Zonation of Rocky Coast Vegetation in Northern Kyushu, Japan*

by

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Introduction

Coastal areas provide the most suitable place to observe the zonation of vegetation. Many authors have studied the zonation of the sand dune vegetation, but only a few have investigated that of the rocky coast vegetation (Randall 1970, Richmond & Mueller-Dombois 1972, Géhu, J. M. & J. Géhu 1977). Particularly in Japan, no report has been published about the zonation of the rocky coast vegetation. We have made phytosociological studies of the rocky coast vegetation in Japan and bring out several reports (Nakanishi & Nakagoshi 1975; Nakanishi & H. Suzuki 1975, 1976). In the course of these studies it was proved that the zonation was clearly recognizable in rocky coast areas.

Most studies of the zonation of coastal vegetations have dealt with the environmental factors such as salinity, moisture, organic matter in soil and airbone salt deposition. It is natural that only selected plants tolerant of severe environmental conditions can grow in seaward zones. With distance from the shoreline, maritime influence becomes milder and the number of species occurring there increases. At the same time, the plants characteristic of seaward zones are gradually replaced by other plants. This may be due to interspecific competition in relation to decreased maritime influence.

Morphological characters of plants are important to understand not only the competition among plants but also the structure of communities. To know the relationship between the vegetation and the environment, the growth form analysis has been employed by several authors (Gimingham 1951, Miyawaki 1960, Précsényi 1963, Suganuma 1967, Nakanishi & Nakagoshi 1975). Nobuhara (1967) obtained a successful result by using growth form analysis in studying the zonation on a sand dune.

The present study is intended to obtain information on the zonation of the rocky coast vegetation and on the reaction of plants to a change of environmental conditions.

I. Area investigated

The investigation was made in northern Kyushu by five belt-transects at four stations where the zonation is comparatively distinct (Fig. 1): two transects in

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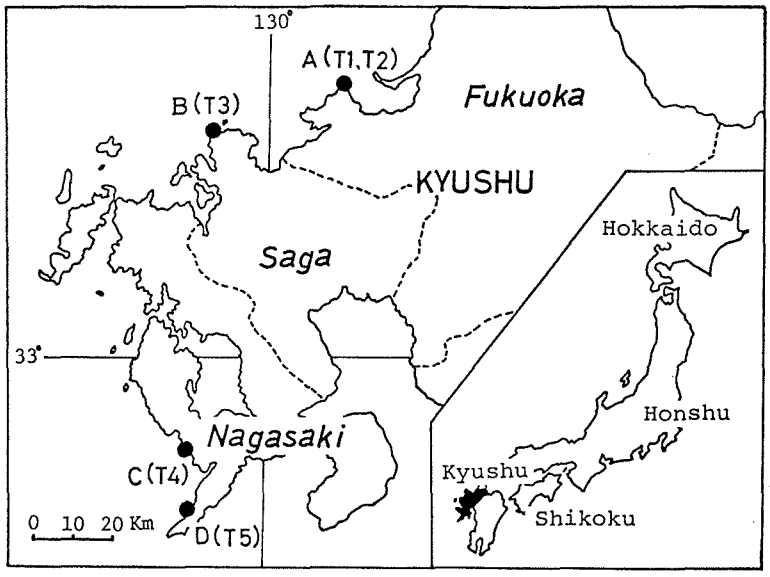

Fig. 1. Map showing the stations investigated.
A. Nishinoura, Fukuoka Pref. B. Hatomisaki Cape, Saga Pref.
C. Shikimi, Nagasaki Pref. D. Kurohama, Nagasaki Pref.

Nishinoura, Kitazaki-mura, Itozaki-gun, Fukuoka Pref.; one transect each in the Hatomisaki Cape, Chinzei-cho, Higashimatsuura-gun, Saga Pref., in Shikimi, Nagasaki City, Nagasaki Pref., and in Kurohama, Nomozaki-cho, Nishisonogi-gun, Nagasaki Pref. The rocky coast vegetation of the district including these stations has already been studied. It includes *Aster spathulifolius–Crepidiastrum lanceolatum* association and *Crepidiastrum lanceolatum–Peucedanum japonicum* association as herbaceous communities and Cyrtomio-Litseetum and Euonymo-Pittosporetum as scrub communities (Nakanishi & H. Suzuki 1975, 1976).

The climate of the district is warm and humid. The mean annual temperature is 15.7° to 16.6°C and the annual precipitation is 1705 to 1976 mm (Tokyo Astronomical Observatory 1975). It becomes warmer with higher precipitation towards the southwest.

II. Methods

The belt-transects of one meter wide starts at the estimated high water mark, and runs inland orthogonally to the shoreline as far as scrub communities. Cover degree, height and growth form of all plants and the total coverage were recorded in each quadrat.

I adopted Gimingham's system of growth form (Gimingham 1951) with some modifications, namely, in my system each form is subdivided into three classes by the height of plants: large (more than 50 cm), medium (20 to 50 cm) and small (less than 20 cm). Thus the growth forms of herbs are classified as follows:

1) Small prostrate form (pr), Medium prostrate form (Pr), Large prostrate form (PR)

2) Small rosette (ro), Medium rosette (Ro), Large rosette (RO)
3) Small tussock (tu), Medium tussock (Tu), Large tussock (TU)
4) Small erect form (er), Medium erect form (Er), Large erect form (ER)
5) Small branched form (br), Medium branched form (Br), Large branched form (BR)

Those of liana and shrubs are classified by the following criteria:

6) Liana (L) (free in height)
7) Shrub branched form (SBR) (including only woody plants of more than 50 cm; those less than 50 cm were treated as herbs)
8) Shrub erect form (SER) (including only woody plants of more than 50 cm; those less than 50 cm were treated as herbs)

Coverage histograms of all species in each quadrat were illustrated and the height of dominant species was shown by a diagram.

