKER
1978. Effects of diflubenzuron on *Chaoborus astictopus* and nontarget organisms and persistence of diflubenzuron in lentic habitats. J. Econ. Entomol. 71: 521-27.

BROADBENT, A. B., and D. J. PREE
1984. Effects of diflubenzuron and BAY SIR 8514 on beneficial insects associated with peach. Environ. Entomol. 13:133-36.

CLEMENT, S. L., A. A. GRIGARICK, and M. O. WAY
1977. The colonization of California rice paddies by Chironomid midges. J. App. Ecol. 14:379-89.

COLWELL, A. E., and C. H. SCHAEFER
1981. Effects of the insect growth regulator BAY SIR 8514 on pest diptera and nontarget aquatic organisms. Can. Ent. 113:185-91.

DARBY, R. E.
1962. Midges associated with California rice fields, with special reference to their ecology (Diptera: Chironomidae). *Hilgardia* 32:1, 206 pp.

DUNCAN, D. B.
1955. Multiple range and multiple F tests. Biometrics 11:1-42.

EDMONDSON, W. T. (ed.)
1959. Fresh-water biology. 2nd ed. New York: John Wiley & Sons. 1248 pp.

ELLGAARD, J. T., J. T. BARKER, S. C. TIWARI, and A. L. FRIEND
1979. An analysis of the swimming behavior of fish exposed to the insect growth regulators, methoprene and diflubenzuron. Mosq. News 39:311-14.

FARLOW, J. E., T. P. BREAUD, C. D. STEELMAN, and P. E. SCHILLING
1978. Effects of the insect growth regulator diflubenzuron on non-target aquatic populations in a Louisiana intermediate marsh. Environ. Entomol. 7:199-204.

GRIGARICK, A.A.
1984. General problems with rice invertebrate pests and their control in the United States. Protection Ecology 7:105-14.

HANSEN, S. R., and R. R. GARTON
1982a. Ability of standard toxicity tests to predict the effects of the insecticide, diflubenzuron, on laboratory stream communities. Can. J. Fish Aquat. Sci. 39:1273-88.
1982b. The effects of diflubenzuron on a complex laboratory stream community. Arch. Environ. Contamin. Toxicol. 11:1-10.

JACKSON, L. F., R. K. WEBSTER, C. M. WICK, J. BOLSTAD, and J. A. WILKERSON
1977. Chemical control of stem rot of rice in California. Phytopathology 67:1155-58.

KEEVER, D. W., J. R. BRADLEY, and M. C. GANYARD
1977. Effects of diflubenzuron (Dimilin) on selected beneficial arthropods in cotton fields. Environ. Entomol. 6:732-36.

KELLEN, W. R.
1954. A new bottom sampler. Limnol. Soc. A. Spec. Publ. 22:1-3.

MEISTER, R. T. (ed.)
1986. Farm chemicals handbook. Willoughby, OH: Meister Publishing Co. P. C 241.

MERRITT, R. W., and K. W. CUMMINS (eds.)
1978. An introduction to the aquatic insects of North America. Kendall/Hunt Publ. Co. 441 pp.

MIURA, T., R. M. TAKAHASHI, and W. H. WALKER
1983. The effect of BAY SIR 8514 against selected organisms associated with mosquito breeding habitats. Proc. Papers 51st Ann. Conf. Calif. Mosq. Vector Cont. Assoc. P. 80-85.

MULLA, M. S., and H. A. DARWAZEH
1975. Evaluation of insect growth regulators against chironomids in experimental ponds. Proc. Calif. Mosq. Cont. Assoc. 43:164-68.

NEBEKER, A. V., P. MCKINNEY, and M. A. CAIRNS
1983. Acute and chronic effects of diflubenzuron (dimilin) on freshwater fish and invertebrates. Environ. Toxicol. Chem. 2:329-36.
PENNAK, R. W.
1978. Fresh-water invertebrates of the United States. New York: John Wiley & Sons. 803 pp.
RODRIGUES, C. S., and N. K. KAUSHIK
1986. Laboratory evaluation of the insect growth regulator diflubenzuron against black fly (Diptera: Simuliidae) larvae and its effects on nontarget stream invertebrates. Can. Ent. 118:549-58.
SCHAEFER, C. H., T. MIURA, E. F. DUPRAS, JR., and W. H. WILDER
1981. Environmental impact of the fungicide triphenyltin hydroxide after application to rice fields. J. Econ. Entomol. 74:597-600.
SHANNON, C. E., and W. WEAVER
1949. The mathematical theory of communication. Urbana, IL: University of Illinois Press.
SMITH, K. A., A. A. GRIGARICK, J. H. LYNCH, and M. J. ORAZE
1985. Effect of alsystin and diflubenzuron on the rice water weevil (Coleoptera: Curculionidae). J. Econ. Entomol. 78:185-89.
SMITH, K. A., and A. A. GRIGARICK
1988. Field evaluations of diflubenzuron and triflumuron for control of the rice water weevil in California rice fields. J. Agric. Entomol. 5:121-26.
STEELMAN, C. D., J. E. FARLOW, T. P. BREAUD, and P. I. SCHILLING
1975. Effects of growth regulators on *Psorophora columbiae* (Dyer and Knab) and non-target aquatic insect species in rice fields. Mosq. News 35:67-76.
USINGER, R. L. (ed.)
1956. Aquatic insects of California. Berkeley, CA: University of California Press 508 pp.
YAHNER, R. H., J. L. QUINN, and J. W. GRIMM
1985. Effects of a nonpersistanct insecticide (Alsystin) on abundance patterns of breeding forest birds. Bull. Environ. Contamin. Toxicol. 34:68-74.

ACKNOWLEDGMENTS

We thank the Rice Research Experiment Station at Biggs, California, for technical support, leasing the land, and preparing the land for the experimental sites. We thank the Rice Research Advisory Board, Mobay Chemical Company, Thompson-Hayward Chemical Company, and Uniroyal Chemical Company for partial financial support of this research.

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or between treatments when grand means for all species by sampling device were calculated. A total of 35 families and 58 taxa were collected from these two studies.

There were only three issues of Hilgardia *printed in 1989.*

The Journal HILGARDIA is published irregularly. Number of pages and number of issues vary per annually numbered volume. Address: Agriculture and Natural Resources Publications, University of California, 300 Lakeside Drive, 6th Floor, Oakland, CA 94612-3560.