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〔Original〕

Vegetation Gradients of Forests in Northwestern Kitakyushu City and Nearby Areas

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Abstract: Fifty forest stands and sixty plant species were ordinated by a reciprocal averaging (RA) method to extract the major vegetation patterns of the forest in northwestern Kitakyushu City and nearby areas. The RA stand ordination on the first and second axes revealed three gradients of vegetation. They are the gradients (1) from the *Quercus serrata*-dominated forest to the *Machilus thunbergii*- or *Aphananthe aspera*-dominated forest, (2) from the *Quercus*- to the *Castanopsis cuspidata*-dominated forest, and (3) from the *Aphananthe*- or the *Machilus*- to the *Castanopsis*-dominated forest. The first two gradients showed high correlations of the stand RA scores to the canopy height and to the number of species found in the stand, but the third one did not. The former two, therefore, were referred to as the successional series of forests on the moist (bottomland) habitat and that on the less moist (foothill) one, respectively, and the third as the environmental gradient from moist to less moist habitats in matured forests. The RA species ordination showed the distribution center of each species in the above mentioned patterns of the forest vegetation.

Key words: *Aphananthe-Celtis* forest, environmental gradient, forest succession, ordination, reciprocal averaging.

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Introduction

Our vegetation studies in the Kitakyushu City area started in 1980, as a part of the environmental studies of the area, to describe the existing, actual plant-communities, to clarify the original vegetation on various habitats (that have been converted to the present-day agricultural, residential and industrial areas), and to find the general vegetation-habitat patterns. Our previous paper (Itow *et al.*, 1981) described, as a first step, the outline of the vegetation with some notes on conservation. The present paper is the second one of our vegetation studies describing the vegetation patterns found in the existing forest communities.

Study Area and Methods

Study area

The area of the present study, as described in the previous paper (Itow *et al.*, 1981), comprises Yawata-nishi and Wakamatsu Wards of Kitakyushu City and the nearby towns in northern Kyushu. The forest tracts studied are all located in lowland and hilly areas, lower than 100 m in altitude, except for two stands. Climatically, the whole study area is in the warm-temperate region. The mean annual temperature ranges from 14 to 15°C, the mean temperature of the coldest month (January) is between 4 and 5°C and that of the warmest month (August) between 25 and 26°C. The annual precipitation is about 1800 mm, including a small amount of snowfall in winter. Ecologically, the area is in the laurel-leaf, or evergreen broadleaf, forest climax region. The maritime forest and scrub are found along the coast but they are excluded from the present paper.

The forest stands studied are distributed separately in well-developed agricultural, industrial, and residential area. Many of them are the precincts of Shinto-shrines in towns and villages. Some are found near Buddist temples. The stands studied totalled fifty in number (Table 1 and Fig. 1).

The trees of the stands were sparsely or densely spaced, covering 40 to 90 per cent of the ground, being accompanied by dense growth of shrubs and herbs. The dominant species of the forest canopy is one of the following species: *Castanopsis cuspidata* (including var. *sieboldii*) (Fagaceae), *Quercus serrata* (Fagaceae), *Machilus thunbergii* (Lauraceae), *Cinna-*

Fig. 1. Map of northwestern Kitakyushu City and nearby area, showing the location of the forest stands studied. Numerals are the stand numbers listed in Table 1.

Table 1. List of the stands studied with their altitude (m), canopy height (m), total number of species recorded (A), number of species excluding those occurred in one or two of the fifty stands (B), and RA scores on first and second axes. Abbreviations for dominants and subdominants are as follows: Apa. *Aphananthe aspera*, Cac. *Castanopsis cuspidata*, including var. *sieboldii*, Ces. *Celtis sinensis* var. *japonica*, Cic. *Cinnamomum camphora*, Cij. *Cinnamomum japonicum*, Cyg. *Cyclobalanopsis gilva*, Els. *Elaeocarpus sylvestris*, Ilr. *Ilex rotunda*, Maj. *Mallotus japonicus*, Mat. *Machilus thunbergii*, Mer. *Meliosma rigida*, Mic. *Michelia compressa*, Pid. *Pinus densiflora*, Prj. *Prunus jamasakura*, Qus. *Quercus serrata*, Zaa. *Zanthoxylum ailanthoides*

