Effects of water depth on clonal characteristics and biomass allocation of *Halophila ovalis* (Hydrocharitaceae)

Na-Na Xu\(^1\), Xin Tong\(^1\), Po-Kueug Eric Tsang\(^2\), Hong Deng\(^1\) and Xiao-Yong Chen\(^1\)*

\(^1\) Department of Environmental Sciences, Shanghai Key Laboratory for Ecological Processes and Restoration in Urban Area, East China Normal University, Shanghai 200062, China
\(^2\) Department of Science and Environmental Studies, Hong Kong Institute of Education, Hong Kong, China

*Correspondence address. Department of Environmental Sciences, East China Normal University, Shanghai 200062, China. Tel: 86-21-6223-3303; Fax: 86-21-6223-3303; E-mail: xychen@des.ecnu.edu.cn

**Abstract**

**Aims**

*Halophila ovalis* is a dioecious seagrass with a wide geographical and water depth range. The objective of this study was to understand its plasticity in clonal characteristics and biomass and also its allocation between above- and belowground in seagrass beds at different water depths.

**Methods**

Four monospecific *H. ovalis* beds, Shabei, Xialongwei, Beimu and Yingluo, which have different water depths at maximum tide level (MTL) but otherwise similar environmental conditions, were studied. We measured main clonal characteristics, i.e. horizontal internodal length, branching angle, shoot height, leaf length and width, and rhizome diameter. Above- and belowground biomasses of *H. ovalis* were also estimated using a harvest method.

**Important Findings**

We found no significant differences in coverage, leaf pair density or number of stem nodes per square meter between the four study sites. However, horizontal internodal length, leaf length, width, rhizome diameter and shoot height all increased significantly with the increases in water depth from 2- to 9-m MTL and decreased when the water depths were greater than 9-m MTL. No significant difference in above- or belowground biomass between the seagrass beds was found. However, the ratio of above- to belowground biomass was significantly higher in the shallowest site compared to the other three seagrass beds, indicating that more biomass was stored belowground in deeper water. The results demonstrated plastic responses in clonal characteristics and biomass allocation in *H. ovalis* across the water depth gradient.

**Keywords:** *Halophila ovalis* • water depth gradient • rhizome • shoot • biomass allocation • seagrass

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**INTRODUCTION**

Seagrasses are productive and fundamental component of coastal ecosystems with important ecological and economic functions (Boström et al. 2006; Duffy 2006; Shi et al. 2010; Short et al. 2007). Recent studies indicated that global seagrasses are declining at an increasing rate as a consequence of human activities, such as pollution, coastal development and climate change (Orth et al. 2006; Waycott et al. 2005, 2009). The distribution and abundance of seagrasses are also affected by other factors, such as temperature, sediment stability, nutrient availability, salinity and water quality (Cabaço et al. 2008; de Boer 2007; Holmer and Laursen 2002; Kliminster et al. 2006; Kuo and Lin 2010; Ibarra-Obando et al. 2004; Torquemada et al. 2005; Udy and Dennison 1997).

Water depth is an integrative index that may reflect the effects of light intensity, water pressure and stability of environmental factors. Deeper water, in general, means lower light intensity, higher pressure, and lower fluctuations in temperature, salinity, nutrients and disturbance. Given the
differences in these environmental factors, zonation of seagrasses can be observed along water depth gradients (Short et al. 2007). For the same species, differences in morphology, physiology or coverage may also be observed along water depth gradients. For example, in deeper water, *H. stipulacea* grew longer leaves and longer internodes, and photosynthetic electron transport rates were relatively slow (Schwarz and Hellblom 2002). The shoots of *Posidonia oceanica* became shorter, but the leaves grew wider (Via et al. 1998). In eelgrass, average cover showed a bell-shaped pattern with water depth (Krause-Jensen et al. 2003).

*Halophila ovalis* is a small, leafy and fast growing seagrass species (Marbà and Duarte 1998). This species occurs in the tropical Indo-West Pacific and extends to some areas beyond the tropics (Den Hartog and Kuo 2006). *Halophila ovalis* has a strong ability to grow clonally, which plays a critical role in its adaption to various environments. Populations of *H. ovalis* can rapidly recover after extensive grazing through horizontal rhizome elongation (Nakaoka and Aioi 1999). This species is capable of living in a range of salinities, sediment types and temperatures (Benjamin et al. 1999; Hillman et al. 1995). It can also survive in a broad range of water depths from shallow intertidal environments to very deep water (up to 60 m) (Kuo et al. 2001). Some studies have investigated the primary production of *H. ovalis* at different water depths, mixed results were observed across water depths (Erfemeijer and Stapel 1999; Hillman et al. 1995; Huong et al. 2003). There is little information about the plasticity in clonal characteristics and biomass allocation on this species. Furthermore, global warming has resulted in rising sea level across the globe (Clark and Huybers 2009). It is both timely and important to understand the growth strategies of seagrasses for their survival in deeper water.

