Free mathematical modeling of predator-prey dynamics essay example

Sociology, Population

One theory in evolution that has consistently been in sync with observations is that of ‘ survival of the fittest’. This is the base for explaining the behavior of all species and their struggle for existence. Since the beginning of time, a balance has always been maintained in the eco-biological system to ensure sustenance and evolution. That there are carnivores and herbivores – predators and preys – show the existence and importance of a natural system for maintaining balance.

Any mechanism can be modeled and analyzed mathematically. The predator-prey interaction is an evolving mathematical problem that has been explained using various theories, the first of which is the Lotka-Volterra model. This model consists of two differential equations, as described below:

dxdt= x(a-by)

dydt=-y(p-qx)

Here dxdt and dydt represent the growth rates of the prey and predator respectively; ‘ x’ and ‘ y’, are the current number of prey and predator respectively; and ‘ a’, ‘ b’, ‘ p’, and ‘ q’ are parameters that depend on the interaction of the two. This model assumes a linear per capita growth rate (Bomze, 1983).

Kermack and McKendrik made applied the epidemiology theory in predator-prey dynamics which resulted in a new model based on herd immunity. In other words, the predators are looked upon as the infectives in an epidemic and the preys are considered to be the vulnerable. The equations in this model suggest that the infectives will initially only try to pass on the infection, and only if they are unable to do so, will it result in an increase in their population. Most importantly, this model predicts that ultimately some number of vulnerables (prey) will always survive. The main mathematical quantity calculated using this method is a number R which determines the tipping point or epidemic threshold of the situation at hand.

The concept of predator-prey is not restricted to interaction between lions and deer, or birds and insects. Any organism feeding on nutrients also makes a predator-prey system. Taking this into account, Jacob and Monod proposed a model relating the number of a specific species x, feeding on another species with a chemical concentration y. This is represented by the following equations:

dxdt= vyS+yx

dydt=-1y(vyS+y)x

Here v represents uptake velocity, Y is the amount of x for every unit of y taken up, and S represents saturation constant. This model is typically useful for cases of continuous flow growth like in a chemo stat (Lotka, 1978).

The above explained are some fundamental models in predator-prey dynamics based on which a lot of extensive research has been/is being done. The end in mind has been to study specific, separate systems, and to incorporate all parameters that influence interaction. For instance, the relation between mobility of the prey and the density limitation of the predator has been studies. It shows that population dependent observations at various spatial scales are related to the individual biology's characteristic scale (DeRoos, 1991). Similarly, coupling and ratio dependence in predator-prey dynamics is a popular problem for research (Arditi, 1989).

The effects of intimidation on the prey, the understanding of a complex system consisting of more than 1 predator/prey, and prey migration decisions have been the most advanced research ideas started in the recent past, for which substantial results are yet to be published (Preisser, 2005).

References

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