Modeling the Dispersal of Adult Stoneflies

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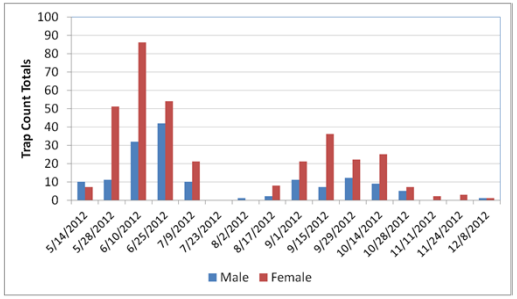
Abstract

Aquatic insects of the orders Ephemeroptera, Plecoptera and Trichoptera (EPT) are commonly used as indicators of freshwater quality. Recolonization of restored waterways by these pollution intolerant insects is frequently employed as a measure of the success of stream restoration efforts. Post restoration monitoring programs based on recolonization by EPT indicator species are typically generalized with little consideration for local conditions. Within Philadelphia urban development has resulted in a lack of unimpaired headwater streams from which refugia of EPT colonists would replenish downstream populations through passive drift of larva and ova. In this case, recolonization will depend largely on overland dispersal by adults from other systems. The purpose of this research is to collect field data on local EPT species and develop a model to predict dispersal patterns.

Field Obs. at Schuylkill Center for Environmental Education

A ten month field study was conducted at the Schuylkill Center for Environmental Education to obtain data on local EPT taxa and dispersal behavior from May 1, 2012 through Mar 3, 2013. A total of six sticky traps were installed adjacent to Meig's Run.

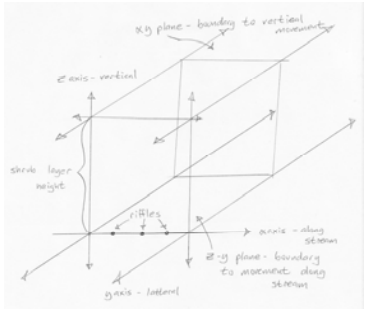
A total of 767 adult EPT specimens from thirteen species were collected. *Leuctra ferruginea* represent the dominant taxa during the study, being caught over two distinct emergence periods. Linear regressions demonstrate a decreasing density with distance from the stream.

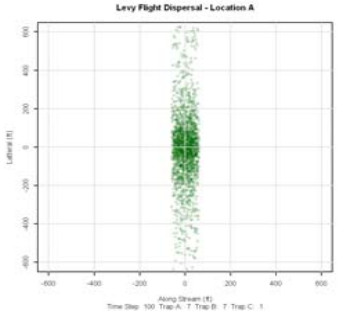


While linear regressions are simple to implement and a reasonable starting point for analysis, they are an over simplification of the problem. Much existing data on stonefly flight is qualitative in nature and cannot be easily defined as a regression variable To properly describe the phenomenon of stonefly dispersal a more sophisticated approach is required.

Model Development

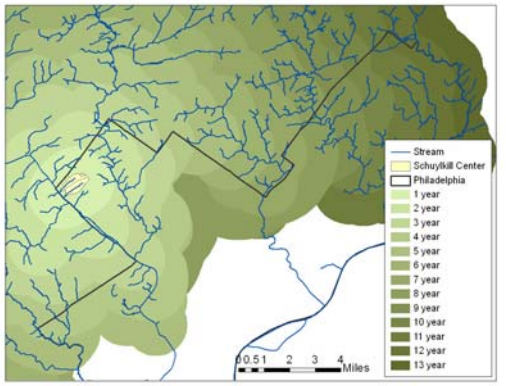
A variety of numerically based models have been proposed to simulate the dispersal of insects. Existing models range in complexity, data requirements, computational demand and the underlying theory describing insect movement. An individual insect based random walk model (Petrovskii, Sergei, Daniel Bearup, Danish Ahmed, Rod Blackshaw. "Estimating Insect Population Density from Trap Counts." Ecological Complexity. (2011). Print.) provides the clearest starting point for modeling stonefly dispersal. Petrovskii's original model was developed for aphids, a crawling insect, therefore several modifications are proposed, primarily the addition of a third spatial dimension and a rethought solution technique. A number of statistical distributions were tested to define the step length distribution. A Levy flight behavior provided the best fit to field observations on *L. ferruginea*.





Dispersal Estimate

The validated model estimate suggests one generation of *L. ferruginea* could disperse roughly 6,000 ft laterally. Given the existing stream network within Philadelphia, it is estimated that *L. ferruginea* would require a minimum of 13 years to migrate across Philadelphia. Migration is highly dependant on the density of the stream network.



Conclusions

The methods presented demonstrate a simulation based approach to estimating stonefly dispersal behavior provides an improvement over linear regressions. Model estimates suggest overland dispersal may be a viable pathway for successful recolonization of adjacent streams by *L. ferruginea*. In order to predict the rate of recolonization of a specific stream reach, however, local conditions such as dispersal distances, the sequence of stream restoration and resulting habitat segmentation must be taken into consideration.