マングローブ林の防災機能に関する研究 (I) : ヤエヤマヒルギの支柱根の形態上の特徴について(林学科)

Studies on the Protective Functions of the Mangrove Forest against Erosion and Destruction

(I) The Morphological Characteristics of the Root System of Yaeyamahirugi (*Rhizophora mucronata* LAMK.)

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INTRODUCTION

Mangroves in general, including Yaeyamahirugi (*Rhizophora mucronata* LAMK.), have specialized or morphologically modified root systems which often give a singular impression to us. The root systems of mangroves are characteristic of functions in exchanging gases sucking air and holding the plant postures to adapt environmental conditions. They are termed aerial roots and prop roots for the function and also stilt roots, knee roots, buttress roots, standing roots, erect roots, etc,[5] for the form. Yaeyamahirugi has the root system termed prop roots or stilt roots.[4].

Several investigators, for example, Davis,[2] Imanishi & Kira,[3] West[8,9] and Anderson[1], pointed out that mangrove stands are quite resistant to the flow and the wave of rivers, the tide, the wave and other marine currents, consequently accelerate the sedimentation of soil or mud to raise the bottom level resulting in extension of the coast. The author agree with what they pointed out and have been investigating the effectiveness of mangrove forest as the disaster prevention forest in protecting tidal shores of the low alluvial coasts and the river mouths in the tropics and subtropics from erosion and destruction by the flow and the wave since 1977. Yaeyamahirugi was chosen to investigate first of all because its root system is very distinctive and the species belonging to the common genus are distributed extensively in the tropics and subtropics.

Most of the literature on the measurement on the distribution of root systems is scattered through a large number of botanical and forestry journals. On the other hand few investigators have studied the distribution of the root systems of mangrove from hydraulical and geographical point of view. It requires many hands and much time to measure the root systems of mangroves which stand on tidal deep swamps. In this report some examples of root system of Yaeyamahirugi on the form were discribed with diagrams and a few characteristics of distribution of them were discussed.

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Sci. Bull. Coll. Agr. Univ. Ryukyus, **25** : 615 ～ 630 (1978)

Photo. 1. Well developed prop roots of Yaeyamahirugi along the tidal channel typify the mangrove forest as a barrier. Photograph taken at low tide

Photo. 2. Forest of Yaeyamahirugi along the inlet

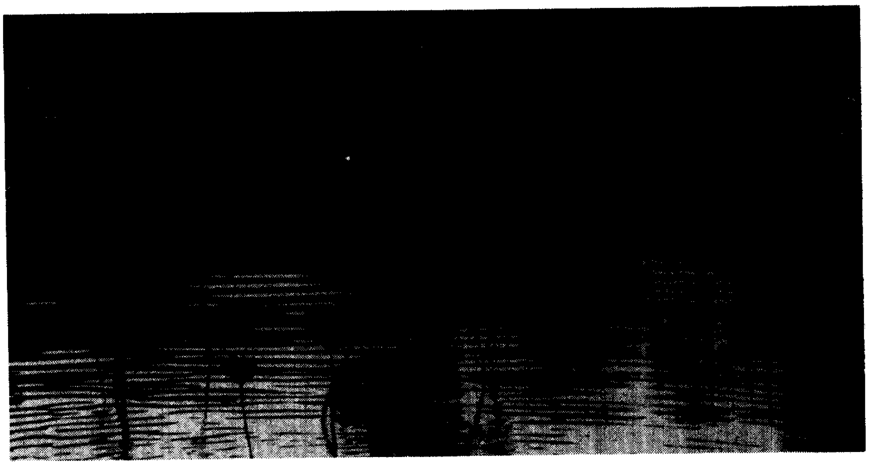

Photo. 3. A typical pioneer of Yaeyamahirugi

METHODS

The root system of Yaeyamahirugi was investigated at the mangrove swamp near Itona, Ishigaki island, Okinawa prefecture for five days from May 3 to 7, 1978.

The prop root ramified directly from the main stem was designated the first order root, the root ramified from the first order root was the second order root and so forth as shown in Fig. 1 and Photo. 4. Five typical smaples were chosen in relation to the size of tree. The x-, y- and z-axes of coordinates were set up at a suitable height from the mud surface and the values of each coordinates were recorded. On the other hand the diameter of the prop roots were measured at the point of ramification and at the mud surface. The angle of the tangent lines for a vertical line at the middle point of arching prop root were also measured.

