Week 4

Evolution of Sociality

Major transitions in evolution

1. Replicating molecules becoming compartmentalised
2. Independent genes (replicators) joining to form chromosomes
3. RNA --> RNA + DNA + Proteins
4. Prokaryotes --> eukaryotes
5. Asexual reproduction --> sexual reproduction
6. Unicellular --> multicellular
7. Solitary --> colonies

Underlying Idea

- Group living can be explained by understanding that helping others can pass on one's genes

Relatedness

- Proportion of alleles shared identical by descent among two individuals (given a reference population)
- Haldane quote: "two brothers or eight cousins"
  - Because brothers/sisters should be 0.5 related
  - Cousins 0.125 related

Inclusive Fitness

- Not just your offspring, but the offspring of your kin

Hamilton's Rule

- An altruistic trait will be selected for if…

  $b \times r > c$
- b - benefit
- r = relatedness
- c = cost
- If benefits are high, altruism may be worth it even if relatedness is low, and vice versa
- Cost depends on environment
- Benefit: extra offspring produced through actions of helper
- Relatedness: of beneficiary to altruist
- Cost: number of children not produced by altruist because of helping

Sociality --> Eusociality

- Eusociality - highest level of animal sociality
- Defined by division of labour:
  - Reproductive and non-reproductive castes
  - Loss of ability to perform duty of other caste
  - Cooperative care of young across generations

Most eusocial species are haplodiploid

- Females diploid - produced from fertilised egg
- Males haploid - non-fertilised egg
- Therefore, males 100% related to mother
- Females 50% related to mother, 50% to father

Diploid	r
Parent-offspring	0.5
Full sibling	0.5

Haplodiploid	r	
Mother-son	0.5	
Son-mother	1	
Father-son	0	Because no father
Mother-daughter	0.5	
Daughter-mother	0.5	
Father-daughter	1	
Daughter-father	0.5	
Sister-brother	0.25	
Brother-brother	0.5	
Sister-sister	0.75	Share all of father's genetic material, and half of mothers

Haplodiploid sisters more related to each other than to their own offspring, more beneficial to help sisters reproduce than to reproduce on their own

Monogamy Hypothesis
Diploid Societies

- High promiscuity = low intergroup relatedness
  - Low relatedness means more likely to go and make your own than help a low-related individual - leads to independent breeding
- Independent breeding reduces promiscuity (monogamy increases), high intergroup relatedness - leads to cooperative breeding

Birds: promiscuity to monogamy scale

- High monogamy, low promiscuity - more likely to have cooperative breeding

Gidgee Skink - *Egernia stokesii*

- Genetic and social monogamy
- Stable family groups
- Delayed maturity and dispersal
- Long-lived

PBTs - *Tiliqua adelaidensis*

- Promiscuous
- Solitary
- Multiple paternities in one litter

Sleepy - *Tiliqua rugosa*

- Solitary most of time, but 86% monogamous in breeding season
- "short-term monogamy"

- But those that return to same partner year after year are probably long-term monogamous
- No evidence of kin association

Conservation Implications of Sociality
- Take into account in captive breeding, reintroductions, translocations
- Greater sociality = smaller N_e
  - N_e = effective population size = contribution of breeders to next generation based on idealised population with random mating, equal sex ratios, equal size family groups
- Increases population subdivision
  - Family groups may become quite distinct
- Individuals become more important

Sociality in Genomics
- Shared social responsiveness genes across species
  - E.g. autism risk genes in humans and genes inactive in bees that don't show much social response

Summary
- Evolution of sociality passed on through our genes

Invasion Biology

Why is it important?
- Environmental
- Economic

What is an invasive species?
- Alien organisms that have established in a new area and are expanding their range
- Alien species are species occurring outside their natural range and dispersal potential

Invasion Process
- Causal: transportation of species to new area and escape to wild as a consequence of human activity
- Naturalised: establishment of self-sustaining populations in new range without reliance on further introductions
- Invasive: spread in new range

How many species become invasive?
10% rule
- 10% introduced become causal
  - 10% causal become naturalised
    - 10% naturalised become invasive
- ~0.1% actually invasive

What factors make a species invasive?
- Taxonomic: life-history - is it related to another invader?
- Propagule Pressure: number and size of introductions, of offspring
- Phenotypic Plasticity: phenotype changes with environment - e.g. pacific oyster invasive and highly phenotypically plastic
- Habitat Matching: habitat similar to that of native range - e.g. Pinus spp. Latitude matching

- Residence Time: lag time from introduction to invasiveness
- Human Use: if associated with humans, more likely to be moved
- Community Invasibility: some communities more vulnerable than others. Biodiverse areas may be more resistant or more vulnerable
- Enemy Release: no natural predators/parasites
- Evolution of Increased Competitive Ability: in absence of predators, natural selection favours genes with increased competitive ability as competition is greatest threat
- Personality Types: asocial and exploratory individuals on the invasion front
- Novel Weapons: e.g. poisons and other chemicals
- Hybridisation: or introgression, take on advantageous alleles of native species
- Admixture: intraspecific hybridisation - multiple introductions, may have some genetic changes
- Mating Systems: asexual is fast, but sexual introduces diversity
- Epigenetic Changes: potentially heritable changes through DNA methylation, good for asexual species
- Adaptation from Standing Genetic Variation: already hold genetic variation that is needed for new environment e.g. cane toads on invasion front have longer limbs
- Adaptation from New Mutations: more relevant to viruses, microbes

Evolution of Invasiveness in Fireweed

- Native to Africa
- Poisonous to cattle
- Lag phase ~80 years
- Potential for high genetic variation
- Self-incompatible
- Readily hybridises with native counterpart

Map temporal and spatial spread

- Herbarium specimens and genetic studies
- 2 invasion fronts
- Multiple introductions from native range