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Seasonal Variations in Species Composition and Biomass of Epiphytic Algal Community in an Eelgrass (*Zostera marina*) Bed

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잘피밭에 서식하는 부착해조류 군집의 종조성 및 계절변동

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Abstract : *A total of 3 epiphytic macroalgae were collected from eelgrass bed in Jindong Bay, and Scytosiphon lomentaria and Colpomenia sp. in Phaephyta, Gracilaria sp. in Rhodophyta occurred during study periods. For epiphytic microalgae (diatoms), Cocconeis scutellum and Cocconeis placentula were common species. Seasonal variations of epiphytic algal biomass were marked: the higher epiphytic macroalgae was 3.3 g DW/㎡ in November 2003, whereas epiphytic diatoms were 43,153 cells/㎡ in June 2003. Diversity and number of epiphytic macroalgae species were the lowest in the study area, compared with those of in other areas such as Kwangyang Bay, Dongdae Bay, and Aenggang Bay. These results were therefore likely due to the severe physical characteristics of the intertidal mudflat, eelgrass biological characteristics, and the deterioration of water quality.*

key words: *Epiphytic macroalgae, Epiphytic diatoms, Eelgrass Bed, Scytosiphon lomentaria, Colpomenia sp., Gracilaria sp., Cocconeis scutellum*

요 약 : 진동만 잘피밭에서 서식하는 대형 부착해조류는 총 3종이었으며, 출현종은 갈조류의 *Scytosiphon lomentaria, Colpomenia* sp., 그리고 홍조류의 *Gracilaria* sp., 으로 구성되어 있었다. 한편 미세 부착해조류는 *Cocconeis scutellum* 와 *Cocconeis placentula*가 우점하였다. 잘피에 부착하여 서식하는 부착해조류의 현존량은 계절 변동이 뚜렷하게 나타났다. 대형 부착해조류는 2003년 11월에 3.3 g DW/m^2, 미세 부착해조류는 2003년 6월에 43,153 cells/m^2 를 보이며 가장 높게 나타났다. 다른 해역의 잘피밭(광양만, 동대만 및 앵강만)과 비교해보면, 본 조사해역의 잘피밭에서 서식하는 부착해조류의 종 다양성 및 현존량이 매우 낮게 나타나 특이하였다. 이와 같은 결과는 잘피밭의 물리학적인 환경특성(예를 들면 조류 및 유속), 잘피 자체의 생물학적인 특성, 그리고 수질의 악화에 기인하였다.

핵심용어: 대형 부착해조류, 미세 부착해조류, 잘피밭, *Scytosiphon lomentaria, Colpomenia* sp., *Gracilaria* sp., *Cocconeis scutellum*

1. Introduction

Epiphytic algae are usually rapidly colonized by micro-algae, and later by larger macroalgae and invertebrates unless the seagrass have chemical or physical mechanisms excluding these organisms(Huh et al., 1998; Hemminga and Duarte, 2000; Nagelkerken et al., 2002). The ecological seagrass studies have emerged that epiphytic algae was one of the most important primary producer which have been supported the invertebrate food web in the seagrass beds(Bulthuis, 1987; Moncreiff and Sullivan, 2001; Hoshika et al., 2006). Eelgrass(*Zostera marina*) is a mono-meristematic leaf replacing and fast-growing seagrass species(Duarte and Chiscano, 1999; Hemminga and Duarte, 2000) occurring in the lower part of mudflats along temperate coasts. Seagrasses occupy approximately about 55 to 70 km^2 around Korean peninsula and eelgrass(*Zostera marina*) occupies about 50 to 60 km^2 as dominant species.

