Game-based tools to transmit freshwater ecology concepts

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INTRODUCTION

- There is an increasing awarness of the public on environmental issues
- Expert knowledge is often required to understand them
  - → **A need for simple and understandable tools to explain environmental issues**
- Games provide a virtual world with given boundaries (rules) that the player needs to understand and to follow to win
- Furthermore, games are dynamic and interactive: the player engagement and its knowledge retention increase
  - → **Games display interesting features to spread scientific thinking[1]**

OBJECTIVE

TO DEVELOP A BOARD GAME AND A COMPUTER-BASED GAME TO EXPLAIN THE BASIC CONCEPTS OF AQUATIC ECOLOGY

The games aim to be **complementary**:

→ in term of **player interactions** and **system dynamics**
→ in **the targeted players** (groups vs isolated gamers)

METHODOLOGY

STEP 1 – CONTEXT
- **Aim** of the games
- **Aquatic species and ecological concepts**
- Inclusion of **time** and **chance**

STEP 2 – PROTOTYPES
- **Design** of the games (players , token, board)
- **Size** and **layout** of the board
- Coding and **calibration** of the model

STEP 3 – TEST AND EVALUATION
- **Gather player feedbacks**
- Refining and **adapting the games**

STEP 4 – DIFFUSION
- Identification of **funding opportunities**
- Construction of a **diffusion network**

BOARD GAME

DEVELOPMENT OF THE PROTOTYPE

• Context

- The **player is a fish**, either a predator or a prey
- The **objective** of the game is **to reach a stable population of fish**
- Concepts illustrated**: feeding strategy, reproduction, predation and competition**

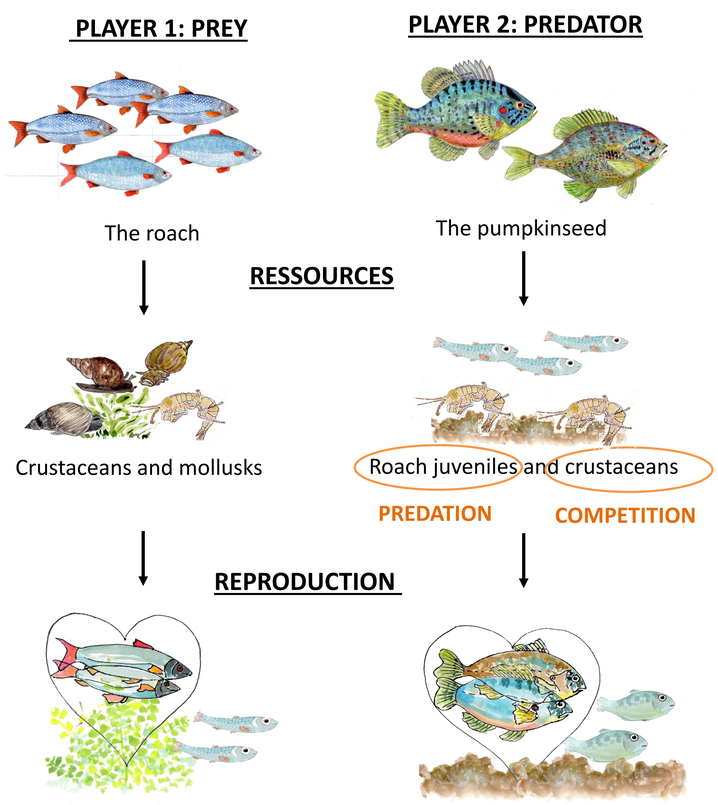
• Basis of the board game

- **Species**: the **roach** (*Rutilus rutilus*) as a prey and the **pumpkinseed** (*Lepomis gibbosus*) as a predator, two **common european small fish**
- Illustration of a **native european shoal fish** (the roach) and of an **invasive species** (the pumpkinseed) with **specific life history** characteristics

HOW TO PLAY THE GAME

- The board represents the **edge of a lake** with **plants, crustaceans, and mollusks**
- The player choses a fish species and starts the game with 2 token (male +female)
- The players **use dices** to **move the tokens** on the board and to **find ressources**
- Each ressource provides the fish with a **given amount of energy** that he accumulates
- This energy can further **be used to reproduce** (adult fish), to **grow** (juvenile) or to **attack** a prey (predator)
- Each turn, the player takes **a card « chance »** representing the **events impacting the lake**

• Ecological characteristics of each player:



EXAMPLE OF « CHANCE » CARD

A solitary pike is swimmig around… Watch out! You just lost one fish

Tonight is full moon. You see as well as in day light: play again

The forestry guards cut threes near the lake: plants become much more light! Snails eat more: they bring twice more energy for 2 turns

A fisherman put his boat onto the water. He repainted it with antifouling: no mollusk for 2 turns

Opening of a fishing contest. The introduced fish destroyed the whole bottom of the lake: no more ressources in the area for 2 turns

