Iheb Belgacem
CS-Mai 2019

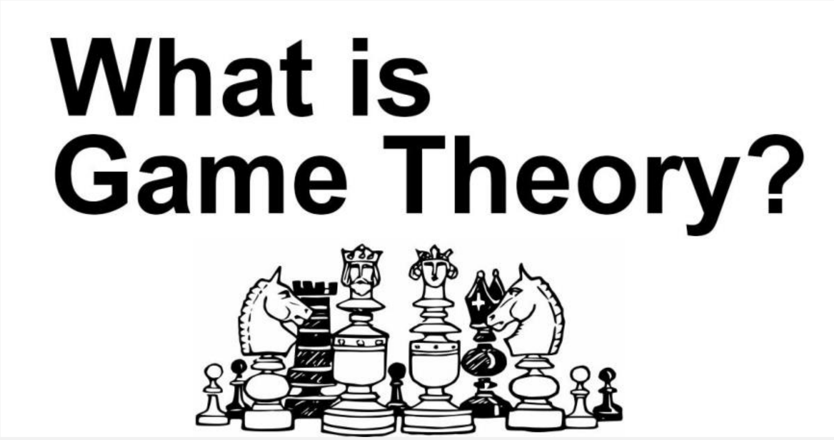
EVOLUTIONARY GAME THEORY

Course PH2821JB

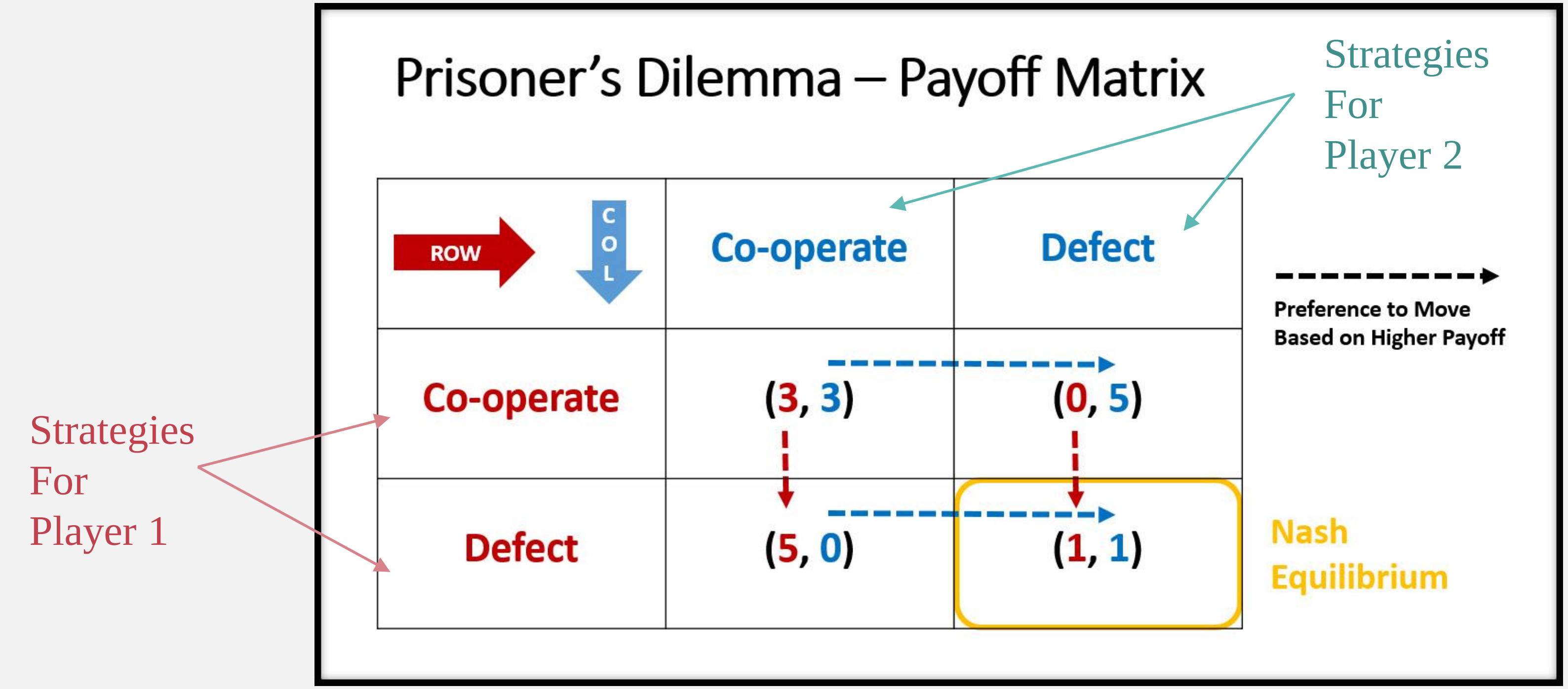
Final Project

CLASSICAL GAME THEORY

- branch of applied mathematics
- provides tools for analyzing situations in decisions that are interdependent.
- A **solution** to a game describes the **optimal decisions** of the players



CLASSICAL GAME THEORY



Source: http://www.studycas.com/component/k2/revisiting-nash-equilibrium-in-prisoner-s-dilemma

EVOLUTIONARY GAME THEORY

- Games played by groups of animals, each group share a gene to which correspond a strategy
