Analysis of the Growth Model

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Abstract

We build the dragon's dynamic growth model with weight as the main criterion for measuring growth.Based on this model and analyze the conditions required for the dragons to survive and the interaction between the dragons and the ecological environment. Based on the dragon's basic model and the weight of the dragon as it approaches adulthood,we established a block growth model. On this basis, we analyze the factors that may affect the growth of the dragon, mainly consider the impact of different food resources on the growth rate, and obtain the changes in the weight of the dragon at different growth rates. After studying the growth model of the dragon, we regard the dragon as a scaled up Dorking. According to the nutrient split model of Dorking, we obtain the nutrient split model of the dragon using an analogy method. And then we obtain the relationship between dragon's body protein and body weight and the relationship between daily food intake and body weight. Later, on the basis of body protein, daily food intake and other factors, we calculate the total energy required for the dragon to grow for one year.

Keywords

Block growth model; The nutrient split model; Energy.

1. Background

The three dragons in A Song of Ice and Fire weigh about 10kg at birth and gain weight to about 30~40kg after one year. Now let these three dragons live in the present, we can make some additional assumptions for him, analyze the conditions he needs to survive on Earth and his interaction with the environment. To solve the energy problem, we built a logistic model of weight gain. The logistic distribution is a continuous distribution of s-types with great practical value. The characteristic of this curve is that it grows slowly at the initial stage, and then the growth rate will increase. Later, due to the limiting factor in nature, its growth rate gradually slows down until the final growth rate tends to 0. Changes in the age and the height of creature also conform to such a pattern.

2. Dragon's growth model

2.1 Differential form of block growth model

The differential form of the Logistic curve equation [1] is:

$$\frac{dN}{dt} = rN(1-\frac{N}{K}) \tag{1}$$

The integral form of the Logistic curve equation is:

$$N = \frac{K}{1+e^{a-rt}} \tag{2}$$

In the formula, N is the weight of the dragon, t is the time, r is the growth rate of the body weight, K is the constant and is the maximum value of the body weight, e is the natural base, and a is the integral constant. Equation (2) is the s-type logistic cumulative distribution curve.

2.2 Dragon's dynamic growth model

Based on our hypothesis that the maximum weight of the dragon is gradually reaching 70,000 kg, we can know that K = 70,000 kg in the block growth model. The dragon weighs 10kg at birth and grows to 30 to 40kg a year later. For the sake of analysis, we take the dragon a weight of 35kg a year. Bringing these data into the formula, we get the relationship between the quality and time (in years) of the dragon:

$$N = \frac{70000}{1 + e^{8.853 - 1.099t}} \tag{3}$$

We make a figure in MATLAB that shows the change in the weight gain of the dragon over time and the rate of increase in the weight of the dragon over time. The curve is shown below:

