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Biomass, Growth and Productivity of Seagrass; *Enhalus acoroides* (Linn. f) in Khung Kraben Bay, Chanthaburi, Thailand

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ABSTRACT

The biomass, growth and productivity of seagrass; *Enhalus acoroides* (Linn. f) were measured in Khung Kraben Bay, Chanthaburi, Thailand during the period of 1995-1996. The average standing crop biomass of leaves was 146.37 g dry wt. m^{-2}, while average relative growth rate ranged from 0.0224 to 0.0359 g g^{-1} day^{-1}. The specific growth rate ranged from 2.5 to 4.7% with turnover time of 21-40 days. Productivity was estimated by leaf marking method. The average leaf productivity was 4.24 g dry wt. m^{-2} day^{-1}. Data on leaf length and leaf growth indicated that new leaf production continued throughout the year with the average leaf growth rate of 1.52 cm day^{-1}.

Key words : seagrass, biomass, productivity, standing crop *Enhalus acoroides* (Linn. f)

INTRODUCTION

In recent years seagrass ecosystems have become recognized as one of the richest and most productive of ecosystems, rivaling cultivated tropical agriculture in productivity (Zieman and Wetzel, 1980; Hillman *et al.*, 1989). The seagrasses are major functioning elements in the complex cyclical processes which maintain the high productivity of estuarine and nearshore marine regions. Several techniques are currently in use for measuring the *in situ* primary production of seagrasses include biomass harvesting, leaf marking (Zieman and Wetzel, 1980; Kirkman *et al.*, 1982), the plastochrone interval (PI) or leaf replacement technique (Brouns, 1985a) and metabolism of seagrass (Roberts and Moriarty, 1987). However, the previous studies in production of seagrasses mostly conducted in the temperate regions especially for *Zostera marina* and *Thalassia testudinum.* The purpose of this study was to investigate the productivity of the tropical seagrass bed such as *Enhalus acoroides* (Linn. f), which was the important part of tropical marine ecosystem.

MATERIALS AND METHODS

Study area

Khung Kraben Bay (Figure 1) is the shallow bay located in Chanthaburi province (12° 34' - 12° 36' N, 101° 53' - 100° 35' E), Eastern Thailand, surrounded by mangrove forest and shrimp culture ponds with small canals as inlet and outlet through inland. Mouth of the bay is 900 meters wide which is the only way connected to the open sea for water exchange. The water depth ranges from 0.2 to 3.0 m during low tide. Seagrasses found in the bay are comprised of 4 species, namely *Enhalus acoroides,*

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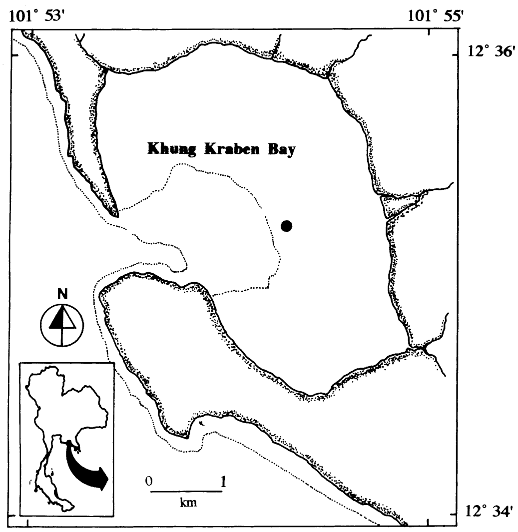

Figure 1 Map of Khung Kraben Bay, Chanthaburi province.

Halodule pinifolia, Halophila minor and *H. decipiens*, with the abundant of the first two species (Aryuthaka *et al.*, 1992). These seagrasses distribute densely from 0.2 m to 1.5 m in water depth at low tide which are found in both monospecific seagrass beds and extensive mixed meadows.

