

A Taxonomic and Ecological Study of *Gloiopeltis furcata* J. Agardh (Rhodophyta) in Korea

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Plants of *G. furcata* were divided into four variant populations. The habit characteristics, external and internal morphology were analysed quantitatively in order to clarify their morphological variation. Among four variant populations, type I (typical *G. furcata* type) and type II (*G. furcata* f. *intricata* type) may be influenced by the time when they develop from the crustose basal discs and the tidal level. Type III is the immature plants, and type IV (*G. furcata* f. *coliformis* type) is a *G. furcata* population in late spring after the luxuriant season. For the reason, the formas of *G. furcata* f. *intricata* and f. *coliformis* are no more valid in *Gloiopeltis furcata*.

Keywords : *G. furcata*, *G. furcata* f. *coliformis*, *G. furcata* f. *intricata*, ecology, taxonomy

The red alga, *Gloiopeltis furcata* (Postels et Ruprecht) J. Agardh grows gregariously on rocks in intertidal zone. The distribution of this characteristic intertidal species extends to Korea, southern China, Japan and the Pacific coast of North America (Fig. 1) (Okamura, 1936; Kang, 1966; Abbott and Hollenberg, 1976; Yamada, 1980). The plants are appreciated as a food and a sizing material for silk and other textile industries (Lobban and Wynne, 1981).

This species was first recorded as *Dumontia furcata* by Postels and Ruprecht (1840) in Russia, and transferred to *Gloiopeltis* by J. Agardh (1851). Another two new species, *G. intricata* and *G. coliformis*, were reported by Suringar (1870) from Japan, which however were placed as varieties of *G. furcata* by Okamura (1902). These two varieties were moved again to formas by Okamura (1936), because they were not firmly established varieties but only local forms. Recently, Yoshida *et al.* (1990) listed *G. furcata* on the basis of Okamura's descriptions. The taxonomic status among the various forms remains still controversial (Suringar, 1870; Okamura, 1902, 1927, 1936; De-Toni, 1924; Yoshida *et al.*, 1990).

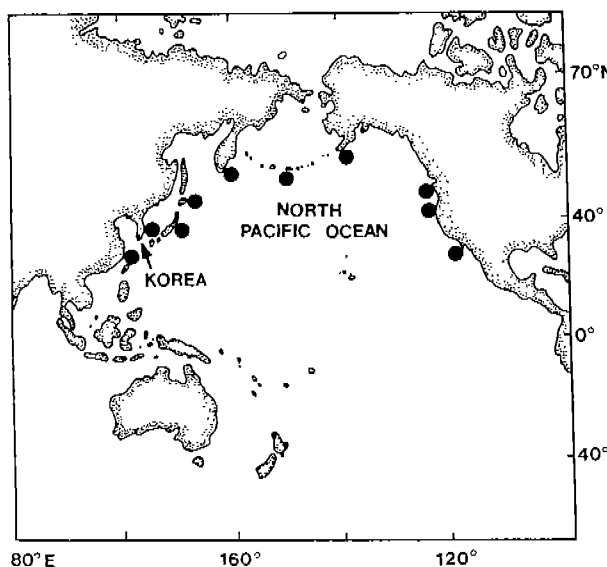


Fig. 1. Distribution of *Gloiopeltis furcata* (Postels et Ruprecht) J. Agardh in the world.

In this study four variant populations of *G. furcata* have been recognized along the coasts of Korea. The habit characteristics, external and internal morphology of these plants were investigated quantitatively in order to clarify their specific demarcation.

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MATERIALS AND METHODS

The field investigation was carried out during October 1991-July 1992 at Sokcho, Jangho and Younghae in the east coast, and during September 1993-June 1994 at Pusan, Samcheonpo, Wando in the south coast and Uihang in the west coast of Korea (Fig. 2). The materials were collected randomly and fixed in 5-10% formalin-seawater. The plants from variant populations (30-210 individuals per site) were selected and measured in their length, breadth and number of branches, except for *coliformis* type plants, which were collected only five individuals. The herbarium specimens investigated were preserved in the Herbarium, Chongju University.

RESULTS

Plants of *G. furcata* are divided into four variant populations, because each populations is clear distinct in the outer appearance. The type I is classified as a typical *G. furcata* type, the type II is classified

G. furcata f. *intricata* type, the type III is classified internally solid and immature one, and the type IV is classified *G. furcata* f. *coliformis* type.

