ANNUAL REPORT FOR COOPERATIVE REGIONAL PROJECT S-300

Mosquito and Agricultural Pest Management in Riceland Ecosystems
Supported by Allotments of the Regional Research Fund
Hatch Act, as Amended August, 1955

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PROGRESS OF WORK AND PRINCIPAL ACCOMPLISHMENTS:

Objective 1: To determine the best chemicals to use in riceland systems in terms of their providing maximum control of rice pests (esp. the rice water weevil) and riceland mosquitoes while causing the least amount of harm to non-target organisms.

Research continued in 2001 with the goals of optimizing the efficacy of diflubenzuron (Dimilin), lambda-cyhalothrin (Karate and Warrior), and fipronil (Icon seed treatment) for control of the primary rice plant pest (rice water weevil) and of other rice plant pests. Evaluation of experimental insecticides, that may provide cost-effective pest control with minimal effects on non-target organisms, was also conducted; zeta-cypermethrin (Fury, Mustang), V-10101, Messenger (harpin proteins that stimulates the natural defenses of plants) and thiamethoxam (Adage seed treatment) were studied. Integrating the management of rice plant arthropod pests with mosquito pests is is a primary goal of this objective. Adage and Icon seed treatments were the most effective products for rice water weevil control in studies conducted in LA. Of the products applied to foliage, Dimilin was the most effective and Fury the least effective. Two applications of Karate and Fury were required to give long-lasting control. A pre-flood application of Karate was as effective as a single post-flood application of Karate in LA and CA studies. Similarly, a tank-mix of Karate and Dimilin was no more effective than applications of Karate or Dimilin alone in LA and CA studies. The residual activity of Fury was inferior to that of Karate in LA studies and the inverse was found in AR studies; studies in CA and TX identified no significant differences in rice water weevil control with these two products. V-10101 was only moderately effective at all locations and Messenger was ineffective for rice water weevil control. Additional studies were conducted with these products targeted against rice stink bug and Mexican rice borer; the latter pest is a relatively new pest into the TX system.

Populations of rice water weevils were higher in a TX study in a conventionally tilled seedbed compared to a stale seedbed, whereas yields in the stale seedbed were more than 1000 lb/acre higher than in the conventionally tilled seedbed. Across tillage treatments, Icon gave better control than Karate and outyielded the untreated by about 950 lb/acre. Field studies were continued in AR to define the proper number and placement of the floating aquatic barrier trap for monitoring rice water weevil adults and in CA to determine the applicability of the trap to

this production system. Benefits already noted include assessment of adult levels to determine need of insecticide treatment within the 10 to 14 day application window for insecticide application. Problems encountered include traps need to be checked daily; traps capture too many aquatic organisms and debris, and shallow water in paddy usually requires traps to be placed in ditches near levees. Use of this trap will help better define the need for post-flood applications; these applications have the potential to most severely disrupt natural controls of blood-sucking arthropods.

Anopheles quadrimaculatus control with a granular, slow-release Bti formulation, LarvX Sgr was evaluated against VectoBac in AR. At 24 hours posttreatment, control of 2nd to 4th instar larvae was 45% and 77%, respectively, in the plots treated with the low rate of LarvX SG and the VectoBac standard and 87% control of 2nd to 4th instar larvae was achieved by LarvX SG and 86% by VectoBac CG at 48 hours posttreatment. Aqua Reslin and Biomist 3030 technical permethrin and piperonyl butoxide were applied via ground ULV against wild-caught adult *Anopheles quadrimaculatus*. The formulations did not differ significantly at 31m;however, at 61-and91-m distances, mortality for 3030 was generally significantly higher than Aqua Reslin at each distance and time. BASF AC 836 and 519 in the chemical family Semicarbazones were tested against *Psorophora columbiae* and *Culex salinarius* larvae in laboratory (probit analysis) and small riceplots in AR. The EC formulation provided excellent control for 5 days posttreatment. No other formulations were effective in the field. Three corncob formulations, one commercial product *Bacillus thuringiensis* subsp. *israelensis* (Bti) (VBC-60021) and two recombinant Bti (VBC-60023 and VBC-60024) were tested and compared for initial and residual activity against laboratory-reared 3rd instar *Aedes taeniorhynchus* larvae in FL. In addition, two formulations (corncob, VBC-60021; and the effervescent pellet, VBC-60030 SK) were evaluated for initial and residual activity against laboratory-reared 3rd instar *Anopheles quadrimaculatus* introduced to the tubs. At 2 days posttreatment, populations were reduced in VBC-treated tubs by 82%, while VBC-60030 SK provided poor control (14% larval reduction). Both formulations lost larvicidal activity at 5 days posttreatment (23% control by VBC-60021). Apparently, the effervescent pellet formulation needs formulation improvement to better disperse the Bti toxins at the water surface. This technology could have applications for management of rice plant pests as well as for mosquitoes in ricelands. *Bacillus thuringiensis tenebrionsis* (Btt), and other microbials, have activity against rice water weevil but consistency, residual, and product placement are challenges. Laboratory and semi-field evaluations in FL of the two granular formulation insect growth regulators, Altosid and Pyriproxyfen, were conducted against laboratory-reared *Aedes aegypti*, *Ae. albopictus*, *Ae. taeniorhynchus*, *Anopheles quadrimaculatus*, *Culex nigripalpus*, and *Cx. quinquefasciatus*. Altosid7 XR-G resulted in variable levels (<39 - 100%) of inhibition of adult emergence in the six species monitored for six weeks posttreatment under both test conditions. *Aedes taeniorhynchus* was the most susceptible to Altosid and *Culex quinquefasciatus* was the most tolerant as was *Ae. albopictus.* In contrast, Pyriproxyfen GR at comparable treatment rates to Altosid7 XR-G, gave very high levels (over 80 to 100% in most cases) of initial and long-term (residual) reductions of the tested species in the laboratory as well as outdoors in experimental tubs. In many species, pyriproxyfen induced complete inhibition of adult emergence for several weeks posttreatment even at the low rate.