The growth form spectra were compiled based on the presence indicated by the "Gruppenanteil" (Knapp 1971). The total occurrence of species belonging to each form was counted in each zone and then the value was indicated by percentage.

III. Results

All the vegetations observed could be divided into four zones along the transect based on dominant species, height of community, total coverage and species composition. These zones are sometimes arranged disorderly irrespective of the distance from the shoreline. Topographic profiles (Fig. 2), coverage histograms of all plants (Figs. 3, 5, 7, 9 and 11) and changes in height of dominant species and total coverage along the transect (Figs. 4, 6, 8, 10 and 12) are shown in diagrams.

1. Transects in Nishinoura, Fukuoka Pref. (T1: Figs. 3, 4; T2: Figs. 5, 6)

The area near the shoreline is covered with stones of 30 to 150 cm in diameter and followed by slopes of 30 to 45 degrees (Fig. 2) or cliffs. The vegetation is chiefly developed on slopes, where the zonation is remarkable. Changes of the vegetation along the transect 1 (T1) are shown in Figs. 3 and 4. In the first seaward zone (Z1), *Fimbristylis ferruginea* var. *sieboldii* is a single component and its coverage is below 10%. In the next zone (Z2), *Peucedanum japonicum*, *Sedum oryzifolium*, *Setaria viridis* var. *pachystachys*, *Lysimachia mauritiana* and some others appear. The total coverage is up to 50% and the height of the community is less than 20 cm. The third zone (Z3) is dominated by *Miscanthus sinensis*, succeeded by *Crepidiastrum lanceolatum* and *Farfugium japonicum*. Some species growing in Z2 disappear here. The total coverage rises to 100% and the height of the community is 40 to 110 cm. The most inland zone (Z4) is dominated by *Eurya emarginata*, with decreased occurrence of *Miscanthus sinensis*.

The transect 2 (T2) is located near the T1. The first zone (Z1) is constantly but poorly covered with *Cynodon dactylon*. In the second zone (Z2), *Fimbrystylis ferruginea* var. *sieboldii* is occasionally dominant, accompanied by *Sedum oryzifolium*, *Crepidiastrum lanceolatum*, *Setaria viridis* var. *pachystachys* and *Lysimachia mauritiana*. The total coverage is below 50% and the height is less than 25 cm. In the third zone (Z3), the vegetation is heigher in coverage and taller (about

50 cm) in height. *Miscanthus sinensis* and *Farfugium japonicum* are co-dominant. The last zone (Z4) is dominated by *Eurya emarginata*. *Pittosporum tobira* and liana plants, such as *Rosa wichuraiana*, *Canavalia lineata* and *Paederia scandens* var. *mairei*, are almost constantly found.