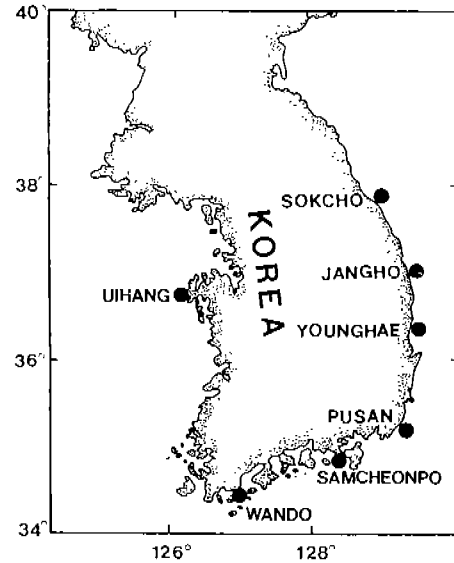
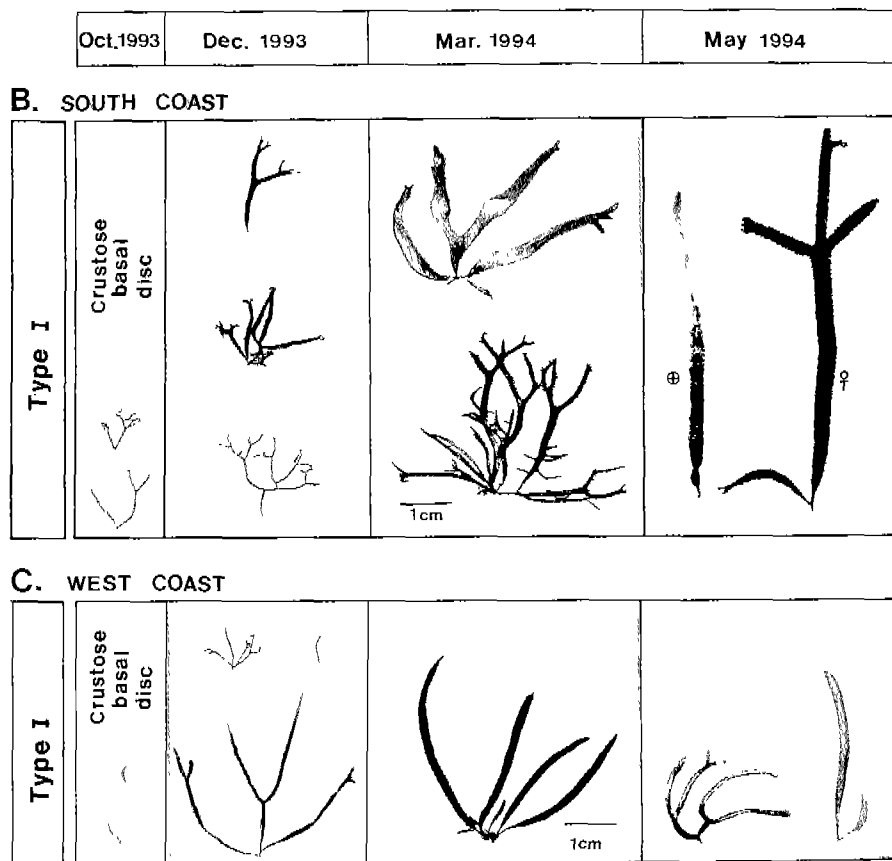


Fig. 2. Sampling sites along the coast of Korea.

	Oct. 1991	Dec. 1991	Mar. 1992	May 1992
A. EAST COAST				
Type III			Disappear	
Type II	Crustose basal disc 			
Type I	Crustose basal disc 			 1 cm

Fig. 3. Seasonal and geographical variations of *Gloiopeltis furcata* (Postels et Ruprecht) J. Agardh in the coasts of Korea (⊕, tetrasporic plant; ♀, cystocarpic plant).



(Fig. 3. continued)

The type I (typical *G. furcata* type)

Vegetative features: The plants classified as a typical *G. furcata* type usually occurred in mid-intertidal zone of rocky substratum. The thalli provided with short and slender stem below and abruptly expanded subcylindrical main branches above. The branches were sometimes simple or frequently divaricato-dichotomous. All the branches were hollow internally. Accessory branchlets were rare in young thalli but were frequent in inner cortex of older thalli. As a result of the measurement of 210 plants, mean thallus length was 3.57 ± 0.15 cm, the breadth was 2.21 ± 0.06 mm, and the number of branches per mature plant was 1.77 ± 0.15 times respectively (Figs. 3 and 4).

