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Research on the Influence of Gender Variability in The Research Model of Lampreys

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Abstract

The lamprey is a species that undergoes changes in its sex ratio with environmental changes. Due to different external environments, the sex ratio within its population also changes, which affects its population density and ecosystem balance. Therefore, based on the Lotka Volterra and logistic models, predicting the dynamic changes of the lamprey population can help maintain ecological balance, protect biodiversity, promote sustainable development, and promote the development and innovation of related disciplines. Therefore, the core of this article is to study the gender variability of lampreys and further investigate the impact of lampreys' gender changes on their population density and ecosystem.

Keywords

Gender variability, Lotka Volterra model, Logistic model.

1. INTRODUCTION

The lamprey is the most primitive vertebrate in existence, serving as a bridge between invertebrates and vertebrates[1]. Its biological characteristics and ecological adaptability have high research value. Its gender fluctuates with the growth rate of juveniles and is subtly regulated by the abundance of environmental resources. This mechanism deeply reflects the exquisite adaptation of lampreys to the environment, which has a complex impact on population reproductive strategies and ecological balance. By exploring the driving factors of gender variability in lampreys, we aim to uncover the effects and roles of certain factors that exist between individuals on their gender changes. At the same time, by comparing the similarities and differences in ecological adaptability, life history characteristics, and genetic diversity among different species[2]. Exploring the gender variability of lampreys and its impact on their population density, other species, and ecosystems, to deepen human understanding of natural laws, promote the progress and development of social civilization, and help realize the vision of harmonious coexistence between humans and nature.

2. TECHNOLOGY

Conduct research on lampreys and other species in the context of resource availability and gender variability, studying their patterns of change and their impact on populations. Determine which genetic factors are related to the pattern that causes this change through experimental data. The Gaussian distribution probability method [3]is used to explore the distribution of the lamprey population, and the definition formula is as follows:

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$$\int_{a}^{b} p(y)dy = \frac{1}{\sigma\sqrt{2\pi}}\int_{a}^{b} e^{-\frac{(y-\mu)^2}{2\sigma^2}}dy \tag{1}$$

Among them, μ is the mean population size of lampreys, and σ is the standard deviation of lampreys population size.

To explore the factors affecting the sex variability of similar species of lampreys and predict the probability of sex change occurring under different conditions. By using a logistic regression model[4], the dependent variable is set to whether there is a gender change in the juvenile lampreys, with values of "yes" or "no". And the independent variables were selected under different temperature conditions. Using logistic regression analysis, we studied the growth changes of gender variability in similar species of lampreys under different environmental temperatures. Definition formula:

$$\operatorname{logit}(P) = \alpha + \beta \bullet x_1 + \lambda \bullet x_2 + \sigma \tag{2}$$

Among them, P represents the probability of female individuals, α, β, λ are regression coefficients, and σ is the error term.

Analyzing the gender variability of similar species of lampreys based on the Lotka Volterra model. This model comprehensively considers the availability of resources and the impact of environmental factors on the gender variability of similar species of lampreys, and can simulate the trend of lampreys population changes over time. Exploring the impact of the Lotka Volterra model [5] on the sex variability of similar species of lampreys, represented by a first-order nonlinear differential equation system:

$$\begin{cases} \frac{dr}{dt} = 2r - \lambda rf, & r(0) = r0 \\ \frac{df}{dt} = -f + \lambda rf, & f(0) = f0 \end{cases} \tag{3}$$

Among them, t is time, r (t) is the number of female lampreys, f (t) is the number of male lampreys, and λ is a positive integer. The system solution has periodicity, which depends on the initial conditions, that is, for any number of r (0) and f (0), there is always a time t=tp that causes the number of male and female lampreys to return to the initial value.

3. METHODS

The study of protein (enzyme) polymorphism mainly uses protein electrophoresis technology to explore genetic variation at the protein level, which is the expression product of genes[6]. After reviewing relevant papers on gender variable species, we boldly speculate that the gender variability of lampreys is related to a certain genetic factor. Some of the factors affecting gender variability are influenced by certain genes such as Tra2a, Fem1b, Fem1c, Sox9, and Dmrt1, which show significant differences in expression between hermaphroditic and hermaphroditic clams at different ages. Foxl2 expression is significantly higher in female and hermaphroditic clams than in male clams at the same time[7]. Analysis of the distribution of serum protein electrophoresis bands and electrophoretic migration rates in male and female individuals of Japanese lampreys reveals significant differences[8].