Locality	Altitude (m)	Dominant and subdominant	Canopy height (m)	No. of spp.		RA score	
				(A)	(B)	1st axis	2nd axis
1) Hakusan S.; Kotake; Wa.	180	Mat / Mic	25	64	60	95	34
2) Hakusan S.; Kotake; Wa.	150	Apa / Mat	25	61	56	95	29
3) Hiruko S.; Kashihara; Ashiya	20	Mat	13	42	38	58	26
4) Ooyamazumi S.; Mizumaki	70	Mat / Cac	20	55	53	100	5
5) Suga S.; Takenami; Wa.	40	Cyg / Cac	20	60	55	90	74
6) Suga S.; Takenami; Wa.	40	Cac / Mer	25	22	20	95	33
7) Izu S.; Mizumaki	80	Mat / Cac	15	39	39	100	40
8) Reservior 2; Tonda; Wa.	30	Cac	18	56	55	69	68
9) Izu S.; Mizumaki	40	Cac / Mat	12	43	42	89	27
10) Kamigumi; Wa.	20	Cac	15	31	31	72	50
11) Tsukue; Mizumaki	90	Mat / Cac	18	40	39	99	0
12) Kozenji T.; Anao; Ya.	20	Cac	15	35	34	87	66
13) Kozenji T.; Anao; Ya.	20	Els / Cac	25	33	32	97	42
14) Hiyoshi S.; Nakatani; Wa.	30	Cac	17	57	55	78	77
15) Toake S.; Amazumi; Wa.	30	Cac / Mat	15	39	39	74	72
16) Handa; Onga	20	Cac / Mat	20	72	62	73	73
17) Handa; Onga	30	Cac / Mat	18	60	55	73	79
18) Handa; Onga	40	Cac	20	42	41	75	85
19) Handa; Onga	20	Cac / Mat	20	49	48	71	88
20) Nakao S.; Takasu; Wa.	15	Cac	10	34	32	66	52
21) Myosenji T.; Ootorii; Wa.	30	Cac / Mat	18	48	47	58	66
22) Toake S.; Ootorii; Wa.	25	Cac / Mat	15	41	41	44	68
23) Reservior 1; Tonda Wa.	50	Cac / Mat	10	41	41	58	75
24) Toake S.; Hakomaru; Wa.	40	Cac / Mat	20	48	48	66	85
25) Ushiro; Wa.	25	Cac / Mat	10	42	40	69	75
26) Yamaga; Ashiya	30	Cij	10	44	44	83	49
27) Towaki S.; Oda; Wa.	30	Cac / Mat	15	35	35	59	68
28) Kario S.; Ashiya	30	Cac / Mat	18	36	36	67	100
29) Giongu S.; Ashiya	30	Cac / Mat	15	28	28	82	77
30) Jugosha S.; Arige; Wa.	20	Cac / Mat	18	48	45	92	61
31) Reservior 2; Tonda; Wa.	40	Cac / Mat	10	27	27	71	29
32) Sakota; Wa.	90	Ilr / Cac	10	55	49	48	58
33) Kuga S.; Mizumaki	50	Apa	12	43	36	95	16
34) Kuga S.; Mizumaki	40	Apa / Ces	20	53	42	91	14

(continued)

(continued)

Locality	Altitude (m)	Dominant and subdominant	Canopy height (m)	No. of spp. (A)	(B)	RA score 1st axis	2nd axis
35) Takami S.; Mizumaki	30	Apa / Ccs	20	51	49	93	16
36) Takami S.; Mizumaki	30	Apa / Ilr	20	40	40	96	44
37) Ookimi S.; Ashiya	40	Qus / Apa	10	39	38	47	21
38) Saruwatari; Ya.	20	Qus	8	57	47	27	34
39) Takenami; Wa.	40	Qus / Pid	6	38	35	23	33
40) Takenami; Wa.	30	Qus / Pid	6	29	24	0	14
41) Ryugaike; UOEH	50	Qus	8	35	35	6	13
42) Ryugaike; UOEH	50	Qus / Zaa	6	23	22	0	15
43) Nurse's Dorm; UOEH	50	Qus / Zaa	8	40	35	14	26
44) Water Supply Facil.; UOEH	30	Qus	10	36	33	61	44
45) Park near UOEH	30	Prj / Qus	10	45	37	46	26
46) Park near UOEH	20	Qus	10	32	31	49	41
47) Mizumaki	80	Cic	15	38	32	86	62
48) Mizumaki	50	Apa / Ccs	18	48	42	99	1
49) Takenami; Wa.	40	Qus / Maj	12	31	30	51	31
50) Takenami; Wa.	40	Bamboo	10	33	32	90	27

momum camphora, *C. japonicum* (Lauraceae), *Elaeocarpus sylvestris* (Elaeocarpaceae), *Ilex rotunda* (Aquifoliaceae), *Aphananthe aspera* (Ulmaceae), *Celtis sinensis* var. *japonica* (Ulmaceae), *Prunus jamasakura* (Rosaceae), *Zanthoxylum ailanthoides* (Rutaceae), *Pinus densiflora* (Pinaceae), and bamboo. The height of the canopy trees varies with stands from 6 to 25 m, depending on the intensity of man's impact in the past and present. Their diameter also varied from 6 cm in young stands to 70 cm in matured stands (Table 1).

Methods

The vegetation of each stand was surveyed and the height and coverage of each foliage layer were recorded (1st-tree, 2nd-tree, shrub, and herb layer). The component species were listed until no additional species could be found even when the sampling area exceeded about 200 m^2. Then the dominance of each species in each layer was recorded according to the Braun-Blanquet's (1964) scale (+ — 5).

The original data thus collected were converted to the presence-absence data. The reciprocal averaging method (Hill, 1973) (hereafter abbreviated as RA) was adopted as the method of data processing, because RA gives effectively the ordination of both stands and species at the same time with little distortion (Gauch *et al.*, 1977). Prior to the RA calculations, the species with high presence percentages were excluded from the data table, because they have little effects on the ordination. They were all evergreen plants like *Eurya japonica* (Theaceae), *Dendropanax trifidus* (Araliaceae), *Litsea sericea* (Lauraceae), *Symplocos lucida* (Symplocaceae), *Dryoteris erythrosora* (Aspidiaceae), and some others. Finally, sixty species were used for the calculation. They were the species whose occurrences were between 4 to 36 out of the 50 studied stands and those that are thought of as indicators of environmental or successional relations in the northern Kyushu regions. The selection of these species was made based on our field experiences. Table 2 gives the presence-absence data of the sixty selected species in the fifty stands studied.