Shallow waters with rich eelgrass beds located around southern Korea including the study area, Jindogn Bay, provide a habitat for variety of invertebrates and small fish, which in turn are the potential food of large fishes. Although some ecological studies on eelgrass associated communities have been conducted in the eelgrass beds of Jindong Bay, their interest is confined to fish assemblages and feeding habits of some fish species(Kwak and Huh, 2004; Kwak et al., 2004; Kwak et al., 2005), and few was reported fundamental studies about epiphytic algal communities. On the other hand, species composition and biomass of epiphytic algae in an eelgrass bed of Kwangyang Bay, Dongdae Bay and Aenggang Bay were described(Huh et al., 1998; Kwak and Huh,

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in press).

The objective of this study was to examine the species composition and biomass of epiphytic algae in an eelgrass bed of Jindong Bay, and to compare with studies in an eelgrass bed of Kwangyang Bay, Dongdae Bay and Aenggang Bay in the southern area, Korea. It is a fundamental part of a wider study aimed at understanding the eelgrass production and growth after recovery from anthropogenic disturbances in this temperate Korean seagrass beds.

2. Materials and methods

The study area, the eelgrass bed of Jindong Bay(Fig. 1), supports a luxuriant eelgrass, *Zostera marina* which is forming subtidal bands(500~700 m wide) in the shallow water(< 3 m). The eelgrass bed extended, forming patches for about 4 km along the shore.

The epiphytic macroalgal samples were estimated from all plant bodies taken in a sea bottom of $0.01m^2$ throughout 2003 and identified according to Lee and Kang(1986, 2001). In order to measure epiphytic macroalgal biomass, these samples dried at 80 ℃ for 24h and then weighed to the nearest gram. For epiphytic microalgae(e.g. diatoms), specimens were scraped from third shoot of eelgrass, and then fixed 2% formaldehyde them in 10 ml cap tube in March, June, September, and December 2003. Epiphytic diatoms were identified according to Round(1990), and Thomas(1996), and counted in Sedwick rafter chamber(×400) with microscope as $cells/m^2$. These samples were also photographed using SEM(Scanning Electron Microscopy).

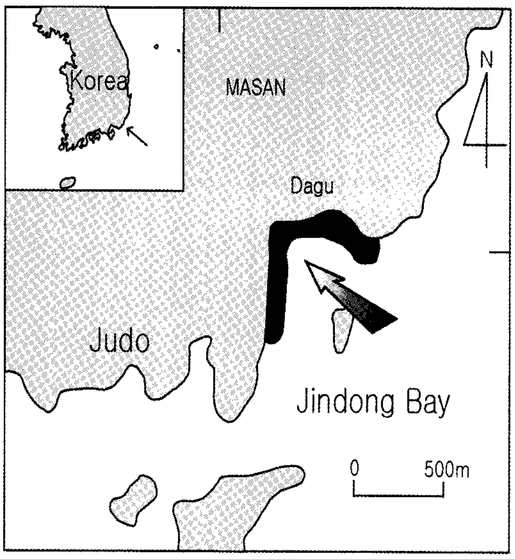

Fig. 1. Map of study sites in an eelgrass bed (black area) of Jindong Bay, Korea.

3. Results and discussions

3.1 Species composition

A total of 3 epiphytic macroalgae were collected from eelgrass bed in Jindong Bay, and *Scytosiphon lomentaria* and *Colpomenia* sp. in Phaeophyta, *Gracilaria* sp. in Rhodophyta, were occurred during study periods(Table 1). All of these species occurred at the apex of blade. Compared with studies in an eelgrass beds of other areas, number of species was lower than that of in other areas(13 epiphytic macroalgae was in Kwangyang Bay, 21 in Dongdae Bay and Aenggnag Bay)(Table 2). In case of floristic composition, *Polysiphonia japonica, Calliophyllis rhynchocarpa, Laurencia* sp., *Lomentaria hakodantensis,* and *Grateoupia* sp. were dominated in Kwangyang Bay, Dongdae Bay and Aenggang Bay although these specimens were few in the study areas(Huh et al., 1998; Kwak and Huh, in press). Especially *Polysiphonia japonica* was one of common epiphytic macroalgae regardless of different locations, and most of these algal species occurred at intertidal zone in the southern area, Korea(Song, 1986; Lee and Kang, 1986; Choi and Huh, 2008).

