Foraging Ecology of Birds in Mudflat Area of Tanjung Laboh, Johor

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Abstract. Tanjung Laboh is located in one out of three Important Bird Areas (IBAs) in Johor called South West Johor Coast which is very crucial foraging ground for resident and migratory shorebirds. However, the airfield development plan located in the area have been an issue as it might disturbed the foraging ecology of the shorebirds. Therefore, it is necessary to analyse the food resources present and the foraging behaviour of the shorebirds in order to determine the effect of disturbance towards the shorebirds’ foraging behaviour. Thus, a study was conducted for a month (July to August 2018) in the mudflat area of Tanjung Laboh to identified the time spent of foraging, food selection and foraging technique of shorebirds by using direct observation method. A total of 212 observations were recorded during sampling period. No significant differences were found in time spent foraging between the bird species, (F = 0.18, p = 0.946).

A Spearman Rank Correlation proved that there is no significant relationship between the time spent of foraging and the number of preys taken by each species (R= 0.436, p > 0.05). Based on observation, fish is the most preferred diet choice among bird species which counts a total of 57% followed by unknown (20%), worm (19%) and bivalve (4%). Significant correlation was found between the abundance of bird and the frequency of disturbances (humans, dogs and vehicles) (p < 0.05) while human contribute to a higher percentage in disruptions towards the species studied (57.7%). The responses of the birds towards the disturbances were varied in this study, however the birds tend to choose foraging ground far from disturbance area as the disturbances might chase birds’ prey away thus reduce their feeding rate. By understanding how the shorebirds response toward disturbance, the conservation action can be enforced in the future.

1. Introduction
Shorebirds usually occupy a wide range of habitat includes coastal, saline and freshwater wetlands. Coastal wetland is one of the most productive habitats in the world, accommodate a huge number of shorebirds species [1]. The non-tidal grounds of saltmarshes and coastal lagoons provide breeding and foraging habitat for many species while foraging flocks which can number into the hundreds of thousands of birds inhabit the tidal mudflats [2,3,4]. Productive mudflat ecosystem serves as a vital feeding ground for shorebirds as it offers a vast diversity and high abundance of prey.

In spite of their importance, wetlands especially mudflat and their associated mangrove are currently facing destruction and have been reduced tremendously throughout Asia due to inflation in human population and corresponding demand for land [5]. Human influences have cause significant
changes in the function and quality of many wetlands. These changes have resulted from alteration of the physical, chemical and biological components of wetland ecosystems. Extensive land development and clearing have caused increased sedimentation in lowland wetlands and alter the chemical and hydrological regime of the wetlands in a relatively short time [6]. Massive alteration on the intertidal habitat in this century has reduced the foraging areas for both resident and migratory shorebirds [7,8,9]. For conservation of shorebirds and its habitat, a full understanding on its foraging ecology are needed as it is one of the most fundamental components for a particular species to exist and survive [10]. Unfortunately, the foraging ecology of shorebird species in Malaysia is still poorly understood and to date, no detailed information on foraging ecology of shorebirds has been recorded and documented in Tanjung Laboh, Johor. Hence, a study on foraging ecology of shorebirds in the mudflat in Tanjung Laboh was conducted. In addition, the effects of disturbances towards the foraging behaviour of the shorebirds was also reported in this study.

2. Materials and Methods

2.1 Study area
Tanjung Laboh is located in the West Coast of Peninsular Malaysia (1.7376° N, 102.9937° E) where it is lies along the coastal line of South West Johor Coast, one of the Important Bird Areas (IBAs) in Johor (Figure 1). The productive mudflat serves as a stopover site and support a high number of migratory shorebirds for foraging and resting before they continue their journey. The study was conducted from July 2018 until August 2018 by using direct observation technique. Three sites with different frequency of visitors were chosen to study the effect of disturbance on the birds. Plot 1 and Plot 2 received a higher number of visitors since the area is located near to the local people residency compared to Plot 3 which is quite isolated.

![Figure 1: The coastal mudflats of Tanjung Laboh, Johor](image)

2.2 Foraging behaviour
Selected focal birds were observed using the binocular (10 × 50 magnifications), stopwatch and video recorder. The actively foraging shorebird individual was observed starting from the time the
individuals searching for prey until it was successfully swallowed. The observation was recorded for at least 30 seconds and up to a maximum of 5 minutes. If the birds left within 30 seconds, the observation are not counted [11]. Observations were only conducted during low tide period to allow shorebirds with different body sizes use the mudflat ground at the same time. Since the birds were not marked, an assumption was made to minimize the repeated counting. The foraging techniques were categorized into three major groups, (1) tactile hunting species: the bird forage as they walk by throbbing their bill to the substrate continuously [12,13]. Secondly, visual feeding species: the bird detects the prey visually [14] and third, pause-travel species: the bird forage by scanning the area and pecking at the prey once it is detected in a stop-run-stop fashion [15,16].