The study sites were selected at the eastward point near central section of the bay where large areas of dense *Enhalus acoroides* were presented. The observations on standing crop, biomass, leaf length, leaf growth and productivity of seagrass *E. acoroides* were made monthly from July 1995 to August 1996.

Standing crop and biomass

The total biomass of *E. acoroides* was estimated by harvesting 4 randomly located 0.09 m^2 quadrats. Leaves were separated from under ground and non photosynthetic parts. All materials were then thoroughly washed under the gentle stream of running tap water, leaves were wiped by hand to remove epiphytes, however, some tightly-adhering diatom and associated epiphytes were still remained, and then oven dried at 105 °C for 24 h before weighing.

Leaf length measurement

Prior to drying samples of the standing crop and biomass, number of shoots and leaves were recorded. Their length and width were measured and the presence or absence of the round tips and the general characteristics of leaves were recorded.

Leaf growth and productivity measurement

In an applied work of Zieman and Wetzel (1980) and Kirkman *et al.* (1982) hole-punching method was used for measuring leaf growth. Three stainless steel quadrats (0.3 × 0.3 m) were marked on the sediment. All of the grass blades within the quadrat were marked using needle, slightly modified to prevent the crushing of the leaves. Since all leaf blade growth occurred between the region of attachment to the sheath and a few centimeters up to the leaf blade, so that a datum mark could be used at harvest. After a period of 10-15 days the shoots were harvested, the lower part was cut off at the datum marked, marked at its upper end by the punched hole was removed. The biomass of the growth section was compared to the biomass of leaf material remaining after the growth section had been removed, and the average relative growth rate of leaves ($\overline{R}_L$) was calculated from

$$\overline{R}_L = (\ln L_2 - \ln L_1) / (T_2 - T_1)$$

where L_1 is total leaf biomass (g dry wt.) at time T_1 (time of marking), L_2 is leaf biomass at time T_2 (harvest time) and $\overline{R}_L$ is expressed in units of g g^{-1} day^{-1}. This figure may be converted to leaf productivity by multiplying average relative growth by leaf biomass per unit area of seagrass bed. Shoots with leaves which were damaged by the hole were discarded.

To investigate the environmental factors controlling growth, it is useful to know the relative efficiency of plants as producers of new plant material. A commonly-used measurement of efficiency is specific growth rate (SGR) - the average instantaneous rate of production of new material expresses relative to the amount of material initially presented (Hillman *et al.*, 1989). Thus,

$$SGR = \frac{dw}{dt} \cdot \frac{1}{w_i}$$

where

w = dry weight,

w_i = initial dry weight,

t = time

The reciprocal of SGR gives the "turnover time" or "crop replacement rate" in days.

RESULTS

Standing crop and biomass

The shoot density of *E. acoroides* ranged from 72 to 203 shoots m^{-2} with the average value of 144 (± 40) shoots m^{-2} depended on the sampling site. From Figure 2, it could be seen that the biomass of leaves (above-ground biomass or standing crop) declined from May to October and recovered from November to April. Roots and rhizomes (below-ground biomass) showed trend to increase twice. Firstly, from August to October then decreased from October to December, secondly, increased from December to May and decreased from May to August. The average above-ground biomass ranged from 70 to 222 g m^{-2} while average below-ground biomass ranged from 457 to 905 g m^{-2}. There was a large difference between above-ground biomass and below-ground biomass of *E. acoroides* throughout the year. The above-ground biomass made up only about 10-25 % of the total plant so that change in biomass of *E. acoroides* was observed mainly from below-ground biomass but it was quite difficult to sample the under ground part adequately because of the penetration of root system. The above-ground biomass of *E. acoroides* showed trend to be high from winter to summer and declined in rainy season. These results agreed well with leaf lengths (Figure 3) which were longer in winter than summer and rainy season. Thus, the