China has a long coastline ranging from the tropics to temperate, and both tropical and temperate seagrass species have been reported (Shi et al. 2010). However, there is very limited information on seagrasses in China (Huang et al. 2006; Shi et al. 2010). In this study, we surveyed the largest *H. ovalis* seagrass beds in Guangxi of China with the following aims: (i) to identify the plasticity in clonal characteristics along a water depth gradient, and (ii) to estimate biomass and its allocation between above- and belowground in seagrass beds at different water depths.

**MATERIALS AND METHODS**

**Study site**

The study was conducted in Hepu Dugong National Nature Reserve, Guangxi (N21°18’–21°30’, E109°34’–109°47’) (Fig. 1), which has the second largest seagrass bed in China (Huang et al. 2006; Shi et al. 2010). The dominate tidal wave in this study area is diurnal tide, and the annual minimum and maximum tidal level of 2008 were 0.64 and 6.69 m, respectively, with the tidal datum of −3.59 m (China Ocean Information
Table 1: Major environmental factors and clonal characteristics of *Halophila ovalis* beds in Hepu Dugong National Nature Reserve, Guangxi of China.

<table>
<thead>
<tr>
<th>Site</th>
<th>GC (N)</th>
<th>WD (m)</th>
<th>WS (mg kg(^{-1}))</th>
<th>OM (g kg(^{-1}))</th>
<th>TN (mg kg(^{-1}))</th>
<th>WT (°C)</th>
<th>C (C%)</th>
<th>LD (mm)</th>
<th>LL (mm)</th>
<th>LW (mm)</th>
<th>LDW (mg)</th>
<th>SH (mm)</th>
<th>SD (m(^{-1}))</th>
<th>RD (mm)</th>
<th>SD (m(^{-1}))</th>
<th>RD (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shabei</td>
<td>21°53'N, 109°37'E</td>
<td>13.2 ± 0.1</td>
<td>7.77 ± 0.02</td>
<td>3.69 ± 0.84</td>
<td>22.0 ± 4.8</td>
<td>48.8 ± 5.8</td>
<td>52.8 ± 9.2</td>
<td>10.9 ± 0.9</td>
<td>16.9 ± 0.9</td>
<td>7.0 ± 2.1</td>
<td>3.3 ± 1.0</td>
<td>47.3 ± 12.0</td>
<td>3.0 ± 1.0</td>
<td>22.6 ± 5.0</td>
<td>6.3 ± 1.0</td>
<td></td>
</tr>
<tr>
<td>Xialongwei</td>
<td>21°27'N, 109°37'E</td>
<td>8.0 ± 0.2</td>
<td>6.67 ± 0.3</td>
<td>2.82 ± 0.6</td>
<td>24.9 ± 4.9</td>
<td>44.8 ± 8.0</td>
<td>7.0 ± 1.7</td>
<td>15.2 ± 1.0</td>
<td>7.0 ± 2.1</td>
<td>3.3 ± 1.0</td>
<td>47.3 ± 12.0</td>
<td>3.0 ± 1.0</td>
<td>22.6 ± 5.0</td>
<td>6.3 ± 1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beimu</td>
<td>21°27'N, 109°37'E</td>
<td>7.2 ± 0.3</td>
<td>7.77 ± 0.1</td>
<td>2.32 ± 0.4</td>
<td>21.6 ± 3.6</td>
<td>40.2 ± 6.9</td>
<td>7.0 ± 1.7</td>
<td>15.2 ± 1.0</td>
<td>7.0 ± 2.1</td>
<td>3.3 ± 1.0</td>
<td>47.3 ± 12.0</td>
<td>3.0 ± 1.0</td>
<td>22.6 ± 5.0</td>
<td>6.3 ± 1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yingluo</td>
<td>21°27'N, 109°37'E</td>
<td>7.2 ± 0.3</td>
<td>7.77 ± 0.1</td>
<td>2.32 ± 0.4</td>
<td>21.6 ± 3.6</td>
<td>40.2 ± 6.9</td>
<td>7.0 ± 1.7</td>
<td>15.2 ± 1.0</td>
<td>7.0 ± 2.1</td>
<td>3.3 ± 1.0</td>
<td>47.3 ± 12.0</td>
<td>3.0 ± 1.0</td>
<td>22.6 ± 5.0</td>
<td>6.3 ± 1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>7.45 ± 0.7</td>
<td>7.77 ± 0.1</td>
<td>2.82 ± 0.6</td>
<td>24.9 ± 4.9</td>
<td>44.8 ± 8.0</td>
<td>7.0 ± 1.7</td>
<td>15.2 ± 1.0</td>
<td>7.0 ± 2.1</td>
<td>3.3 ± 1.0</td>
<td>47.3 ± 12.0</td>
<td>3.0 ± 1.0</td>
<td>22.6 ± 5.0</td>
<td>6.3 ± 1.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