2.3 The effect of disturbance while foraging
Five species of shorebirds have been identified during the preliminary observation and the species was used to study their responses toward the disturbances. These species were often found near the human community compared to other species such as Great Egret (Casmerodius albus/Ardea alba), Little Heron (Butorides striata), Little Egret (Egretta garzetta), Lesser Adjutant (Leptoptilos javanicus), and Common Redshank (Tringa totanus). The response of the shorebirds towards the disturbance was categorized into 4 categories which are (1) stop feeding and stay (alert), (2) stop feeding and fly, (3) stop feeding and run and (4) continue feeding (habituated). The disturbances were classified into groups of activities under human, dogs and vehicles. The frequency of disturbance recorded was compared between sites.

2.4 Data analysis
The data collected from this study was analyzed using Paleontological Statistics (PAST) [17]. All the data sets from the observation were tested using Anderson’s Darling test to check for normality. In all cases, α = 0.05 was used. One-way Anova was used to determine the significant differences the time spent foraging between species while Spearman Rank Correlation was used to show if there is any significant relationship between time spent foraging and the number of preys taken by each species. One-way Anova analysis was used to infer any significant differences of foraging techniques between species. The differences of the number of shorebird individuals between three plots were determined. Significant correlation between the abundance of shorebirds and the frequency of disturbance were determined by using Spearman’s Rank Correlation analysis.

3. Results and Discussions

3.1 Taxonomic composition
A total of 212 observations were recorded in 3 plots in Tanjung Laboh that includes 8 species of birds that belongs to 5 families (Table 1) (Table 2). One species, Lesser Adjutant (Leptoptilus javanicus) classified as Vulnerable according to IUCN Red List of Threatened Species, while the remaining 7 species were classified as Least Concern. Table 1 shows Plot 3 recorded the highest number of shorebird individuals followed by Plot 1, while Plot 2 recorded the least number of individuals. The location of Plot 3 that is isolated with limited the number of visitors and vehicles into the area allows the shorebirds species to forage without any disturbance. Grey Heron (Ardea cineria) recorded the highest number of individuals compared to the other bird species (Table 1). As Grey Heron is a resident species, it can be found throughout the time either during the migratory season or non-migratory in which they permanently inhabit the mudflat area for foraging, nesting and roosting (Table 1).

3.2 Foraging Ecology
One-way ANOVA analysis shows no significant different for time spent foraging between shorebird species (F = 0.18, P= 0.946). However, observations show Little Heron (Butorides striata) spent the longest time of foraging compared to other species, while Collared Kingfisher (Todiramphus chloris) spent the shortest time of foraging (Table 3). The different types of feeding techniques are likely to
influence the average time spent by the shorebird species. Little Heron are immobile foragers [18]. They seek prey by pause-travel technique that required more time for searching and scanning of prey before capture it. While Collared Kingfisher was observed to practice visual-feeding technique that required short time for scanning and searching the prey. Collared Kingfisher will observe their prey from tree branches before fly down to capture their prey once detected (Figure 3). On the other hand, a Spearman Rank Correlation proved that there is no significant relationship between the time spent foraging and the number of preys taken by each species ($R=0.436$, $p > 0.05$). Result shows Grey Heron (Ardea cinerea) recorded the highest number of prey taken even the time of foraging it spent is short while Great Egret (Casmerodius albus/Ardea alba) consume the least number of prey but it required a longer time to forage (Table 3). Even though both species practiced pause-travel technique in which more efficient compared to the other techniques that require lower energetic cost [18], however observation shows Great Egret are solitary feeders. They required longer handling time associated with larger prey slowed their foraging rate. Barbosa (1995) suggested that the pause-travel species tend to be solitary or to form small flocks.

In terms of food selection, four preys were observed as the main diet for the birds which are fish, worms, bivalve and the rest are unknown. Based on observation, the most preferred diet choice among bird species is fish which counts a total of 57% followed by unknown preys (20%), worm (19%) and bivalve (4%). The foods that categorized under unknown were the foods that cannot be seen and identified during the observation. Fish is the most preferred diet choice among the shorebirds. This is due to the high availability of mudskippers that usually exposed during the low tide in the mudflat area. All shorebird species observed consumed fish as their main diet except for Kentish Plover (Charadrius alexandrinus) (Figure 2) due to its morphology in which they have very small bill that restrict them to only eat small prey such as invertebrate and bivalve [20,21]. Smaller prey reduced handling time and thus reduced time spent foraging.

