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# Dugong feeding grounds and spatial feeding patterns in subtidal seagrass: A case study at Sibu Archipelago, Malaysia

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ABSTRACT

In Southeast Asia, seagrass meadows are under threat through coastal development and increased pollution, but remain understudied. The dugong is a marine herbivore that is dependent on the availability of seagrass as a primary food source. In this study, we assess the patterns of co-occurrence between dugongs and seagrass. We hypothesize that the changing spatial patterns of dugong feeding are positively correlated to the seasonal variation in distribution and abundance of mixed species in subtidal tropical seagrass meadows. We documented seagrass cover and dugong feeding trails in the Sibu Archipelago meadow in Johor, Malaysia, across the monsoon seasons of 2016–2017 using an underwater towed video method. Moran's *I* and Getis-Ord Gi* statistics were used to quantify the degree of clustering in feeding trails, feeding patch size, and to identify feeding hotspots and coldspots. This site has the single largest subtidal meadow in Peninsular Malaysia known to date, measuring 12.88 $km^2$. The study captured a reduction in seagrass extent and coverage during the study. Feeding trail occurrence averaged three per image throughout the seasons, with the maximum number being 14 trails per image. Dugongs fed in a spatially clustered manner leaving two distinct feeding trail patterns: (1) a dispersed pattern when seagrass cover was high or low (76–100% and 0–25%) that resulted in larger patch sizes, and (2) a concentrated pattern in moderate seagrass cover (26–75%) that resulted in smaller patch size. Feeding hotspots and coldspots had significantly different seagrass cover, suggesting that dugongs foraged strategically within the meadow. Our results demonstrate that seagrass cover played a significant role in driving dugong feeding patterns and in creating feeding hotspots and coldspots in tropical subtidal meadows.

## 1. Introduction

The dugong (*Dugong dugon*) is the only herbivorous mammal which is strictly marine, feeding almost exclusively on seagrass (Anderson and Birtles, 1978; Preen, 1995; Chilvers et al., 2004). It is listed as vulnerable to extinction on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (Marsh and Sobtzick, 2015); many dugong populations globally occur in highly depleted numbers or are close to extinction (Marsh et al., 2011). In Malaysia, the dugong is listed as a marine endangered species within the Fisheries Act 1985, and in Peninsular Malaysia specifically, the species can be reliably found in the state of Johor (Mansor et al., 2000; Ponnampalam, 2012). Among the many threats that cause reduction in numbers across the species' range are fragmentation and loss of seagrass habitats. Additionally, large knowledge gaps remain on the scientific and socio-economic-cultural aspects of seagrass importance; this is especially true within Southeast Asia (Fortes, 2018; Sudo et al., 2021). Globally, seagrasses are being lost at an alarming rate (Waycott et al., 2009) as a consequence of extreme natural events (e.g., monsoon, flood, hurricane, cyclone and disease), human impacts (e.g., land reclamation, port expansion, increased nutrient input and pollution) (Duarte, 2002; Orth et al., 2006), and the consequence of extreme marine heatwaves due to climate change (e.g., Kendrick et al., 2019). As a result, seagrass cover within meadows may be spatiotemporally patchy and dugongs must make decisions that

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