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# The Effects of Disturbance on the Abundance and Foraging Behaviour of Shorebirds and Waterbirds in the Tropical Mudflat Areas

(Kesan Gangguan Terhadap Kelimpahan dan Tabiat Pemakanan Burung Pesisir Pantai dan Burung Air di Kawasan Berlumpur Tropika)

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ABSTRACT

*A study was conducted in the mudflats of Jeram and Remis Beaches, Selangor, Peninsular Malaysia from November 2013 until July 2014 to determine the effects of disturbance on shorebird and waterbird abundance and foraging behavior. Direct observation was used in this study. Mann-Whitney test showed no significant difference in abundance of bird in Jeram and Remis Beaches (*t=*2.96,* p=*0.05). A significant difference were detected between the sampling plots in Jeram Beach (*S=*16.67,* p<*0.001) and Wilcoxon Signed Rank Test shows a significant difference between the sampling plots in Remis Beach (W=78,* p=*0.003). Spearman's rank correlation shows significant association between the abundance of bird with the abundance of humans, dogs and vehicles (*p<*0.05) in both Jeram and Remis Beaches. Humans contribute to a higher percentage in disruptions towards the species studied (47.5%), followed by dogs (32.1%) and vehicles (20.4%). Thirty-six percent of birds stopped feeding and flew away upon disruption, 23% stopped feeding and run away, 22% stopped feeding but stay alert and 19% continue feeding (habituated). Analysis on the responses of birds toward the disturbance show significant difference between species (*$\chi^2$ *= 98.77,* p<*0.05). This study concluded that anthropogenic disturbance caused a major impact on shorebird and waterbird abundance and influenced their foraging behavior. Response of bird towards disturbance was varied according to the species and types of disturbance. By understanding how the bird species response toward disturbance, the conservation efforts can be implemented more effectively in the future.*

*Keywords: Disturbance; habituation; intertidal mudflats; shorebirds; waterbirds*

ABSTRAK

*Suatu kajian telah dijalankan di kawasan berlumpur di Pantai Jeram dan Pantai Remis, Selangor, Semenanjung Malaysia dari November 2013 sehingga Julai 2014 bertujuan untuk mengenal pasti kesan gangguan terhadap kelimpahan dan tabiat pemakanan burung pesisir pantai dan burung air. Teknik pemerhatian secara langsung telah digunakan dalam kajian ini. Ujian 'Mann-Whitney' menunjukkan tiada perbezaan ketara dalam kelimpahan burung di Pantai Jeram dan Pantai Remis (*t=*2.96,* p=*0.05). Perbezaan ketara telah dikesan di antara plot-plot pensampelan di Pantai Jeram (*S=*16.67,* p<*0.001) dan Ujian 'Wilcoxon Signed Rank' menunjukkan terdapat perbezaan ketara di antara plot-plot persampelan di Pantai Remis (*W=*78,* p=*0.003). Kolerasi 'Spearman Rank' menunjukkan terdapat hubungan yang signifikan antara kelimpahan burung dengan kelimpahan manusia, anjing dan kenderaan (*p<*0.05) di Pantai Jeram dan Pantai Remis. Manusia menyumbang kepada peratusan gangguan tertinggi terhadap spesies yang dikaji (47.5%), diikuti oleh anjing (32.1%) dan kenderaan (20.4%). Tiga puluh enam peratus burung berhenti makan dan terbang sejurus gangguan berlaku, 23% berhenti makan dan lari, 22% berhenti makan tetapi berwaspada dan 19% tidak berhenti makan (habituasi). Perbezaan ketara telah ditunjukkan di antara spesies-spesies burung melalui maklum balas ke atas gangguan (*$\chi^2$ *= 98.77,* p<*0.05). Kajian ini menyimpulkan bahawa kelimpahan dan tabiat pemakanan burung pesisir pantai dan burung air terjejas oleh gangguan antropogenik. Tindak balas burung terhadap gangguan berbeza mengikut spesies dan jenis gangguan. Dengan memahami bagaimana spesies burung bertindak balas terhadap gangguan, usaha pemuliharaan dapat dijalankan dengan lebih berkesan pada masa hadapan.*