- Frequency dependent fitness

. Natural Selection determines which strategy becomes predominant in the overall population.

Strategy

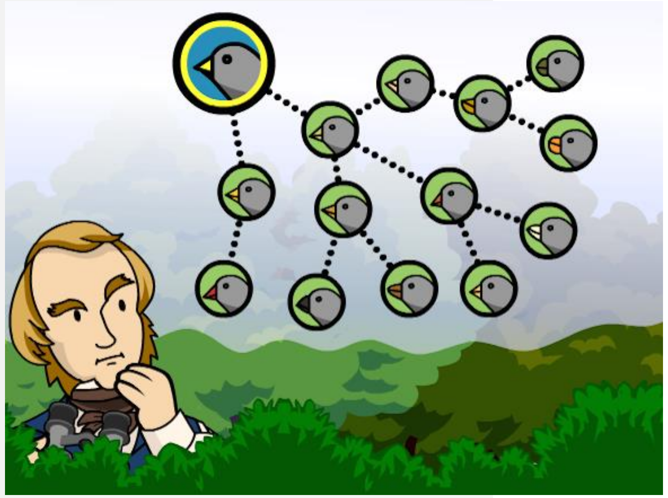
EVOLUTIONARY GAME THEORY

In the context of EGT:

- Strategies are not deliberate decisions made by the players
- Survival of the fittest

Payoff ⟷ Darwinian fitness

Expected number of offspring



Natural Selection

EVOLUTIONARY STABLE STRATEGIES

An evolutionarily stable strategy (ESS) is a strategy which, if adopted by a population in a given environment, is impenetrable, meaning that it **cannot be invaded** by any alternative strategy that is initially rare.

