A Trojan Y Chromosome Model for Eradication of Exotic Species in a Riverine System

Second SIAM Gators Student Conference, March 3-5, 2009.
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1 Introduction

We propose an eradication strategy for invasive fish in rivers. It involves the addition of sex-reversed female fish bearing two Y chromosomes (r) at a constant rate μ to a target population containing normal XX females (f) and normal XY males (m). This theoretical method of eradication is known as *Trojan Y Chromosome* strategy (*TYC*) [1].

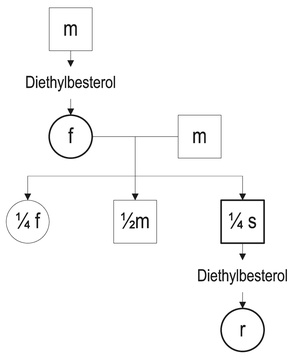

Figure 1: Sex-reversal process with feminizing hormones. **f** = **f**emale, **m** = **m**ale, **r** = sex-**r**eversed male, **s** = **s**upermale.

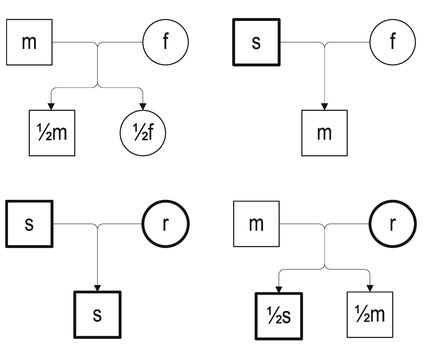

Figure 2: TYC Pedigree.

2 Mathematical Model

Assume a 1-D domain with Dirichlet boundary conditions. The TYC system is represented by the following system of equations:

$$\dot{f} = D\Delta f + \frac{1}{2}fm\beta L - \delta f,$$
$$\dot{m} = D\Delta m + \left(\frac{1}{2}fm + \frac{1}{2}rm + fs\right)\beta L - \delta m,$$
$$\dot{s} = D\Delta s + \left(\frac{1}{2}rm + rs\right)\beta L - \delta s,$$
$$\dot{r} = D\Delta r + \mu - \delta r,$$
$$L = 1 - \frac{f + m + s + r}{K},$$

where

- D = Diffusivity coefficient,
- β = Birth coefficient (proportional to the viability of the progeny),
- δ = Death coefficient (proportional to the rate fish are retired from the system by predators, disease, etc),
- K = Carrying capacity of the ecosystem, as a total number of individuals,
- μ = Constant influx of r,
- L = Logistic term. When the population surpasses K, the rate of change is negative (population decay); when it is below K, the rate of change is positive (population growth).

3 Results

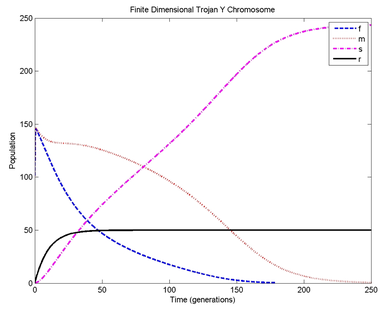

Figure 3: Behavior of the ODE system.

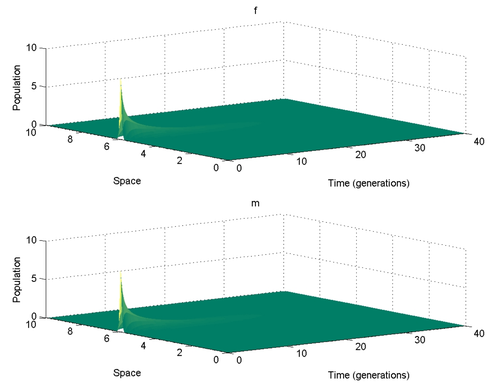

Figure 4: Invasion failure due to critical aggregation.

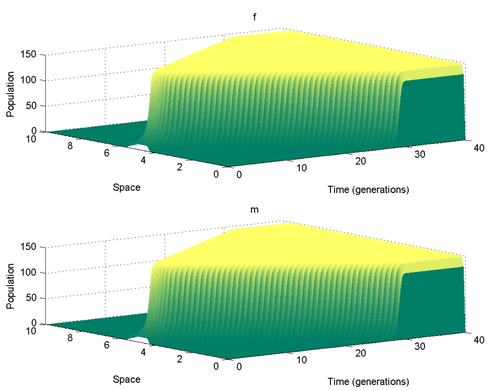

Figure 5: Invasion success.

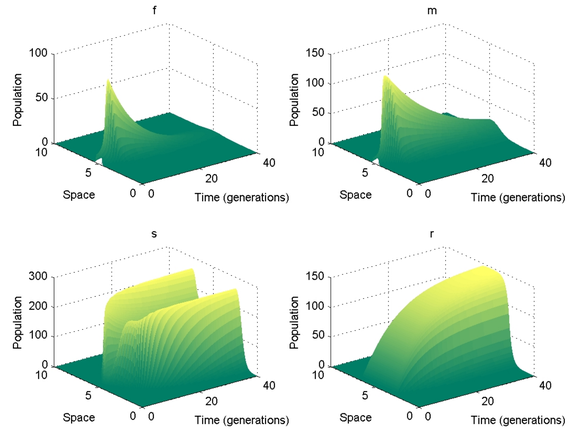

Figure 6: Invasion control. TYC contention measures at time 5.

4 Conclusions

Addition of Trojan individuals (r) can result in local extinction. There is a minimum value of μ required to achieve extinction. As a result of diffusion, the value of μ required to drive the system to extinction is higher in spatial settings with respect to the case in which only variation in time is considered. We predict the existence of critical aggregation and a wave of invasion that will propagate at a linear speed.

Acknowledgments

This work is supported by *Centro Avanzado de Investigación en Inteligencia Artificial* (CAVIIAR - Advanced Research Center in Artificial Intelligence). We would like to thank Dr. John Teem (Florida Department of Agriculture, Division of Aquaculture) for his direction in the biological aspects of this problem.

References

[1] J. Gutierrez and J. Teem. A model describing the effect of sex-reversed yy fish in an established wild population: the use of a trojan y chromosome to cause extinction of an introduced exotic species. *Journal of Theoretical Biology*, 241(22):333–341, July 2006.