2. Transect in the Hatomisaki Cape, Saga Pref. (T3: Figs. 7 and 8)

Rocky area spreads near the shoreline, but the inland side forms a silty slope

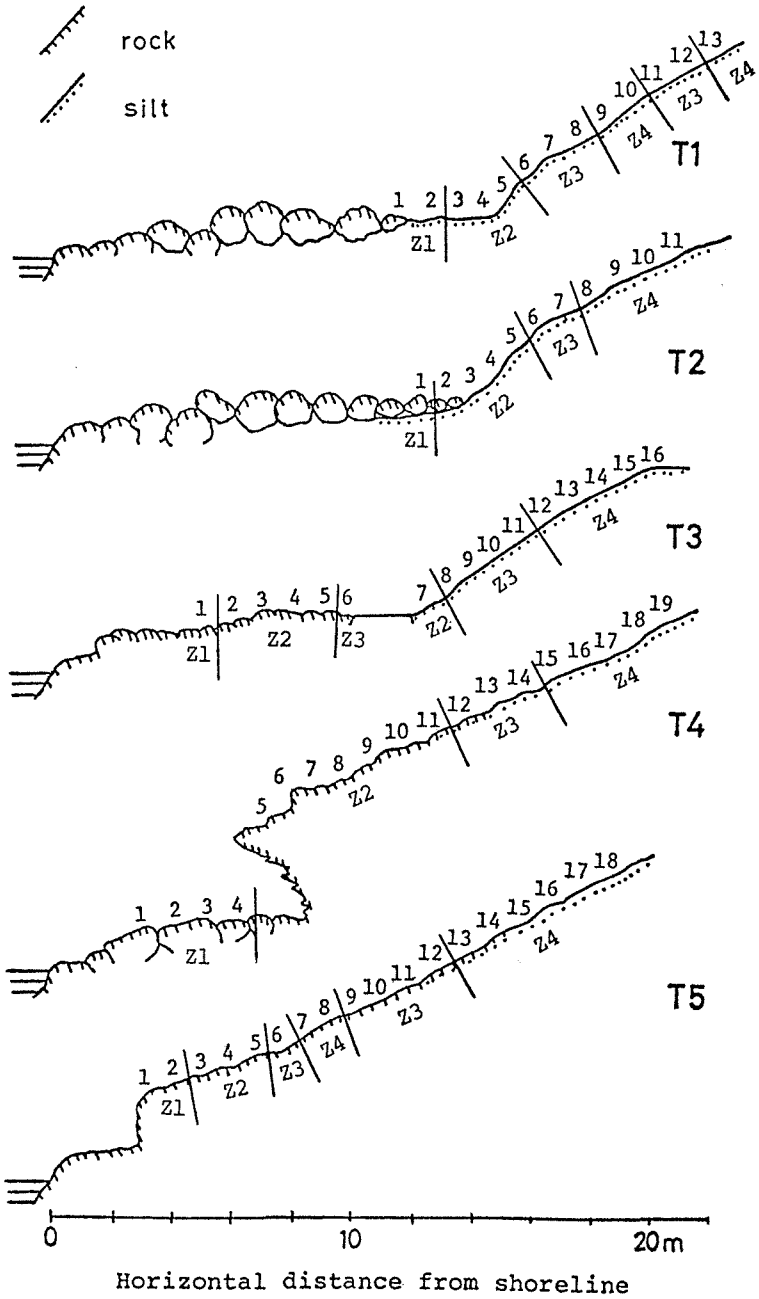

Fig. 2. Topographic profiles of the transects studied (Arabic numerals show quadrat number).

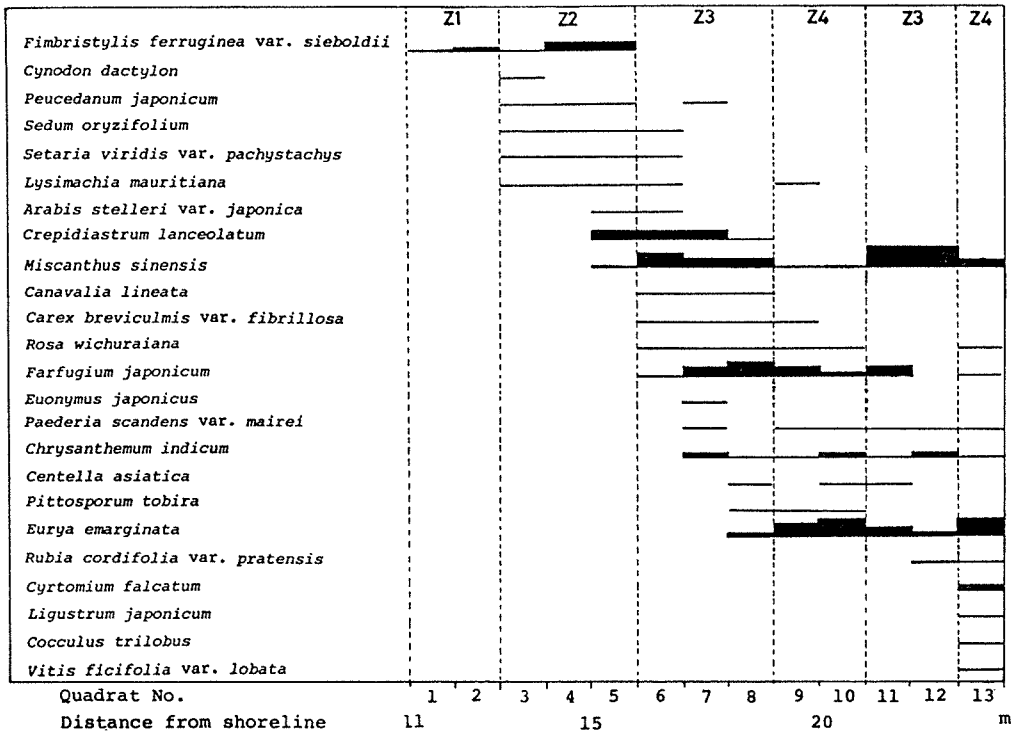

Fig. 3. Coverage histograms of all species found in each quadrat along the transect 1 (T1). Thickness of line indicates cover degree.

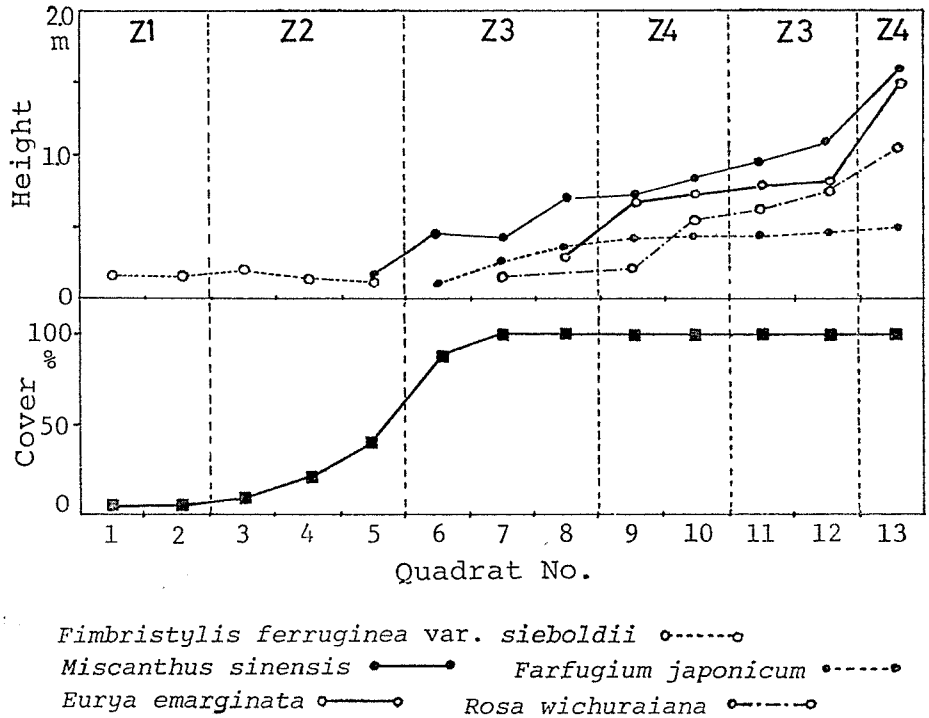

Fig. 4. Fluctuations of the height of dominant species and the total coverage in each quadrat along the transect 1 (T1).

