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Biomass and Carbon Estimation of *Eugeissona tristis*

(Biojisim dan Anggaran Karbon *Eugeissona tristis*)

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ABSTRACT

Plant biomass represents a sink for atmospheric carbon dioxide, which is one of the most important greenhouse gas. Eugeissona tristis *(Bertam) is a common palm species found in tropical lowland forest contributing to carbon and biomass stock estimation. However, the species has been neglected in most studies because of differences in sampling procedures and lack of equations. The objective of this study was to develop an allometric equation in estimating biomass and carbon content of* Eugeissona tristis. *This study was conducted in 10 20 m × 50 m plots in Ayer Hitam Forest Reserve (AFHR). Carbon content was estimated using carbon analyzer. The results showed AHFR contained 104 clumps/ha and distribution of* E. tristis *was not influenced by slope. The aboveground biomass of* E. tristis *was estimated to be 0.879 t ha^{-1} corresponding to 1096 t for AHFR area (0.4% from total aboveground biomass). It contains 51% of carbon which contributes about 0.44 t C ha^{-1} and 548 t C for the whole area, depicting that this species contributed to the overall carbon stock to a reasonable extent in AHFR.*

Keywords: Biomass; Carbon; Eugeissona tristis

ABSTRAK

Biojisim tumbuhan merupakan salah satu takungan karbon dioksida atmosfera yang penting dalam penyelesaian masalah pemanasan global. Eugeissona tristis *(Bertam) adalah salah satu spesies palma yang biasa dijumpai di hutan pamah tropika dan salah satu spesis yang menyumbang kepada anggaran stok karbon dan biomas. Walau bagaimanapun, ia telah diabaikan dalam banyak kajian dan pengiraan stok karbon. Objektif kajian ini adalah untuk membangunkan persamaan alometrik dalam menganggar biojisim dan kandungan karbon* Eugeissona tristis. *Kajian ini telah dijalankan dalam 10 20 m × 50 m plot di Hutan Simpan Ayer Hitam Forest (HSAH), Puchong, Selangor. Kandungan karbon dianggarkan menggunakan analisis karbon. Keputusan menunjukkan HSAH mengandungi 104 rumpun/ha dan pengagihan* E. tristis *tidak dipengaruhi oleh cerun. Biojisim atas tanah* E. tristis *dianggarkan pada 0,879 t ha^{-1} bersamaan dengan 1096 t bagi kawasan HSAH (0.4% daripada jumlah biojisim atas tanah). Ia juga mengandungi 51% karbon yang menyumbang kira-kira 0.44 t C ha^{-1} dan 548 t C bagi seluruh kawasan HSAH. Kajian ini menunjukkan bahawa* E. tristis *menyumbang kepada keseluruhan stok karbon di HSAH.*

Kata kunci: Biojisim; Eugeissona tristis*; karbon*

Introduction

General Background

Palm species are an important components of tropical rainforest and present in all forest strata. They are distinctive that they can become tall and long-living trees entirely by primary development processes (Henderson 2006, Tomlinson 2006). According to Walther et al. (2007) palm species from Arecacea family are important indicators for obtaining information on the past climate. Although palm is regarded as an obstacle in the establishment of other species, it has become significant global bioindicator for climate change and projected near future global warming. Recent expansion of the global range of palms across various continents coincides with current global warming (Walther et al. 2007).

Asia is endowed with the world's greatest palm biodiversity and possesses the highest diversity of palm utilization. They have a long history of management for both subsistence and as commercial product embedded in local culture. Palms are also an important food resource for animals and have great economic value for humans (Henderson 2006). The family Palmae includes 2700 species belonging to 202 genera. Out of these nearly 1385 species are in Asia and Pacific Islands and 1147 in North and South America (Moore 1973). Species such as coconut (*Cocos nucifera*) and oil palm (*Elaeis guinensis*) are major producers of biomass in tropical forests. Despite their current status, they still possess considerable potential for further development.

Eugeissona is a clustering genus of flowering plants in palm family native to Malaysia, Borneo and Thailand. The six monoecious species provide a wide range of local uses and are commonly called Bertam or Wild Bornean Sago. *Eugeissona tristis*, the stemless, clump-forming palm belongs to Lepidocaryoideae sub-family, which commonly flourishes in disturbed, open areas up to 800 m above sea level (Burgess & Lowe 1971; Lack 2009). It has 6 m tall large ascending leaves with a green leaflet and spiny leafstalks. Their presence is regarded as an obstructer to the establishment of other species. It poses serious problems for the forest department to regenerate forest which has been logged (Manokaran 1979). However they are used extensively by locals for a variety of purposes. *E. tristis* seeds need at least 7 months to germinate (Wong 1959) and the earliest germination is 21 weeks after sowing (Manokaran 1976).

