

Reproductive Ecology & Sexual Selection



REPRODUCTION

- Asexual
- Sexual
 - Attraction, Courtship, and Mating
 - Fertilization
 - Production of Young

Benefits of Asex

1. Eliminate problem to locate, court, & retain suitable mate.
2. Doubles population growth rate.
3. Avoid “cost of meiosis”:
 - genetic representation in later generations isn't reduced by half each time
4. Preserve gene pool adapted to local conditions.

The Evolutionary Enigma of Sexual Reproduction

- Sexual reproduction produces fewer reproductive offspring than asexual reproduction, a so-called reproductive handicap

Asexual reproduction

Sexual reproduction

Figure 23.16

The Energetic Costs of Sexual Reproduction

- Allocation of Resources

Brood Size	Male Survival (%)	Female Survival (%)
Reduced brood size	~85	~95
Normal brood size	~55	~60
Enlarged brood size	~25	~50

Benefits of Sex

1. Reinforcement of social structure
2. Variability in face of changing environment.
 - why buy four lottery tickets w/ the same number on them?

Relative benefits: Support from organisms both asexual in constant & sexual in changing environments

- aphids have wingless female clones & winged male & female dispersers
- ciliates conjugate if environment is deteriorating

Reproductive Ecology & Sexual Selection

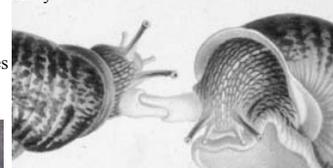
TWO SEXES



- **Conjugation**
 - Ciliate protozoans with + & - mating types.
- **Monoecious:** both sexes in one individual.
- **Dioecious:** separate sexes
 - one sex makes small haploid gametes (sperm)
 - the other makes big ones (eggs)

Simultaneous Hermaphrodites

- Advantageous if limited mobility and sperm dispersal and/or low population density
- Guarantee that any member of your species encountered is the “right” sex
- Self fertilization still provides some genetic variation
- Or prevent self-fertilization by
 - copulation
 - producing sperm or eggs at different times



sponges, flatworms, snails, earthworms
Notice the fire tracks!
8' long earthworm from Ecuador

Simultaneous sperm exchange

Sequential Hermaphrodites

- **Protandry:** when all else equal
 - make sperm when small
 - you still make more than needed
 - make eggs when large
 - costlier & bigger
- **Protogyny:** when all else isn't equal
 - especially if big individuals get more mates
 - be a big male: wrasses.

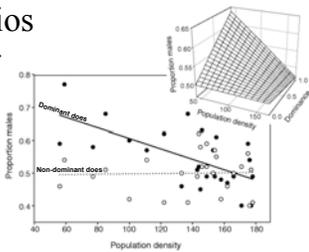
Determinate (fixed) Gender

- Gametic determination
 - Heterogenic male determination (XY male)
 - Heterogenic female determination (XY female)
 - Haplotypic male determination (XO male)
- Environmental determination
 - Temperature
 - Intrauterine position

Determinate Gender, yet Biased Sex Ratios

- Primary Sex Ratio:
 - Sex ratio at fertilization
- Secondary Sex Ratio:
 - Sex ratio at birth
- Tertiary Sex Ratio:
 - Sex ratio at sexual maturity
- Quaternary Sex Ratio:
 - Sex ratio of adult population

Biased Sex-ratios in Red Deer

- ↑ frequency of male calves to dominant mothers
 - Dominant moms more likely to yield dominant bucks → ↑ odds of perpetuating her genes
 - Δ ratio probably from pre-implantation events
- ↓ frequency of male calves in poor conditions (E.g., ↑ density)
 - Males larger → more expensive to raise
 - Δ ratio probably from post-implantation events

Reproductive Ecology & Sexual Selection

External Fertilization

- Only in water
 - gametes must be moist.
- Gamete release is synchronized.



