1.6.2 Summary Quiz: Other Models of Species Interaction

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We've examined a few different population models so far: exponential, logistic, and predator-prey and developed some strategies to make sense of the models.

In this next quiz, you'll get the chance to use these strategies in thinking about different models of species interaction.

Question 1

0/1 point (graded)

Here's a variation on the predator-prey model for sardine and marlin. M is measured in hundreds of marlin, S is hundreds of thousands of sardines, and $a, b, c,$ and d are positive constants. If there are no marlin present, which of the following are possible outcomes for the sardine population according to this model? Choose all that apply.

$$\frac{dS}{dt} = \mathbf{a}S(5 - S) - \mathbf{b}SM$$

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

The sardine population...

- [ ] grows larger and larger without bound
- [ ] oscillates between a value slightly less than 500,000 and slightly more than 500,000

- [ ] increases toward 500,000 ✔
- [ ] decreases toward 500,000 ✔
- [x] remains at exactly 500,000 ✔
- [ ] decreases towards 0 (extinction)

✖

Explanation
If $M = 0$, then $\frac{dS}{dt} = \mathbf{a}S(5 - S)$. This is a logistic growth model with $S = 5$ as carrying capacity. We know from previous sections that there are three possible outcomes is we start with some sardines. If $S > 5$, then S decreases toward 5 ($500,000$ fish). If $S < 5$, then S increases toward 5 ($500,000$ fish). If $S = 5$, then $\frac{dS}{dt} = 0$ and the population remains constant.

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Answers are displayed within the problem

Question 2

5/5 points (graded)
There are other ways species interact, other than predator-prey.

For each species' interactions, try to match it with one of the systems below. At first, it may look like the systems are very similar but focus on the interaction term: is the constant positive? What does this mean?

A. Predator and Prey (one species' survival depends on eating the other species)

B. Competition (both species compete with each other for the same resources)

C. Mutualism/Symbiosis (both species benefit from the interaction)

D. Commensalism (one species benefits, the other is unaffected)

E. Parasitism (one species, the parasite, benefits at the expense of the other, the host)

- The constants A, B, C, D are positive.
- For each match you make, consider what the constants A, B, C and D might represent.
- You may use the systems more than once.
- There is one type of interaction which is not modeled by any of the systems of equations below. Can you think of a system to model that interaction?

(For more on competition models for species, see the "Bifurcations: Species in Competition" section later in the course, appearing in a few weeks.)

A. Predator and Prey (one species' survival depends on eating the other species)

- (selected) i.

$$\frac{dx}{dt} = Ax - Bxy$$
$$\frac{dy}{dt} = -Cy + Dxy$$

✔

- ii.

$$\frac{dx}{dt} = Ax + Bxy$$
$$\frac{dy}{dt} = -Cy + Dxy$$

iii.

$$\frac{dx}{dt} = Ax + Bxy$$

$$\frac{dy}{dt} = Cy + Dxy$$

iv.

$$\frac{dx}{dt} = Ax - Bxy$$

$$\frac{dy}{dt} = Cy - Bxy$$

v.

$$\frac{dx}{dt} = Ax - Bxy$$

$$\frac{dy}{dt} = -Cy - Bxy$$

vi. None of the Above

B. Competition (both species compete with each other for the same resources)

- i.

$$\frac{dx}{dt} = Ax - Bxy$$
$$\frac{dy}{dt} = -Cy + Dxy$$

- ii.

$$\frac{dx}{dt} = Ax + Bxy$$
$$\frac{dy}{dt} = -Cy + Dxy$$

- iii.

$$\frac{dx}{dt} = Ax + Bxy$$
$$\frac{dy}{dt} = Cy + Dxy$$

- iv.

$$\frac{dx}{dt} = Ax - Bxy$$
$$\frac{dy}{dt} = Cy - Bxy$$

✔

- v.

$$\frac{dx}{dt} = Ax - Bxy$$
$$\frac{dy}{dt} = -Cy - Bxy$$

- vi. None of the Above

C. Mutualism/Symbiosis (both species benefit from the interaction)

- i.

$$\frac{dx}{dt} = Ax - Bxy$$
$$\frac{dy}{dt} = -Cy + Dxy$$

- ii.

$$\frac{dx}{dt} = Ax + Bxy$$
$$\frac{dy}{dt} = -Cy + Dxy$$

- [x] iii.

