**APPENDIX 2-6: Diazinon Species Sensitivity Distribution Analysis for Fish**

**Summary**

SSDs were fit to test results for aquatic vertebrates exposed to diazinon. Five potential distributions were considered (log-normal, log-logistic, log-triangular, log-gumbel, and Burr). Goodness-of-fit for each of the individual distributions was examined using parametric bootstrapping with 5,000 replicates, which suggested significant lack-of-fit for the burr distribution. As a further check on the fit and uncertainty of the fitted SSDs, the quantile of the fitted SSD corresponding to the upper 95% confidence limit on the HC05 was examined and found to be generally below 0.16 for the competitive distributions, suggesting reasonably precise estimation of the location of the HC05 relative to the variance of the SSD.

Using the results of the maximum likelihood fits (excluding the burr distribution due to lack-of-fit), model-averaged SSD and model averaged quantiles, including the HC05 were estimated. From the model-averaged HC05, the direct and indirect effect thresholds were also calculated. The model-averaged HC05 estimate was 237.9 ug/L (SE = 115.3 ug/L, CV = 0.48). The resulting threshold for direct effects was 20.9 μg/L and the threshold for indirect effects was 123.5 μg/L.

1. **Data**

Data were received from Scott Glaberman on 14 October 2014 in the file:

 “SSD Data Diazinon 10.10.14.xlsx”

From this file I created the working file “DiazinonAllAqVerts\_ugL.xlsx”

This file contains four fields (**Table B 2-6.1**), required to run the SSD tool.

**Table B 2-6.1. Fields in working files**

|  |  |
| --- | --- |
| Field in working files | Field in received file |
| 1. Genus | Genus |
| 2. Species | Species |
| 3. Toxicity | Conc #1 Purity Adjusted in Preferred Unit Mean |
| 4. Media | Media |

The working file contained 49 test results on 29 taxa (**Figure B 2-6.1**). Of these, four test results were obtained in saltwater medium and three were on anurans. Otherwise all results pertained to freshwater fish. Because of the small number of results for saltwater tests and for amphibians, all aquatic vertebrate data were combined into a single dataset for generating an SSD.



**Figure B 2-6.1. Distribution of the number of test results per species in Diazinon aquatic vertebrate data**

**II. Comparison of distributions using AICc**

AICc was used to compare the five distributions. For these comparisons all SSDs were fit using maximum likelihood. AICc suggested that the logistic distribution provided the best fit, followed closely by the triangular and normal distributions (**Table B 2-6.2**). The burr and gumbel distributions were not competitive.

**Table B 2-6.2. Comparison of distributions for all aquatic vertebrate toxicity data for Diazinon**

|  |  |  |  |
| --- | --- | --- | --- |
| distribution | AICc | ∆AICc | Weight |
| logistic | 580.4 | 0.00 | 0.37 |
| triangular | 580.7 | 0.28 | 0.32 |
| normal | 581.0 | 0.60 | 0.28 |
| burr | 586.2 | 5.82 | 0.02 |
| gumbel | 589.0 | 8.56 | 0.01 |

The model-averaged quantiles of the distribution, including standard errors and coefficients of variation, are presented in **Table B 2-6.3** below. The cumulative distribution function for the SSD is presented in **Figure B 2-6.2** below. In general the SSD shows reasonably good fit, though the model tends to overestimate tolerance for more sensitive organisms (see lower 20% of distribution in **Figure B 2-6.2**).

**Table B 2-6.3. Model-averaged HC05 estimates from five distributions fit using maximum likelihood**

|  |  |  |  |
| --- | --- | --- | --- |
| Quantile | Mean | SE | CV |
| HC05 | 237.9 | 115.3 | 0.48 |
| HC10 | 433.2 | 193.9 | 0.45 |
| HC50 | 3368.2 | 964.8 | 0.29 |
| HC90 | 27084.6 | 11543.7 | 0.43 |
| HC95 | 49300.5 | 27633.8 | 0.56 |



**Figure B 2-6.2. Model-averaged SSD for aquatic vertebrates exposed to diazinon.**

**III. Goodness of fit and the importance of fitting method**

To test goodness-of-fit parametric bootstrap sampling with 5,000 bootstrap replicates was used on every combination of distribution and fitting method employed. Note that not all fitting methods are available for each distributions. **Table B 2-6.4** gives results of these fitting exercises. No distribution showed significant lack-of-fit, except the burr distribution. In general, the coefficient of variation for the HC05 was below 1, except for the normal distribution fit using maximum likelihood. For the competitive distributions, the cv was 0.5 or 0.6.

