Pesticide Concentrations in Water and Sediment and Associated Invertebrate Toxicity in Del Puerto and Orestimba Creeks

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Abstract

From December 2007 through June 2008, water and sediment samples were collected from Orestimba (OC) and Del Puerto Creeks (DPC) in Stanislaus County to determine the concentrations of organophosphate and pyrethroid insecticides, and to identify related toxicity to *Ceriodaphnia dubia* and *Hyalella azteca*. Diazinon, chlorpyrifos, or dimethoate were detected in 12 of 21 water samples from both sites but only two samples from OC were toxic to *C. dubia*. Chlorpyrifos was implicated as the cause of this toxicity. Three pyrethroids detected in water samples from OC had no associated *C. dubia* toxicity. Pyrethroids including cyfluthrin, bifenthrin, esfenvalerate, or lambda-cyhalothrin, were detected in all sediment samples from DPC. All but one of these samples caused 100% *Hyalella azteca* mortality in all but one of these samples. To determine the cause of toxicity, Toxicity Units were calculated using published LC_{50} values. Bifenthrin was primarily responsible for the toxicity; lambda-cyhalothrin also was implicated. At OC, three pyrethroids were detected in 11 sediment samples and survival of *H. azteca* was reduced in four samples. However, the cause of toxicity could not be determined.

Objectives

1. Collect water and sediment samples from Del Puerto Creek and Orestimba Creek and take environmental measurements to determine the associated water quality parameters.
2. Determine the concentrations of organophosphate and pyrethroid insecticides in these samples.
3. Determine the related toxicity of these samples to representative invertebrate organisms, *Ceriodaphnia dubia* and *Hyalella azteca*.

Introduction

Pyrethroids and organophospates are routinely used for insect control in the San Joaquin Valley. Orestimba and Del Puerto Creeks are listed on the ξ303 (d) list due to the presence of organophosphate and pyrethroid insecticides and for sediment toxicity (CA EPA, 2007). These insecticides are routinely detected in these two creeks and water and sediments are frequently toxic to *C. dubia* and *H. aztecta* (Spurlock, 2002; Weston *et al*., 2008).

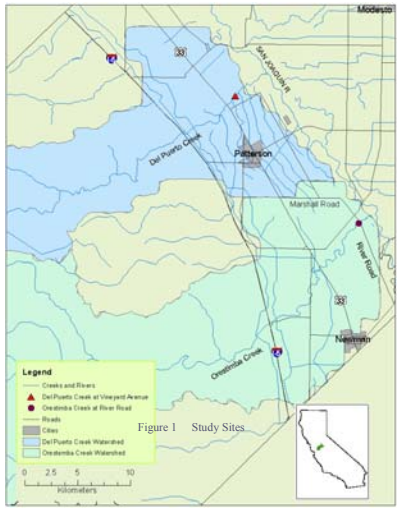

Figure 1 Study Sites

Figure 2 Del Puerto Creek Study Site

Figure 3 Orestimba Creek Study Site

Methods

Water and sediment samples were collected monthly between December 2007 and June 2008 at both Del Puerto and Orestimba Creek. Additional samples were collected in the dormant season (December, January, and February) during rain events. Two samples were also collected in June.

Analysis included:

-Environmental measurements, Grain size, Total Organic Carbon (TOC), and Total Suspended Solids (TSS)

-The CDFG Fish and Wildlife Water Pollution Control Laboratory analyzed water and sediment samples of organophosphates (azinphos methyl, chlorpyrifos, diazinon, dimethoate, disulfoton, malathion, methidathion, methyl parathion, phorate, and phosmet) and pyrethroids (bifenthrin, cyfluthrin, cypermethrin, deltamethrin, esfenvalerate, fenpropathrin, permethrin, and lambda-cyhalothrin).

-The University of California, Davis, Aquatic Toxicology Lab conducted toxicity tests with *C. dubia* (water samples) *H. azteca* (sediment samples).

Acknowledgements

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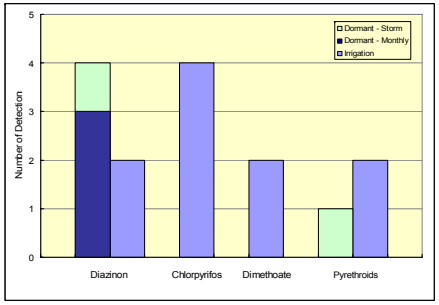

Figure 4. Seasonal detections of organophosphates and pyrethroids in water samples from Del Puerto and Orestimba Creeks.

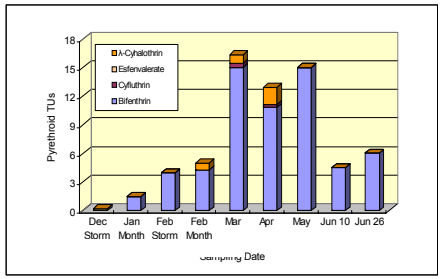

Figure 5. Pyrethroid TUs of sediment from Del Puerto Creek.