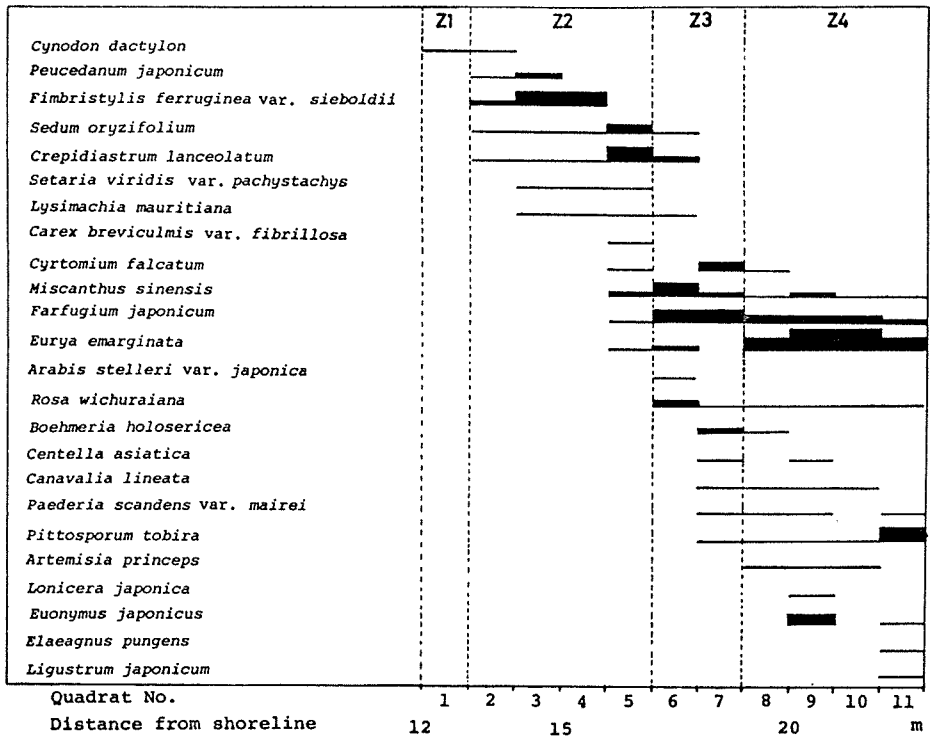

Fig. 5. Coverage histograms of all species found in each quadrat along the transect 2 (T2).

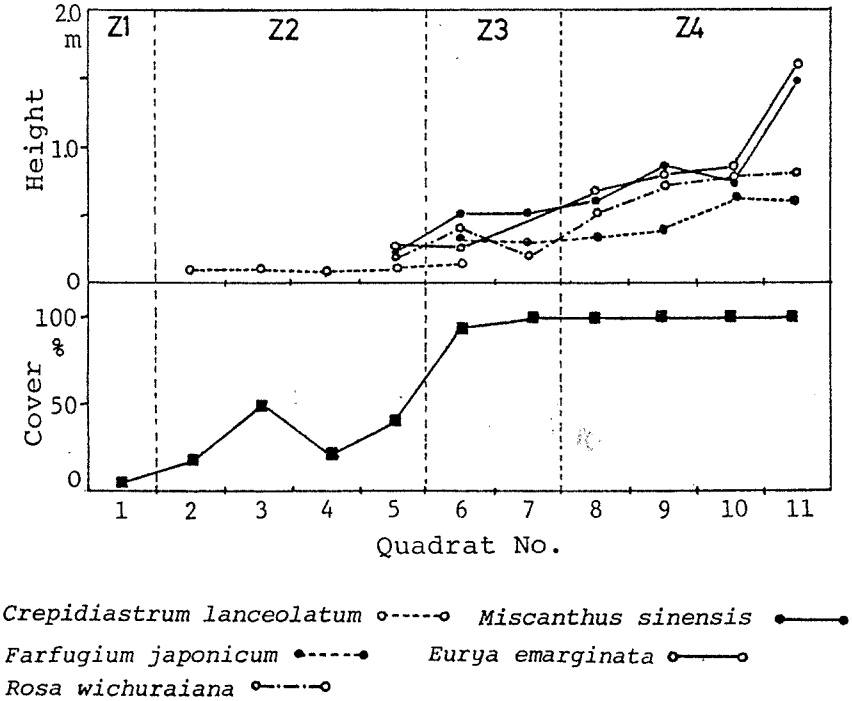

Fig. 6. Fluctuations of the height of dominant species and the total coverage in each quadrat along the transect 2 (T2).