Broadcast Spawning

- E.g. marine inverts - larval mortality is high.
- Release in response to:
 - smell of other gametes
 - environmental cues
 - Palolo Worm

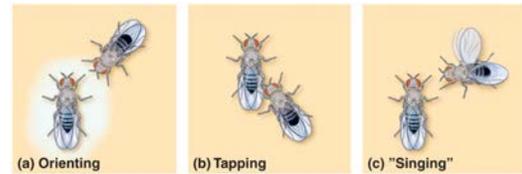


Mate Attraction — Courtship

- Auditory
- Chemical
 - Pheromones
- Visual
 - Colors
 - Bioluminescence
 - Behaviors



Courtship Behavior



Courtship Spawning

- In fish, amphibians, & some marine inverts
- Behaviors stimulate gamete release
- Produce fewer eggs
 - but may add in parental care
 - it's a balance of investment strategy



Internal Fertilization

- Terrestrial forms need internal fertilization so gametes don't dry out
- Decreases energy spent on sperm production
- Ensure large amounts of *your* sperm are on target
- Allow females to store concentrated sperm

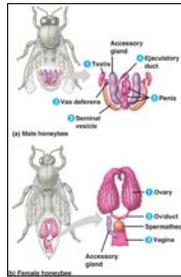
- **Spermatophores** are sperm packages
 - spiders, squid, salamanders
- **Adpressed Cloacas**
 - birds lack intromittive organs



Reproductive Ecology & Sexual Selection

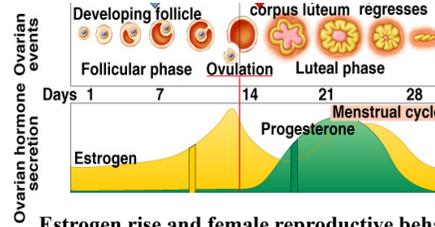
Copulatory Organs

- Legs
 - squids & spiders
- Claspers
 - sharks & rays
- Penises
 - insects
 - turtles, crocodiles — protrusable
 - lizards, snakes w/ paired **hemipenes** — eversible
 - marsupials w/ bifurcated penis
 - eutherian mammals w/ penis & **baculum**.



Estrogens & Ovulation

Ovulation triggered by a sharp rise in estrogens

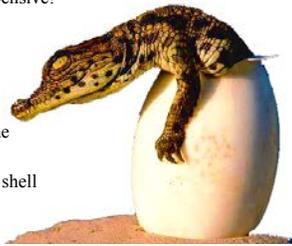


Estrogen rise and female reproductive behavior

- **Proceptive behavior:** “flirting” — advertising sexual state
- **Receptive behavior:** attentive to male courting
- **Conceptive behavior:** accepting copulation

Oviparity: Egg Laying

- Yolk w/ protein & fats
 - Energetically *very* expensive!
- Protective Coating
 - jelly-like substance in aquatic forms
 - earthworm's cocoon
 - horny egg case of some sharks
 - calcareous or leathery shell of birds & reptiles



Oviparity

- Birds



Continued Parental Investment

- Nest guarding
- Brooding
- **Resource allocation**
 - Less energy spent on egg production
 - Use energy insuring development of fewer offspring
 - Often, females spend energy on egg production
 - Males do the parental care



Ovoviviparity: Retain Eggs Internally

- “Mobile nest”
- Keeping eggs warmer speeds development.
 - Cold climate reptiles retain eggs rather than laying them.



Dogfish shark “candle” from female’s uterus

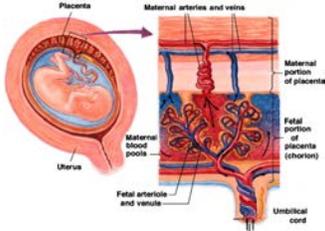


“Candle” opened to show small embryos with large yolk

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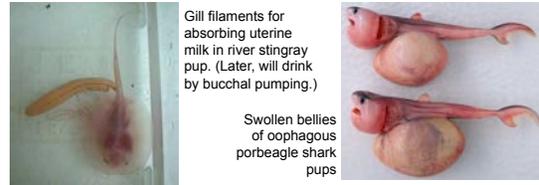
Viviparity: Maternal Nourishment

- **Maternal Nourishment**
 - Spreads maternal energy demand over longer time period
 - Allows embryo to grow beyond original egg size
- **Placenta** connects embryo to mother for nutrition & gas exchange.
 - Placental mammals
 - Reptiles (rattlesnakes & sea snakes)
 - Fish (sharks, guppies, surf perch)



Viviparity: Maternal Nourishment

- **Maternal Nourishment**
 - Spreads maternal energy demand over longer time period
 - Allows embryo to grow beyond original egg size
- **Aplacental viviparity: intra-uterine feeding.**
 - “Uterine milk” – rays
 - Oophagy (& adelphophagy!) – mackerel sharks



Aphids — a little bit of everything!