There were no statistically significant differences of foraging techniques between species ($F = 0.47$, $p = 0.718$). A similar result was recorded in a study in Jeram and Remis Beach of Selangor [22]. The foraging techniques were different among shorebird species. The pause-travel techniques are the most dominant technique used by Little Heron (Butorides striata), Lesser Adjutant (Leptoptilos javanicus), Little Egret (Egretta garzetta), Grey Heron (Ardea cinerea), Common Redshank (Tringa totanus) and Great Egret (Casmerodius albus/Ardea alba) whereas the visual feeding technique only used by Collared Kingfisher (Todiramphus chloris) and tactile-hunting was the only techniques used by Kentish Plover (Charadrius alexandrinus) (Figure 3). The pause-travel techniques increase the chances of successful attempt made by the shorebirds even it requires more time in scanning the prey. The longer time spent for scanning the prey, the higher the chance to catch it because the slow step took by the shorebirds can prevent the prey from running away. Moreover, this foraging technique is likely associated with movement from one micro-patch to another rather than active search or pursuit of prey. This resulted in reduced rates of foraging effort [18]. However, different result has been shown in the previous study that suggested the tactile-hunting technique is the most efficient because much of the bird’s time spent was concentrated on searching for food compared to pause-travel technique as the bird spends most of its time being more vigilant than foraging [22].

3.3 Response of birds towards the disturbance

The number of individuals of the shorebird between Plot 1, Plot 2 and Plot 3 shows no significant differences ($F = 2.095$). However, by using T-test, the results show that the number of individuals in Plot 3 was the highest compared to Plot 1 and Plot 2. Five species of shorebirds were identified for further analysis. These species were used to study their response towards frequency of disturbance (these species were often found near the human community compared to other species). These species are Great Egret (Casmerodius albus/Ardea alba), Little Heron (Butorides striata), Little Egret (Egretta garzetta), Lesser Adjutant (Leptoptilos javanicus), and Common Redshank (Tringa totanus). Significant correlation was found between the abundance of bird with the frequency of disturbances (humans, dogs and vehicles) ($p < 0.05$) (Table 4). Human was a major contributor of disturbance towards shorebirds (57.7%), followed by vehicles (36.1%) and dogs (6.0%). Among these, the most
disruptive activity was walking human (38.5%) (Figure 4). Observation proved that Plot 3 recorded the lowest number of disturbance since it is situated far from any human intervention and recreational activity. Whereas Plot 1 and Plot 2 were located near the access road and often visited by local people for recreational purpose and mussels collecting activities. Plot 2 recorded the highest number of dog presence as disturbance. Similar result was found in several beaches in New Jersey that were strongly disturbed by the presence of dogs and human [23]. Human activity is the most impact disturbance to the foraging behaviour of the birds. This includes fishing, walking and mussels collecting. The effect of intruders including human can be disruptive, especially when human activity is intense [24].

The response of the shorebirds towards the disturbance were varied in this study. Great Egret (Casmerodius albus/Ardea alba), Little Heron (Butorides striata), Little Egret (Egretta garzetta) and Lesser Adjutant (Leptoptilus javanicus) shows no response to the disturbances. Whereas Common Redshank (Tringa totanus) will responses to the disturbance by stop eating and stay alert. From 55 observations done, 65% of shorebirds shows no response to the disturbances and continue foraging. We believe that the species shows no response because of the birds was habituated by human presence since Plot 1 and Plot 2 receives high frequency of visitors for recreational purpose. In fact, only 9% of the shorebird fly away when they encounter the disturbances. This might due to the different types of disturbance encountered by the shorebirds. Due to the lack information on the distance between bird individuals and disturbance, we cannot predict the level of tolerance of the shorebirds towards disturbances. However, previous study proved that the tolerance towards disturbances varies among species [25]. Bellefleur et al., (2009) showed that different types of disturbance affect response time by individual birds. The types of disturbance cause birds to flush sooner included any activities with rapid movement such as running and unleashed dogs. Habituation require predictable patterns of human activity in which birds can learn and identify which one do not pose any threat [27]. A few studies show the shorebirds might risk their life due to starvation if they flush sooner due to the disturbance, hence birds with poor condition may need to continue forage until the last possible moment because they need to consume as much resources as possible [28,29].