As shown in Table 1, the distribution of electrophoretic bands of the remaining serum proteins is consistent. From this, it can be seen that there are significant differences in serum proteins between individuals of different genders of lampreys, among which the electrophoretic

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mobility of 0.083, 0.210, 0.275, 0.328 corresponds to the most obvious change in band number 16, 108, and 6, showing a clear difference between male and female individuals but not females. Therefore, it can be assumed that there are also related genes in the lamprey. The differences in serum protein profiles between male and female individuals may be related to their physical characteristics, physiological structure, and secretion levels of male and female hormones. Proteins are a manifestation of life, and their expression requires gene regulation, which may be related to the genotype that determines gender[9].

Table 1. Distribution of electrophoretic migration in different genders

electrophoretic mobility	band number	male	female
0.083	16	exist	absent
0.210	10	exist	absent
0.275	8	exist	absent
0.328	6	exist	absent

The impact of resource quantity and gender ratio on reproductive success rate is shown in Fig.1. The change in gender ratio has a certain impact on reproductive success rate under different resource levels. When the sex ratio approaches 0.5, the reproductive success rate is relatively high; When the gender ratio deviates from 0.5, the reproductive success rate is relatively low.

When the availability of resources increases, it can promote the synchronous growth rate of males and females, but both begin to slow down after reaching a certain threshold, and the growth rate of females is always higher than that of males, highlighting their efficient utilization ability of resources. When resources are scarce, the growth of larvae almost stagnates, making it difficult to sustain their survival; The increase in resources leads to a gradual peak in the growth rate of both males and females, accompanied by fluctuations. At the same time, the impact of gender ratio changes on reproductive success rate is significantly different: male success first increases and then decreases, while female success overall increases, as shown in Fig.2.

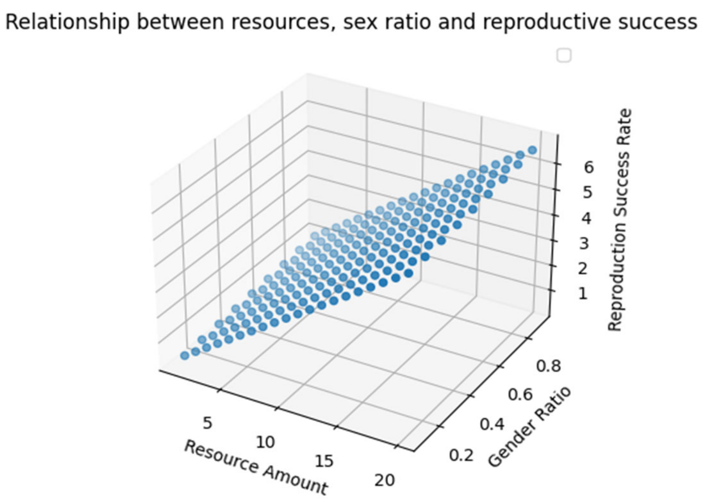

Figure 1. Relationship between Resource Quantity, Gender Ratio, and Reproductive Success Rate

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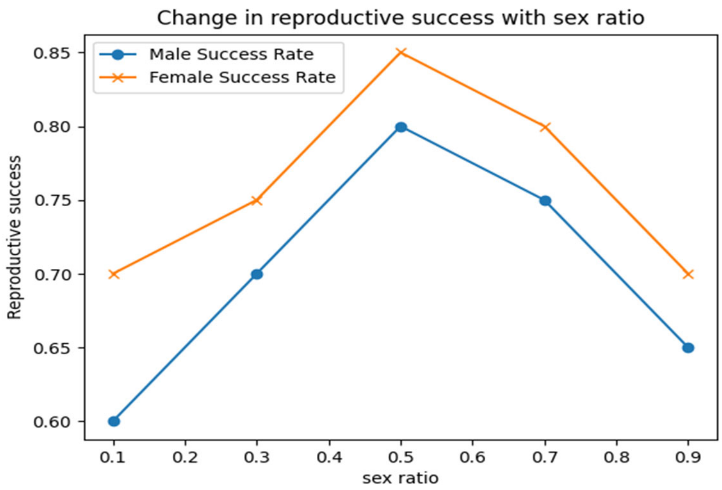

