Available online at www.sciencedirect.com
ScienceDirect
Forest Ecology and Management 255 (2008) 179–182
Forest Ecology and Management
www.elsevier.com/locate/foreco

# Net primary productivity of *Bruguiera parviflora* (Wight & Arn.) dominated mangrove forest at Kuala Selangor, Malaysia

Mahmood Hossain [a,*], Saberi Othman [b], Japar Sidik Bujang [c], Misri Kusnan [d]

[a] Forestry and Wood Technology Discipline, Khulna University, Khulna 9208, Bangladesh
[b] Department of Biology, University Pendidikan Sultan Idris, 35900 Tg. Malim, Perak, Malaysia
[c] Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Campus, P.O. Box 396, 97008 Bintulu, Sarawak, Malaysia
[d] Department of Biology, University Putra Malaysia, 43400 UPM, Serdang, Malaysia

Received 12 February 2006; received in revised form 14 July 2007; accepted 3 September 2007

**Abstract**

The net primary productivity of *Bruguiera parviflora* dominated mangrove forest at Kuala Selangor, Malaysia was estimated from the average yearly biomass increment and litter production. The average yearly biomass increment in saplings and trees was 0.58 and 16.51 t $ha^{-1}$, respectively, and the annual amount of total litter production was 10.35 t $ha^{-1}$. The biomass increment in saplings and trees was not significantly different (*t*-test, $p > 0.05$) in 2 successive years and the estimated net primary productivity was 27.44 t $ha^{-1}$ $year^{-1}$. The ratio (2.65:1) of net primary productivity and litterfall suggests that this mangrove forest is at a juvenile stage.


*Keywords:* Biomass increment; *Bruguiera parviflora*; Ecosystem; Litter production; Mangroves; Productivity

## 1. Introduction

Mangrove ecosystems are economically and ecologically important as renewable resources (Field, 1995) and productive coastal ecosystems (Clough and Attiwill, 1982; Hutchings and Saenger, 1987; Aksornkoae, 1993). However, there are few studies on the net primary productivity of Malaysian mangrove forests (e.g. Gong et al., 1984; Ong et al., 1985, 1995, 2004; Putz and Chan, 1986) and they were studies of almost pure stands of *Rhizophora apiculata* in the Matang mangrove forest. *Bruguiera parviflora* is an important mangrove species in Malaysia and widely distributed from South and Southeast Asia to tropical Australia. *B. parviflora* is one of the least studied mangrove species. Ong et al. (1985) and Clough and Scott (1989) developed only an allometric relationship to calculate the above-ground biomass of the species. No attempt has yet been made to estimate the net primary productivity of this species. The net primary productivity and the ratio of net primary productivity and litterfall indicate the maturity of an ecosystem (Kimmins, 2004) and provide baseline information for sustainable management. The present study aimed to estimate the net primary productivity of a naturally growing, *B. parviflora* dominated mangrove stand at Kuala Selangor, Malaysia.

## 2. Materials and methods

The study area includes 100 ha of *B. parviflora* dominated mangrove forest in the Kuala Selangor Nature Park, between 3°19′–3°20′N and 101°14′–101°15′E on the west coast of the Malay Peninsula. It is a fringing mangrove growing at the mouth of the Selangor River, which has an average width of 200 m (varying from 150 to 250 m) between sea and embankment and belongs to Watson's (1928) tidal inundation class 4 (the maximum tidal height is 4 m above the datum). *B. parviflora* contributes more than 80% of the total growing stock of the area. *Avicennia alba*, *R. apiculata*, *R. mucronata* and *Sonneratia caseolaris* were found within 5 m from the seaward side of the forest, although some *R. apiculata* and *R. mucronata* were found in depressions within the inner part of the forest. The mean annual rainfall of the area is about 1790 mm. The wet season (September to December), intermediate season (January to April) and dry season (May to August) contribute 46, 31 and

* Corresponding author. Tel.: +880 171959380; fax: +880 41 731244.
*E-mail addresses:* mahmoodhossain@hotmail.com (M. Hossain), saberi@upsi.edu.my (S. Othman), Japar@science.upm.edu.my (J.S. Bujang), misri@fsas.upm.edu.my (M. Kusnan).

0378-1127/$ – see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.foreco.2007.09.011

23% of the annual rainfall, respectively. The mean minimum and maximum temperatures are 24 and 32 °C, respectively. The Selangor River is the main source of freshwater input to the area. The salinity of the river water was 25 ppt during the wet season and 34 ppt during the dry season, while the salinity of the infiltration water was 30 and 41 ppt, respectively (Mahmood et al., 2005a).