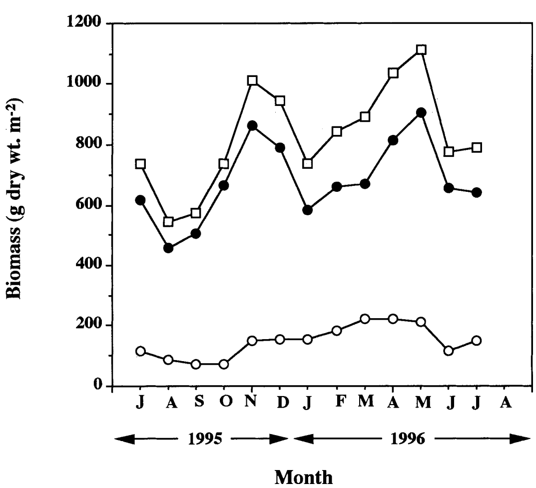

Figure 2 Average biomass of *Enhalus acoroides* in Khung Kraben Bay (–○– ; above-ground biomass –●– ; below-ground biomass, –□– ; total biomass).

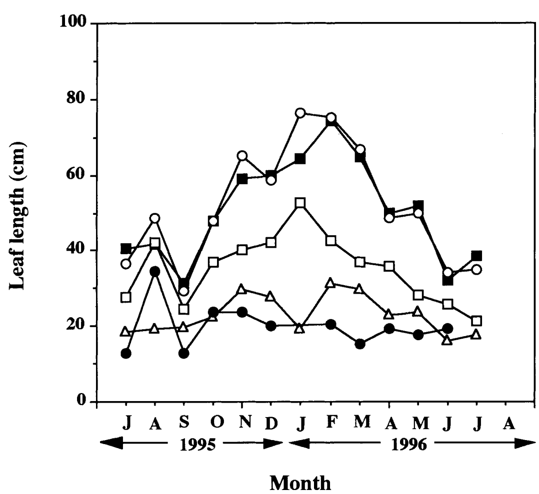

Figure 3 Leaf length of *Enhalus acoroides* in Khung Kraben Bay (–Δ– ; Leaf No. 1, –■– ; Leaf No. 2, –○– ; Leaf No. 3, –□– ; Leaf No. 4, –●– ; Leaf No. 5).

high shoot biomass resulted from exceptionally long leaves.

The distribution of leaf length of *E. acoroides* is shown in Figure 3. New leaves of plant are produced from centermost of the shoot and old leaves are shaded from the younger leaves. With the passage of time the erected shoot may be seen to have a constant leaf number of 2-5 leaves, yet several new leaves may have been produced and the same number lost. If leaf No. 1 referred to the youngest leaf, and leaf No. 5 was the oldest one then, the average lengths of leaf No. 1, 2, 3, 4, and 5 were 22.92±5.11, 48.65±13.58, 51.64±15.69, 35.12±9.09, and 22.04±8.60 cm, respectively. The first two youngest leaves always presented of rounded leaf tip but sometimes the presence of leaf tip also could be seen in leaf No. 3 depending on the degree of epiphyte and the changing of seasonal environment. An analysis of variance indicated no significant difference in leaf length between rainy season and winter (P>0.05) but resulted in a highly significant during summer (P<0.01). The average values of selected leaf No. 2 and No. 3 were in the range of 30.4 to 74.6 cm.

Leaf growth

Leaf growth rate of *E. acoroides* is shown in Figure 4. Leaf No. 1, leaf No. 2 and leaf No. 3 grew in the same pattern which were higher in winter with gradually diminishing leaf growth rates in summer and rainy season. Growth rate of leaf No. 1, No. 2 and No. 3 ranged from 1.01 to 2.35 cm day^{-1}, 0.86 to 2.08 cm day^{-1} and 0.33 to 1.09 cm day^{-1}, respectively. It could be concluded that younger leaf of *E. acoroides* grew with faster rate than older leaf. For comparative leaf growth rate study, it is recommended that leaf No. 1 and/or No. 2 should be selected thus, the average leaf growth rate of *E. acoroides* in the present study is 1.52 cm day^{-1}.

