An Analysis of Sex Ratio Management in Captive Primates

Jason Scott
Sex Allocation Theory

• Natural Selection should favor mothers that produce offspring of the sex that most increases their own fitness
  – Trivers-Willard Effect (Trivers and Willard 1973)
  – Local Resource Competition (LRC) (Clark 1978)

• In most cases a 50:50 sex ratio should be favored by natural selection
The Trivers-Willard Effect

• Females in good condition should favor sons
  – Sons should benefit from good condition of mother

• Females in lesser condition should favor female offspring
  – Less variance in reproductive success
Trivers-Willard Effect in Action

- Demonstrated in humans on the Forbes billionaire list (Cameron and Dalerum 2009)
  - Women in highest economic bracket give birth to more sons
  - Significantly different from general population

The Romney Effect?
Local Resource Competition (LRC)

• Natural selection will favor the production of the dispersing sex if the non-dispersing sex is likely to engage in competition with relatives
• Males are the dispersing sex in most primate species
Evidence for LRC

• Clark (1978) found evidence for this hypothesis in the brown greater galago
  – Exhibited a male-biased sex ratio at birth
  – Adult females antagonistic towards unrelated young females
Why is this important?

• Potentially useful for captive breeding programs
  – Could allow zookeepers to avoid the inadvertent skewing of sex ratios
  – Could allow for the intentional manipulation of sex ratios
Why is this important?

• Excess males already posing problems for zoos (Faust and Thompson 2000)
  – Propensity to form bachelor groups complicated by space restrictions

• Others Complications:
  – Unstable age structures
  – Reduction in reproductive potential
Question of Interest

• Do management practices/decisions seem to play a major role in shaping the sex ratio of captive primates?

• Expectation:
  – 50:50 sex ratio for monogamous species
  – Female-biased for polygynous species
What I did

- Collected the species holding records of every primate species in the ISIS database

- Compared the sex ratios of primate species in captivity to published birth sex ratios and to predictions of sex allocation theory
Methods

• 25 species of primates
• Collected information for each species
  – Sex ratio of species in captivity
  – Published records of sex ratio at birth
  – Dispersing Sex
  – Social System
Results

• 7 species had no bias in actual sex ratio (ASR) or birth sex ratio (BSR)
• Of the 13 species with a biased BSR, 11 were male-biased and two were female-biased
• Of the 13 species with a biased sex ratio in captivity (ASR), 6 were male-biased and 7 were female-biased
Results

- 5 species had a biased birth sex ratio, but no bias in actual sex ratio in captivity

<table>
<thead>
<tr>
<th>Species</th>
<th>Social System</th>
<th>Dispersing Sex</th>
<th>ASR Bias</th>
<th>BSR Bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown capuchin (<em>Cebus apella</em>)</td>
<td>Polygynous</td>
<td>Male</td>
<td>None</td>
<td>Male (P&lt;0.01)</td>
</tr>
<tr>
<td>Golden-headed lion tamarin (<em>Leontopithecus chrysomelas</em>)</td>
<td>Monogamous</td>
<td></td>
<td>None</td>
<td>Male (P&lt;0.05)</td>
</tr>
<tr>
<td>Crab-eating macaque (<em>Macaca fascicularis</em>)</td>
<td>Promiscous</td>
<td>Male</td>
<td>None</td>
<td>Male (P&lt;0.05)</td>
</tr>
<tr>
<td>Lion-tailed macaque (<em>Macaca silenus</em>)</td>
<td>Polygynous</td>
<td>Male</td>
<td>None</td>
<td>Male (P&lt;0.05)</td>
</tr>
<tr>
<td>Emperor tamarin (<em>Saguinus imperator subgrisescens</em>)</td>
<td>Promiscous</td>
<td>Both</td>
<td>None</td>
<td>Male (P&lt;0.01)</td>
</tr>
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</table>
Results

- 5 species had a biased sex ratio in captivity, but no bias in birth sex ratio

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<tr>
<td>Western gorilla (Gorilla gorilla gorilla)</td>
<td>Polygynous</td>
<td>Female</td>
<td>Female (P&lt;0.05)</td>
<td>None</td>
</tr>
<tr>
<td>Golden lion tamarin (Leontopithecus rosalia)</td>
<td>Monogamous</td>
<td>Male</td>
<td>Male (P&lt;0.001)</td>
<td>None</td>
</tr>
<tr>
<td>Mandrill (Mandrillus sphinx)</td>
<td>Polygynous</td>
<td>Male</td>
<td>Female (P&lt;0.001)</td>
<td>None</td>
</tr>
<tr>
<td>Chimpanzee (Pan troglodytes)</td>
<td>Promiscous</td>
<td>Female</td>
<td>Female (P&lt;0.001)</td>
<td>None</td>
</tr>
<tr>
<td>White-faced saki (Pithecia pithecia)</td>
<td>Monogamous</td>
<td>Male</td>
<td>Male (P&lt;0.05)</td>
<td>None</td>
</tr>
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Results

- 2 species had actual sex ratios that were opposite those reported for birth

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<tr>
<td>Japanese macaque (<em>Macaca fuscata</em>)</td>
<td>Promiscous</td>
<td>Male</td>
<td>Female (P&lt;0.001)</td>
<td>Male (P&lt;0.05)</td>
</tr>
<tr>
<td>Common squirrel monkey (<em>Saimiri sciureus</em>)</td>
<td>Polygynous</td>
<td>Both</td>
<td>Female (P&lt;0.001)</td>
<td>Male (P&lt;0.01)</td>
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Results

- 6 species had matching biases in birth and actual sex ratios

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<td>Common marmoset (<em>Callithrix jacchus</em>)</td>
<td>Promiscous</td>
<td>Male</td>
<td>Male (P&lt;0.01)</td>
<td>Male (P&lt;0.01)</td>
</tr>
<tr>
<td>Ring-tailed lemur (<em>Lemur catta</em>)</td>
<td>Polygynous</td>
<td>Male</td>
<td>Male (P&lt;0.001)</td>
<td>Male (P&lt;0.01)</td>
</tr>
<tr>
<td>Rhesus macaque (<em>Macaca mulatta</em>)</td>
<td>Promiscous</td>
<td>Male</td>
<td>Female (P&lt;0.01)</td>
<td>Female (P&lt;0.01)</td>
</tr>
<tr>
<td>Hamadryas baboon (<em>Papio hamadryas</em>)</td>
<td>Polygynous</td>
<td>Male</td>
<td>Female (P&lt;0.001)</td>
<td>Female (P&lt;0.01)</td>
</tr>
<tr>
<td>Cotton-top tamarin (<em>Saguinus oedipus</em>)</td>
<td>Monogamous</td>
<td>Male</td>
<td>Male (P&lt;0.05)</td>
<td>Male (P&lt;0.01)</td>
</tr>
<tr>
<td>Black-and-white ruffed lemur (<em>Varecia variegata</em>)</td>
<td>Promiscous</td>
<td>Male</td>
<td>Male (P&lt;0.01)</td>
<td>Male (P&lt;0.01)</td>
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Discussion

• Management decisions seem to affect the sex ratios of many but not all species in captivity

• Sex ratios of some captive primate species do seem to be influenced by the birth sex ratios

• BSRs seem to provide evidence for local resource competition hypothesis
Questions?