

Analysis of Forest Ecosystems: Vertical Structure of Woody Plants and Mushrooms in Substitutional Forests

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Abstract

A total of six young substitutional forests were examined vertical distribution of woody plants and mushrooms. The vertical structure was analyzed on flowering seasons, flower colors, fruit colors, fruit types, mushroom colors, and mushroom types. The woody plants of the tree layer have yellowish flowers blooming in spring, and have brownish hard fruits. The plants of the undertree layer have whitish or yellowish flowers evenly, and have brownish hard, reddish, or purplish soft juicy fruits almost evenly. The plants of shrub layer have the mixed characteristics of flower colors and fruit colors. The characteristics of this layer are sharply contrast to those of the mature climax forests. There is no clear grass layer plants. Also, there is no mushrooms in the canopy and undertree layers. Only four mushroom species were identified in the shrub layer. The mushroom species having brownish and dry caps were found in 40 % and that of mucous caps were found in 10 %. There is no clear vertical distribution of mushrooms as for their cap coloration and cap condition.

Introduction

A forest is usually composed of several layers of woody plants. A typical evergreen broad-leaved forest has four layers; namely, the tree-, undertree-, shrub-, and grass layers. Even in each layer, flowering period, flower color, fruiting season, fruit color, and fruit type has a range of varieties, however there exist layer-specific modes (Nakanishi et al., 1983; Yamaguchi and Tsuchida, 1995). Especially, fruit has a shift of the modes from brownish and hard to reddish and soft via purplish and soft as its color and type in the sequence of vertical layers. Mushrooms follow this tendency but with less exaggeration (Yamaguchi and Tsuchida, 1995). A summer green for-

est or a coniferous forest follows basically these tendencies with slight differences (Yamaguchi and Tsuchida, 1996; Yamaguchi, Tsuchida and Yamamoto, 1997). So far, three major types of mature forests, which show the potential natural vegetation, have been analyzed distribution of woody plants and mushrooms in this aspect. Are these tendencies universal in any forest ecosystems, even in successional young forests? In this article, young forests which show substitutional vegetation are subjected to examine ecological characteristics of its vertical structure and further to confirm the vertical shift of fruit modes and mushroom modes observed in mature climax forests.

Materials and Methods

Study sites: A total of six substitutional forests were chosen in Yashiro Town of Hyogo Prefecture. They are dominated by *Pinus densiflora* and *Quercus serrata* trees, and are classified as so-called "Satoyama". A quadrat measuring 20 x 20 meters was built in each forest. Woody plant vegetation was examined and described by the method of Baun-Blanquet (Nakanishi et al., 1983). The ages of the forests are from 4 to 30 years. The woody plant and mushroom vegetation, the date of examination, and their geographical characteristics are shown in Iwabuchi et al. (1994).

Flower colors, flowering seasons, fruit colors, and fruit types of woody plant species were examined as for their vertical layers. Cap colors and cap conditions of mushroom species were also examined in the same manner. These description followed Satake et al. (1989a, b) and Imazeke and Hongo (1987, 1989). The layer-specific modes were described in this article.

Results and Discussion

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Stratification of woody plants in substitutional forests: Vegetation was examined phytosociologically, and was described in the order of vertical layers. A total of 61 woody plant species appeared. The canopy layers are formed of mainly *Pinus densiflora* and *Quercus serrata*, and the remaining of 22 tree species. The most of them are deciduous broad-leaved species. This point is sharply contrast to that of evergreen broad-leaved forest, which is the potential vegetation of the present study area. The undertree layers are composed of 12 species. The most dominant species is *Lyonia ovalifolia* var. *elliptica*. or *Ilex pedunculosa*. The shrub layers are composed of 25 species. *Rhododendron reticulatum* is the most dominating among

them. Using these results, their flowering seasons, flower colors, fruit colors, and fruit types are examined. The characteristics of the canopy layer are the followings: The mode of flower color is yellowish (13/24). They bloom in spring, and develop to brownish and hard fruits (14/24). This is the identical tendency to those of any mature climax forests. The characteristics of the undertree layer is a codominating of yellowish and whitish flower colors evenly. They also have fruits of the three types almost evenly; brownish hard, reddish soft, and purple soft. The characteristics of the shrub layer are centered on the dominating of whitish flower blooming in summer (8/25) and on the dominance of

Table 1. Distribution of flower colors, blooming seasons, fruit colors, and fruit types of woody plants in the vertical structure of substitutional forests.

Stratification	Flower			Fruit		
	Color	Season	No. of species	Color	Type	No. of species
Tree layer (B1)	yellow	spring	13	brown	hard	14
	yellow	summer	1	red	soft	8
	white	spring	5	purple	soft	2
	white	summer	2			
	purple	spring	1			
	purple	summer	1			
	green	summer	1			
	Total			24		
Under tree layer (B2)	yellow	summer	3	brown	hard	4
	yellow	spring	2	red	soft	5
	white	summer	3	purple	soft	3
	white	spring	2			
	red	summer	1			
	red	winter	1			
Total			12			12
Shrub layer (S)	white	summer	8	brown	hard	11
	white	spring	5	purple	soft	7
	white	autum	2	red	soft	7
	red	spring	4			
	red	summer	2			
	yellow	spring	4			
Total			25			25
Pooled	white		27	brown		29
	yellow		23	red		20
	red		8	purple		12
	purple		2			
	green		1			
	Total		61			61
		spring	36		soft	32
		summer	22		hard	29
		autum	2			
		winter	1			
Total		61			61	

brownish hard fruit (11/29). These are contrast to that of climax forest, where reddish soft fruits are almost fixed (Yamaguchi and Tsuchida, 1995 and 1996; Yamaguchi, Tsuchida and Yamamoto, 1997). There lacks of the woody plants of the grass lalyer commonly found in climax forest. These results are shown in Table 1. There is some extent of fazziness between the vertical laylers. A part of this reason is due to immaturity of the forests.

Mushroom distribution in the vertical structure of substitutional forests: A total of 100 mushroom species wer examined their vertical distribution.

Approximately 30 additional species were disclosed, but they were excluded from the analysis because of no species identification. There was no mushrooms in the tree- and undertree layers. Only four species were observed in the shrub layer. These were brownish, purple and whitish dry caps. The rest of species were observed in the grass layer. The most popular pattern is of brownish and dry cap (38/96). Only ten or 10 per cent species have mucous caps. Their cap colors have a wide range. Forty per cent of mushroom species showed brownish and dry caps. These results are shown in Table 2.

Table 2. Distribution of mushroom colors and cap conditions in the vertical structure of substitutional forests.

Stratification	Mushroom color	Cap condition	No. of species
Tree layer (B1)			none
	Total		0
Under tree layer (B2)			none
	Total		0
Shrub layer (S)	brown	dry	2
	purple	dry	1
	white	dry	1
	Total		4
Grass layer (K)	brown	dry	38
	brown	mucous	5
	white	dry	14
	white	mucous	1
	red	dry	9
	red	mucous	1
	purple	dry	10
	purple	mucous	1
	yellow	dry	9
	yellow	mucous	1
	gray	dry	4
	gray	mucous	1
	black	dry	2
	Total		96
Grand total		100	

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