

Zombies (and other stuff) in a Mathematical Biology Special Topics Course

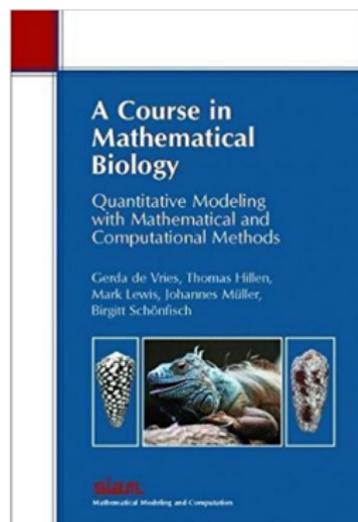
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 Mount Saint Mary College

October 14, 2017 – SCUDEM

MTH 3850: Special Topics: Mathematical Biology

- ▶ This course was NOT Differential Equations.
- ▶ Prerequisite: Calculus II
- ▶ Textbook: De Vries, G., et al. (2006). *A course in mathematical biology: quantitative modeling with mathematical and computational methods*. (Vol. 12) Siam.



Some Covered Topics

- ▶ m&m activity!
- ▶ Discrete-Time Models
 - ▷ created our own difference equations to describe a changing elephant population
 - ▷ logistic growth
 - ▷ cobweb analysis
 - ▷ fixed points, solution plots, stability, and phase lines for one difference equation
 - ▷ fixed points, stability, and phase portraits for systems of two difference equations

Some Covered Topics

▶ Continuous-Time Models

- ▷ intro to differential equations
- ▷ equilibria, phase-line analysis, stability theorem, and solution plots for one ODE
- ▷ vector fields
- ▷ predator/prey
- ▷ interpreted equations to find biological meaning
- ▷ equilibria, stability, and nullclines for systems of two ODEs
- ▷ created our own ODEs to describe competing fish populations and thinking about environmental factors
- ▷ bifurcation diagrams

And finally... SIR models!

In: Infectious Disease Modelling Research Progress

ISBN 978-1-60741-347-9

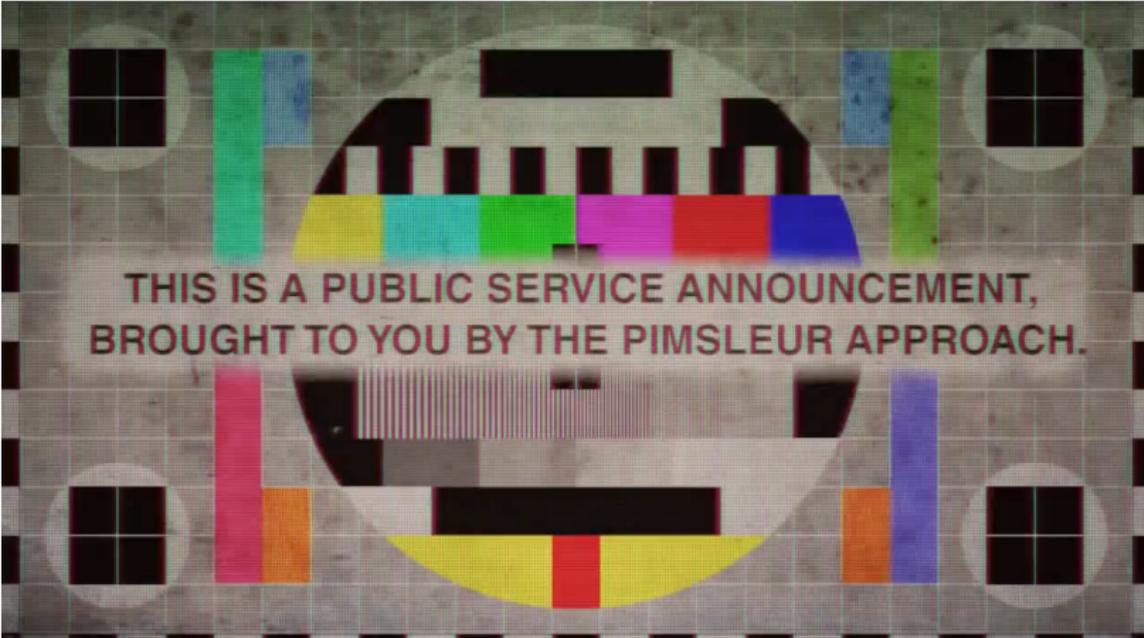
Editors: J.M. Tchuenche and C. Chiyaka, pp. 133-150 © 2009 Nova Science Publishers, Inc.

