Lab4 Simulation :

SIMULATION OF RABBIT POPULATION GROWTH

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I. Rabbit population simulation : Fibonacci method :

For the first experience of the simulation, we used Fibonacci numbers to generate rabbits family tree

1. Code:

```
int fibonnaci(int N) {

    if (N == 0 || N == 1) {
        return 2;
    }
    else {
        return fibonnaci(N - 1) + fibonnaci(N - 2);
    }
}
```

We used recursive technic to create a Fibonacci function in C language, it consists of a sequence of Fibonacci's function calls inside itself, with the adjustment of the parameter N, which represent the number of steps in Fibonacci numbers. The Fibonacci numbers used in this function starts with 2, 2 comparing to the original one that starts with (0, 1), because in our experience, we need at least a couple to simulate a population, which modify the original Fibonacci numbers but apply the same method of calculation.

2. Results:

We supposed that the rabbits tree starts with an immature couple (N=0) and by the first step (N=1) they became mature, which makes us assume that the first step is between 5 and 8 months in real life. By the second step (N=2), and following Fibonacci's calculation, the first couple produce their first pair, making a total population of 4.

The following figure shows a sequence of 23 generation (steps) using Fibonacci function.

STEP	POPULATION	STEP	POPULATION	STEP	POPULATION	STEP	POPULATION
0	2	6	26	12	466	18	8362
1	2	7	42	13	754	19	13530
2	4	8	68	14	1220	20	21892
3	6	9	110	15	1974	21	35422
4	10	10	178	16	3194	22	57314
5	16	11	288	17	5168	23	92736

figure 1 : Table of 23 generations of Fibonacci's technic

3. Analysis:

The main problem with the Fibonacci rabbits' tree is that we don't take into consideration the death of a rabbit, as shown in the function, the rabbits generated are immortal, which is far from reality as the life expectancy of a rabbit is about 9 years, which lead us to a population of zombie rabbits that are dead but still giving birth.

The second problem is the unrealistic steps and generation duration, as explained before, each step for an immature pair (the first generation and every new born) represent their hole maturity phase which is 5 to 8 months, at the same time, one step represent to a mature pair their pregnancy and giving birth of pair, the duration in real life is one month, so one step is time irrational.

There are many other probability problems as the fact of obtaining in each litter two baby rabbits, one male and one female which is far from the real statistics.

II. Rabbit population simulation: More realistic population growth:

For the second part, we will be using a more realistic program to generate the rabbit population, using life observed statistic and probability, to try and solve some of the problems observed in the last experience.

1. Code :

```
typedef struct Rabbit {
    char sex;            // M: Male, F: Female
    int status;           // 0:dead ou 1:alive
    int age;              // 0:just born, >0 age in months
    int mature;           // 0:no, x1:yes(adult) x is the age it become adult
    int pregnant;         // 0:no, 1:yes
    int nbLittersY;       // number of litters a female rabbit must have in a
                          // year

    int nbLitters;        // number of litters made in a year
    int srvRate;          // survive rate <= 100%, <0 means has been used, >=0
                          // will be used (is positif when created or updated)
    struct Rabbit* nextRabbit;  // next rabbit

}Srabbit;
```

During this we will consider the rabbit tree as a linked list sorted by generation, more precisely every brother and sister will be linked closely to each other, and at the same time followed by the other siblings on the same generation.

Every element of the list, that represent a rabbit, is a C structure that contain 9 parameters: rabbit information's parameters like sex, status, age, maturity, pregnant, and probability parameters nbLittersY that represent the yearly number of litters that will be generated, nbLitters that shows how many litter the rabbit did for that year, the srvRate for survive rate and finally a pointer to the next rabbit in the list.

The probabilities in the code works monthly but with a yearly cycle, as for the number of litter that each female will do this year is calculated for the first time in the month she became mature, we will calculate how many litter a female will do that year and then we will distribute that number of litters on the 12 next months, at the end of the year a new number will be generated for her second maturity year. As for survival rate, it will be recalculated and applied once every year.

2. Results:

The program takes two parameters, the first for the number of rabbits of the first generation, and the second one the duration, in months, of the experience.

Here's the results of an experience with 10 rabbits at the begging for 30 months.

