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MEMORANDUM

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TO: John S. Sanders, Ph.D., Chief
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SUBJECT: BRIEF COMPARISON OF PYRETHRIN AND SYNTHETIC PYRETHROID FATE CHARACTERISTICS

Introduction

The Environmental Monitoring Branch recently requested re-evaluation of synthetic pyrethroid products. Pyrethrins were not included in that request because they possess much different fate characteristics than the synthetic pyrethroids. This memorandum briefly analyzes those differences, providing the rationale for exempting pyrethrin products from re-evaluation.

Pyrethrin/Synthetic Pyrethroid Comparison

Sediment toxicity was the primary factor leading to the Environmental Monitoring Branch 's request for re-evaluation of pesticide products containing synthetic pyrethroids (Sanders, 2005). Pyrethrins are a mixture of six naturally occurring chemicals: pyrethrin I and II, cinerin I and II, and jasmolin I and II. From the standpoint of potential to cause sediment toxicity, pyrethrins differ in three important ways from synthetic pyrethroids. They (a) display a lower affinity for soils and sediment, (b) are less toxic to aquatic organisms, and (c) are less persistent in the environment.

Pyrethrins are less hydrophobic than synthetic pyrethroids and display a lower affinity for soils and sediments as shown by their lower organic normalized soil sorption coefficients K_{OC} and their correspondingly higher water solubilities (Table 1). The soil sorption coefficient K_{OC} is a measure of a nonionic organic chemical's affinity for soils and sediments. While there is limited experimental K_{OC} data for the pyrethrins, the particular K_{OC} estimation method used in Table 1 has been shown to yield the most realistic estimates of K_{OC} for pyrethroids (Spurlock et al., 2005) as well as other pesticides (Meylan et al., 1992). Because pyrethrins have a much lower affinity for soil and sediment than pyrethroids, they will demonstrate a lesser tendency to be sediment associated in the environment.

There are few if any datasets available for comparing toxicities of synthetic pyrethroids and pyrethrins to sediment dwelling organisms. However, the synthetic pyrethroids were developed with the goal of being more toxic to insects than pyrethrins. As expected, synthetic pyrethroids are also much more toxic to aquatic arthropods (Figure 1a, 1b) and fish (Figure 1c, 1d) than pyrethrins. Pyrethrin LC50s for the arthropods *Americamysis bahia* and *Daphnia magna* are 175 and 50 times greater, respectively, than the median LC50s across all pyrethroids/pyrethrins for which there are data. In the case of *Lepomis macrochirus* (Bluegill sunfish) and *Onchorhynchus mykiss* (Rainbow trout), the pyrethrin LC50s were 10 and 13 times greater than the respective median LC50s. While data for the four organisms were compared here because they were the most comprehensive toxicity datasets available in the U.S. EPA ecotox database, data for other organisms demonstrate a similar trend of lower toxicity for pyrethrins as compared to synthetic pyrethroids.

TABLE 1. Synthetic pyrethroid and pyrethrin solubilities and sorption coefficients

Chem	Solubility (ppb)[A,B]	K_{OC} measured[A]	K_{OC} estimated[B]
bifenthrin	0.014	237000	**3200000**
cyfluthrin	2.3	124000	**180000**
cypermethrin	4	310000	**108000**
esfenvalerate	6	252000	**440000**
λ -cyhalothrin	5	326000	**480000**
permethrin	5.5	277000	**180000**
pyrethrin I	**76**	5100[C]	**10460**
pyrethrin II	**962**	2000[C]	**3030**
cinerin I	**85**	---[D]	**5700**
cinerin II	**301**	---[D]	**1640**
jasmolin I	**27**	---[D]	**10500**
jasmolin II	**94**	---[D]	**3030**

[A] from Laskowski (2002) unless otherwise noted
[B] estimated values **(shaded and in bold)**
water solubility estimated using WSKOW v. 1.41
K_{OC} estimated using PCKOCWIN v. 1.66
both program modules and documentation available in EPI Suite v. 3.12, available on-line: <http://www.epa.gov/opptintr/exposure/docs/episuite.htm>
[C] from data of Antonious et al. (2004) assuming [2 g org. matter/g org. C]
[D] no data available