GC = geographic coordinate; WD = water depth at MTL; WS = salinity; TN = total nitrogen; OM = organic matter content; WT = water temperature; C = coverage; LD = leaf pair density; SD = stem nodes density; RD = diameter; LL = leaf length; LW = leaf width; LDW = leaf dry weight; SH = shoot height. Same superscript letters indicate no significant difference. Values in parenthesis are the number of measurements.

Measures of clonal characteristics

*Halophila ovalis* was investigated in four seagrass beds, i.e. Shabei, Xialongwei, Beimu and Yingluo Bay (Fig. 1). In the study area, *H. ovalis* was found in the tidal flat of the intertidal zone and the clay-like and arenaceous parts of subtidal zones (Shi et al. 2010). Our study was conducted during low tide in December 2008. Five to 9 quadrats of 50 × 50 cm were randomly established with an interval of >100 m between quadrats. Each quadrat was positioned using a GPS receiver (eTreX, GARMIN, Taiwan) and the water salinity and temperature were recorded using PCS Testr 35 (Thermo Fisher Scientific, China).

In view of the fact that water depth changes with the tides, the water depth (WD) of each quadrat was calibrated at the MTL using the following equation: WD = MTL – TL – AH, where TL and AH were altitudes of tidal datum and the plot, respectively. In each quadrat, all above- and belowground parts of *H. ovalis* were collected after coverage was measured. Samples were transported to the laboratory located at the management station of Hepu Dugong National Natural Reserve. Specimens were identified and washed carefully with fresh water. The numbers of leaf pairs and stem nodes from each quadrat were then counted.

Intact fragments were selected to characterize clonal traits: horizontal internodal length, branching angle, shoot height, leaf length, width, and rhizome diameter. The distances between consecutive nodes were measured using a millimeter graduated scale, so were the shoot height, including petiole and leaf. The branching angle was estimated using a protractor between conjoint stems. For a single leaf, the longest and widest measured values were taken as length and width. The diameter of the horizontal rhizome was measured using a micro Vernier caliper.

Estimation of biomass

After the measurements were completed, leaves, rhizomes and roots were sorted, oven-dried at 60°C for 48 h and weighed. Aboveground biomass of leaf materials were measured and
belowground biomass was calculated as the sum of rhizome and root materials.

### Statistical analysis

Statistical analysis was performed using SPSS for Windows (SPSS, Chicago, XII). For all variables, the effect of water depth was analyzed by one-way analysis of variance, followed by Bonferroni post hoc test. In all cases, the significance level was set at 5%. Additionally, one element regression analysis was performed to determine the relationships between clonal characteristics and water depth.

### RESULTS

The mean coverage of *H. ovalis* was 43 ± 4% (mean ± SE), without significant differences among the four seagrass beds. The average shoot density was 600.6 ± 58.7 leaf pairs per square meter, with no significant difference among the four beds ($P = 0.056$). The average number of stem nodes per square meter of the four beds was 1366.0 ± 163.9 and differed significantly among the four beds ($P = 0.037$) (Table 1).

Rhizome diameter ranged from 0.50 to 2.16 mm. Rhizome diameter at the shallowest site, Yingluo (0.84 ± 0.02 mm), was significantly smaller than those at the other three sites ($P < 0.001$), while the rhizome diameter of the deepest site, Shabei (1.14 ± 0.02 mm), was significantly smaller than those of moderate water depths ($P < 0.001$) (Table 1). Horizontal internodal length showed the same trend as the rhizome diameter. Xialongwei and Beimu seagrass beds had significantly longer horizontal internodal length than those in Shabei and Yingluo seagrass beds (Fig. 2). In addition, the branching angle differed significantly between sites ($P = 0.028$) (Fig. 2); branching angle at Yingluo was significantly smaller than that at the deepest seagrass bed Shabei ($P = 0.049$).