*Kata kunci: Burung air; burung pesisir pantai; gangguan; habituasi; lumpur pasang surut*

## INTRODUCTION

Shorebirds generally feed at low tide and can be observed on beaches, intertidal mudflats, freshwater and brackish wetlands, farmland and salt marshes (Spencer 2010). Meanwhile, waterbirds refer to the bird species that entirely depend on wetlands for a variety of activities such as foraging, nesting, loafing and moulting (Rajpar & Zakaria 2010). Mudflat or tidal flat are intertidal, non-vegetated, soft sediment habitats, found between mean high-water and mean low-water spring tide cycles (Dyer et al. 2000; Smithsonian Institution 2010) that can be found generally in estuaries and other low energy marine environment. Mudflats perform many ecological functions by providing spawning grounds for fish, habitats for birds, reptiles and

other important fauna as well as protecting the coastal zone from erosion (University of Sydney 2010). Both shorebirds and waterbirds are important components of estuarine mudflats.

Increasing levels of human disturbances in estuaries are exerting pressures on shorebirds populations (Hill et al. 1997). On their roosting and foraging grounds, shorebirds can have high disturbance rates by fisherman, watercrafts, walkers and dogs (Blumstein et al. 2003; Burger & Gochfeld 1991; Fitzpatrick & Bouchez 1998; Paton et al. 2000) or coastal developments (Burton et al. 2002; Durell et al. 2005). Waterbirds often respond to the presence of recreational activities in their environment by deviations from their predominant behavior (Platteeuw & Henkens 1997). Human-induced disturbance at high tide roost sites (Burton et al. 1996) and low tide feeding sites (Burger 1981; Thomas et al. 2003) can also results in higher energy expenditure and a reduction in food intake for birds at their non-breeding or staging sites (Coleman et al. 2003; Stillman & Goss-Custard 2002), which can impinge on their ability to build fat reserves to fulfil their annual cycle of moult, migration and breeding (Spencer 2010). In coastal wetlands, the loss and degradation of roosting habitat can directly impact shorebird populations, as roosting takes up to 50% of their daily activity (Burton et al. 1996). Birds that remain in areas with high disturbance may spend less time roosting and more time being vigilant or active (Barbee 1994; Morton 1996). Previous study recorded that the scanning rate of shorebird increases with respect to disturbance, implying a greater proportion of time spent in vigilance (Fitzpatrick & Bouchez 1998). Burger et al. (2004) found that shorebird foraging is disrupted by the presence of people and dogs. Furthermore, Burger and Gochfeld (1998) found that many species of waterbirds decreased their foraging time and increased their vigilance when people were nearby.

Most studies on the effects of disturbance on shorebirds and waterbirds were conducted in temperate areas while ecological investigations on shorebirds and waterbirds in tropical environments are scarce (Kober 2004). To date, no detailed study was conducted to determine the factors affecting the distribution of the shorebird and waterbird species in Malaysia. Therefore, this study aims to investigate how disturbances caused by humans, vehicles and dogs are affecting the abundance and feeding behavior of shorebirds and waterbirds species utilizing the coastal mudflats area of Jeram and Remis Beaches in Selangor, Peninsular Malaysia. The effect of disturbance on bird's abundance and behavior were investigated by comparing the bird's abundance within the plots in respective beaches and between the beaches.

## Materials and Methods

### Study Area

Jeram and Remis Beaches are located in West Coast of Peninsular Malaysia (3° 13' 27" N, 101°18'13"E) (Figure 1). The distance between Jeram Beach and Remis Beach is approximately 2 km. The selected study areas comprise approximately 55 ha of the intertidal mudflats area. The selection of these sites was based on past history of shorebird and waterbirds counts reported by Wetland Internationals in 1999-2004 (Li & Ounsted 2007) which shows that these sites were known as important stopover site for shorebirds and waterbirds. Besides that, to study the disturbance effects on shorebird and waterbird, two beaches were chosen due to differences in visitors number. Remis Beach is quite popular among tourist compared to Jeram Beach which is quite isolated. In Jeram Beach, the mudflat was fringed by a mangrove stand of stunted *Avicennia alba* Blume and few scattered *Sonneratia* sp. (Polgar 2012). The study areas were further divided into small plots. In Jeram Beach, three plots were setup in which the size of each plot is approximately 900 m length and 100 m width. The total sampling area in Jeram Beach is 27 ha. However, only two plots were established in Remis Beach due to high intensity of human activities. The size of each plot is approximately 700 m length and 200 m width. A total sampling area in Remis Beach is 28 ha.