In the RA calculations, first and second axes were extracted in both the stand and species ordinations. The calculations were made according to the Hill's method (Hill, 1973) on an integer basis. The iterative calculations in the second axis was discontinued when the difference in score total was minimum (not zero) between the previous and the succeeding calculations.

Results and Discussion

The RA calculations yielded interpretable results in both the stand and species ordinations and revealed several new facts, as given below.

Stand ordination

The last two columns of Table 1 give the RA scores of stands from 0 to 100 for the first and second axes. Fig. 2 is the scatter diagram of the stands, showing the forest-types categorized by the canopy dominants (or subdominants) (see Table 1 for the original data). The forest-types recognized are (i) the *Quercus serrata* forest in the bottom-left of the diagram, (ii) the *Machilus thunbergii* forest in the bottom-right, (iii) the *Aphananthe aspera* forest in the bottom-right corner and (iv) the *Castanopsis cuspidata* forest in the top-right. Three exceptional stands are shown by open triangles in Fig. 2. No stands were plotted in the top-left of the diagram.

Fig. 3 and 4 are the scatter diagrams of the canopy height and the number of species recorded in the stands, respectively. Apparently, the canopy is higher and the number of species is more at the bottom-right and the top-right of the diagram. This fact shows that the stands at the right-hand side of the diagram are well developed forests characterized by high canopy and many species. To assure these relations, correlation coefficients between the stand RA scores and the vegetation characteristics were calculated in the gradients (1) from the bottom-left to the bottom-right (that is, from the *Quercus* through *Machilus* to *Aphananthe* stands), (2) from the bottom-left to the top-right (from the *Quercus* to *Castanopsis* stands), and (3) from the bottom-right to the top-right (from the *Aphananthe* or *Machilus* to *Castanopsis* stands). Table 3 shows the results of the correlation calculations, showing highly correlated relations between the stand RA scores and the canopy height in the gradients (1) and (2), but few correlation in (3). The correlation between the RA scores and the numbers of species is also recognized in (1) and (2) but not in (3).

Based on the results mentioned above, the *Quercus-Machilus-Aphananthe* series and the *Quercus-Castanopsis* series can be interpreted as those of the forest succession from the early to later phases. The *Aphananthe-Machilus-Castanopsis* series, on the other hand, cannot be

Table 2. Presence-absence data used for RA calculation. For stand nos, see footnote

Alpinia japonica	1111...1..	.111.....1	..1.......	....	....	Hanamyoga
Cornus brachypoda	11.111....	.1........	......1...	....	....	Kumanomizuki
Aucuba japonica	1111.111..	.1.1......	....	..1.......	....	Aoki
Aphananthe aspera	1111111.11	.1.1..1.1.	1.........	....	.11.......	Mukunoki
Celtis sinensis var. *japonica*	111.111..1	..1.......	1...1.....	....	..1.......	Enoki
Symplocos glauca	1111...11.	1111...11.	..1.1..1.1	1	1.........	Mimizubai
Ilex chinensis	111..111.1	...11.....	...1.11...	....	..11......	Nanamenoki
Rumohra aristata	...1...1.1	11....11..	....	....	....	Hosobakanawarabi
Quercus gilva	...1......	11.....1..	....	....	....	Ichiigashi
Maesa japonica	..11......	.1....11..	1	....	....	Izusenryo
Meliosma rigida	.......1..	1...1..1..	....	....	....	Yamabiwa
Liriope platyphylla	1111111111	.111..1111	..1.11.1.1	..1.11....	....	Yaburan
Damnacanthus major	.....1.111	......1.1.	...1.11.1.	....	....	Juzunenoki
Trachelospermum asiaticum	1111111111	.1111.1111	1111.11111	1......1..	....	Teikakazura
Hedra rhombea	1111111111	1111..1111	111.111111	1..111..11	1.........	Kizuta
Anodendron affine	...1......	.1....1...	..1..11.1.	....	....	Sakakikazura
Damnacanthus indicus	.......1..	.......1..	...1.11...	....	....	Aridoshi
Camellia japonica	.111111111	11.1.1111.	111111.11.	11.111.1.1	.1........	Yabutsubaki
Quercus glauca	1.1.1111.1	...1...1..	..1.111..1	1..111...1	..1.......	Arakashi
Elaeocarpus sylvestris	.....1..11	.1..1.....	....	1.....11..	....	Horutonoki
Viburnum japonicum	.....1...1	.....1....	11........	11........	....	Hakusanboku
Ilex buergeri	11...11111	11.1111111	.111111111	111111111.	....	Shiimochi
Actinodaphne lancifolia	...111....	....	1..1.11...	....	....1.....	Kagonoki
Ophiopogon ohwii	11111111.1	.111..11..	1111111111	.111111.11	.11.1.....	Nagabajanohige
Fatsia japonica	..111111.1	.111.111.1	1.1.1.11.1	.1.1.1.11.	1..1..1...	Yatsude
Michelia compressa	...1......	.1....11..	...1.11.11	...1.1..1.	....	Ogatamanoki
Elaeocarpus japonicus	....	.......1..	..11.1.111	....	....	Kobanmochi
Ilex rotunda	...1.1.1.1	11.11111..	1111111..1	11111111.1	.11.......	Kuroganemochi
Ilex integra	11.1.1.111	.11111111.	1111111111	1111111111	.11.11....	Mochinoki
Cinnamomum japonicum	1111111111	.1111111.1	1111111111	111..111.1	1111.1.11.	Yabunikkei
Ternstroemia gymnanthera	....	.....1.1..	..11111...	11..1.....	....	Mokkoku
Stauntonia hexaphlla	1..1.1.111	.1.1111111	1.1.111111	1111111111	1111.....1	Mube
Woodwardia japonica	....	11	....111.11	.1.1.1.1..	....	Ookaguma
Myrsine seguinii	....	......111.	..1.1....1	11.1..1...	.....1....	Taimintachibana
Gardenia jasminoides	.....1.1..	..1..1.111	.111111111	1111111.1.	1.1.1.....	Kuchinashi
Ardisia japonica	1.111.11.1	.11.1....1	1..1.11111	1.11.111.1	111111.1..	Yabukoji
Daphniphyllum teijsmannii	1	.1..11....	1111111.1.	.111111.1.	....1.....	Himeyuzuriha
Machilus thunbergii	11.1.111.1	111111111.	1111111.11	1111111111	1.11111.11	Tabu
Kadsura japonica	..11......	.1.1.111.1	1.11111.11	.1.1.11111	11..1.11..	Binankazura
Ligustrum japonicum	.1.11.1.1.	..1111111.	1.11.11111	1111111111	.11111111.	Nezumimochi
Clerodendron trichotomum	....	.....1.1.1	.....11..1	.1.....1..	.1...1....	Kusagi
Cymbidium goeringii	1...1.....	..1.1.1...	..11.11.11	1.111.1.1.	1...1111..	Shunran
Euscaphis japonica	...1......	....	....1.1.11	1.11...1..	111..11...	Gonzui