Three transects were established randomly along the width of the forest and 20 random sample plots (10 m × 10 m) were studied in those three transects during the wet season (September 2001). All saplings (diameter at breast height, DBH < 4 cm) and trees (DBH > 4 cm) in the plots were identified and counted, and their height and DBH (diameter at 1.30 m from the ground level) were measured. The whole-tree method (Gong and Ong, 1990; Ong et al., 2004) was followed to derive the allometric relationship between DBH and biomass. Ten saplings and six trees of *B. parviflora* were selected (avoiding mechanically or insect damaged ones) with a DBH in the ranges of 1–3.9 cm and 4–15.9 cm, respectively, during the wet season (September 2001). The selected saplings and trees were felled at ground level. The above-ground components of each individual sapling and tree were then separated into leaves, buds, branches and stems. Stem sections, 50 cm long from saplings and 1 m long from trees, were collected from the base, the middle and the upper portion of the stem in each sapling and tree. These stem sections were then debarked in the field. The root system of each sapling and tree was excavated, following the buttress roots, by using a water jet and portable winch. The roots were washed thoroughly and air-dried. All the components of the individual saplings and trees were weighed fresh in the field. The total fresh weight of the bark from each individual sapling and tree was calculated from the ratio of the fresh weight of the debarked stem and its weight before debarking. Representative samples of each component were taken to the laboratory to determine the ratios for fresh to oven dry weight at 80 °C. Using this ratio, the oven-dry weight of the different components of the saplings and trees were calculated. Linear regression equations ($\text{Log}_{10}$ Biomass = $A + B$ $\text{Log}_{10}$ DBH) were used to develop the allometric relationships between the biomass of each component and the DBH of saplings and trees. Statistical tests for significance of the regression slopes and co-efficients of the equations for the different components of saplings and trees were calculated by using SAS (6.12) statistical software.

Three representative samples of both saplings and trees were selected randomly from each diameter class (Table 1), a total of 9 saplings and 18 trees. These saplings and trees were tagged and their DBH was first measured at the beginning of the wet season (September 2001), and two subsequent measurements were taken at yearly intervals in 2002 and 2003. The biomass of each tagged sapling and tree was estimated by using the derived allometric equations. The biomass accumulation in each sapling and tree was computed by subtracting the initial biomass from the final biomass. The biomass accumulation in the above and below-ground components of saplings and trees was calculated from the mid-DBH of the each DBH class by using the derived allometric equations (Cintrón and Novelli, 1984). The litter production data for the study area was taken from Mahmood et al. (2005b). The net primary productivity was estimated from the average yearly biomass increment and litter production (Newbould, 1967; Clough and Attiwill, 1982).

Table 1
DBH classes of *Bruguiera parviflora* saplings and trees

| Diameter class (cm) | Trees or saplings $\text{ha}^{-1} \pm$ S.E. | Percentage contribution of DBH classes in the sample plots |
|---|---|---|
| Saplings | | |
| 1–1.9 | 235 ± 18 | 41.59 ± 4.34 |
| 2–2.9 | 190 ± 19 | 33.63 ± 3.33 |
| 3–3.9 | 140 ± 8 | 24.78 ± 2.34 |
| Trees | | |
| 4–5.9 | 280 ± 20 | 13.79 ± 0.44 |
| 6–7.9 | 355 ± 19 | 17.49 ± 0.88 |
| 8–9.9 | 460 ± 27 | 22.66 ± 2.13 |
| 10–11.9 | 510 ± 12 | 25.12 ± 1.98 |
| 12–13.9 | 300 ± 12 | 14.78 ± 1.23 |
| 14–15.9 | 125 ± 34 | 6.16 ± 0.56 |

## 3. Results

Five mangrove species belonging to the families of *Avicenniaceae*, *Rhizophoraceae* and *Sonneratiaceae* were recorded during the field study. The relative dominances of these species were 7.37% (saplings), 6.42% (trees) for *A. alba*; 88.06, 81.66% (*B. parviflora*); 1.09, 0.34% (*R. apiculata*); 2.87, 5.57% (*R. mucronata*) and 0.61, 5.97% (*S. caseolaris*). *B. parviflora* had the maximum DBH of 16 cm and the highest densities were 235 saplings $\text{ha}^{-1}$ and 510 trees $\text{ha}^{-1}$ for the DBH classes 1–1.9 cm and 10–11.9 cm, respectively (Table 1).

The allometric relationships ($\text{Log}_{10}$ Biomass = $A + B$ $\text{Log}_{10}$ DBH, where $A$ and $B$ are regression constants) for both saplings and trees were significant ($p < 0.05$). The regression coefficient of equations for the individual components of saplings and trees varied from 0.89 to 0.99 (Table 2). The regression slopes and coefficients of the different equations for the sapling and tree components differed significantly ($t$-test, $p < 0.05$). Therefore, different allometric equations were used to estimate the biomass of the different components of saplings and trees. The average yearly biomass increment in saplings and trees was 0.58 and 16.51 t $\text{ha}^{-1}$, respectively. Mahmood et al. (2005b) reported that the litter production of the study area was 10.35 t $\text{ha}^{-1}$ $\text{year}^{-1}$. The net primary productivity of 27.44 t $\text{ha}^{-1}$ $\text{year}^{-1}$ was estimated from the values of the average yearly biomass increment and litterfall.

## 4. Discussion

The linear transformation ($\text{Log}_{10}$ Biomass = $A + B$ $\text{Log}_{10}$ DBH) proved to be a good descriptor of the relationship between the above-ground biomass and the DBH or GBH for mangrove species (Ong et al., 1985, 2004; Putz and Chan, 1986; Clough and Scott, 1989; Clough et al., 1997; Comley and McGuinness, 2005) and terrestrial forest (Whittaker and Marks, 1975; Ketterings et al., 2001). *B. parviflora* had a higher rate of