The traits of leaves and shoots varied among the four seagrass beds. Both the length and width of leaves were significantly different ($P < 0.001$). Significant differences were detected in the size of leaves among seagrass beds, except that between Shabei and Xialongwei. In the Yingluo seagrass bed, leaves of *H. ovalis* were the smallest with average length and width of 19.3 ± 0.3 and 11.0 ± 0.3 mm, respectively. The dry weight of a single leaf differed significantly between sites ($P = 0.017$) (Table 1). Shoot length observed in the four sites was significantly different, and the smallest shoot length occurred in the shallowest seagrass bed Yingluo (Table 1). These results indicated that the traits did not change linearly with water depth. Regression analysis indicated that a quadratic equation can be used to describe the relationships between clonal characteristics and water depth. All characteristics had maximum values at a water depth of ~9 m (Fig. 3).

The total biomass of *H. ovalis* ranged from 17.38 ± 4.71 to 37.62 ± 8.83 g DW m$^{-2}$ in the four seagrass beds. There was no significant difference in above- or belowground biomass per square meter among the four seagrass beds ($P = 0.361$). However, allocation of biomass varied significantly ($P = 0.035$). In the Yingluo seagrass bed, aboveground biomass was 1.58-fold greater than found in belowground biomass, while in the other seagrass beds, aboveground biomass was less than or almost equaled to belowground biomass (Fig. 4).

### DISCUSSION

All seagrass species grow through horizontal rhizome elongation, which plays an important role in the survival and persistence of seagrass beds (Marba' and Duarte 1998; Miao et al. 2009). Rhizome diameter and the size of leaves of *H. ovalis* reported here were similar to those found in previous reports (Vermaat et al. 1995). However, horizontal internodal length was longer than previously reported on the same species (Table 2). The obvious morphological variation in the genus *Halophila* reflects the plasticity of clonal growth, as a response to the variations in environmental factors.

Water depth is an important environmental factor shaping clonal characteristics of *H. ovalis*. This may be accomplished by affecting light availability because there is a strong negative correlation between seagrass colonization depth and light extinction coefficient (Duarte et al. 2007; Nielsen and Pedersen 2000). It was demonstrated that the rate of electron transport and efficiency of photosynthesis declined with increasing
depth in the congeneric \( H. \) *stipulacea* growing along a depth gradient from 7 to 30 m in the Gulf of Aqaba (Schwarz and Hellblom 2002). With increasing water depth, light is generally reduced for submerged seagrasses, and this has negative effects on seagrass growth, leading to morphological changes (Erftemeijer and Stapel 1999; Longstaff \textit{et al.} 1999; Ralph \textit{et al.} 2007). \( H. \) *stipulacea* grew longer leaves and internodes with increasing water depth (Schwarz and Hellblom 2002). However, a study showed that \( Z. \) *caulescens* has the longest shoot at moderate water depth (Sultana and Komatsu 2002). Our study indicated that clonal characteristics did not change linearly with water depth. Shoots, leaves and horizontal rhizomes of \( H. \) *ovalis* became larger with increasing water depth ranging from 2- to ~9-m MTL and then became smaller at water depths below 9-m MTL (Fig. 3). This result indicated that 9-m MTL seemed to be the optimum water depth for the growth of \( H. \) *ovalis* in the study region. Growing in shallow water, \( H. \) *ovalis* may suffer from disturbances due to periodical tides and exposure to excessive light, which may have negative effects on growth. In deep water, the light levels are too low and the growth is limited.

As a small seagrass with a height <5 cm, \( H. \) *halophila* beds generally have lower standing biomass, but higher productivity compared to large seagrasses. The mean above- and

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**Figure 3**: relationships between water depth and clonal characteristics of \( H. \) *ovalis*. Each point represents the average values for each quadrat. The vertical axis indicates (a) shoot height, (b) leaf length, (c) leaf width, (d) rhizome diameter and (e) horizontal internodal length, respectively.
Above-ground biomasses of 30 seagrass species were 224 and 237 g m\(^{-2}\), respectively (Duarte and Chiscano 1999). Among these species, aboveground biomasses of \textit{Halophila}, ranging from 2.3 to 104 g m\(^{-2}\), were lowest, while \textit{Amphibolis antarctica} had the highest aboveground biomass (1 005 g m\(^{-2}\)) (Duarte and Chiscano 1999). \textit{Halophila ovalis} biomass in the present study ranged from 17.38 to 37.62 g m\(^{-2}\). These values were higher than \textit{H. ovalis} biomass reported in the Northern hemisphere (Table 2, Duarte and Chiscano 1999), but lower than \textit{H. ovalis} biomass in Western Australia (Hillman et al. 1995).