**Table B 2-6.4. Range of HC05 values for Diazinon SSDs for all aquatic vertebrates**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| distribution | method | HC05 | SE | CV | LCL | UCL | LCQ | UCQ | P |
| gumbel | ML | 215.8 | 96.8 | 0.4 | 118.6 | 488.6 | 0.01 | 0.16 | 1.00 |
| gumbel | MO | 386.2 | 142.4 | 0.4 | 190.9 | 756.3 | 0.01 | 0.17 | 1.00 |
| gumbel | GR | 307.5 | 107.7 | 0.4 | 103.3 | 517.0 | 0.00 | 0.12 | 1.00 |
| normal | ML | 46.8 | 61.8 | 1.3 | 11.0 | 228.0 | 0.01 | 0.14 | 0.59 |
| normal | MO | 223.5 | 120.2 | 0.5 | 90.3 | 552.5 | 0.01 | 0.14 | 0.99 |
| normal | GR | 174.9 | 85.6 | 0.5 | 47.5 | 370.8 | 0.01 | 0.11 | 0.98 |
| logistic | ML | 277.4 | 155.9 | 0.6 | 104.8 | 713.3 | 0.02 | 0.13 | 0.93 |
| logistic | MO | 231.4 | 141.4 | 0.6 | 78.4 | 618.2 | 0.02 | 0.14 | 0.91 |
| logistic | GR | 159.7 | 89.3 | 0.6 | 26.1 | 362.1 | 0.01 | 0.11 | 0.79 |
| triangular | ML | 196.0 | 114.2 | 0.6 | 118.8 | 549.5 | 0.02 | 0.16 | 1.00 |
| triangular | MO | 212.9 | 109.4 | 0.5 | 97.0 | 524.2 | 0.01 | 0.15 | 1.00 |
| triangular | GR | 184.2 | 92.6 | 0.5 | 66.8 | 414.8 | 0.00 | 0.13 | 1.00 |
| burr | ML | 237.7 | 141.0 | 0.6 | 105.3 | 651.3 | 0.02 | 0.16 | 0.01 |

**V. Calculation of other quantiles**

**Table B 2-6.5** provides estimates of the HC05 as well as other quantiles of the fitted SSDs.

**Table B 2-6.5. Estimated quantiles of the fitted SSDs for Diazinon LC50s for all aquatic vertebrates**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| dist | method | HC05 | HC10 | HC50 | HC90 | HC95 |
| gumbel | ML | 215.8 | 337.0 | 2573.2 | 62502.9 | 211482.6 |
| gumbel | MO | 386.2 | 537.7 | 2431.7 | 25961.0 | 64162.9 |
| gumbel | GR | 307.5 | 447.9 | 2490.0 | 36749.9 | 102791.0 |
| normal | ML | 46.8 | 126.8 | 4272.3 | 143930.8 | 390101.4 |
| normal | MO | 223.5 | 401.5 | 3169.0 | 25016.0 | 44935.3 |
| normal | GR | 174.9 | 331.7 | 3169.0 | 30281.0 | 57419.0 |
| logistic | ML | 277.4 | 531.1 | 3586.0 | 24212.7 | 46356.6 |
| logistic | MO | 231.4 | 449.5 | 3169.0 | 22340.7 | 43404.4 |
| logistic | GR | 159.7 | 340.9 | 3169.0 | 29461.7 | 62886.7 |
| triangular | ML | 196.0 | 336.6 | 3300.0 | 32350.8 | 55564.1 |
| triangular | MO | 212.9 | 357.2 | 3169.0 | 28117.4 | 47165.0 |
| triangular | GR | 184.2 | 317.7 | 3169.0 | 31610.4 | 54516.1 |
| burr | ML | 237.7 | 414.5 | 2902.3 | 32190.2 | 76660.1 |

**VI. Calculation of thresholds**

Thresholds were calculated using a probit curve with the HC05 as the mean and three different slopes (2, 4.5, and 9). Calculated thresholds are provided in **Table B 2-6.6**.

**Table B 2-6.6. Thresholds for determination of action area for Diazinon LC50s for all aquatic vertebrates**

|  |  |  |  |
| --- | --- | --- | --- |
| distrib. | method | Mortality Threshold (10-6) | Indirect Effects Threshold (10-1) |
| slope = 4.5 | slope = 2 | slope = 9 | slope = 4.5 | slope = 2 | slope = 9 |
| gumbel | ML | 19.0 | 0.9 | 64.0 | 112.0 | 49.3 | 155.5 |
| gumbel | MO | 33.9 | 1.6 | 114.5 | 200.5 | 88.3 | 278.3 |
| gumbel | GR | 27.0 | 1.3 | 91.1 | 159.6 | 70.3 | 221.6 |
| normal | ML | 4.1 | 0.2 | 13.9 | 24.3 | 10.7 | 33.7 |
| normal | MO | 19.6 | 0.9 | 66.2 | 116.0 | 51.1 | 161.0 |
| normal | GR | 15.4 | 0.7 | 51.8 | 90.8 | 40.0 | 126.0 |
| logistic | ML | 24.4 | 1.2 | 82.2 | 144.0 | 63.4 | 199.9 |
| logistic | MO | 20.3 | 1.0 | 68.6 | 120.1 | 52.9 | 166.7 |
| logistic | GR | 14.0 | 0.7 | 47.3 | 82.9 | 36.5 | 115.1 |
| triangular | ML | 17.2 | 0.8 | 58.1 | 101.7 | 44.8 | 141.2 |
| triangular | MO | 18.7 | 0.9 | 63.1 | 110.5 | 48.7 | 153.4 |
| triangular | GR | 16.2 | 0.8 | 54.6 | 95.6 | 42.1 | 132.7 |
| burr | ML | 20.9 | 1.0 | 70.5 | 123.4 | 54.4 | 171.3 |