Figure 2. Trend of Breeding Success Rate with Gender Ratio

4. RESULTS ANALYSIS

4.1. The impact of gender variability on ecosystems

When the sex ratio of lampreys is unstable, the population size and predator population of lampreys will fluctuate greatly, leading to ecosystem instability. When the number of female lampreys increases, the population of lampreys also increases, posing a risk of massive predation of prey. If the prey source is sufficient, the population of lampreys can maintain stable growth; On the contrary, if prey resources are scarce, the population of lampreys will decrease. At the same time, the increase in the population of lampreys also provides abundant food supply for their natural enemies, promoting the expansion of their living space and the survival rate of their offspring, thereby increasing the number of natural enemies. As shown in Fig.3.

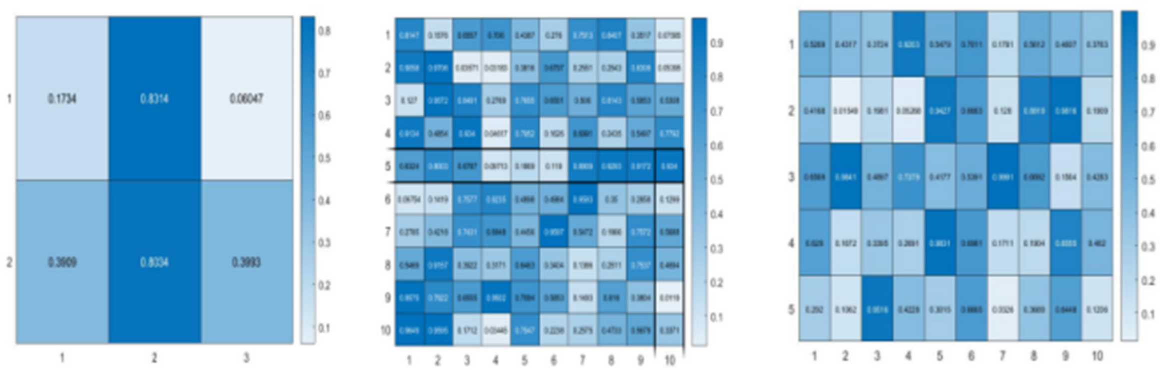

Figure 3. Relationship between Male and Female Sexuality and Factors Influencing Species Dynamics

On the other hand, the reduction in food sources can lead to a greater tendency for juvenile lampreys to develop into males. The scarcity of survival resources intensifies competition within the population, resulting in a decrease in the number of lampreys. This change indirectly affects the number of natural enemies, which is not conducive to the expansion of the reproductive space of lampreys and their natural enemies. On the contrary, the increase in food sources promotes the development of more juvenile lampreys into females, and the abundance of survival resources slows down internal struggles within the population, driving the growth

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of lampreys population and indirectly promoting changes in the number of natural enemies, providing favorable conditions for the reproduction of lampreys and their natural enemies.

4.2. The impact of gender variability on population density

Under the premise of relatively stable gender ratio, the Lotka Volterra model is used to describe the population density of lampreys, and Python programming is used to solve it, obtaining the trend chart of the population size change of lampreys. As shown in Fig.4.

