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鼎湖山森林群落演替之研究

彭少麟
（中国科学院华南植物研究所，广州 510650）
王伯荪
（中山大学生物系，广州 510275）

摘　要

鼎湖山森林群落在自然状态下遵循一定的客观规律向更优化的气候顶极群落演变。本文分析其1955年至1989年（35年）来的演替结果，总结出鼎湖山森林群落演替的进程和模式，进一步应用植物群落演替系统的线性模型和非线性模型对演替进程进行定量研究，并做出相应的演替进程的数量预测。

关键词：演替；森林群落；鼎湖山；阳性树种；中性树种；演替系列

FOREST SUCCESSION AT DINGHUSHAN，GUANGDONG，CHINA

Peng Shaolin
（*South China Institute of Botany*，*Academia Sinica*，*Guangzhou*　510650）
Wang Bosun
（*Biology Dept.*，*Zhongshan University*，*Guangzhou*　510275）

Abstract

The Succession of the forest communities at Dinghushan is to tend to climax following the objective law under the natural condition。The paper analyses the successional results of forest on the area from 1955 to 1989，and summarizes the successional process and model，and then proceeds to make to quantitative research with the pattern of linear and unlinear system。The relatitivant numerical expectations of the successional process are calculated。

It is shown by the researched examples in this paper that the studies on the succession are useful to afforestation in the practice，the management and the use of forest communities，as well as giving full play to the functions of the education and the science research and demonstration and the preservation of the Biosphere Reserve。

Key words：Succession；Forest community；Dinghushan；Heliophytes；Mesophytes；Successional series

Dinghushan is a part of the Network of World's Biosphere Reserve organized by MAB, UNESCO. It is situated in the center part of Guangdong Province, South China, at 112°35′E and 23°08′N. The altitude of the highest peak is 1000. 3 m. The rocks are sand-stone and shale belonging to the devonian period. The annual mean temperature is 21. 4℃, the mean temperature of the coldest month (January) is 12. 0℃. Rainfall averages 1927. 3 mm, rainfall from May to September makes up 69% of a year. The mean relative humidity is 80%. The forest soil is lateritic red earth, pH 4. 5—5. 0, humus is rather rich. In this paper, the forest succession was studied with qualitative and quantitative ways.

Forest succession of Dinghushan

Dinghushan forest communities suffered a great change in the last 35 years. It can be clearly seen in some typical communities in different successional stages.

1. *Cryptocarya concinna*+*Castanopsis chinensis*+*Cryptocarya chinensis*+*Schima superba* Community (Com. 1)

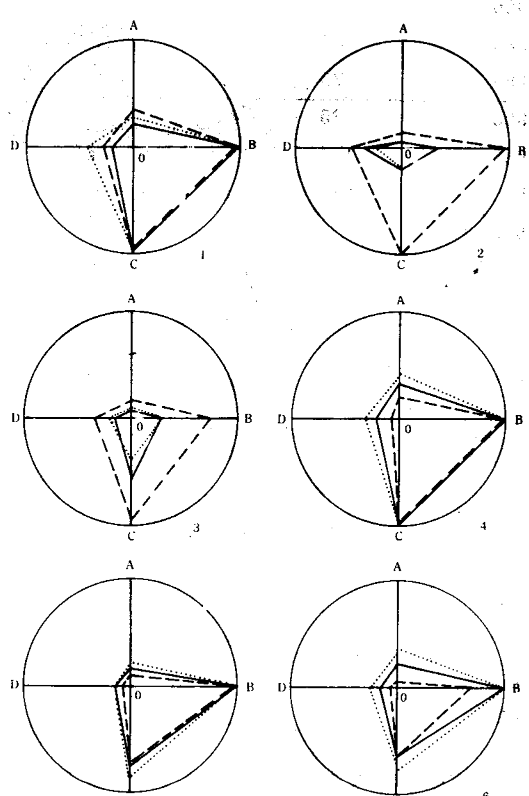


Fig. 1 The changes of dominant populations in *Cryptocarya concinna*+*Castanopsis chinensis*+*Cryptocarya chinensis*+*Schima superba* community (2000 m²)

…1989; ——1980; - - -1955; OA abundance; OB frequency; OC class-rate; OD DBH-rate

1 *Cryptocarya concinna*; 2 *Castanopsis chinensis*; 3 *Schima superba*; 4 *Cryptocarya chinensis*; 5 *Syzygium rehderianum*; 6 *Aporosa yunnanensis*

The community is the largest one in the natural forest vegetation of Dinghushan, which is over 400 years old. It almost occupies all area of the natural forest but the foot of the mountain, and it is a typical forest type of evergreen broad leaved forest in low subtropic. Comparing to that of 35 years ago, although the species component of the community barely change, the individuals of dominant populations change a lot. *Castanopsis chinensis* and *Schima superba* are decreasing, *Cryptocarya concinna*, *Cryptocarya chinensis*, *Aporosa yunnanensis* and *Calamus rhabdocladus* are developing to absolute predominant populations in some layers (FIg. 1). The community is near climax.

