Scrutinizing the ADH Proposition for Maggot Growth

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A basic form of question addressed by statistical inference is, "Do different conditions x affect the distribution of responses y?" In this form, we are looking for *effects* of conditions on responses.

Inverse problems take a different form: "What conditions x might reasonably be considered to have given rise to this response y_*?" The statistical approach to inverse problems is termed "inverse prediction" or "calibration." Such settings are diverse: How old at death was the person with this os pubis bone? What is the gestational age of the fetus with femur length 70.57 mm and biparietal diameter 89.89 mm, as determined by ultrasound imagery? An iris plant has sepal length and width 50 mm and 33 mm, and petal length and width 14 mm and 2 mm. Which species is it, setosa, versicolor, or virginica? An L. sericata maggot found on a murder victim is in its third instar, 14 mm long, and its dry weight is 12 mg. How old is it?

Addressing such questions requires *training data* comprising measurements of y for multiple subjects at each of a range of conditions x, along with a model relating parameters of the distributions of y to x.

The growth rate of maggots is affected by temperature. This appears to require training data at a range of temperatures and a model that incorporates temperature effects in addition to age effects. In a variety of growth or development settings, it is assumed that temperature and age act together through Accumulated Degree Hours (ADH), defined as Age×(Temp - Base)$_+$, where $(x)_+$ is x if $x > 0$ and 0 otherwise. A widely-used base is 10°C; the idea is that no growth occurs when the temperature is 10°C or less. If this ADH model is correct, then training data can be gathered at just one temperature, and the model for the distribution of y is simpler because it is in terms of ADH instead of age and temperature.

For more than a decade, I have been working with Jeff Wells, a forensic entomologist, developing statistical methods to infer ages of maggots from measures of size, like length and dry weight. In his lab, Jeff has reared thousands of maggots under controlled conditions. In one data set, we have measurements on length and dry weight of about 1600 maggots raised at two temperatures and sampled at several ages. The model we have been using to relate size to age and temperature is linear interpolation between specified age-temperature knots, both for mean vectors and variance-covariance matrices. This can be re-expressed as a multivariate mixed linear model.

In this talk, I'll describe my efforts to formulate and fit models to these data in order to test the ADH proposition. Results so far indicate that the ADH proposition is not correct, that is, that temperature affects the growth path in addition to the growth rate.