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MEMORANDUM

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SUBJECT: SUMMARY OF PUBLISHED SYNTHETIC PYRETHROID MONITORING AND BIOASSAY DATA FOR CALIFORNIA URBAN AND AGRICULTURALLY-DOMINATED WATERWAYS

Introduction

The purpose of this memorandum is to provide a brief overview of published synthetic pyrethroid (SP) monitoring and sediment bioassay data from California agriculturally-dominated and urban waterways.

Agriculturally-dominated waterways

Weston et al. (2004) conducted a survey for contaminants and toxicity in bed sediments of California water bodies dominated by agricultural runoff. Seventy sediment samples were collected from forty-two locations in ten Central Valley counties and analyzed for bifenthrin, esfenvalerate, lambda-cyhalothrin, permethrin (cis- and trans-), chlorpyrifos, eighteen legacy organochlorine (OC) pesticides, and two current use OC pesticides. In addition, sediment bioassays were conducted using *Hyalella azteca*, a resident species found in some Central Valley waterbodies (Amweg et al., 2005). Significant toxicity was observed at 42% of the sites, including both major rivers sampled, 8 of 19 creeks and 7 of the 17 drainage canals. There was a high correlation between SP concentrations and observed toxicity (Figure 1). As reported by Amweg et al. (2005), SPs were reported to approach or exceed acutely toxic concentrations in 70% of the samples that exhibited significant *H. azteca* toxicity. The data indicate that pyrethroids were primary contributors to toxicity in about 20% of all samples.

The authors concluded that legacy OCs, while widely distributed in Central Valley sediments, were generally far below acutely toxic concentrations to sensitive aquatic invertebrates. Current use OCs were below toxic thresholds in the majority of samples, although they may have contributed to toxicity in a few of the drainage canals. The data suggest that pyrethroid sediment detections and toxicity are widespread in agriculturally-dominated waterways in portions of California's Central Valley (Weston et al., 2004). More recent sediment bioassay and pyrethroid monitoring data have confirmed this conclusion (D.P. Weston, personal communication).

Urban waterways

In a separate study, Weston et al. (2005) recently sampled several creeks that drained a typical suburban development near Roseville, California. They reported that sediment from 9 of the 21 sites caused total or near total (>90%) mortality of *H. azteca.* The observed bioassay mortalities were highly correlated with total SP concentrations as expressed in LC50 equivalents (toxic units, [TU]) (Figure 2). In contrast, chlorpyrifos and the OCs were below levels associated with *H. azteca* toxicity. Both the presence of significant *H. azteca* toxicity and the highest sediment concentrations of SPs were observed near storm drains and outfalls, and the authors concluded that any given outfall affected sediment quality for a distance of tens to hundreds of meters downstream. However, they note that because of the numerous outfalls throughout the system, the result is a patchwork of highly contaminated reaches. In addition, native populations of *H. azteca* were generally low or zero in areas with TU>1, whereas populations were variable but generally higher in other areas with lower pyrethroid concentrations. The authors concluded that the SP sources appear to be structural pest control and/or lawn care products, and that similar sediment quality degradation is likely in other urban areas. More recent monitoring data from other California urban studies support the latter contention (D.P. Weston, personal communication).

Causality

Evidence for a causal relationship between SPs and *H. azteca* sediment toxicity consists of:

1. Consistent correlations between predicted toxicity (TU, based on sediment concentration and LC50s) and observed toxicity (Figures 1 and 2).
2. The absence of other known agent generally capable of explaining the observed toxicity.

The relationship between TU and *H. azteca* mortality in the agricultural site bioassays is noisy (Figure 1). In some cases toxicity is observed for TU<<1, while in a few cases no significant toxicity is observed when TU>1. The former observation may be a result of contributions to toxicity from chemicals that were not analyzed. The latter case of no significant toxicity when TU>1 may be a result of simplifying assumptions involved in calculating TUs. The procedure relies on using organic carbon-normalized LC50s, and does not account for variability in sediment OC characteristics or the role of dissolved organic carbon. The Department of Pesticide Regulation is currently funding research to investigate these effects on sediment toxicity, but limited data suggests that OC-normalized LC50s vary by a factor of ~ three to four in typical California sediments (Amweg et al., 2005). Consequently, although some uncertainty exists in calculating TUs, the overall correlation remains convincing.

