CMEE Miniproject: Population Growth

How well do different mathematical models, e.g., based upon population growth (mechanistic) theory vs. phenomenological ones, fit to functional responses data across species?

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1 Introduction

The study of population growth, or dynamics, began in earnest in the early 20th century as a way to manage and predict agricultural stocks in the wake of the World Wars [9]. Since that time the field has developed and been applied to conservation efforts and in predicting the impacts of climate change [12] [7]. Fluctuations in population abundance can impact keystone processes and ecosystem dynamics [15]. Emergent functional characteristics such as disease transmission can also be affected by host/pathogen population dynamics [2]. Moreover, population dynamics for species such as phytoplankton dictates rates of carbon fixation in aquatic systems [13].

Turchin asserts that there are three general laws of population dynamics: populations tend to grow exponentially, population growth is self-limiting and consumer-resource populations tend to oscillate [17]. Patterns of population dynamics include exponential growth, logistic growth and predator-prey interactions [14]. Exponential population growth describes a continually increasing number of individuals under conditions where resources are not limiting [4]. Logistic growth occurs when population growth rate decreases as it reaches carrying capacity [8]. Predator-prey interactions are concerned with the feeding relationship between species, resulting in a temporally staggered undulating pattern, with predator numbers lagging behind prey [3].

Population ecologists are concerned with quantifying these patterns of growth. Levin's stated that, "it is of course desirable to work with manageable models that maximise generality, realism and precision" [10]. Over the past century a wealth of models have been devised to fit the various patterns of population growth observed in nature. Models may be either phenomenological or mechanistic. Mechanistic models often need a large number of parameters to describe complex ecological systems, whilst phenomenological models may need relatively few [16]. In mechanistic models then we loose generality, in gaining precision and realism. In phenomenological models we may loose sight of the real-world mechanisms at play.

Understanding microbial patterns of population growth is important for food microbiology, risk assessment and water protection [19] [11] [6]. Microbial growth patterns also play a significant role in ecosystem processes, particularly in habitats newly exposed through climate change [5]. Typically, bacteria in culture has a four phase growth curve: the lag phase, exponential or log phase, stationary and death phase [1]. Two types of models can be applied to bacterial growth: 1) models concerning changes in population over time; 2) models predicting changes in population in changing environmental conditions; 3) models combining the two [18].

In this investigation I compare a variety of both mechanistic and phenomenological mathematical models, to see how well each characterises patterns of bacterial growth over time. Here I use a variety of statistical measures to find which model best fits the bacterial sigmodial growth curve see in the given dataset.

2 Methods

2.1 Computing Tools

3 Data

4 Results

5 Discussion

References

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