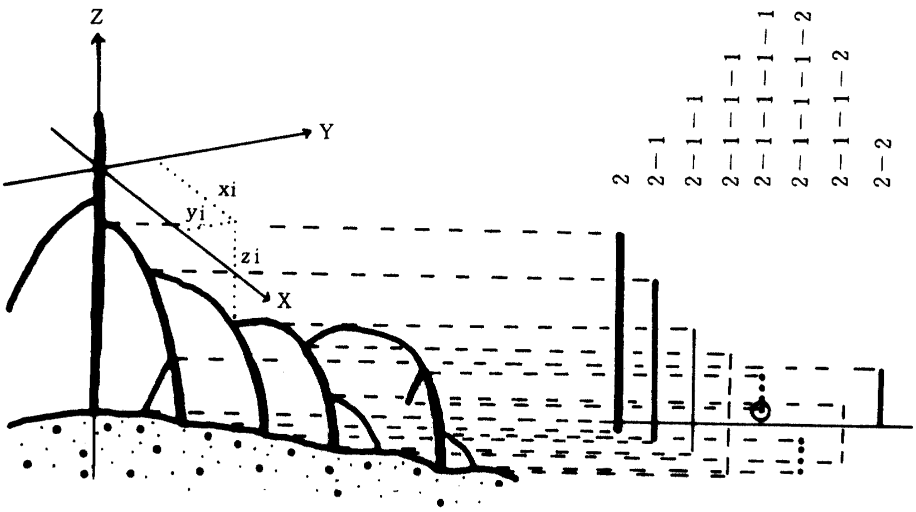

Fig. 1. Outline of measurement and numerical expression of the root

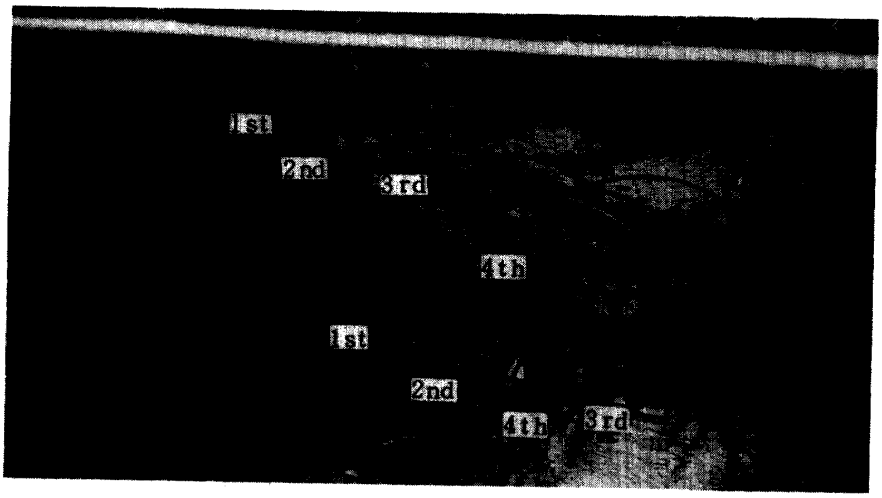

Photo. 4. Prop roots of Yaeyamahirugi at low tide

RESULTS AND DISCUSSION

The root was numbered in due course from the highest to the lowest points of ramification within the same order roots. And the resultant numbering, for example, for the third order root ramified at the highest point of the second order root that ramified secondarily from the first order root No. 5 was 5-2-1.

The projections of each root system to the x-y and x-z planes were shown in Fig. 2, 3, 4 and 5. The legend was included in Fig. 2. The root system of sample No. 1 was illustrated with several divided diagrams for a convenient presentation of the complicated root system and the numbering of the first order roots ramified from the main stem and five branches were in Table 1. On the basis of the ground plane (x-y plane) projection, it was found that the root extension was in radial manner from the main stem or branches and the root distribution of the sample trees was impartial as a whole except that the second quadrant of sample No. 2 was a little thinner. The mode of the root extension was possibly divided into three types as the root system was projected to the both x-y and x-z planes. The first type was distinctive in that the root spreads outside, the second type was that the root spreads downwards as a prop from the root of the first type and the third type was that the root extends slantwise from the root of the first or second type as a strut. These prop roots appeared to compose a reasonable mechanical structure.

