Sexual Selection

10 February 2020

Origin and evolution of sex

- Sex was present in the Last Eukaryotic Common Ancestor[1] (LECA), ca 1100-2300 million years ago[2] (Mya)

[1] Chernikova, D, et al. (2011). Biol Direct. 6:1-18.
[2] Speijer, D, et al. (2015). Proc. Natl. Acad. Sci. 112:8827-8834.
[3] Parker, G A, et al. (1972). J. Theor. Biol. 36:529-553.

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  - Selection initially increases gamete size to increase survival of zygote
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- Evolution of anisogamy as two strategies for fertilisation

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Sexual selection: Motivation and definition

Figure 1: Long-tailed widow-bird

- **Observation:** Animal traits do not always appear adaptive for survival[1]
  - Weaponry
  - Ornaments

[1] Darwin, C. (1859). The Origin of Species. New York: Penguin.
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[3] **Image:** *Euplectes progne* Bernard Dupont. CC 2.0

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- **Sexual selection:** Individuals compete for access to gametes of the opposite sex[2]

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Two types of sexual selection

Figure 2: White-tailed deer

- **Intrasexual selection:** Individuals of the same sex compete for access to mates (selection for weaponry)

[1] **Image:** *Odocoileus virginianus* Brian Stansberry.

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- Weapons and ornaments are expensive to make and maintain, and might reduce survival
- Competition strongest in mate-limited sex (typically males)

[1] **Image:** *Odocoileus virginianus* Brian Stansberry.

The Bateman gradient: theory

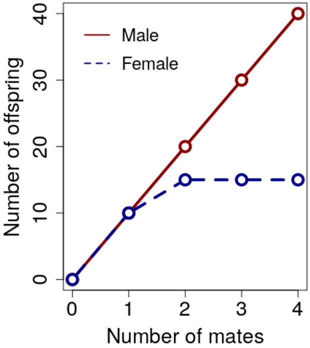

Figure 3: The Bateman gradient

- Bateman[1] reasoned that benefits of mating multiply often differ between sexes
  - **Males:** Often increase reproductive output by mating multiply
  - **Females:** Often do not increase reproductive output by mating multiply

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[1] Bateman, A J (1948). Heredity, 2:349–368.

[2] Kokko, H, et al. (2012). Ecol. Lett. 15:1340-1351.

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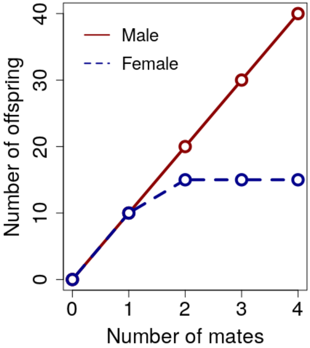

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- Bateman[1] reasoned that benefits of mating multiply often differ between sexes
  - **Males:** Often increase reproductive output by mating multiply
  - **Females:** Often do not increase reproductive output by mating multiply
- Contributes to understanding variation in the strength of sexual selection between sexes and across species[2]

[1] Bateman, A J (1948). Heredity, 2:349–368.
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Factors affecting competition for gametes

- **Parental investment (PI)**: Anything that a parent does to increase its offspring's viability at the expense of its other actual or potential offspring[1]

[1] Trivers, R. (1972). Parental investment and sexual selection. In B. Campbell (Ed.), Sexual Selection and the Descent of Man, 1871-1971 (pp. 136-179). London: Heinemann.

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- **Operational Sex Ratio (OSR)**: Average ratio of males to females who are ready to mate (forming the 'mating pool') at a given time and place[2,3]

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- In many species, male reproductive success is primarily determined by their ability to monopolise mating with females

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[3] Kokko, H, et al. (2012). Ecol. Lett. 15:1340-1351.

The Bateman gradient: observations

Figure 4: Rough-skinned newt

- Jones et al.[1] quantified sexual selection in *Taricha granulosa*
- Females lay 300 eggs sequentially over several weeks
- Males compete to fertilise eggs; no parental care

[1] Jones, A G (2002). Proc. R. Soc. B. 269:2533-2539.

[2] **Image:** Public domain.

The Bateman gradient: observations

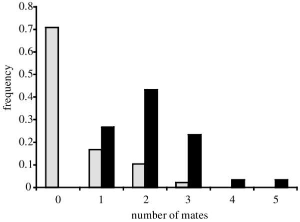


Figure 1. Distributions of genetically documented mating events for male and female newts. Grey bars, males; black bars, females.

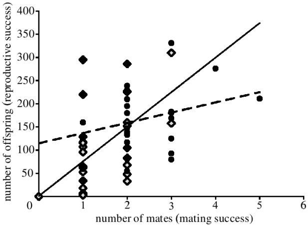


Figure 2. A plot of reproductive success versus mating success for newts from our focal population, showing Bateman gradients (also known as sexual-selection gradients) for males (solid line) and females (dashed line).

[1]**Image:** Jones, A G (2002). Proc. R. Soc. B. 269:2533-2539.

