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Study of Fungi as Decomposer

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Abstract: This paper links environmental factors with the activity, growth and reproduction of fungi, and then analyze the changes of envi-ronment and biodiversity in the entire simulated environment. Firstly, the paper simulates the decomposition of woody fiber, getting the inherent growth rate, random diffusion rate, intra-species competition coefficient and inter-species competi-tion coefficient of the three fungi.Through the establishment of different kinds of biological competition model, we simulate the changes in their population density. Secondly, the model is built for evaluating the advantages and disadvantages of species and species combinations, and then obtain the relative dominance of each species, the competitiveness of different groups fluctuates greatly, and the long-term result is that a combination loses competitiveness.

1. Introduction

The carbon cycle is a biogeochemical cycle, which refers to the exchange of carbon el-ements in the earth’s biosphere, lithosphere, soil sphere, hydrosphere and atmosphere.The cycle describes the recovery and reuse of carbon on the earth, including removing carbon dioxide from the atmosphere and releasing carbon dioxide into the atmosphere. The decom-position of compounds is the process of producing carbon dioxide, and the decomposition of plant materials and woody fibers is a key part of this process.

Fungi plays a key role in the process of woody fiber decomposition.Recently, scholars have determined the fungal characteristics that determine the decomposition rate, such as growth rate, moisture resistance and so on, they also discovered the intrinsic relationship between these characteristics.

2. Models and solutions

2.1 Different Kinds of Biological Competition Model

2.1.1 Analyze

On the land we determine, we need to describe the dynamic changes of different types of fungi under short-term and long-term interactions.Therefore, we build a model of the repro-ductive pressure of multiple competing species within and between populations to illustrate the dynamic changes of their species.

2.1.2 Model Construction

We use Lotka-Volterra competition model [5] to study the reproductive pressure of com-peting species within and between populations.Then we extend it to a fixed environment.Based on three kinds of fungi: Fomitopsis pinicola, Clonostachys rosea and Phlebia centrifuga, we build the corresponding competition model, so we get:

$$\frac{\partial x}{\partial t} = \Delta U + x \cdot (a_1 - b_1 \cdot x - c_1 \cdot y - c_3 \cdot z) \tag{1}$$

$$\frac{\partial y}{\partial t} = \Delta V + y \cdot (a_2 - b_2 \cdot y - c_1 \cdot x - c_2 \cdot z) \tag{2}$$

$$\frac{\partial z}{\partial t} = \Delta W + z \cdot (a_3 - b_3 \cdot z - c_2 \cdot y - c_3 \cdot x) \tag{3}$$

Where

$$\begin{cases} U = d_1 \cdot x + \rho_{11} \cdot x^2 + \rho_{12} \cdot x \cdot y \\ V = d_2 \cdot y + \rho_{21} \cdot x \cdot y + \rho_{22} \cdot y^2 + \rho_{23} \cdot y \cdot z \\ W = d_3 \cdot z + \rho_{31} \cdot y \cdot z + \rho_{32} \cdot y \cdot z + \rho_{33} \cdot z^3 \end{cases}$$

When self-diffusion and cross-diffusion terms are not considered, that is ρ_{ij}= 0, where i, $j \in \{1,2,3\}$, the model degenerates to the classic Lotka-Volterra competition model, so we have:

$$\frac{\partial x}{\partial t} = d_1 \cdot x + x \cdot (a_1 - b_1 \cdot x - c_1 \cdot y - c_3 \cdot z) \tag{4}$$

$$\frac{\partial y}{\partial t} = d_2 \cdot y + y \cdot (a_2 - b_2 \cdot y - c_1 \cdot x - c_2 \cdot z) \tag{5}$$

$$\frac{\partial z}{\partial t} = d_3 \cdot z + z \cdot (a_3 - b_3 \cdot z - c_2 \cdot y - c_3 \cdot x) \tag{6}$$

Where $bi = \frac{a_i}{n_i}$, that is different kinds of biological competition model.