WHEN ZOMBIES ATTACK!: MATHEMATICAL MODELLING OF AN OUTBREAK OF ZOMBIE INFECTION

Philip Munz^{1}, Ioan Hudea^{1†}, Joe Imad^{2‡}, Robert J. Smith^{2§}*

Abstract

Zombies are a popular figure in pop culture/entertainment and they are usually portrayed as being brought about through an outbreak or epidemic. Consequently, we model a zombie attack, using biological assumptions based on popular zombie movies. We introduce a basic model for zombie infection, determine equilibria and their stability, and illustrate the outcome with numerical solutions. We then refine the model to introduce a latent period of zombification, whereby humans are infected, but not infectious, before becoming undead. We then modify the model to include the effects of possible quarantine or a cure. Finally, we examine the impact of regular, impulsive reductions in the number of zombies and derive conditions under which eradication can occur. We show that only quick, aggressive attacks can stave off the doomsday scenario: the collapse of society as zombies overtake us all.



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After the video...

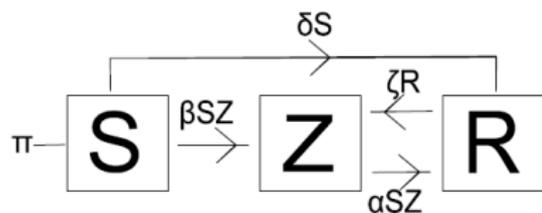
What should we include in a model that describes zombies infecting humans?

After the video...

What should we include in a model that describes zombies infecting humans?

- ▶ how fast zombies walk
- ▶ zombies biting humans
- ▶ humans killing off zombies
- ▶ location of zombie attack
- ▶ how many zombies have already been created
- ▶ can zombies rise from the dead?
- ▶ can zombies swim?

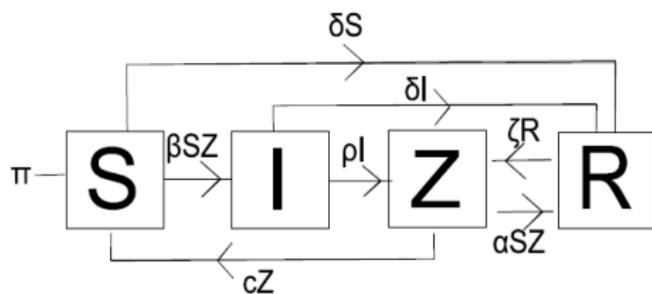
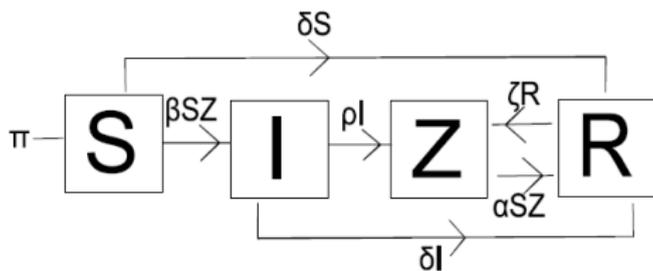
The first zombie model:



$$\begin{aligned} S' &= \pi - \beta SZ - \delta S \\ Z' &= \beta SZ + \zeta R - \alpha SZ \\ R' &= \delta S + \alpha SZ - \zeta R \end{aligned}$$

- ▶ constructed compartmental model ourselves
- ▶ came up with equations based on compartmental diagram
- ▶ found equilibria and discussed disease-free vs endemic
- ▶ determined stability
- ▶ introduced R_0 , what it means, and how to find it

Other zombie models:



Student comments about zombie part of class...

- ▶ “Really interesting class, it was fun learning about zombies”
- ▶ “From the description I thought the class would be more fun and more focused on zombies and stuff like that but it feels like we just glanced over it.”

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- ▶ But... the other half of the class was bored with zombies and so I decided to talk about other things...

Other “end of the semester” topics:



- ▶ more SIR-type models involving other diseases
- ▶ sensitivity analysis
- ▶ herd immunity
- ▶ Leslie matrices
- ▶ final projects

Thank You!