Sexual Selection in Guppies

WHAT IS IT?
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Darwin (1871) defined sexual selection as selection on those traits specifically involved with acquiring mates. Examples of traits that are thought to be sexually selected include bright, conspicuous coloration (e.g. a peacock’s tail) to attract mates, or weaponry in males (e.g. tusks or horns) to battle other males for access to females. Often, traits that convey a sexual selection advantage may be counterbalanced by natural selection. For example, African Widowbird males have unusually long tails, much longer than females of the species. Andersson (1981) found that females prefer males with experimentally lengthened tails but that these males were more likely to succumb to predation. Thus the naturally occurring tail lengths are thought to be a balance of natural and sexual selection.

This model is an agent-based simulation of John Endler’s (1980) classic experiment on the balance of sexual selection and natural selection. Guppies are familiar small fish that live in freshwater on Caribbean islands and in South America. They are sexually dimorphic, with males being smaller than females, with much larger tails and fins. In Trinidad they live in small pools associated with mountain streams, some of which have pike cichlid (which prey on guppies) and some do not. Endler found that females prefer to mate with ‘flashier’ males, those with more orange spots on their tail. However, the flashier males may also be more conspicuous to predators and be more likely to be eaten. Thus, there are conflicting selective pressures on male guppies. With this model, you can set up virtual experiments similar to Endler’s artificial pond experiments. You can vary the strength of female preference and the number of pike, and another species *Rivulus*, in the pool.
**HOW IT WORKS**

The agents are fish in a small pond. Tracked is the number of tail-spots on male (range 0 to 10). The model simulates overlapping generations, with reproduction occurring whenever guppies may meet. Pike and *Rivulus* will attack male guppies, with the likelihood of attack increasing with the number of tail-spots. Female guppies are attacked at a rate similar to unspotted males. Most of the genes for tail-spots are on the Y-chromosome (Brooks & Endler, 2001; Karino & Hajima, 2001) and are modeled as such. Females exhibit preference by roughly comparing an individual male to their sense of the average population (Houde, 1997). Thus preference is relative, not absolute, and is modeled as such.

**Monitored data include:**
- Number of guppies in the population
- Sex ratio (F:M) of the guppy population
- Average number of tail-spots (of male guppies)
- Standard deviation in the number of tail-spots

**Graphed data include:**
- Distribution of tail spots (histogram)
- Average number of tail-spots over time
  - A reference line of the starting average is included
- Sex ratio (F:M) over time
  - A reference line of 50:50 ratio is included
**Settings**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
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<tbody>
<tr>
<td>Init_Guppies</td>
<td>Starting population size of guppies</td>
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<tr>
<td>Brood_Size</td>
<td>The number of guppies hatched in a reproductive event</td>
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<tr>
<td>Freq_Spots</td>
<td>Average number of tail-spots at the start (individual spot numbers are normally distributed around the mean)</td>
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<tr>
<td>Guppy_K</td>
<td>The maximum number of guppies that can be sustained in the pond</td>
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<tr>
<td>Mortality</td>
<td>The probability that a guppy will randomly die in 100 ticks. This is the maximum value reached at carrying capacity.</td>
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<tr>
<td>Num_Pike</td>
<td>The number of pike cichlids in the pond</td>
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<tr>
<td>Num_Rivulus</td>
<td>The number of <em>Rivulus</em> in the pond</td>
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<tr>
<td>Run_Time</td>
<td>The number of ticks the model will run</td>
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</tbody>
</table>

**HOW TO USE THE MODEL**

To start, set sliders:

- Init_Guppies = 75
- Guppy_K = 150
- Fem_Pref = 0.5
- Run_Time = 5000
- Brood_Size = 10
- Mutation = 0.001
- Num_Pike = 0
- Num_Rivulus = 0
- Freq_Spots = 0.5
- Mortality = 0.4

Press the ‘Set up’ button and fish will appear in the pond. Press ‘Go’ and the fish will swim around and breed new fish. The population should grow and hover around 150 fish. The initial distribution of tail-spots will have a mean of 0.5. With no predators in the pond, and with female preference for males with more spots (sexual selection), what should happen to the average number of tail-spots to increase over time? Run the model under these conditions a few times to understand the results. Next, add predators to the pool and observe the effects on average and standard deviation in number of spots. What happens to the sex ratio with predators? Why might you see this change? What effect does adding *Rivulus* have on the population?
REFERENCES
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Darwin, C. 1871. The descent of man and selection in relation to sex


CREDITS
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Sexual Selection in Guppies 1.0 (2008)
Thomas C. Jones
Dept. of Biological Sciences
East Tennessee State University
jonestc@etsu.edu

‘Sexual Selection in Guppies’ can be run from the web at:

http://faculty.etsu.edu/jonestc/EducationalResources.htm

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