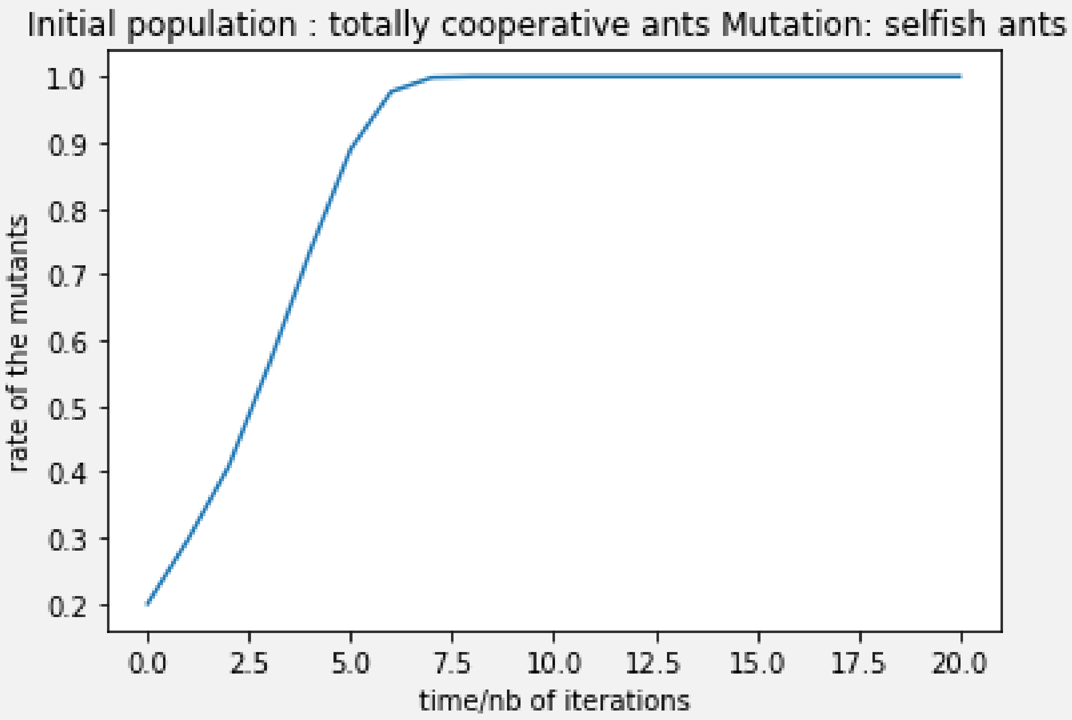
For Example : **Prisoner's Dilemma**

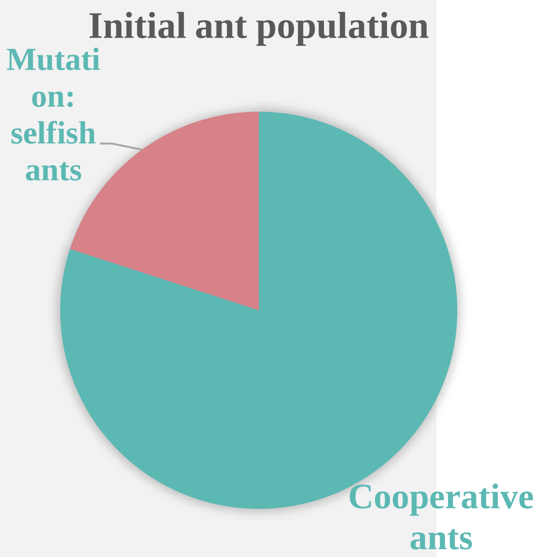
We have a population of **N cooperative** ants, if there is a **mutation** that creates ants that are selfish. How will evolve the group of the mutant ants?

