**APPENDIX 2-5. Thiamethoxam Species Sensitivity Distribution Analysis for Aquatic Insects**

# **Summary**

Species Sensitivity Distributions (SSDs) were fit to median lethal or effects (immobility) concentrations (LC50 or EC50 values, respectively) for aquatic insects exposed to thiamethoxam. In previous biological evaluations for other insecticides, a combined SSD was conducted for all aquatic invertebrates; however, due to the differences in sensitivity between insects and non-insects, this was not done for thiamethoxam. Additionally, separate SSDs for mollusks were also developed in previous biological evaluations; however, this was not done for thiamethoxam due to a lack of data.

Six distributions (normal, logistic, triangular, gumbel, weibull and burr) were fit to the available toxicity data for aquatic insects. For aquatic insects, the gumbel distribution provided the best fit for the datasets (**Figure 1**). This decision was based on the Akaike Information Criterion (AIC)c weight and confidence limits for the different distributions (especially around the HC05 and HC50). Summary statistics from the fitted SSD for aquatic insects are provided in **Table 1**. The fifth and fiftieth percentiles of the SSD (abbreviated HC05 and HC50, respectively, where “HC” stands for “hazard concentration”) are used to calculate mortality endpoints representing effects to listed species of aquatic invertebrates associated with their prey, pollination, habitat and dispersal (PPHD).



**Figure 1. Gumbel SSD for thiamethoxam toxicity values for aquatic insects.**

**Table 1. Summary of thiamethoxam mortality endpoints for aquatic insects (values in µg a.i./L).**

|  |  |
| --- | --- |
| Statistic | Aquatic Insects |
| HC05 (95% CI) |  11.87 (5.19-40.87) |
| HC50 (95% CI) |  140.38 (53.55-438.30) |
| Slope | 1.89 |

CI = confidence interval

# **Toxicity Data**

Because an SSD depicts relative sensitivities of different species exposed to the same stressor, it is necessary to standardize the data as much as possible to eliminate variables that would confound the relative sensitivities of species. Such variables can include study exposure duration, age class of organisms tested, and other study design factors. The EC/LC50 values that were included in the analysis were all definitive mortality or immobility endpoints from either 48 or 96-hour tests, with a minimum of five concentrations of technical grade active ingredient, plus appropriate controls, tested within each study. Additionally, if a definitive immobility and mortality endpoint were available from the same test, the mortality endpoint was used (because immobility is intended as a surrogate for mortality). In some cases, only the genus was available, so the species is unknown. Endpoints without definitive endpoints were not used to derive SSDs.

Data used to derive SSDs are from literature that passed the ECOTOX quality screen (catalogued in **APPENDIX 2-2**) and data from unpublished, registrant-submitted studies. Those data are included in **Table 2**. There was a total of 14 aquatic insect species tested (**Table 3**). Note that for some of the species in Raby *et al*. 2018 (178290), wild caught species were only identified down to the genus level; however, they are assumed to represent the same species. For all species, there are either one or two different toxicity endpoints (LC50 or EC50 values) available. In cases where two endpoints were available for the same test species, values were similar (differing by only 1.3-2.5x). Using the available data, the slope was calculated for all aquatic invertebrates resulting in a median slope of 1.89. The data in **Table 2** are from 5 different studies, with one study (Raby *et al*., 2018, ECOTOX # 178290)[[1]](#footnote-1) representing toxicity data for 12 different test species.

**Table 2. Test results used to derive SSDs for thiamethoxam for aquatic insects.**

| **Genus or Species** | **Acute EC/LC50 value (µg/L)** | **Slope** | **Reference (ECOTOX #)** |
| --- | --- | --- | --- |
| *Neocloeon triangulifer* | 7.07 | NA | 178290 |
| *Chironomus xanthus* | 32 | NA | 183669 |
| *Chironomus riparius* | 351 | NA | MRID 44714918 |
| *Micrasema sp.* | 39.5 | 8.27 | 178290 |
| *Gyrinus sp.* | 44.2 | NA | 178290 |
| *Chironomus dilutus* | 55.34 | NA | 183458 |
| *Chironomus dilutus* | 74.1 | 1.89 | 178290 |
| *Aedes sp.* | 84 | 2.69 | 178290 |
| *Chironomus riparius* | 86.41 | NA | 175180 |
| *Cheumatopsyche sp.* | 198 | 2.55 | 178290 |
| *Stenelmis sp.* | 205 | NA | 178290 |
| *Ephemerella sp.* | 366 | 1.57 | 178290 |
| *Caenis sp.* | 381 | 1.65 | 178290 |
| *Trichocorixa sp.* | 1660 | 1.24 | 178290 |
| *Cloeon sp.* | 4740 | NA | 178290 |
| *Coenagrion sp.* | 35400 | NA | 178290 |

