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FACULTY OF AGRICULTURE
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佐賀大農彙 (Bull. Fac. Agr., Saga Univ.) 52 : 1~11 (1982)

On the Flower Characteristics and the Chromosome Numbers of Higo-chrysanthemum (*Chrysanthemum morifolium* Ramat)

Sadami MIYAZAKI, Yousuke TASHIRO, Kōzō KANAZAWA, Akito TAKESHITA and Tadayoshi ŌSHIMA*
(Laboratory of Olericulture and Floriculture)

Received October 15, 1981

Summary

This report describes the flower characteristics and chromosome number of 38 cultivars in Higo-chrysanthemum which has been cultivated exclusively in Kumamoto Prefecture of Kyushu in Japan for about 200 years.

The flowers were single, having one outer row of either flat or tubular ray florets with small yellow disk florets at the center, showing flatter appearances, and depending upon size, were divided into small, medium and large group. The number of ray florets was 22 on the average and showed almost no relation with the flower size and the petal shape. The colors were red, white, and yellow, and almost no tint color was found among them.

The somatic chromosome numbers in root tip cells of 38 cultivars varied between 52 and 56, and the rates of cultivars with 52, 53, 54, 55, and 56 chromosomes were 2.5, 10.5, 60.5, 23.5, and 2.5%, respectively.

Introduction

There is a special group of chrysanthemums called Higo-chrysanthemum in Japan. Little is known even in our country as well as in foreign countries about these neat and elegant chrysanthemums, though they have been cultivated for about 200 years. The cultivation of Higo-chrysanthemums was originated by the encouragement of the 8th feudal load of Higo, Shigetaka Hosokawa, from the viewpoint of building up the moral education and character of his clansmen in the middle of eighteenth century. Higo is the old name for the area which is now Kumamoto Prefecture on the island of Kyushu. In 1819, Shichiemon Hideshima, a clansman and Confucian of Higo, published a notable book called '*Yōgiku-shinan-guruma*' (*yōgiku*: cultivation of chrysanthemum; *Shinan-guruma*: guidance book) on the cultivation and exhibition method of the chrysanthemums. His method has been handed down to the 'Aiju-kai', or Higo-chrysanthemum Lovers' Society established in 1887. Through the Society's effort, the chrysanthemum achieved unique development in Higo and a new form appeared, which is called Higo-giku in Japanese, or Higo-chrysanthemum. The plants, however, were never allowed to be taken out of the Society until recent years. In the Second World War, Kumamoto City, which had been the center of cultivation of the plants, was bombed, and unfortunately many old Higo-chrysanthemums were reduced to ashes. They were also seriously damaged by the Great Flood of Kumamoto in 1953[8)]

* Agricultural Extention Section, Kumamoto Prefectural Goverment.

The chrysanthemums bloom in November. Once the flower has been seen, it can easily be distinguished from other chrysanthemums with respect to its neatness and elegance, especially its shape. Flower is single, with about 20 ray florets arranged in one series around a small yellow central disk, showing a flatter apperance. They not only have special features in their shape but also in their cultivation and exhibition method. They are almost exclusively cultivated in special beds, and therefore the total effect arising not nearly from the flowers themselves but also from the beds in which they are planted becomes an object of esthetic attention (Plate 1). All the activities to grow and exhibit the chrysanthemums are carefully scheduled so that neat and elegant flowers are produced.

Higo-chrysanthemums have been classified according to the size and color of their flowers and the petal shape of the ray florets. In bedding, they are planted in a special arrangement on the basis of principles of Confucianism. The plants are arranged in 3 rows and one after another from right to left 55 cm apart. Large-flowered cultivars (12–20 cm in diameter) called *Ten-giku* or *Ushiro-giku* (*ten*: haven; *ushiro*: back; *giku* a variant of *kiku*, chrysanthemum) are planted at the back row in the beds with 75 cm in width and varing length of 360, 540, or 900 cm; medium-flowered ones (6–12 cm) called *Jin-giku* or *Naka-giku* (*jin*: man; *naka*: middle) at the middle row, and small-flowered ones (3–8 cm) called *Chi-giku* or *Mae-giku* (*chi*: earth; *mae*: front) at the front row. In both the front row and the back row, a cultivar with red flat ray florets is planted at the right side, followed by a cultivar with white tubular ray florets, a cultivar with yellow flat ray florets, a cultivar with red tubular ray florets, and so on in that order from right to left. The cultivars in the middle row are spaced at 25 cm from cultivars of the other rows. A cultivar with yellow tubular ray florets belonging to a medium-flowered group is set out at the right side, followed by a cultivar with red flat ray florets, a cultivar with white tubular ray florets, a cultivar with yellow flat ray florets, and so on in that order from right to left. In addition, the plant height and the number of flowers produced differ according to flower size; large-flowered cultivars are grown to a height of 130 cm producing 9 flowers, medium-flowered ones are grown to 85 cm with 11 flowers, and small-flowered ones are to 50 cm with about 50 flowers.