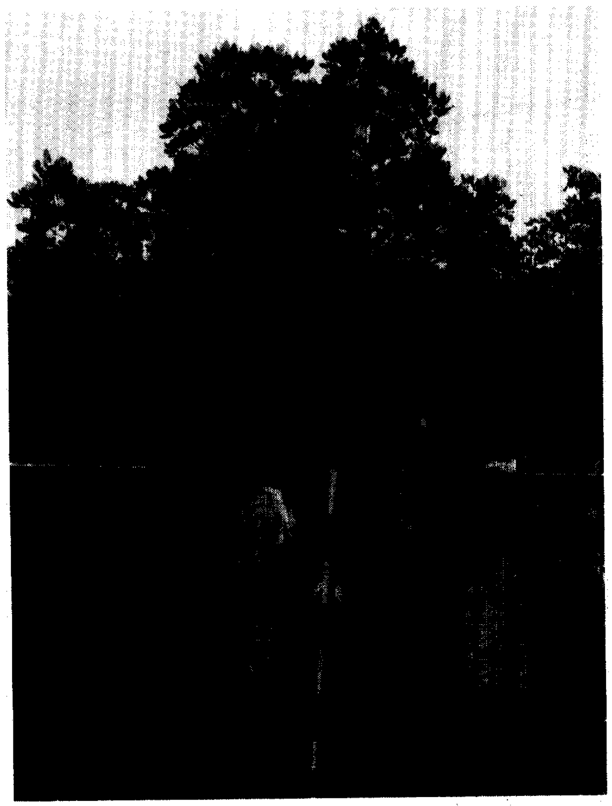

Photo. 5. Sample No. 1

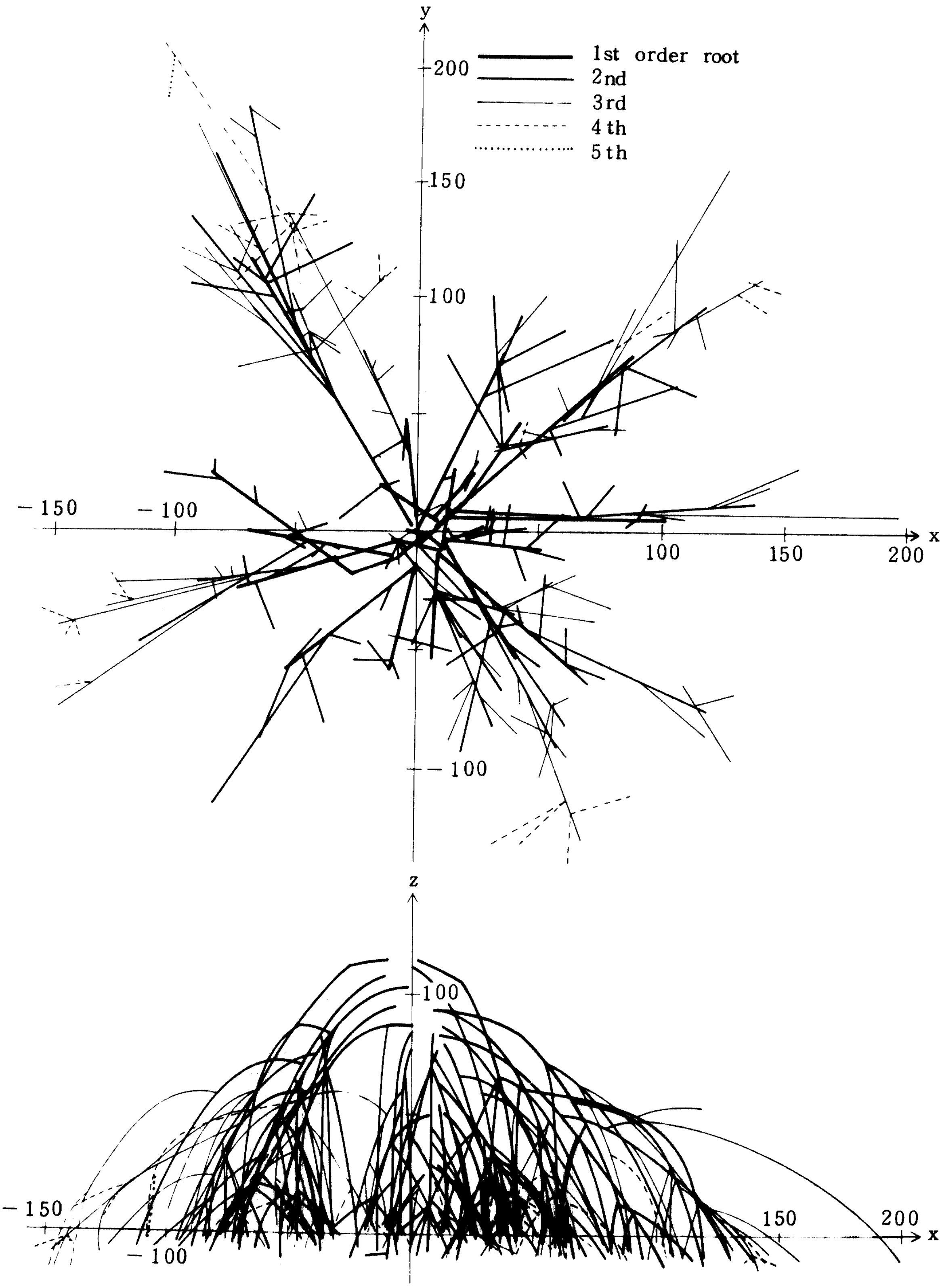

Fig. 2—(a). Projections of prop roots of the main stem of sample No. 1

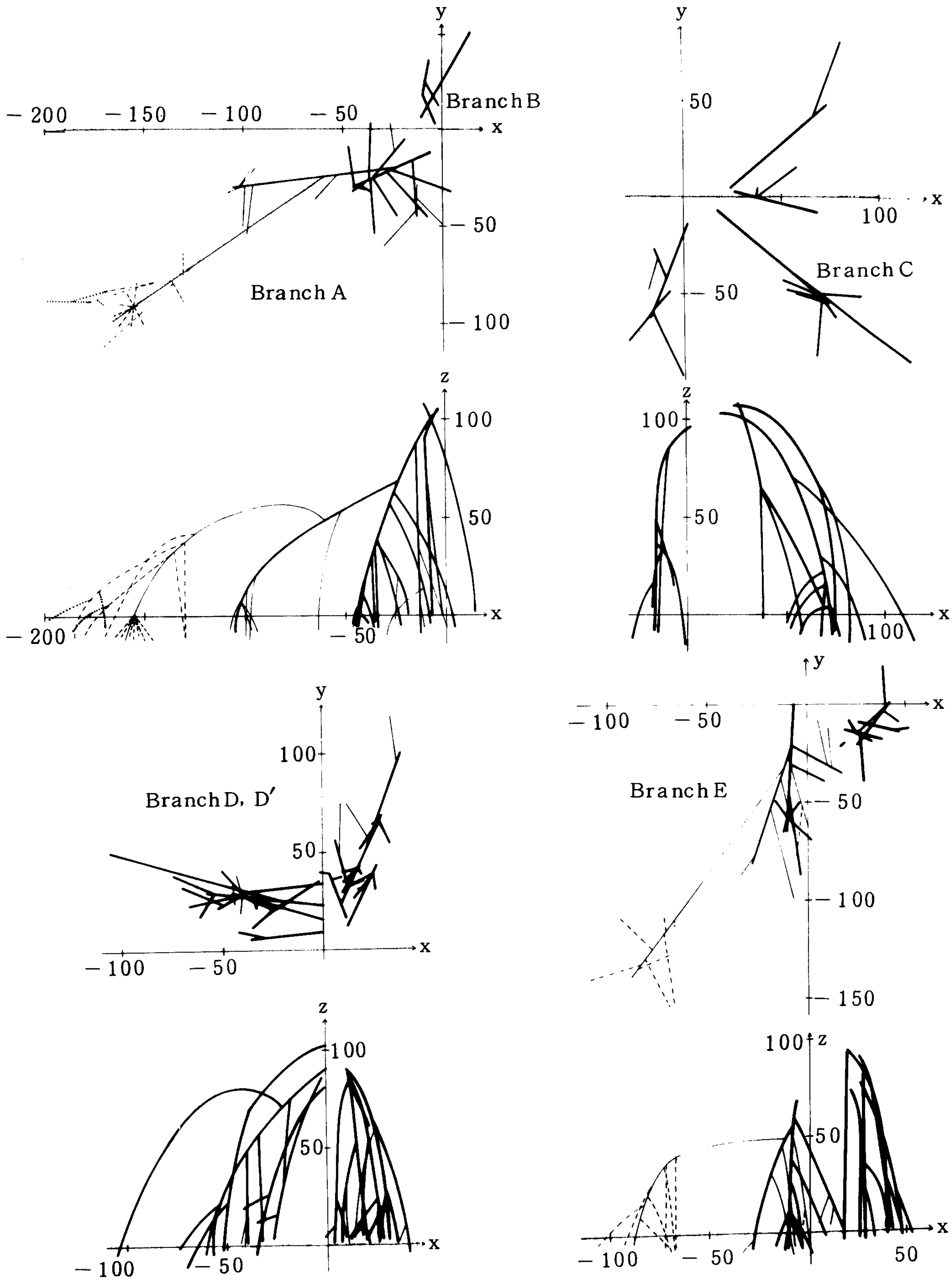

Fig. 2—(b). Projections of prop roots of each branches of sample No. 1

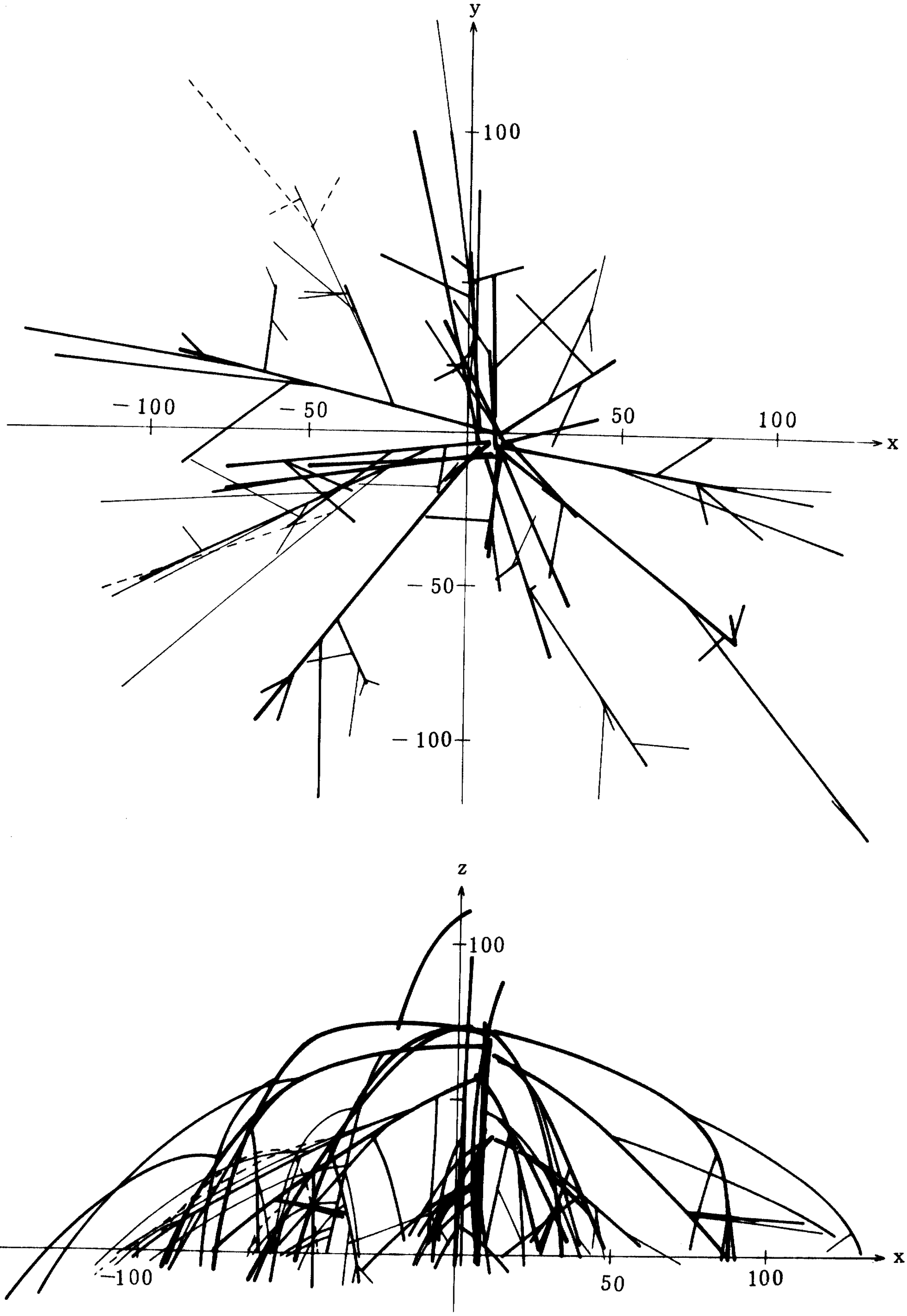

Fig. 3. Projections of prop roots of sample No. 2

