Predicting how Ranavirus Affects the Chiricahua Leopard Frog

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Abstract

According to Earl and Gray (2014), local wood frog populations have been predicted to decline and even die off due to ranavirus exposure under certain conditions. The same could also be true for the Chiricahua leopard frog (*Lithobates chiricahuensis*). The purpose of this research is to determine if the Chiricahua leopard frog, an endangered species, could go extinct when exposed to ranavirus. This research further asks that question for a strain of ranavirus, Frog virus 3 (FV3). We hypothesize that, because the Chiricahua leopard frog is listed as an endangered species, there will be possible, and probably faster, extinction scenarios given different levels of FV3 exposure.

Using the model

Using the values in the table to parameterize the Leslie matrix model, simulations were run for the ranavirus varying both number of years between exposure (as set by the infection probability) and adult carrying capacity (120-1200). On years with ranavirus exposure, S1, the normal average first year survival rate, was multiplied by the ranavirus survival rate. The model was run for 100 years and the whole model was run 1000 times; the results of each trial were averaged to produce a reasonable probability of extinction.

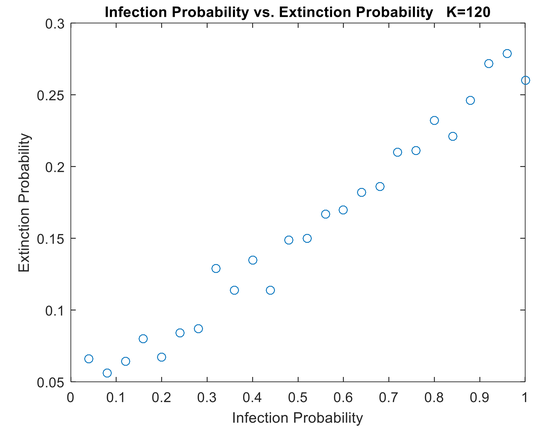
Background

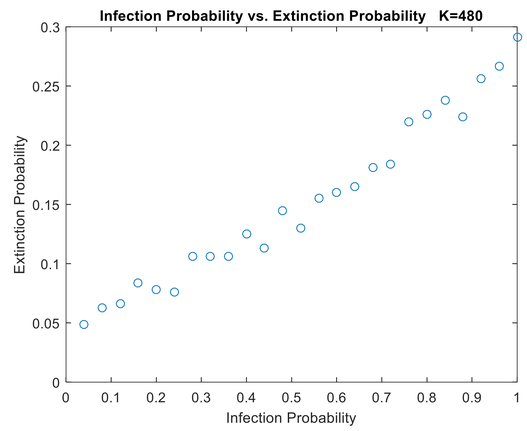
Biology: The Chiricahua Leopard Frog is an endangered species for a number of reasons including loss of habitat, predation by the non-native American bullfrog, and natural disaster (U.S. Fish and Wildlife Service, 2007). Moreover, this endangerment has been the case with other amphibians worldwide suggesting possibly a greater, global cause (2007). Earl and Gray have shown that wood frogs (*Lithobates sylvaticus*) could definitely experience declines due to exposure to ranavirus (2014). This is significant due to the fact that both the wood frog and the Chiricahua leopard frog are of the same genus, *Lithobates,* and are therefore closely related.

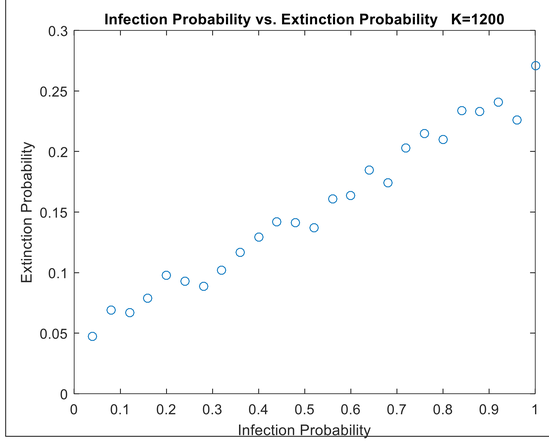
Math: Key to determining extinction probability was the Leslie matrix model, a discrete time, age-structured matrix model. Time steps were one year each and the age structure was pre-metamorph , year 1, year 2, and year 3+. Ranavirus exposure that can seriously impact the frog population only occurs during the pre-metamorph stage, affecting only P1. One time step of this model is shown below. If the population ever went below ten, then we defined this as extinction.

Parameter	Abbrev.	Estimate
Survival from pre-metamorph to Year 1	P1	0.024
Survival from Year 1 to Year 2	P2	0.335
Survival from Year 2 to Year 3	P3	0.335
Survival (Staying in Year 3+)	P4	0.335
Fecundity (Year 2)	F1	187
Fecundity (Year 3)	F2	337
Fecundity (Year 4)	F3	487
Ranavirus Survival Rate	-	0.27

Results/Future Work







$$\begin{pmatrix} N_{pm}(t) \\ N_1(t) \\ N_2(t) \\ N_{3+}(t) \end{pmatrix} = \begin{pmatrix} 0 & F_1 & F_2 & F_3 \\ p_1 & 0 & 0 & 0 \\ 0 & p_2 & 0 & 0 \\ 0 & 0 & p_3 & p_4 \end{pmatrix} \times \begin{pmatrix} N_{pm}(t-1) \\ N_1(t-1) \\ N_2(t-1) \\ N_{3+}(t-1) \end{pmatrix}$$

The results were surprising to us. We expected at least some instances of high extinction possibility, but the highest was only a 30.9% chance. That didn't even correpsond with the lowest carrying capacity. Overall, carrying capacity didn't seem to have an effect on extinction probability. As we expected, infection probability correlated with extinction probability. This research, though, just scratches the surface. We intended to run simulations with another ranavirus, but the data wasn't available, yet; it's expected this summer, opening the door for future work on that and other viruses, perhaps also testing different initial populations or varying the ranavirus survival rate.

Sources

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Earl, J. E., & Gray, M.J. (2014, June 25). *Introduction of Ranavirus to Isolated Wood Frog Populations Could Cause Local Extinction* [Scholarly Article]

U.S. Fish and Wildlife Service. 2007. Chiricahua Leopard Frog (Rana chiricahuensis) Recovery Plan. U.S. Fish and Wildlife Service, Southwest Region, Albuquerque, NM. 149 pp. + Appendices A-M.

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