## ECOLOGY OF WATERBIRDS IN SOUTH WEST JOHOR COAST, MALAYSIA

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A thesis submitted in fulfillment of the requirement for the award of the Degree of Master of Science

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This thesis is dedicated to the memory of my father, Haji Fauzi Che Yusuf and my lovely mother, Salina Mokhtar. Whose valued education above all.

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### ABSTRACT

Mangroves and mudflats play an important role in enriching the intertidal habitats with benthic communities for waterbirds to feed. Thus, the degradation of these intertidal habitats due to coastal reclamation might indirectly impact the prey availability and the populations of coastal waterbirds in South West Johor Coast. With more avian studies in Johor concentrated on forest birds, waterbird studies in coastal areas remained critically scarce in diversity documentation and feeding ecology aspects. This contributes to a huge gap in the conservation of waterbirds in the coast of Johor. Therefore, this research was conducted to study the diversity and abundance of waterbirds, their relationship with prey availability, and their feeding behaviour and diet composition. The study was conducted in three coastal mudflat sites along the South west Johor coast from November 2020 to May 2021. The direct observation technique was used to determine the abundance and feeding behaviour of waterbirds, meanwhile, benthic core sampling method was used to assess the availability of prey in all study sites. A total of 3,717 waterbird individuals comprised of 17 species were recorded in all three study sites. Apart from that, the study confirmed a positive numerical relationship between the abundance of waterbirds and the prey availability  $(R^2=0.501)$ . Overall, this study reveals that the feeding behaviour of the coastal waterbirds are highly influenced by their morphology. Large waterbirds recorded a higher percentage of successful attempts, even though lower feeding rates and shorter feeding times were measured. All this evidence pointed out that larger waterbirds are more efficient at feeding and fulfilling their energy requirement. At present, the results of this study will serve as an important baseline data as references for future studies on the conservation of coastal waterbirds along the South West Johor Coast.



### ABSTRAK

Paya bakau dan tanah lumpur memainkan peranan yang penting dalam memperkayakan habitat di zon pasang surut dengan komuniti bentos untuk sumber makanan burung air. Justeru, degradasi habitat dia zon pasang surut yang disebabkan oleh penambakan tanah di persisiran pantai secara tidak langsung memberi impak kepada ketersediaan mangsa dan populasi burung air di pesisiran pantai di Pantai Barat Daya Johor. Dengan kajian burung di Johor yang lebih tertumpu kepada burung hutan, kajian mengenai burung air di persisiran pantai masih sangat terhad dalam aspek dokumentasi kepelbagaian burung dan ekologi pemakanan mereka. Hal ini telah menyumbang kepada jurang yang besar dalam konservasi burung air di persisiran pantai Johor. Oleh itu, kajian ini dijalankan bagi mengkaji kepelbagaian dan kelimpahan burung air serta hubungannya dengan ketersediaan mangsa dan mengkaji tingkah laku tabiat pemakanan dan komposisi makanan burung air. Kajian ini dijalankan di tiga kawasan persisiran pantai berlumpur di sepanjang Pantai Barat Daya Johor dari November 2020 sehingga Mei 2021. Teknik pemerhatian secara langsung telah digunakan bagi menentukan kelimpahan burung air dan tingkah laku tabiat pemakanan burung air, manakala, kaedah persampelan teras bentos telah digunakan untuk menaksir ketersediaan mangsa di semua kawasan kajian. Sebanyak 3,717 individu burung air terdiri daripada 17 spesies telah direkodkan di ketiga-tiga kawasan kajian. Selain itu, kajian ini menunjukan hubungan yang positif antara kelimpahan burung air dan ketersediaan mangsa (R<sup>2</sup>=0.501). Keseluruhannya, kajian ini menunjukkan bahawa tingkah laku tabiat pemakanan burung air amat dipengaruhi oleh morfologi mereka. Burung air yang besar merekodkan peratusan yang tinggi bagi percubaan yang berjaya walaupun mempunyai kadar pemakanan yang rendah dan masa makan yang pendek. Kesemua bukti menunjukkan bahawa burung air yang besar adalah lebih efisyen dalam pemakanan dan memenuhi keperluan tenaga. Di masa hadapan, dapatan kajian ini boleh menjadi data asas yang penting serta rujukan bagi kajian konservasi burung air persisiran pantai di sepanjang Pantai Barat Daya Johor.