Photo. 6. Sample No. 3

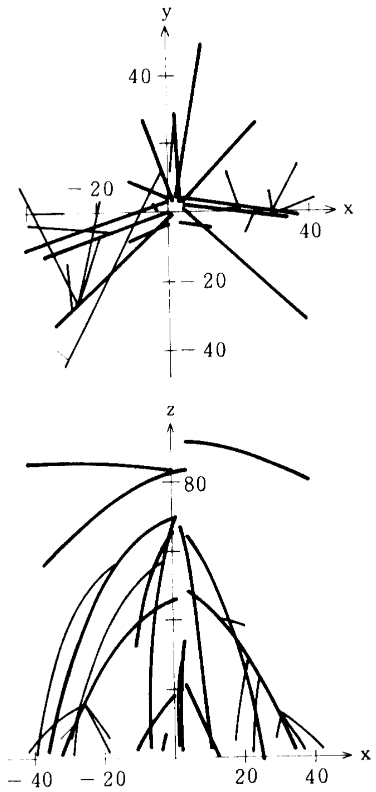

Fig. 4. Projections of prop roots of Sample No. 3

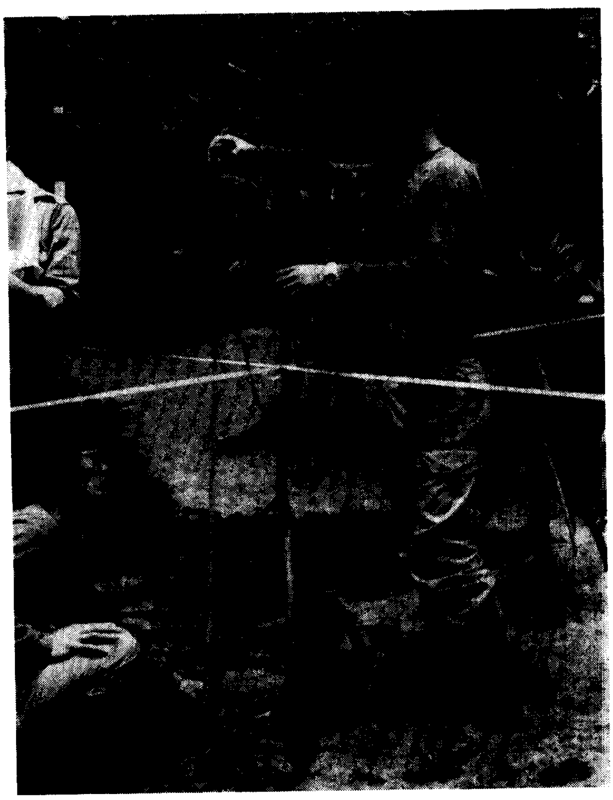

Photo. 7. Sample No. 4

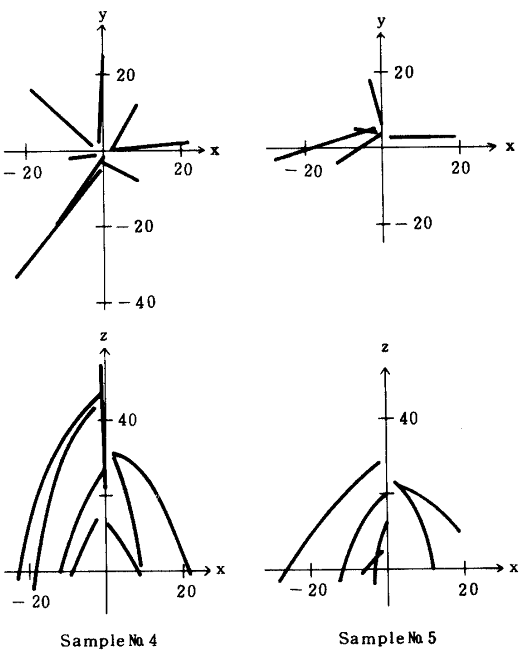

Fig. 5. Projections of prop root of samples No. 4 and No. 5

Table 1. Numbering of the first order root belonging to the main stem and branches of sample No. 1