For epiphytic diatoms, genus *Cocconeis* was dominated during study periods(Fig. 2). Especially *Cocconeis scutellum* and *Cocconeis placentula* were common species except *Hantzschia amphioxys* and *Cymbella gracilis* were dominant species in September 2003(Table 2). *Cocconeis placentula* was also dominated. Diatoms and coralline algae predominated on the blade of eelgrass in an intial phase, and genus *Cocconeis* was common in the shoot of *Zostera* sp. worldwide(Round, 1990; Thomas, 1996; Hemminga and Duarte, 2000).

(A) (B)

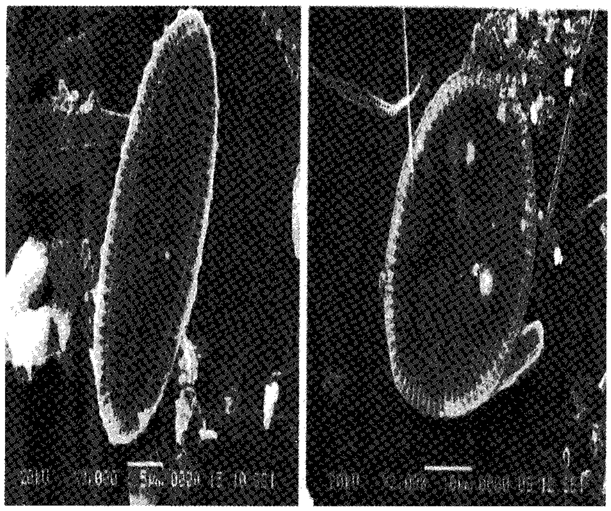

Fig. 2. SEM micrographs (A)*Cocconeis placentula* (Ehrenberg) and (B)*Cocconeis scutellum*(Ehrenberg).

3.2 Seasonal variations of biomass

The epiphytic macroalgae was ranged from 0.08 g DW/m^2 in July to 3.3 g DW/m^2 in December 2003(Fig. 3). On the other hand, higher mean density of epiphytic microalgae was 43,153 cells/m^2 in summer 2003, while lower value was 14,593 cells/m^2 in fall 2003(Fig. 4).

Compared with studies in an eelgrass beds of other areas(Table 2), biomass of epiphytic macroalgae was higher in Kwangyang Bay(Huh et al., 1998), but the lowest value was in Jindong Bay; the range of biomass was from 8.4 g DW/m^2 at August to 35.7 from 3.1 g DW/m^2 at July to 26.7 g DW/m^2 at January 2005 in Dongdae Bay, and 2.2 g DW/m^2 at July to 25.3 g DW/m^2 at January 2005 in Aenggang Bay(Kwak and Huh, in press). g DW/m^2 at December 1994 in Kwangyang Bay(Huh et al., 1998). On the other hand, eelgrass biomass was shown in Dongdae Bay, Aenggang Bay and Jindong Bay in order of decreasing biomass, while the lowest of them was in Kwangyang Bay. Biomass of epiphytic macroalgae thus was few or nearly none in an eelgrass bed of Jindong Bay although eelgrass biomass as substrate occurred moderate value. It might be explained to describe some reasons about these results.

The first reason was that rocky substrates were fewer for settlement of macroalgae close to eelgrass beds in Jindong Bay, and then macroalgae diversity and biomass was lower than those of in other areas. It was very important for macroalgae to settle in an initial phase with development. Higher diversity and biomass of marine algal community were demonstrated in Kwangyang Bay(Song, 1986; Choi and Huh, 2008), while few studies of algal community have been described in Jindong Bay so far.