Leaf productivity

Average relative growth (ARG, $\overline{R}_L$) of *E. acoroides* ranged from 0.0224 to 0.0359 g g^{-1} day^{-1} (Figure 5) with the average value of 0.0290± 0.0048 g g^{-1} day^{-1}. The statistical analysis indicated no differences between season (P>0.05). However, the trend of maximum growth was in February-March. By multiplying the standing crop by average relative growth gave the estimation of leaf productivity of 2.42 g dry wt. m^{-2} day^{-1} for the

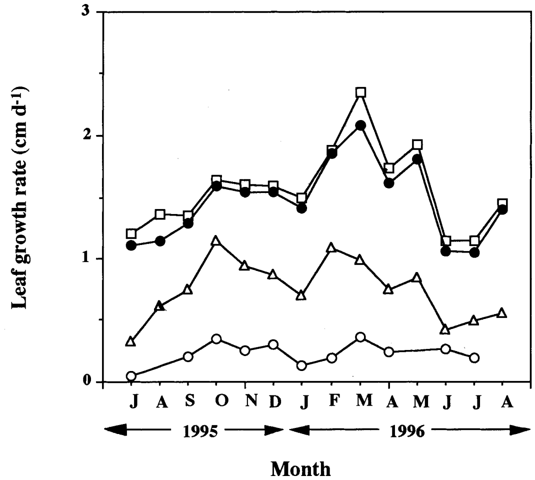

Figure 4 Leaf growth rate of *Enhalus acoroides* (–□– ; Leaf No. 1, –●– ; Leaf No. 2, –Δ– Leaf No. 3, –○– ; Leaf No. 4)

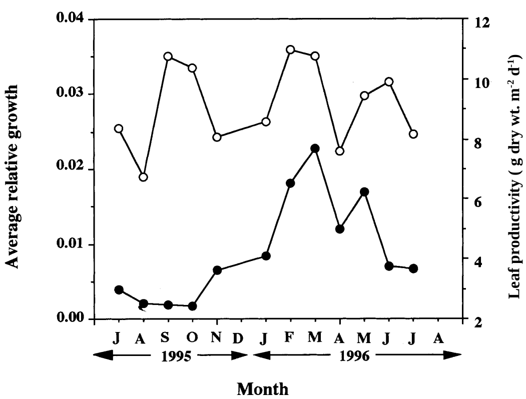

Figure 5 Average relative growth (–○–) and estimated leaf productivity (–●–) of *Enhalus acoroides*.

month of the slowest growth, to 7.68 g dry wt. m^{-2} day^{-1} for the peak growth months of February-March. The average productivity was 4.24 g dry wt. m^{-2} day^{-1}. Such a change in leaf productivity of *E. acoroides* was due to changing of the above-ground biomass. The seasonal trend of leaf productivity of *E. acoroides* has clearly seen as a unimodal seasonal pattern. The minimum productivity generally occurred during summer to rainy season (April-October) similar to that observed for above-ground biomass then rose up during winter (November-March) and reached the maximum in March.

The specific growth rate of *E. acoroides* in this study was in the range of 2.5-4.7% day^{-1} with the average of 3.49% day^{-1} and the turnover time was in the range of 21-40 days with the average of 30 days, therefore, *E. acoroides* in Khung Kraben Bay could produce 9-17 leaf crops per year.

DISCUSSION

In Khung Kraben Bay, *E. acoroides* is restricted mainly to inshore mudflats which are exposed for relatively long periods at low tide. In summer low tide always occurs during daytime, hence, the erected shoot of *E. acoroides* is exposed directly to sunlight which causes burning of leaf and leaf tip. Whilst, in rainy season the bay receives freshwater from small canal from inland, salinity is decreased considerably and degree of epiphyte is greater which damages *E. acoroides* leaf tip. Thus, the proliferation of epiphyte and epizoae on leaves are other factors in the reduction of *E. acoroides* biomass. On the other hand, in winter low tide occurs during the night and degree of epiphyte is lesser, these results are clearly considerable that the primary production of *E. acoroides* leaf is greatest in winter and falls away in summer and rainy season.