Callicarpa mollis	....1..1..11 .1.1.1.11. ..1...1...	Yabumurasaki
Myrica rubra	.....1.... ....11111.1. 11.11.1111 ....1...11	Yamamomo
Smilax china	.... .1.1...11. 1111..1111 111111111. .111111111	Sarutoriibara
Platycarya strobilacea	.....1.... ....1... ....1. ...1..1...	Nogurumi
Prunus jamasakura	.1........ ...1.1.... .....1.1.. ..1.11.1.1 ..1111..11	Yamazakura
Quercus salicina	....1..... ..111.111. 11..1...11 .11111.111	Urajirogashi
Mallotus japonicus	..1....... .1...1.... ......1..1 1......1.. 1.1.1111.1	Akamegashiwa
Kalopanax pictus	....1.... ....1 11.111....	Harigiri
Zanthoxylum ailanthoides	......1... .....1.... ....1111. ....1.1..1	Karasuzansho
Dicranopteris linearis	....1....1 ..1111.... .1..11.111	Koshida
Vaccinium bracteatum	.... 1......... ....1.1 .... 111.11.111	Shashanbo
Quercus serrata	....1..... .....1.... ....1.1 1111111111	Konara
Pinus densiflora	....11.1. .....1.11.	Akamatsu
Rhus javanica	....1.... ....1.11. 111	Nurude
Lyonia ovalifolia		
var. *elliptica*	....1...1. ..1...11.1	Nejiki
Miscanthus sinensis	....1.. ....1.1.1.	Susuki
Rhododendron kaempferi	....1.111111	Yamatsutsuji

Order of stands, from left to right : 4,11,48,2,33,35,34,7,13,36,6,1,50,9,31,3,30,5,12,47,26,29,14,18,15,17,16,10,19,8,25,28,20,24,27,21,23,32,22,44,49,46,37,45,38,39,43,41,40,42. (cf. Figs. 1,2)

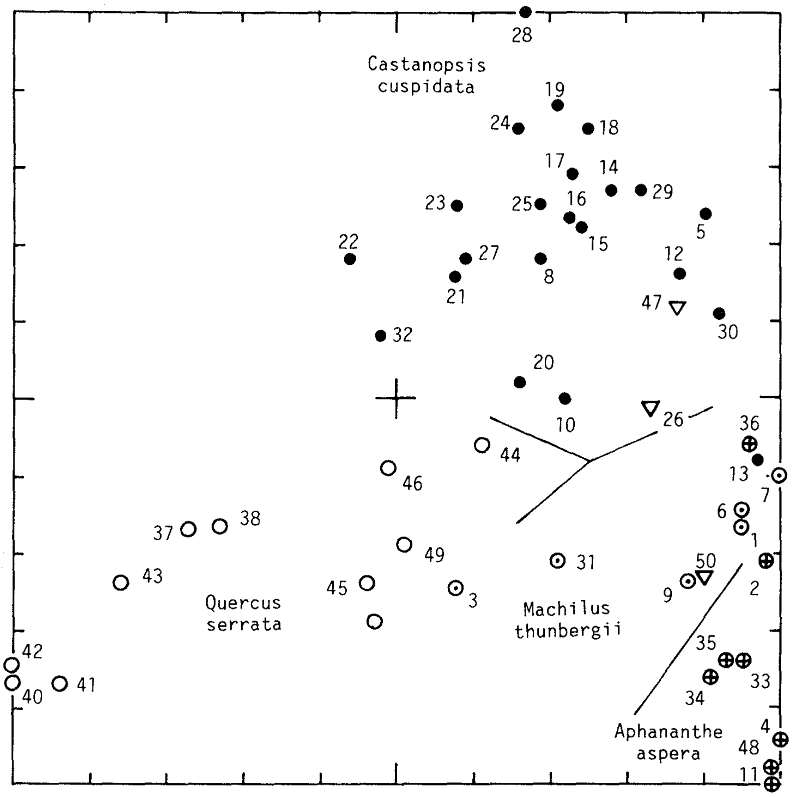

Fig. 2. Stand ordination diagram by reciprocal averaging (RA). Open circles: *Quercus serrata*-dominated stands, open circles with a point at each center: *Machilus thunbergii*-dominated stands, open circles with a cross: *Aphananthe aspera*-dominated stands, solid circles: *Castanopsis cuspidata*-dominated stands, triangles: abberant stands dominated by *Cinnamomum japonicum* (Stand 26), *C. camphora* (Stand 47) and bamboo (Stand 50). Numerals are the stand numbers listed in Table 1.