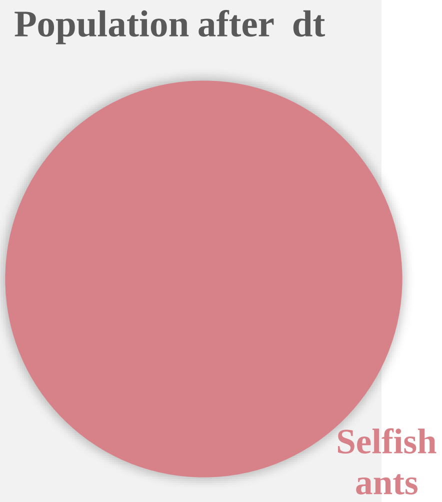
Payoff Matrix

	C	D
C	**(2,2)**	**(0,3)**
D	**(3,0)**	**(1,1)**

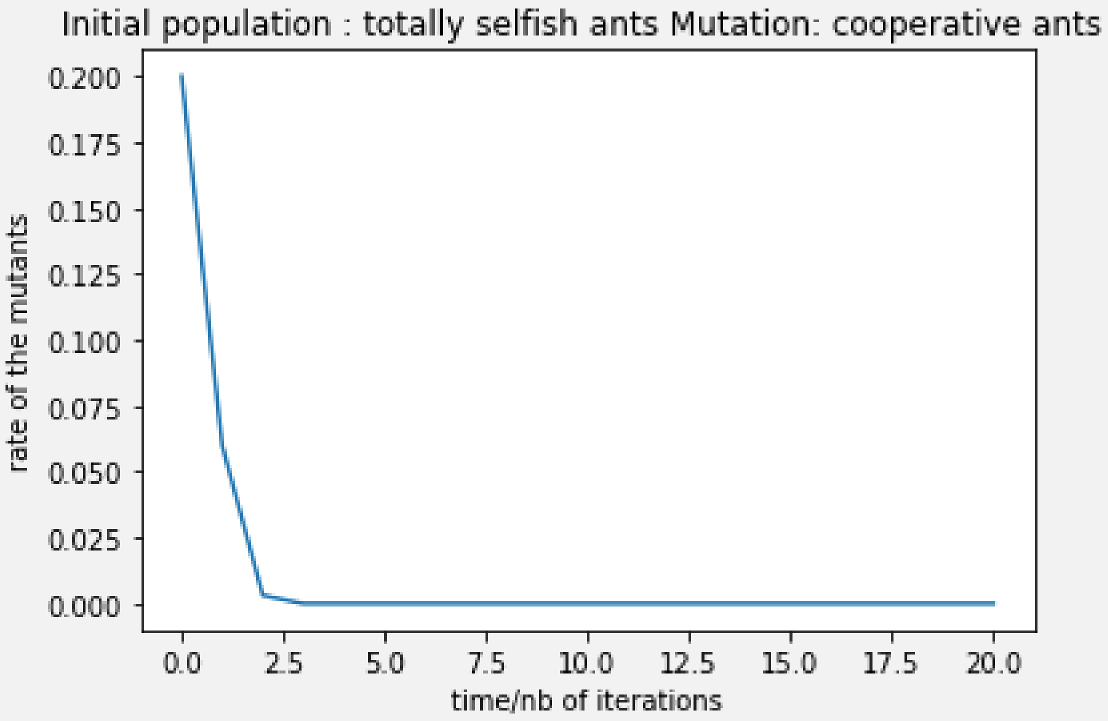
EVOLUTIONARY STABLE STRATEGIES

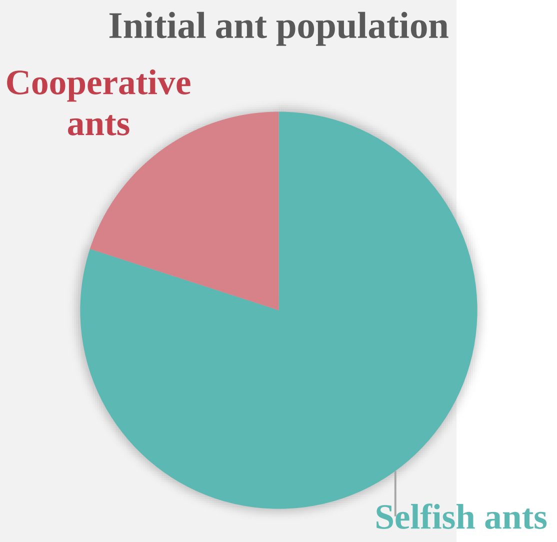


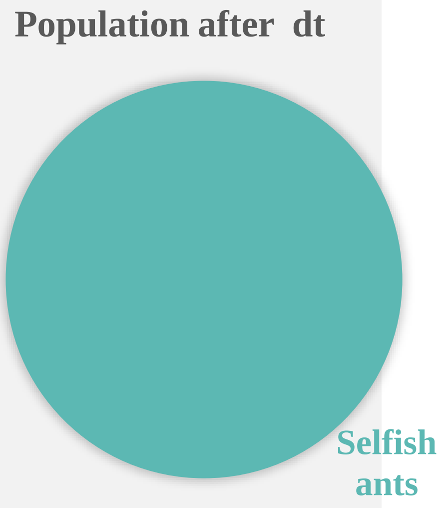




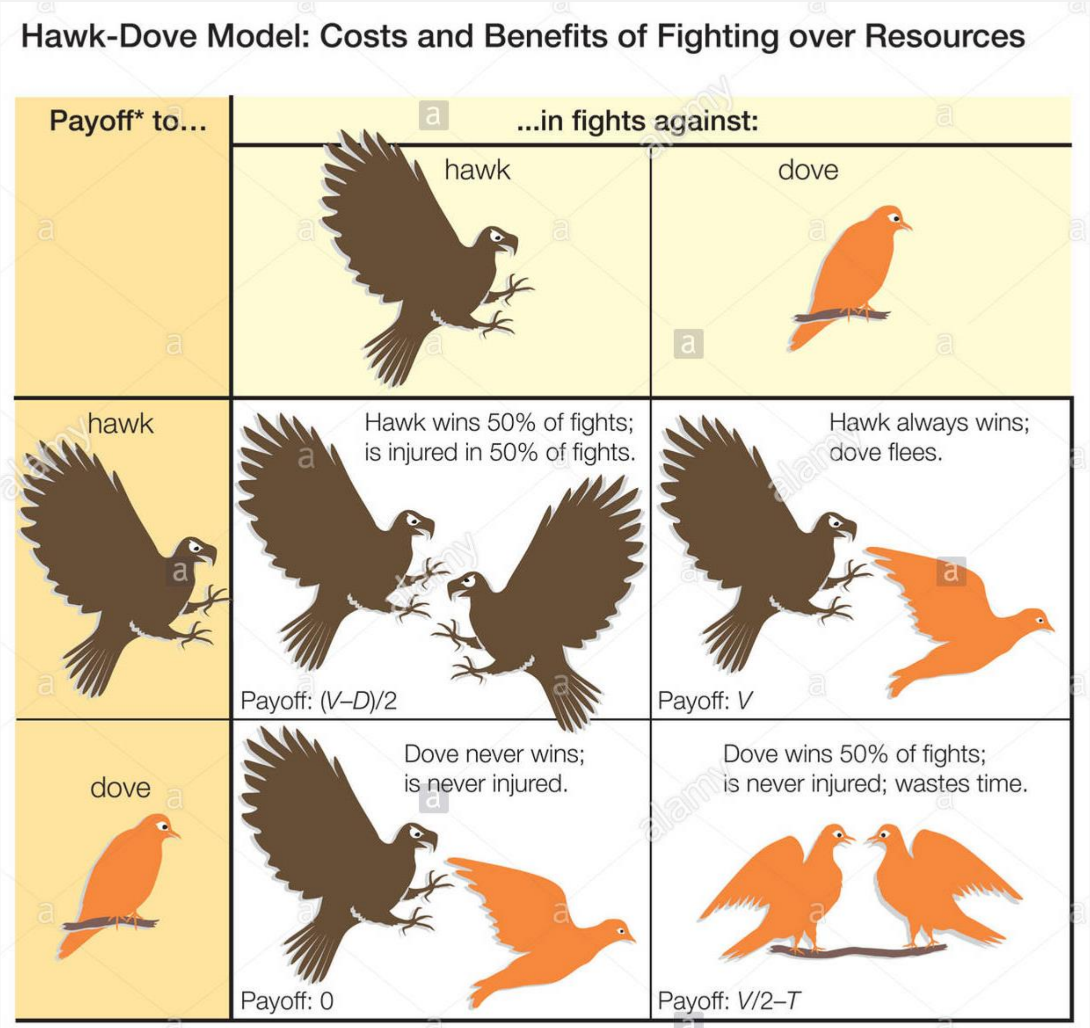
EVOLUTIONARY STABLE STRATEGIES







A CLASSICAL EXAMPLE



REPLICATOR DYNAMICS

- Symmetric Game with payoff Matrix A, Population of n types
- $\boldsymbol{x_i = f(t)}$:frequency of strategy **i**
- State of the population is represented by the vector **x**= $\begin{pmatrix} x1 \\ x2 \\ . \\ . \\ xn \end{pmatrix}$
- Expected payoff for an individual of type **i**: $(A * x)_i$
- Average payoff in the population state **x**: $x^T * A * x$
- Replicator dynamics equation: $$\frac{d\boldsymbol{x_i}}{dt} = \boldsymbol{x_i} * ((A * x)_i - x^T * A * x) \quad \forall\, i \in \{1..n\}$$