| Common name      | Scientific name     | Family        | IUCN status | Distribution status |
|------------------|---------------------|---------------|-------------|---------------------|
| Collared Kingfish| Todiramphus chloris | Alcedinidae   | LC          | Resident, Migrant   |
| Little Heron     | Butorides striata   | Ardeidae      | LC          | Resident, Migrant   |
| Lesser Adjutant  | Leptoptilus javanicus | Ciconiidae | VU          | Resident            |
| Little Egret     | Egretta garzetta    | Ardeidae      | LC          | Resident, Migrant   |
| Grey Heron       | Ardea cineria       | Ardeidae      | LC          | Resident            |
| Common Redshank  | Tringa totanus      | Scolopacidae  | LC          | Migrant             |
| Kentish Plover   | Charadrius alexandrinus | Charadriidae | LC          | Migrant             |
| Great Egret      | Casmerodius albus/Ardea alba | Ardeidae | LC          | Resident, Migrant   |

Table 1: List of bird species found in the study areas with its distribution status and IUCN status.
Table 2: Summary of frequency of bird species observed foraging in three plots

| Species            | Scientific Name               | Number of individuals (n) | Plot 1 | Plot 2 | Plot 3 | Total |
|--------------------|-------------------------------|---------------------------|--------|--------|--------|-------|
| Collared Kingfisher | Todiramphus chloris          |                           | 16     | 6      | 4      | 26    |
| Little Heron       | Butorides striata            |                           | 15     | 11     | 13     | 39    |
| Lesser Adjutant    | Leptotilus javanicus         |                           | 2      | 0      | 6      | 8     |
| Little Egret       | Egretta garzetta             |                           | 3      | 1      | 8      | 12    |
| Grey Heron         | Ardea cineria                |                           | 21     | 4      | 19     | 44    |
| Common Redshank    | Tringa totanus               |                           | 3      | 10     | 25     | 38    |
| Kentish Plover     | Charadrius alexandrinus      |                           | 0      | 11     | 32     | 43    |
| Great Egret        | Casmerodius albus/Ardea alba |                           | 0      | 0      | 2      | 2     |
| **Total**          |                               |                           | 60     | 43     | 109    | 212   |

Table 3: The summarized value of number of preys taken and average time spent foraging

| Species               | No. of prey taken | Average time spent foraging (min) |
|-----------------------|-------------------|----------------------------------|
| Collared Kingfisher   | 28                | 2.58                             |
| Little Heron          | 42                | 26.34                            |
| Lesser Adjutant       | 12                | 6.32                             |
| Little Egret          | 17                | 7.36                             |
| Grey Heron            | 49                | 6.57                             |
| Common Redshank       | 42                | 13.48                            |
| Kentish Plover        | 47                | 9.46                             |
| Great Egret           | 5                 | 12.49                            |
| **Total**             | 242               | 86.40                            |
**Figure 2:** Diet choice and their abundance choose by species

**Figure 3:** Foraging technique used by bird species
Table 4: Results of Spearman’s rank correlation analysis on the relationship between shorebird with disturbance from human, dogs and vehicles on Plot 1, Plot 2 and Plot 3.

| Sites  | Human R | Human p | Dogs R  | Dogs p  | Vehicles R | Vehicles p |
|--------|---------|---------|---------|---------|------------|------------|
| Plot 1 | -0.224  | <0.05   | 0.525   | <0.05   | 0.297      | <0.05      |
| Plot 2 | 0.472   | <0.05   | 0.395   | <0.05   | 0.352      | <0.05      |
| Plot 3 | 0.437   | <0.05   | 0.605   | <0.05   | 0.594      | <0.05      |

Figure 4: Percentage of disturbance of recorded in the study.
4. Conclusion

For conclusion, each species of shorebird engaged with different type of foraging techniques. The pause-travel technique is the most suitable foraging techniques in the study area due to the type of prey available and it can increase the chance of successful feeding rate compared to other techniques. This study shows that most of the birds in the study area have been habituated by the disturbances. Most of the species does not giving any response towards the disturbance and continue to eat. The birds might have encountered the disturbance since a long time ago and have been manage to change their habit or behaviour towards the disturbance. However, the shorebirds are preferable to forage in less disturbed areas to ensure the chances of capturing prey are high. One way to reduce the impact of human activities is to introduce the physical barriers such as retaining walls, it can be used to prevent the direct visual contact between the shorebirds and disturbances. This can be implied in the area where the foraging activities of the shorebirds were the highest.

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