CHEMICAL CONTROL OF GLASSY-WINGED SHARPSHOOTER: ESTABLISHMENT OF BASELINE TOXICITY AND DEVELOPMENT OF MONITORING TECHNIQUES FOR DETECTION OF EARLY RESISTANCE TO INSECTICIDES

Project Leaders:
Nick Toscano, Nilima Prabhaker and Frank J. Byrne
Department of Entomology
University of California
Riverside, CA 92521

Steven J. Castle
USDA, ARS
Phoenix, AZ

Reporting Period: The results reported are from work conducted from December 2001 through November 2002.

INTRODUCTION

The possibility of resistance development when insecticides are used necessitates the development of an effective resistance-monitoring program that enables early detection of even low-frequency resistance alleles in natural populations. The initial step for monitoring of resistance is through development of appropriate bioassay techniques that can establish baseline susceptibility data among populations. Our goal for the first year was to study the effectiveness of selected insecticides that represent various chemistries against GWSS and determine regional comparisons of GWSS responses to these insecticides. Simple and suitable bioassay techniques were developed to detect toxicological responses and to establish baseline susceptibility data of GWSS to various insecticides. Three techniques, petri-dish, leaf-dip and systemic bioassays were described in the previous report (Toscano et al. 2001). Evaluation continued during the second season to assess any changes in responses of GWSS to a wide range of chemistry. The present report compares the toxicological responses of GWSS for a period of two years.

Resistance does not evolve at the same rate for all pests that come under selection pressure. Many factors influence the rate at which resistance develops in a pest. In the case of GWSS, we have no information on the potential for resistance development in this species. One method to estimate the potential for resistance risk is to artificially select resistant strains under greenhouse conditions.

In addition to conventional bioassay methods, we have completed our development of a biochemical assay that measures the levels of sensitivity of sharpshooter acetylcholinesterases (AChEs) to inhibition by organophosphate (OP) insecticides. Insensitivity of the AChE target-site can seriously impair the effectiveness of the OPs in control programs. The assay can be used on all nymphal instars and adults, and is an excellent tool for monitoring the frequencies of AChE variants in populations because it provides inhibition data for individual insects. Monitoring populations of GWSS and smoke-tree sharpshooter that have been exposed, either directly or indirectly, to OPs such as chlorpyrifos will enable us to detect resistant AChE alleles should they arise.

OBJECTIVES

1. Develop reliable bioassay technique(s) to evaluate baseline toxicity of insecticides from major classes of insecticides against all life stages of GWSS.
2. Monitor all life stages of GWSS populations collected from insecticide-treated citrus orchards and vineyards in Riverside, Redlands, San Joaquin Valley and Temecula to determine baseline susceptibility to various insecticides.
3. Investigate the rate of development of resistance to a selected organophosphate (OP), pyrethroid and a neonicotinoid by artificial selection in the greenhouse.
4. Develop electrophoretic techniques to identify esterase profiles in individual GWSS of all life stages including eggs.

RESULTS AND CONCLUSIONS

Results showing a two-year comparison of toxicity data to various insecticides using the three techniques are presented in Table 1. In general, GWSS populations are quite susceptible to most insecticides tested. The LC_{50} values indicate considerable variation in susceptibility to insecticides by both techniques. Mortality increased in the treatments over time. Monitoring data for chlorpyrifos and dimethoate indicated a difference of 10- and 15-fold between the two techniques. No significant changes in responses of GWSS to chlorpyrifos were observed from year to year. A slight shift is observed to esfenvalerate towards lower sensitivity. Insects from Redlands appear to be more sensitive than other populations. Similarly, acetamiprid was also quite toxic to GWSS from Redlands with a lower LC_{50} compared to the Riverside or Ventura populations. Among the neonicotinoids, thiamethoxam appears to be slightly less toxic to GWSS populations in 2002 with insects from Redlands showing more sensitivity to acetamiprid than the previous year. No significant differences in responses of GWSS from various locations to endosulfan are observed. In conclusion, two-year comparison of toxicity studies shows that GWSS are still quite susceptible to all insecticides tested so far with small variations between populations from different regions.

