高寒草甸生态系统消费者亚系统生物量动态模型的研究

II. 消费者亚系统生物量动态模型的构造

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STUDY ON THE BIOMASS DYNAMIC MODEL OF CONSUMER SUBSYSTEM IN THE ALPINE MEADOW ECOSYSTEM

II. A STRUCTURE OF THE BIOMASS DYNAMIC MODEL OF CONSUMER SUBSYSTEM

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ABSTRACT

A consumer subsystem biomass dynamic model of the alpine meadow ecosystem (called QHB) is a deterministic mathematical model with a view to understanding its structure and function and to predicting some properties of the system. A simulation calculation has been done successfully at IBM-PC/XT.

In the area of Haibei Research Station, some major consumers, such as Tibeten sheep, plateau pikas (Ochotona curzoniae Hodgsin), plateau zokosr (*Myospalax fontanierii Mline-Edwards*), Horned larks (*Eremophila alpestris*) and alpine weasels (*Mustela altaica*), have been studied to a varying extend from various angles in the previous decade. It the meantime, the principal vegetable types, e.g. major plant communities and their production in that area have been approached. QHB is built with the help of the above mantioned conditions and experiences of other researchers (Bledsoe, et al., 1971; Anway, 1978; Cole, 1975).

The process of solving the problems could be illustrated in figure 1.

Construction of the model

Objectives: 6 consumers and dynamics of their biomass.

Hypotheses:

1. The instantaneous values of plant biomass are found with an algebraic interpolating function among standing crops per month.

2. The amount of food intake and metabolism are both principal factors which have an effect on the body weight of animals.

The amount of food intake per day is determined by energy requirement and it is also affected by the proportion of the diet, food intake order and assimilation efficiency and so on.

Metabolism expenditure is divided into 4 parts: rest, movement, organism growth and reproduction.

3. The density variation of the animals is controled by birth rate, death rate and harvest rate. A set of nonlinear differential equations is used to describe the dynamic of density and weight:

Density equation:

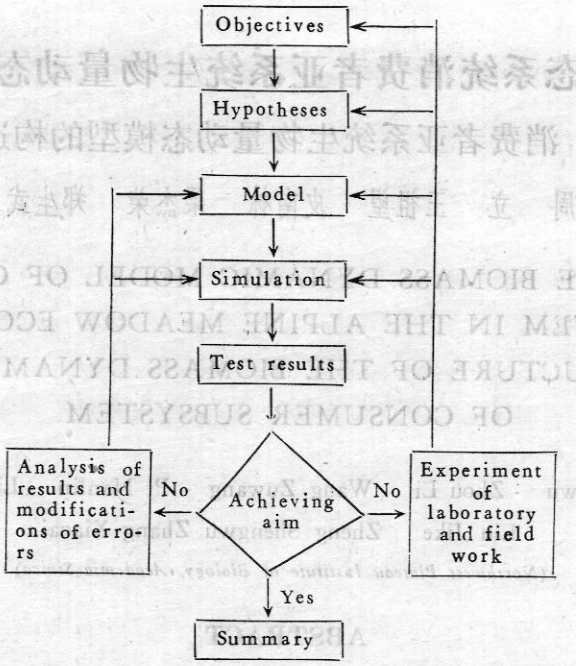

Fig. 1 The simulation process of the model

$$\frac{dpn(i)}{dt} = pn(i)[b(i) - d(i)]\left[1 - \frac{pn(i)}{ke(i)}\right]$$

$$- [ha(i+7) + hmk(i)]/w(i) + xim(i) - em(i)$$

$$i = 1, \cdots, 6$$

where

pn (i)——density of the animals in group i, i=1 to 6 are Tibeten sheep, plateau pikas, plateau zokors, alpine weasels and insects respectivily.

w(i)——average weight of individual in ith animal group

b(i)——instantaneous birth rate of ith animal group

d(i)——instantaneous death rate of ith animal group

ke(i)——upper weight threshold of ith animal group

t——time

ha(i+7)——harvest rate of ith animal group

hmk(i)——destroy rate of ith animal group

xim(i) [em(i)]——immigration [emigration] rate of ith animal group.

Body weight equation:

$$\frac{dw(i)}{dt} = \text{rbf}(i)\text{eff}(i) - \text{re}(i)$$

$$i = 1, \cdots, 6$$

where

rbf(i)——food intake rate for ith animal group

eff(i)——assimilation efficiency of ith animal group

re(i)——total metabolism rate of ith animal group.

The dynamic of biomass for the animal group is indicated by a product of body weight and density:

$$c(i) = w(i)pn(i) \qquad i = 1, \cdots, 6$$

The following are equations for feces and death materials:

$$\frac{dfe}{dt} = \left\{\sum_{i=1}^{6} [1 - \mathrm{eff}(i)]\mathrm{af}(i)\right\} - \mathrm{hs}$$

$$\frac{dad}{dt} = \left\{\sum_{i=1}^{6} [xc(i+7)d(i)]\right\} - \mathrm{ha}$$

where

fe——total biomass of animal feces

ad——total biomass of death materials from animals

af(i)——food intake rate of itn animal group, per unit area, under actual availability conditions

xc(i)——biomass density of consumed species, xc(i) will be that of animal as i>7

hs, ha——harvest rate of feces and animal death materials by microbes.

Results and disscusions

QHB describes dynamic changes of biomass for 6 consumers that occur in Haibei alpine meadow from green-up period to withering. 6 animal species are the representatives of the major consumers only, simulation results, parameters and formula may give an expression to some characteristics of the consumers in the alpine meadow since most of the data are taken from Haibei Research Sation.

The model could provid some important informations related to the consumers. First, the amount of natural food becomes seasonally unsteady due to the climate, soil conditions and so on. By using food composition, grazing level and hunger formation, the model simulated a relationship of "supply and demand" among consumers and its food. Thirdly, the competition between pikas and sheep and damaging level to the grassland done by mice are also simulated according to the mechanism of the grazing priority of pikas over sheep and the similarity of the two animals in their preference to certain food, and the results could be usefull to control pest of rodents.

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