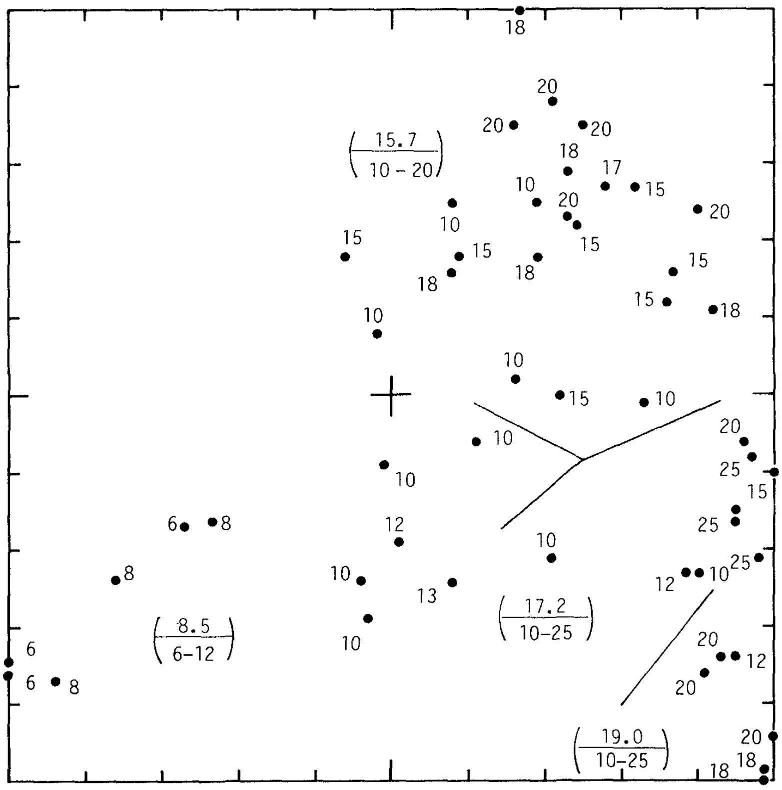

Fig. 3. Scatter diagram of canopy height (m). Numerals in brackets mean (above) the average height and (below) the range for the forest-type.

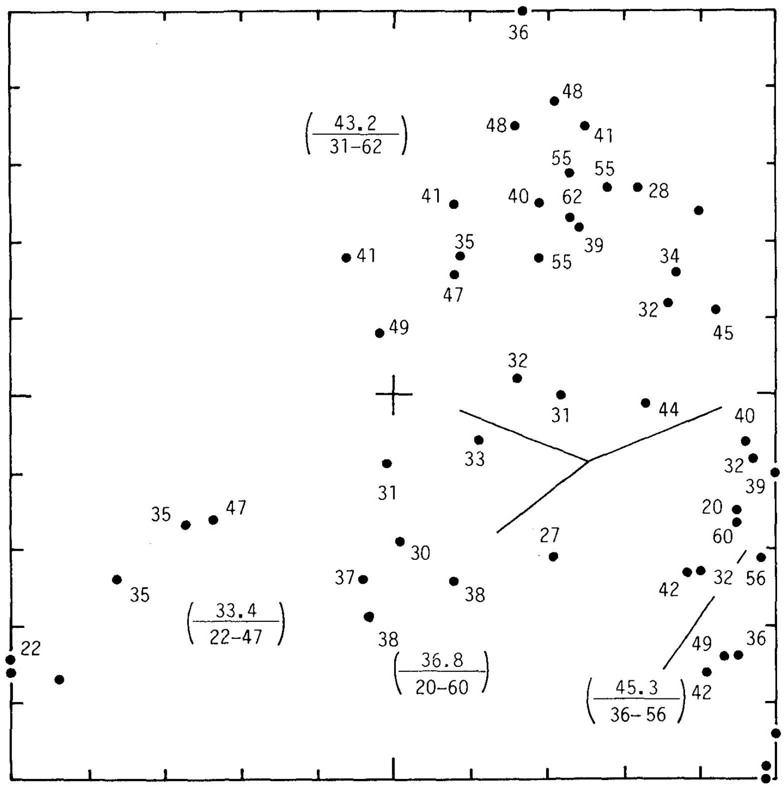

Fig. 4. Scatter diagram of the number of species found in a stand (excluding the species that occurred only in one or two stands out of fifty). Numerals in brackets show (above) the average number of species and (below) the range for the forest-type.

considered to be a successional one but a moist to — less moist habitat gradient, because the canopy height and the number of species are not correlated with the stand RA scores.

