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

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Abstract

A total of eight mature coniferous forests were examined vegetation and distribution of 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 browinish hard fruits. The plants of the grass layer have whitish or purplish or yellowish flowers, and have reddish or purplish soft and juicy fruits. The plants intermediate between these layers have the mixed characteristics of flower colors and fruit colors. The intermeidiate layers are not so characteristic as those of evergreen broad-leaved forests. The vertical distribution of mushrooms has the identical tendency; the most of mushrooms grow above the forest ground, and only few of mushroom species are in the shrub and under tree layers.

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, flowing period, flower color, fruiting season, fruit color, and fruit type has a ragne 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 exageration (Yamaguchi and Tsuchida, 1995). A summr green forest follows basically these tendencies with slight differencies (Yamaguchi and Tsuchida, 1996). Are these tendencies universal in any forest ecosystems? In this article, coniferous forests 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 evergreen broad-leaved and summer green forests.

Materials and Methods

Study sites: A total of eight climax coniferous forests were chosen in our country. They are dominated by *Abies sachalinensis, A. mariesii, A. veitchii or Picea jezoensis var. hondoensis* trees. They are all in regions of national or quasi-national parks. Basically, 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 study sites, the date of examination, and their geographical characteristics are shown in Tables 1 and 2. The study sites are also described in abbreviation by using two their capital letters.

Analysis: Diversity and identity in woody plants among the forests was expressed by a quantity known as the similarity index, SI. The SI value was calculated as follows: $SI = 2C/(A+B)$, where A and B are the numbers of species observed at forests A and B, respectively. C is the number of species observed in common (Odum, 1971).

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Table 1. Vertical structure of the coniferous forests in Mt. Oominezan, Mt. Oodaigahara, Mt. Ontakesan, and Nomugitoge.

Oominezan quadrat 20 x 20m, at altitude 1550m, October 15, 1993

B1: Tree layer		*B2: Undertree layer*		*S: Shrub layer*		*K: Grass layer*	
Coverage and sociability	n	Coverage and sociability	n	Coverage and sociability	n	Coverage and sociability	n
4,4 *Picea jezoensis var. hondoensis*	6	3,2 *Acer tenuifolium*	4	4,4 *Acer tenuifolium*	9	2,2 *Acer tenuifolium*	63
3,3 *Abies homolepis*	2	1,1 *Abies homolepis*	2	3,3 *Abies homolepis*	28	2,2 *Abies homolepis*	46
2,1 *Fagus crenata*	2	r *Hydrangea petiolaris*	2	r *Hydrangea petiolaris*	5	1,1 *Picea jezoensis var. hondoensis*	14
1,1 *Chamaecyparis obtusa*	1	r *Picea jezoensis var. hondoensis*	1	r *Picea jezoensis var. hondoensis*	3	r *Skimmia japonica var. intermedia*	6
		r *Chamaecyparis obtusa*	1	r *Viburnum furcatum*	3	r *Sorbus alnifolia*	5
				r *Sorbus alnifolia*	2	r *Chamaecyparis obtusa*	2
				r *Chamaecyparis obtusa*	1	r *Ilex geniculata*	1
				r *Fagus crenata*	1	r *Sorbus commixta*	1
				r *Hydrangea involucrata*	1	r *Symplocos coreana*	1
				r *Symplocos coreana*	1		
Total	11		10		54		139

Oodaigahara quadrat 20 x 20m, at altitude 1560m, October 19, 1993

B1: Tree layer		*B2: Undertree layer*		*S: Shrub layer*		*K: Grass layer*	
Coverage and sociability	n	Coverage and sociability	n	Coverage and sociability	n	Coverage and sociability	n
3,4 *Picea jezoensis var. hondoensis*	8	1,1 *Sorbus commixta*	1	1,1 *Pourthiaea villosa var. laevis*	3	5,5 *Sasa nipponica*	
2,3 *Abies homolepis*	6	r *Rhus ambigua*	3	r *Sorbus commixta*	1		
		r *Hydrangea petiolaris*	1	r *Quercus crispula*	1		
		r *Abies homolepis*	1	r *Acer shirasawanum*	1		
Total	14		6		6		