PALM ROLE IN ESTIMATING ABOVEGROUND BIOMASS

Biomass is seen as an interesting energy source for several reasons. The main reason is that bio-energy can contribute to sustainable development (Hoogwijk et al. 2003; Ozturk 2010; Ozturk et al. 2006). Brown (1997) stated that biomass estimation of tropical forest has received much attention in recent years because the change in regional biomass is associated with the important component of climate change. According to Whitmore (1984), forest biomass is a function of density of stems, height of the trees and basal area of the tree of a given location. The contribution of these parameters to aboveground biomass differs with sites, successional stage of the forest, disturbance levels, species composition and other factors. Biomass is also a prime substitute for quantifying forest resources, including timber and fuel representing a key indicator of biodiversity and forest structure.

Even though palms are common in many tropical forests, they are often ignored in the forest inventories. Their contribution towards biomass density can be variable, from nearly 100% to less than a few percent (Brown 1997). In most studies, palms are frequently excluded from the aboveground biomass or treated differently (Laurance et al. 1999). Many have used general palm equations (Cummings et al. 2002; Saldarriaga et al. 1988). However, there are also specific species regressions developed by Frangi and Lugo (1985) and Hughes et al. (1999). Compared with trees, most palms change less in diameter while growing in height (FAO 2010). According to Castilho et al. (2006), palms represent less than 1% of the aboveground biomass estimates per plot. Still, palm biomass is highly variable between plots and sometimes it represents 10% of the total biomass per plot. It also varies between forest types (Cummings et al. 2002) and sites (Clark & Clark 2002; De Walt & Chave 2004).

Considering palms as part of the forest biomass is important for better understanding towards the structural differences of changing landscape between tree and non-tree in carbon balance model (Brown & Lugo 1992). The high palm biomass in certain areas does affect the nutrient cycling processes, such as decomposition rates. According to Frangi and Lugo (1985), palm leaves on the ground decompose slowly, whereas palm trunks decompose faster than tree boles. Therefore, this will affect the carbon cycle. The palms generally contribute about 3.5% of the aboveground biomass in tropical forest (Fearnside 1994). In larger scales, forest that is dominated by large palms, cover around 20% of the original forest area (Castilho 2006; IBGE 1997). Stemless palm, which is very common in understory forest represents 0.4% of the aboveground biomass (Nascimento & Laurance 2002). Using this information on biomass and carbon content, energy and nutrient turnover could be estimated easily. The objective of this study was to develop an allometric equation in estimating biomass and carbon content of *Eugeissona tristis*.

MATERIALS AND METHODS

STUDY SITE

The study area is located in Ayer Hitam Forest Reserve (AHFR), Puchong Selangor (Figure 1). It is situated approximately 45 km from Kuala Lumpur. The forest belongs to the lowland dipterocarp forest type and is classified as a secondary disturbed forest, because it has been logged and treated several times since 1930's. Currently, the forest comprises a total area of 1248 ha. The minimum and maximum temperature throughout the Ayer Hitam Forest Reserve is 22.7°C and 32.1°C, respectively; while the daily average temperature is 26.6°C. The minimum and maximum relative humidity is 59% and 96%, respectively, while the average relative humidity is 83% (Primus 2000). The forest elevation is between 15 and 233 m above sea level and 10-20% rugged and hilly slope slant. The Rasau River in the South and Bohol River in the north are the primary source of the irrigation in this forest. Soil type ranges from Serdang-Kedah series to Serdang-Bungor series and slope soils with the combination types of local alluvium-colluvium have resulted from metamorphic rock.

SAMPLING DESIGN

A stratified random sampling approach was followed, assessing *Eugeissona tristis* in 10 rectangular plots of $20 \times 50 = 1000\ m^2$. The plots were established according to the topographic contour at three different slope positions; bottom, middle and ridge.