NA = Not available

1EC50 value

**Table 3. Distribution of test results available for thiamethoxam.**

|  |  |  |
| --- | --- | --- |
| Media | Test results | Species |
| Aquatic Insects | 16 | 14 |

# **Determining Distribution with Best Fit**

## P-values

Six potential distributions for the thiamethoxam data were considered (*i.e.,* normal, logistic, triangular, gumbel, weibull and burr). To fit each of the six distributions, the toxicity values were common log (log10) transformed. The SSD toolbox includes four different fitting methods (*i.e.,* maximum likelihood, moment estimators, linearization and metropolis-hastings). All six distributions were fit using the maximum likelihood (ML) method. To test goodness-of-fit, all six distributions were fit to the thiamethoxam data and bootstrap goodness-of-fit tests were run with 10,000 replicates. The results of these fitting exercises are presented in **Table 4**. The p-value for the Weibull distribution is <0.05, indicating that this SSD is not a good fit for the available data[[2]](#footnote-2). Therefore, the Weibull distribution will not be considered further for the insect data.

**Table 4. P-values calculated for SSDs using aquatic invertebrate and insect toxicity data for thiamethoxam.**

|  |  |
| --- | --- |
| Distribution | Aquatic insect SSD |
| Normal | 0.27 |
| Logistic | 0.42 |
| Triangular | 0.12 |
| Gumbel | 0.85 |
| Weibull | <0.01 |
| Burr | 0.82 |

## Akaike’s Information Criteria Weights

Akaike’s Information Criterion corrected for sample size (AICc) was used to compare the five distributions for aquatic insects at the HC052. For aquatic insects, the majority of the weight is attributed to the gumbel distribution (with ≤16% each attributed to logistic, normal, triangular and burr; ***Table 5***). Based on the AIC weights, the gumbel distribution is used for aquatic insect data.

**Table 5. Akaike’s Information Criteria (AICc) for distributions for aquatic insect toxicity data for thiamethoxam.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Distribution | AICc | Delta AICc | Wt | HC05 | SE HC05 |
| Gumbel | 212.61 | 0 | 0.46 | 11.87 | 6.03 |
| Logistic | 214.71 | 2.11 | 0.16 | 4.78 | 4.41 |
| Normal | 214.95 | 2.35 | 0.14 | 5.79 | 5.13 |
| Triangular | 215.07 | 2.46 | 0.14 | 6.65 | 7.37 |
| Burr | 215.92 | 3.31 | 0.09 | 11.87 | 6.03 |
|  |  |  |  |  |  |

# **Conclusions**

For aquatic insects, the gumbel distribution provided the best fit for the dataset. This decision was based on the AICc weight and confidence limits for the different distributions (especially around the HC05 and HC50). The gumbel distribution for aquatic insects will be used in the BE to derive HC05 and HC50 values for listed aquatic invertebrates and for assessing effects to PPHD.

1. M. Raby, M. Nowierski, D. Perlov, X. Zhao, C. Hao, D. G. Poirier, and P. K. Sibley. 2018. Acute Toxicity of 6 Neonicotinoid Insecticides to Freshwater Invertebrates. Environmental Toxicology and Chemistry, 37 (5): 1430–1445. ECOTOX# 178290; MRID 50776401 [↑](#footnote-ref-1)
2. Etterson, M. 2011. Appendix C. Analyses of sensitivity distributions for estimation of acute hazard concentrations to aquatic animals. https://www.regulations.gov/document?D=EPA-HQ-OPP-2011-0898-0009 [↑](#footnote-ref-2)