Ontakesan quadrat 20 x 20m, at altitude 2180m, October 30, 1995

B1: Tree layer		*B2: Undertree layer*		*S: Shrub layer*		*K: Grass layer*	
Coverage and sociability	n	Coverage and sociability	n	Coverage and sociability	n	Coverage and sociability	n
5,5 *Abies veitchii*	36	+ *Betula ermanii*	2	1,1 *Euonymus macropterus*	6	5,5 *Sasa senanensis*	
+ *Picea jezoensis var. hondoensis*	1	+ *Abies veitchii*	1	1,1 *Enkianthus campanulatus var. rubicundus*	2		
				+ *Abies veitchii*	6		
				r *Betula ermanii*	3		
				r *Acer tschonoskii*	1		
Total	37		3		18		

Nomugitoge quadrat 20 x 20m, at altitude 1680m, October 29, 1995

B1: Tree layer		*B2: Undertree layer*		*S: Shrub layer*		*K: Grass layer*	
Coverage and sociability	n	Coverage and sociability	n	Coverage and sociability	n	Coverage and sociability	n
5,5 *Abies veitchii*	16	1,2 *Abies veitchii*	11	1,3 *Tsuga diversifolia*	21	5,5 *Sasa senanensis*	
2,2 *Tsuga diversifolia*	4	1,2 *Acanthopanax sciadophylloides*	6	1,2 *Abies veitchii*	6		
1,1 *Picea jezoensis var. hondoensis*	2	+ *Tsuga diversifolia*	2	+ *Acanthopanax sciadophylloides*	4		
+ *Quercus crispula*	1	+ *Betula ermanii*	1	+ *Viburnum furcatum*	4		
				r *Carpinus tschonoskii*	2		
				r *Betula ermanii*	1		
				r *Schizophragma hydrangeoides*	1		
Total	23		20		39		

Table2. Vertical structure of the coniferous forests in Mt. Norikuradake, Mt. Nishihodakadake, Mt. Kisokomagatake, and Mt. Rausudake.

Norikuradake quadrat 20 x 20m, at altitude 2400m, August 20, 1994

B1: Tree layer Coverage and sociability		*B2: Undertree layer* n Coverage and sociability		*S: Shrub layer* n Coverage and sociability		*K: Grass layer* n Coverage and sociability	
5,5	*Abies mariesii*	27 1,1	*Abies mariesii*	7 4,4	*Vaccinium smallii*	220 1,3	*Sasa senanensis*
+	*Picea jezoensis var. hondoensis*	1 1,1	*Sorbus commixta*	4 2,2	*Sorbus commixta*	112	
				1,1	*viburnum furcatum*	64	
				+	*Acer tschonoskii*	48	
				+	*Cladothamnus bracteatus*	48	
				+	*Lonicera tschonoskii*	32	
				+	*Ribes japonicum*	16	
Total		28		11		542	

Nishihodakadake quadrat 30 x 30m, at altitude 2200m, June 6, 1994

B1: Tree layer Coverage and sociability		*B2: Undertree layer* n Coverage and sociability		*S: Shrub layer* n Coverage and sociability		*K: Grass layer* n Coverage and sociability		n
3,3	*Abies mariesii*	14 3,2	*Abies mariesii*	10 2,2	*Viburnum furcatum*	29 5,5	*Sasa senanensis*	
2,3	*Picea jezoensis var. hondoensis*	5 1,1	*Betula ermanii*	1 2,2	*Abies mariesii*	15 r	*Abies mariesii*	11
2,1	*Tsuga diversifolia*	3 r	*Sorbus commixta*	1 1,1	*Sorbus commixta*	10 r	*Ilex rugosa*	6
				r	*Euonymus planipes*	5 r	*Skimmia japonica var. intermedia*	1
				r	*Tsuga diversifolia*	3 r	*Sorbus commixta*	1
				r	*Picea jezoensis var. hondoensis*	1		
				r	*Vaccinium oralifolium*	1		
Total		22		12		64		19