### Disturbance

This study was conducted from November 2013 until July 2014. Monthly observations were conducted to count birds individuals in both study areas for ten consecutive days by direct observation technique using a binoculars (12 × 42 magnification) and a video recorder (Nagarajan & Thiyagesan 1996). The count was divided into four daily sessions, i.e. from 0800 - 1000 h, 1000 - 1200 h, 1400 - 1600 h and 1600 - 1800 h. Preliminary study indicated that birds are less active during midday (from 1200 until 1400 h), therefore no observation and recording were done during this session. During each session, birds in all plots were counted for the first 30 min while the remaining time was used to study bird's reaction towards disturbance. All birds present in each plot can be easily identified and counted because the intertidal mudflat areas of Jeram and Remis beaches were relatively open and unvegetated. Flying forward birds were excluded from counting and only those feeding and flying within the sampling area were recorded (Pandiyan et al. 2010). Extreme care was practiced to locate all birds present within the sampling plots. To minimize multiple counting, the birds were counted twice in each plot and the results were divided by two to obtain the average values. During sampling, birds were counted from at least 100 m away to ensure the researcher's presence did not affect bird numbers (De Boer & Longamane 1996). Counting of birds under extreme weather conditions (e.g. windy and/or rainy days) was not conducted due to possible adverse effects on bird's activity and density (Conner & Dickson 1980). The number of bird species, type of disturbance (from humans, dogs or vehicles), disturbance's frequency and disturbance's activity (fisherman, walkers, passed by dogs, dogs whose intentionally chased the birds, seen and heard vehicles,

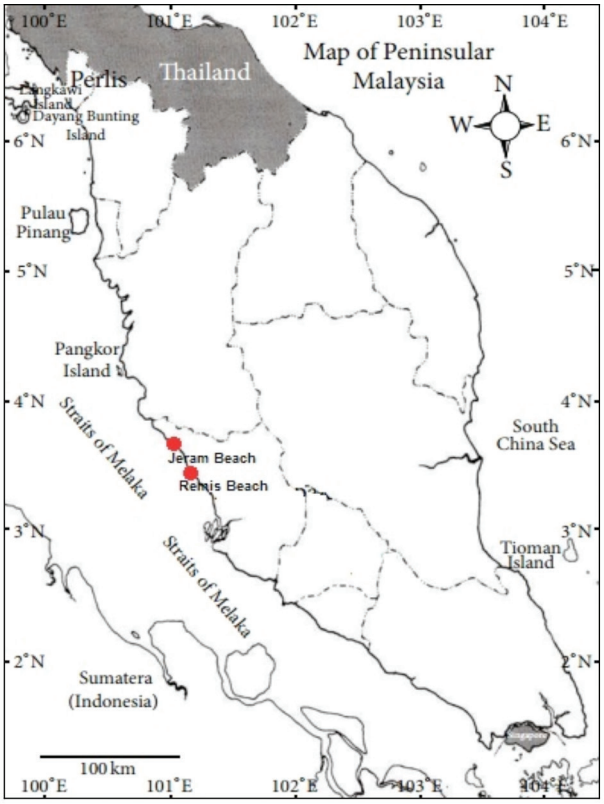


FIGURE 1. The location of coastal mudflats of Jeram and Remis Beaches in Selangor, Peninsular Malaysia

unseen but heard vehicles) were recorded. In addition, the response of birds towards disturbance and their distance from disturbances were also recorded. The approximate distances from approaching disturbance were recorded as soon as the bird started showing responses towards the disturbance.

