Virtual life

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Abstract: In order to preserve the ecological basis of fiction, understanding the growth mechanisms of organisms in an ecosystem is crucial. Our team's goal is to digitize the virtual dragon, analyze its characteristics, behaviors, habits and interactions with the environment, and make the virtual dragon more compatible with real creatures. To achieve this, our team built two models.

Keywords: Growth feature model; Energy distribution model

1. Introduction

The dragon has a spiritual, have special skills, such as, flight, breath fire, and resist tremendous trauma, when consider they are living today, so we can compare it to the most peculiar human being in the biological world, and we can compare its growth characteristics to children and teenagers aged 0-18 years.

The dragon continue to grow throughout their life, their weight, height, and surface area all change as they grow. Their weight changes can be analyzed by Logistic curve, their height changes can be analyzed by analogy with children and adolescents aged 0-18 years, and their body surface area is correlated with their weight and height.

The flow of energy in an ecosystem obeys the first law of thermodynamics, which states that "energy can be changed from one form to another, but cannot be created or destroyed". The dragon is also bound to have an energy budget process. The mechanism of energy distribution is as follows:

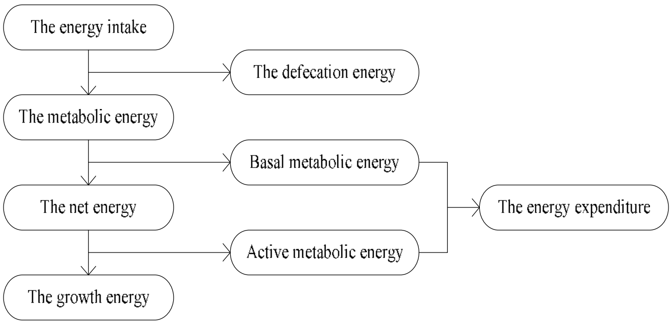

Figure 1. The energy conversion is related to behavior, habit and diet, so we can analyze the energy of each component, solve the energy distribution equilibrium equation to describe it.

2. Growth Feature Model

2.1. Weight change model

Since the weight growth trend of most wildlife conforms to the Logistic curve, we can use it to study the growth trend of dragons. It is known that the birth weight of a dragon is 10kg, and the weight increases to 20-30kg at the age of one year. We assume that the mature dragon weighs 20 tons.

The basic equation of Logistic equation is:

$$\frac{d_x}{d_t} = \frac{rx(k-x)}{k} \tag{1}$$

Establish the equation of weight growth curve based on the Logistic equation：

$$W(t) = \frac{w_1 w_0 e^{rt}}{w_1 + w_0 (e^{rt} - 1)} \tag{2}$$

Where t is the age of the dragon;

W is the weight of the dragon at time

W_1 is the weight at maturity is 200000kg;

r is how fast the curve changes.

The initial conditions are

$$when\ t = 0,\ \ W = W_0 = 10kg \tag{3}$$

The calculation result is $r = 1.254$

$$W(t)=\frac{2\times 10^{6}\times e^{1.254t}}{2\times 10^{5}+10\times (e^{1.254t}-1)} \quad (4)$$

The trend of weight gain was described by a curve as

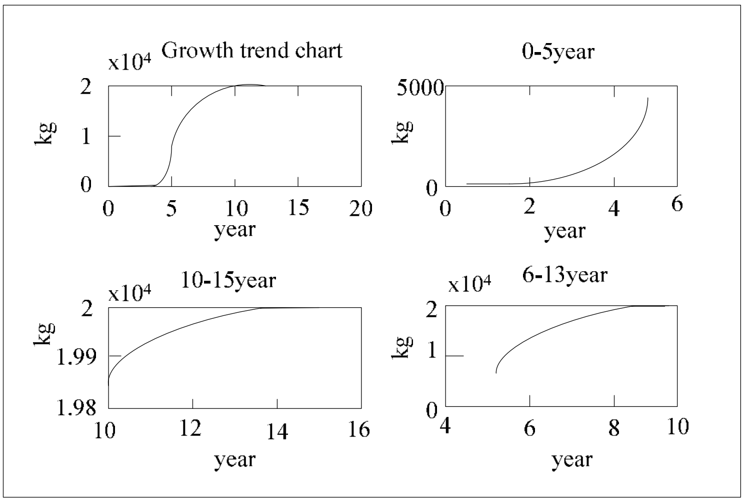

Figure 2. Trend curve of weight change

As can be seen from the figure, the weight growth rate of the dragon is relatively slow after the age of 14. We call it the juvenile stage of the dragon when it is 0~14 years old, and the mature stage after 14 years old.