Kisokomagatake quadrat 30 x 30m, at altitude 1660m, June 8, 1994

B1: Tree layer Coverage and sociability		*B2: Undertree layer* n Coverage and sociability		*S: Shrub layer* n Coverage and sociability		*K: Grass layer* n Coverage and sociability		n
4,4	*Abies veitchii*	71 2,2	*Abies veitchii*	38 r	*Schizophragma hydrangeoides*	7 r	*Abelia spathulata*	2
2,2	*Larix kaempferi*	41 r	*Larix kaempferi*	10 r	*Prunus nipponica*	2 r	*Fraxinus sieboldiana*	2
		r	*Prunus nipponica*	8 r	*Abies veitchii*	1 r	*Fagus crenata*	1
		r	*Schizophragma hydrangeoides*	3 r	*Abelia spathulata*	1		
		r	*Chamaecyparis obtusa*	2 r	*Tsuga diversifolia*	1		
		r	*Sorbus commixta*	1				
Total		112		62		12		5

Rausdake quadrat 20 x 20m, at altitude 800m, July 18, 1994

B1: Tree layer Coverage and sociability		*B2: Undertree layer* n Coverage and sociability		*S: Shrub layer* n Coverage and sociability		*K: Grass layer* n Coverage and sociability		n
2,2	*Quercus crispula*	16 2,2	*Alnus maximowiczii*	5 2,1	*Sorbus commixta*	21 1,1	*Daphniphyllum macropodum var. humi.*	17
2,2	*Abies sachalinensis*	11 2,2	*Sorbus commixta*	5 1,1	*Sorbus matsumurana*	14 1,1	*Ilex sugerokii var. brevipedunculata*	10
1,1	*Pinus pumila*	4 1,1	*Sorbus matsumurana*	3 1,1	*Weigela middendorffiana*	12 1,1	*Vaccinium smallii*	8
+	*Betula ermanii*	1 1,1	*Betula ermanii*	3 1,1	*Ligustrum tschonoskii*	9 +	*Vaccinium uliginosum*	3
		+	*Prunus nipponica var. kurilensis*	1 +	*Acer tschonoskii*	4 +	*Skimmia japonica var. intermedia*	2
		+	*Taxus cuspidata*	1 +	*Actinidia kolomikta*	4 r	*Sasa kurilensis*	
		r	*Acer mono var. glabrum*	1 +	*Ilex sugerokii var. brevipedunculata*	2		
		r	*Acer japonicum*	1 +	*Quercus crispula*	2		
Total		32		20		68		40

Table 3. Distribution of flowring seasons, flower colors, fruit types, and fruit colors of woody plants in the vertical structure of coniferous forests.

