# Classwork: Sibly et al. article
## (on $\theta$-logistic model data sets for 3200 species)

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These discussion exercises are based on the following article:

> R.M. Sibly, D. Barker, M.C. Denham, J. Hone and M. Pagel. On the regulation of populations of mammals, birds, fish and insects. *Science*, **309**, 607–610 (2005).

We will attempt to gain an understanding of how the "$\theta$-logistic model" used in this article works.

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1. How is the per capita growth rate in this model different from the logistic model that we discussed in class? For a general value of $\theta$, discuss the potential of analytically solving the corresponding differential equation for population growth.

2. This data set is *discrete*, and not continuous. That is, they have values $N_t$, where $t$ represents consecutive years. Therefore, you may wonder how the authors obtained the graphs in Figure 1. Which of the following do you think the authors may have used as a "proxy" for the per capita growth rate (which they call pgr)? [Hint: it may help to review last class' handout on the discrete logistic model.]

   (a) $\dfrac{1}{N}\dfrac{dN}{dt}$

   (b) $\dfrac{N_{t+1} - N_t}{N_t}$

   (c) $N_{t+1} - N_t$

   (d) $\ln \dfrac{N_{t+1}}{N_t}$

   (e) $\dfrac{\ln N_{t+1}}{\ln N_t}$

3. What ecological reasons are important in differentiating between the "concave" and "convex" per capita growth curves? [Hint: Figure 2.2 and the accompanying discussion in your textbook may be of help.]

4. Try to identify the main conclusion in this article.

5. The authors claim that "many animals may spend most of their time at or above carrying capacity." Why does this follow from their results? Write down the reasons for this in your own words.

6. Why do the authors claim that if the per capita growth rate is estimated from life history data in standard models, the per capita growth rate is probably overestimated? (Last paragraph in the article.)

7. Now try to test the authors claims that "many animals may spend most of their time at or above carrying capacity," which you thought about before. Choose parameter values $r_0 = 0.1$, $K = 100$ and $\theta = 0.5$. Set up the solution in Excel, using a time-step $\Delta t = 0.5$. Choose a range of initial conditions $N(0)$ going from 20 to 200 in steps of 20, and run your solution in each case up to a time $t = 50$. Look at the distribution of values you get for $N(50)$. Do these verify the author's claim?

8. Now choose different $\theta$ values for a *specific* $N(0)$ value (we will choose 80). By choosing $\theta = 0.1$, 0.3, 0.5, 0.7, 0.9, 1.1, 1.3, 1.5, 1.7 and 1.9, determine how long it takes the population to approach the carrying capacity. Now redo your calculations but now choose $N(0) = 120$. Compare your results, with a view towards examining the authors' claims in this article (one claim was that the approach towards carrying capacity is quicker from below carrying capacity than from above; your simulations may help analyze other claims).

9. **(Homework – only for interested students)** Finally, to burst the bubble: the following articles are available from the course webpage:

   - J.V. Ross. Comment on "On the regulation of populations of mammals, birds, fish and insects" II. *Science*, **311**, 1100b (2006).
   - R. Sibly *et al.* Response to Comment on "On the regulation of populations of mammals, birds, fish and insects". *Science*, **311**, 1100d (2006).
   - S. Balasuriya. Comment on "On the regulation of populations of mammals, birds, fish and insects". Submitted to *Science* (2009).

   Do you believe the original article by Sibly *et al.*?