Reproductive features: Tetrasporangia were developed on the whole branches derived from (4) 5-6th cortical cells from the surface, and divided cruciately at maturity. Cystocarps developed on whole frond.

Two-celled carpogonial branch and auxiliary cell arose on a same ampulla which was derived from 7-10th cells of inner cortex. After fertilization, the auxiliary cell fused with neighboring ampullar cells, and became a fusion cell. The fusion cell produced gonimoblast initials, which eventually became a cystocarp. Ostiole was not developed.

Cystocarpic plants occurred mainly in early spring, whereas tetrasporic plants were in late spring (Fig. 5).

The type II (*G. furcata* f. *intricata* type)

Vegetative features: The plants accorded well with the descriptions of *G. furcata* f. *intricata* (Surin-gar, 1870; Okamura, 1936). Comparing with the type I, they were more slender and irregularly dichotomous in branch and grew in upper zone than the type I (Fig. 3).

Hollow characteristics and internal structure of the branches were same as the type I. As a result of

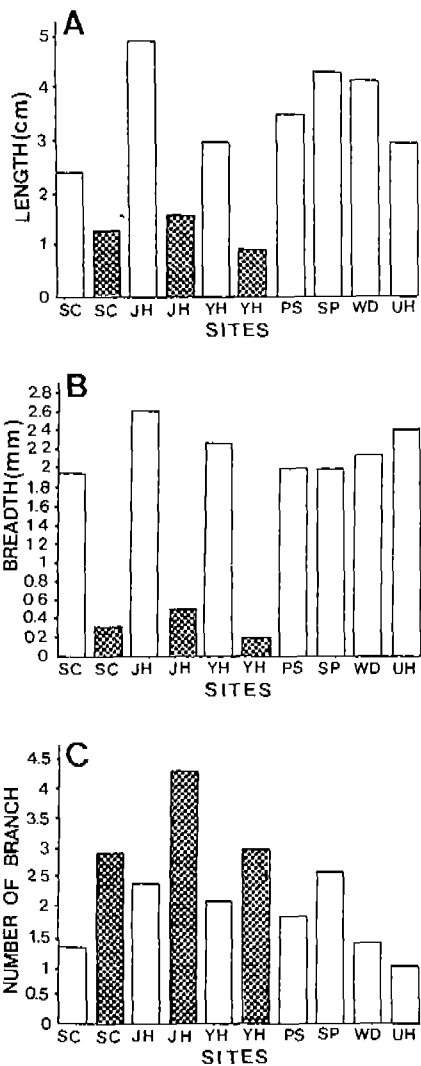


Fig. 4. Mean thallus length (A), breadth (B), and number of branch (C) of mature plants. White columns, type I (*G. furcata* type); black columns, type II (*G. furcata* f. *intricata* type). (SC, Sokcho; JH, Jangho; YH, Younghae; PS, Pusan; SP, Samcheonpo; WD, Wando; UH, Uihang).

the measurement of 90 plants, mean thallus length was 2.37 ± 0.66 cm, the breadth was 0.36 ± 0.003 mm, and the number of branches per mature plants was 3.43 ± 0.24 times respectively (Fig. 4).

Reproductive features : The development of cystocarps and tetrasporangia were basically same as the type I. However the developing period of reproductive structures and the ratios of both cystocarpic and tetrasporic plants were variable according to the sites and seasons. Especially, only vegetative plants were collected at Sokcho of the east coast (Fig. 5).