$$\frac{dx}{dt} = Ax + Bxy$$
$$\frac{dy}{dt} = Cy + Dxy$$

- [ ] iv.

$$\frac{dx}{dt} = Ax - Bxy$$
$$\frac{dy}{dt} = Cy - Bxy$$

- [ ] v.

$$\frac{dx}{dt} = Ax - Bxy$$
$$\frac{dy}{dt} = -Cy - Bxy$$

- [ ] vi. None of the Above

D. Commensalism (one species benefits, the other is unaffected)

- i.

$$\frac{dx}{dt} = Ax - Bxy$$

$$\frac{dy}{dt} = -Cy + Dxy$$

- ii.

$$\frac{dx}{dt} = Ax + Bxy$$

$$\frac{dy}{dt} = -Cy + Dxy$$

- iii.

$$\frac{dx}{dt} = Ax + Bxy$$

$$\frac{dy}{dt} = Cy + Dxy$$

- iv.

$$\frac{dx}{dt} = Ax - Bxy$$

$$\frac{dy}{dt} = Cy - Bxy$$

v.

$$\frac{dx}{dt} = Ax - Bxy$$

$$\frac{dy}{dt} = -Cy - Bxy$$

vi. None of the Above ✔

E. Parasitism (one species, the parasite, benefits at the expense of the other, the host)

i.

$$\frac{dx}{dt} = Ax - Bxy$$

$$\frac{dy}{dt} = -Cy + Dxy$$

✔

ii.

$$\frac{dx}{dt} = Ax + Bxy$$

$$\frac{dy}{dt} = -Cy + Dxy$$

iii.

$$\frac{dx}{dt} = Ax + Bxy$$
$$\frac{dy}{dt} = Cy + Dxy$$

iv.

$$\frac{dx}{dt} = Ax - Bxy$$
$$\frac{dy}{dt} = Cy - Bxy$$

v.

$$\frac{dx}{dt} = Ax - Bxy$$
$$\frac{dy}{dt} = -Cy - Bxy$$

vi. None of the Above

Explanation

Part (a): This is the same type of system as the marlin and sardines (without fishing). Thus, we expect the equations to look like (i). A represents species x rate of reproduction; B represents the predation rate of y on x; C represents species y death rate; and D represents the synthesis rate between x and y that benefits y.

Part (b): Imagine both species are in competition for the same food. This would be like the sardines and another low-level fish species both feeding on plankton, if we also define the overall plankton supply to be limited. So we expect both species to have the sardines' first exponential-like growth term. Yet in this system, the bigger both populations become, the harder it is for each to find food. Thus, bigger populations of x and y decrease the growth rate of each species. The only system that has these properties is (iv). Here, A is the reproduction rate of x, C is the reproduction rate of y, and B is the degree to which it is harder to find food as the two populations increase. Note that B is the same for both species. Since both x and y feed on the same resource, a decrease in that resource makes it more difficult for x and y to find that resource.

Part (c): We imagine two species, again like the marlin and another low-level fish, which each feed on different resources, yet who can interact and thus make it easier for each other to survive. We expect the equation for each species population change to start with the same exponential-like term from the marlin's equation. Added to each equation should be a term which increases the rate of increase of each population according to how much the two species interact. The only system which has these properties is system (iii). A is the reproduction rate of x, B is the synthesis rate for x from the interaction, C is the reproduction rate of y, and D is the synthesis rate for y from the interaction. Note that B and D can be different, since the interaction does not have to benefit both species equally.

Part (d): Here, we expect both species' equations again to start with an exponential-like growth term. One equation should additionally have a term like the added growth terms in the mutualism interaction; the other equation should not have any interaction terms, since the other species is unaffected by the interaction. There are no systems in the list which match these conditions (even simpler, every equation in the list has interaction terms, so none of these equations could model the behavior of the species which is unaffected by the interaction). A system which includes the terms listed above would look like:

$$\begin{aligned}\frac{dx}{dt} &= Ax + Bxy \\ \frac{dy}{dt} &= Cy\end{aligned}$$

A and C are the reproduction rates of x and y, respectively

Part (e): This interaction looks qualitatively like the predator-prey interaction. There, too, one species (the predator) benefits at the expense of the other (the prey). Thus, this interaction is again modeled by system (i). A and C represent the reproduction and death rates of the host and parasite, respectively. B represents the "infection" rate of the parasite on the host, and D represents the synthesis rate for the parasite from the interaction.

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Answers are displayed within the problem

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