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## LIST OF PUBLICATIONS

### **Journals:**

- i) Fauzi, N. A. Munian, K & Norazlimi, N. A. (2023). Species composition and diversity of waterbird community in Important Bird Area (IBA) of South West Johor Coast. (Submitted for publication).
- ii) Fauzi, N. A. & Norazlimi, N. A. (2023). Foraging behaviour and diet composition of selected waterbird in three different coastal areas along the U TUN AMINAH South West Johor Coast. (Submitted for publication).

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## **CHAPTER 1**

## INTRODUCTION

#### 1.1 Research background

The coastal wetland is one of the integral parts of Malaysia's landscape that plays a crucial part in maintaining the distribution of avifauna in Malaysia. Out of the 672 Important Bird Areas (IBAs) that have been identified within Southeast Asia, 181 (26.9%) of them are from the coastal wetlands cover areas (Yong *et al.*, 2022). In particular, Malaysia holds the third-largest number and area of IBAs with coastal wetlands (15 sites with total cover of 4,316 km<sup>2</sup>) after Indonesia and Myanmar (Yong *et al.*, 2022). The west coast of Peninsular Malaysia (Malacca Strait) and Sumatra collectively hold the most extensive areas of intertidal flats, mangroves, and associated wetlands in Southeast Asia, and these areas have significant congregations of migratory waterbirds (Crossland *et al.*, 2006; Wei *et al.*, 2006; Iqbal *et al.*, 2010).

Waterbirds are usually confused with shorebirds when it comes to their definition. Waterbirds are any bird species, including egrets, shorebirds, herons, cranes, terns, ducks, rails, and ibises, that live near bodies of water (Laviad-Shitrit *et al.*, 2019). Meanwhile, shorebirds are a group of bird species generally belonging to the order Charadriiformes that inhabit open areas of the coastline, including beaches, mudflats, grasslands, and wetlands (Zhang *et al.*, 2019). In this study, the term "waterbird" refers to any bird species that perform all ecological activities within the shoreline system (Mendonça *et al.*, 2007; Zakaria *et al.*, 2009).

Waterbirds play a vital role in the enrichment of biodiversity of wetlands. Almost 10% of the world's avian species depend completely on wetland systems, and some species use the wetlands at some life cycle stages (Williamson *et al.*, 2013).



Furthermore, migratory waterbirds, especially shorebirds, rely on these habitats as stopover sites within their flyways during migration. The large coastal area in Malaysia offers ideal foraging and roosting habitat for many species of migratory waterbirds during the winter and migration seasons. Thus, their population change is often used to reflect the wetland conditions (Sutherland *et al.*, 2012; Murray *et al.*, 2015) as it was estimated that between 60,000 to 100,000 migratory coastal waterbirds used the coastal wetlands of Malaysia during the non-breeding season (Wei *et al.*, 2006)

Intertidal mudflats are important feeding areas for coastal waterbirds for various reasons. These areas are often hosting rich benthic communities and a high abundance of potential food sources for waterbirds (Meijer et al., 2021). Most of the infauna and epifauna prey in the mudflat sediment are the primary food resources for coastal waterbirds (Bowgen et al., 2015). Therefore, the waterbird's densities are often matched with the distribution of their preferred prey species (Zharikov & Skilleter, 2004). Studies on the relationship between coastal waterbird density and prey density in mudflat areas are still lacking in Malaysia. The previous study in Kuala Gula, Perak, had shown a positive correlation between bird density and macrobenthos density (Lomoljo et al., 2010). The study also reported that the high abundance of waterbirds, species diversity, species richness and species evenness was based on the quality and quantity of habitat available, as the waterbirds had been observed to switch their current habitat to take advantage of prey resources and maximize their foraging efficiency. Optimal foraging theory predicts that animals should forage on prey with the most energy content relative to foraging effort (Pyke et al., 1977). Therefore, the density of coastal waterbirds that forage in intertidal mudflats should increase with prey availability (Finn, 2010).