2.2. Hight change model

It is found in relevant data files on the Internet that according to a large number of statistical materials of people with different body types in the world, the standardized data of height and weight of children and adolescents aged 0-18 in the normal range are as follows:

Table 1. Standard condition data for weight and height of children and adolescents aged 0-18 years

Height (cm)	75	86	95	108	112	116	135	151	155	160	163	167	171	178	185
Weight (kg)	10	12	15	17	20	22	35	41	48	50	51	54	59	66	75

Since the volume of the corresponding part is proportional to the cube of the length of the corresponding part, and the volume is proportional to the weight, then there is :

$$w=kh^{3} \quad (5)$$

Where h is the height of people.

w the weight of people.

Using the least square method to calculate:

$$k=1.2079\times 10^{-5} \quad (6)$$

$$w=1.2079\times 10^{-5}\times h^{3} \quad (7)$$

Similarly, we apply this relation to the height and weight of the dragon. Let the height of the dragon be H , then:

$$H=\sqrt[3]{\frac{W}{1.2079\times 10^{-5}}} \quad (8)$$

The trend of weight gain was described by a curve as

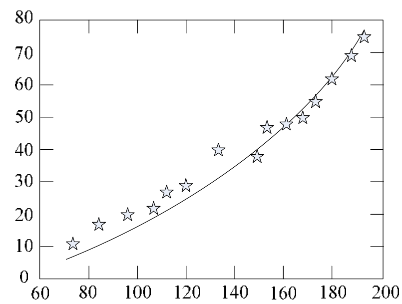

Figure 3. Curve of height change and weight change

2.3. Surface area change model

The research of human body surface area has made new progress continuously. The Taiwan institute of industrial technology [5] Innovated the hardware and software of 3D scanner, thereby reducing the error brought by the unmeasurable human body cavity and convex part. The error of the formula can be as small as 0.91%.

We apply the results to the dragon, Let the dragon's body surface area be A, then:

$$A = 71.3989 \times H^{0.7437} \times W^{0.4040} \quad (9)$$

3. Energy Distribution Model

In the ecosystem, Biological energy fluid is related to behavior, habit and diet. On this basis, we can establish the dragon's energy budget equation as follows:

$$C = R + K + P + U \quad (10)$$

Where C is the feeding energy:;

R is the basal metabolic energy;

K is the active metabolic energy;

P is the growth energy;

U is the fecal energy.

3.1. Metabolic energy

Some physiologists have accurately measured the metabolic rate of some organisms with instruments, combined with the corresponding weight data (weight is a commonly used index to measure the size of an individual) and found that the metabolic rate is proportional to the 3/4 power of the weight, and the self-similarity of the supply network and the law of fluid mechanics can be export:

$$B = aW^{\frac{3}{4}} \quad (11)$$

We found that the normal adult (75kg) metabolic rate was 50kcal/ (m2*h) at the time of sitting, then

$$\begin{aligned} R &= 0.5W^{\frac{3}{4}} \times A \times 24 \\ &= 12W^{\frac{3}{4}} \times A \end{aligned} \quad (12)$$

This is because the body's metabolic rate is 0.7 times higher when sitting down, 2.0 times higher when walking, and 7.6 times higher when playing basketball. We can think that the dragon will hunt food by flying, breathing fire and fighting, and the active metabolic rate of predation is c_1 times of the basal metabolic rate, and the general active metabolic rate of predation is t_1 times of the basal metabolic rate. The dragon predation movement time is c_2, the general movement time t_1 other time is the sleep time t_2. Then the active metabolic energy of the dragon is:

$$K = 0.5W^{\frac{3}{4}} \times A \times (c_1 t_1 + c_2 t_2) \quad (13)$$

3.2. Growth energy

The growth energy is greater than the energy expenditure of other components it is mainly reflected in the change of body weight. It is assumed that the energy conversion efficiency is extremely high the energy required for weight gain of 1kg is 7700kcal.

Growth energy/day = weight change/day * unit conversion energy

Namely,

$$P = 7700 \times \frac{dW}{dt} \quad (14)$$

3.3. Fecal energy

In the biological world, we found that the fecal energy accounted for 15%~30% of the feeding energy of most organisms by referring to the data. Here, we take 20%, then there is

$$U = 0.2C \quad (15)$$

3.4. Feeding energy:

Take the habitat of the dragon as the center of the circle, and the range of activity of the dragon is shown in the figure r as the radius, and dr as the increase value of the radius of activity per unit time, also known as the hunting range of the dragon. It can be said that the amount of hunting exercise of the three dragons every day is equivalent to going around n circle in the hunting range, then