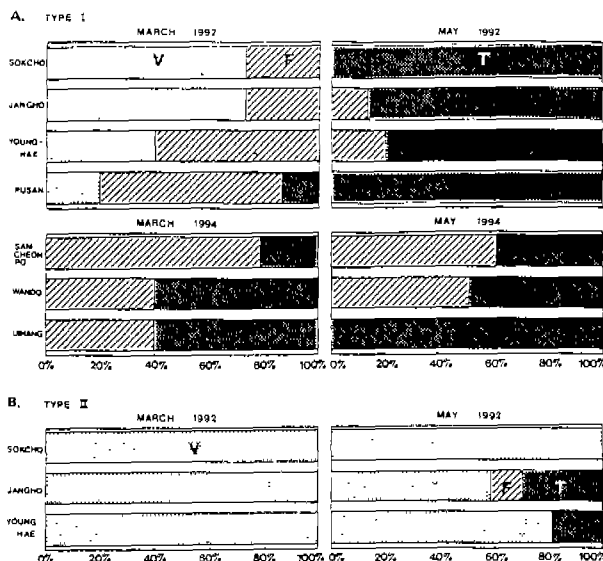


Fig. 5. The ratio of vegetative plants (V), cystocarpic plants (F) and tetrasporic plants (T). A, type I (*G. furcata* type); B, type II (*G. furcata* f. *intricata* type).

The type III (internally solid and immature plants)

Vegetative features : The young plants of this type were first collected in October, 1991 from the east coast. The transverse section of the branches showed a clearly solid cylinder structure. Stipes and branches were not distinguished. The branch forked dichotomously in 2-6 times. In December 1991 during the next sampling, the plants did not vary in form, and they were not observed nor more at further samplings. As a result of the measurement of 30 plants, mean thallus length was 8.23 ± 0.26 mm, and the breadth was 0.21 ± 0.002 mm (Fig. 3).

The type IV (*G. furcata* f. *coliformis* type)

The plants belonging to type IV were very similar to the aged plants of the typical I, but the plants were characterized by articulato-constricted branches (Suringar, 1870; Okamura, 1902, 1936). Thallus length, ca. 15 cm, was greater comparing with the type I. These plants were very rarely collected among the typical *Gloiopeltis furcata* populations at late spring in Wando of the south coast (Fig. 6).

DISCUSSION

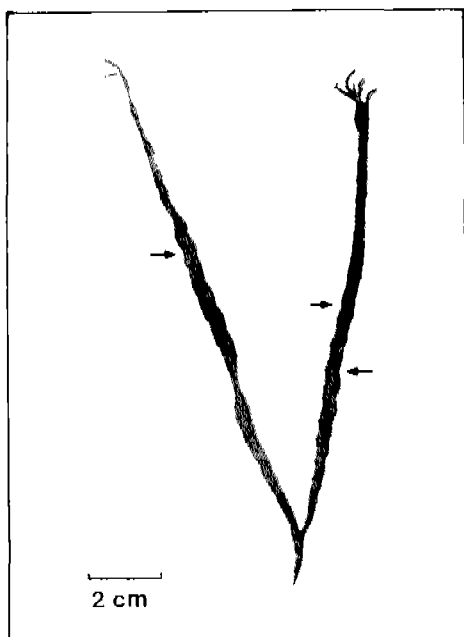


Fig. 6. The plant of type IV (*Gloiopeltis furcata* f. *coliformis* type) collected in Wando south coast of Korea (arrowsheads, articulo-constricted branch).

The coasts of Korea are under the influence of two main currents, the Tshushima Warm Current and the North Korea Cold Current. The east coast is subjected to the influence of the East Coast Warm Current, a branch of the Tshushima Warm Current and the North Korea Cold Current. Both south and west coasts are influenced by the Tshushima Warm Current. Salinity varies between ca. 33.50‰ and 33.85 ‰ during the year. The surface water temperature is 23–26°C in summer season, and fluctuates from 3°C to 14°C in winter. The daily tidal difference is about 0.3 m in the east, 1.2–3.0 m in the south, and 3.0–8.0 m in the west coast. The mean sea level is higher in summer than in winter (Anonymous, 1990).

Plants of *Gloiopeltis furcata* exhibit an annual life cycle in the field. The young plants germinate from the crustose basal discs on rocky substratum from autumn to winter and grow between upper and mid-intertidal zones. The adult plants gradually disappear after releasing spores in spring season of the next year (Fig. 3).

The young type III plants (internally solid and immature plants) mainly grow in the upper intertidal zone in late summer, because the mean sea level

is high during summer. When the mean sea level of summer gradually is lowered by seasonal change, these plants growing in upper intertidal zone suffer the stresses of lower seawater level, long time desiccations and deficiencies of nutrients (Dring, 1982), so that the plants remain immature or at last to be dead.