Table 1 The change of main populations in *Castanopsis fissa* Community (100 m²)

species	year	species Class I	II	III	IV	V
Castanopsis	1955	47	19	16	5	0
fissa	1980	111	0	2	1	0
	1989	98	10	1	1	0
Schima	1955					
superba	1980	50	1	8	4	0
	1989	75	3	9	5	0
Cryptocarya	1955	20	4	2	0	0
concinna	1980	112	8	4	6	0
	1989	211	11	6	7	0
Castanopsis	1955	4	4	1	0	0
chinensis	1980	0	0	1	2	0
	1989	4	1	0	2	0
Lindera	1955	3	11	4	1	0
metcalfiana	1980	0	2	0	1	1
	1989	0	1	2	1	1
Craibiodendron	1955	34	1	1	0	0
kwangtungense	1980	4	4	1	1	0
	1989	15	3	2	1	0
Cryptocarya	1955					
chinensis	1980	4	3	1	1	0
	1989	23	3	0	2	0
Sarcosperma	1955					
laurinum	1980	3	2	2	0	0
	1989	0	2	1	1	0
Diospyros	1955					
morrisiana	1980	4	2	0	0	0
	1989	6	4	1	0	0
Neolitsea	1955					
pulchella	1980	6	1	0	0	0
	1989	11	3	3	0	0

2. ***Catanopsis fissa*** **Community (Com. 2)**

The community which was a consociation 35 years ago has developed into a polydominant community dominated by *Cryptocarya concinna*, *Castanopsis chinensis*, *Schima superba* etc. Not only the increment of floral element leads to complex layer structure and more shady environment, but also mesophytic mixed one (Table. 1)。

3. ***Pinus massoniana+Castanopsis chinensis+Schima superba*** **Community (Com. 3)**

The community which was the mixed forest dominated by *pinus massoniana* 35 years ago has changed to a broad-leaved and needle leaved mixed forest dominated by *Castanopsis chinensis* and *Schima superba* (Table 2). The vertical structure which was single tree layer has developed into two layers.

Table 2 Changes of dominant populations of *Pinus massoniana+Castanopsis chinensis+Schima superba* Community (200 m²)

Species	Year	Individuals	Relative abundance (%)	Height mean ht, (m)
Pinus massoniana	1955	26	45.6	6.9
	1980	5	18.5	10.0
	1989	4	10.3	11.3
Castanopsis chinensis	1955	4	12.2	4.2
	1980	7	14.8	6.0
	1989	9	20.6	9.5
Schima superba	1955	17	29.8	4.7
	1980	9	33.3	11.0
	1989	14	35.0	9.0
Castanopsis fissa	1955	7	12.2	1.3
	1980	9	33.3	3.0
	1989	8	20.6	6.0

4. ***Pinus massoniana*** ***Community*** **(*Com.* 4)**

Thirty-five years ago, the community was only *Pinus massoniana*, appeared in the tree layer, and *Brainea insignis* was most dominant under tree layer. At present, the community is developing to needle and broad-leaved mixed forest. *Brainea insignis* is declining in shadier habitant (Table 3).

Table 3 The change of dominant populations of *Pinus massoniana* Community (200 m^2)

Species	Year	Individuals	DBH (cm^2)	Height (mean, m)
Pinus	1980	4	2700.1	12.5
massoniana	1989	3	1910.4	13.8
Castanopsis	1980	3	1364.9	10.5
chinensis	1989	7	1886.7	9.0
Schima	1980	7	2157.8	9.5
superba	1989	11	3004.7	10.5
Acronychia	1980	4	24.8	6.5
pedunculata	1989	5	136.8	7.0

Process and mechanism of forest succession of Dinghushan

The main path of forest succession at Dinghushan is to follow certain law in natural condition。 *Pinus massoniana* and other *Pinus* species of higher vitality can grow rapidly in waste land. Pinus forest has simple structure, weak cover action, stong photic ratio, high temperature, low humidity, great variance in day-night temperature. But it provides better conditions for heliophytes, such as *Castanopsis chinensis*, *Schima superba* etc, to grow well than a waste land does. These heliophytes enter *Pinus massoniana* forest and grow rapidly. The forest becomes strong cover action and shady inside forest. Consequently, Pinus plants can not regenerated and mesophytes, such as *Cryptocarya concinna*, *Cryptocarya chinensis* etc, grow in strength step by step. Therefore, pioneer Pinus plants disappear, and heliophytes decline. The community tends to climax which is evergreen broad-leaved forest dominated by mesophytes. That is the successional mechanism of forest in the area. The process can be summarized as in Fig. 2.