However, as the waterbird species are highly dependent on wetlands habitats for their survival, the reduction of wetlands, especially intertidal coastal (Camacho *et al.*, 2016) and mangroves (Giri *et al.*, 2011; Hamilton & Casey, 2016), has led to the extinction and threat of many species. The issue has reduced the distribution and abundance of waterbirds and prey availability (Brandis *et al.*, 2009). Since many waterbird populations often use the same area to forage simultaneously, these sites act as a geographic bottleneck, where environmental and anthropogenic influences are strongest (Warnock, 2010). Many migratory waterbirds on the west coast of Peninsular Malaysia have also reportedly declined dramatically (Wei *et al.*, 2006). This applies



particularly to the states of Perak and Selangor, with a reported decline of over 50% in the last twenty years.

Habitat loss and degradation, especially along the East Asian- Australasian Flyway (EAAF), have been the prime reason behind these declines (Barter, 2002; van de Kam *et al.*, 2010). Along with climate effects derived from global changes (Erwin, 2009), wetland loss has driven negative effects on biodiversity by a reduction of potential and available foraging habitats for waterbirds (Quesnelle *et al.*, 2013), and this directly impacts the ecologically dependent species (Zwarts *et al.*, 2009; Ma *et al.*, 2010; Murray *et al.*, 2014). A previous study by van de Kam *et al.* (2004) indicated that many waterbird species could not adapt and shift their feeding and nesting areas due to habitat degradation, as they are extremely reliant on a particular site. Those species and individuals that eventually relocated face an increase in competition with waterbirds already at the site, leading to an increase in mortality or a reduction in fitness. It became worst when through time, waterbirds were forced to evolve into opportunist species, utilizing abandoned mines, lakes, and ponds, taking advantage of whatever resources they could find in their range, as the number of accessible habitats for foraging and nesting had declined (Ismail & Rahman, 2012).



Apparently, the importance of wetlands as staging and foraging areas for waterbirds and their global decline has earned the concerns and attention of conservationists, scientists, politicians and the public. Government agencies, nongovernmental organizations, and other international organizations have pursued efforts to conserve and protect waterbirds and wetlands. The abundance of waterbirds has been observed to be significantly related to the protection of natural habitats, as reported in the well-known Ramsar sites around the world (Rahman & Ismail, 2018). In addition, several key wetland sites for migratory birds have been recognized as Important Bird and Biodiversity Areas (IBAs) by Birdlife International. Many of these areas have also been designated as protected areas at the national level and have been converted into national parks and bird sanctuaries. These efforts are always moving along with ongoing research and surveys to achieve the objectives and increase the conservation efforts of the waterbirds and their habitats.

Understanding the waterbirds' feeding ecology, especially the interaction between the bird and their prey, helps to guide habitat conservation and accountable development decisions (Jardine *et al.*, 2015). The issues on habitat conservation

require the attentiveness of stakeholders in order to cooperate and coordinate the actions, especially in terms of management and protection of significant sites.

#### **1.2 Problem statement**

With its long coastline, the intertidal wetland is one of Malaysia's dominant habitat types. The multiple functions supported by the intertidal wetland have unfortunately led to its extensive exploitation (UNEP, 2001). These coastal ecosystems, especially mangrove forests, have the highest loss rate in developing countries and Malaysia. The destruction rate was estimated to increase by about 1% or 1282 hectares per year since 1990 (Omar, 2012). Mangroves are cleared for coastal development, aquaculture, timber and fuel production (Polidoro *et al.*, 2010). Similar to the fast pace urbanization at the global level, the loss of mangroves in Johor is the third largest in Malaysia, after Selangor and Pahang states (Kuenzer *et al.*, 2011). The intertidal landscapes along the South West Johor coast are continuously being cleared via massive coastal reclamation works for housing, industrial buildings, ports, and power plants (Kanniah *et al.*, 2015).