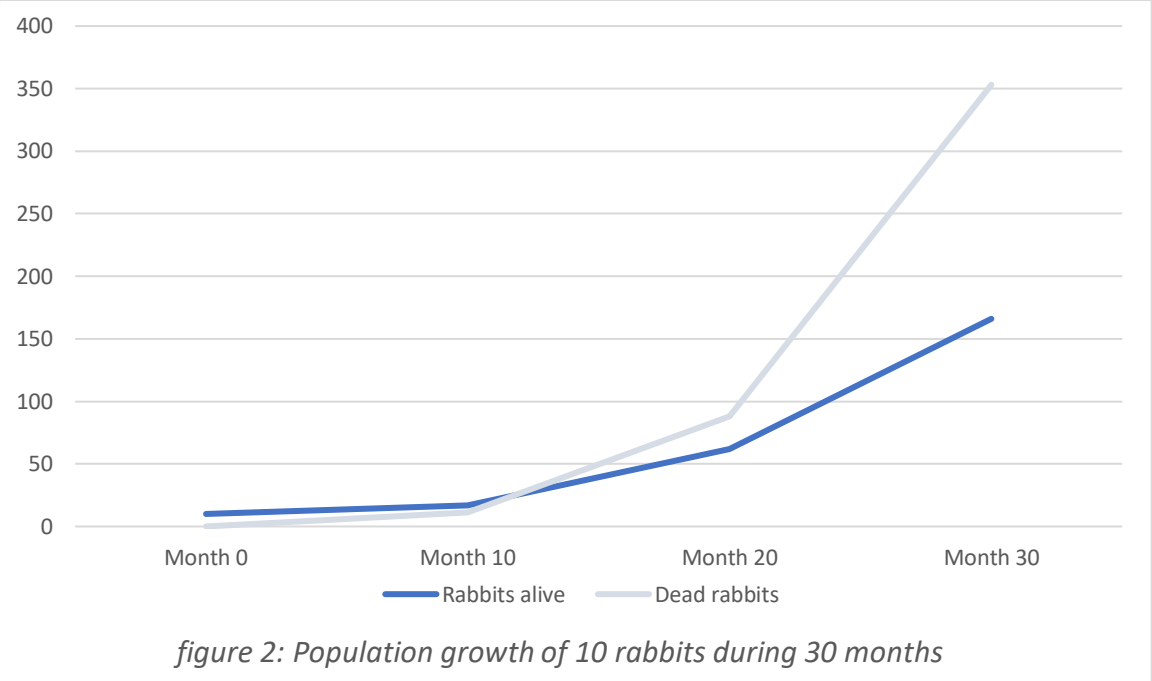

figure 2: Population growth of 10 rabbits during 30 months

In the first experiment, we observed that the number of dead rabbits was almost twice the number of alive rabbits, likely due to the high number of new kittens being born and the relatively low 35% survival rate. This survival rate appears to decline rapidly, as the number of alive rabbits was only slightly higher than the number of dead rabbits until the 10th month, when the number of litters was still low.

For the second experiment, we will run 10 times 4 populations for 50 months, each with a different initial population size and then get the average for each population. The purpose of this experiment is to investigate how the initial population size affects population growth and survival rates.

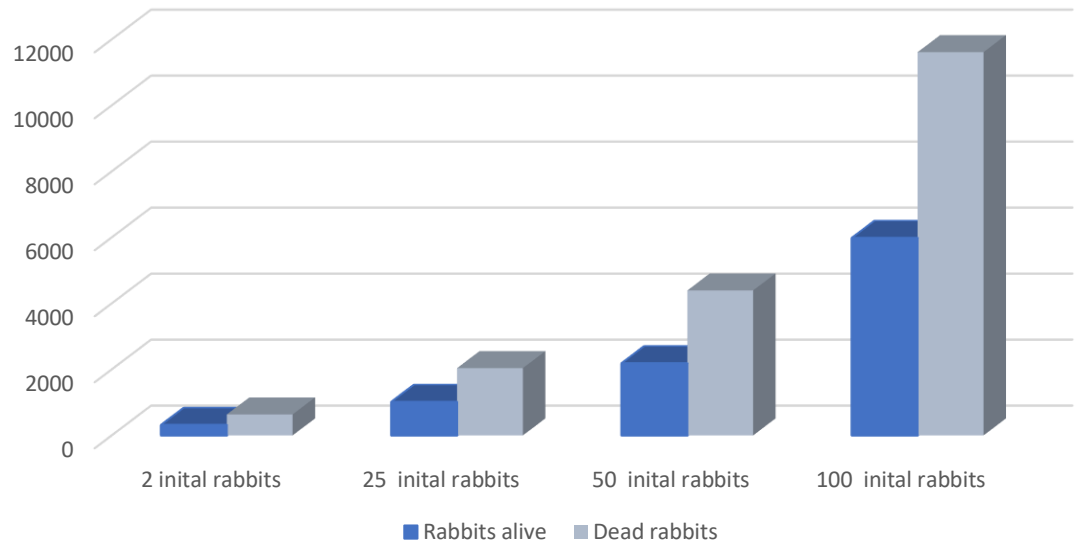

figure 3: The growth of 5 differnts population during 50 months

The number of rabbits generated is proportional to the number of initial rabbits, which suggests that a larger initial pool can provide greater stability of growth. To investigate this phenomenon further, we will run 5 trials of 2 experiments: one with a single pair of initial rabbits and the other with 100 initial rabbits (50 pairs). The aim is to determine whether the number of initial rabbits affects the consistency and continuity of population growth, and to what extent.