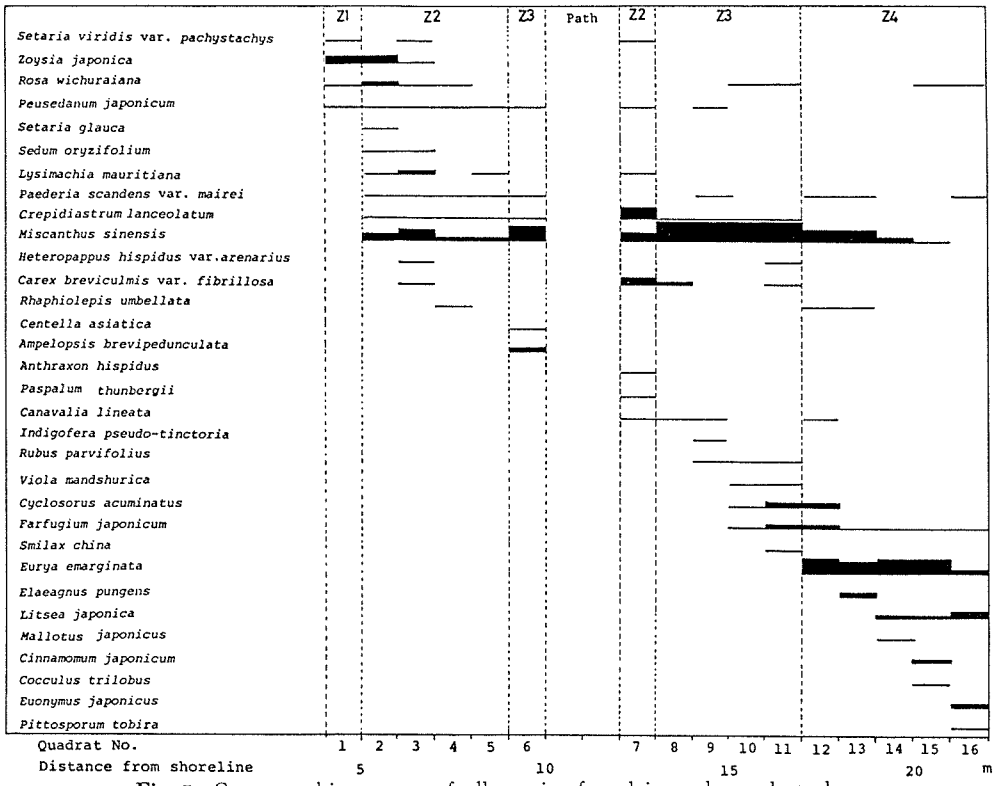

Fig. 7. Coverage histograms of all species found in each quadrat along the transect 3 (T3).

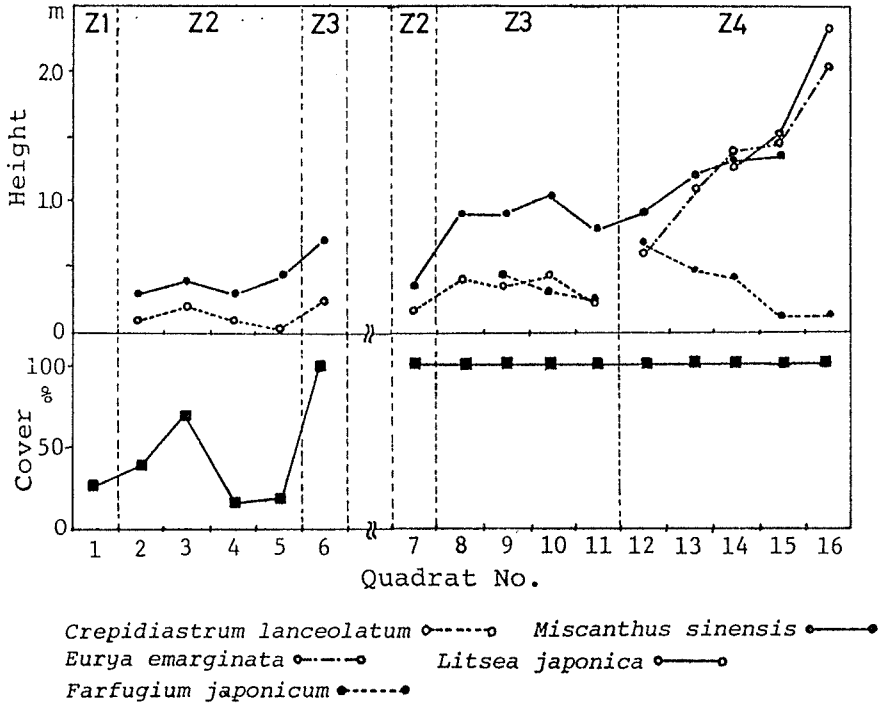

Fig. 8. Fluctuations of the height of dominant species and the total coverage in each quadrat along the transect 3 (T3).

with about 35 degrees. In the first zone (Z1), plants are sparse and less than 15 cm in height. The second zone (Z2) is demarcated by the occurrence of *Lysimachia mauritiana*, *Paederia scandens* var. *mairei*, *Crepidiastrum lanceolatum* and *Miscanthus sinensis*. This zone is 30 to 45 cm in height and is below 70% in coverage. The third zone (Z3) dominated by *Miscanthus sinensis* comes next but is intersected by a path. In the first quadrat (Quad. No. 7) on the inland side of the path, *Crepidiastrum lanceolatum* becomes dominant under the trample by hikers. So it forms an isolated zone of Z2. The height of the Z3 is 80 to 105 cm and its coverage is 100%. The last zone (Z4) is dominated by *Eurya emarginata*. *Litsea japonica* and *Pittosporum tobira* also occur here.