Fig. 2 Successional process of forest of Dinghushan

	stage 1		**stage** 2		**stage** 3	
Succession stage	needle-leaved forest	⟶	needle and broad-leaved mixed forest dominated by needle plants	⟶	broad and needle-leaved mixed forest dominated by broad-leaved heliophytes	⟶
Representative community	*Pinus massoniana* Community		*Pinus massoniana* + *Castanopsis Chinensis* + *Schima superba* Community		*Castanopsis chinensis* + *Schima Superba* + *Pinus massoniana* Community	

stage 4		stage 5		stage 6
evergreen broad-leaved forest dominated by heliophytes	→	evergreen broad-leaved forest dominated by mesophytes	→	mesophytic forest (climax)
Castanopsis fissa Community		*Cryptocarya concinna* + *Castanopsis chinensis* + *Cryptocarya chinensis* + *Schima superba* Community		*Cryptocarya concinna* + *Cryptocarya chinensis* Community

Based on Fig. 2 as compared with the mentioned four communities, we find that Com. 1, Com. 2, Com. 3 and Com. 4 were in stages 1, 2, 4 and 5, respectively, 35 years ago, and are now in stages 2, 3, 5 and near to 6, respectively。Ther form successional series

Linear model and unlinear model of successional systems of forest communities of Dinghushan

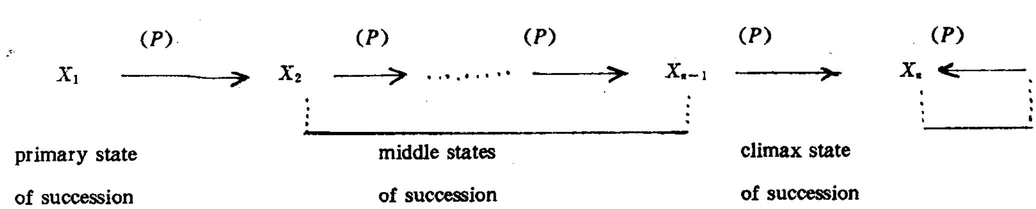
1. Linear model

successional process of plant community can be described by Markov models. Linear model of successional system can be described by Markov link. If we suppose each successional stage as a state or a son system, successional process of community is a system. In the process, that one stage changes into another stage in a community implies that one state transits to another state in a system. The successional series make up successional system. Supposing a system recorded as $S(X)$, it accords with plus-reiteration principle. It is a linear system:

$$S[r_1X_1(t)+r_2X_2(t)]=r_1S[X_1(t)]+r_2S[X_2(t)] \quad \cdots\cdots (1)$$

In the formula, r_1 and r_2 are constants, X_1 and X_2 are states. This linear system of community succession is a certain successional process. If a succession undergoes n states, transition matrix is (P), behaviour of linear system can be shown as in Fig. 3.

Fig. 3 The behaviour of linear system



To stabilize transition matrix (*P*), we need to suppose the death rate of plants being unchange. It means that human disturbance to succession should be excluded. With formula (1), the late state can be deduced by the early state in an equal time intermission. The relations are: $X_2 = P^T X_1$, $X_3 = P^T X_2$ etc. We have the general formula:

$$X_{i+1} = P^T X_1 \qquad \cdots\cdots (2)$$

In this formula, $i=1, 2, 3 \cdots\cdots n$; P^T = transposed matrix (*P*); X_i is state vecter.

$$X_i = \begin{bmatrix} P_{1i} \\ P_{2i} \\ \cdot \\ \cdot \\ P_{mi} \end{bmatrix}$$

P_{1i}, $P_{1i} \cdots P_{mi}$ is percentage of composition. Forest succession from one state to another state can be shown from development of populations. Comparing Fig. 2 with Fig. 3, it is easy to find the succession process accords with the behaviour of linear model. Let relative abundances of different kinds on character as indexes, on the basis of survey data, we get the regenerated rates of different tree components (Table 4). It means that (*P*) is as follows:

Table 4 The regenerated rates of different tree components

after 25 years / now	I	II	III
I	20+6	66	8
II	1	44+12	43
III	0	4	69+27

$$(P) = \begin{matrix} 0.26 & 0.66 & 0.09 \\ 0.01 & 0.56 & 0.43 \\ 0.00 & 0.04 & 0.96 \end{matrix}$$

(*In table 4, 5, 7, I means Pinus trees; II means heliophytic tree; III means mesophytic trees*)

According to the survey, *Pinus massoniana* makes up 90% of all individuals and heliophytic trees are 10% in matured *Pinus massoniana* forest. On the basis of formula (2) and (*P*), the change of different tree components in successional process can be calculated, successional state can be divided, and successional course and dynamics can be predicted (Table 5, 6).

Table 5 Expectation on components in successional process with linear model

year	0	25	50	75	100	125	150	175	200	…	
I	90	24	7	2	0	0	0	0	0	…	0
II	10	65	53	36	23	15	11	9	8	…	6
III	0	11	40	62	77	86	89	91	92	…	94

Table 6 Dividing on time of different successional stage

year	0	<25	25—<50	50—<75	75—<150	150—
stage	stage 1	stage 2	stage 3	stage 4	stage 5	stage 6

2. Unlinear model

There are some strict suppositions with linear model. For example, supposing death rate of populations is unchange in all successional process. It's impossible to accord with real situation. In fact, habitat and relations between populations are continuously changing in successional process, death rates are not a constant. In natural condition, there is no strict linear successional system, but there are some unlinear systems which are close to linear system. Unlinear successional models are universal.

The studies on unlinear systems are more difficult. But even though all process of succession is unlinear, some stages can be considered to be close to linear. The successional process can be divided into several sub-processes, in which part linear is formed. Then, next stage can be calculated on the basis of $X_2=P_1^T X_1$, $X_3=P_2^T X_2\cdots$,

$$X_{i+1}=P_i^T X_i \quad \cdots\cdots (3)$$

Based on Fig. 2, the succession of forest communities at Dinghushan is unlinear system, i t' s divided into three subprocess. Each is close to linear.

a. needle-leaved forest to needle and broad-leaved mixed forest (stage 1 to stage 2);

b. needle and broad-leaved mixed forest to evergreen broad-leaved forest dominated by heliophytes (stage 3 to stage 4);

c. evergreen broad-leaved forest dominated by mesophytes to climax (stage 5 to stage 6).

Surveying the change of the above four comunities in 35 years, the matrix of each sub-process is as follows:

$$(P_1)=\begin{matrix}0.30 & 0.63 & 0.07\\ 0.04 & 0.54 & 0.42\\ 0.00 & 0.08 & 0.92\end{matrix} \quad (P_2)=\begin{matrix}0.22 & 0.69 & 0.09\\ 0.02 & 0.58 & 0.40\\ 0.00 & 0.06 & 0.94\end{matrix} \quad (P_3)=\begin{matrix}0.00 & 0.00 & 0.00\\ 0.00 & 0.48 & 0.52\\ 0.00 & 0.02 & 0.98\end{matrix}$$

On the basis of transition matrixes and formula (3), the tree components in different periods can be measured (table 7). The result is similar to that of linear model. It shows that successional system of forest at Dinghushan is unlinear system and close to linear system.

Table 7 Expectation on components in successional process with unlinear model

Year	0	25	50	75	100	125	150	175	200	…	
I	90	27	7	3	1	0	0	0	0	…	0
II	10	62	55	39	28	15	10	7	5	…	4
III	0	11	38	58	71	85	90	93	95	…	96

Some enlightenment

The above results show that heliophytes can develop quickly after entering *Pinus massoniana* Community. They become dominant populations after staying in the community for 25 years. Then the forest will tends towards mesophytic forest. It implies, following the successional law, this is the way for forest management. Undoubtedly, reconstruction and devepopment of forest can be speed up with human interference under the good climate condition of South China.

In the countryside of south China, energy resource is deficient. There are some characters, such as quick growing and good shooting, with some heliophytes, such as *Schima superba and Castanopsis fissa* etc, which are very good fuel wood. These trees grow well only in successional stage 3 or 4. With reasonable controlling and using, the forest can be stabilized at these stages, in which will be a good fuelwood forest.

Some rare and dangerous species have to grow in special successional stage. For example, *Brainca insignis* must live in open environment. To conserve it, we should keep the community in successional stage 1 or 2.

It' s clear that study on forest succession and keeping typical space—series of succession will be useful for research, science education and demonstration.

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