## Appendix J. Method for Deriving Species Sensitivity Distributions

### 1. Introduction

The objective of this document is to describe methods for deriving species sensitivity distributions (SSDs), using available acute oral avian toxicity data for a pesticide of interest. An SSD is a statistical model of the variation in sensitivity of different species exposed to a stressor. The method described in this paper includes two steps for deriving SSDs: 1) standardization of data for inclusion in an SSD and 2) fitting an SSD.

### 2. Standardization of data for inclusion in SSD

Because the focus of the SSD is to depict relative sensitivities of different avian 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 species sensitivities. The following criteria should be considered when considering which registrant-submitted and open literature data will be used to derive an avian SSD:

- The endpoint should be the median lethal dose ($LD_{50}$) from an acute oral toxicity study.
- The duration should be consistent with standard toxicity studies (*i.e.*, single acute dose for birds followed by 7-14 d observation period).
- The endpoint should be expressed in units of mg a.i./kg-bw.

Endpoints should be normalized to represent birds with a body weight that is representative of the assessed species (mean value in g), using the following equation:

$$Normalized\ LD_{50} = LD_{50}\left(\frac{100}{TW}\right)^{(x-1)}$$

Where:

- The $LD_{50}$ value on the right side of these equations is the endpoint reported from the study (units expressed as mg a.i./kg-bw).
- TW represents the body weight (in g) of the species tested. Generally, acute oral tests involve adult animals. If body weight data are not available in the study report, the literature can be cited for species specific body weights.. For the laboratory rat, the default body weight is 350 g. Default body weights for the the bobwhite quail and mallard duck are 178 and 1580 g, respectively. Body weights for additional bird species can be found in Dunning (1984).
- The Mineau scaling factor (x) is used to adjust bird body weights. When chemical specific values are available in Mineau (1996), they should be used. If not, the default value of 1.15 should be used.

In cases where multiple endpoints are available for the same species, the geometric mean of the toxicity values will be calculated, and that single mean value will be used in the SSD. Where data from a single species indicate a notable difference in sensitivity of different life stages (juvenile vs. adult), only the more sensitive life stage may be used in the SSD.

## 3. Fitting the SSD

Fitting an SSD requires several important decisions, including which distribution to fit, how the distribution will be fit, and how fit will be evaluated. For each distribution, these decision points will be explored in order to determine the most appropriate $HC_{05}$.

This analysis involves fitting four distributions: log-normal, log-logistic, log-triangular and Burr. For the first three distributions the analysis involves fitting each distribution using three methods: maximum likelihood, moment estimation, and graphical methods. A parametric bootstrap procedure with 5000 replicates is used to evaluate the fit of the distributions.

For the four distributions fit using maximum likelihood, fits are compared among distributions, using Akaike's Information Criterion, adjusted for small sample size ($AIC_c$). Akaike's information criterion is a metric derived from the fitted log-likelihood function summed over all data points, with an adjustment for the number of parameters that must be estimated. Specifically,

$$\mathsf{AIC} = -2L + 2K$$

In the above equation, $L$ is the value of the log-likelihood function evaluated against the data at the maximum likelihood estimates for the parameters of the distribution. $K$ is the number of estimated parameters (two for all distributions considered here, except for Burr, which has three estimated parameters). The lower the value of AIC, the better the fit; thus when multiple distributions are compared, AIC can help distinguish among competing fits. Because AIC may be biased at small sample sizes, a sample-size corrected metric ($AIC_c$, where $n$ = number of geometric mean toxicity values available) is used:

$$\mathsf{AIC}_c = \mathsf{AIC} + \frac{2K(K+1)}{n-K-1}$$

Comparison among distributions using AIC and $AIC_c$ depends only upon the differences among AIC values, not on the absolute magnitude of the AIC values themselves, which can be either negative or positive. Thus it is conventional when using AIC to report the $\Delta$AIC value, which is the difference between AIC for a given distribution and the minimum AIC over all distributions. In general, distributions (models) with a $\Delta$AIC value greater than about 4 or 5 compared to the lowest AIC will not be very competitive (though this is by no means a strict criterion). Distributions can also be assigned weights based on their $\Delta$AIC values, which can help resolve the confidence for a given distribution as being the best for a given dataset. These weights can also be used to derive weighted $HC_{05}$ estimates. The AIC methods described here are presented in much greater detail in standard texts (*e.g.*, Burnham and Anderson, 2002 and Anderson, 2008).

**References**

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