BIOMASS ESTIMATION

Palms are components of tropical forests, often excluded from aboveground biomass assessments or treated as trees (Laurance et al. 1999). Assessing their biomass is quite difficult as only a few studies have been made in this direction. In this investigation, *Eugissona tristis* clump circumference and number of fronds was measured. The number of fronds of each individual clump in the plot were counted and multiplied by a mean weight per leaf derived from a random sample of 30 fronds which were oven-dried and weighed. These were cut into smaller components (leaflet, sheath and petiole) and weighed. Since these palms have no stem, allometric estimation was done using clump circumference instead of DBH. In the estimation, the

FIGURE 1. Location of the study area

TABLE 1. Allometric equations used to estimate palm aboveground biomass (Y, kg ha^{-1})

Palm allometric equations (dbh ≥1cm)	Source
$Y = 10.0 + 6.4 \times$ total height (m)	Frangi & Lugo 1985
$Y = \text{Exp}(-6.3789 - 0.877 \times \ln(1/dbh2)) + 2.151 \times \ln(H)$	Saldarriaga et al. 1988

The equations were based on diameter at breast height (dbh,cm) and /or height (H,m)

circumference was divided into half to assume the empty space within has been removed (Saldarriaga et al.1988). Biomass estimated from palm was derived from the allometric equation developed by Frangi and Lugo (1985) and Saldarriaga et al. (1988) (Table 1).

PALM DENSITY ESTIMATION

Wood density must be taken into consideration when calculating carbon content. Wood density of palms varies considerably by species and within the stem of the same species. It can range from about 0.25 to almost 1.0 t/m^3 (Rich 1987). The small component of palm biomass has to be added, which in total may range from 10 to 65% (Frangi & Lugo 1985: Rich 1986) such as petiole and sheath. To estimate the density, a palm sheath from each section was removed. The volume of every piece was calculated by the water-displacement method (Chave et al. 2005). Sub-sample of 2 cm was extracted from each section. The mass of the liquid displaced by the oven dried sample was determined by using a densimeter (Electronic Densimeter MH-123U/204S). A beaker capable of holding the samples was filled with water and placed on a densimeter. The sample was then submerged under water until the reading on the monitor was stable.

CARBON ESTIMATION

For *E. tristis,* carbon content of the palm samples was determined following dry combustion method and LECO CNS-2000 was used. Samples were first ground according to their component and sieved to obtain the powder before analyzing.

DATA ANALYSIS

ANOVA was used to test the significance between the slope condition and the palm distribution.

RESULTS AND DISCUSSION

The population size of *E. tristis* varies among plots and 60% of the study area has more than 8 clumps per plot (Figure 2). Total number of clumps in the study plot at Ayer Hitam Forest Reserve was 104. General palm allometric equations are scares (Cummings et al. 2002; Saldarriaga et al. 1988) or species-specific (Frangi & Lugo 1985; Hughes et al. 1999) and the use of tree equations probably overestimates their biomass, but this should have a modest effect on total estimates (Clark & Clark 2002), since palms are a relatively minor component in estimating aboveground biomass.

Figure 3 shows the distribution of *E. tristis* in three different slope positions. Statistical analysis shows that distribution of the palm in Ayer Hitam Forest Reserve is not influenced by slope ($p = 0.357$). Furthermore, the differences between the location of the plots within the slopes may be small since the highest point in this forest is only 230 m above sea level. *E. tristis* only shows variation in distribution when altitude reaches up to 800 m. The