A given cultivar is almost never used again in the same bed. Accordingly, for example, in a bed with a space of 75×540 cm, at least 29 cultivars are required. At present, about 70 cultivars are cultivated in Kumamoto Prefecture. However, among them about 20 cultivars are susceptible to diseases as the result of being successively cultivated for 70 years or more. In addition, the cultivars have gradually decreased in number, since they have not been bred systematically to raise new cultivars suitable for the bed.

The purpose of the present report was to investigate the flower characteristics and the chromosome numbers of Higo-chrysanthemums cultivated exclusively in Kumamoto Prefecture at present.

Materials and Methods

Higo-chrysanthemums used in this examination were kindly supplied by the Division of Horticulture, Kumamoto Prefectural Agricultural Experiment Station and by Higo-chrysanthemum Lovers' Society. Thirty eight cultivars were grown in a field of Saga University as stock plants. About 10 cm stem tip cuttings were taken from the stock plants and were planted in rooting media. After rooting, they were transplanted in pots and then set out in the field. The plants were pinched 2 weeks after establishing and

then pruned to 3 stems per plant. The diameter and color of heads, number of ray florets, and the shape and width of petals of ray florets were recorded on the date of full bloom. Root tips for the survey of mitotic chromosomes were taken from potted plants and were pretreated with a solution of 0.05% colchicine for 2 to 3 hours at room temperature. After fixation in a mixture consisting of 3 parts ethanol: 1 part glacial acetic acid, they were hydrolyzed by 1N HCl at 60°C for 10 minutes and then stained with leucobasic fuchsin for 30 minutes or over. The squashes were prepared in 45% aceto-carmine. Each preparation was examined immediately.

Results and Discussion

1. Flower characteristics

The results of examination of the flower characteristics of Higo-chrysanthemum are shown in Table 1. The flower size ranged from 13.4–20.5 cm in *Ushiro-giku* (back row plating cultivars), 6.5–12.4 cm in *Naka-giku* (middle row planting ones) to 3.1–8.2 cm in *Mae-giku* (front row planting ones). In usual classification of the autumn-flowered Japanese chrysanthemums, Higo-chrysanthemums have been classified as a medium-flowered group (9–18 cm)[9] but such cultivars were found as 'Nijugo-kō' and 'Iwato-no-hiraki' which may belong to the large-flowered group (more than 18 cm) in usual classification, and also almost all *Mae-giku* were found to be so small that they may belong to the small-flowered group (less than 9 cm).

The colors were red, white, and yellow. It has been said that the cultivars with tint color are out of keeping with the special effect and the cultivars with such 'red' color as dusky red in 'Iwato-no-hikari' are preferred. A few had such red color, which was not common in other usual Japanese chrysanthemums.

On the basis of petal shapes of ray florets, Higo-chrysanthemums have been divided into 2 groups: flat and tubular. The cultivars with these two petal shapes are planted in alternate arrangement within the same row of a bed. Most of Higo-chrysanthemums examined in this experiment had primarily either flat petals or tubular petals, but there were 4 cultivars with spoon-like petals both in a medium-flowered group and a small-flowered group. They are usually planted in place of the cultivars with tubular petals. The petal width of cultivars with flat petals varied with flower size: large-flowered cultivars were 10–15 cm, medium-flowered ones 8–11 mm, and small-flowered ones 5–7 mm.

In general, the petals of ray florets open horizontally and in a stright line, giving the flower a flatter appearance, but in some cultivars of the large-flowered group, they were twisted and curled adaxially. "Kin-kujaku' had both flat and tubular ray florets in a head.

Higo-chrysanthemums had about 22 ray florets, and their average number showed almost no variation with reference to the flower size and the petal shape. All the cultivars except 'Kimi-ga-sode', which was semi-double and had 49 ray florets in a head, were single. The cultivars with tubular ray florets were somewhat similar in appearance to spiders and fujis[6] except that not all the central florets elongated.