### STATISTICAL ANALYSIS

STATISTICA was used in this study to analyze all data (StatSoft. Inc. 2007). All data sets were tested with Shapiro Wilke's W test and Anderson's Darling test for normality. In all cases, $\alpha = 0.05$ was used. Mann-Whitney test was used to determine the difference in the abundance of bird species in Jeram and Remis beaches. One-way ANOVA was then carried out to test the differences in bird's abundance in all plots in Jeram Beach while Wilcoxon Signed Rank Test was conducted to analyse bird's abundance in Remis Beach. The Spearman's rank correlation was then used to identify the relationships between bird abundance with types of disturbances. Shannon-Weiner Diversity Index, H', was used to compare the number of the bird species presence in both beaches. The Spearman's rank correlation was then used to identify the relationships between birds. The frequencies of each type of responses (feeding behavior) toward disturbance were compared between the seven species which commonly exposed to disturbances by using Chi-Square, $\chi^2$ tests (Fizpatrick & Bouchez 1998).

## RESULTS AND DISCUSSION

The abundance of birds between Jeram Beach and Remis Beach shows no significant differences ($t = 2.96$, $p = 0.05$). However, more birds species were recorded in Jeram Beach ($H' = 2.338$) than Remis Beach ($H' = 2.3154$). On contrary, the abundance of bird was different in all sampling plots. A significant different on bird's abundance was recorded between the sampling plots in Jeram Beach ($S = 16.67$, $p < 0.001$). The pairwise comparisons analysis proved differences between plot 2 and plot 3 are significant ($z = 1.667$, $p < 0.001$). Likewise, Wilcoxon Signed Rank Test shows a significant difference on bird's abundance between the sampling plots in Remis Beach ($W = 78$, $p = 0.003$). In Jeram Beach, plot 2 recorded highest number of bird counted throughout study period followed by plot 1 and plot 3.

Seven species of shorebirds and waterbirds were identified. 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 (*Ardea alba*), Little heron (*Butorides striata*), Lesser sand plover (*Charadrius mongolus*), Little egret *(Egretta garzetta*), Lesser adjutant (*Leptoptilos javanicus*), Whimbrel (*Numenius phaeopus*) 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 1). Human was major contributor of

disturbance towards birds (47.5%), followed by dogs (32.1%) and vehicles (20.4%). Among these, the most disruptive activity was mussel collection by human (29.3%) (Table 2).

The responses towards disturbance are varied between species (Figure 2). $\chi^2$ analysis indicated that all species responded to disturbance in all of four ways categorized, but there were significant differences between the species in the frequencies of these responses ($\chi^2 = 98.77, p < 0.05$). Figure 3 shows the percentage of bird's responses towards disturbance. The most preferred distance by bird species in tolerating approaching disturbance was between 0 to 5 meters (Figure 4).

Any deviation from normal behavior in response to unexpected occurrences in the vicinity of a bird can be defined as a disturbance (Platteeuw & Henkens 1997). Higher index value reflects higher species richness and diversity in a particular habitat compared to habitat with lower index value. The number of species documented in a community may reflect the characteristics of the habitat and the interactions among species that live in that community (Schluter & Ricklefs 1993). The higher number of species within a particular habitat indicates that the habitat is of better quality and therefore more interaction occurred between species living in the community.

Although the abundance of bird was not significantly different between sampling areas, the abundance of bird was different in all sampling plots. In Jeram Beach, plot 2 recorded the highest number of bird counted throughout the study period followed by plot 1 and plot 3. Observations proved that less disturbance were recorded in this plot. Plot 1 was located near to the food stalls and people have tendency to wander around this plot compared to the other plots. The presence of dogs in plot 3 was most influenced disturbance recorded in that plot. Plot 2 was considered to be the most isolated from disturbances and small mangroves area also situated in this plot area. Adjacent mangrove forest had served as protection area for birds during disturbance. Most bird species flew towards the mangrove forest upon disturbance. The presence of dogs was seen as threats by bird species in plot 3. Similar result was found in Southern California beach which recorded 39% of disturbance was caused by dogs (Lafferty 2001). The effect of disturbance on birds by dogs is disproportionate due to some dogs have tendency to chase birds. Therefore some birds are more sensitive to the disturbance caused by dogs than human (Lafferty 2001).

