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Photosynthetic capacity of various parts of the blade of *Laminaria longissima* Miyabe (Phaeophyta)*

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The rates of photosynthesis and dark respiration of discs cut from the basal, subbasal, middle, subdistal and distal parts of *Laminaria longissima* blades were measured once a month for a year. The photosynthetic rate at 10°C and 400 μE m^{-2} s^{-1} was generally highest near the midlength of the blade and lower in the basal and the distal parts. However, during the fertile period the photosynthetic rate was lowest in the sorus-bearing part of the blade and the respiratory rate was highest in the basal and sorus-bearing parts. The photosynthetic rates of discs cut from all parts of the blade showed almost identical seasonal trends, being generally highest during the colder season.

*Key Index Words: blade—blade discs—intra-thallus variability—*Laminaria longissima*—Phaeophyta—photosynthesis—respiration—seasonal variation.*

The brown alga *Laminaria longissima* Miyabe is distributed along the eastern Pacific coast of Hokkaido from Kushiro to Nemuro and usually grows subtidally between the low water mark and 5 m depth. This species is utilized as human food and its annual yield is the highest of all the edible species of *Laminaria* in Japan (Kawashima 1972, Torii and Tazawa 1987). Although intensive ecological studies concerning growth, reproduction, recruitment and mortality have been made on *L. longissima* (Sasaki 1969, 1973, Kawashima 1972), photosynthesis, which is the basis of growth, has scarcely been studied in this species.

In a previous paper (Sakanishi *et al.* 1990), we documented the photosynthesis-light relationships and seasonal changes of photosynthetic capacity in *L. longissima* by using blade discs cut from near the midlength of each plant as material. However, it is not clear whether the midlength region accurately represents the whole plant, and it is important to know whether there are differences in photosynthetic characteristics along the whole blade. The present study compares the photosynthetic capacity and the seasonal variation in photosynthetic capacity of various parts of the blade of *L. longissima*.

Material and Methods

Photosynthesis and respiration of *Laminaria longissima* were measured monthly from September 1987 to August 1988 using plants growing in the upper subtidal zone at Katsurakoi, Kushiro, Hokkaido. Sampling, preparation of blade discs and measurements of photosynthesis and respiration were performed as previously described (Sakanishi *et al.* 1990). Sample plants ranged from 1.88 to 7.12 m in blade length (Fig. 1). A single disc of 3.1 cm^2 was respectively cut out of the peripheral portion in the basal, the subbasal,

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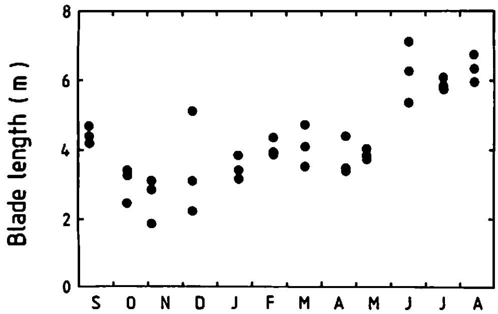

Fig. 1. *Laminaria longissima.* Seasonal change in the blade lengths of sample plants.

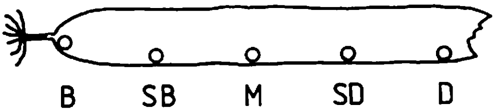

Fig. 2. *Laminaria longissima.* Sampling sites within a blade for measurements of photosynthesis and respiration. Discs were cut out of the basal (B), the subbasal (SB), the middle (M), the subdistal (SD) and the distal (D) parts.

the middle, the subdistal and the distal parts of a blade (Fig. 2). Discs were cut out of three sample plants every month. From September 1987 to February 1988, approximately 30% of the discs obtained bore zoosporangial sori. Photosynthesis or respiration was measured with all discs held under constant conditions of 10°C and either 400 $\mu E\ m^{-2}\ s^{-1}$ or darkness, respectively.

Results

Figure 3 shows for each month the net photosynthetic and respiratory rates measured for blade discs of *Laminaria longissima*. From September to February, when zoosporangial sori were present within the blades, the photosynthetic rate was generally lower in the basal and the sorus-bearing parts of the blades than in other parts, and showed no marked longitudinal pattern. From March to August, when the blades lacked zoosporangial sori, the photosynthetic rate increased from the basal part of the blade to reach a maximum at midlength and then declined toward the distal end. The longitudinal pattern of photosynthetic capacity was independent of blade length (cf. Fig. 1). The respiratory rate was relatively high in the basal part throughout the year except for September and November, and also in the sorus-bearing part during the fertile period.