The three study sites chosen in this study were shown to have received different intensities of coastal reclamation activities. In Tanjung Piai National Park, the nearby reclamation land was built close to the breakwaters previously built to reduce wave energy and halt erosion along the shore. The presence of this reclamation land has cause localized current speed to increase, thus leading to more erosion events (Tan *et al.*, 2021) that further disturbed the growth of existing mangroves (Awang *et al.*, 2014). Approximately 70 hectares of mangrove forests have been reportedly diminished due to erosion over two decades ago in Tanjung Piai National Park (Perbadanan Taman Negara Johor, 2007).

Similar cases are currently happening on the Pontian Kechil coast, as this coastline has been reclaimed and extended for economic and recreational purposes. Land reclamation is the main factor causing the reduction of tidal flat areas (Zhao *et al.*, 2020) and simultaneously the reduction of foraging ground for waterbirds. Due to the expansion of coastal land, the mudflat areas remained unexposed even at low tide, consequently forcing the waterbirds to fly to other areas to forage. Meanwhile, the coastline habitats in Muar, including mangroves and mudflat ecosystems, are jeopardized as a new development project of an energy hub and deep-sea port, called

The Maharani Energy Gateway, has been proposed in that area. This project involved large-scale reclamation activities, notably creating three man-made islands that are located very close to the shore (Golden Ecosystem Sdn. Bhd., 2022). The impacts of this project are highly concerned and may affect not only the local community in Muar but also wetland-dependent species. Although the project will not directly impact the waterbird along the Muar coast, the reclamation activities may alter and disrupt the mangroves and mudflats which are extremely important foraging and roosting grounds for them. According to the Environmental Impact Assessment report on the project, some of mangrove areas along the Muar coast may experience altered tidal flushing which can deteriorate the health of the mangroves in the area due to irregular flooding (Golden Ecosystem Sdn. Bhd., 2022). Furthermore, as the reclamation project will completely transform the site from a marine to terrestrial habitat, all the existing sedentary benthic organisms in which the main food source for waterbirds will be annihilated.

Several studies have highlighted the adverse impacts of coastal reclamation, including the detrimental effects on the ecosystems and the organisms these systems are supporting and, consequently, the impacts on humans (Yang *et al.*, 2011, Wang *et al.*, 2012). The degradation of the foraging habitat of waterbirds may have a critical impact on their feeding ecology. This factor may be the main cause of the decline in waterbird populations (Hua *et al.*, 2015; Piersma *et al.*, 2016). Therefore, as the next step to investigate the anthropogenic impacts on the waterbird species that are endemic along the South West Johor coast, a strong foundation of research evidence regarding waterbirds, especially on their diversity, distribution and feeding ecology, should be taken seriously.

In general, previous research on waterbirds in Malaysia primarily focused on waterbirds populating non-coastal wetlands (Ismail *et al.*, 2012; Ismail & Rahman, 2012; Rajpar & Zakaria, 2012; Rajpar & Zakaria, 2013; Rajpar & Zakaria, 2014). On the other hand, coastal waterbird studies were mainly aimed at obtaining basic information on species diversity and distribution, with most of the data coming from the annual inventory, census, and checklist. Only in recent years, a few studies on the feeding ecology of coastal waterbirds were conducted by Ismail and Rahman (2016) in Kuala Gula Bird Sanctuary and Norazlimi and Ramli (2015) in Pantai Jeram and Pantai Remis, Selangor. Plenty of baseline data have been collected throughout the decades by the Malaysian Nature Society (MNS), focusing on the distribution and



abundance of waterbirds from a few sites along the South West Johor coast. Despite the abundance of checklists on waterbirds in coastal wetlands, several aspects of ecological studies remain unresolved. The assessment of collected data is frequently limited to the percentage of species or family lists targeted for investigation. The correlation and relationship between waterbird abundance and factors affecting their distribution are still poorly known. Moreover, there is also a lack of rigorous scientific studies on the feeding ecology of waterbirds in those areas. To date, only a study reported on the bird diversity in Tanjung Piai National Park has been published (Yatim-Mustafar et al., 2019). Besides that, three observation studies on coastal birds in Tanjung Laboh, Johor focusing on the species composition within different microhabitats, potential of avian tourism and the foraging ecology of birds utilizing the mudflat of Tanjung Laboh, were carried out and reported by Mokhter et al. (2021), Jien et al. (2021) and Fauzi & Norazlimi (2021), respectively. Meanwhile, an assessment on the abundance and diversity of coastal island bird was carried out by Mokhter & Norazlimi (2020) in Pulau Tinggi Marine Park, Johor. However, none of these previous studies touched on the critical aspect of the feeding ecology, in other words, the prey population.



