高寒草甸生态系统消费者亚系统生物量动态模型的研究

III. 消费者亚系统生物量动态模拟过程与结果讨论

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

III. THE SIMULATING PROCESS, SIMULATED RESULTS AND DISCUSSION OF THE BIOMASS DYNAMIC MODEL OF CONSUMER SUBSYSTEM

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ABSTRACT

The Simulating Process

1. The computation method

The mathematical structure of the model (called QHB) consists of a set of nonlinear ordinary differential equations and algebraical equations. The key to solve numerically the model is to integrate numerically the initial problem of the nonlinear ordinary differential equations

$$\begin{cases} d\tilde{V}/dt = f(V, P, D, t) \\ \tilde{V}(t_0) = \tilde{V}_0 \end{cases} \quad (3.1)$$

where

V = the state vector of the consumer subsystem which consists of all state variables: Liomass, densities, body weight of every consumer, total deah materials, feces, biomass of every plant and time, which determines states of the consumer subsystem at every simulated time.

V = the part state vector which consists of the part of state variables: densities, body weight, total death materials and feces, the values of which are determined by ordinary differential equetions.

P = the parameter vector determined by the specific environment and specific population of consumers.

D = the external drive vector which represents climate conditions.

f = the function vector which represents the varying rate (derivatives) of V with time

t = the time independent variable in the subsystem.

t_0 = the time at which the model begins to simulate.

V_0 = the value of the part state vector at t_0, i.e., the initial value of V.

To decrease the error of numerical solutions and to increase computation speed, we select the 4-order single-step Runge-Kutta-Merson method with control of precision and varying length of integration steps to solve the initial problem (3.1). Calculating formulae of the method which calculate the value of the solution V(t) of (3.11) at t_0+h (h is step length of time) according to the initial value V_0 at t_0 are written in (3.2). The cut off error of the method is $O(h^5)$, estimates of both absolute and relative error respectively are given by (3.4) and (3.5). The procedure and order in calculating values of the function vector f(V, P, D, t) is written

in Table 3.1.

2. The program design

According to both characteristics in the mathematical structure of the model QHB and used numerical integration method, we have selected the method of structured programming. The source program consists of many modules that are subroutines. First, modules completing calculations of biological mechanism formulae are designed. Second, the basic subroutine DER that calculates values of the function vecton f(V, P, D, t) according to the calculation order of the Table 3.1 is constructed. Then, the subroutine KUTTA is constructed with formulae (32). And finally, the main program (also called QHB) is designed. DER and KUTTA are subroutines with parameter variables because they are called with different values of the parameter variables frequently. A diagram of DER, which calls other subroutines, is drawn up in Fig. 1 and a flow chart of main program is drawn up in Fig. 2. The source program has written with IBM FORTRAN 77 and has more than 1000 program lines.

The simulated results and discussion

Dynamic curves of biomass, density, body weight (Fig. 3—7) in 5 major consumer population: plateau pikas (*Ochotona curzoniae*), Tibeten sheep, alpine weasels (*Mustela altaica*), horned larks (*Eremophila alpectris elwesi*) and plateau zokors (*Myospalax baileyi*) in the Haibei Alpine Meadow Ecology Research Station, Academia Sinica, are drawn with the computer output during the period from April to November.

The subsystem model has been verified for the density and body weight in both plateau pika and plateau zokor population and for the daily body food intake of plateau pikas, plateau zokors and Tibeten sheep per unit body weight (Table 3.3—3.9). That the simulated values of them by the computer output almost approach the observed values in Haibei Research Station indicates that the mathematical model of consumer subsystem is valid as abstract theoritical representation of consumer subsystem in the alpine meadow ecosystems.

Using the model, we can obtain many useful results, for example, the daily intake rate of major herbivorous consumer population: plateau pikas, plateau zokors and Tibeten sheep, and major omnivorous consumer population like horned larks for plant or plant seeds in unit area in each phenology period is obtained (Table 3.10). Table 3.10 indicates that the food intake of plateau pika population is more than 47% of food intake of Tibeten sheep population. The two animals not only have almost the same preference for food so there is the competition of food between pikas and sheep, but allso pikas (and zokors) damage to grassland. As a result, it is necessary to wipe out plateau pikas and plateau zokors or to decrease numbers of them for developing livestock husbandry. Another example is that the extent biomas, consunted biomass by the consumers and consumed rate of every plant or animals food in each phenology period (Table 3.11) indicate that the consumed rate of each food except roots's food in Green up period is highest and in Withering period is lowest among 3 phenology periods. Specially, that the consumed rate of promineoe preferred by sheep and pikas in Green up period is highest (39.4%) indicates the sheep are hungry in different degrees in Green up period.

In summary, the model provides us with a lot of information about consumers and their effect on variations in food and environment conditions. But the model is deficient in some aspects, e.g., consumers can not affect primary producers (i.e. consumers do not feed back to prime producers) because a model of prime producer subsystem has not completed, the age structure in all consumer population has not been considered so that some results are rough, etc.

The model will be improved with collecting data, constantly verifying, modifying, and constructing the model of primary producer subsystem.