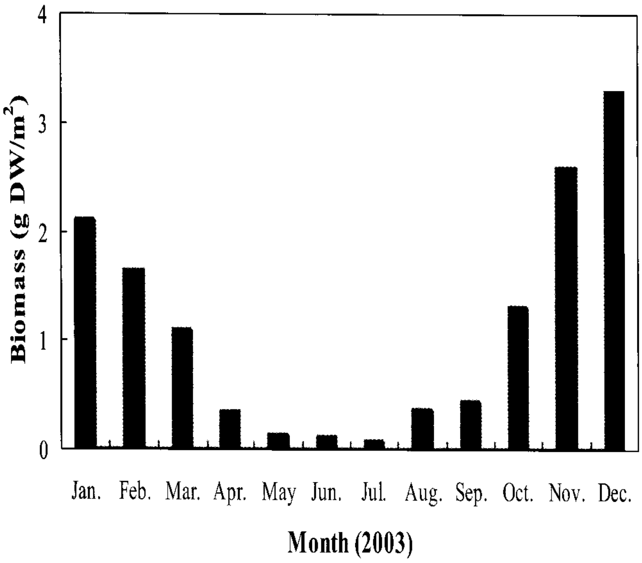

Fig. 3. Monthly variations of epiphytic macroalgae biomass in an eelgrass bed of Jindong Bay in 2003.

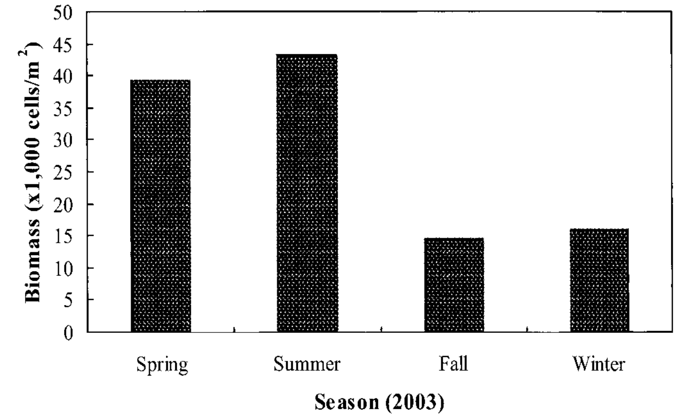

Fig. 4. Seasonal variations of epiphytic diatoms biomass in an eelgrass bed of Jindong Bay in 2003.

Chemically eelgrass appear to be relatively innocuous. For example many brown algae and red algae contain a wide range of antibiotic and toxic compounds and released to surrounding medium. Hoshika et al.(2006) have demonstrated that eelgrass shoot contain water-soluble phenolic acids, some of which are potent inhibitors of the growth of marine bacteria. The release of dissolved organic materials from seagrasses in vivo is low, and consists largely of high molecular weight compounds.

The second reason was that eelgrass bed of Jindong Bay was located in the intertidal zone while most of eelgrass beds such as Kwangyang Bay, Dongdae Bay and Aenggang Bay were in the subtidal areas. Physical factors were also important in affecting epiphytic macroalgae distribution. For example, strong tidal current and water movement might it give a severe environment to attach epiphytic macroalgae on eelgrass shoot. Neither animals nor macroalgae except 3 epiphytic macroalgaes(*Scytosiphon lomentaria, Colpomenia* sp., *Gracilaria* sp.) were found on eelgrass leaf, but only two species of epiphytic diatoms, *C. scutellum* and *C. placentula* were dominated. Our study is thus strongly in opposition with most studies on epiphytic algae diversity, which generally report a high species richness for epiphytic algae from unicellular algae to large macrophytes(Round, 1990; Neckles et al., 1994; Thomas, 1996).