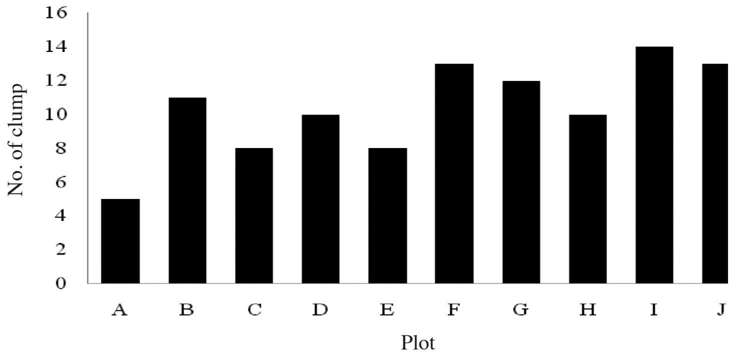

FIGURE 2. *Eugeissona tristis* clump/plot

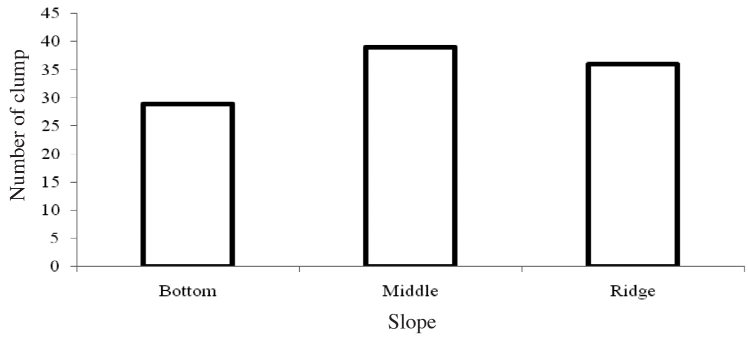

FIGURE 3. Number of clump according to slope

relationship between biomass and topography is quite complex since topography covaries with other variables such as soil type (Chauvel et al. 1987; Robert 2003) and soil water potential (Becker et al. 1988 & Daws et al. 2002) (Table 2).

Mean palm biomass per plot was 87.93 kg/plot, ranging from 30.82 kg to 138.24 kg (Table 3). Palm biomass represented less than 1% of the total biomass in all plots, but attained 10% level of the total biomass in one plot. For vegetation index, the result showed clump density average value as 10.4% per ha which indicates that the study area is not a palm dominant forest. *E. tristis* biomass estimation was done using Frangi and Lugo (by height) and Saldarriaga equation and compared with the manual calculation done during this study. For AHFR, the biomass estimated for *E. tristis* was 0.879 t ha^{-1} (Table 4). The values were between both equation (4.316 t ha^{-1} and 0.423 t ha^{-1}), which were over and under estimation. According to Ismariah and Ahmad Fadli (2007), the total aboveground biomass of AHFR was estimated to lie around 209-222 t ha^{-1}, this shows that Bertam palm represents about 0.41% of the aboveground biomass in Ayer Hitam Forest Reserve.

For the carbon content in *E. tristis*, it was found that the average C value in all compartments was 51% (Figure 4). The highest value was found in the leaves (52%) while

TABLE 2. Descriptive statistics of distribution of *Eugeissona tristis*

	N	Mean	Std. Deviation	Minimum	Maximum
1	3	9.67	4.16	5	13
2	4	9.75	2.36	8	13
3	3	12.00	2.00	10	14
Total	10	10.40	2.80	5	14

TABLE 3. *Eugeissona tristis* biomass per plot

Plot	A	B	C	D	E	F	G	H	I	J	Mean
Biomass (kg)	30.82	84.96	64.22	94.46	78.62	99.36	91.58	78.05	138.24	118.94	87.93

TABLE 4. Estimation of total *Eugeissona tristis* biomass

Equations	Biomass (t ha^{-1})
Frangi and Lugo (by height)	4.316
Saldarriaga	0.420
This study	0.879

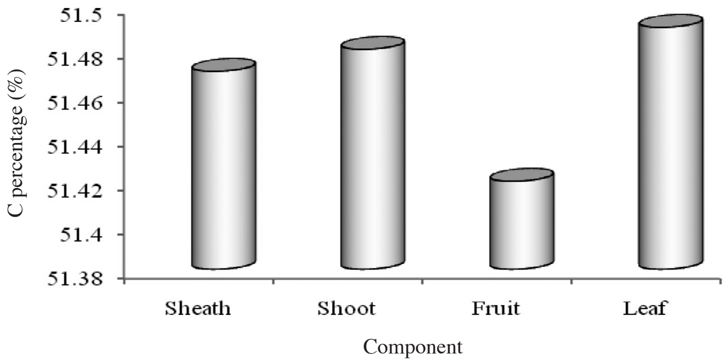

FIGURE 4. Carbon concentration by component

the lowest value was in the fruit (51%). Therefore, carbon stock value for this palm was 0.44 t C ha^{-1} and 548 t C ha^{-1} for the whole AHFR area. Specific gravity test was also done for this species. *E. tristis* specific gravity for palm density is 0.3319 g/cm^3 for sheath and 0.631 g/cm^3 for shoot. The value is in the range study reported by Rich (1987).

CONCLUSION

The total biomass of *E. tristis* was 0.879 t ha^{-1} and represented 0.41% of the aboveground biomass in Ayer Hitam Forest Reserve. Palm biomass contributes to carbon cycling processes and carbon sequestration. *E. tristis* biomass is important both as a habitat for biodiversity and as a carbon stock.

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