In CA, multi-year laboratory selection projects designed to delay the onset of resistance to the bacterial larvicide *Bacillus sphaericus* (Bs) and to test whether susceptibility can be restored in BS-resistant *Culex quinquefasciatus* were carried out. Interactions among microbial toxins from Bti with Bs and the testing of a newly developed bacterium which combines characteristics of Bti and Bs were conducted. Susceptible and resistant mosquito strains were selected with either Bs alone or the combination of Bs and the cytolytic toxin (Cyt 1A) from Bti. No changes of resistance levels have been detected in the susceptible series to date. The newly

developed bacterium which combines characteristics of Bti and Bs exhibited greater toxicity against *Culex* mosquitoes than does either bacterium alone and lessens the likelihood that riceland mosquitoes will rapidly evolve resistance to this environmentally friendly, mosquito-specific bacterial larvicide. TAES continued to conduct insecticide susceptibility monitoring tests on select populations of *Cx. quinquefasciatus* in the rice-producing region of southeast Texas. Populations of this species in Orange County, TX, continue to be susceptible to all commonly-used mosquito adulticides. This is primarily due to an insecticide resistance management program that was implemented in this county several years ago. An elevation in tolerance to malathion in a select population of *Cx. quinquefasciatus* in Galveston County, TX, was detected during 2001; and it has been recommended that an insecticide resistance management program be initiated in this county beginning in the spring of 2002. A garlic-based mosquito repellent formulation designed to protect outside premises from mosquito attack was tested in two urban/suburban settings. Neither of the two formulation strengths applied had an effect on mosquito activity in the areas treated.

Objective 2: To determine the best nonchemical tactics to use in riceland systems to manage problems with rice pests, weeds, and mosquitoes.

Susceptibility of common rice varieties to key arthropod pests was evaluated. Bengal was consistently shown to support the highest rice water weevil populations in AR, TX, and LA whereas Jefferson was the most resistant. Conversely, Jefferson was one of the more resistant/tolerant varieties to stemborer (Mexican and sugarcane) in TX and to rice stink bug injury in AR. In CA, no differences in susceptibility were seen among 8 California rice varieties. The resistance to rice water weevil of approximately 100 lines of rice from various geographic sources was compared in a field study in LA. Although larval densities differed significantly among lines, no highly resistant lines were found.

Several other cultural control measures for rice plant pests were evaluated including the effects of delayed flooding, early planting, shallow flooding, and fertilization of rice fields. The challenges of using insecticides in the aquatic rice system and the undesirable indirect effects on mosquito management have placed added importance on this area. Young plants appear to be less tolerant of feeding by larvae than older plants, and feeding by large larvae appears to be more deleterious than feeding by smaller larvae. These results provide the biological rationale for the cultural practice of delayed flooding. The relationship between densities of rice water weevil larvae and yield losses was investigated in 2001 in LA and CA. Rice yield losses were greater in plots of rice flooded at the 2-3 leaf stage (or infested at this stage in the water-seeded CA system) than in plots flooded at the 4-5 leaf stage. The influence of planting date on yield loss from the rice water weevil was investigated in LA. Plots of rice planted in late March, before initial emergence of weevils, had lower densities of rice water weevil larvae approximately 3 weeks after flooding than did rice planted one month later. The impact of rates of N fertilization on the ability of rice to tolerate feeding by the RWW was investigated in experiments replicated in LA, TX, and AR. Higher rates of N fertilization were associated with higher densities of weevil larvae; however, yield losses were not reduced by higher rates of fertilization.