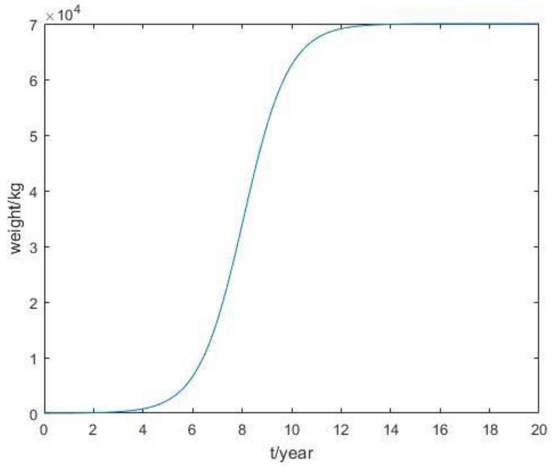


Figure 1: Curve of dragon's weight gaining

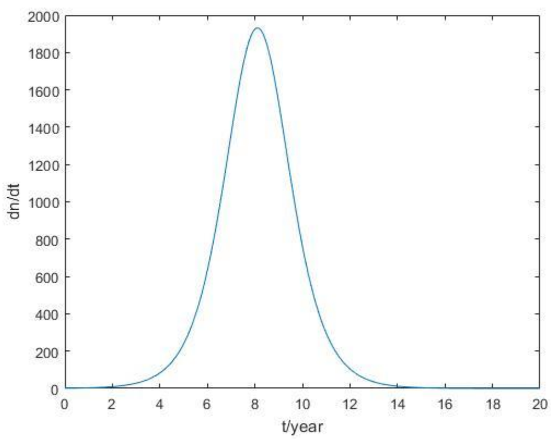


Figure 2: Curve of dragon's weight growth over the years

Through the curve, we can know that the growth rate of the dragon's weight has increased year by year in the first eight years, and the growth rate has gradually decreased after the eighth year. At about the fifteenth year, the growth rate of the dragon has approached zero [2].

3. Influencing factors of dynamic growth model

In the entire growth process of the dragon, the initial space, food and other resources are sufficient, in an ideal environment, the dragon grows very fast. However, as the dragon ages, food resources, space resources, climate and other factors affect the growth of the dragon. These factors mainly affect the growth rate of dragons. Among these factors, food resources are dominant. Therefore, we mainly analyze the impact of food resources on dragon growth.

When the material resources are sufficient, which means that the growth of the dragon satisfies the conditions of lack of material resources and guarantees that the dragon will not starve to death, then the lack of material resources will have different degrees of influence on the growth rate. Because this effect cannot be determined, so we only analyze the growth of the dragon under different growth rates.

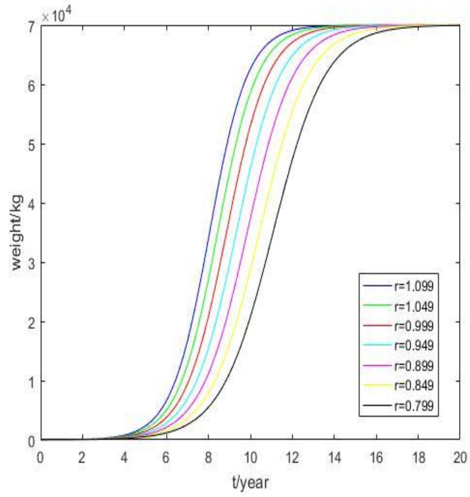


Figure 3: The effects of material scarcity on the growth rate of the dragon.

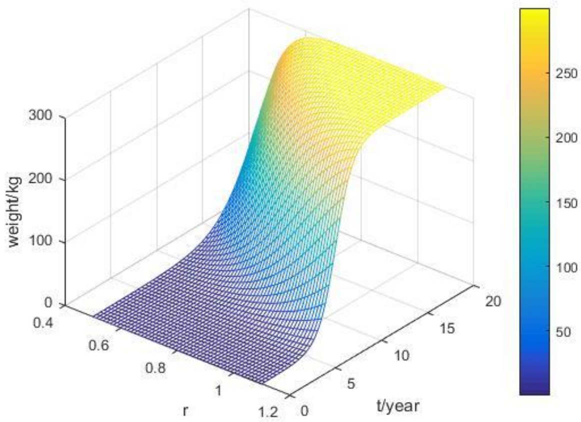
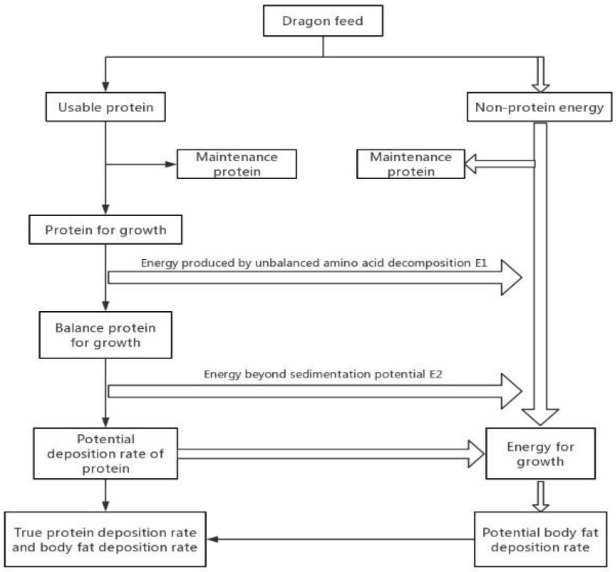