		Height (m)	Numbering of the 1st order root
Main stem		4.06	1, 2, 3, 6, 11, 14, 16, 17 23, 26, 29, 30, 33, 34, 36, 37 39, 41, 42, 43, 44, 45, 46, 47 48, 49
Branch	A	3.75	10
	B	3.32	5, 8
	C	4.47	4, 7, 9, 13
	D	4.05	19, 21, 22, 24, 47, 28, 32
	D′*		12, 25
	E	3.65	15, 18, 20, 31, 35, 38, 40

* The branch ramified from the branch D

The root system was divided into five orders and the roots of each order were projected to the z-axis as shown in Fig. 6. The z=0 level as shown in Fig. 6 was taken as the ground level around the base of main stem. It is obvious that the upper or outside roots are younger than the lower or inside roots as a whole. The first order roots which were ramified from the medium height of the main stem had more roots of the second order than those from the lower or upper height. The early first order roots near the base of the main stem in particular ramified few second order roots. This tendency was observed on the younger sample No. 3. It was found at the sight of Fig. 6 that the ramification of the root markedly increased with a decrease of the height from the ground level around the base of main stem. The relations between the height from the z=0 level and the number of prop roots were shown in Fig. 7-(a) and -(b), where they indicated close linear correlations on the normal-logarithmic scale except for the highest and lowest points of the main stem. It appeared that taller trees had a larger gradient and more roots at z=0 than smaller trees did.

The root was thinner at the point of ramification but thicker at the point of entering the mud surface with a few exceptions. Table 2 shows the result of diameter determinations for the respective order roots at the two contrasting points. The mean diameter at the both points was largest with the first order root and became smaller as the root order advanced.

The result obtained above suggests that the root system of Yaeyamahirugi plays resistance against the flow of water by it numerous roots coupled the thickness of the roots near the mud surface. This is evidenced by the fact that the particle size of the sediment inside the mangrove forest is so fine that the sediment is clearly distinguished between the inside and the edge of the forest.[6,7]