On a contrary, the analysis showed that plot 2 in Remis Beach recorded highest number of birds utilizing the mudflats area although the intensity of disturbance was higher than plot 1. We believe that this occurred because bird in this area was habituated by humans. Birds can become habituated to disturbance (Fitzpatrick & Bouchez 1998) because habituation require predictable patterns of human activity which birds can learn and identify which one do not pose any threat (Burger 1989; Burger & Gochfeld 1991). In this context, birds ignore human which they usually encountered and show no harms towards them. In our study, the habituation can be seen when the birds show no response although the disturbance agent was too close to the birds. Compared to plot 1, mussel's collection activities were the highest in plot 2. This indicated that plot 2 may have more food resources for birds. Individual birds keen to forage in the area where the food is plentiful although disturbance by humans occurred. This is to optimize energy use because flying to another foraging area will increase energy expenditure (Lafferty 2001; Nudds & Bryant 2000). When some patches are richer than others,

TABLE 1. Results of Spearman's rank correlation analysis on the relationship between shorebirds and waterbirds with disturbance from human, dogs and vehicles on Jeram Beach and Remis Beach

| Sites | Human | | Dogs | | Vehicles | |
|---|---|---|---|---|---|---|
| | R | p | R | p | R | P |
| Jeram | 0.7236 | <0.05 | 0.0836 | <0.05 | 0.4531 | <0.05 |
| Remis | 0.6862 | <0.05 | 0.2576 | <0.05 | -0.0255 | <0.05 |

TABLE 2. Types of disturbance source, activities, frequency and percentage of disturbance of shorebirds and waterbirds

| Types of disturbance source | Type of activities | Frequency | Percentage (%) |
|---|---|---|---|
| Human | Fishermen | 12 | 2.7 |
| | Walkers | 69 | 15.5 |
| | Collecting mussels | 131 | 29.3 |
| Dogs | chasing the birds | 54 | 12.1 |
| | passing by | 89 | 20 |
| Vehicles | Sound but not seen | 25 | 5.6 |
| | Sound and can be seen | 66 | 14.8 |

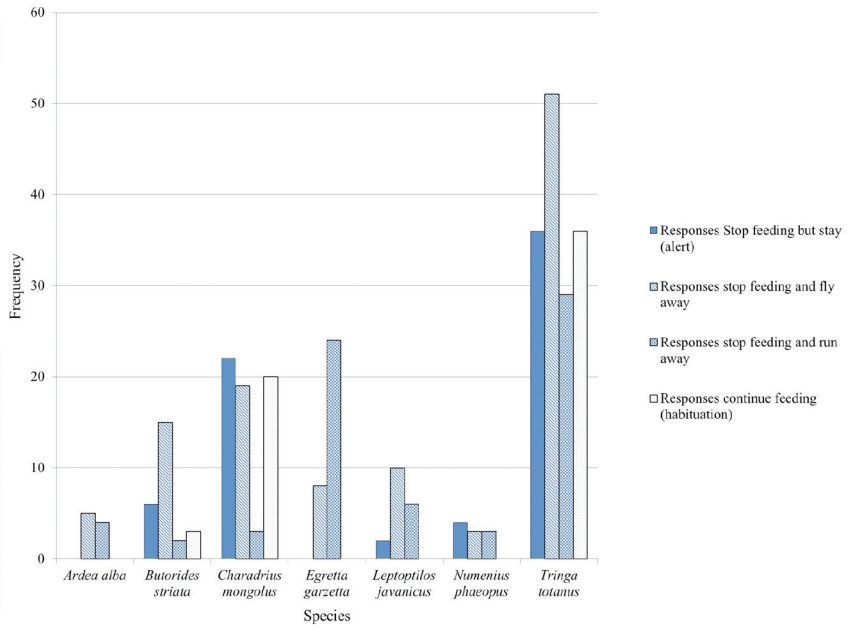


FIGURE 2. Frequency of responses shown by different species of shorebird and waterbirds towards disturbances