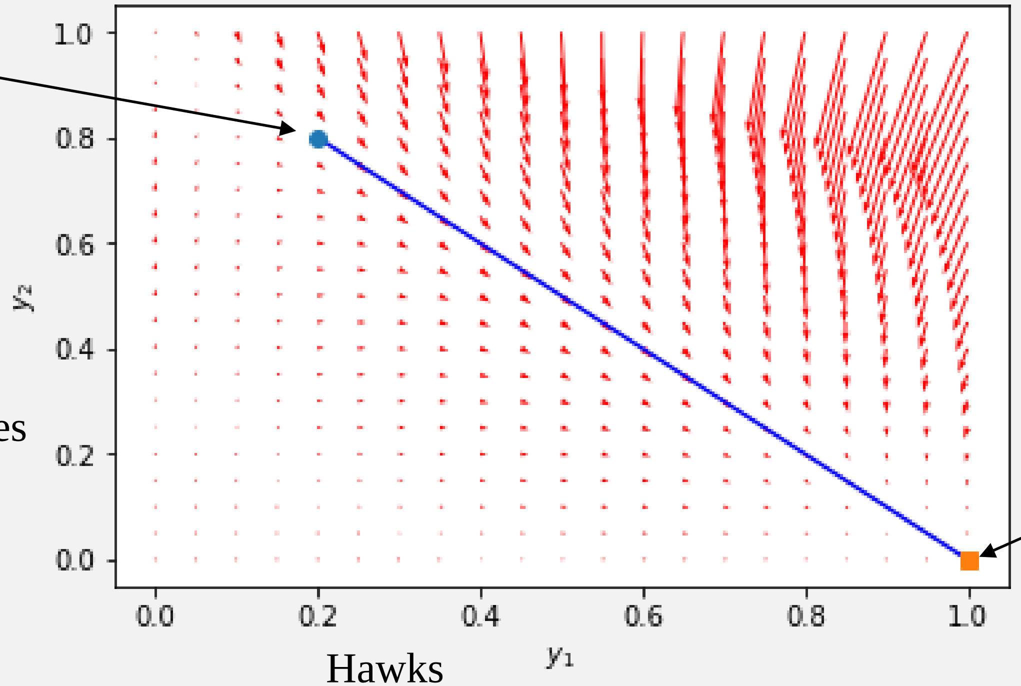
DISCUSSING THE RESULTS

- *First Case : V>= C*
- We have one evolutionary stable situation, a situation where there are only Hawks in the population,

In fact, if the value of the resource is high and the cost of fighting low, it’s logical to observe fights between animals

Initial distribution of genes

% Doves



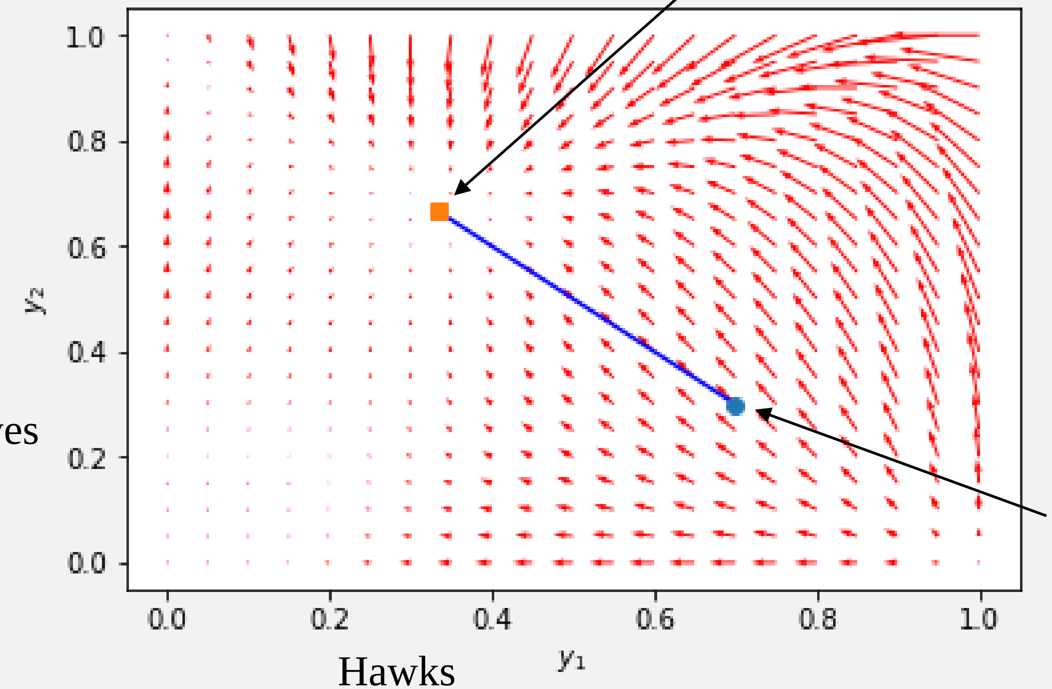
Hawks

ESS

DISCUSSING THE RESULTS

- *Second Case : C>= V*
- We have one evolutionary stable situation, a situation where there is V/C Hawk (in this case 1/3) and the rest of the Population is Dove This situation is the most commun in nature.