Since the young plants growing in winter season do not encounter serious stresses and their growth is not limited by the seawater level, they grow into the type I (typical *G. furcata*) and the type II (*G. furcata* f. *intricata*) forms. Morphological variations of these two types are observed within very short vertical distances of about 0.3 m in the east coast. Most plants of type II grow above the zone where the type I plants occur.

The outer appearance of seaweeds often varies among individuals according to the vertical seawater levels on the same shore. For example, *Enteromorpha linza* exhibits a graded change from long lanceolate plants near the high water mark to short and broad ones on the lower shores. However, the most common difference among intertidal species is that they become smaller and sometimes less fertile, towards the top of their zone, as in *Prasiola stipitata*, *Fucus spiralis*, *Halosaccion ramentaceum* and several other red algae (Lobban and Wynne, 1981). Thallus length, breadth, and number of branches are significantly different ($p < 0.01$) between the type II and the type I, while their internal structure of the two types are very similar. The external morphology of the two types is due to the difference of environmental factors during their growing time. This fact demonstrates that the type II (*G. furcata* f. *intricata*) can not be treated as an intraspecific taxon of the species.

Tidal curves of all coasts of Korea show two low tides and two high tides per tidal day, namely mixed tides. The daily tidal difference of the southern and western coasts is greater than that of the eastern coast. The part of *G. furcata* zone in the southern and western coasts is exposed to severe desiccation during low water period, and wave action affects *G. furcata* habit indirectly. Therefore, plants of the type II seem to be not collected in the south and west coasts. They remain in a form of crustose basal discs at summer season. The plants *G. furcata* of the west coast however occur on higher rocky substrata of north-facing slopes. The south-facing slopes will be

Table 1. The treatment of intraspecific taxa in *Gloiopeltis furcata* J. Agardh

J. Agardh (1851)	Suringar (1870)	Okamura (1902)	Okamura (1936)	Yoshida <i>et al.</i> (1990)	This study
<i>G. furcata</i>	<i>G. furcata</i> <i>G. intricata</i>	<i>G. furcata</i> <i>G. intricata</i> var. <i>intricata</i>	<i>G. furcata</i> <i>G. intricata</i> f. <i>intricata</i>	<i>G. furcata</i>	<i>G. furcata</i>
	<i>G. coliformis</i>	<i>G. coliformis</i> var. <i>coliformis</i>	<i>G. coliformis</i> f. <i>coliformis</i>		

heated and dry out very rapidly, whereas the north-facing can remain cool and moist under exactly the same weather condition (Dring, 1982; Nybbaken, 1993).

The type IV (*G. furcata* f. *coliformis* type) is the very similar to the typical type, but the branches are characteristically articulo-constricted (Suringar, 1870; Okamura, 1902, 1936). These plants are rare among typical *G. furcata* populations in late spring. We could find them only in the southern coast. Even though the Japanese plants of *G. furcata* f. *coliformis* are mainly collected in the part of northern coast of Japan, and *G. furcata* f. *intricata* in the southern (Okamura, 1902), so that the distribution patterns of these local forms are not same as Korean coasts, the ecological habit seems not to be fixed as an independent one. For the reason, the type IV (*G. furcata* f. *coliformis* type), as well as *G. furcata* f. *intricata*, is not treated as an intraspecific taxa of the species (Table 1).

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 韓國產 紅藻 불등플가사리(*Gloiopeltis furcata* J. Agardh)의 分類 生態學的 研究

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摘 要

한국산 홍조 불등플가사리 식물은 4개의 변이 집단으로 나누어진다. 형태학적인 변이를 연구하기 위하여 서식처의 특성, 식물체의 외부 및 내부 구조를 정량적으로 조사하였다. 4개의 변이체중에서 변이형 I(전형적인 *G. furcata* 형태)과 변이형 II(*G. furcata* f. *intricata*)는 반상근에서 자랄 때의 시기와 조위에 따라 영향을 받는다. 변이형 III(internally solid, immature type)은 성숙하지 못하고 조기에 사멸하였다. 또한, 변이형 IV(*G. furcata* f. *coliformis*)는 늦봄에 극소수의 개체만이 전형적인 *G. furcata* 집단에서 채집되었다. 종내 분류군인 *G. furcata* f. *intricata*와 f. *coliformis*는 폐기되어야 할 것으로 사료된다.

주요어: *G. furcata*, *G. furcata* f. *intricata*, *G. furcata* f. *coliformis*, 분류, 생태연구

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