USE OF MODELLING FOR PREDATOR-PREY INTERACTIONS ANALYSES

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The term "model" is widely used since several years either in crop protection research or crop protection recommandations. Probably, this fashionable word is most of the time overuse but on the other hand the use of models is older than it could seem. Why do we do modelling? what are modelling and model? what are the elements to take into account in predator-prey interactions modelling? Which kind of application can be done with models? Some answers are given in this presentation.

Why do we model ? We do modelling hoping it will be easier to reason about the model than to reason about datas. It means, we think the analyses with the model will be easier than with expected results coming from very difficult experiments to set up.

What is modelling ? First of all, is not a way to replace the lack of results. It is and it remains a tool to understand the experimental datas (to clarify personal ideas and experimental datas). Modelling is a tool, it means, it needs to be built, and we need to know how to use it. On an other hand, modelling is also a translation; we go from experiments to the model, i. e., we translate empirical values into mathematical language. Thus a model is a tool to understand datas giving a concrete support to our reflexions; is the outcome of datas transformations, more frequently under a mathematical form and thus its validity and its justification will be always limited by imprecisions due to experimental datas and an inevitable part of arbitrary contained in the operated transformation.

Finally the definition of a good model could be the following: a model is satisfactory if it gives a satisfactory answer to the question which motivated modelling.

In crop protection, and particularly in predator-prey system management, literature is full of numerous models using different approaches and discuss them is out of the purpose of this presentation. Basically, it can be distinguished two principal types of models: models specially built for crop protection and used either in a tactical way (at field level and for a given time) or in a strategical way (at more global scale). In practice, they are simples and essentially attempt to describe the phenology of given populations in fonction of a little number of parameters like temperature, relative humidity, rainfall....for example.

The second type is the group of models called research models. They are developed to study and to analyse systems more complex. The aim of these models, which the high level of realism necessary is reached via a more detailed consideration of factors of environement, is to study the dynamic of organisms considering relationships in the same and between different trophic levels.

The caracter analitical and explicative of these models give them essentials tools not only in the context of studies of system complex but also to decision-making for the management of agrosystems.

The principal elements to take into account, even if it depends on objectives for modelling, are the following: general procedures, driving variables, developmental rates, fecundity rate, mortality rates and predator functional response.

General procedures: because age-structure is not constant, the best way to represent demographic events can be 1) the used of modified Von Forster equation and build the complete model as differential or difference equations. But in both case, the models become complex rather quickly. 2) the use of Leslie-matrix or difference-equation equivalent; the remaining models however include features which require more advanced modelling approaches.

Driving variables. because arthropods are poikilothermic organisms, in model designed for unstable environement conditions, temperature becomes therefore the main driving variable. But others such as hygrometry, rainfall, water and nitrogen inputs (in case of multitrophic levels model including plant) or predation can also be considered as driving variables.

Developmental rates. In models built on difference equations for simulating field dynamics, developmental rates are related to time-dependent temperature, either linearly or nonlinearly. Time is then expressed in physiological units of day-degrees above a thermal threshold and predicts a life-stage completed once a thermal constant has been reached. Developmental variance can be considered in various ways, but time distributed processes remain the technic the most common used.

Fecundity rates. Prey fecundity is generally treated as a function of temperature and age, but a trend to incorporate more quantitative and qualitative elements of the host plant already exists. Thus prey fecundity can be related to plant age and plant nitrogen content for example. Predator fecundity is usually related to the functionnal response and experimental evidence for prey material transfer into predator eggs is given.

Mortality rates. Intrinsic mortalities of immature life stages and adult longevity are mostly modelled on empirical bases and will not discussed here. Field conditions model require elements of the weather such as temperatures, relative humidity, rainfall to take into account. Leaf drop and drought stress can cause substantial losses to prey and predator populations. Predator-prey interactions is also an important source of prey mortality and much emphasis is given to the choice of an appropriate functionnal response model.

Spatial dynamics. The trend of recent models is to incorporate the processes of migration, emigration and imigration, more often than earlier one and include within-system movement as a new element.

Finally, exemples of model outputs and applications are illustrated using results obtained by various authors for various predator-prey system. Models can provide valuable informations on biological control operations like selecting biological control agents and planning biological control mesures.