The flowering date varied somewhat with the cultivars, but most of them bloomed in early or mid November.

Table 1. Characteristics of the flower of Higo-chrysanthemum

Cultivar	Date examined (in November)	Capitulum			Ray floret		
		No. examined	Mean diam. (cm)	Color	Mean no.	Mean width (cm)	Petal shape
Large-flowered							
Chihiro-no-umi*	7–19	12	13.9	White	26	11	Flat, straight
Chiyo-no-kotobuki*	4– 7	19	14.3	Light magenta	24	12	Flat, twist
Genji-guruma	9–14	30	15.9	White	15	6	Tubular, straight
Hakuryu	4– 6	16	18.0	White	21	4	Tubular, twist
Hatsu-shigure*	6–11	16	14.8	White	38	2	Tubular, straight
Hōren*	6–14	17	14.0	Rouge	32	4	Tubular, twist
Iwato-no-hikari*	17	8	19.6	Maroon	23	12	Flat, twist
Kinjōkaku*	12–19	12	14.8	Bright yellow	22	13	Flat, twist, bilge-like
Kin-kujaku*	7–14	21	17.2	Bright yellow	32	10	Flat, bilge-like
						4	Tubular, straight
Kuni-no-hikari*	12–14	13	16.8	Rouge	23	5	Tubular, twist
Matsukaze*	—	13	16.4	Bright yellow	28	2	Tubular, straight
Nijugo-kō*	17–22	15	20.5	Bright yellow	24	4	Tubular, straight
Tennyo-no-mai	12–22	17	13.4	Magenta	20	15	Flat, twist, bilge-like
Yōrō	22–30	9	16.0	Bright yellow	20	14	Flat, twist, bilge-like
Medium-flowered							
Aijuhime	14–22	16	8.6	Vermilion	22	11	Flat, straight
Inkunshi*	14–22	16	9.7	Golden yellow	20	11	Flat, straight
Kinyō	4– 9	15	8.6	Golden yellow	32	2	Tubular, straight
Kojō-no-tsuki*	14–22	19	6.5	White	21	8	Flat, straight
Mado-no-tsuki	12–14	11	8.5	White	19	3	Tubular, straight
Mado-no-yuki	6–12	17	11.7	White	21	4	Tubular, straight
Matsu-no-midori	9–14	21	9.7	Bright yellow	21	8	Flat, straight
Miyuki-no-matsu	17–19	18	7.5	Lemon-yellow	17	3	Spoon-like, straight
Shiranui*	14–22	22	12.4	Vermilion	25	9	Flat, twist
Shokō	6–10	16	6.9	Rouge	25	3	Spoon-like, straight
Tagoto-no-tsuki	7–14	12	8.0	White	22	10	Flat, straight
Takaragasa*	17–22	13	8.6	Lemon-yellow	15	8	Flat, straight
Tansei	14–22	14	6.8	Vermilion	19	2	Spoon-like, straight
Yumejiguruma	17–22	15	9.3	Snow-white	20	8	Flat, straight
Small-flowered							
Beni-suzume	14–22	12	4.2	Rouge	19	2	Spoon-like, straight
Kimi-ga-sode*	6–14	16	3.7	Lemon-yellow	49	6	Flat, straight
Mikakimori	11–12	14	3.9	Light rouge	25	2	Tubular, straight
Mine-no-matsu*	6– 9	14	6.1	Bronze	20	3	Tubular, straight
Momiji-gari*	5– 9	17	4.3	Vermilion	14	5	Flat, straight
Nogiō*	11–22	15	5.2	Lemon-yellow	17	7	Flat, straight
Nowake*	4–12	21	3.1	Vermilion	17	4	Flat, straight
Shūkō	4–12	19	4.7	Purplish red	21	6	Flat, straight
Yuki-no-karasaki*	10–12	16	8.2	White	21	4	Tubular, straight
Zuisei	14–22	21	6.5	Snow-white	19	6	Flat, straight

*: Old cultivars raised about 70 years ago.