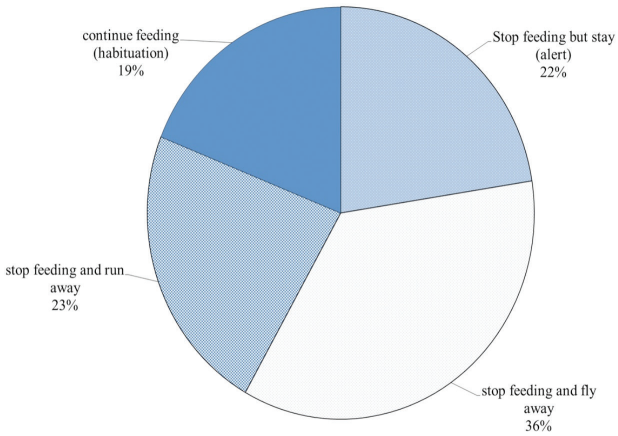


FIGURE 3. Percentage of response of shorebirds and waterbirds upon disturbance

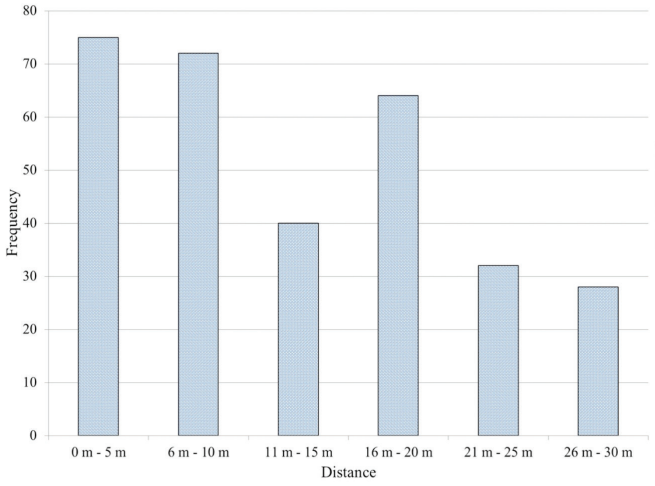


FIGURE 4. Preferred distance by shorebirds and waterbirds towards sources of disturbances

optimally foraging individuals that maximizes energy gain should allocate their foraging effort to those patches that are more productive than the average patch in environment (Charnov 1976).

Because of the tidal restrictions on their foraging area, disturbance by human activities during their feeding periods might cause serious effects on the ability of birds to acquire sufficient food (Fitzpatrick & Bouchez 1998). We found that humans have the greatest impact on birds in the study areas. The results from studies of disturbance effects on foraging behavior have been inconsistent with some studies found a negative association between human activity and time spent foraging (Burger & Gochfeld 1991; Thomas et al. 2003), whereas others found no effect (Barbee 1994; Morton 1996; Trulio & Sokale 2008). Previous studies have demonstrated that human activity on beaches affects shorebird feeding activities (Burton 2007; Thomas et al. 2003). Burger (1993) found that shorebirds devoted nearly 70% of their time foraging and 30% of their time watching for people or predators. When the population of people increases, shorebirds forage less than 40% of their time while the rest of their time is spent avoiding people. The human-related disturbance that seems to cause the greatest negative impact on coastal birds is the presence of dogs, whether on a leash or frees to roam. In multiple studies, it has been found that shorebirds and other types of birds responded to dogs as more of a threat than people walking without a dog and the birds tended to flush sooner when a dog was present (Gray 2006; Lord et al. 2001; Miller et al. 2001).

