A Simulation Application for Predator-Prey Systems

Ulrike Leopold-Wildburger[1], Silja Meyer-Nieberg, Stefan Pickl[2], and Jörg Schütze

[1] Karl Franzens Universität Graz, Austria
ulrike.leopold@uni-graz.at
[2] Universität der Bundeswehr München, Germany
stefan.pickl@unibw.de

Summary. We intend to optimize harvesting of two populations within a business cycle of an economy with appropriate means. The simulation model we have in mind concentrates on the problem of profit maximization within an interdependent system. Furthermore, we deal with the task of explaining phenomena of the typical behavior of the subjects while operating a complex system, e.g., a market, a company, ...

First studies of predator-prey systems give interesting insights into those subjects who behave optimally. In our model, maximal harvesting means letting the prey population grow first during the starting phase and taking constant quantities during the sustainability phase.

1 Introduction

The purpose of our model is to examine a dynamic system experimentally with the aim of optimizing harvesting within a sustainable environment. The complexity of the model (see also [6]) is based on the interdependencies of the two populations. Subjects are asked to deal with a simulation of increases and decreases in population numbers. The underlying Lotka-Volterra predator-prey experiment models an open, natural, discrete-state system. The main idea is based on [1].

2 The Model

The model underlying the experiment includes some fundamental assumptions listed here:

- isolated habitat,
- prey population grows logistically, predator population decreases exponentially,
- mutual influences are due to predator-prey relationship,

- prey population is diminished by predation,
- predation boosts predator population.

The mathematical background is given in the following way:
The basis for the formal model (1) is a system of two non-linear first-order differential equations:

$$\begin{aligned} dy/dt &= (-e + cx)y \\ dx/dt &= (a - by)x \end{aligned} \tag{1}$$

with a,b,c,$e > 0$. This system was first studied by [5] and [7]. The variables x and y are considered to be the populations of a species of prey and a species of predators, respectively. The coefficients, a, b, c, and e are positive constants.
Volterra considered the system as an attempt to explain the fluctuations in observed data on the catches of two species of fish in the Adriatic Sea. The populations of a species of small fish and a species of larger fish which feed on the small fish appear to fluctuate periodically, but out of phase.

After the large fish (the predators) kill off too many small fish (the prey) the large fish themselves begin to die out due to food shortage. This in turn gives the small fish population a chance to recover. But then the large fish population begins to boom again because of the abundance of food as shown by Figure 1. Our aim is to lead the system into an orbid where in harvesting of both populations can be maximized. Harvesting is done at the beginning of each period; the natural development determines the growth of both populations.

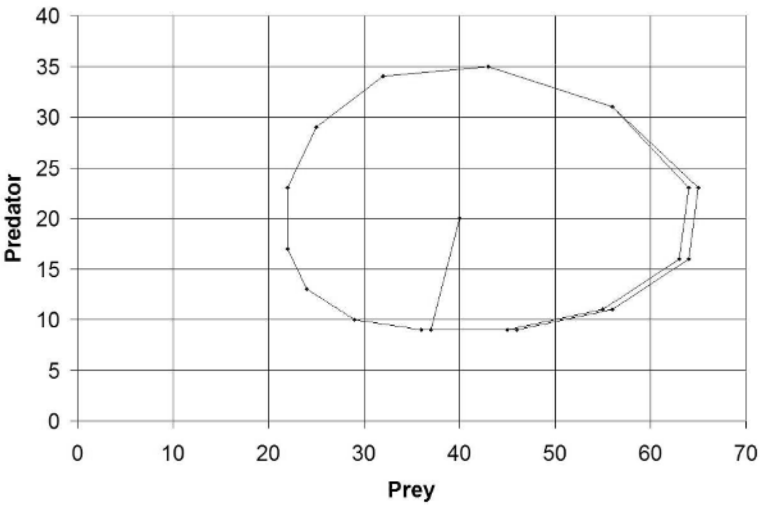

Fig. 1. Cycles of predators and prey