Pyrethrins degrade relatively rapidly in crop foliage and soils. Antonious (2004) recently reported degradation half-lives for pyrethrin I and II of < 2 hours on leaves of peppers and tomatoes under field conditions. Soil half-lives of 8.6 d and 3.1 d have been reported for pyrethrin I and II (Antonious et al., 1997). Given the similar structures of cinerin I and jasmolin I to pyrethrin I, and cinerin II and jasmolin II to pyrethrin II, similarly short soil and foliar half-lives are expected for these compounds also. By way of comparison, terrestrial field dissipation half-lives for bifenthrin, cyfluthrin, cypermethrin, lambda cyhalothrin, esfenvalerate, and permethrin are 110, 13.5, 27, 23.4, 31.1, and 38.4 d (Department of Pesticide Regulation Pestchem database), while aerobic soil degradation half-lives for these synthetic pyrethroids range from 40 to 890 days. One reason for the rapid breakdown of pyrethrins under field conditions is that they are very susceptible to photolytic degradation (Crosby, 1995; Leahy, 1985). In general, pyrethrin field half-lives are expected to range from days to weeks (Crosby, 1995; Todd et al., 2003; EXTOXNET, 2005).

Conclusion

Pyrethrins demonstrate different environmental fate characteristics than synthetic pyrethroids, including lower aquatic toxicities, lesser persistence, and a lower affinity for soil and sediments. Consequently pyrethrins are not expected to accumulate to toxic levels in California stream bed sediments as synthetic pyrethroids have done.