In connection with the *Aphananthe*-dominated forest, Miyawaki & Fujiwara (1974) first referred to it as a forest on the alluvial plain in Kinki district, central Honshu. Miyawaki *et al.* (1976) and Miyawaki (1981) described an *Elaeocarpus sylvestris-Aphananthe aspera* forest in Kumamoto Prefecture, and recognized it as a related but different community from the above-mentioned forest in the sense of the Braun-Blanquet's phytosociology. Ohno (1979) studied the *Aphananthe aspera-Celtis sinensis* var. *japonica* forest found in moist habitats of alluvial plains, on river banks and riverside terraces in western Honshu and Shikoku, and named it Aphanantho-Celtidetum japonicae, according to the phytosociological tradition. Miyawaki *et al.* (1979a, b) and Miyawaki (1982, 1983) also recognized this forest community as a potential natural community in regions west of the Kanto district of Honshu, Shikoku and Kyushu, but its actual presence has not yet been recognized in Kyushu. The present paper is the first record of the *Aphananthe-Celtis* forest as an existing forest community in Kyushu.

Minamikawa (1974) and Ohno (1979) considered that the *Aphananthe*-dominated forest was succeeded by the *Machilus* forest in the succession. This is a possible interpretation concerning the *Aphananthe-Machilus* series. We consider it to be the environmental gradient from moist to less moist habitats in lowland area, on the basis of the fact that there is no correlation between the stand RA scores and the canopy height and the number of species (see Table 3 and Figs. 3 and 4).

Species ordination

The distribution behavior of the component species can be studied by plotting their presence on the stand ordination diagram (Fig. 5) and by the RA species ordination itself (Table 4 and Fig. 6). Fig. 5 shows the distribution of 13 selected species on the stand

Table 3. Correlations between stand RA scores and vegetation characteristics

	n	r
Bottom-left to bottom-right		
1st-axis score to canopy height	27	0.797**
1st-axis score to No. of species 1)	27	0.436*
Bottom-left to top-right		
Combined 1+2 axes score to canopy height	34	0.830**
Combined 1+2 axes score to No. of species	34	0.514*
Bottom-right to top-right		
2nd-axis score to canopy height	39	−0.061
2nd-axis score to No. of species	39	0.126

1) Number of species excluding those occurred in one or two out of the fifty stands studied.
* $P < 0.05$ ** $P < 0.01$