Biological control using mosquitofish (*Gambusia affinis*), reduction of surface coverage by emergent vegetation, and both temporal and spatial changes in water quality affected mosquito (*Culex* spp.) populations at a constructed treatment wetland in southern CA. As compared to a previous design in which 80% of the wetland surface was covered by emergent vegetation and mosquitofish were absent from the wetland ecosystem, host-seeking adult mosquito populations were reduced up to 50-60 fold during the third year after reducing

vegetated coverage of the wetland surface to 50% and adding mosquitofish. Changes in larval mosquito abundance associated with changes in the wetland included a 10-fold reduction in *Culex tarsalis* (the predominant vector of arboviruses to humans and livestock), comparatively larger variation in dip counts among the seven marshes in the wetland than under the previous design, and an earlier seasonal decline of larval mosquito abundance. Ammonium nitrogen additions to constructed treatment wetland research cells in CA did not sustain mosquito production and failed to produce a significant increase of mosquito abundance as compared to control research cells. The wetland research cells in both treatments contained more than 90% of the surface area covered by emergent vegetation and supported large mosquitofish populations. Ammonium nitrogen concentration in the enriched wetland research cells did not differ significantly from that in the control cells on most sampling dates probably due to volatilization of unionized ammonia.

Objective 3: To develop a database on the bionomics of rice pests, riceland mosquitoes and beneficial aquatic fauna coming to associate with harvested rice fields flooded during the winter.

The effects of rice straw management and winter flooding of rice fields on populations of mosquitoes, and other aquatic invertebrates including predators were evaluated for the third year with the plots under the same management regime. Rice straw burning is being phased out in CA to improve air quality, and more farmers are now either discing straw into fields and/or flooding fields in winter to decompose straw and attract waterfowl. In both 1999 and 2000, *Culex tarsalis* larvae were much more abundant in winter-flooded fields where rice straw was not burned. Winter flooding also benefitted most other aquatic invertebrates, including predators of mosquitoes, however the additional predators did not yield adequate natural mosquito control. Populations of rice plant pests were also monitored during the rice growing season in plots that had been winter-flooded vs. no flood during the winter. Consistent with past years, rice water weevil larval populations were nearly twice as prevalent in the non-flooded than in the winter-flooded areas. Sampling for mosquitoes and invertebrates was extended to 25 commercial rice fields in 2001. Field treatments included burned/winter dry, disced/dry, bale/flood, and disc/flood. Samples from experimental and commercial fields were collected May-September 2001.

A webpage was created for the S-300 Multi-State Project, on which last year's report is available: http://entomology.ucdavis.edu/ricemosquito/index.htm.

Objective 4: To update and refine existing databases on the local distribution, genetic relationships and disease vector potential of mosquito species occurring in rice-producing areas of the U.S.

Investigations are ongoing to study biology, ecology and pathogen compatibilities of *Anopheles quadrimaculatus* and *Culex salinarius* in IL and AR. A cooperative Arbovirus Surveillance Program to monitor mosquitoes and birds for arbovirus activity was established in AR. Multi-county collections of mosquitoes were tested for eastern equine encephalitis (EEE) and west Nile virus (WNV). Dead birds were tested for WNV. Mosquitoes were collected bimonthly from 19 counties with gravid and CDC light traps and aspirated from resting locations. Species-specific mosquito pools were subjected to virus culture and reverse transcriptase polymerase chain reaction. Of the 14,560 mosquitoes (425 pools) tested, none were virus-positive. Two hundred sixty-five dead birds (23 species) from 62 counties were tested for WNV. Four blue jays in 3 counties were WNV positive. These infections are the first reported cases of WNV in AR. Twenty three species records from 7 counties were established including 5

new counties for *Aedes albopictus*. Initial laboratory studies in IL have provided results that indicated the reverse transcriptase (RT) - polymerase chain reaction (PCR) assay for detection of St. Louis encephalitis virus was validate for the detection of SLE and WNV in both immature and adult stages. Planned field studies in rice and associated wetland are planned for 2002.