Woody plant species	Layer	Fl. s.	Fl. c.	Fr. t.	Fr. c.	OM	OD	ON	NM	NK	NH	KK	RS
		Month											
Abies homolepis	B1	5-6	yel	hard	prp	○	○						
Abies mariesii	B1	6	yel	hard	prp					○	○		
Abies sachalinensis	B1	6	yel	hard	brw								○
Abies veitchii	B1	6	yel	hard	brw			○	○			○	
Betula ermanii	B1	5-6	yel	hard	brw			○	○		○		○
Chamaecyparis obtusa	B1	4	yel	hard	brw	○						○	
Fagus crenata	B1	5	yel	hard	brw	○						○	
Larix kaempferi	B1	4-5	yel	hard	brw							○	
Picea jezoensis var. hondoensis	B1	5-6	yel	hard	brw	○	○	○	○	○	○		
Pinus pumila	B1	6-7	yel	hard	brw								○
Quercus crispula	B1	5	yel	hard	brw		○		○				○
Tsuga diversifolia	B1	4-5	yel	hard	brw				○		○	○	
Acanthopanax sciadophylloides	B2	8-9	yel	soft	prp				○				
Acer japonicum	B2	5-6	red	hard	brw								○
Acer mono var. glabrum	B2	4-5	yel	hard	brw								○
Acer tenuifolium	B2	4-5	red	hard	brw	○							
Alnus maximowiczii	B2	5-7	yel	hard	brw								○
Hydrangea petiolaris	B2	6-7	wht	hard	brw	○	○						
Prunus nipponica	B2	5-6	wht	soft	prp							○	
Prunus nipponica var. kurilensis	B2	5-6	wht	soft	prp								○
Rhus ambigua	B2	6-7	yel	hard	brw		○						
Schizophragma hydrangeoides	B2	5-7	wht	hard	brw				○			○	
Sorbus commixta	B2	5-7	wht	soft	red	○	○			○	○	○	○
Sorbus matsumurana	B2	6-8	wht	soft	red								○
Taxus cuspidata	B2	3-4	yel	soft	red								○
Abelia spathulata	S	4-6	yel	hard	brw							○	
Acer shirasawanum	S	5	red	hard	brw		○						
Acer tschonoskii	S	6-7	yel	hard	brw			○		○			○
Actinidia kolomikta	S	6-7	wht	soft	brw								○
Carpinus tschonoskii	S	4-5	yel	hard	brw				○				
Cladothamnus bracteatus	S	7-8	wht	hard	brw					○			
Enkianthus campanulatus var. rubicundus	S	5-6	red	hard	brw			○					
Euonymus macropterus	S	6-7	yel	soft	red			○					
Euonymus planipes	S	5-6	yel	soft	red						○		
Hydrangea involcrata	S	7-9	prp	hard	brw	○							
Ilex sugerokii var. brevipedunculata	S	7	wht	soft	red								○
Ligustrum tschonoskii	S	6-7	wht	soft	prp								○
Lonicera tschonoskii	S	7-8	wht	soft	red					○			
Pourthiaea villosa var. laevis	S	4-5	wht	soft	red		○						
Rhibes japonicum	S	5-7	prp	soft	prp					○			
Sorbus alnifolia	S	5-6	wht	soft	red	○							
Symplocos coreana	S	6	wht	soft	prp	○							
Vaccinium ovalifolium	S	7	yel	soft	prp						○		
Vaccinium smallii	S	6-7	yel	soft	prp					○			○
Viburnum furcatum	S	4-6	wht	soft	red	○			○	○	○		
Weigela middendorffiana	S	5-7	yel	hard	brw								○
Daphniphyllum macropodum var. humile	K	4-5	prp	soft	prp								○
Fraxinus sieboldiana	K	4-5	wht	hard	brw							○	
Ilex geniculata	K	6-7	wht	soft	red	○							
Ilex rugosa var. hondoensis	K	6-8	wht	soft	red						○		
Sasa kurilensis	K												○
Sasa nipponica	K						○						
Sasa senanensis	K							○	○	○	○		
Skimmia japonica var. intermedia	K	4-5	wht	soft	red	○					○		○
Vaccinium uliginosum	K	6-7	yel	soft	prp								○

Results

Vegetation and stratification of woody plants in coniferous forests: Vegetation was examned phytosociologically, and was described in the order of vertical layrs. A total of 55 woody plant species appeared. The canopy layers of the Oominezan forest (OM) and Oodaigahara forest (OD) were composed of *Picea jezoensis* var. *hondoensis*. Those of the Ontakesan forest (ON), Nomugitoge forest (NM), and Kisokomagatake forest (KK) were formed of *Abies veitchii*. And those of Norikuradake forest (NK) and Nishihodakadake forest (NH) are formed of *A. mariesii*. The Rausudake forest (RS) has the canopy formed by *A. sachalinensis*. The plants of the other layers are slightly diffrent one another. These results are shown in Tables 1 and 2. They are also shown in vertical order in Table 3. Using these results in vegetation, similarity indeces were calculated. They are able to be classified into four groups. These groups are well characterized by their dominating coniferous tree species. The results are shown in Table 4.