COMPUTER-BASED GAME

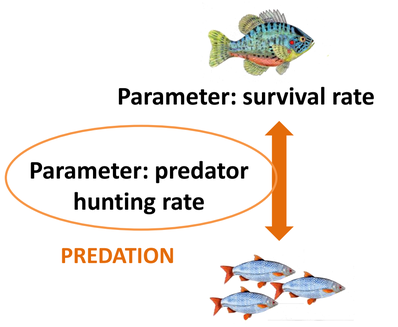
DEVELOPMENT OF THE PROTOTYPE

• Context

- The **player controls an ecosytem with preys** (the roach) **and predators** (the pumpkinseed)
- The **objective** of the game is to **maintain the stability of the ecosystem**
- Concepts illustrated: **population dynamic** and **ecosystem resilience**

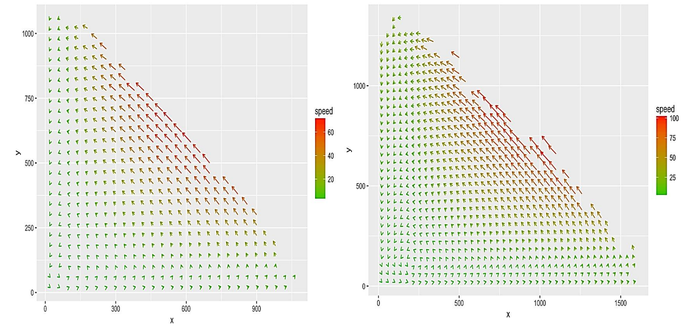
• Basis of the computer-based game:

- **An agent-based model[2]** (ABM) for a simple prey-predator system is proposed as a basis of the computer game (Netlogo software)
- ABM **simulate the behavior and interactions between agents** (fish) to reconstruct the **population dynamic** (bottom-up approach)
- **Stochasticity** is included with spatialized interactions (smoothed brownian motions), illustrating the **randomisation of prey-predator interactions**



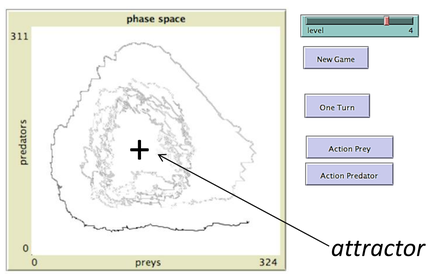
• Model calibration:

- **Systematic exploration of parameter space** using OpenMole software[3], to verify theoretical average trajectories in phase space, which allows analytical and numerical determination of initial position (**attractor**) and justify the use of this system for the game. The figures show **estimated average trajectories** for two points in parameter space.

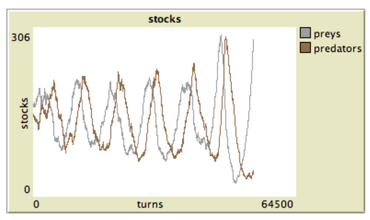


HOW TO PLAY THE GAME

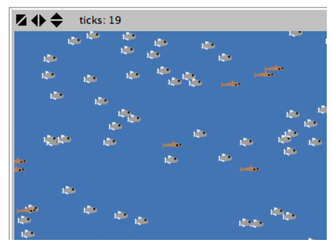
- The player starts the game with **a stable ecosystem:** the **initial position** is the **attractor**
- The button « **one turn** » makes the ecosystem evolve during **50 time steps**
- The player **sees the changes** in the fish populations **simustaneoulsy on the screen**
- **The trajectory can be corrected** towards the attractor **in the phase space** by **changing the parameters** of the model (predator survival, prey reproduction and hunting behavior)
- **External events randomly perturbate the ecosystem**
- The game includes **5 levels of difficulty** based on **event strength**



Phase space figuring in **Y axis the predators** and in **X axis the preys** (Netlogo interface)



The stock: representation of the **oscillations in fish populations** (Netlogo interface)



The **ecosystem**: representation of the **fish populations** (Netlogo interface)

- Open source: code available at https://github.com/JusteRaimbault/MediationEcotox

DISCUSSION

- ✓ Demonstration of the **proof-of-concept**: the **prototypes are available for testing**
- ✓ Both game are **complementary** as they integrate different time scales and illustrate diverse basic concepts of aquatic ecology
- ✓ **No knowledge in aquatic ecology is needed to play both games**: wide possibilities in targeted audiences
- ✓ The methodology is **flexible** and **adaptable**:
  - **On-going development** of the games
  - **Refinements** and changes are **easy to integrate** in new versions of the games

PERSPECTIVES

Short term perspectives:

- **Next step** of the project: **test the games and gather player feedbacks** → do players like the games?
- **Identification of potential players** (children, school/university, family, adults…) and **adaptation of the games** accordingly (simplication/complexification)

Long term perspectives:

- **Potential uses** of the games as **educational tools** (with educative support) or **sensibilisation tools** (e.g. adapting the species and perturbations)
- **Funding** and **diffusion** of the **board game** through **crowdfunding plateforms and game festivals**
- **Diffusion** of the **computer-based game**: open online access through **Netlogoweb** and development of **mobile applications**

References: [1]Morris, B. J. et al. (2013). Gaming science: the "Gamification" of scientific thinking. *Frontiers in psychology, 4.* - [2]Grimm, V., et al. (2005). Pattern-oriented modeling of agent-based complex systems: lessons from ecology. *Science, 310(5750), 987-991.* - [3]Reuillon, R., et al. (2013). OpenMOLE, a workflow engine specifically tailored for the distributed exploration of simulation models. *Future Generation Computer Systems, 29(8), 1981-1990.*