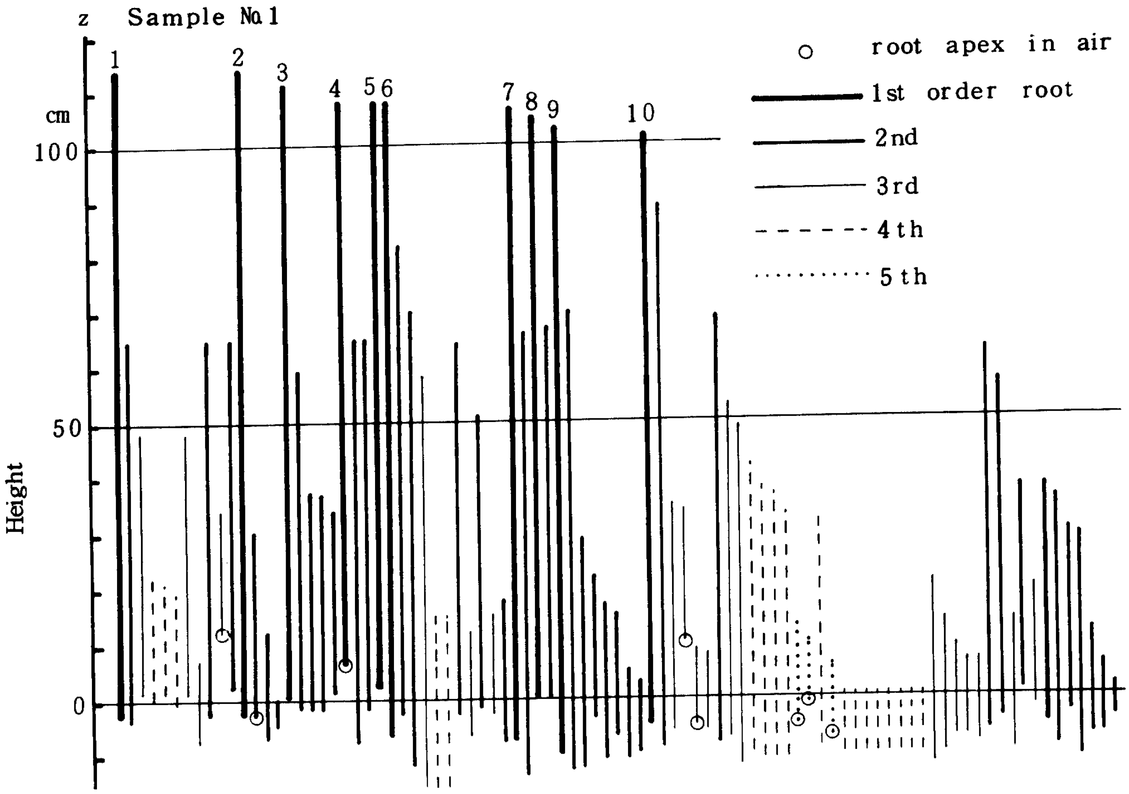

Fig. 6-(a). Projections of prop roots to the z-axis

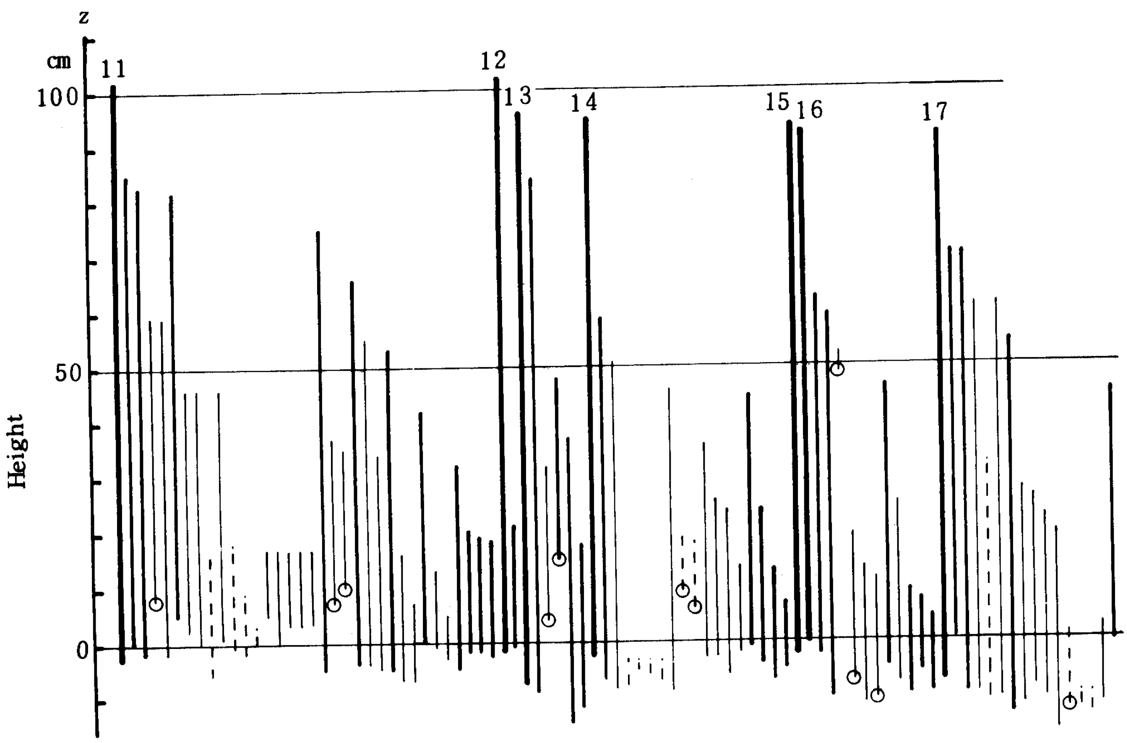

Fig. 6-(b). Projections of prop roots to the z-axis

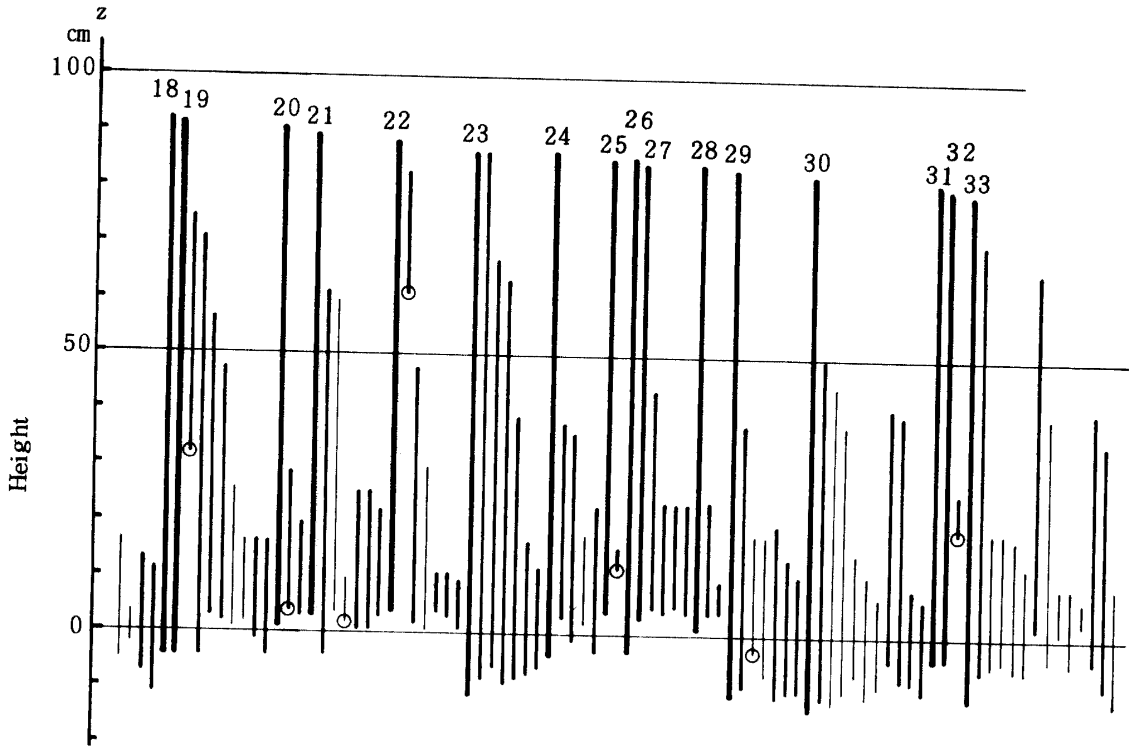

Fig. 6-(c). Projections of prop roots to the z-axis

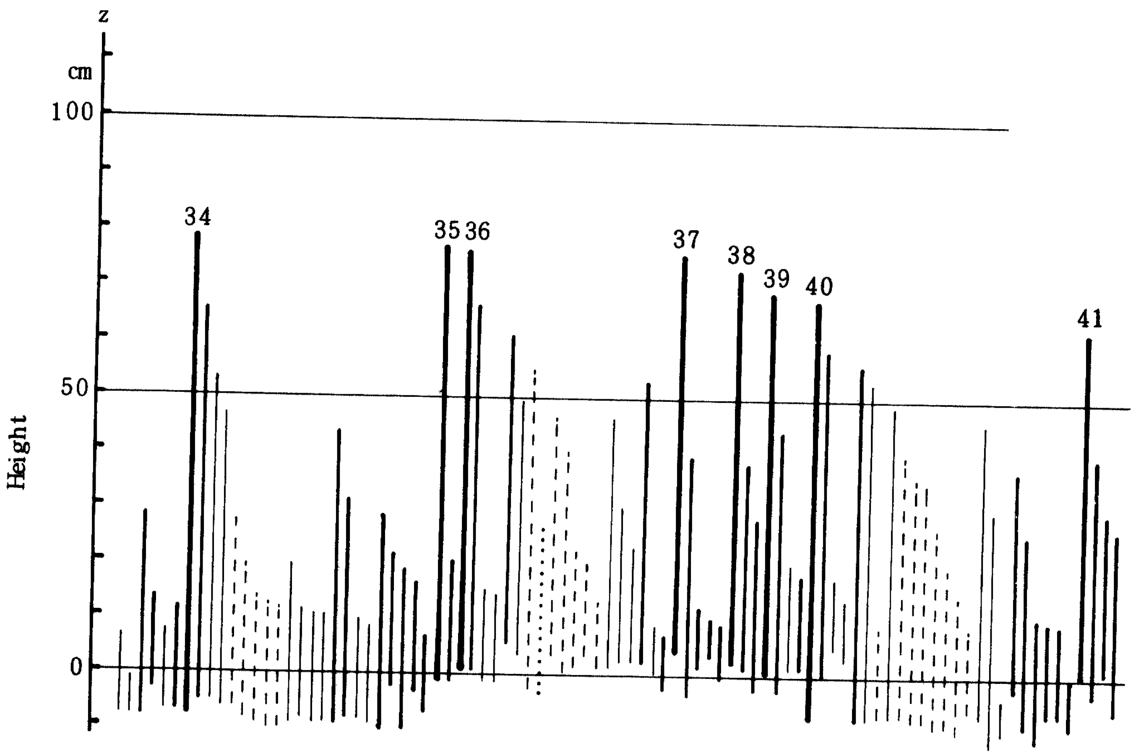

Fig. 6-(d). Projections of prop roots to the z-axis

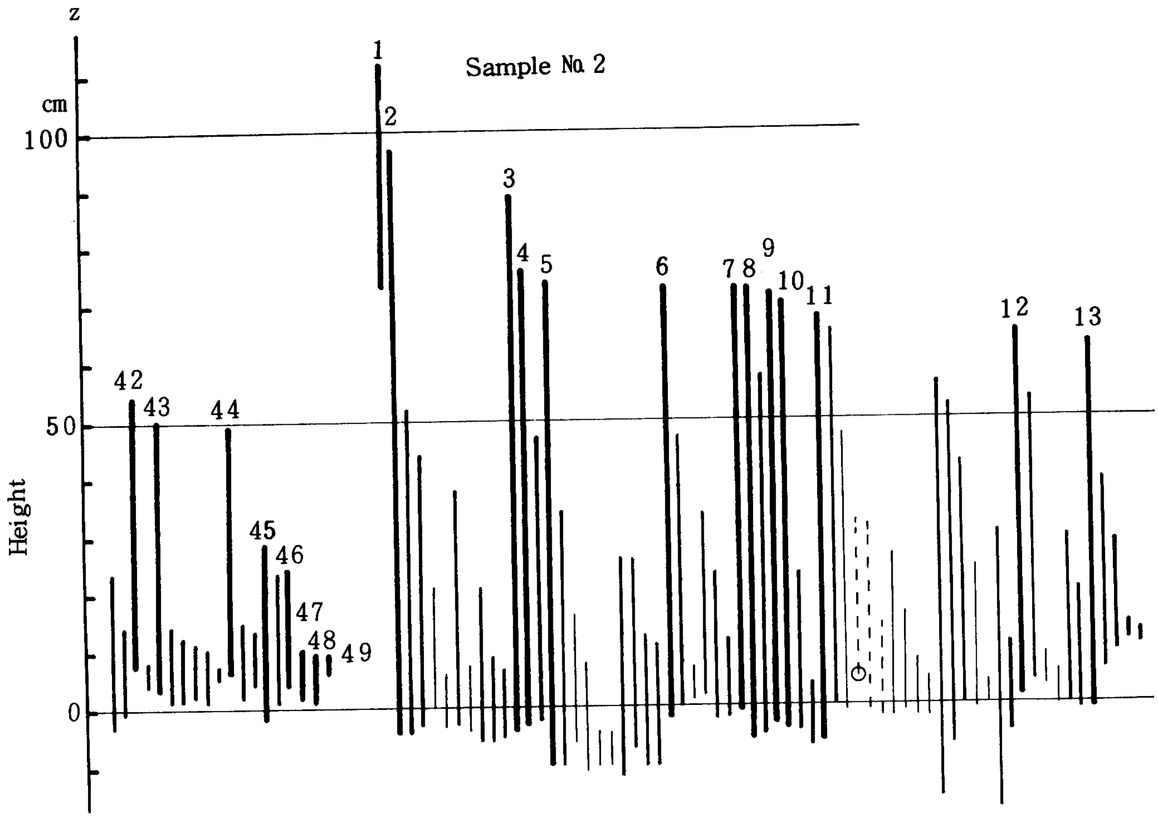

Fig. 6 —(e). Projections of prop roots to the z—axis

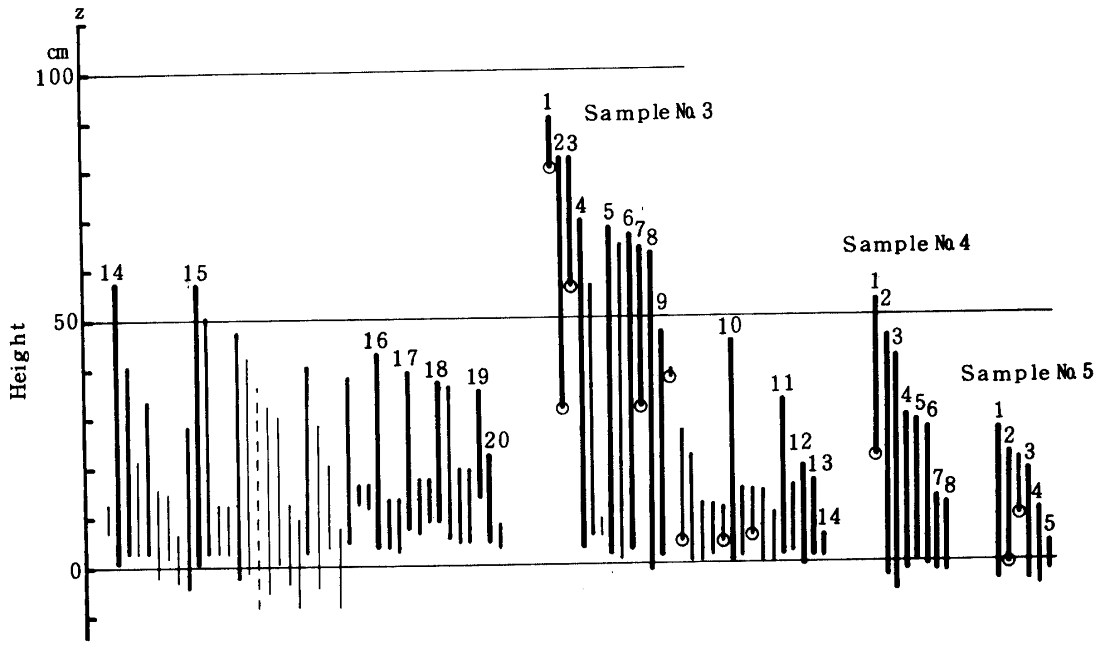

Fig. 6 —(f). Projections of prop roots to the z—axis

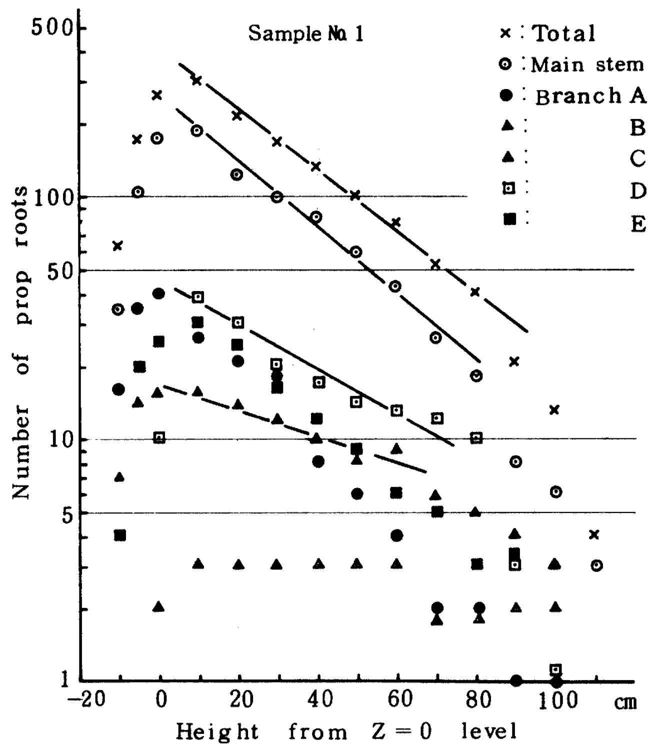

Fig. 7—(a). Relation between number of prop roots and Height from z=0 level

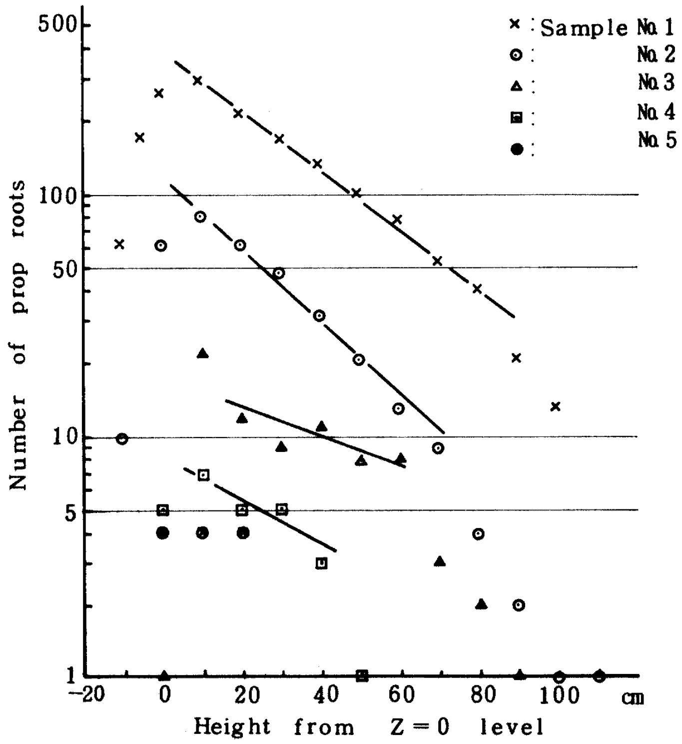

Fig. 7—(b). Relation between number of prop roots and Height from z=0 level

Table 2. Mean, Standard deviation of diameter and number of prop roots

	1st order root		2nd order root		3rd order root		4th order root		5th order root	
	point ramified	point into mud								
	(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)
Sample No. 1										
Number	49	48	164	157	106	94	52	49	4	1
Mean	3.0	3.9	2.7	3.3	2.4	3.0	2.4	2.9	1.5	1.2