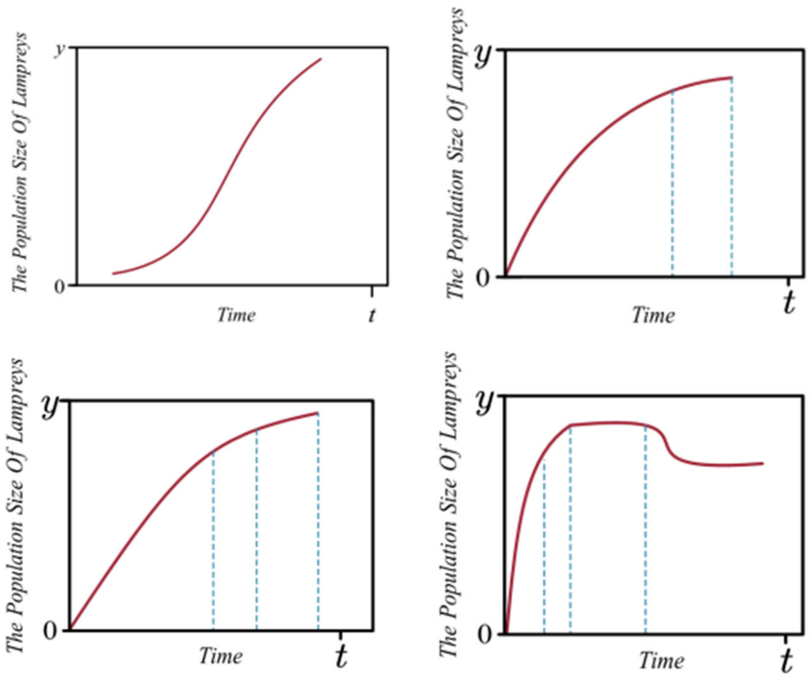

Figure 4. Changes in population size of lampreys

According to Fig.4, under the influence of external food supply, the population changes of lampreys can be discussed in two situations:

1. When there is sufficient external food, $m_2 = 0$, and the number of lampreys increases geometrically.

2. When there is insufficient external food, $m_2 > 0$, and population growth is divided into three stages:

Phase 1: When $x > 0$ and $m > 0$, the mortality rate of lampreys increases, but the birth rate is still higher than the mortality rate $a > m$, and the population size increases.

Phase 2: When $x = 0$, the population of lampreys reaches equilibrium.

Phase 3: When $x < 0$, the population of lampreys decreases.

As shown in Fig.5. By comparing the two model graphs, it can be seen that the population of lampreys, while controlling the sex ratio, controls the maximum value of its own population, delays the ecological damage caused by excessive population size, and also suppresses the rapid growth of its natural enemies.

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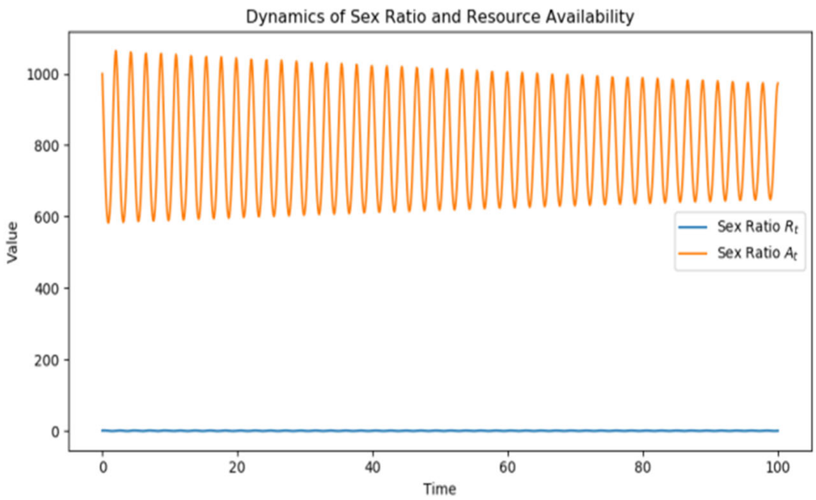

Figure 5. Dynamic changes in gender ratio and resource supply of lampreys

Fig.5 simulates the dynamic changes of gender ratio and resource quantity over time by solving differential equations, and plots these changes. By adjusting parameters and initial conditions, we can explore the potential impact of gender ratio changes on ecosystems in different scenarios. This provides a more powerful adaptation scenario for understanding the ecosystem functions of gender ratio adaptation to changes.

5. CONCLUSION

Gender variability plays a key role in the population of lampreys and has a profound impact on ecosystem stability. As one of the key means for lamprey populations to adapt to environmental changes and maintain ecological balance, gender variability demonstrates its extraordinary ecological adaptability. By combining Lotka Volterra and logistic models, we found that the sex regulation mechanism of lampreys not only helps the population survive and reproduce in unfavorable environments, but also indirectly affects the number and distribution of natural enemy populations through food chain relationships, promoting the dynamic balance of the ecosystem. This article deeply analyzes the complex interactions of gender variability, aiming to clarify how environmental factors subtly regulate the sex ratio of lampreys and its impact on population density and ecosystem. It provides a reference for achieving sustainable development and utilization of lampreys resources, as well as maintaining the harmony and stability of the ecosystem.

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