bcc: Spurlock Surname File

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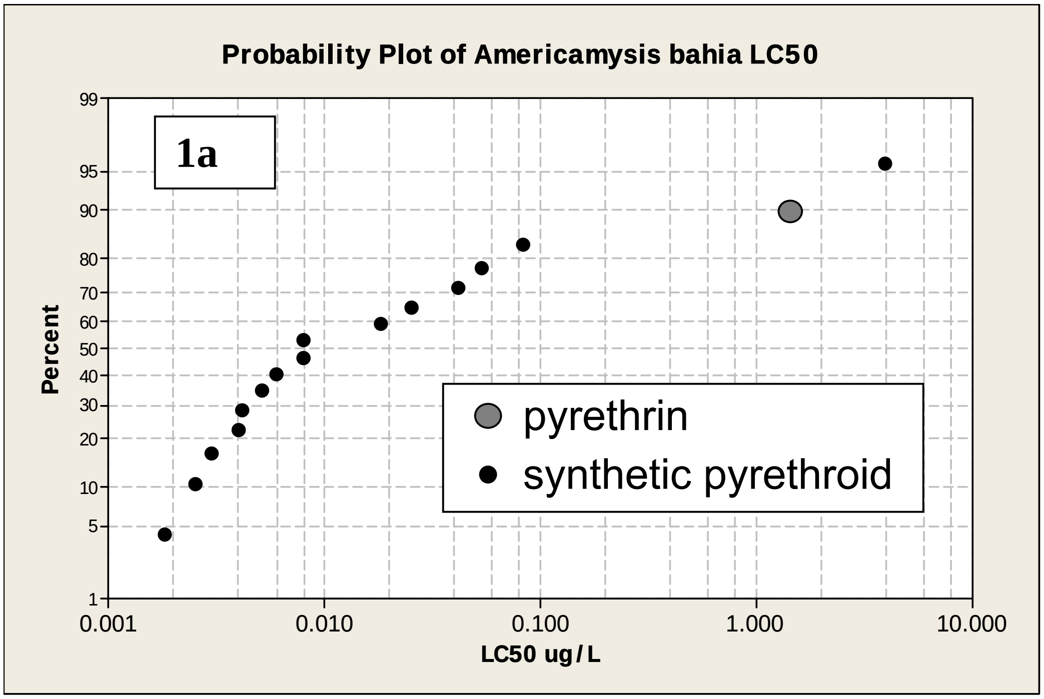
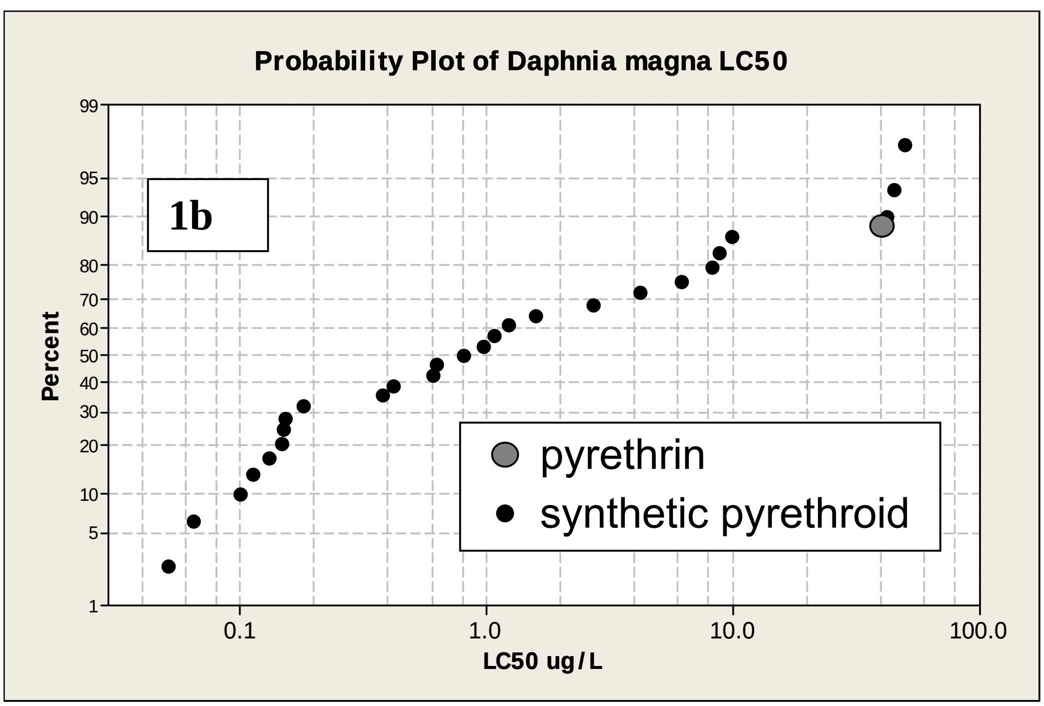
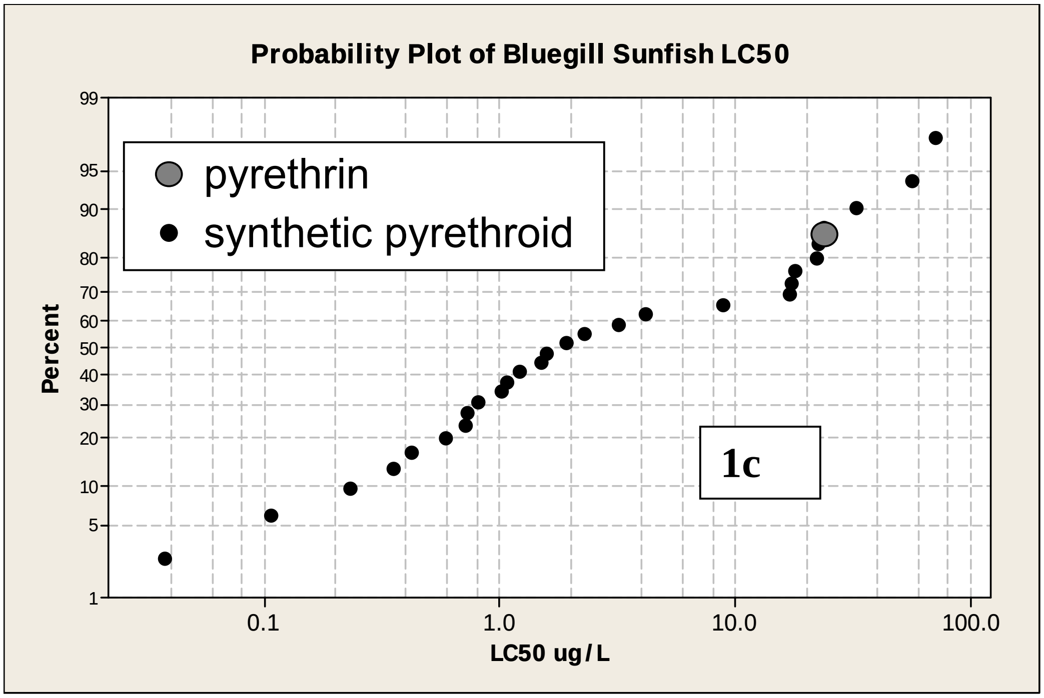
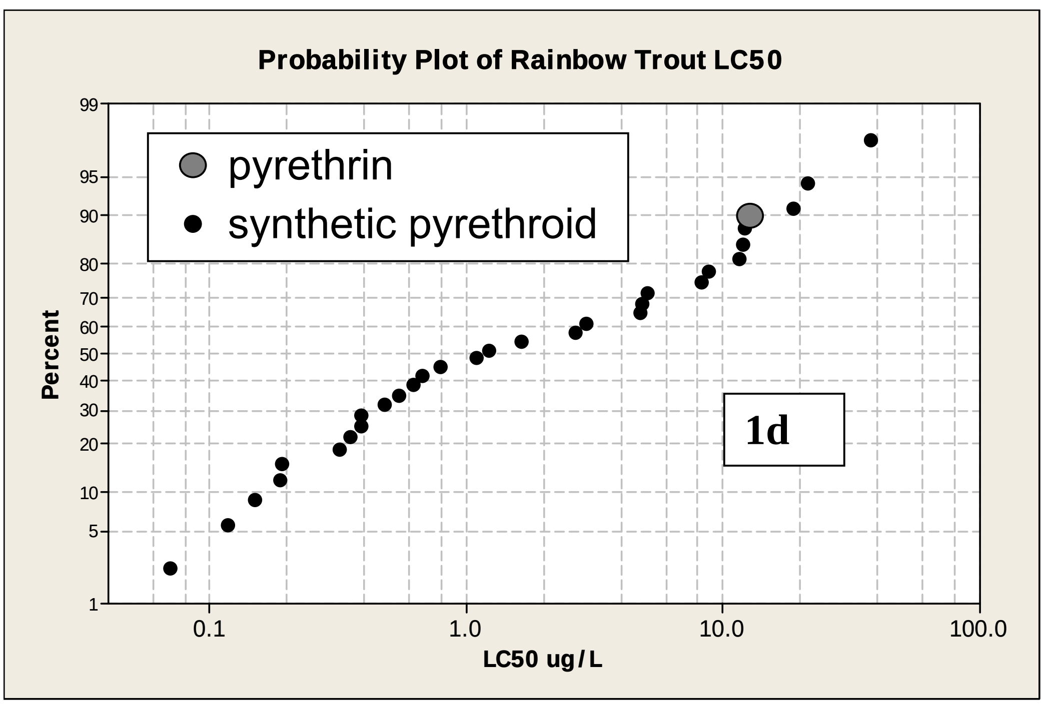
Figure 1a-d. Cumulative probability plots of pyrethrin and synthetic pyrethroid LC50s for various aquatic organisms (Data from US EPA ecotoxicity database)






Probability Plot of Bluegill Sunfish LC50
pyrethrin
synthetic pyrethroid
Percent
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
1.0
10.0
100.0
LC50 ug/L
1c


Probability Plot of Rainbow Trout LC50
pyrethrin
synthetic pyrethroid
Percent
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
1.0
10.0
100.0
LC50 ug/L
1d