3. Transect in Shikimi, Nagasaki Pref. (T4: Figs. 9 and 10)

The lower part of the slope is rocky outcrop of lutaceous crystaline schist and the upper part is composed of agglomerate whose surface is weathered. The foot of the cliff is occupied by big boulders. In the first seaward zone (Z1), *Rumex acetosa* and *Miscanthus sinensis* are scattered among the boulders. The second zone (Z2) is characterized by the occurrence of *Peucedanum japonicum*, *Setaria viridis* var. *pachystachys* and *Rosa wichuraiana*. They grow in cracks of rocks with heights of 20 to 40 cm. The total coverage is low; usually 10 to 20%. The third zone (Z3) is dominated by *Miscanthus sinensis*. *Chrysanthemum indicum* is also abundant here. The coverage is 90%, and the height of the community varies from 60 to 170 cm. The shrub zone (Z4) is dominated by *Litsea*

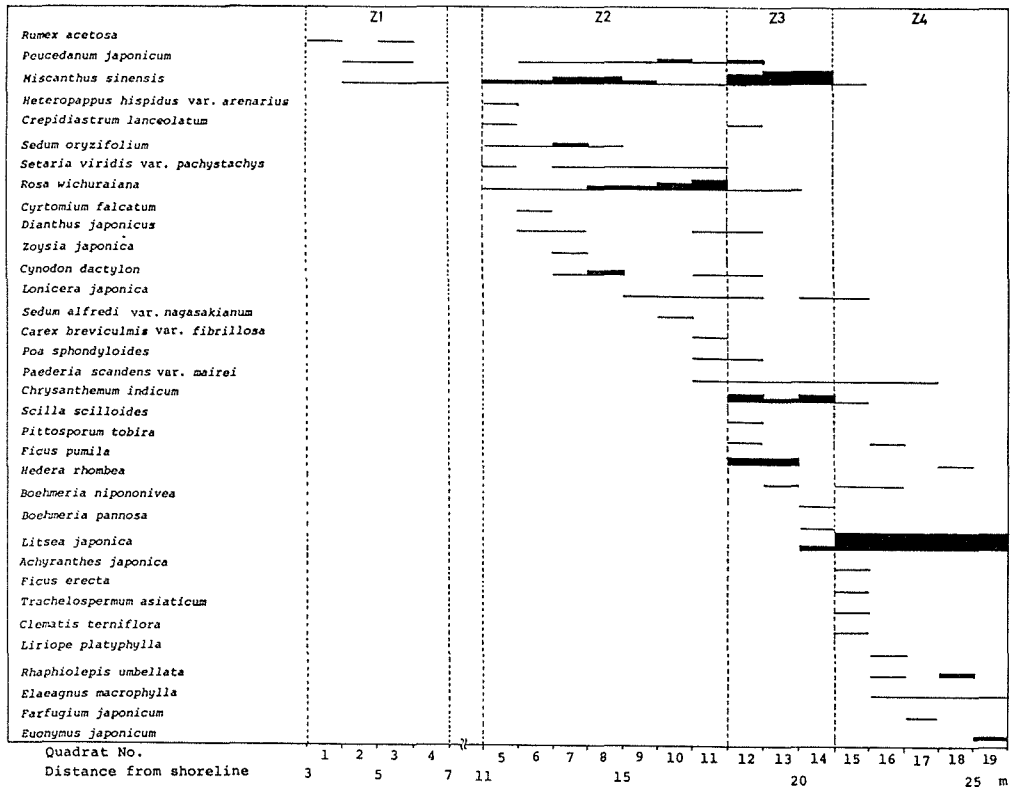

Fig. 9. Coverage histograms of all species found in each quadrat along the transect 4 (T4).

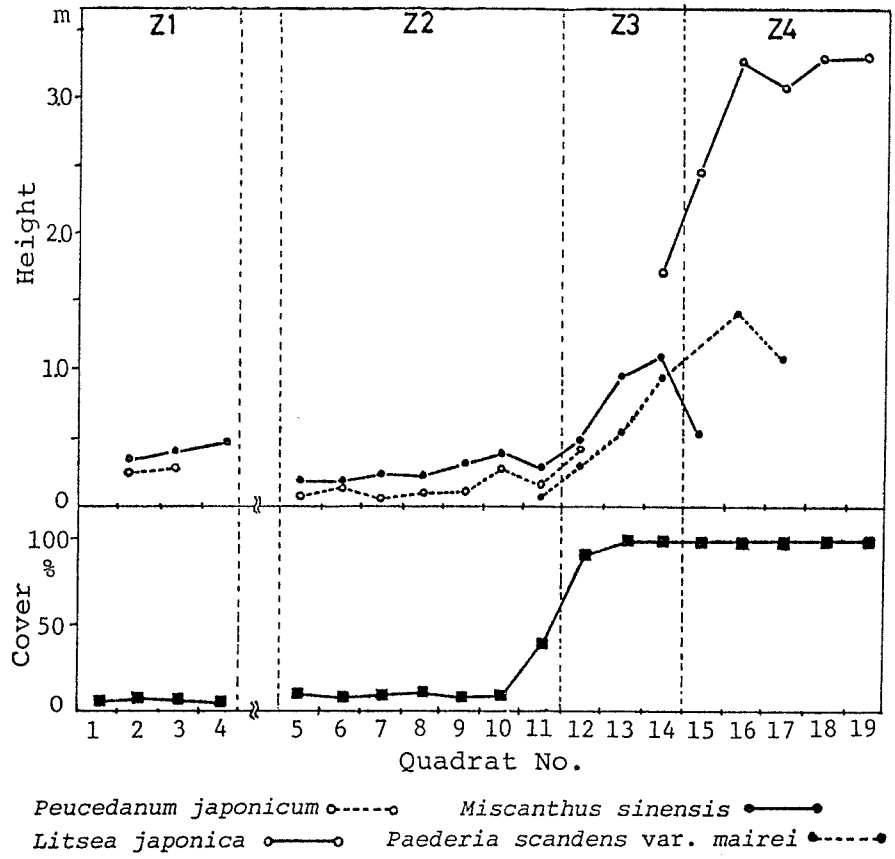

Fig. 10. Fluctuations of the height of dominant species and the total coverage in each quadrat along the transect 4 (T4).

japonica which are 250 to 330 cm in height.