Toxicity identification evaluation (TIE) procedures capable of unequivocably identifying causes of sediment toxicity are still under development. However, certain general characteristics of

SP toxicity have been well documented, and sediment TIE development is proceeding based on these characteristics. These include the synergistic action of piperonyl butoxide on SP toxicity and the general increase in SP toxicity with decreasing temperature (e.g., Johnson, 1990). Trial TIE studies were conducted on two acutely toxic sediment samples collected at Ingram Creek and Del Puerto Creek (UCD, 2002; UCD, 2005). SP concentrations were high enough to yield calculated *H. azteca* TU>1. Tests for both samples indicated that toxicity was caused by an organic contaminant that displayed both increased toxicity with decreased temperature and enhanced toxicity with piperonyl butoxide addition. Both characteristics are consistent with SP-caused toxicity. Although the trial TIE procedures do not unequivocally demonstrate toxicity was solely due to an SP, based on the weight of evidence it is unlikely that the principal toxicant was a nonSP contaminant.

Differences between synthetic pyrethroids

Bifenthrin was the dominant contributor to toxicity in the urban samples, followed by cyfluthrin and cypermethrin. In the agricultural samples, there were contributions to toxicity from all four SP analyzed by Weston et al. (2004) depending on the particular sample. These were bifenthrin, esfenvalerate, lambda-cyhalothrin, and permethrin. Subsequent sampling of agricultural areas in Monterey County by the Department of Pesticide Regulation has also identified residues of resmethrin and fenpropathrin in sediment, although *H. azteca* LC50 data are not available to evaluate the potential toxicity of these detections. Given (1) the existing monitoring and bioassay data that documents contributions to toxicity from several different SPs, (2) the similarity in SP physical-chemical properties (Laskowski, 2002), and (3) their uniformly high toxicities, it appears that the potential for SPs to accumulate to toxic levels in sediment is a general characteristic of the chemical class. Consequently, mitigation measures or label language that limit off-site movement should be generally applicable to all members of the class.

Conclusion

Published data document the widespread presence of SPs and accompanying toxicity in agriculturally-dominated California waterways. Additional unpublished data support this conclusion. A recent study of urban creeks similarly demonstrated numerous instances of SP detections–often at high levels–and associated toxicity. Additional urban data currently being developed demonstrate that toxicity and sediment contamination due to pyrethroids is probably common in many of California's urban waterways. Although the causal link between pyrethroid sediment toxicity and concentration is based largely on correlation, the correlations are significant, consistent with predicted toxicities based on laboratory measured LC50s, and there is no general alternative explanation for the observed toxicity. The physical, chemical, and toxicological properties of pyrethroids are unique. Consequently the potential for pyrethroids to accumulate in sediment to toxic levels appears to be a general characteristic of the chemical class, and mitigation measures should be generally applicable to all members of that chemical class.