1. **Asexual** (parthenogenic) **viviparity**
 - And “telescoping generations” (born pregnant!)
2. Seasonally alternating with a dioecious generation having:

Sexual oviparity



- Parthenogenic live birth (all females)
- And the baby being born already has a baby!

Aphids — a little bit of everything!



Aphid yearly cycles

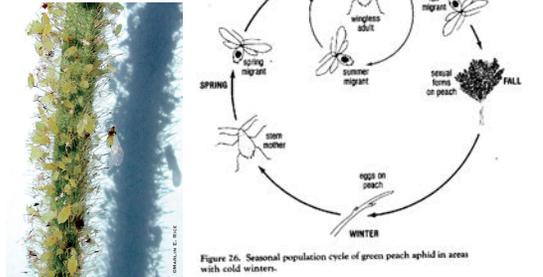


Figure 26. Seasonal population cycle of green peach aphid in areas with cold winters.

EVOLUTION OF POPULATIONS

- Genetics & Variability
- Non-Adaptive Evolution
- Adaptive Evolution: Natural Selection
- **Sexual Selection**

“Survival of the fittest”

“**Reproduction of the fittest**”

Sexual Selection

- **Natural Selection (NS):** differential reproduction due to differential survival.
- **Sexual Selection (SS):** differential reproduction due to **increased Reproductive Success (RS)** despite possible **decreased survival**.

Sexual Selection

- Even though some variations may **increase** survival, health, competitive success, etc., ...
- they will **not increase in frequency** in the gene pool **if** they are **not also** associated with increased reproductive success!



- Even though some variations may **decrease** survival, health, competitive success, etc., ...
- they will **increase in frequency** in the gene pool **if** they are **also** associated with increased reproductive success!

Sexual Selection and the Energetic Costs of Reproductive Success

- **Increased** Reproductive Success comes at **increased energetic costs** → **decreased survival**

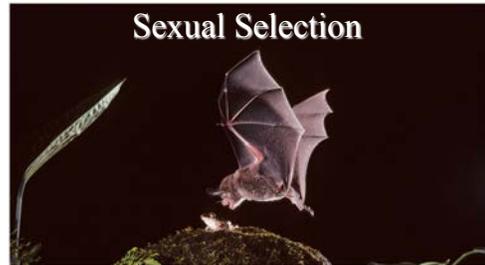
Mating calling in frogs the most energetically expensive activity in their life.

• Aerobic metabolism up 25x for several hours

1. Advertising calls (chorus)
2. Aggressive calls
3. Courtship calls (solo)



Sexual Selection



- **Sexual Selection:** differential reproduction due to **increased** Reproductive Success despite possible **decreased** survival.
 - **Louder vocalizations** → **stronger attraction for mates**
 - **Louder vocalizations** → **stronger attraction for predators!**

Sexual Selection

- Observed **sexual dimorphism**
 - sexes differ in size, color, or behavior
- Some differences don't aid survival
 - dimorphic feature makes **animal more obvious**



Social Sex

- Promiscuous
 - No social bonding
- Monogamous
 - One female + one male
- Polygamous (sexually dimorphic)
 - Polygynous
 - One male + multiple females
 - Polyandrous
 - One female + multiple males



(a) Monogamous species



(b) Polygynous species



(c) Polyandrous species

Reproductive Ecology & Sexual Selection

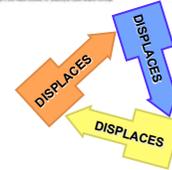
Sexual Selection

- **Intrasexual Selection:**
 - competition among members of one sex for access to members of the other sex.
 - a.k.a. Male-Male Competition.