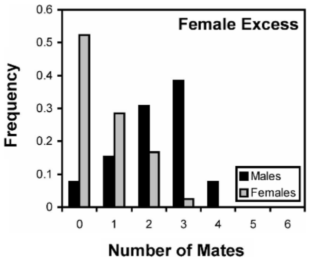
The Bateman gradient: observations

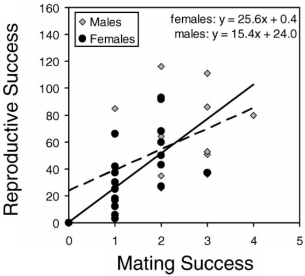
Figure 5: Broad-nosed pipefish

- In a different paper, Jones et al.[1] quantified sexual selection in *Syngnathus typhle*
- Females lay eggs within a male brood pouch
- Males provide all parental care

[2]**Image:** Public domain.

The Bateman gradient: observations





[1]**Image:** Jones, A G (2005). Integr. Comp. Biol. 45:874-884.

Theory summary slide

- **Sexual selection** occurs when individuals compete for access to gametes of the opposite sex
- **Intra-sexual selection** is a type of sexual selection where individuals of the same sex compete for access to mates
- Limited availability of mates can increase sexual selection on the mate-limited sex
  - **Operational Sex Ratio (OSR)**: Average ratio of males to females who are ready to mate
  - **Parental Investment (PI)**: Parents increase offspring viability at the expense of its other actual or potential offspring
- Next, a case study of intra-sexual selection in marine iguanas

Case study in the Galápagos marine iguana

[1]**Image:** Charles J Sharp. CC 3.0

Case study in the Galápagos marine iguana

Figure 6: Marine iguana

- Graze on algae in intertidal zone
- Bask at water's edge for warmth & digestion
- No predation or competition for food[1]
- Relatively high female PI; very low male PI
- Males are larger than females

[1] Wikelski, M, et al. (1997). Ecology. 78:2204-2217.

[2] **Image:** *Amblyrhynchus cristatus* Diego Delso.

Case study in the Galápagos marine iguana

Figure 7: Basking marine iguana

[1]**Image:** Bernard Gagnon. CC 4.0

Case study in the Galápagos marine iguana

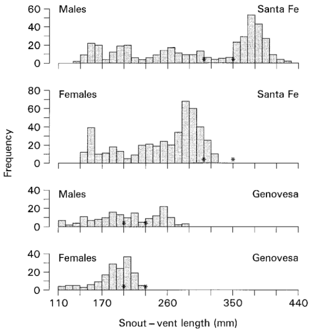
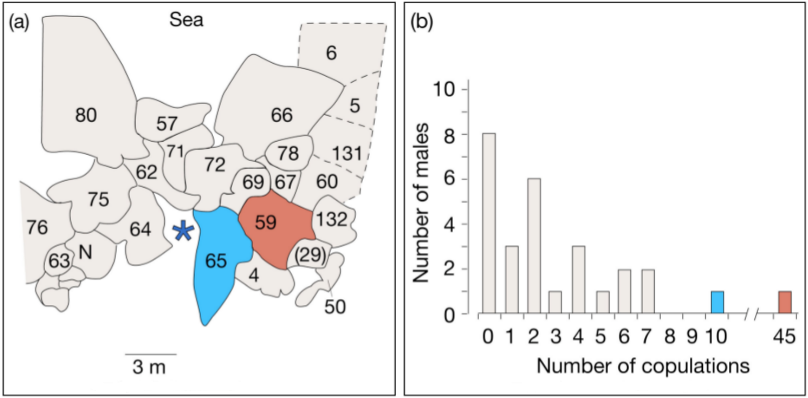


Figure 8: Marine iguana body size distributions

- Wikelski et al.[1] identified energy limits to iguana body size
- Stars in figure to right show where body mass becomes unsustainable for normal (right) and El Niño (left) years
- Low survival for big iguanas when food is scarce

[1]Wikelski, M, et al. (1997). Ecology. 78:2204-2217.

Case study in the Galápagos marine iguana



[1]Freeman, S, & Herron, J C. (2007). Evolutionary analysis. Upper Saddle River, NJ: Pearson Prentice Hall.

[2]Trillmich, K G. (1983). Zeitschrift für Tierpsychologie, 63:141-172

Case study in the Galápagos marine iguana

TABLE 3. Standardized selection differentials (I, see Endler 1986) for natural and sexual (males) and fertility (females) selection on body size in Genovesa and Santa Fé island marine iguanas; + and − indicate the direction of selection toward larger or smaller body sizes, respectively. For each row, the upper line indicates mean body size (SVL) of the study population (e.g., adult males) before the selective event, the lower line the mean SVL of "selected" animals before the selective event (e.g., those that survived or reproduced, respectively). Abbreviations indicate: SVL: snout-to-vent length in mm; VAR: variance; n: sample size; I: directional selection differential.