ESS

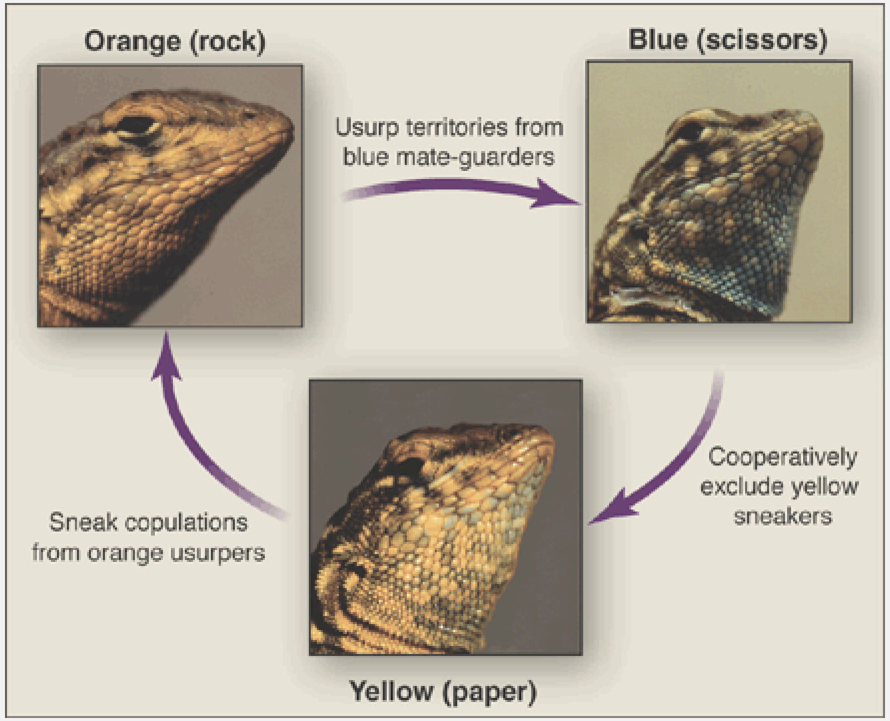


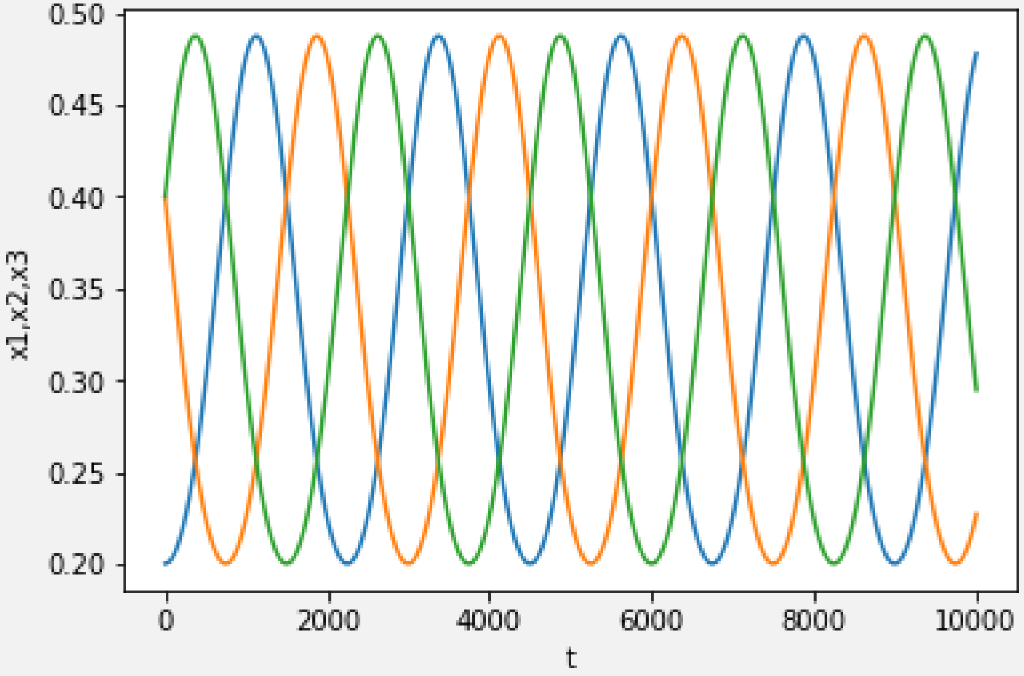
% Doves

Hawks

Initial distribution of genes

THE SIDE-BLOTCHED LIZARD





- *There is no evolutionary stable strategy !*

BIBLIOGRAPHY

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- *Game Theory with Engineering Applications :* Asu Ozdaglar- MIT
- *Evolutionary game Theory* Karl Sigmund and Martin A. Nowak
- *Evolutionary game Theory*, Jörgen Weibull, Toulouse School of Economics,

THANK YOU FOR YOU ATTENTION