Sexual Selection

- **Game Theory (rock-paper-scissors)**
- **Frequency-dependent Intrasexual Selection:**
 - Oscillating frequencies
- **Side-blotch lizard**
 - Orange-spotted males
 - Aggressive, large harems
 - Blue-spotted males
 - Less-aggressive, small harems
 - Yellow-spotted males
 - Non-aggressive, no harems



Sexual Selection

- **Intrasexual Selection**
- **Intersexual Selection:**
 - ability of one sex to woo the opposite sex.
 - a.k.a. Female Choice.

Female Choice



Female Choice in New Guinea Birds of Paradise & Hills Tribes



<https://www.youtube.com/watch?v=KIYkpwYKEhY>
<https://www.youtube.com/watch?v=DU-V3OYwwQU>

Female Choice

- Bowerbirds: display is separate from bird.



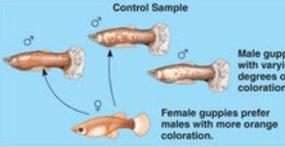
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Social Learning & Mate Choice



- Female guppy introduced to unaccompanied males
 - > Choose most brightly ornated
- Female guppy introduced to one accompanied male + unaccompanied males
 - > Choose whichever color-pattern the accompanied male has

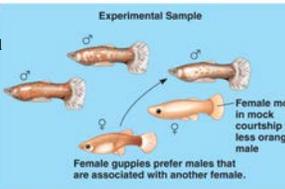
Control Sample



Male guppies with varying degrees of coloration.

Female guppies prefer males with more orange coloration.

Experimental Sample



Female model in mock courtship with less orange male

Female guppies prefer males that are associated with another female.

Why Females Choose and Males Fight: Parental Investment & Sexual Selection

- Sex w/ most invested has most to lose:
 - Eggs more "expensive" than sperm
 - Females must be selective
- Female RS limited by # of young they raise.
- Male RS limited by # of females they mate.

Reversed Dimorphism

Where the female is the pursuer because she invests less.

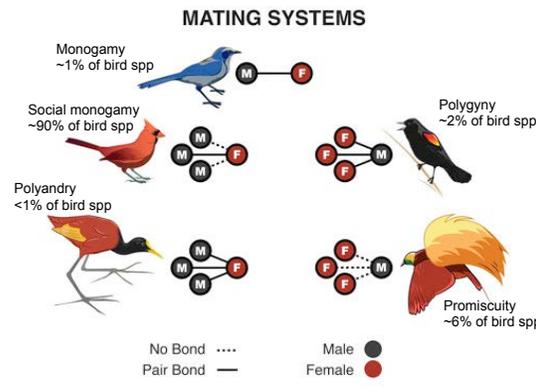
- Phalarope females are bigger and brighter.




- Females lay a clutch every 10-12 days
- Male clutch care takes 3 months
- Females will destroy eggs to free up a male

Ala male lions, primates, mice

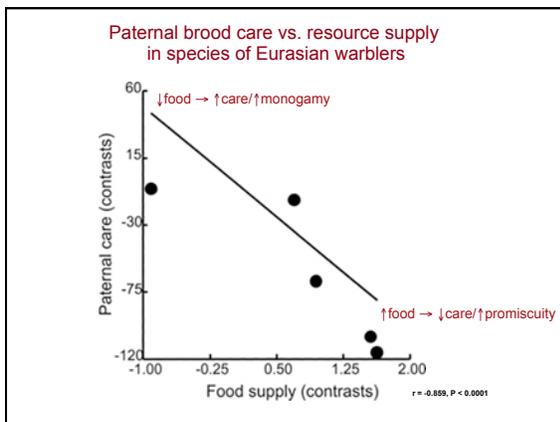
MATING SYSTEMS



- Monogamy ~1% of bird spp
- Social monogamy ~90% of bird spp
- Polygyny ~2% of bird spp
- Polyandry <1% of bird spp
- Promiscuity ~6% of bird spp

No Bond ----
 Pair Bond —

Male ●
 Female ●



Speaking of the Birds and the Bees ...



- Super polyandry / abbreviated promiscuity
- Sperm competition

<https://www.theguardian.com/environment/video/2015/sep/06/queen-bee-wedding-fight-video>