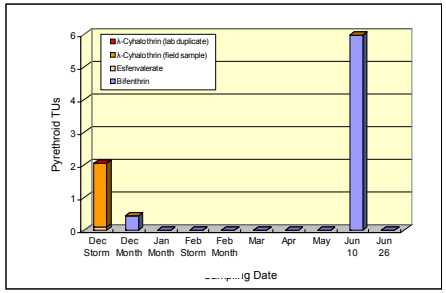

Figure 6. Pyrethroid TUs of sediment from Orestimba Creek.

Results from Chemical Analysis

Organophosphates

Three organophosphates were detected.

-Diazinon was the most frequently detected organophosphate, with six detections; chlorpyrifos (4), dimethoate (2)

*Diazinon was primarily detected in the dormant season and chlorpyrifos and dimethoate were only detected during the irrigation season. There were more diazinon detections in the monthly dormant sampling season than the dormant rain-associated sampling events (Figure 4).

Pyrethroids in Water

Three pyrethroids were detected in water samples from Orestimba Creek. No pyrethroids were found in the water samples from Del Puerto Creek.

-Bifenthrin and lambda-cyhalothrin were detected in the irrigation season (Figure 4).

-Cyfluthrin was detected during the January rain event during the dormant season (Figure 4).

Pyrethroids in Sediment

Pyrethroids were detected in all sediment samples collected at Del Puerto Creek and from three of 10 samples taken from Orestimba Creek. Detections were slightly more abundant during the irrigation season (10 detections) than in the dormant season (eight detections).

-Bifenthrin was the most frequently detected (10 detections) and was detected at the highest concentrations. This pyrethroid has a long half-life (up to 16 months; Gan *et al*., 2008) and may be persisting from applications made in the 2007 water year.

-Lambda-cyhalothrin was detected in four samples, divided equally between the dormant and irrigation season.

-Cyfluthrin was detected twice during the irrigation season but not during the dormant season.

-Esfenvalerate was also detected twice. Both detections were associated with a rain event during the dormant season.

Results from Toxicity Studies

Ceriodaphnia dubia

-Chlorpyrifos was associated with toxicity in two water samples from Orestimba Creek. The concentration of chlorpyrifos exceeded water quality objectives in two other samples, but were not toxic to *C. dubia*. Based on the water quality objective for diazinon (0.1 μg L^{-1}; Diane Beaulaurier, CA SWCRB, personal comm.), the May sample from Orestimba Creek (0.912 μg L^{-1}), and both of January's samples from Del Puerto Creek exceeded the water quality objective. There was no associated toxicity with these water samples.

-Pyrethroids (cyfluthrin, bifenthrin, and lambda-cyhalothrin) detected at Orestimba Creek were below reported LC_{50} values and did not cause any toxicity of *C. dubia* (Figure 5).

Hyalella azteca

All samples (except one) taken at Del Puerto Creek caused 100% mortality to *H. azteca*. Four of eleven samples at Orestimba Creek had significant toxicity (survivability was between 55-72% of control values).

-Toxicity Units (TUs) of pyrethroids were associated with toxicity at Del Puerto Creek but not at Orestimba Creek.

-Bifenthrin was highly associated with toxicity at Del Puerto Creek. Bifenthrin TUs ranged from 1.5 to 15 (Figure 5).

-Lambda-cyhalothrin was also associated with toxicity at Del Puerto Creek. Lambda-cyhalothrin TUs ranged from 0.72 to 1.79 (Figure 5).

-The June 10 water sample from Orestimba Creek had six TUs, but there was no associated toxicity (Figure 6).

References:

Gan, J., S. Bondarenko, and F. Spurlock, F. 2008. Persistence and phase distribution in sediment. In Synthetic Pyrethroids, Occurrence and Behavior in Aquatic Environments; Gan, J., F.Spurlock, D. Weston, Eds., American Chemical Society, Washington, D.C., pp. 203-222.

Spurlock, F., 2002. Analysis of diazinon and chlorpyrifos surface water monitoring and acute toxicity bioassay data, 1991 – 2001. CDPR Report EH 01-01. Accessed at http://www.cdpr.ca.gov/docs/emon/surfwtr/swemreps.htm March 4, 2009.

Weston, D.P., J. You, E.L. Amweg, and M.J. Lydy. 2008. Sediment toxicity in agricultural areas of California and the role of hydrophobic pesticides. In Synthetic Pyrethroids, Occurrence and Behavior in Aquatic Environments; Gan, J., F.Spurlock, D. Weston, Eds., American Chemical Society, Washington, D.C., pp. 26-54.

California EPA. 2007. Central Valley Regional Water Quality Control Board. Accessed at http://www.swrcb.ca.gov/centralvalley/water_issues/tmdl/impaired_waters_list/index.shtml on July 9, 2008.

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Full report and poster available at http://www.cdpr.ca.gov/docs/sw/index.htm