Game theory

- What it is
- What it can do
- What it is used for

Games and theory

- Originally developed to literally analyze optimal strategies in games (chess, tic-tac-toe)
- Describes interactions of individuals, their strategies, outcomes of those, and how to 'win'

Hawks and Doves

- Model of animal fighting behavior / ritualization of fights

Payoff to Player A	B plays Hawk	B plays Dove
A plays Hawk	Both get injured: **very bad**	B flees, A wins: good
A plays Dove	A flees, B wins: bad	Win 50%, neither gets injured: ok

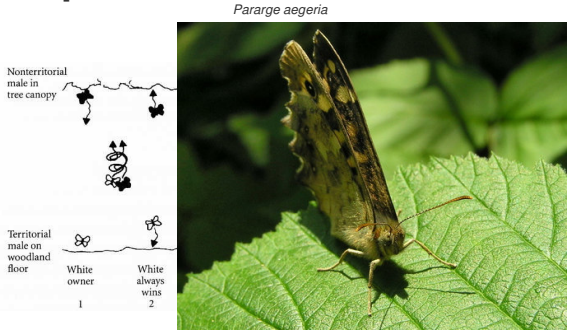
No single best strategy: each strategy is the best answer to the other (frequency dependence)

Analysis of the payoff matrix

- Which strategy gives the highest payoff on average?
- Which is robust (=high payoff against many other strategies)?
- Which is evolutionary stable (=can't be invaded by any other strategy)?
- Which could invade any other strategy (=initial viability at low frequency)?

Speckled wood butterflies

Pararge aegeria



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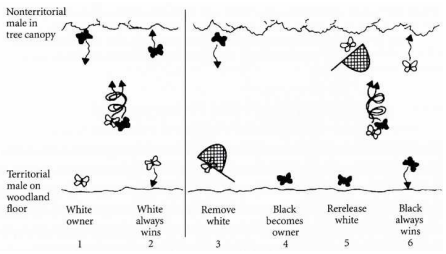

If territory is important, why can the owner always hold it?

Evolution of fighting strategies

'Bourgeois' is an ESS

Because it is the optimal strategy with this payoff matrix...

Payoff to Player A	B plays Hawk	B plays Dove	B plays Bourgeois
A plays Hawk	**injury, win 50%**	**win**	**injury & win 50% (D) / no win (I)**
A plays Dove	**no win**	**win 50%**	**win (D), win 50% (I)**
A plays Boureois	**injury & win 50% (D) / no win (I)**	**win (D), win 50% (I)**	**win (D), no win (I)**

Evolution of altruism

The Prisoner's Dilemma

- Model of animal cooperation vs. competition

Payoff to Player A	B cooperates	B defects
A cooperates	Both benefit: **good**	A gets exploited: **very bad**
A defects	A exploits B: **very good**	No interaction / mutual exploitation: **bad**

- In a single game, you always defect

Game theoretic methods

More sophisticated analyses

- Iterated games with fixed number of interactions or certain probability of repeated interaction
- Spatially explicit games with unequal probabilities for interacting with different individuals
- Stochasticity in interactions or outcomes
- Evolution: replicator dynamics and adaptive dynamics

Example

Evolution of altruism

Evolution of altruism in the iterated prisoner's dilemma

Payoff to Player A	B cooperates	B defects
A cooperates	Both benefit: good	A gets exploited: very bad
A defects	A exploits B: very good	No interaction / mutual exploitation: bad

- If defectors can be recognized and punished
- If interaction probabilities are changed by spatial viscosity, relatedness, etc.
- If interactions can be terminated

Game theory applications

Classic questions investigated by game theory

- Evolution of ritualization
- Resolution of conflicts
- Evolution of altruism
- Public goods games ('tragedy of the commons')
- Role of reputation in cooperation

Discussion questions I

- Did you understand the difference between 'replicator dynamics' and 'adaptive dynamics'?
- Is game theory too simplistic? What if the contestants have different probabilities of winning, for example?

Discussion questions II

- How does game theory change our understanding of the 'fitness landscape'?
- How are ESSs realized in individuals – are individuals actually at the ESS? Is there frequency dependence for adopting the ESS?