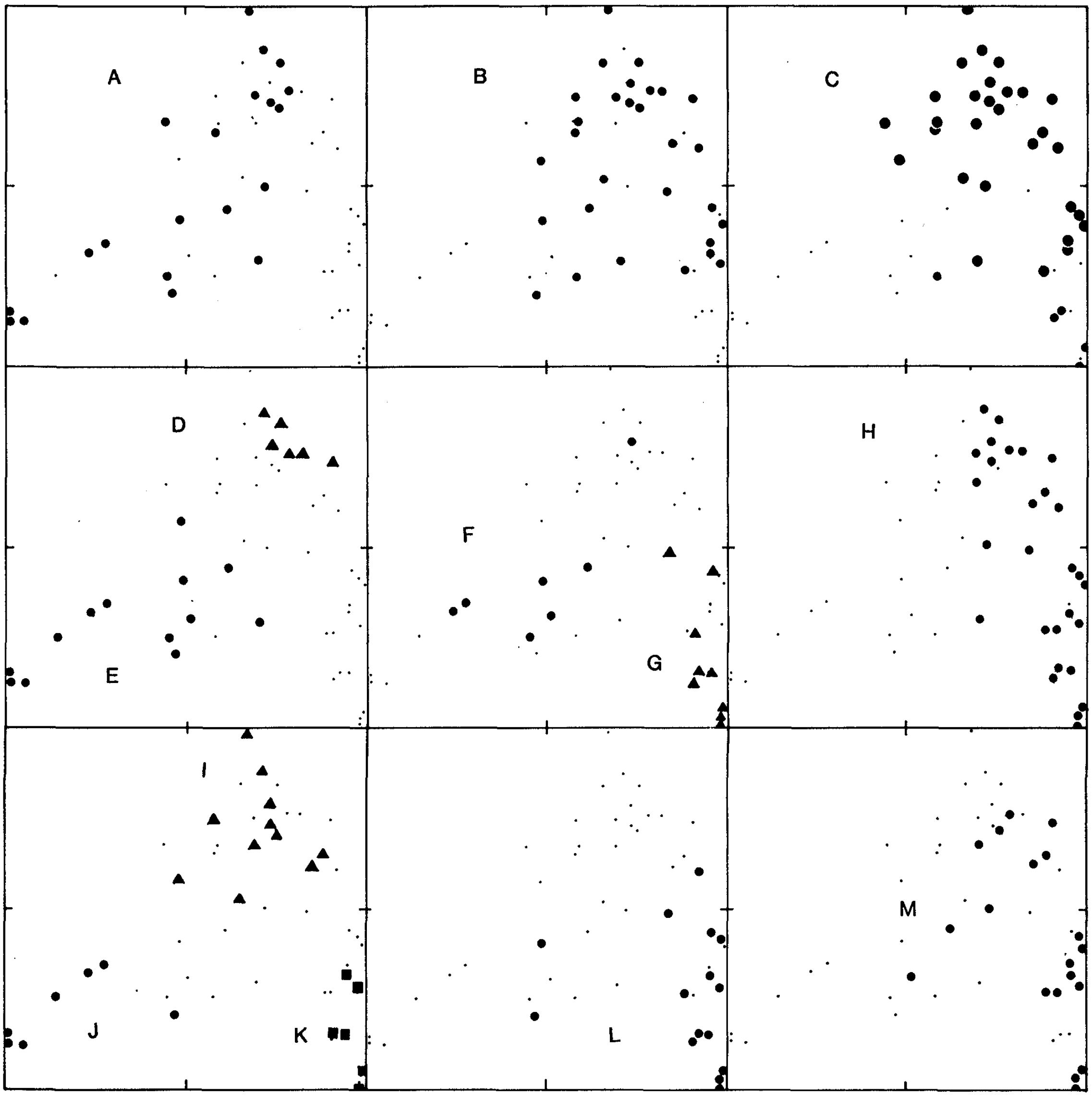

Fig. 5. Distribution behaviors of 13 selected species on the stand ordination diagram. A. *Histiopteris glauca*, B. *Ilex rotunda*, C. *Castanopsis cuspidata* (including var. *sieboldii*), D. *Elaeocarpus japonicus*, E. *Quercus serrata*, F. *Kalopanax pictus*, G. *Celtis sinensis* var. *japonica*, H. *Trachelospermum asiaticum*, I. *Woodwardia japonica*, J. *Rhododendron kaempferii*, K. *Cornus brachypoda*, L. *Aphananthe aspera*, M. *Symplocos glauca*.

ordination diagram.

The last two columns of Table 4 give the RA scores of the 60 selected species in the species ordination. The position of the species on the species ordination diagram indicates the distribution center in the detected vegetation gradients shown in Figs. 2, 3 and 4, and Table 2. The species plotted near the average point, which is at 65 on the first axis and 50 on the second, are those that are distributed in the central region of the ordination diagram, or those distributed through the whole vegetation.

The study of species distribution patterns in Fig. 6 and Table 2 revealed the groups of species with similar behaviors as follows. (1) Species whose distribution center is in

Table 4. Scores of species in RA ordination on first and second axes

	Species	Axis (1)	Axis (2)	Japanese common name
1.	*Rumohra aristata*	100	41	(Hosobakanawarabi)
2.	*Cyclobalanopsis gilva*	99	36	(Ichiigashi)
3.	*Alpinia japonica*	98	14	(Hanamyoga)
4.	*Cornus brachypoda*	98	9	(Kumanomizuki)
5.	*Aucuba japonica*	97	3	(Aoki)
6.	*Maesa japonica*	94	40	(Izusenryo)
7.	*Meliosma rigida*	92	49	(Yamabiwa)
8.	*Aphananthe aspera*	91	15	(Mukunoki)
9.	*Celtis sinensis* var. *japonica*	91	7	(Enoki)
10.	*Liriope platyphylla*	88	40	(Yaburan)
11.	*Symplocos glauca*	88	32	(Mimizubai)
12.	*Damnacanthus major*	88	70	(Juzunenoki)
13.	*Trachelospermum asiaticum*	87	47	(Teikakazura)
14.	*Ilex chinensis*	84	24	(Nanamenoki)
15.	*Anoderon affine*	84	73	(Sakakikazura)
16.	*Damnacanthus indicus*	84	86	(Aridoshi)
17.	*Hedra rhombea*	83	49	(Kizuta)
18.	*Camellia japonica*	81	56	(Yabutsubaki)
19.	*Quercus glauca*	79	48	(Arakashi)
20.	*Elaeocarpus sylvestris*	79	53	(Horutonoki)
21.	*Viburnum japonicum*	79	77	(Hakusanboku)
22.	*Castanopsis cuspidata*	78	65	(Shii)
23.	*Actinodaphne lancifolia*	77	50	(Kagonoki)
24.	*Ophiopogon ohwii*	76	51	(Nagabajanohige)
25.	*Fatsia japonica*	75	49	(Yatsude)
26.	*Michelia compressa*	75	81	(Ogatamanoki)
27.	*Elaeocarpus japonicus*	75	94	(Kobanmochi)
28.	*Ilex rotunda*	74	66	(Kuroganemochi)
29.	*Ilex integra*	72	59	(Mochinoki)
30.	*Cinnamomum japonicum*	71	46	(Yabunikkei)
31.	*Ternstroemia gymnanthera*	70	100	(Mokkoku)
32.	*Stauntonia hexaphlla*	69	58	(Mube)
33.	*Woodwardia japonica*	68	93	(Ookaguma)
34.	*Myrsine seguinii*	68	88	(Taimintachibana)
35.	*Gardenia jasminoides*	68	75	(Kuchinashi)
36.	*Ardisia japonica*	67	42	(Yabukoji)
37.	*Daphniphyllum teijsmannii*	66	82	(Himeyuzuriha)
38.	*Machilus thunbergii*	65	51	(Tabu)
39.	*Kadsura japonica*	63	62	(Binankazura)
40.	*Ligustrum japonicum*	61	52	(Nezumimochi)
41.	*Clerodendron trichotomum*	60	79	(Kusagi)

(continued)

(continued)