In particular, there is a lack of information on waterbirds' diets, foraging rates, and prey availability in this region. Therefore, besides reinforcing the conservation efforts through surveys and checklists only, it is also crucial to understand their feeding ecology, as this factor is essentially linked to its population dynamics and helps in understanding the contrasting trophic interactions, such as prey selection, evolution, predation, and energy transfer within and between ecosystems (Braga *et al.*, 2012). This type of ecological information is critical for the survival of species and ecosystems. Therefore, extensive research is needed to gain a comprehensive understanding of ecology. The feeding ecology is often characterized by food selection, habitat preference and prey capturing techniques or behaviour employed by avian species from a particular habitat (Danchin *et al.*, 2008; Aboushiba *et al.*, 2013). Hence, this study aims to investigate the waterbird's diversity and some aspects of their feeding ecology, including prey availability, feeding behaviour and diet composition.

#### **1.3 Research objectives**

The objectives of this study are as follows:

- i. To evaluate the abundance and diversity of waterbird species, and their relationship with prey availability in the three selected coastal mudflat sites along the South West Johor coast.
- To describe the feeding behaviour and diet composition of waterbird populations that are utilizing the three coastal mudflat sites located along the South West Johor coast.

#### **1.4** Significance of the study

Intertidal flats, also known as mudflats, are extremely important feeding areas for coastal waterbirds for various reasons. These productive habitats offer a wide diversity and a high abundance of potential food (Warnock et al., 2010). As mudflats are tidallystructured environments, waterbirds can only feed when the mudflat becomes exposed and accessible to forage (van de Kam et al., 2004). The movement of waterbirds across the exposed intertidal flats area also integrates information on the distribution of food resources (Escudero et al., 2012). The distribution and behaviour of waterbirds within and across mudflats could reflect the current and long-term changes in ecological conditions (Mathot et al., 2018). Therefore, studies on waterbird diversity and abundance along the coastal area of the South West Johor coast are important for developing a sound management plan for conservation purposes. This might become one of the most important baseline data to provide the historical point of reference for the next conservation actions of coastal waterbirds along the South West Johor coast if any development occurs. The ornithological information obtained can also be used to indicate and directly answer the effects of environmental changes due to land reclamation activities on the waterbirds population and its feeding ecology in the three study sites.

The ecosystem functioning and ecosystem services supported by intertidal mudflat have provided a rationale for conservation over the past decades (Cabello *et al.*, 2012). Across the globe, intertidal mudflat habitats are the most important foraging, staging and breeding areas to millions of waterbirds (Delany *et al.*, 2009).



Apart from that, intertidal mudflats functions in nutrient cycling, erosion protection and carbon sequestration (Foster et al., 2013). The soft flats provide natural coastal erosion defence by dissipate wave energy, lowering water velocities and shear the stress on the estuary bed (Spalding et al., 2014). Research suggest that waterbirds could have significant direct and/or indirect effects on ecosystem function of intertidal mudflat via the impacts of feeding on macrofauna, disturbance and reworking sediments (Mathot et al., 2018). The ecology of intertidal mudflats is complex, therefore, the design of effective protection and restoration measures needs to be based on solid ecological knowledge at the local scale, such as waterbird's habitat used, prey availability and feeding ecology (Hua et al., 2015). Considering the lack of detailed studies on the feeding ecology of coastal waterbirds in Johor, especially on their diet composition, this study is considered one of the most important components for the management of coastal waterbirds on the South West Johor coast. Given the current reduction and modification of waterbirds' feeding areas, it is necessary to understand the processes that determine what the waterbirds are eating and how they are selecting their food sources, and thus to predict the likely effects of such changes on their habitats.