Spatial and temporal distributions of chironomid larvae, *Glyptotendipes paripes* in particular, were examined monthly for two years in Lakes Dora, Yale,and Wauberg in FL. Water depth, Secchi disk transparency, water temperature, dissolved oxygen, specific conductance, chlorophyll a, chlorophyll b, total chlorophyll, and sediment dry weight were considered as factors influencing distribution. *G. paripes* larvae were most common in Lake Wauberg and ranged from 5206/ square m (August) to 19442/ square m (March), and formed 97.8% of total chironomid larvae collected during the study year. In Lake Dora, *G. paripes* larvae comprised only 7.6% of total chiromid larvae during both years of the study; Tanytarsini (mostly *Cladotanytarsus* spp.) predominated forming 74.3% of total midge larvae collected in this lake. In Lake Yale, *G. paripes* formed 25.4% of total annual collection and Tanytarsini (*Cladotanytarsus* spp.) formed 53.9% of the total midge collections. Canonical correspondence analysis indicated that the primary, significant influences on spatio-temporal distribution of chironomid larvae in the study lakes were water depth, sediment dry weight, presence of sand or muck (total organic carbon), and vegetation. *Glyptotendipes paripes* larval distributions tended to be associated with shallower, sandy substrates in Lakes Dora and Wauberg. Compositions of chironomid larvae consumed by the predatory fish, bluegill (*Lepomis macrochirus*) were examined in relation to associated standing crop of midge populations in Lakes Dora and Yale for biological control perspective. Tanytarsini (mostly *Cladotanytarsus* spp.) were most common in the guts of fish from both lakes; *Goeldichironomus* spp. larvae were the next most common in the fish guts from Lake Dora. Developmental requirements (in degree-days) of *G. paripes* were studied in the laboratory. The developmental zero growth was estimated at 9 degrees C based on the regressions for development to 1st, 2nd, 3rd, 4th instar and pupa to adult. Degree-day requirement for *G. paripes* development from egg to adult was estimated at 717 degree-days above 9 degrees C. Larvae of *Chironomus crassicaudatus* were reared individually at a range of constant temperatures between 12.5 and 32.5 degrees C; the slowest development was observed at 15 degrees C, with development rate peaking between 25 - 27.5 degrees C, and decreasing at temperatures higher than 27.5 degrees C. Based on development time estimates in this study, the potential number of generations of *C. crassicaudatus* per year (365/development time in days) may vary from 11 at 27.5 degrees C to 6 at 15 degrees C.

TAES initiated research on the effects of different temperatures and humidity levels on the survivorship of *Ae. aegypti* and *Ae. albopictus* eggs. Laboratory colonies of these two species weve established using wild-caught specimens from the Galveston, TX area. The experimentation phase of this project will begin in 2002.

USEFULNESS OF FINDINGS:

Research conducted in 2001 by all participating members of S-300 resulted in significant progress in understanding the biology and ecology of mosquitoes and production insects associated with the rice agroecosystem and other wetlands. Rice entomologists are striving to derive improved management schemes for key rice plant pests. These schemes will stress the use of reduced risk insecticides, more judicious use of insecticides, cultural control measures and/or biological control measures. This overall IPM package will reduce costs of production for growers, protect the environment, along with the most important benefit of conserving natural enemies of mosquitoes and mitigating mosquito production from ricelands. Improved

protection of human and animal health will be realized through this program; improved rapport with populated areas, i.e., urban zones, will result from the lower levels of mosquitoes. As production practices evolve, due to advances in technology and changes in regulatory policies, pest management practices must also evolve. Results were disseminated to producers via extension meetings and publications. Mosquito entomologists continued to provide updated research results and management guidelines to clientele including mosquito control districts, farmers and government health officials. New pests continue to plague entomologists such as the Mexican rice borer which is a potentially important rice plant pest. Mosquito entomologists are also carefully monitoring the spread of recently introduced mosquito borne diseases such as West Nile Virus which was found in the core of the rice production area in 2001 (Arkansas). This proactive approach serves to dampen the debilitating effects of these diseases.

In summary, in 2001, S-300 participants continued to add new knowledge relative to pestiferous insects associated with artificial and natural wetlands. This knowledge is being used to develop more effective, safe and affordable management of these insect pests.

WORK PLANNED:

Participants in S-300 will cooperate in research studies across state and disciplinary lines to better understand how management of a single insect affects the population dynamics of other insects associated with wetlands. For instance, insecticides registered for RWW will be evaluated for effects on mosquitoes and their aquatic predators. Production practices, such as straw removal and winter flooding, recently adopted by rice farmers in California will be investigated to determine the effects on rice production pests and mosquitoes. Better management of nuisance Chironomidae will be studied and basic physiological information on mosquitoes will be collected.

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ANNUAL REPORT FOR COOPERATIVE REGIONAL PROJECTS

Supported by Allotments of the Regional Research Fund
Hatch Act, as amended August, 1955

Project Number: S-300
Title: Mosquito and Agricultural Pest Management in Riceland Ecosystems
Duration: October 1, 2000 - September 30, 2005

APPROVALS:

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