

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 | ~90 | ~85 |
| Normal brood size | ~60 | ~60 |
| Enlarged brood size | ~30 | ~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

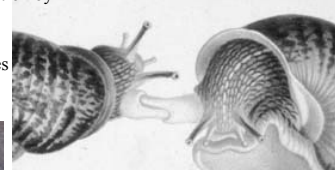
TWO SEXES



- **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.

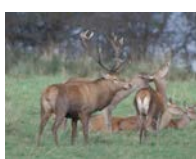
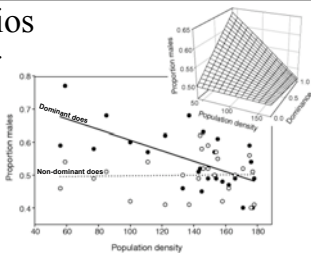
Determinate (fixed) Gender

- 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

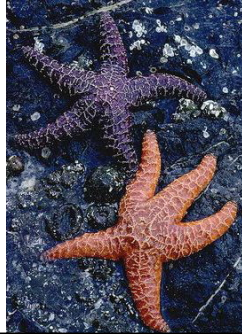



- ↑ frequency of male calves to dominant mothers
 - Dominant moms more likely to yield dominant bucks → ↑ odds of perpetuating her genes
 - Δ ratio probably from pre-implantation events
- ↓ frequency of male calves in poor conditions (E.g., ↑ density)
 - Males larger → more expensive to raise
 - Δ ratio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

Reproductive Ecology & Sexual Selection

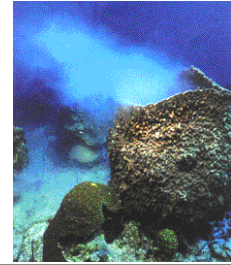
External Fertilization

- 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

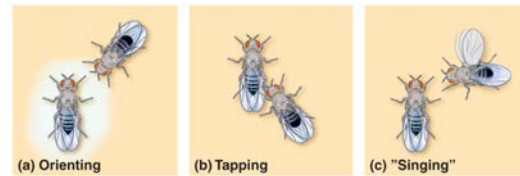


Mate Attraction — Courtship

- 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

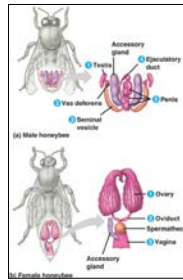
- **Spermatophores** are sperm packages
 - spiders, squid, salamanders
- **Adpressed Cloacas**
 - birds lack intromittive organs



Reproductive Ecology & Sexual Selection

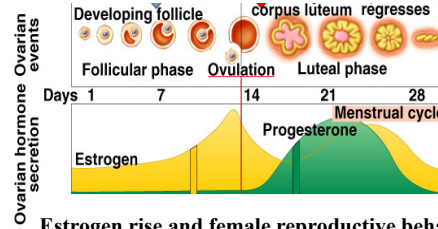
Copulatory Organs

- 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

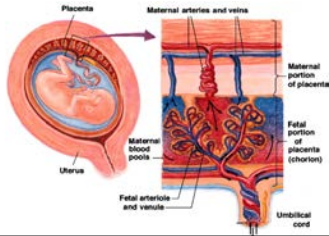


“Candle” opened to show small embryos with large yolk

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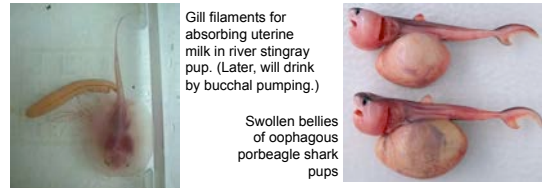
Viviparity: Maternal Nourishment

- **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

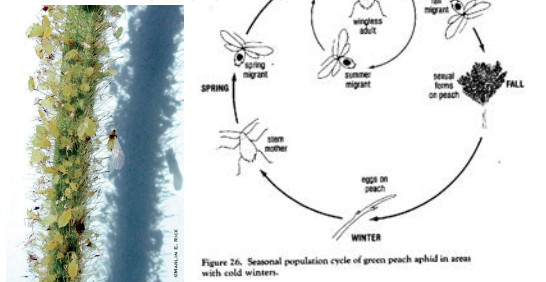


Figure 26. Seasonal population cycle of green peach aphid in areas with cold winters.

EVOLUTION OF POPULATIONS

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

“Survival of the fittest”

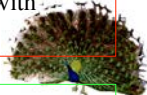
“**Reproduction of the fittest**”

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*

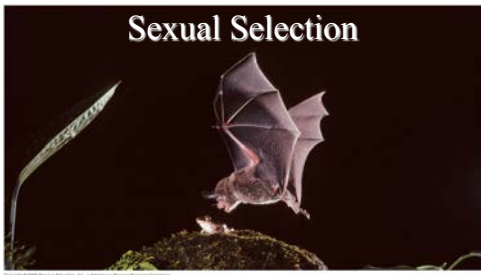
Mating calling in frogs the most energetically expensive activity in their life.

- 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

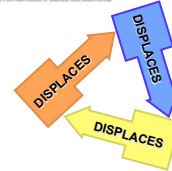
Sexual Selection

- **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.



Reproductive Ecology & Sexual Selection

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

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

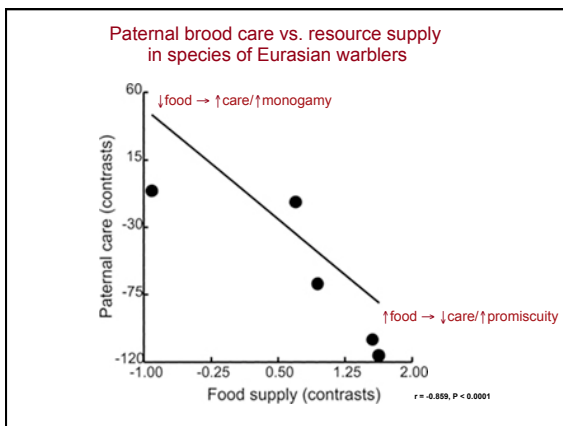
Ala male lions, primates, mice

MATING SYSTEMS

Monogamy ~1% of bird spp
 Social monogamy ~90% of bird spp
 Polyandry <1% of bird spp
 Polygyny ~2% 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-night-video>