Goal 3, stated in the National Policy on Biological Diversity 2016-2025 (NPBD, 2016), mentioned that at least 10% of coastal and marine areas should be protected by 2025 through a representative system of protected areas and other effective area-based conservation measures. To conserve and protect nature in general, in addition to preventing species extinction, we need to know their ecology, for example, how they all fit together, what their habitat requirements are, how they interact, and what minimum population sizes are required to ensure their survival (Litvaitis, 2000; Ahlbeck *et al.*, 2012). Comprehensive and coordinated conservation actions are needed from the government, civil society, donors, and corporate sectors since around 62% of IBA in Malaysia are still not officially protected (Yeap *et al.*, 2007). This step can only be done by having a solid foundation of scientific knowledge, especially on the diversity of waterbirds and their feeding ecology. The data collected in this study can also help decision-makers and stakeholders review and, where possible, expand national protected area systems to fill the gaps in the coverage of the IBA network.

#### **1.5** Scope of the study

The scope of this study was to evaluate the waterbirds in three coastal sites along the South West Johor coast (namely Tanjung Piai National Park, Pontian Kechil coast and Muar coast), mainly in terms of diversity and feeding ecology. The duration of this study was for six months, with two months interval set for each study site. The feeding ecology of waterbirds was focused on their feeding behaviour and diet composition, as well as prey availability at the three study sites. The direct count method was used to determine the species composition, and the abundance of waterbird's individuals and species diversity for each site was analysed using Paleontological Statistics software (PAST) (Hammer & Harper, 2006). The number of individuals of each species was counted and recorded for each study site. However, the probability of repeated counts is high because the waterbird individuals are not marked. Therefore, the average number of individuals counted per interval session was instead calculated to minimize the risk of double counting.

At the same time, focal observations were used to study the waterbirds' diet composition and foraging behaviour, including their foraging techniques and prey of the waterbirds. Three distinguished techniques are observed in the feeding patterns of waterbirds: (i) tactile hunting species, in which the birds forage as they walk and throb their bill to the substrate continuously, (ii) visual feeding species, in which the birds visually detect and catch their preys, and (iii) pause-travel species, in which the birds scan the area and peck at the prey in a stop-run-stop manner once they had detected it. On the other hand, macroinvertebrate collection was conducted using sediment cores to determine prey availability in each plot.



## **CHAPTER 2**

### LITERATURE REVIEW

As in most animal groups, the diversity of bird species is the greatest in tropical

#### 2.1 Diversity of avifauna in Malaysia

regions, specifically near the equator and decreases in areas toward the poles (Hillebrand, 2004; Schumm *et al.*, 2019). Tropics are surrounded by 25 biodiversity hotspots in the world that are home to 2821 endemic birds (Myers *et al.*, 2000), including Tropical Andes, Madagascar, Caribbean, Indo-Burma, Western Ghats and Sri Lanka, Wallacea, Philippines and Sundaland (Brummit & Lughadha, 2003). In addition, the Sundaland region that encompasses Peninsular Malaysia on the Asian mainland, Borneo, Sumatra, Java and its surrounding islands is the home to about 139 species of bird that are endemics to this region (Myers *et al.*, 2000). The latest number of bird species documented in Malaysia is 847 (Puan *et al.*, 2020), with Peninsular Malaysia harbouring more than 670 species (MNS Bird Conservation Council, 2015) that range from endemic and resident to migratory and vagrant. Like other tropical countries, Malaysia possesses a wide variety of habitats, with plentiful resources that lead to the harbouring of a high number of avian species. In fact, Malaysia ranks among the 12 mega-diverse countries which contain about 70% of the world's species (Ministry of Natural Resources and Environment, 2015).

Different species of birds require different natural habitats (Tu *et al.*, 2020). The productive environments in natural habitats offer high availability of food sources and wide ranges of habitat niches to support a diverse variety of bird species living in those particular habitats. Blessed with a vast array of ecosystems, the tropical rainforest constitutes the core of biodiversity in Malaysia, a unique natural heritage



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