4. Transect in Kurohama, Nagasaki Pref. (T5: Figs. 11 and 12)

The belt-transect was placed on a rocky slope of diorite. In the first zone (Z1), some pioneer plants are scattered. In the next zone (Z2), many species occur and their total coverage ranges from 20 to 40%. The *Miscanthus* zone (Z3) is associated with some liana plants and seedlings of shrubs, and followed by the shrub zone (Z4) dominated by *Rhaphiolepis umbellata*. On the inland side, however, another *Miscanthus* zone (Z3) appears in a place of shallow soil. In the last zone (Z4), *Rhaphiolepis umbellata* and *Pittosporum tobira* are co-dominant, although the coverage and the height of the community are largely varied according to the soil condition.

The growth form spectra in each zone are summarized in Table 1. The first seaward zone (Z1) is characterized by pioneer plants, with sparse coverage and poor species composition. At the foot of slopes, plants often grow among boulders having fallen from the upper part of the slope. In this zone, small growth forms are usually found: e. g. in the transect 1 (T1) the small erect form (er) and in the transect 2 (T2) the small tussock (tu) is dominant. At the foot of a cliff (T4), however, the medium rosette (Ro) and the medium tussock (Tu) are abundant.

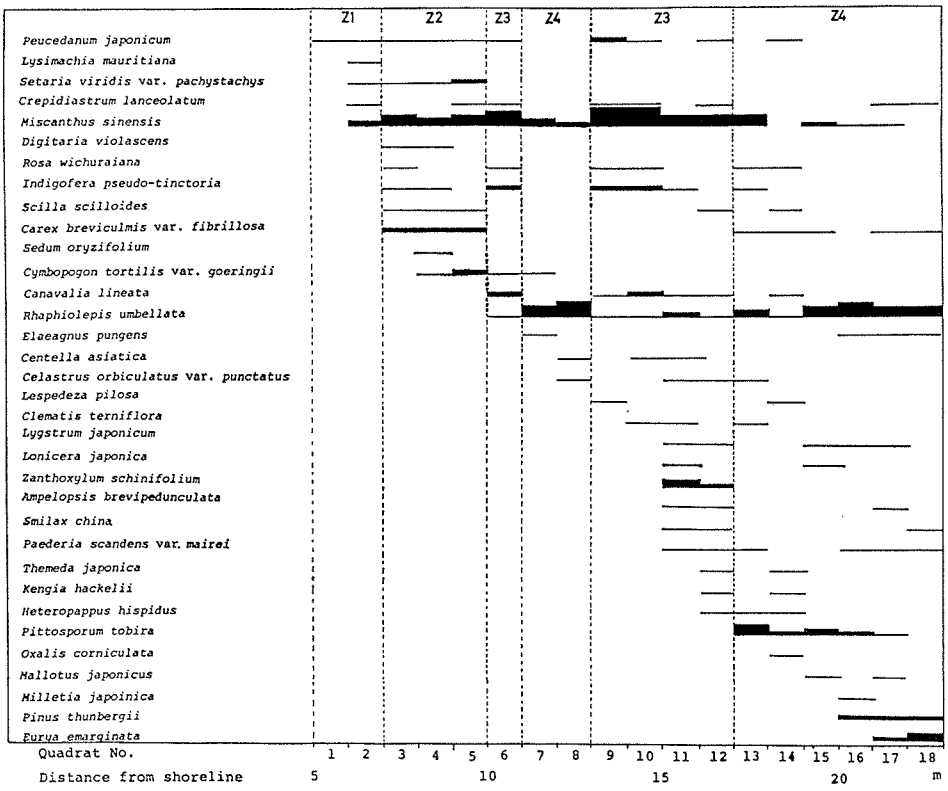

Fig. 11. Coverage histograms of all species found in each quadrat along the transect 5 (T5).