2. Chromosme number

In Table 2 data are given on the different chromosome numbers of root tips in 38 cultivars of Higo-chrysanthemum. The somatic numbers of the cells of the cultivars counted varied between 52 and 56. Most of the cultivars have between 53 and 55 chromosomes with the peak at 54. Accompanying the chromosome variation among cultivars there was also variation within individual plants. In two cultivars 'Chiyo-no-kotobuki' and 'Kimi-ga-sode', the variation was observed not only among their cuttings but also in the roots and/or cells of a cutting shown Table 3. These phenomena have often been reported in chrysanthemums.[1)2)5)7)10)]

Dowrick,[1)] Dowrick and El-Bayoumi,[2)] and Sampson *et al.*[10)] have confirmed that a positive correlation between inflorescence size and chromosome number in English or American cultivars, and Endo has observed 54–75+B[3)] and 53–62 chromosomes[4)] in large-flowered Japanese exhibition forms, and large- and medium-flowered forms for cut-flower use, respectively. In Higo-chrysanthemum, the maximum number was 56, and such correlation was not found, but the variation range in chromosome numbers

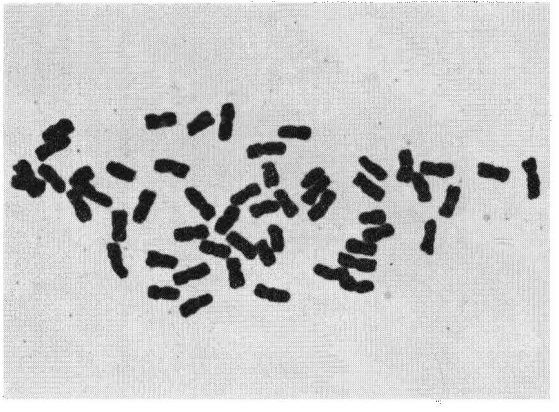

Fig. 1.

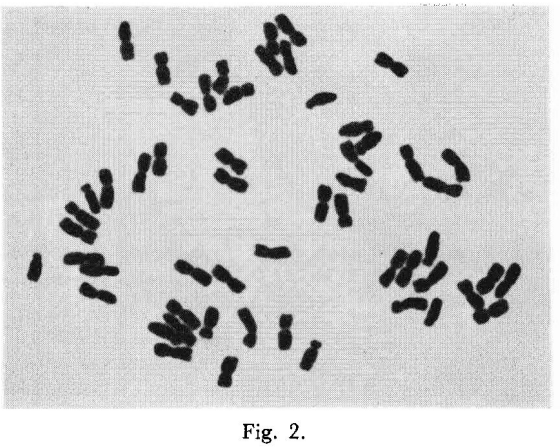

Fig. 2.

Fig. 1, 2. Chromosomes in a root tip cell of Higo-chrysanthemums. ×ca.1500.

Fig. 1. 'Shiranui', 2n=53. Fig. 2. 'Matsukaze', 2n=55.

Table 2. Chromosome numbers of mitotic cells in root tips of Higo-chrysanthemum

Cultivar	No. of plant	No. of root	No. of cell observed	Distribution of cells				
				Chromosome number				
				52	53	54	55	56
Large-flowered								
Chihiro-no-umi*	3	12	173			173		
Chiyo-no-kotobuki*	3	15	171	10	143	18		
Genji-guruma	1	3	35			35		
Hakuryu	2	5	61			61		
Hatsu-shigure*	1	5	45			45		
Hōren*	3	6	53			53		
Iwato-no-hikari*	1	4	35				35	
Kinjōkaku*	1	3	56			56		
Kin-kujaku*	1	4	52				52	
Kuni-no-hikari*	2	5	32			32		
Matsukaze*	5	14	94				94	
Nijugo-kō*	3	10	162			162		
Tennyo-no-mai	1	3	16				16	
Yōrō	2	8	54			54		
Medium-flowered								
Aijuhime	2	6	72		72			
Inkunshi*	1	5	108			108		
Kinyō	3	8	77				77	
Kojō-no-tsuki*	2	5	71					71
Mado-no-tsuki	2	3	27				27	
Mado-no-yuki	2	6	131			131		
Matsu-no-midori	3	5	40		40			
Miyuki-no-matsu	2	7	127			127		
Shiranui*	2	6	178		178			
Shokō	3	7	62			62		
Tagoto-no-tsuki	3	5	49			49		
Takaragasa*	3	4	34			34		
Tansei	2	4	56	56				
Yumejiguruma	2	7	153			153		
Small-flowered								
Beni-suzume	3	4	35			35		
Kimi-ga-sode*	4	11	112			23	89	
Mikakimori*	2	3	18			18		
Mine-no-matsu*	3	5	83				83	
Momiji-gari*	1	1	22			22		
Nogiō*	3	13	147			147		
Nowake*	3	15	236				236	
Shūkō	2	9	133			133		
Yuki-no-karasaki*	2	5	115			115		
Zuisei*	3	13	171			171		

*: Old cultivars raised about 70 years ago.

