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1.1.3 Exploratory Quiz: Does this model capture outbreaks?

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Question 1

1/1 point (graded)

Consider the budworm population model with carrying capacity $q = 3$:

$$\frac{dP}{dt} = \frac{1}{2}P\left(1 - \frac{P}{3}\right).$$

Which of the following are true?

- [ ] $P = 0$ is a stable equilibrium solution.
- [x] $P = 0$ is a unstable equilibrium solution. ✔
- [ ] $P = \frac{3}{2}$ is a stable equilibrium solution.
- [ ] $P = \frac{3}{2}$ is a unstable equilibrium solution.
- [ ] $P = \frac{3}{2}$ is a semi-stable equilibrium solution.
- [x] $P = 3$ is a stable equilibrium solution.> ✔
- [ ] $P = 3$ is a unstable equilibrium solution.
- [ ] $P = 3$ is a semi-stable equilibrium solution.
- [ ] None of the above.

✔

Note: For more on the logistic model or definitions of stable, unstable and semi-stable, see Section 1.2.3 of the Bifurcations I section.

Explanation

This is a logistic model for populations. The equilibrium points are $P = 0$, which is unstable, and $P = 3$, which is stable and corresponds to the carrying capacity.

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Answers are displayed within the problem

Question 2: Think About It...

1/1 point (graded)

What is the effect on population of varying q in this model? Do the equilibrium point(s) change? Does their stability change?

$$\frac{dP}{dt} = \frac{1}{2}P\left(1 - \frac{P}{q}\right)$$

Use the slider on the left of the dynamic graph in Desmos to answer the questions.

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When we increase the parameter q gradually, the stable
equilibrium population increases gradually, not suddenly.
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Thank you for your response.

Varying q changes the location of the non-zero equilibrium but does not affect the stability of either. The equilibrium point $P = 0$ is still unstable, and the equilibrium point $P = q$, which corresponds to the carrying capacity, is still stable. This means increasing q allows for larger populations.

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Question 3

1/1 point (graded)

Wes said that the logistic model $\frac{dP}{dt} = \frac{1}{2}P(1 - \frac{P}{q})$ is not sufficient to capture the phenomenon of outbreaks. By "outbreak", we mean a sudden jump from one stable equilibrium to a much higher stable equilibrium as a result of a gradual change in a parameter of the model.

Why does the logistic model not predict outbreaks in the population P?

- When we increase the parameter q gradually, the stable equilibrium population decreases not increases.
- (selected) When we increase the parameter q gradually, the stable equilibrium population increases gradually, not suddenly. ✔
- When we increase the parameter q gradually, the stable equilibrium population becomes unstable.
- When we increase the parameter q gradually, there is no stable equilibrium: populations oscillate between high and low values.
- None of the above

Explanation

According to the logistic model, for a non-equilibrium starting population, there is only one possible long-term behavior: tending toward a stable equilibrium which is equal to the carrying capacity q. Thus as q increases gradually, the stable equilibrium population increases gradually, not suddenly.

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Question 4: Think About It...

1/1 point (graded)

The budworm model $\frac{dP}{dt} = rP(1 - \frac{P}{q})$ takes into account the reproduction rate of the budworms (r) and the carrying capacity (q). What other factors might affect the budworm population? How might you modify the model to account for those factors (and potentially able to capture the outbreak phenomenon?

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Effect of predators survival and pesticides
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✔

Thank you for your response.

Here are some other factors that might affect the budworm population: predators who eat budworms, competing species that eat fir foliage, and seasonal effects on the population. (There may be others as well.)

If we include predator effects, then we could add terms like we did for the marlin-sardine populations and expand our model to incorporate predator-prey population dynamics.

If we allow for competing species, we might want to try a model like the one described in the Population Dynamics I section Summary Quiz.

To account for seasonal effects, we could let the carrying capacity, q depend on time in some predetermined way, adjusting the maximum number of budworms the environment can support based on the resources available at a certain time of year.

The next video discusses how we can modify our model based on predation.

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