The responses towards disturbance were varied between species in this study. Larger and solitary birds such as Lesser adjutant, Great egret and Little egret often responses by run away or flew away when encountered disturbance at a distance of at least 10 m away from the source of disturbance. In contrast, smaller and flocking birds such as Common redshank and Lesser sand plover are likely to fly or run away from the approaching disturbance of at least 1 m away from them. Some of the flocks are habituated with the presence of human and did not fly away but continue feeding. However, either larger or smaller bird shows no tolerance towards the presence of dogs. All of them flew away as soon as the dogs were approaching them. Common redshank was observed to ignore sound produced by vehicles and continue feeding but was flying away from the feeding ground when vehicles approaching them. Earlier studies noted that different species responded differentially to disturbances (Burger 1981; Fitzpatrick & Bouchez 1998). Fitzpatrick and Bouchez (1998) suggest that this relates to differences among species in cryptic plumage. Although it is not clear that plumage explains most of the variation, such a pattern is consistent with the observation that snowy plovers rely on cryptic coloration and remaining motionless to avoid predators and were much more hesitant to fly (25%) from a disturbance relative to other species (75%) (Lafferty 2001). Individuals that do not flush until the disturbance source is very close are trading the risk of starvation against the risk of predation (Beale & Monaghan 2005; Stillman & Goss-Custard 2002). Individuals that flush sooner due to disturbance may be in a better condition and have the capability to respond to the disturbance, while birds in poorer condition may need to continue forage until the last possible moment because the need to consume as much resources as possible (Beale & Monaghan 2005; Stillman & Goss-Custard 2002). Larger species tended to flush when the disturbing agent was further away, likely due to their need for more space to take off compared to a smaller bird (Rodgers & Schwikert 2003, 2002).

The types of disturbance also affect response time by individual birds. Borgmann (2011) showed that types of disturbances cause birds to flush sooner included motorized boats at high speeds (Bellefleur et al. 2009), all-terrain vehicle (McGowan & Simons 2006), and activities with rapid movement such as running and unleashed dogs (Burger 1981; Lafferty 2001). Similar results were found in this study which shows that vehicles and dogs give greater impacts to the birds. The birds will flush immediately when encountering vehicles and unleashed dogs. Birds react to the presence of nearby humans in various ways. Depending on the proximity and type of human activities, such as walking, running, fishing or dog exercising, birds may respond either by spending more time watching the potential human threat (Burger 1991; Fitzpatrick & Bouchez 1998), or by walking away from approaching human (Fitzpatrick & Bouchez 1998), or by taking flight and moving to nearby undisturbed section of the beach (Smit & Visser 1993). High levels disturbance caused by human activity can affect the survival and fitness of shorebirds (Durell et al. 2005; Goss-Custard et al. 2006). However, their tolerance towards disturbances varies among species (Durell et al. 2005; Furness 1973). The frequency of disturbance and distance at which shorebirds take flight are often the quantified measure of disturbance (Burger 1981). Although these types of reactions have some effects on shorebirds and waterbirds, particularly a reduction in foraging time, a potentially more serious consequence of human and dog activities would be the abandonment of a valuable foraging area by some or all shorebirds. However, these large behavioral responses do not necessarily mean that more birds will die, as they may have spare time to compensate for the disturbance or might simply move to another feeding area after being disturbed (Gill et al. 2001). Moreover, because flying is energetically expensive, birds that flush in response to disturbance will need to acquire additional resources to compensate both for increased energy expenditure due to flight and lost foraging time. Thus, frequencies of disturbance could have large energetic consequences for shorebirds and waterbirds and potentially affect population size.

## Conclusion

This study concluded that anthropogenic disturbance caused a major impact on shorebirds and waterbirds

abundance and influenced their foraging behavior. Responses of bird towards disturbance were varied according to the species and types of disturbance. By understanding how the shorebird and waterbird species response toward disturbance, the conservation efforts can be implemented more effectively in the future. Such efforts might include building of mitigation or physical barrier (such as retaining wall) to prevent direct visual contact between birds and disturbances with low noise levels. This can be implied particularly in the area where the foraging and loafing activities of birds were the highest. Concentrating ecotourism only on certain areas to allow birds to become habituated to disturbance and also to help isolate source of disturbance. Visitors should be educated about the effects of their behavior towards bird, how to reduce their negative impacts and how their activities influence management of species of conservation concern and finally more stringent law enforcement to the owner of the dogs.

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