H119 Statistical Confidence Limits for a Prediction of Carrion Insect Age Based on a Categorical Response Variable

Lynn R. LaMotte, PhD, Louisiana State University, Health Sciences Center, School of Public Health, 2020 Gravier Street, New Orleans, LA 70112; Amanda L. Roe, PhD, College of Saint Mary, 7000 Mercy Road, Omaha, NE 68106; Jeffrey D. Wells, PhD, FL International University, Dept Biological Sciences, 11200 SW 8th Street, Miami, FL 33199; and Leon G. Higley, PhD, University of Nebraska, 306B Biochemistry Hall, Lincoln, NE 68583-0760*

After attending this presentation, attendees will be aware of a method for calculating statistical confidence limits of an estimate of carrion insect age based on the categorical variable instar.

This presentation will impact the forensic science community by promoting the objective expression of the uncertainty associated with the typical forensic entomological conclusion and for a Postmortem Interval (PMI) estimated from any categorical measurement of decomposition.

The most common forensic entomological analysis involves estimating the age of a carrion insect associated with a corpse. If circumstances suggest that the individual insect was deposited on the victim following death (e.g., the victim was not colonized before death and the larva did not crawl to the victim after developing for some time on a different food source), this age value equals a minimum Postmortem Interval (PMImin). In the language of statistical models, an analyst "predicts" condition (e.g., specimen age) from response (e.g., specimen size), and a model of the relationship between condition and response also includes the effects of important covariates (e.g., insect species and environmental temperature).

It is desirable to be able to make an objective statement of uncertainty concerning any forensic science conclusion, and methods are available for calculating a confidence interval about an insect age estimate based on a continuous quantitative response(s) such as specimen length or weight; however, some forensic entomologists prefer to estimate age based only on life stage, because size can vary considerably between individuals of the same age and because size is also influenced by the specimen preservation method. Unfortunately, no statistical model has been proposed for estimating carrion insect age from a categorical response such as instar. This presentation will illustrate how statistical methods originally designed for estimating PMI from the categorical data of a carrion insect succession model can be applied to categorical insect development data.[1]

The *Lucilia sericata* (Diptera: Calliphoridae) development data recently published by Roe and Higley was used.[2] *L. sericata*, one of the most common and widely distributed insects used in death investigation, was reared at 11 constant temperatures from 12.5°C to 32.5°C (see reference 2 for a more complete description of the experimental methods and results). Age was converted to Accumulated Degree Hours (ADH) using threshold 10°C (ADH10) in order to increase the number of observations for an age category and to explore the utility of measuring time in ADH as a method for accommodating the well-known effect of temperature on development rate.

The analysis was confined to the life stages egg, first larva, second larva, and feeding third larval instar, because the post-feeding larva developed independently of temperature. Samples from different rearing temperatures were pooled into one set of age categories within which individual age in ADH10 varied by not more than 1%, and into an alternative set within which individual age in ADH10 varied by not more than 5%. Choice of this bin size involves a potential trade-off between age estimate confidence interval width (=precision) and lack of statistical power resulting from fewer individuals in an age class, which can yield a discontinuous confidence interval. Calculating a p-value, the criterion by which a potential specimen age is excluded, differed from the example illustrated for a succession model in that, as with all development models that have been proposed, an age estimate is based on a single specimen at a time rather than some set of observations.[1]

The age prediction performance of a model is indicated in part by the precision of an estimate and a continuous prediction interval. For this analysis, there was little difference in prediction performance between the model based on all temperatures compared to the model omitting the extreme high and low temperatures. The model based on 5% ADH10 bins performed slightly better than the model based on 1% ADH10 bins. For example, 95% prediction intervals in ADH units for the model with 5% ADH10 bins covering 15°C -30°C were: egg 100-505; first larva 195-755; second larva 560-1,040; and, third larva feeding 840-1,962.

This method is easy to implement in practice. It can be immediately applied to casework if a development model has been validated. It can be used to define the threshold for success in a validation study, and it also provides guidance for future development reference studies in that it specifies a minimum sample size needed for sufficient statistical power.

*Presenting Author

Reference(s):

1. LaMotte L.R., Wells J.D. 2000. *p*-values for postmortem intervals from arthropod succession data. *Journal of Agricultural, Biological, and Environmental Statistics* 5:58-68.
2. Roe A., Higley L.G. 2015. Development modeling of *Lucilia sericata* (Diptera: Calliphoridae). *PeerJ* 3:e803; DOI 10.7717/peerj.803.

Forensic Entomology, Postmortem Interval, Statistical Methods

*Presenting Author