Figure 4: Dragon's weight changes with food resources and time

4. Nutritional dissection model of dragon growth

4.1 Basic principles of nutrition dissection model[3]



(1) Minimum value Pdopt of the upper limit of deposition of balanced protein and body protein for growth:

Male dragon:

$$Pdopt = 0.004466 \times LBW^{1.0639} \times \ln\left(\frac{6130.87}{LBW}\right) \tag{4}$$

Female dragon:

$$Pdopt = 0.00558 \times LBW^{1.0615} \times \ln\left(\frac{3965.15}{LBW}\right) \tag{5}$$

(2)Dragon's daily feed intake fi:

Male dragon:

$$fi = 0.556 \times LBW^{0.75} \tag{6}$$

Female dragon:

$$fi = 0.5313 \times LBW^{0.75} \tag{7}$$

We assume that only 80% of all foods eaten by dragon are absorbed, then the daily absorption of dragon f is:

Male dragon:

$$f = 0.556 \times LBW^{0.75} \times 80\% \tag{8}$$

Female dragon:

$$f = 0.5313 \times LBW^{0.75} \times 80\% \tag{9}$$

(3)Energy required to maintain state Em:

Male dragon:

$$Em = B \times \left(\frac{LBW}{1000}\right)^{0.75} \times 16744 \tag{10}$$

Female dragon:

$$Em = B \times \left(\frac{LBW}{1000} \right)^{0.75} \times 16744 \tag{11}$$

(4)Protein content required to maintain Pm:

$$Pm = A \times \left(\frac{LBW}{1000} \right)^{0.75} \tag{12}$$

(5)Available protein intake Ap:

$$Ap = fi \times 80\% \tag{13}$$

(6)Balance protein for growth Pg:

$$Pg = (Ap - Pm) \times RAP \tag{14}$$

(7) Energy produced by unbalanced amino acid decomposition: E1

$$E_1 = (Ap - Pm - Pg) \times 14.52 \times 16744 (15)$$

(8) Energy beyond sedimentation potential E2

$$E_2 = (Pg - P\text{dopt}) \times 14.52 \times 16744 \ (16)$$

(9)Non-protein energy E3

$$E_3 = (fi \times 70\% - Ap) \times 16744 \tag{17}$$

(10)Energy for growth Eg

$$Eg = E_1 + E_2 + E_3 + Pdopt \times \omega - Em \tag{18}$$

4.2 Establishing allometric equation of protein′s mass and weight

Body protein is the most important substance in the body composition, and its content is related to body weight. Animal growth is also mainly manifested by changes in the amount of body protein. In 1988, Whittemore [4] used the allometric equation to describe the relationship between the amount of protein in the growing body and the net body weight: The x in the equation represents the body weight of the animal, y represents the amount of body protein in the animal, and a and b are coefficients which vary with the species and sex.

In this paper, we regard the dragon as Dorking. Therefore, we take the coefficient of allometric equation of body protein and body weight of Dorking in 2004 belonging to Chen Zhimin as the coefficient of the body weight and body weight of the allometric equation.