$$C = \frac{2p\,rn.dr.r\,m \times 7700}{3} \quad (16)$$

$$\mathrm{N} = rp\left(r_m^2 - r^2\right) \quad (17)$$

Where N is quantity of food；

r is food population density；

m is the average weight of a food population；

The dragon and the arrested are in the same ecosystem. After a period of time, the dragon's predation quantity and the total number of the arrested will always reach a dynamic balance, that is, there is enough large area to support the growth of the dragon. Set the maximum activity area of the radius of the circle is r_m, assuming that those arrested in line with the natural growth of population growth model：

growth model：

$$\frac{dN}{dt} = gN \quad (18)$$

Where g is the intrinsic rate of increase

3.5. Model synthesis

Substitute the energy model of each component into equation (1), then the energy distribution model of the dragon is

$$\frac{2p\,rn.dr.r\,m \times 7700}{3} = 0.2\mathrm{C} + 7700 \times \frac{dW}{dt} + 0.5W^{\frac{3}{4}} \times A \times (24 + c_1 t_1 + c_2 t_2) + +aW^{\frac{3}{4}} \quad (19)$$

The differential equation turns into a difference equation, the relationship model of energy is established as

$$\begin{cases} \Delta r(t) = \dfrac{[w(t) - w(t-1)] \times 7700 + \left[9.2454 + 1.4658 \times \dfrac{n}{v} \times p \times r(t)\right] \times w(t)^{1.487}}{15400 mp\, r(t) \times p(t) - \dfrac{1.4658}{v} \times w(t)^{1.487}} \\ P(t+1) = (1+B) \times \dfrac{P(t) \times \left[r_m^2 - r^2(t) - 2r(t) \times \Delta r(t)\right]}{r_m^2 - r^2(t+1)} \\ h(t) = 2r(t) \times \dfrac{np+1}{v} \end{cases} \quad (20)$$

3.6. Simulation analysis

Based on energy distribution model, we changed the characteristics, behavior, habits, diet and other conditions of the dragon, and analyzed the impact on the changing trend of the environment to describe the interaction with the environment.

3.7. Flight velocity

By referring to relevant literatures, statistics show that the flying speed of most flying animals is 30~40km/h (up to now, the fastest flying animal is 200km/h). There was no correlation between speed and age or weight. According to the morphological characteristics of the dragon, we assume that the range of its flight speed is 40~70km/h.
It can be said that the amount of hunting exercise of the three dragons every day is equivalent to going around $n=10$ circle in the hunting range, The initial scope range of the dragon to $r_0 = 1\text{km}/\text{h}$ for the radius of circle, those arrested population density number $\rho = 10000 km^2$.
The flying speed is the behavior characteristic of the dragon. When other conditions are fixed, we change the flying speed. By applying the energy difference model, we can get the radius value of each day's activity range under different flying speeds.
Take the flight speed as the independent variable and the radius value of the range of activity as the dependent variable, the two-dimensional picture is as follows：

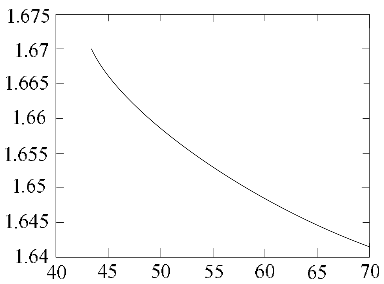

Figure 4. V-r diagram in year 14

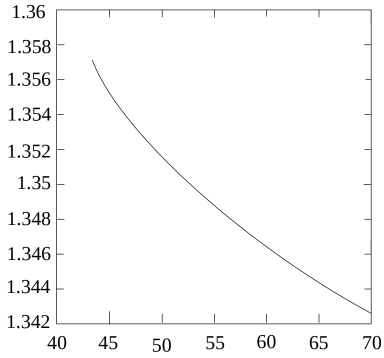

Figure 5. V-r diagram in year 15

As you can see from the two-dimensional picture, when flying at different speeds, the radius values of different days are different, but the trend of flying speed and activity range is roughly the same. As the flight speed increases, the radius of the range decreases.
The reason is that the flight speed increases, the initial radius is the same, the flight distance is the same, so the flight time is small, the energy consumption is small. With the same weight change, you eat less, you hunt less. Therefore, in the case of the same initial value of the range of activities, the range of activities is small when the speed is high.

4. Strengths and Weaknesses

4.1. Advantages

Our model takes into account dragon characteristics, behavior, habits, diet and other factors For example, the dragon's flight speed and activity time make it more accurate to predict the dragon's activity range and provide accurate reference for the author.
Our model is a continuous partial differential equation, which can predict the future form of variables more accurately.
Our model combines a lot of existing data and theory, have very strong reliability.

4.2. Disadvantages

In the body length and weight model of dragons, only body height and weight are considered to be related to time, and the influence of external environment on body length and weight growth is not taken into account.
The effect of different regions on the model only considers the population density of the region, which is one-sided.
The daily habits and flight speeds of the dragons were too rigid to take into account their influence.

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