Other environmental factors and animal grazing may also affect depth range and biomass of seagrasses (Abal and Dennison 1996; Hammerstrom et al. 2006). For example, Paynter et al. (2000) found that \textit{Thalassia testudinum} biomass was correlated with sediment nature, while Smith et al. (2008) found that in \textit{Heterozostera nigricaulis} seagrass beds, the shoreward edge always had lower seagrass biomass. Peak biomass values in \textit{Halophila ovalis} (Hillman et al. 1995) and \textit{Z. caulescens} (Sultana and Komatsu 2002) were found at the moderate depths. In west Florida shelf, \textit{H. decipiens} biomass was lowest at the offshore/deeper station (Hammerstrom et al. 2006). These values, however, were considerably lower than those reported in deeper sites at St Croix, US Virgin Island (Josselyn et al. 1986). These mixed findings might be explained by differences in environmental factors. We found no significant difference in total biomass among the four study sites (Fig. 4), which was most likely due to insignificant difference in sediment types and nutrients.

Although biomass did not vary greatly among the studied sites, a significant difference was found in the allocation of biomass. The ratio of above-/belowground biomass at the shallow site, Yingluo, was significantly higher than that found at the deeper sites. These ratios were also higher than those observed at Langkai Island where the water depth was 14–16 m (Erftemeijer and Stapel 1999). With increasing water depth, seagrasses grow extensive rhizomes and store more carbohydrates, leading to lower above-/belowground biomass ratios (Carlson and Acker 1985; Elkalay et al. 2003). Such a tendency is likely the result of its response to reduced light intensity. In experiments of light deprivation for \textit{H. ovalis}, the ratio of above- to belowground biomass appeared to decline with light reduction (Longstaff et al. 1999). Also, a larger quantity of stored carbohydrate was found in the belowground biomass of \textit{Zostera noltii} under low light intensity (Peralta et al. 2002). These observations suggest that seagrasses could adjust their biomass allocation with the changes in light density. When light intensity was low, more biomass was allocated to belowground when the energy generated through photosynthesis was lower than the energy consumed by respiration. This behavior is quite different from that of land plants, where a higher shoot/root + rhizome ratio for plants grown at low light, but may be mediated by nutrients (He et al. 2007).

**CONCLUSIONS**

Our results show that the variations in clonal characteristics and biomass allocation in \textit{H. ovalis} were closely related to water depth. Larger-size leaves and taller but sparser shoots were found at water depths from 2- to 9-m MTL, but below 9 m, these characteristics were found to subside. In deep water, more biomass was allocated to belowground parts. The strong phenotypic plasticity in clonal characteristics and biomass may play an important role in maintaining the abundance of seagrasses in view of the environmental effects caused by global issues such as climate change and recovery from ecological disturbances, such as grazing or harvesting of shellfish. At present, \textit{H. ovalis} seagrass beds do not seem to be suffering significantly from the negative impacts of sea level rise in the area under study. Nevertheless, further studies and monitoring are needed to gain more understanding of the changes in seagrass beds in this region, especially under the existing and predicted future impacts of human activities.

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**Conflict of interest statement**. None declared.
Table 2: Clonal characteristics and ratio of above/below ground biomass (R) of *Halophila* species