Differentiation of flowering seasons, flower colors, fruit colors, and fruit types in the vertical structure of coniferous forests: Description of flowering season, flower color, fruit color, and fruit type followed Satake et al. (1989a and 1989b). Flower color was determined by that of male flowers. The majority of woody plants of the tree layer have yellowish flowers blooming in spring. Most of them have brownish hard fruits. A few of them have purplish hard fruits. At the under tree layer, the mode of flower color is white, and they blooms rather in summer. They have brownish hard fruits, but some have purplish or reddish soft fruits. At the shrub layer, the plants have a high diversity in flowr color, flowering season, fruit color, and fruit type. Especially, soft fruits are superior to brownish hard fruits. The plants of the grass layer have a wide floweing seasons but the mode of fruits is reddish and soft. These results are shown in Table 5.

Mushroom distribution in the vertical structure of coniferous forests: A total of 101 mushroom species were identified and examined their vertical distribution. Approximately 30 additional species were disclosed, but they were excluded from the analysis because of no species identification. Their color patterns and cap conditions were classified by following Imazeki and Hongo (1987 and 1989). There was no mushroom in the tree layer. Only one species was observed in the under tree layer. It was browinish and dry cap although color pattern changes to be purplish later. Eighteen species were observed in the shrub layer. The color patterns showed brown, yellow, white, puple, gray, and red. There was no clear mode although the brownish color was mostly dominant. Only two species showed mucous caps. Eighty-two mushroom species in the grass layer have a wide range of cap colorations and cap conditions. Approximately 40 per cent of mushroom species showed browinsh and dry caps. Fifteen per cent of them showed mucous cap condition. These results are shown in Table 6, and are summerized in Table 7.

Table 4. Similarity indices (SI) of woody plant vegetation among eight climax coniferous forests.
Forests in Box A are classified as a groupe, and those in Box B are classified as an other group.

	Oominezan (OM)	Oodaigahara (OD)	Ontakesan (ON)	Nomugitoge (NM)	Norikuradake (NK)	Nishihodaka (NH)	Kisokoma (KK)	Rausudake (RS)
OM	A	0.36	0.11	0.17	0.26	0.33	0.26	0.12
OD			0.13	0.25	0.11	0.21	0.11	0.13
ON			B	0.47	0.35	0.33	0.12	0.14
NM					0.31	0.38	0.31	0.13
NK						0.48	0.11	0.13
NH							0.19	0.13
KK								0.06
RS								

Table 5. Distribution of flower colors, blooming seasons, fruit colors, and fruit types of woody plants in the vertical structure of coniferous forests.

Stratification		Flower			Fruit		
		Color	Season	No. of species	Color	Type	No. of species
Tree layer		yellow	spring	8	brown	hard	10
(B1)		yellow	summer	4	purple	hard	2
	Total			12			12
Under tree layer		white	spring	4	brown	hard	7
(B2)		white	summer	2	purple	soft	3
		yellow	spring	3	red	soft	3
		yellow	summer	2			
		red	spring	2			
	Total			13			13
Shrub layer		white	summer	6	brown	hard	8
(S)		white	spring	3	brown	soft	1
		yellow	summer	4	red	soft	7
		yellow	spring	4	purple	soft	5
		red	spring	2			
		purple	summer	2			
	Total			21			21
Grass layer		white	spring	3	red	soft	3
(K)		white	summer	1	purple	soft	2
		yellow	not clear	3	brown	hard	1
		yellow	summer	1	not clear		3
		purple	spring	1			
	Total			9			9
Pooled		yellow		29	brown		27
		white		19	red		13
		red		4	purple		12
		purple		3	not clear		3
	Total			55			55
			spring	30		hard	28
			summer	22		soft	24
			not clear	3		not clear	3
	Total		Total	55			55