The moderate water movement is probably also important for epiphytic algae nutrition and growth. The epiphytic algae on the terminal parts of the seagrass leaf are exposed to higher light intensities, and presumably a much greater nutrient supply, than those growing further down the leaf. These factors probably account for the higher biomass of epiphytic algae at the apex of eelgrass leaves(Silberstein et al., 1986). On the other hand, epiphytic algae may also hasten the loss of seagrass leaves by physical forces. In those seagrasses where the epiphytic algae

Table 1. Total list of epiphytic macroalgae in an eelgrass bed

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Phaeophyta												
Colpomenia sp.	+	+	+	+	+	+			+	+	+	+
Scytosiphon lometaria	+	+	+	+	+				+	+	+	+
Rhodophyta												
Gracilaria sp.	+	+	+	+			+	+	+	+	+	+

Table 2. Comparisons between this study and other studies of epiphytic macroalgae in an eelgrass bed

Study area	Sampling periods	Epiphytic macroalgae		Eelgrass biomass (g DW/m^2)	Remarks
		No. of species	Biomass(g DW/m^2)		
Jindong Bay	2003.1~12	3	0.08(Jul.)~3.3(Dec.)	21.8(Dec.)~368.7(May)	This study
Kwangyang Bay	1994	13	8.4(Aug.)~35.7(Dec.)	85.4(Nov.)~235.4(Jul.)	Huh et al.(1998)
Dongdae Bay	2005	21	3.1(Jul.)~26.7(Jan.)	54.3(Nov.)~509.2(Jul.)	Kwak and Huh (in press)
Aenggang Bay	2005	21	2.2(Jul.)~25.3(Jan.)	46.6(Feb.)~436.7(Jul.)	Kwak and Huh (in press)

Table 3. The dominant species of epiphytic diatoms in an eelgrass bed

Items/Season	Spring	Summer	Fall	Winter
Dominant species	*Cocconeis scutellum* *Cocconeis placentula*	*Cocconeis scutellum*	*Hantzschia amphioxys* *Cymbella gracilis*	*Cocconeis scutellum* *Cocconeis placentula*

cover consists largely of encrusting coralline algae and small filamentous algae, the leaves of the seagrass become much more brittle and less flexible, and show a greater tendency to break off in periods of heavy wave surge(Heijis, 1984). Indeed, the lower mean annual diversity of epiphytic algal community on the oldest leaves of eelgrass may be due to the loss of leaf tips in certain seasons. Epiphytic algae may therefore be a liability to seagrasses, as they generally are to other organisms upon which they grow, and their detrimental effects are minimised by rapid replacement of the leaves. Such a strategy only works if rapid leaf growth is possible, and this may partially explain why the distribution of most seagrasses is limited to waters with a high photon flux density(Bulthuis, 1987; Hemminga and Duarte, 2000).

The third reason for the lower water quality(e.g. red tide, jellyfishes etc.) due to locate many farms for valuable shellfishes around eelgrass bed and the interaction between epiphytic animal and eelgrass in Jindong Bay. Epiphytic organisms may also be important as environmental indicators(May, 1982; Duarte and Chiscano, 1999). The epiphytic algae and invertebrates generally grow rapidly and a number of species occur all year around. They can therefore respond swiftly to changes in the environment. Epiphytic algae primarily affect seagrasses by reducing the amount of light reaching the host plant's chloroplast, and the rate of diffusion of CO_2(and presumably other nutrients) to the seagrasses. This inhibition of seagrass photosynthesis by epiphytic algae is a possible reason for the decline of seagrass populations in eutrophic areas where the epiphytic algae density increases markedly due to the increase in nutrient supply. For example, Morgan and Kitting(1984) found that eelgrass grew better when it was grazed by invertebrates, and have also noted the decline in seagrass due to excessive epiphytic algae growth in South Australia.

Thus eelgrass bed of Jindong Bay was characterized by the very low quantitative importance of epiphytic macroalgae, compared to the other primary producers, and by their very low diversity. Indeed, epiphytic macroalgal biomass observed in the Jindong Bay turned out to be the lowest recorded value. The very low epiphytic macroalgae diversity and biomass measured in this study are therefore likely due to the severe physical characteristics of the intertidal mudflat and eelgrass biological characteristics. Disentangling physical characteristics from biological parameters that control epiphytic macroalgae development would need more work.

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