Table 3. Variation of chromosome number within individual plants of 2 cultivars

Cultivar	Plant no.	Root no.	No. of cell observed	No. of cells with the following chromosome number			
				52	53	54	55
Chiyo-no-kotobuki	1	1	14	6	5	3	
		2	9	4	2	3	
		3	9		7	2	
		4	10		10		
		5	15		15		
	2	1	8		8		
		2	15		15		
		3	15		15		
		4	20		20		
	3	1	10			10	
		2	7		7		
		3	19		19		
		4	11		11		
		5	5		5		
		6	4		4		
Kimi-ga-sode	1	1	3			3	
		2	14			12	2
		3	7			4	3
	2	1	7				7
		2	2				2
		3	5				5
	3	1	6				6
		2	22			4	18
	4	1	26				26
		2	13				13
		3	7				7

Table 4. Relationship between flower size and chromosome number

Flower size	No. of cultivar examined	No. of cultivars with the following chromosome number				
		52	53	54	55	56
Large	14		1	9	4	
Medium	14	1	3	7	2	1
Small	10			7	3	
Total	38	1	4	23	9	1

Table 5. Relationship between petal shape of ray florets and chromosome number

Petal shape	No. of cultivar examined	No. of cultivars with the following chromosome number*				
		52	53	54	55	56
Flat	20		4	11	4	1
Tubular	13			9	4	
Spoon-like	4	1		3		

* A large-flowered cultivar 'Kin-kujaku' which had 55 chromosomes and both flat and tubular ray florets in a head was not given in this table.

Table 6. Relationship between flower color and chromosome number

Flower color	No. of cultivar examined	No. of cultivars with the following chromosome number				
		52	53	54	55	56
Red	14	1	3	7	3	
White	11			9	1	1
Yellow	13		1	7	5	

Table 7. Relationship between old- and new cultivars and chromosome number

Cultivars	No. of cultivar examined	No. of cultivars with the following chromosome number				
		52	53	54	55	56
Old*	22		2	13	6	1
New	16	1	2	10	3	

* Old cultivars raised about 70 years ago.

showed differences among the cultivars with different flower sizes, petal shapes of ray florets and colors. The range was larger in both the medium-flowered cultivars (Table 4) and the cultivars with flat ray florets than in others (Table 5). All white-flowered cultivars except 'Kojō-no-tsuki' and 'Mado-no-tsuki' had 54, whereas almost all yellow-flowered ones had 54 to 55, and red-flowered ones had various numbers (Table 6). Although new cultivars have been consistently produced by open-pollinated seeds, they have differed little in chromosome number from the old cultivars[11] raised about 70 years ago and still growing today (Table 7).

摘　　要

肥後ギクの花の形質と染色体数について

宮崎貞巳・田代洋丞・金澤幸三
竹下昭人・大島唯由
(蔬菜・花卉園芸学教室)

昭和56年10月15日　受理

200年ほど前から熊本県で栽培されている肥後ギクについて，38品種の花の形質と染色体数を調査した．肥後ギクの花は一重で，外側には一列の平弁ないし管弁の舌状花を，花芯には小型の黄色の筒状花を有していて平咲きで，その大きさから小輪，中輪および大輪にわけられた．舌状花の数は，平均22で，花の大きさや花弁の形態との間にはほとんど関連がなかった．花色は，赤，白，黄で，中間色はほとんど認められなかった．38品種の根端細胞の染色体数は52から56の間にあり，52，53，54，55，56本の染色体を有する品種の割合は，それぞれ2.5，10.5，60.5，23.5，2.5%であった．

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Explanation of Plates

Plate 1. Higo-chrysanthemums exhibited at the garden of the Kumamoto Castle in the autumn of 1977.

Plate 2–7. Flowers of Higo-chrysanthemum.

Plate 2, 3. Large-flowered cultivars.

Plate 2. 'Matsukaze' with yellow tubular ray florets.

Plate 3. 'Hatsu-shigure' with white tubular ray florets.

Plate 4, 5. Medium-flowered cultivars.

Plate 4. 'Aijuhime' with red flat ray florets.

Plate 5. 'Kojō-no-tsuki' with white flat ray florets.

Plate 6, 7. Small-flowred cultivars.

Plate 6. 'Nogiō' with yellow flat ray florets.

Plate 7. 'Beni-suzume' with red spoon-like ray florets.