Discussion

Vertical structure of flower colors and fruit colors in coniferous forests: The most of woody plants in coniferous forests have the flowering season in spring, There was no plant flowering in autumn or in winter. The plants in the tree layer have yellowish flowers and brownish hard fruits. Those of the under tree layer have yellowish or whitish flowers, but they share brownish hard fruits and purplish or reddish soft fruits almost equally. Those of the shrub layer have the most wide range in flower color and fruit color. Soft and juicy fruits are dominant over hard fruits. Especially, reddish soft fruits are characteristic to this layer. The woody plants in the grass layer follow this tendency, and reddish soft fruits are mostly dominant. All the above vertical distribution of flower colors and fruit colors is in good coincidence with the results observed in evergreen broad-leaved forests (Yamaguchi and Tsuchida, 1995) and in summer green forests (Yamaguchi and Tsuchida, 1996). Especiallly, fruit colors change from brown to red via purple in the vertical structure of the forests. The basic type of canopy trees has yellowihs flowers and blooms in spring. They have browish hard fruits. The trees under the canopy have more divergent flower colors and fruit types. They have purplish or reddish juicy fruits.

Table 6. Distribution of mushroom colors and cap conditions in the vertical structure of coniferous forests.

Mushroom species	Stratification	Cap color	Cap condition	OM	OD	NH	KK
Lampteromyces japonicus	B2	purple	dry	○			
Armillariella mellea	S	brown	dry	○		○	○
Crepidotus mollis	S	brown	dry				○
Hypsizigus marmoreus	S	brown	dry	○			
Panellus serotinus	S	brown	dry	○			
Polyporellus brumalis	S	brown	dry			○	
Fomes fomentarius	S	gray	dry	○	○		
Trichaptum biforme	S	purple	dry				○
Trichaptum fuscoviolaceum	S	purple	dry				○
Laetiporus sulphureus	S	red	dry	○	○		
Hericium ramosum	S	white	dry	○			
Mycoleptodonoides aitchisonii	S	white	dry	○	○		
Pleurotus pulmonarius	S	white	dry	○			
Oudemansiella mucida	S	white	mucous		○		
Fomitopsis pinicola	S	yellow	dry	○			
Gymnopilus liquiritiae	S	yellow	dry		○		○
Lachnellula willkommii	S	yellow	dry			○	○
Pholiota squarrosa	S	yellow	dry	○			
Tremella mesenterica	S	yellow	mucous			○	○
Amanita vaginata var. fulva	K	brown	dry		○		
Boletus quercinus	K	brown	dry		○		
Chroogomphus tomentosus	K	brown	dry			○	
Clitocybe clavipes	K	brown	dry				○
Clitocybe gibba	K	brown	dry			○	
Collybia butyracea	K	brown	dry				○
Collybia confluens	K	brown	dry				○
Collybia dryophila	K	brown	dry			○	○
Coriolus versicolor	K	brown	dry		○		○
Cystoderma granulosum	K	brown	dry			○	○
Dermocybe cinnamomea	K	brown	dry		○	○	
Galerina vittaeformis	K	brown	dry			○	○
Inocybe cookei	K	brown	dry				○
Ischnoderma resinosum	K	brown	dry			○	
Laccaria bicolor	K	brown	dry		○		○
Laccaria laccata	K	brown	dry			○	○
Laccaria vinaceoavellanea	K	brown	dry				○
Lactarius chrysorrheus	K	brown	dry				○
Lycoperdon pyriforme	K	brown	dry	○			
Marasmius cohaerens	K	brown	dry				○
Marasmius graminum	K	brown	dry				○
Naematoloma dispersum	K	brown	dry			○	○
Omphalina epichysium	K	brown	dry			○	○
Oudemansiella pudens	K	brown	dry	○			
Paxillus involutus	K	brown	dry				○
Polyporellus badius	K	brown	dry			○	
Rhodophyllus staurosporus	K	brown	dry			○	○
Russula foetens	K	brown	dry				○
Russula laurocerasi	K	brown	dry		○		
Strobilurus stephanocystis	K	brown	dry			○	
Tricholoma psammopus	K	brown	dry				○
Tricholoma ustale	K	brown	dry				○
Tricholomopsis banbusina	K	brown	dry			○	
Xeromphalina campanella	K	brown	dry		○		○
Cortinarius anomalus	K	brown	mucous			○	
Cortinarius pseudosalor	K	brown	mucous			○	
Amanita farinosa	K	gray	dry		○		
Helvella atra	K	gray	dry		○		
Mycena amygdalina	K	gray	dry	○			
Mycena galericulata	K	gray	dry		○	○	○
Mycena polygramma	K	gray	dry			○	○
Pseudoclitocybe cyathiformis	K	gray	dry		○		
Tricholoma saponaceum	K	gray	dry	○			

Table 6. Continued.