Table1: The allometric equation for the relationship between weight and body protein fitted based on experimental data:

Project	Reflection	Absorption	Water cycle	Wind and tide	Photosynthesis
Proportion	30%	46%	23%	3.00%	0.80%

The above figure shows the coefficients of a and b measured by Chen Zhimin, so the relationship between the body protein content and body weight of the dragon we obtained is:

Male dragon: Y=0.1166X^1.0639 (19)

Female dragon: Y=0.1168X^1.0615 (20)

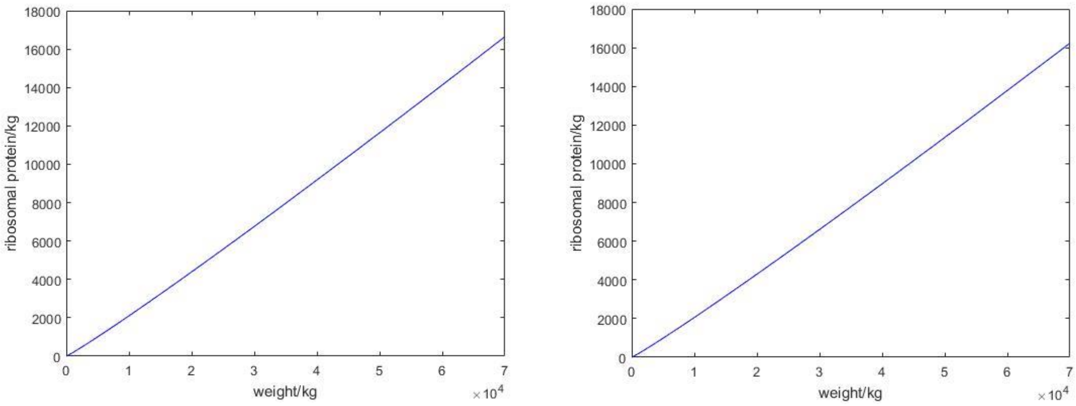


Figure 5: The relationship between body protein and weight of male dragon (first figure) and female dragon (second figure)

4.3 Energy required for dragon to grow

According to the simultaneous and applying MATLAB, we can calculate the energy needed for the male dragon and the female dragon to survive each year. Then we can know that the maximum energy that a male dragon needs to grow each year is: 1.0087*10^14 J; the maximum energy that a female dragon needs to grow each year is1.0085*10^14 J. The relationship between the energy and the year required for each year is as follows:

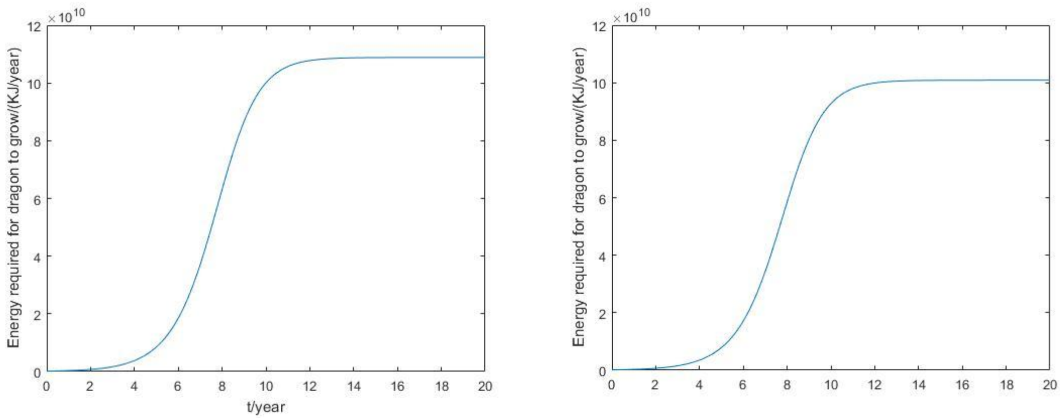


Figure 6: Annual energy required by male dragon (first figure) and female dragon (second figure)

5. Conclusion

Based on the block growth model. We analyse the factors that may affect the growth of the dragon, mainly consider the impact of different food resources on the growth rate, and obtain the changes in the weight of the dragon at different growth rates. After studying the growth model of the dragon, we obtain the nutrient split model of the dragon using an analogy method and the relationship between dragon's body protein and body weight and the relationship between daily food intake and body weight. On the basis of body protein, daily food intake and other factors, we calculate the total energy required for the dragon to grow for one year.

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