Considering that the degraded model is in an ideal state and does not conform to re-ality, first,we use the population density obtained at each moment for normal distribution random processing.Then,it can be obtained taht the population density of three species at time t, obtain a normal distribution with a variance of 1 through the method of normal distribution random processing and take its mean.At time t, estimate the population density of Fomitopsis pinicola to be x X,the population density of Clonos-tachys rosea to be y X,the population density of Phlebia centrifuga to be $z \pm X$, where $X \in [-3,3]$, and meet the probability of 68.3%, 27.1%, 4.3% respectively.Finally,we get the result by random processing.

2.1.3 Solving the Model

The corresponding data is substituted into the model, where

Table 1: The corresponding data

$a_1 = 1{:}5$	$a_2 = 1$	$a_3 = 2$
$b_1 = 1{:}5{=}25$	$b_2 = 1{=}25$	$b_3 = 2{=}25$
$c_1 = 0{:}0425$	$c_2 = 0{:}024$	$c_3 = 0{:}04$
$d_1 = 1$	$d_2 = 1$	$d_3 = 1$

with the help of matlab, we get the population changes of three fungi, from the rusults, it can conclude that over time, the population density of fungus 1 and 2 decrease exponentially, the population density of fungus 1 increases in a logarithmic function, finally all of them show a stable change.And fungus 1, 2 and 3 are 2.409 pcs/m^2, 10.42 pcs/m^2, 46.9 pcs/m^2.

Since the three fungi grow on the surface of woody fiber, woody fiber are reguarded as a rectangular plane.

In addition, in order to better observe the population density relationship of the three fungi, first select $T = 0$, $T = 10$, $T = 20$, $T = 30$ four time nodes, and then use the Monte Carlo algorithm, combined with formula 2 ,4 ,5,6,7. The number of individuals in the pop-ulation corresponding to the four time points is expressed on the two-dimensional plane abstracted by woody fiber, as shown in the Figure 1:

(a) $T = 0$ (b) $T = 10$ (c) $T = 20$ (d) $T = 30$

Figure 1: Population density simulation model

2.2 Species and Species Combination Evaluation Model

2.2.1 Analyze

In order to predict the relative advantages and disadvantages of each species and the combination of species that may continue to exist, we establish an evaluation standard to measure the advantages and disadvantages of the fungi we select in the entire community.

2.2.2 Model Construction

Determine the advantages and disadvantages of species and species combinations in the environment by calculating relative dominance [6].

$$A_i = \frac{n(i,t)}{\sum_{i=1}^{3} n(i,t)} \tag{7}$$

$$C_i = \frac{n(i,t) - n(i,t-1)}{n(i,t-1)} \tag{8}$$

$$D_i = \frac{A_i + C_i}{2} \tag{9}$$

Following the analysis above, it can be obtained the calculation formulas for the relative abundance, relative colonization frequency, and relative dominance of the combined species after the combination of species, as follows:

Combination of 1, 2:

$$A_{12} = \frac{n(1,t) + n(2,t)}{\sum_{i=1}^{3} n(i,t)} \tag{10}$$

$$C_{12} = \frac{[n(1,t) + n(2,t)] - [n(1,t-1) + n(2,t-1)]}{n(1,t) + n(2,t)} \tag{11}$$

Where subscript 12 represents the combination of population 1 and population 2.

Combination of 1, 3:

$$A_{13} = \frac{n(1,t) + n(3,t)}{\sum_{i=1}^{3} n(i,t)} \tag{12}$$

$$C_{13} = \frac{[n(1,t)+n(3,t)]-[n(1,t-1)+n(3,t-1)]}{n(1,t)+n(3,t)} \tag{13}$$

Where subscript 13 represents the combination of population 1 and population 3.
Combination of 2, 3:

$$A_{23} = \frac{n(2,t)+n(3,t)}{\sum_{i=1}^{3} n(i,t)} \tag{14}$$

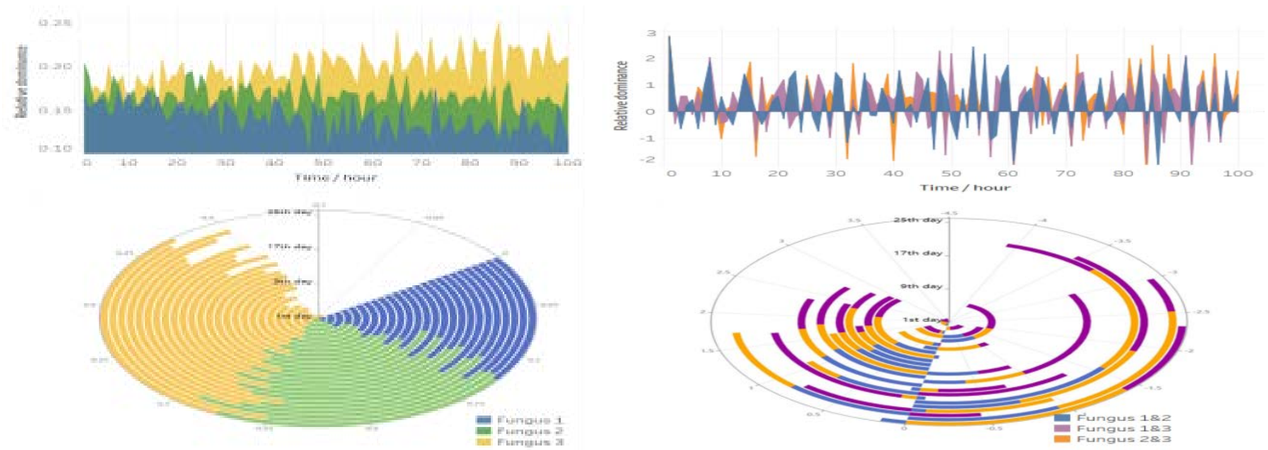
$$C_{23} = \frac{[n(2,t)+n(3,t)]-[n(2,t-1)+n(3,t-1)]}{n(2,t)+n(3,t)} \tag{15}$$

Where subscript 23 represents the combination of population 2 and population 3.

Using the calculated individual numbers in the populations of the three fungi at each time point, substitute formulas 1 to 15, it can be obtained the relative dominance of each species and the combination of species that may persist.

2.2.3 Solving the Model

According to the data obtained from the solution of 2.1, substituting the equations in the evaluation model of the advantages and disadvantages of species and species combi-nations, the relative advantages of species and species combinations are obtained as follows:



(a) Separate competition for short-term models and long-term forecast results

(b) Cooperative competition short-term model and long-term forecast results

Figure 2: The relative advantages of species and species combinations

a: In this set of comparison images show the results of the relative dominance of the three species of fungi competing with each other over time. The upper area stacked chart and the lower circular pie chart show the short-term time (100 hours) and long-term time (25 Days). The circular pie chart shows the sequential results of long-term forecasts from the inside out. It can be clearly seen that the fungus 3 has achieved a relatively large competitive advantage in a short period of time. After a long period of time, the competitive advantage of the three fungi is roughly 1:1:2.

b: In this set of comparison images show the results of the relative dominance of the three fungi in the cooperative competition over time. The icon is the same as above. In this kind of competition, the combination of fungi 1 and 2 has a relatively large competitive advantage in the first 65 hours. From this moment to the 13th day, the combination of fungi 2 and 3 has the largest competitive advantage, but after 13 days, this the combination began to lose competitiveness.

It can be concluded from the table: For each species, within 0-20 hours, the relative dominance of the three fungi is not much different, that is, they are all dominant popula-tions; within 20-100 hours, the third fungus The relative dominance is significantly greater than the other two fungi, that is, fungus 3 is the dominant population, and the other two are inferior populations. The competitiveness of the three fungi remains basically unchanged for a long-term period of 25 days; for the combined species, it is 0- Within 65 hours, the rel-ative dominance of fungus 1 and fungus 2 combination species is relatively large, which is the dominant combination. From 65 hours to the 13th day, the relative dominance of fungus 2 and fungus 3 combination species is greater. Combining the population for the advantage, the other two combinations will become the highest equally competitive population in the following period.

3. Strengths and Weaknesses

Strengths:

1. The models built in the article are interlinked, qualitatively analyzing the impact of environmental factors on the entire biodiversity.

2. The model has a good verifiability to real data, and can better simulate the activ-ity, growth and reproduction of decomposers under certain environmental con-ditions.

Weaknesses:

The model built in the problem cannot be quantitatively analyzed, and not build the direct relationship between environmental factors and biodiversity.

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