

Insect Life Cycle Modeling (ILCYM) software: a new tool for regional and global insect pest risk assessments under current and future climate change scenarios

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The relationship between aspects of an insect life-history (development, survival, reproduction, etc.) and environmental variables (temperature) can be well described by process-based phenology models. These models can be used to identify environments where insects might persist and are realistic and preferable tools to predict the risks of establishment and population growth potential of invasive insects' species. This paper describes a novel tool (software), named Insect Life Cycle Modeling (ILCYM), to support the development of process-based temperature-driven and age-stage structured insect phenology models and to apply these models for insect species distribution and risk mapping. ILCYM is an open-source computer aided tool build on R-codes with a user friendly interface in Java computing language. It is linked to an Udig platform, which is a geographic information system (GIS), an application that contains basic tools for managing and mapping geographic information. The software has three main modules: the model builder, the validation and simulation module, and the potential population distribution and risk mapping module. For the demonstration of the various modeling steps and outputs, we used the phenology of the potato tuber moth *Phthorimaea operculella* (Zeller) (Lepidoptera: Gelechiidae) as an example. The positioning of ILCYM among available process-based insect modeling computer-aided packages, some special features of ILCYM as well as the software limitations and future prospects are discussed.