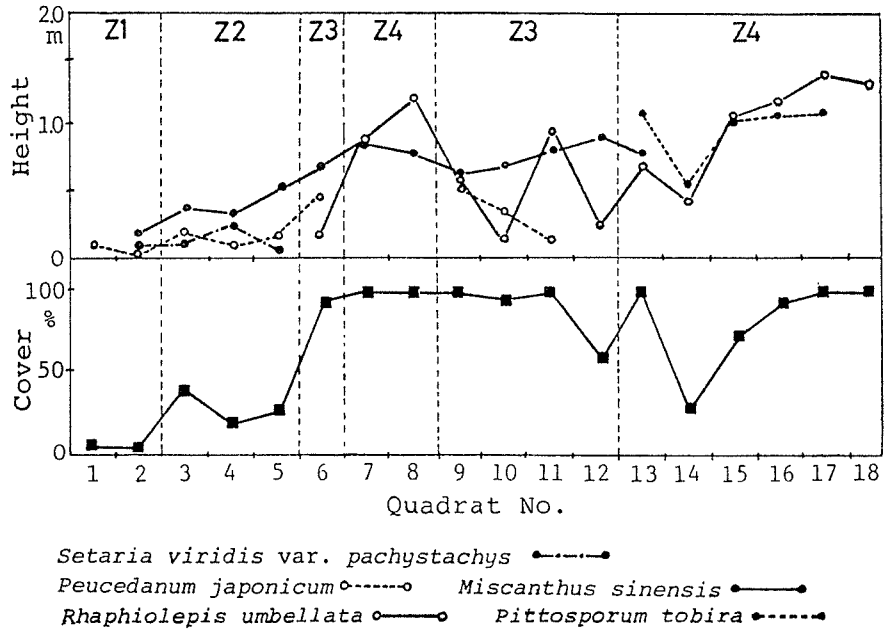

Fig. 12. Fluctuations of the height of dominant species and the total coverage in each quadrat along the transect 5 (T5).

Table 1. Growth form spectra of each zone in transects

Zone	Transect	ro	Ro	RO	tu	Tu	TU	pr	Pr	PR	er	Er	ER	Br	BR	L	SBR	SER	Number of species
Z 1	T1				100														1
	T2										100								1
	T3	25			50			25											4
	T4		57			43													3
	T5	67			33														5
Z 2	T1	42			37			16				5							9
	T2	44			24	8		8			12	4							12
	T3	38			13	15		20			15								16
	T4	23	2		6	13		25	2		2	21				6			16
	T5	25	4		25	21	8	13				4							11
Z 3	T1	17	7		10	5	7	12	12		5	5	2		5	7	5		18
	T2	18	18			12		18	6		6	18				6			14
	T3	12	26		6		15	12	15			6	3			6			16
	T4	12					12		8	8		8	8		16	24	4		17
	T5	8	2	2			13	6	13		8	9	8	2		19	11		22
Z 4	T1	3	10	3	3		10	3	7		3				10	24	21		15
	T2		8	5			11	5			5	11	3			27	24		15
	T3	6	6	6			13					3				22	44		15
	T4	7		3	3		3	13			17	3			3	17	30		16
	T5	6			8		12	9	3			6	3	2	2	12	31	6	29

The second zone (Z2) is composed of many maritime plants. Due to the dominant bare rock and shallow soil, the plant cover is not closed and the height of the community is not beyound 30 cm. In the growth form spectra, the small rosette (ro) and the small tussock (tu) are most abundant, followed by the small prostrate form (pr). In the third zone (Z3), various growth forms occur. The large tussock (TU) and some medium types of prostrate (Pr), erect (Er) and rosette forms (Ro) are abundant. The last inland zone (Z4) is dominated by coastal shrubs. Consequently, the shrub branched form (SBR) and the liana (L) are dominant, followed by the large tussock (TU).

IV. Discussion

The rocky coast vegetation in northern Kyushu was divided into four zones. The first zone (Z1) is associated with a few pioneer maritime plants. The second zone (Z2) is composed of many maritime plants. In the third zone (Z3) demarcated by dominant growth of *Miscanthus sinensis*, most of the maritime plants disappear and are replaced by inland species. These facts may be a result of interspecific competition. Maritime species such as *Crepidiastrum lanceolatum*, *Dianthus japonicus* and *Setaria viridis* var. *pachystachys* are poor in growth plasticity and they can not grow into dense and tall community. On the contrary, *Miscanthus sinensis* varies in plant height from 15 to 160 cm, growing under several conditions. Consequently, this species can spread widely from Z2 to Z4. In *Chrysanthemum indicum* its growth form varies from the medium prostrate

(Pr) to the large branched form (BR) corresponding to the habitat condition. *Paederia scandens* var. *mairei*, *Rosa wichuraiana* and *Lonicera japonica* are prostrate, forming low communities, but they can climb up over scrubs as lianas, so that they are also found widely from Z2 to Z4. Dierschke (1974) studied the zonation of forest edges in middle Germany and mentioned that the skert-plants obtained the competitive advantage by stolon or shoot-system which made it possible for them grow over the bush.

Plants vary, to some extent, in their height and growth form corresponding to the difference of environmental conditions and these plasticities are different among species. The interspecific competition by such a difference of growth plasticity is an important factor related to the zonation of the coastal vegetation. However, the difference in ecological tolerance of plants has mainly been considered in previous studies.

Summary

1. The present paper deals with the zonation of the rocky coast vegetation in northern Kyushu, Japan.
2. According to physiogonomical differences, each vegetation studied was divided into four zones along the transect.
3. The first seaward zone (Z1) is a pioneer vegetation, poor in both coverage and number of species.
4. The second zone (Z2) is rich in maritime plants but not so dense in coverage. The height of the community is less than 30 cm. In the growth form spectra, the small rosette (ro) and the small tussock (tu) are most abundant.
5. The third zone (Z3) is dominated by *Miscanthus sinensis* and associated with some inland species. Its height is greater than 40 cm. The coverage is usually 100%. In this zone the large tussock (TU), the medium prostrate form (Pr), the medium erect form (Er) and the medium rosette (Ro) are abundant.
6. The last inland zone (Z4) is occupied by scrubs, dominated by coastal shrubs such as *Litsea japonica*, *Eurya emarginata* and *Rhaphiolepis umbellata*. Some liana plants are constantly found.
7. The plants with poor ability to grow tall are not found in dense and tall communities. On the contrary, the plants which grow in several different heights can occur more widely.
8. The interspecific competition by the difference of growth plasticity is an important factor related to the zonation of the coastal vegetation.

Acknowledgement

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