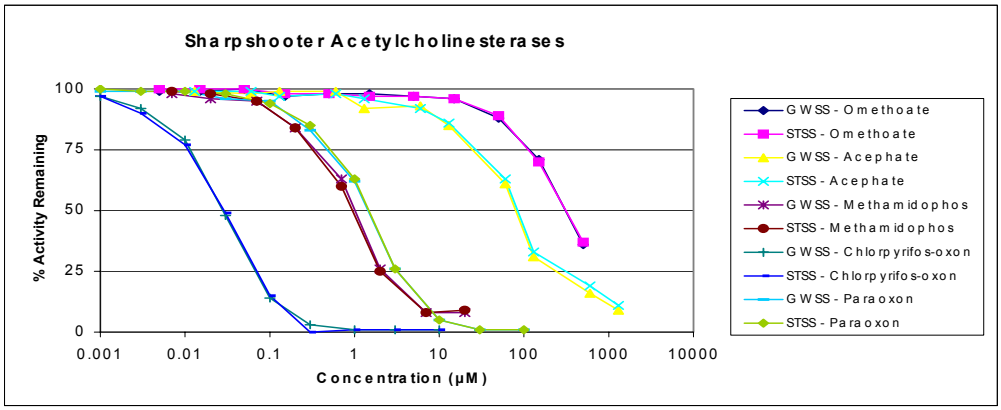
In a comparison of AChEs in the GWSS and the STSS, we found a similar response to a wide range of OP insecticides. The enzyme activity in both species was especially sensitive to chlorpyrifos, and was least affected by omethoate, the active form of dimethoate. Using a diagnostic concentration of 10µM paraoxon, we assayed insects from Riverside, Redlands and Ventura citrus orchards. We found that the AChE activity in insects from these areas was sensitive to this concentration, thereby providing encouraging evidence for the absence of OP resistance based on insensitivity of the target site.

***Selected strains of GWSS**:*
Selection of GWSS strains that are tolerant to an OP, a pyrethroid and a neonicotinoid is underway and will be maintained under selection for a few more generations for further studies.

Table 1. A two year comparison of toxicological responses of GWSS to various insecticides.

Insecticide Class	*Insecticides*	Sample Location	2001		2002	
			LC_{50} Petri dish	LC_{50} Leaf dip	LC_{50} Petri dish	LC_{50} Leaf dip
Organophosphates	Chlorpyrifos	Riverside	0.001	0.013	0.0038	0.0124
		Redlands	0.001	0.015	0.0067	0.0562
		Ventura	0.005	0.032	0.00208	0.045
	Dimethoate	Riverside			0.0091	0.038
		Redlands			0.0176	0.0932
		Ventura			0.0298	0.0699
	Cyfluthrin	Riverside	0.038		0.0023	0.0019
		Redlands	0.004		0.0221	0.252
		Ventura			0.0043	0.338
	Esfenvalerate	Riverside	0.0027	0.022	0.006	0.010
		Redlands	0.00003	0.00004	0.0009	0.0042
		Ventura			0.009	0.034
	Fenpropathrin	Riverside	0.042	0.168	0.044	0.551
		Redlands	0.019	0.012	0.0812	0.376
		Ventura			0.0202	0.1431
Cyclodiene	Endosulfan	Riverside	0.006		0.00832	0.0723
		Redlands	0.003		0.00349	0.0195
		Ventura			0.00104	0.0089
Neonicotinoids	Acetamiprid	Riverside	0.01	0.091	0.005	0.072
		Redlands	0.003	0.008	0.0009	0.014
		Ventura	0.04	0.097	0.025	0.074
	Imidacloprid	Riverside		1.64		0.08
		Redlands		0.61		0.034
		Ventura		1.92		0.121
	Thiamethoxam	Riverside	0.0037	0.0085	0.003	0.004
		Redlands	0.0004	0.0012	0.002	0.008
		Ventura	0.0052	0.0093	0.009	0.020

Figure 1. Inhibition of sharpshooter acetylcholinesterase activity by OP insecticides. The response of both the GWSS and the STSS was the same for each OP. Inhibition at lower concentrations indicates greater sensitivity of the target enzyme.



REFERENCES

Toscano, N., N. Praphaker, F.J. Byrne and S.J. Castle. 2001. Chemical control of glassy-winged sharpshooter: Establishment of baseline toxicity and development of monitoring techniques for detection of early resistance to insecticides. Proc. Pierce's Disease Research Symposium held December 5-7, 2001 at Coronado Island (eds. M. Athar Tariq, Stacie Oswalt and Tom Esser. California Department of Food and Agriculture, Sacramento, California, pp. 119-120.

FUNDING AGENCIES Funding for this project was provided by the UC Pierce's Disease Grant Program.