Seasonal variation in seagrass productivity has been attributed to seasonal variation in temperature, light, salinity and endogenous growth substance. As for biomass, the lack of clear seasonal trends in subtropical and tropical seagrass productivity may be due to less pronounced seasonal changes in light and temperature (Hillman *et al.*, 1989). Many workers have concluded that temperature is fundamentally important in controlling the seasonal growth cycle of seagrass. Barber and Behrens (1985) demonstrated that water temperature was major importance to primary production of *Thalassia testudinum* and *Syringodium filiforme*. However, in Odawa Bay, temperature cannot be considered as the critical factor for controlling the vegetative growth of eelgrass (*Zostera marina* L.). The vegetative growth of eelgrass is more likely to be regulated by irradiance (Aioi, 1980).

Kirkman *et al.* (1982) studied the relationship between average relative growth, water temperature and solar irradiance. They concluded that both temperature and solar irradiance were linked with average relative growth as a combination factors to determine the growth rate of temperate seagrass *Zostera capricorni*. However, in tropical zone like Thailand, the variation of average relative growth of *E. acoroides* does not indicate a relationship to the changing of water temperature.

On the basis of specific growth rate, Hillman *et al.* (1989) have recognized two broad categories of seagrasses. The small species, (the genera *Halodule*, *Halophila* and *Syringodium*) often have specific growth rates greater than 4% day^{-1} and may produce more than 5 leaf crops per year, whilst the larger species usually have specific growth rates less than 4% day^{-1} and produce 2-5 leaf crops per year. However, the specific growth rate of *E. acoroides* in this study was in the range of 2.5-4.7% day^{-1} with the average of 3.49% day^{-1} and the turnover time was in the range of 21-40 days with the average of 30 days, therefore, *E. acoroides* in

Khung Kraben Bay could produce 9-17 leaf crops per year. Brouns (1985b) suggested that in tropical water the turnover times of sparse meadows of large species under stressed conditions may approach the lower end of the range for small species.

Leaf productivity measured in other seagrass communities was in range of 0.7 to 5.5 g dry wt. m^{-2} day^{-1} for *Posidonia australis* depending on site and season (West and Larkum, 1979). The minimum leaf productivity was 0.34-0.77 g dry wt. m^{-2} day^{-1} and the maximum was 2.6-4.2 g dry wt. m^{-2} day^{-1} at four sites study for *Heterozostera tasmanica* (Bulthuis and Woelkerling, 1983). Larkum *et al.* (1984) found that the annual above-ground productivity of *Zostera capricorni* was 5.86 g dry wt. m^{-2} day^{-1}. In the present study, the leaf production rates for *E. acoroides* were 2.42-7.68 g dry wt. m^{-2} day^{-1} with the average productivity of 4.24 g dry wt. m^{-2} day^{-1}. This value was somewhat higher than *Posidonia australis* and *Heterozostera tasmanica* but less than *Zostera capricorni*. However, considerably shoot density of other seagrasses was 80-240 shoots m^{-2} for *Posidonia australis* (West and Larkum, 1979), 544-3,440 shoots m^{-2} for *Heterozostera tasmanica* (Bulthuis and Woelkerling, 1983) and 1,084-2,480 shoots m^{-2} for *Zostera capricorni* (Larkum *et al.* 1984) but shoot density of *E. acoroides* was only 72-203 shoots m^{-2} hence, productivity per individual plant of *E. acoroides* should be the highest. This primary production is likely to be very significant in supporting the food-web in the waters where this seagrass occurs.

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