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ORIGINAL ARTICLE

Stand structure and biomass estimation in the Klang Islands Mangrove Forest, Peninsular Malaysia

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Abstract
A study was carried out at three sites in the Klang Islands Mangrove Forest Reserve, in Selangor, Malaysia, to obtain baseline information on how land use could affect forest community metrics. The objective was to obtain baseline ecological data that would allow assessment of different land-use types (industrial, village, and pristine mangrove forests) on species composition, stand density, diversity, similarity, important value index, and biomass. Undisturbed pristine mangrove forest was sampled at Pulau Klang, while disturbed mangrove forests were sampled at Teluk Gong and Pulau Ketam. A total of 14 species from five families were counted across the three sites, with the highest tree density found at Pulau Ketam (2034 trees ha^{-1}), followed by Pulau Klang and Teluk Gong (1627 and 753 trees ha^{-1}, respectively). The dominant species on Pulau Klang and Pulau Ketam was *Rhizophora apiculata* (importance value index, IVI = 181.4). Shannon–Weaver diversity was highest at Pulau Ketam ($H' = 1.81$) and the tree species on that island were also the most evenly distributed (Pielou evenness index, $J' = 0.87$). The highest above-ground and below-ground biomass values for a single species were recorded at Pulau Klang for *R. apiculata* (80.51 and 41.63 t ha^{-1}, respectively), while the second highest values were at Teluk Gong for *Rhizophora mucronata* (71.33 and 27.07 t ha^{-1}, respectively). As a whole, however, the remaining large trees in a disturbed site in Teluk Gong contributed to the highest total biomass (220.64 t ha^{-1}) followed by Pulau Klang and Pulau Ketam (192.22 and 161.93 t ha^{-1}, respectively). Proper assessment and management of these valuable mangrove forests are crucial to ensure mangrove ecosystem health.

Keywords Diversity index · Importance value index · Species composition · Pulau Ketam · Pulau Klang · Telok Gong

Introduction

Mangroves are defined as assemblages of halophytic shrubs and trees growing in the brackish to saline tidal waters of coastal areas (Nagelkerken et al. 2008). The location of mangroves has made them an important zone for flora and fauna, and is characterized by highly variable environmental factors such as temperature, salinity, rainfall, tidal currents, sedimentation, and nutrients (Ashton and Macintosh 2002; Ellison 1999; Wakushima et al. 1994). The peculiar architecture of mangrove trees is unique and functions to help them survive in an unusual environment. For example, some species like *Rhizophora* and *Bruguiera* spp have massive and spreading root systems, enabling them to stand upright in soft mud.

Species composition, diversity, and biomass of mangroves are important study subjects in coastal research and development (Norhayati et al. 2009; Shah et al. 2016). These parameters can address many mangrove rehabilitation problems and aid in understanding the dynamics of vegetation recovery (Zhu et al. 2015). Mangrove forests can be used sustainably and their management improved, by estimating biomass accumulation rates (Alemayehu et al. 2014). Biomass estimates facilitate the determination of the status of mangrove forests and assessment of the 'potential revenue' of commercial timber products, and are a principal component in estimating carbon sequestration (Kirui et al. 2006).

The context of species diversity is an expression of some relation between number of species or species richness and their abundance (Spellerberg 1991). The Shannon–Weaver diversity index, important value index, and similarity index

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