Camarophyllus subviolaceus	K	gray	mucous			○	
Mycena vulgaris	K	gray	mucous			○	○
Neobulgaria pura	K	gray	mucous			○	
Pseudohydnum gelatinosum	K	gray	mucous			○	○
Russula aeruginea	K	green	dry			○	
Russula virescens	K	green	dry			○	
Boletellus mirabilis	K	Purple	dry			○	
Russula cyanoxantha	K	purple	dry			○	○
Boletellus emodensis	K	red	dry		○		
Mycena haematopoda	K	red	dry		○	○	
Naematoloma sublateritium	K	red	dry	○	○		○
Russula emetica	K	red	dry				○
Russula mariae	K	red	dry				○
Russula neoemetica	K	red	dry			○	
Russula olivacea	K	red	dry				○
Russula sanguinea	K	red	dry			○	
Tricholomopsis rutilans	K	red	dry	○			
Gomphidius roseus	K	red	mucous				○
Hygrocybe conica	K	red	mucous		○		
Lactarius hysginus	K	red	mucous				○
Suillus grevillei	K	red	mucous				○
Hemimycena delicatella	K	white	dry			○	○
Marasmiellus chamaecyparidis	K	white	dry				○
Mycena osmundicola	K	white	dry				○
Pleurocybella porrigens	K	white	dry			○	
Bisporella citrina	K	yellow	dry				○
Callistosporium luteoolivaceum	K	yellow	dry				○
Cystoderma amianthinum	K	yellow	dry				○
Gerronema fibula	K	yellow	dry			○	○
Hygrophoropsis aurantiaca	K	yellow	dry				○
Lactarius porninsis	K	yellow	dry				○
Mycena citrinella	K	yellow	dry			○	
Mycena luteopallens	K	yellow	dry	○			
Naematoloma fasciculare	K	yellow	dry	○		○	○
Tricholoma auratum	K	yellow	dry	○			
Tricholoma sejunctum	K	yellow	dry	○		○	
Tricholomopsis decora	K	yellow	dry		○		
Hygrophorus lucorum	K	yellow	mucous				○
Leotia lubrica	K	yellow	mucous			○	

Table 7. Distribution of mushroom colors and cap conditions in the vertical structure of coniferous forests.

Stratification	Mushroom color	Cap condition	No. of species
Tree layer (B1)			none
Total			0
Under tree layer (B2)	purple	dry	1
Total			1
Shrub layer (S)	brown	dry	5
	yellow	dry	4
	yellow	mucous	1
	white	dry	3
	white	mucous	1
	purple	dry	2
	gray	dry	1
	red	dry	1
Total			18
Grass layer (K)	brown	dry	34
	brown	mucous	2
	yellow	dry	12
	yellow	mucous	2
	red	dry	9
	red	mucous	4
	gray	dry	7
	gray	mucous	4
	white	dry	4
	purple	dry	2
	green	dry	2
Total			82

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Vertical structure of mushroom colors and mushroom types in coniferous forests: The most of mushrooms grow above the forest ground. They also show the most wide range in mushroom color and mushroom type. Approximatelly 80 per cent of the species built their fruit bodies above the ground. Forty-four per cent of them are browish mushrooms and form the mode of colors. Brown seems to be the basic color pattern in mushrooms. The mushrooms in the shrub layer are only on the decayed woods. Brownish mushrooms are 28 per cent. The proportion of mushrooms which have colors deviating from the basic brownish color increased. Mushrooms seem to have the identical direction of divergence of color patterns to that of fruits of woody plants in the vertical structure of coniferous forest. This tendey is observed also in evergreen broad-leaved and summer green forests (Yamaguchi and Tsuchida, 1995 and 1996).

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