Type of selection / Island	Season	Males (SVL > 200 mm)				Females (SVL > 156 mm)			
		SVL	VAR	n	I	SVL	VAR	n	I
Natural selection	91/93	241	487	88	−1.40*	195	255	143	−0.31
Genovesa		211	28	8		190	230	32	
Natural selection	91/93	382	487	416	+0.11	276	783	145	0.0
Santa Fé		385	368	256		276	649	77	
Sexual selection (males)	92/93	227	442	147	+0.77*	182	427	153	−0.07
Genovesa		243	681	25		185	338	338	
Fertility selection (females)									
Genovesa									
Sexual selection (males)	92/93	390	677	343	+0.42*	287	1013	256	+0.27
Santa Fé		401	175	253		295	353	353	
Fertility selection (females)									
Santa Fé									

*Indicates significant results ($P < 0.05$).

- Large male iguanas reproduced more than small iguanas
- Female reproduction was unaffected by body size
- **Intra-sexual selection for male body size as a consequence of male-male competition**

[1] Wikelski, M, & F Trillmich (1997). Evolution. 51:922-936.

Inter-sexual selection

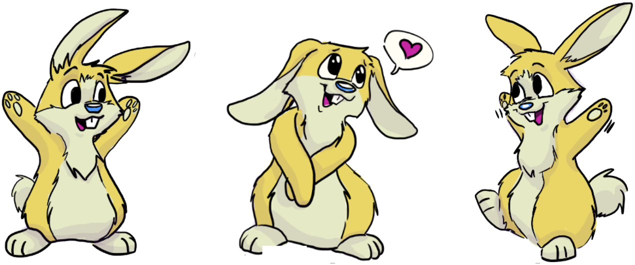


Figure 9: Individuals of one sex choose mates of the opposite sex

- Selection for elaborate ornamentations or behaviours
- Sex being chosen is the mate-limited sex
- Sex choosing is typically resource-limited

Inter-sexual selection: Red-Collared Widowbirds

Figure 10: Male Red-Collared Widowbird

- Eastern and southern Africa
- Males have very long tail feathers
- Males hold territories, but territory quality and size are unrelated to feather length
- Sarah Pryke and Staffan Andersson tested for female choice[1]

[1]Pryke, S R, & S Andersson (2005). Biol. J. Linnean. Soc. 86:35-43.
[2]**Image:** *Euplectes ardens* Nigel Voaden. CC 2.0

Inter-sexual selection: Red-Collared Widowbirds

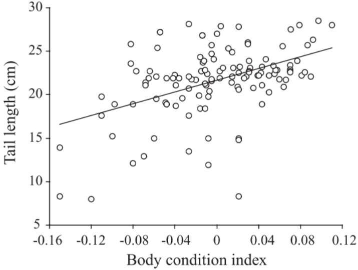


Figure 2. Linear regression of full-grown tail length (cm) on a body condition index (relative body mass) ($F_{1,98} = 31.34$, $P < 0.001$, $R^2 = 21.2\%$) at the onset of the breeding season (prior to territory establishment).

- Red-collard widowbird body condition is positivey correlated with tail length[1]
- Pryke and Andersson[1] decided to shorten the tail feathers of some males
- Males were randomly assigned to shortened or unshortened ('control') groups

[1]Pryke, S R, & S Andersson (2005). Biol. J. Linnean. Soc. 86:35-43.

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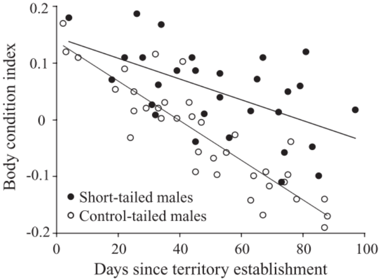

Figure 3. Body condition (relative body mass) of recaptured resident males during the breeding season as a function of the number of days since they established territories (overall: $F_{1,65} = 64.84$, $P < 0.001$, $R^2 = 51.1\%$). Body condition declined over the season in both short-tailed ($y = 0.14–0.002x$, $F_{1,27} = 15.79$, $P < 0.001$, $R^2 = 37.8\%$) and control-tailed ($y = 0.13–0.030x$, $F_{1,35} = 28.34$, $P < 0.001$, $R^2 = 68.2\%$) territory owners but was steeper in control-tailed males (see text for details on significance tests).

Body condition of males with experimentally shortened tail feathers declined more slowly than that of males with long tail feathers ('control')[1]

[1] Pryke, S R, & S Andersson (2005). Biol. J. Linnean. Soc. 86:35-43.

Inter-sexual selection: Red-Collared Widowbirds

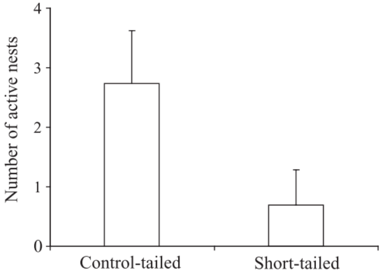

Figure 1. Mean (± SD) number of actively nesting females (i.e. male reproductive success) attracted by the control-tailed ($N = 43$) and short-tailed ($N = 48$) males. See Table 3 for significance values.

- More females nested in the territories of males with long tails ('control')[1]
- Pryke and Andersson conclude that females prefer long-tailed males
- But why are female choosy?

[1] Pryke, S R, & S Andersson (2005). Biol. J. Linnean. Soc. 86:35-43.