STAND STRUCTURE AND DISTRIBUTIONAL PATTERNS OF A MANGROVE FOREST IN OURA BAY, OKINAWA

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1. Introduction

In Japan, mangrove forests locate in their northern limits, and distribute from Yaeyama Islands in subtropical zone to southern parts of Kyushu Island in warm temperate zone (Nakasuga, 1979). The analysis of stand structure will provide a basic information for ecological studies and management of the mangroves. Stand structure of mangrove forests in Japan has been generally described by Nakasuga (1979). Mangrove forest of Oura Bay was studied by Urasaki (1975, 1982), Nakasuga and Kobashigawa (1976). In order to understand the ecological aspects of the forest, more data and ditailed studies are still necessary to obtain. In this study, an attempt was made to analyze stand structure and distributional patterns of the forest.

2. Materials and methods

This study was carried out in a mangrove forest which is located in Oura Bay, Nago City, Okinawa prefecture. It is situated approximately at N 26°31′, E 128°5′. Three plots, P1, P2 and P3 (each 10m×10m in size) which were supposed to be representative samples of the forest, were established in December 1986. All vegetation in the plots were numbered, and their diameters and heights were measured. Based on the height, the mangrove plants were classified into three groups: trees (H≧4m), saplings (4m>H≧1.2m) and seedlings (H<1.2m). The seedlings were further classified into two, big seedlings (0.6≦H<1.2m) and small seedlings (H<0.6m). The plots were divided into subplots, 2m×2m in size. Position of every tree, sapling and seedling as well as crown position of every tree and sapling were measured and mapped. Distributional pattern of the tree, sapling and seedling was analyzed by the change of Morishita's I_δ-index corresponding to the change in quadrat size. The largest and the smallest quadrat size were 10m×10m and 0.625m×0.625m respectively.

3. Results and discussion

Stand structure of the Oura mangrove forest is shown in Table 1. Relative density of *Kandelia candel* tree was 89.3%, 57.1% and 21.0%, while *Bruguiera gymnorrhiza* was 10.7%, 42.9% and 79.0% in P1, P2 and P3 respectively. Number of small seedling of *K. candel* were 35 in P1, 10 in P2 and 1 in P3; but big seedling was not found at all in the three plots and even no sapling stage in P2. Number of dead small seedling of *K. candel* were, 39 in P1 and 6 in P2; and also in the sapling stage, 17 in P1 and 7 in P3. It can be inferred from this data that even though many seeds of *K. candel* were able to sprout and grow, but only for a short period, they could not persist and continue to grow for a longer period. This may be due to the light requirement of the seedlings. They are intolerant under the shade of any tree, and can thrive only in the open or gap areas. As Nakagoshi (1987) recognized that after 2.5 years planting, *K. candel* survied much better in the open area than under the forest canopy of Oura mangrove forest.

The frequency distribution of *K. candel* height was a J-shaped type in P2 and P3, and a bell shaped type in P1. A similar result was previously obtained by Nakasuga (1979), that a bell shaped and a J-shaped type are the most average type in the *K. candel* community of mangrove forests in Japan. It is thought that being *K. candel* an intolerant or a pioneer species, its height distribution tends to be a J-shaped type. This species will probably persist on invading the gaps in the forest canopy or margin areas, and therefore, it has a tendency to distribute and grow along mangrove channel, stream and seaward edges, as well as in gap or margin areas. This finding is in an agreement with the report of Urasaki (1982).

Number of dead and alive seedling and sapling of *B. gymnorrhiza* is shown in Table 1. It can be regarded from this observation that even though number of dead seedling of *B. gymnorrhiza* was also high, but more seedlings and also saplings managed to survive. There was an indication that *B. gymnorrhiza* is more tolerant under the forest canopy than *K. candel*. This fact supports the description of Macnae (1968) that species of *Bruguiera* are able to develop under the shade of other trees or themselves.

The distributional pattern of *B. gymnorrhiza* tree was more or less contagious with small clumps in P1, P2 and P3 ; while *K. candel* distributed uniformly in P3, contagiously with small clumps in P1 and P2. Sapling of *B. gymnorrhiza* tended to distribute randomly in P1 and P3, contagiously with small clumps in P2 ; and *K. candel* also showed a contagious distribution with small clumps in P1 and P3. The distributional pattern of all seedlings was contagious with small clumps in P1 and P2, and with a large clump in P3. The uniform distribution was only found in P3 of *K. candel* tree ; random distribution was also rare, occurred in P1 and P3 of *B. gymnorrhiza* sapling. These distributional patterns appeared as a result of the responses of individuals to their environment, such as Odum (1971) described that random distribution is occurrring where the environment is very uniform and there is no tendency to aggregate ; and uniform distribution may occur where competition between individuals is severe or where there is positive antagonism which promotes even spacing.

The most common distribution was contagious with small or large clumps, which occurred in all stages (tree, sapling, and seedling) of both *B. gymnorrhiza* and *K. candel*. It was supposed that viviparous seeds of mangrove were distributed in groups, and deposited in such places as holes, river or stream edges and surroundings of mounds by water ; or the seeds might fall and sprout near their mother trees. In the places they sprouted together in clumps. If their environment factors are favorable, they will persist and continue to grow into big seedlings, saplings and even tree stage. It seemed that gap areas in the forest also played a very important part in process of the individuals clumping, as is shown in P3, a large clump of seedling occurred in a gap area of the plot.

From this study it can be concluded that *B. gymnorrhiza* is more tolerant under forest canopy than *K. candel*. Its height distribution tends to be a bell or L-shaped type, while *K. candel* has a tedency to be a J-shaped type. Moreover, that the average crown cover as measured by the crown diameter of *B. gymnorrhiza* was much larger than *K. candel*. i.e. : 2.02, 2.70 and 2.01m, while *K. candel* was only 0.79, 1.05 and 0.80m in P1, P2 and P3 respectively. Therefore, *B. gymnorrhiza* will enable to shade and oppress *K. candel*. It is supposed from these facts that *B. gymnorrhiza* will be capalbe of replacing *K. candel*, so it is predictable that the climax of Oura mangrove forest will be a *Bruguiera gymnorrhiza* community.

Table 1 :Stand structure of a mangrove forest in Oura Bay(number of individuals per 100m²).

	Bruguiera gymnorrhiza						*Kandelia Candel*					
	P1		P2		P3		P1		P2		P3	
	Alive(%)	Dead	Alive(%)	Dead	Alive(%)	Dead	Alive(%)	Dead	Alive(%)	Dead	Alive(%)	Dead
Small seedling	6(6.5)	3	7(7.6)	3	3(1.5)	4	35(17.4)	39	10(21.7)	6	1(4.3)	-
Big seedling	21(22.8)	11	28(30.1)	14	80(39.0)	18	-	-	-	-	-	-
Sapling	49(53.3)	2	31(33.3)	2	77(37.6)	7	33(16.4)	17	-	-	10(43.5)	5
Tree	16(17.4)	-	27(29.0)	-	45(21.9)	-	133(66.2)	2	36(78.3)	2	12(52.2)	-
Total	92(100)	16	93(100)	19	205(100)	29	201(100)	58	46(100)	8	23(100)	5
Relative density of tree(%)	10.7		42.9		79.0		89.3		57.1		21.0	

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