<table>
<thead>
<tr>
<th>Species</th>
<th>Location</th>
<th>WD (m)</th>
<th>LD (m⁻²)</th>
<th>RD (mm)</th>
<th>IL (mm)</th>
<th>LL (mm)</th>
<th>LW (mm)</th>
<th>BA (°)</th>
<th>LDW (mg)</th>
<th>TB (g m⁻²)</th>
<th>R</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Halophila ovalis</em></td>
<td>Guangxi, China</td>
<td>2–13</td>
<td>381.7–832.0</td>
<td>0.84–1.41</td>
<td>23.3–47.3</td>
<td>19.3–26.5</td>
<td>11.0–14.2</td>
<td>65.9–74.7</td>
<td>6.1–8.2</td>
<td>17.38–37.62</td>
<td>0.94–1.58</td>
<td>The present study</td>
</tr>
<tr>
<td><em>H. ovalis</em></td>
<td>Cape Bilinao, Philippine</td>
<td>3</td>
<td>16</td>
<td>1.09</td>
<td>17.0</td>
<td>15.4</td>
<td>8.5</td>
<td>72.0</td>
<td>3.5</td>
<td>0.2</td>
<td>1.0</td>
<td>Vermaat et al. (1995)</td>
</tr>
<tr>
<td><em>H. ovalis</em></td>
<td>W. Australia</td>
<td>2</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>7.3–14.2</td>
<td>Up to 120</td>
<td>—</td>
<td>Hillman et al. (1995)</td>
</tr>
<tr>
<td><em>H. ovalis</em></td>
<td>Indonesia</td>
<td>12–16</td>
<td>1 099</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>10.93</td>
<td>0.72</td>
<td>—</td>
<td>Erftemeijer and Stapel (1999)</td>
</tr>
<tr>
<td><em>H. ovalis</em></td>
<td>Masirah Island</td>
<td>&lt;0.5–3</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.5–11.4</td>
<td>—</td>
<td>—</td>
<td>Jupp et al. (1996)</td>
</tr>
<tr>
<td><em>Halophila capricorni</em></td>
<td>Coral sea</td>
<td>20</td>
<td>—</td>
<td>0.9–1.5</td>
<td>—</td>
<td>15–30</td>
<td>5–9</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Larkum (1995)</td>
</tr>
<tr>
<td><em>Halophila decipiens</em></td>
<td>Okinawa Island, Japan</td>
<td>15–18</td>
<td>—</td>
<td>0.8–1</td>
<td>15–25</td>
<td>Up to 20</td>
<td>4–6</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Kuo et al. (1995)</td>
</tr>
<tr>
<td><em>H. decipiens</em></td>
<td>US virgin Island</td>
<td>15–27</td>
<td>1 099–4</td>
<td>600</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>5–12</td>
<td>1.06</td>
<td>—</td>
<td>Joselyn et al. (1986)</td>
</tr>
<tr>
<td><em>H. decipiens</em></td>
<td>Hawaiian</td>
<td>1–40</td>
<td>0.57–0.7</td>
<td>2.8–29.8</td>
<td>12.9–18.5</td>
<td>3.8–6.3</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>McDermid et al. (2002)</td>
</tr>
<tr>
<td><em>H. decipiens</em></td>
<td>Costa Raja, CA</td>
<td>4–6</td>
<td>2 964–4</td>
<td>016</td>
<td>—</td>
<td>—</td>
<td>14.5–18.6</td>
<td>6.4–5.8</td>
<td>—</td>
<td>5.2–8.5</td>
<td>—</td>
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<tr>
<td><em>Halophila stipulacea</em></td>
<td>Aqaba, Jordan</td>
<td>10</td>
<td>403</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.4</td>
<td>—</td>
<td>—</td>
<td>Erftemeijer and Stapel (1999)</td>
</tr>
<tr>
<td><em>H. stipulacea</em></td>
<td>Vulcano Island, Oliver-Tindari, the western Mediterranean</td>
<td>2–25</td>
<td>—</td>
<td>—</td>
<td>1.24–2.91</td>
<td>4.96–8.43</td>
<td>0.65–1.01</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Procaccini et al. (1999)</td>
</tr>
<tr>
<td><em>H. stipulacea</em></td>
<td>Florida</td>
<td>10–20</td>
<td>118–1 990</td>
<td>—</td>
<td>—</td>
<td>6.8–11.2</td>
<td>29.9–44.3</td>
<td>—</td>
<td>—</td>
<td>0.02–2.64</td>
<td>1.56–2.50</td>
<td>Hammerstrom et al. (2006)</td>
</tr>
<tr>
<td><em>H. stipulacea</em></td>
<td>Gulf of Aqaba, the Red Sea</td>
<td>7–30</td>
<td>—</td>
<td>—</td>
<td>6.8–11.2</td>
<td>29.9–44.3</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>1.56–2.50</td>
<td>Schwarz and Hellblom (2002)</td>
</tr>
<tr>
<td><em>Halophila sulawesii</em></td>
<td>Indonesia</td>
<td>15</td>
<td>0.3–0.8</td>
<td>—</td>
<td>Up to 50</td>
<td>10–25</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Kuo (2007)</td>
</tr>
</tbody>
</table>

WD = water depth; LD = leaf pair density; RD = mean rhizome diameter; IL = horizontal internodal length; LL = leaf length; LW = leaf width; BA = branching angle; LDW = leaf dry weight; TB = total biomass.