S. D.	1.12	0.72	0.58	0.68	0.55	0.69	0.39	0.57	0.11	
Sample No. 2										
Number	20	20	50	50	32	32	4	3		
Mean	2.9	3.8	2.5	3.1	2.3	2.8	2.3	2.8		
S. D.	1.14	0.73	0.67	0.97	0.67	0.80	0.25	0.24		
Sample No. 3										
Number	14	10	13	9	1	1				
Mean	2.1	3.2	1.7	2.3	1.8	2.2				
S. D.	0.69	0.69	0.46	0.51						
Sample No. 4										
Number	8	7								
Mean	1.9	2.3								
S. D.	0.31	0.10								
Sample No. 5										
Number	5	4	1	0						
Mean	1.9	2.3	1.5							
S. D.	0.42	0.58								

* Differences between A and B occur as B doesn't include the roots having root apex in air

SUMMARY

Morphological characteristics of Yaeyamahirugi were investigated in the mangrove swamp near Itona in Ishigaki island, Okinawa.

Five typical samples of Yaeyamahirugi were projected to x-y and x-z planes for morphological analysis.

Three types of the prop root were explained.

The degrees of ramification of the prop root were found most advanced at medium heights.

Good linear correlations between the numbers of prop root and the heights from the ground level around the base of main stem were obtained on the normal-logarithmic scale.