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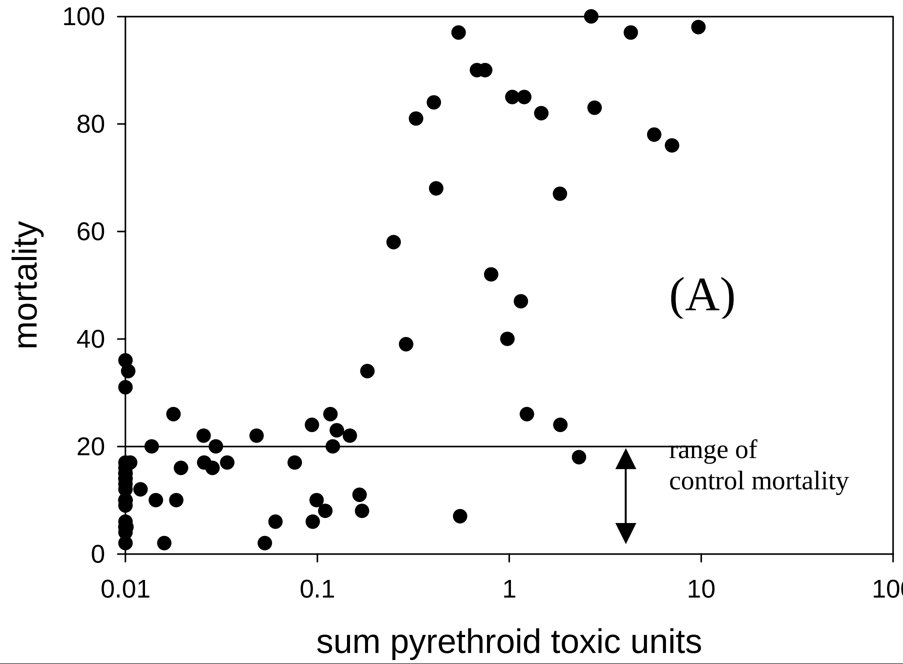
Figure 1A and B. Agriculturally-dominated streams, monitoring data of Weston et al. (2004) and LC50 data of Amweg et al. (2005).
Figure after Amweg et al. (2005)



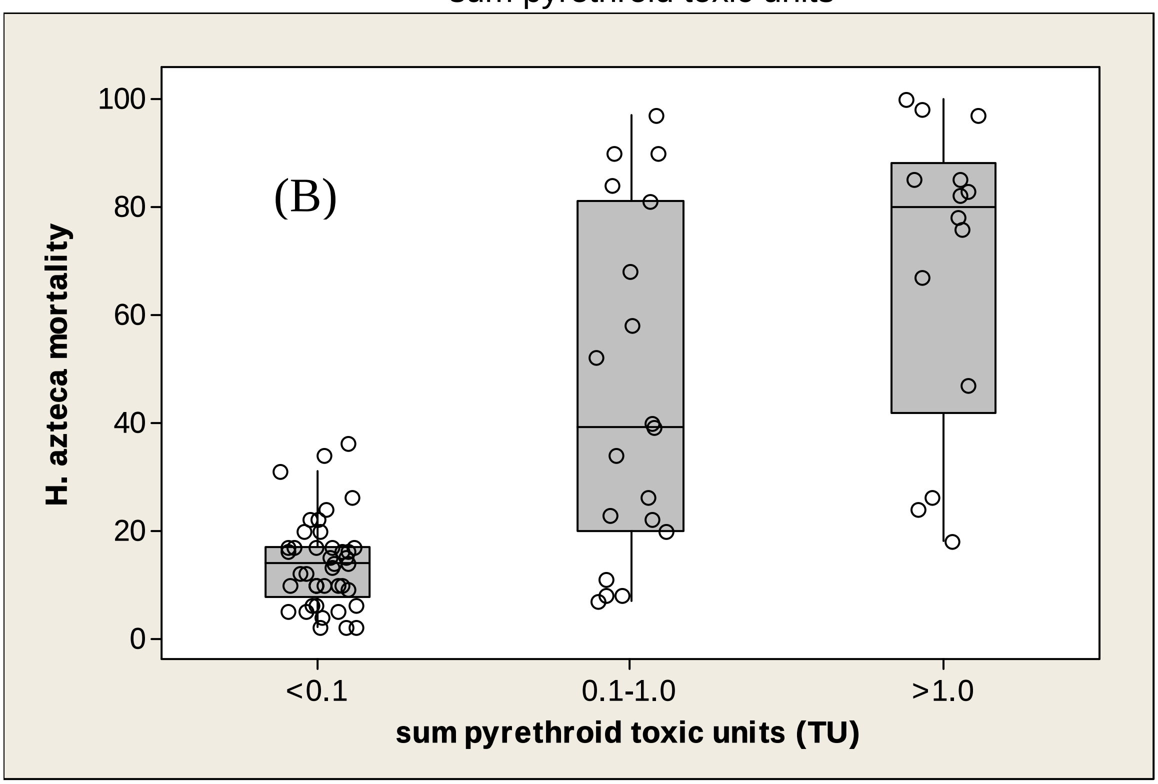


Figure 2. Urban data, from Weston et al. (2005)