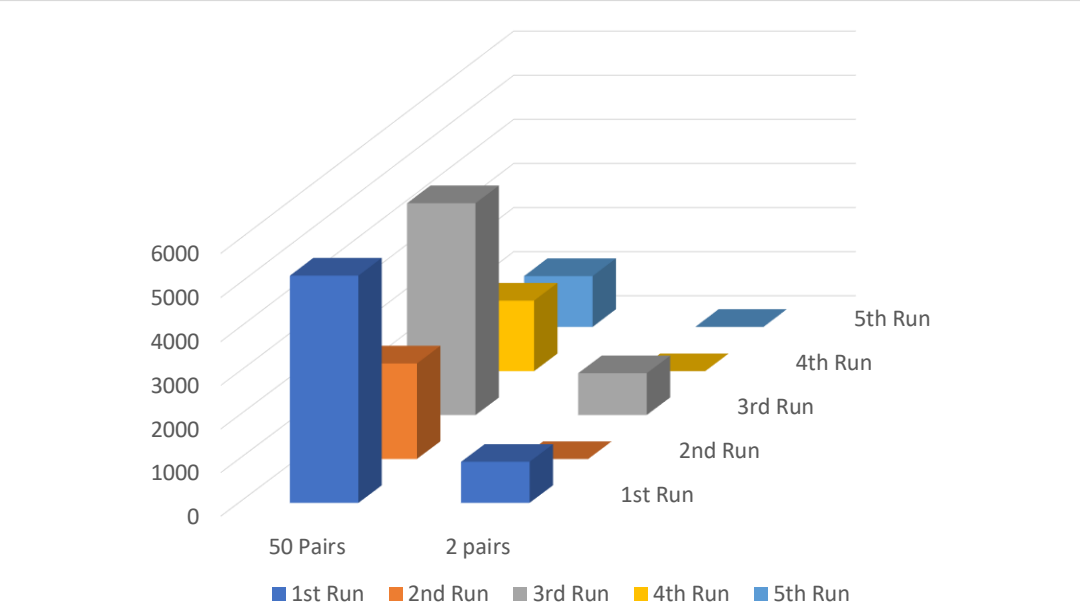

figure 4: Set of run for 2 population for 50 months

For the two populations, 3 out of 5 runs showed a remarkable decrease in the final number of rabbits. For the 2 pair pool, the growth stopped from the beginning as the pair died before maturity, leading to 0 rabbits alive at the end. The same happened to the 50 pair pool; three runs ended up with half the population compared to the other two, with the explanation being the 35% survival rate for the initial pool that decreased from the beginning. Despite this, due to the high number of pairs in the initial pool for the second experiment, some pairs experienced population growth.

III. Conclusion:

The rabbit population growth tree experience is a complex model that requires careful consideration of multiple parameters and factors. While the Fibonacci technique provides a simplified first prediction, it has several limitations that can affect its accuracy and realism.

In the second part of the experience, we considered factors such as age, maturity, survival rate, and litters rate to create a more realistic population growth model. We incorporated these factors into the model by adjusting the number of rabbits that survive to reproductive age, predators' threat, the number of litters per year, and the number of kittens in each litter.

However, there are still many factors that we did not consider in the model, such as geographical location, weather, and how seasons affect growth, maturity, and survival rate. These factors can have a significant impact on the growth of a rabbit population and should be taken into account in future iterations of the model.

Overall, through this lab, we went from a simple generic simulation of a rabbit population growth into a more realistic version, but it requires ongoing refinement and improvement to accurately reflect the complex dynamics of real-world populations.

SOURCES:

Lab4 link : https://perso.isima.fr/~dahill/L2-SIMU/Lab%20%23%204a%20-%20Rabbit%20Population%20growth.pdf

Fibonacci numbers: https://r-knott.surrey.ac.uk/Fibonacci/fibnat.html

Image: https://education.nationalgeographic.org/resource/limiting-factors/

Checking for grammatical errors and comprehension revision : https://chat.openai.com/