The seasonal changes in the net photosynthetic and respiratory rates of discs from various parts of the blades are presented in Fig. 4. The photosynthetic rate of each part showed an almost identical seasonal trend, being generally higher in the colder season. The photosynthetic rates were low in July–September, began to increase in October and reached their maxima (52–65 $\mu l\ O_2\ cm^{-2}\ h^{-1}$) in January or February. The photosynthetic rates declined in spring and reached a lower level in summer, the minima (3–30 $\mu l\ O_2\ cm^{-2}\ h^{-1}$) being obtained in July–September. During the period from June to August the photosynthetic rates of the basal and the distal parts of the blades were clearly lower than those of other parts.

The respiratory rates of various parts of the blade ranged from 2 to 13 $\mu l\ O_2\ cm^{-2}\ h^{-1}$. The respiratory rate of the basal part was at its highest from mid-winter to early spring. The respiratory rates of the subbasal, middle and subdistal parts were at their lowest from spring to early summer. The rate of the distal part of the blade showed no marked change throughout the year.

Discussion

The distribution pattern of photosynthetic capacity along the fronds has been reported for several species in the Laminariales: *Laminaria digitata* (King and Schramm 1976), *Laminaria solidungula* (Dunton and Jodwalis 1988), *Macrocystis pyrifera* (Sargent and Lantrip 1952, Clendenning 1964, Wheeler 1980), *Undaria pinnatifida* f. *distans* (Matsuyama 1983) and *Ecklonia cava* (Sakanishi *et al.* 1989). In those species, the photosynthetic rate increased with the age of the blade tissue until it reached a maximum and then decreased with further aging. Although the distribution of photosynthetic capacity along the blades of *Laminaria longissima* varied with

