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1.4.2 Explanation of Lotka-Volterra Predator Prey Model Terms

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Before we look at what this system predicts, let's recap the **Lotka-Volterra** predator-prey model.

> **Note:** We know Volterra, but you might be wondering: who is the Lotka of the Lotka-Volterra predator-prey model? Alfred Lotka (1880-1949) is a scientist who studied chemistry, physics and statistics working for many government organizations and private companies. Independently from Volterra, Lotka came up with the same model in the context of chemical reactions, published in 1910 as *Contribution to the Theory of Periodic Reaction*. His work focused on physical and life sciences but is considered a precursor to some ecology and economic theories.
>
> *Source: Alfred J. Lotka article from Wikipedia.*

Here is the model in the case of sardine as prey and marlin as predator.

$$\frac{dS}{dt} = \mathbf{a}S - \mathbf{b}SM,$$

$$\frac{dM}{dt} = -\mathbf{c}M + \mathbf{d}SM.$$

Let's sort through the variables, parameters and constants of this model.

> - t is the independent variable;
> - S and M are functions which depend on time (so when we write S we really mean $S(t)$);
> - $\mathbf{a}, \mathbf{b}, \mathbf{c},$ and $\mathbf{d}$ are parameters of the model. Recall that a *parameter* is a quantity that influences the behavior of a graph or equation or system. It is fixed within a particular context (for a particular predator-prey relationship), but the parameter can vary from context to context (for example, a, b, c and d will be different for different species).
>
> (For more on parameters, look back to the first section of the course: What Makes a Good Test Question?)

How do we interpret the parameters?

- We assume that without marlin present, the rate of reproduction of sardines is proportional to the size of the population of sardines (exponential growth). This is what the $\mathbf{a}S$ term represents; the parameter a reflects the growth rate of the sardines.
- We assume without sardines present to eat, the marlin population will die off proportionally to the size of the population (exponential decay). This is what the $-\mathbf{c}M$ term represents; the parameter $-c$ reflects the natural death rate of the marlin.
- The product SM represents the effect of the interaction of the two species -- marlin eat sardines. The effect on the sardines is proportional to the number of sardine-marlin interactions. The constant of proportionality is the parameter b, which

represents the rate of predation. Thus the differential equation for S includes the negative term $-\mathbf{b}SM$.

- For the marlin, the positive effect of eating sardine is also proportional to the number of sardine-marlin interactions. The constant of proportionality is the parameter d, which represents the synthesis rate (how the population of marlin will grow because they eat sardines). Thus the differential equation for M includes the positive term $\mathbf{d}SM$.

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