Species	Axis (1)	Axis (2)	Japanese common name
42. *Cymbidium goeringii*	58	57	(Shunran)
43. *Euscaphis japonica*	53	57	(Gonzui)
44. *Callicarpa mollis*	52	80	(Yabumurasaki)
45. *Myrica rubra*	52	74	(Yamamomo)
46. *Smilax china*	51	58	(Sarutoriibara)
47. *Platycarya strobilacea*	48	42	(Nogurumi)
48. *Prunus jamasakura*	45	34	(Yamazakura)
49. *Hicriopteris glauca*	43	54	(Urajiro)
50. *Mallotus japonicus*	41	32	(Akamegashiwa)
51. *Kalopanax pictus*	39	34	(Harigiri)
52. *Zanthoxylum ailanthoides*	35	46	(Karasuzansho)
53. *Dicranopteris linearis*	32	44	(Koshida)
54. *Vaccinium bracteatum*	30	18	(Shashanbo)
55. *Quercus serrata*	26	22	(Konara)
56. *Pinus densiflora*	19	41	(Akamatsu)
57. *Rhus javanica*	18	40	(Nurude)
58. *Lyonia ovalifolia* var. *elliptica*	15	23	(Neziki)
59. *Miscanthus sinensis*	7	19	(Susuki)
60. *Rhododendron kaempferi*	0	0	(Yamatsutsuji)

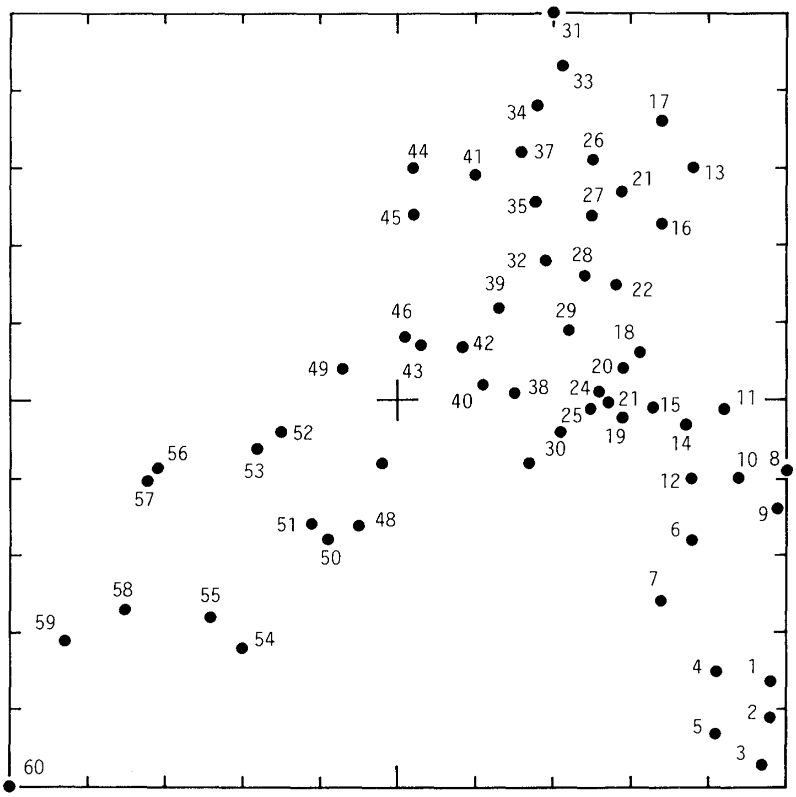

Fig. 6. Species ordination diagram by RA. Numerals are the species numbers listed in Table 4.

the *Quercus* forest (so far as the present data are concerned) are *Rhododendron kaempferi, Miscanthus sinensis, Lyonia ovalifolia* var. *elliptica, Vaccinium bracteatum, Quercus serrata, Rhus javanica, Pinus densiflora,* and *Dicranopteris linearis.* (2) Species whose center is in the *Aphananthe* forest are *Aucuba japonica, Celtis sinensis* var. *japonica, Cornus brachypoda* and *Aphananthe aspera.* (3) Species whose center is in both the *Aphananthe* and *Machilus* forests are *Alpinia japonica, Symplocos glauca,* and *Ilex chinensis.* (4) Species whose center is in the *Castanopsis* forest are *Damnacanthus indicus, D. major, Anodendron affine, Elaeocarpus japonicus, Michilia compressa, Woodwardia japonica, Ternstroemia gymnanthera, Myrsine seguinii, Myrica rubra, Gardenia jasminoides,* and *Daphniphyllum teijsmanii.* *Castanopsis cuspidata* is distributed over the *Castanopsis* and the *Machilus* forest but its dominant status can be seen in the former. (5) *Liriope platyphylla, Trachelospermum asiaticum, Hedera rhombea, Camellia japonica, Quercus glauca* and *Ilex rotunda* are distributed in the well-developed *Aphananthe-, Machilus-* and *Castanopsis*-dominated forest. (6) *Machilus thunbergii, Ilex integra, Cinnamomum japonicum, Ophiopogon ohwii, Kadsura japonica, Ligustrum japonicum* are distributed nearly throughout all the stands studied.

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北九州市北西部および近隣地における森林植生の傾度

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要 旨: 医生ヶ丘をふくむ北九州市北西部および近隣地において，森林群落50スタンドを調査した．それらを優占種により分類すると，コナラ群落，タブノキ群落，ムクノキ群落，シイノキ群落であった．50スタンド，60種の群落資料を反復平均法により解析した結果，次の三つの植生の系列が明らかとなった．(i)コナラ群落―タブノキ群落―ムクノキ群落，(ii)コナラ群落―シイノキ群落，(iii)タブノキおよびムクノキ群落―シイノキ群落．前2系列は樹高の増大および種類の増加と有意の相関をもつ森林の群落遷移の系列であり，第3の系列ではそれらと相関がなく，環境傾度上の系列であることが明らかとなった．

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