The mean of prop root diameter was largest at the mud surface, and the diameter tended to become smaller as the root order advanced.

ACKNOWLEDGMENT

The author wish to express his gratitude to Mr. Akio KAMI, Mr. Masahiro NAGANO and Mr. Shogo MAENO, who were students belong to the forest influences laboratory, and gave much help to this field survey and drawing of the figures in this report.

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マングローブ林の防災機能に関する研究（Ⅰ）

ヤエヤマヒルギの支柱根の形態上の特徴について

佐　藤　一　紘

要　　約

ヤエヤマヒルギの支柱根の防災機能について検討する基礎として，その形態について，石垣島伊土名のヒルギ林で計測した。その結果を，５例について図示した。その平面図・側面図から，支柱根には３つの型があるように思われた。１つは，外側へ外側へと伸びる型，１つは，それから，ほぼ真下へ，柱のように出る型，もう１つは，前二者から，斜に控えのような形で出る型である。これは，総合的に支柱根の構造として理にかなっていると思われる。

支柱根を各次数で分類した。主幹から出ているものを１次根とし，その１次根から出るものを２次根以下同様に分類した。

高さによる支柱根の出方にも，ある傾向がみられた。主幹下部から出ている初期の支柱根は，１次根か，若干の２次根であるのに対し，中位の高さから出ている支柱根は，分岐が進み，５次根までみられた。上部から出ている新しい支柱根では，未だ分岐が進んでいない。

高さと，根の数の間には，片対数紙上で，直線となる関係がみられる。ただし，極く上部と，極く地際に近い所では，直線からはずれる。大きくなるに従って，全体の根の数も増し，勾配も大きくなるようである。

支柱根の太さは，一般に，分岐点で最も細く，徐々に太くなり，地際で最も太くなる。平均的には，１次根が最も太く，次数が下る程細くなっている。

地際で最も本数も多く，太さも大きくなることから，相乗的に，地際に近い程，流れに対する抵抗も大きくなると思われる。この事は，マングローブ林内の堆積が，林縁から，林内に入るに従って，急に粒径が小さくなる事とも深く関連しているものと思われる。