Plate 1

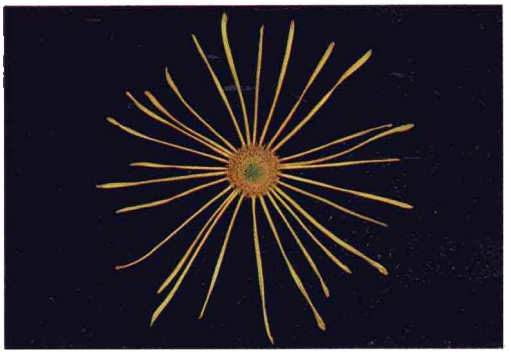

Plate 2

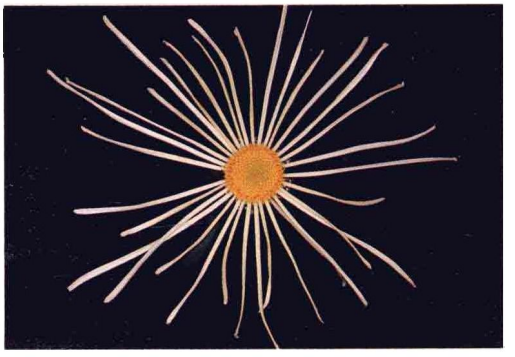

Plate 3

Plate 4

Plate 5

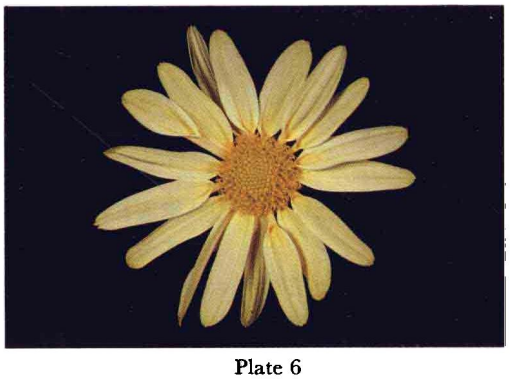

Plate 6

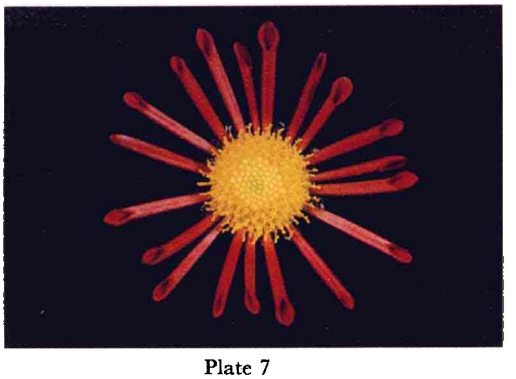

Plate 7

佐賀大農彙 (Bull. Fac. Agr. Saga Univ.) 52 : 13～27 (1982)

リモートセンシングによる有明海沿岸の情報処理に関する研究

I. 有明海に流入する河川の河口映像について

渡 辺 潔・中 島 明
(干拓水工学研究室)

昭和56年11月24日 受理

Studies on the Data Reduction of the Coast of the Ariake Sea by the Remote Sensing

I. On the images of the estuaries where the rivers flow into the Ariake Sea

Kiyoshi WATANABE and Akira NAKAJIMA
(Laboratory of Shore Reclamation and Hydraulic Engineering)

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Summary

The Chikugo River, the Rokkaku River, and the Shoita River flow into the coast of the Ariake Sea. In these estuaries the tidal land is growing and it seems to cause the singular phenomena.

By airplane with MSS (Multi Spectral Scanner) we gathered the phenomena of the Ariake Sea and converted them into CCT (Computer Compertible Tape). We operated PARS (Program Package for the Remote Sensing Data Analysis) of Kyushu University Computation Center to output by job control from Saga University Computation Center. The objects of information extraction are the estuaries of the Hayatsue River, the Rokkaku River and the Shiota River.

We did unsupervised classification of three estuaries, and compared the results. There was no difference in relative cumulative frequency distribution. But in case of the mediam, there were some differences in frequency of spectral value by electromagnetic waves.

ま え が き

測定すべき面積が広くなればなるほど小範囲の微視的なもののかわりに，巨視的な測定方法を考える必要がある．

有明海のような広さになると同時測定の可能な巨視的方法が要求され，そのための測定方法としてリモートセンシング（空中探査）がある．探査方法としては衛星，飛行機による場合があるが，ここでは，飛行機による場合を対象とし，これによりえられたデータを，電子計算機により処理し，比較検討を行なった．