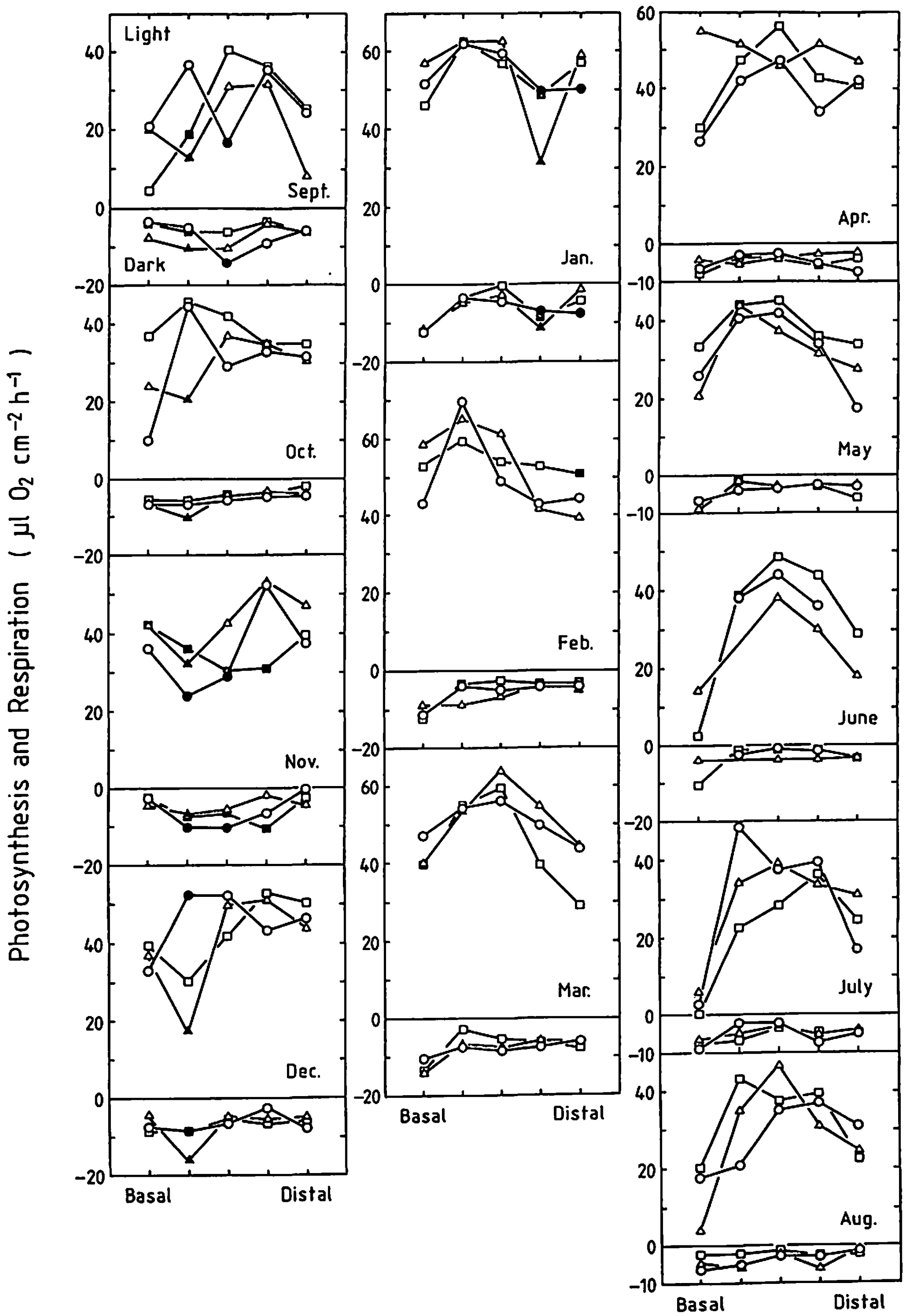

Fig. 3. *Laminaria longissima*. Comparisons of the net photosynthetic rates at 10°C and 400 $\mu E\ m^{-2}\ s^{-1}$ and respiratory rates at 10°C and in darkness in different parts of the blade over 12 months. Each symbol shows a value obtained from a single plant. Closed symbols show values obtained with sample discs bearing zoosporangial sori.

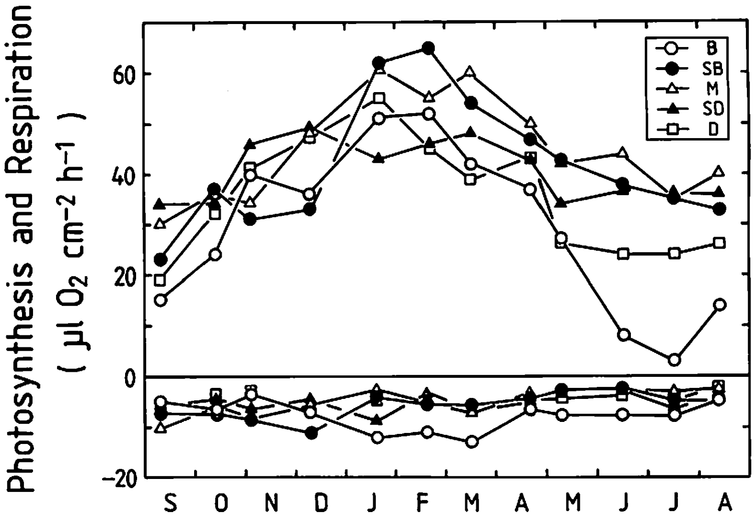

Fig. 4. *Laminaria longissima*. Seasonal changes of the net photosynthetic rates at 10°C and 400 μE m^{-2} s^{-1} and respiratory rates at 10°C and in darkness of discs from various parts of the blade, as indicated in the key by the abbreviations used in Fig. 2. Means for 2-3 replicates.

season (Fig. 3), the pattern was almost the same as that in other Laminariales except during the fertile period. The lower photosynthetic capacity of the sorus-bearing portion in *L. longissima* agrees with that reported by Aruga *et al.* (1990) in *Ecklonia cava.*

The seasonal changes in the photosynthetic rates of various parts along the blade of *L. longissima* (Fig. 4) suggest that the photosynthetic capacity of the whole blade is highest during the colder season. The seasonal trend in the photosynthetic capacity of the midlength region in blades of *L. longissima* reported by Sakanishi *et al.* (1990) represents that of the whole blade moderately well, since the photosynthetic capacity of various parts of the blade shows almost identical seasonal trends (Fig. 4).

Although the seasonal trends in the respiratory rates of the basal and the distal parts of the blade were different from those in other parts, the seasonal trend in the middle part can be assumed to represent that of the whole blade since the basal and distal parts with distinctive characteristics probably represent a small portion of the total blade area.

All the blade tissue of *L. longissima* used in January was at least as old as the blade tissue used at other times of the year, yet in January relatively high or even the highest photosynthetic rates throughout the year were observed (Fig. 4). These results suggest that the photosynthetic capacity of *L. longissima* is affected by seasonal changes in physiological state rather than by the aging of its blade tissue.

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坂西芳彦[1]・横浜康継[2]・有賀祐勝[3]：褐藻ナガコンブ藻体の種々の部位における光合成活性

ナガコンブ藻体の基部，中央，先端，ならびにこれらの中間の縁辺部から切り出した藻体片 (3.1 cm^2) を用い，9月から翌年8月まで毎月1回，10°C·400 $\mu E\ m^{-2}\ s^{-1}$ における光合成ならびに10°C における暗呼吸を測定した。光合成活性は，一般に藻体の中央に近い部位で高く，基部および先端では低かったが，子嚢班をもつ時期には光合成活性は子嚢班部で最も低く，呼吸速度は基部ならびに子嚢班部で最も高かった。光合成活性の季節変化は各部位ともほとんど同じ傾向を示し，一般に秋季に高まり始め，厳冬に極大に達した後低下し，夏季に極小に達することが明らかになった。([1]085 北海道釧路市桂恋116 水産庁北海道区水産研究所；[2]415 静岡県下田市5丁目10-1 筑波大学下田臨海実験センター；[3]108 東京都港区港南4-5-7 東京水産大学藻類学研究室)