Temporal Variation of Shorebirds Population in Two Different Mudflats Areas

N. Norazlimi, R. Ramli

Abstract**—**A study was conducted to determine the diversity and abundance of shorebird species habituating the mudflat area of Jeram Beach and Remis Beach, Selangor, Peninsular Malaysia. Direct observation technique (using binoculars and video camera) was applied to record the presence of bird species in the sampling sites from August 2013 until July 2014. A total of 32 species of shorebird were recorded during both migratory and non-migratory seasons. Of these, eleven species (48%) are migrants, six species (26%) have both migrant and resident populations, four species (17%) are vagrants and two species (9%) are residents. The compositions of the birds differed significantly in all months ($\chi^2 = 84.35$, $p < 0.001$). There is a significant difference in avian abundance between migratory and non-migratory seasons (Mann-Whitney, $t = 2.39$, $p = 0.036$). The avian abundance were differed significantly in Jeram and Remis Beaches during migratory periods ($t = 4.39$, $p = 0.001$) but not during non-migratory periods ($t = 0.78$, $p = 0.456$). Shorebird diversity was also affected by tidal cycle. There is a significance difference between high tide and low tide (Mann-Whitney, $t = 78.0$, $p < 0.005$). Frequency of disturbance also affected the shorebird distribution (Mann-Whitney, $t = 57.0$, $p = 0.0134$). Therefore, this study concluded that tides and disturbances are two factors that affecting temporal distribution of shorebird in mudflats area.

Keywords**—**Biodiversity, distribution, migratory birds, direct observation.

I. Introduction

NATURAL wetlands including tidal flats tend to be highly productive and are a vital habitat for shorebirds [1], [2]. Tidal flats are intertidal, non-vegetated, soft sediment habitats that can be found between mean high-water and low-water spring tide cycles [3]. They are generally located in estuary and other low energy marine environment. Although tidal flats comprise only about 7% of total coastal shelf areas [4], they are highly productive components of shelf ecosystems responsible for recycling organic matter and nutrients from both terrestrial and marine sources and also areas of high primary productivity. Mudflats in estuaries are vital feeding habitats for resident bird populations and provide important overwintering sites for migratory shorebirds [5].

In coastal wetlands, shorebird generally feed on the invertebrates in the exposed intertidal mudflats at low tide and then was forced to rest at high tide [6]. Most shorebirds prey on infaunal and epifaunal prey in the sediment [7], therefore their densities often match the distribution of their preferred prey species [8]. For example, bird density in estuaries areas of South East England [9] and South East Scotland [10] is significantly associated with their main prey (marine worms). In Malaysia, study on the relationship between shorebird density and prey density in the mudflats areas still lacking. Previous study in Kuala Gula, Perak have shown that there is a positive correlation between bird density and macrobenthos density [11]. Optimal foraging theory stated that animals should forage in a manner that maximizes their energy gain [12]. Therefore, the density of shorebirds that forage in intertidal mudflats should increase with prey availability [13]. Many studies have suggested that shorebirds choose to feed in habitats where foraging success is the greatest [14]–[16].

State of tidal cycle also influences the distribution of shorebird since tidal cycle alters available habitat and prey for foraging [17]. In addition, most shorebird selects sites with low risk of disturbance [18]. Although the effect of tidal cycle [19] and disturbance on shorebird density were widely studied in temperate regions, ecological investigations on shorebirds in tropical environments are rare and widely scattered.

Knowledge of the species composition and diversity of migrant shorebirds is essential in the development of management and conservation strategies [20]. Moreover parameters such as species density, richness and diversity are good indicators of habitat quality [21]. Although many studies have been conducted on shorebird diversity in Malaysia, the relationship between shorebird density and factors affecting shorebird distribution is poorly known. Some study of shorebird diversity in mudflat areas in Malaysia only compared the composition and abundance of shorebird during southward and northward migration [11], [22]. Therefore, the aims of this study are, (1) to study the temporal distribution and diversity of shorebird species in the mudflat areas of Jeram and Remis Beaches and determine the factors affecting their distribution, (2) to compare the distribution and abundance of shorebird between migratory and non-migratory periods and examine the effects of migrant species on resident species.

II. Materials and Methods

A. Study Sites

Jeram and Remis Beaches are located in West Coast of Peninsular Malaysia (3°13'27"N, 101°18'13"E) (Fig. 1) where semidiurnal tides prevail. 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 counts reported by Wetland Internationals in 1999-2004 [23] which shown that these sites are important stopover sites for shorebirds. The study areas were further divided into

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small plots and zones. However, zones were not used in this study but instead used for another aspect of the study. In Jeram Beach, three plots (with dimension of 900m long and 100m width) were established (Fig. 2 (a)). In total, the size of all plots in Jeram Beach is 27ha. However, only two plots were established in Remis Beach due to high density of human activities (Fig. 2 (b)). The dimension of each plot in this site is 700m long and 200m width. A total of 28ha of Remis Beach was sampled in this study.

Fig. 1 The Mudflat Areas of Jeram and Remis Beaches, Selangor, West Coast of Peninsular Malaysia

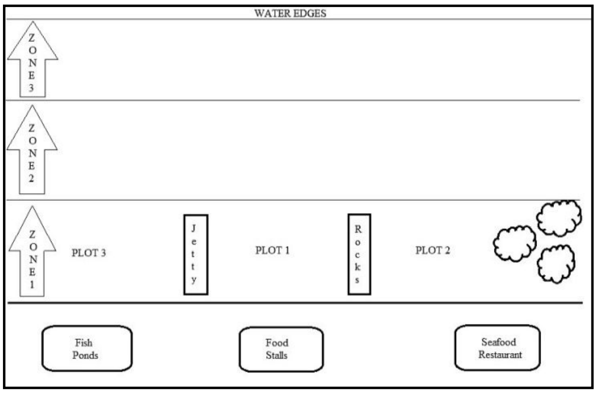

Fig. 2 (a) The design of sampling plots in Jeram Beach

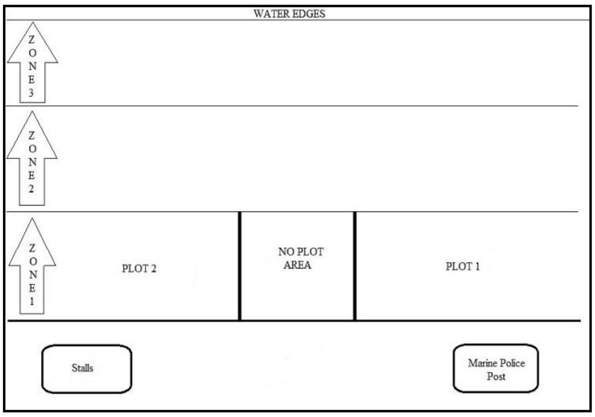

Fig. 2 (b) The design of sampling plots in Remis Beach

B. Bird Population Survey

The survey of bird's population at Jeram Beach and Remis Beach, Selangor was conducted from August 2013 until July 2014. A monthly observation was conducted in both study areas for ten consecutive days by using direct observation technique (with the aid of binoculars (12 X 42 magnifications) and a video recorder). 'Direct counting technique' was used to count individual bird [24]. To facilitate observation and data recording, the count was divided into four time intervals; i.e. from 0800 - 1000 hours, 1000 - 1200 hours, 1400 - 1600 hours, and 1600 - 1800 hours. During each period, shorebirds in all plots were counted for the first 30 minutes while the rest of the time was used for other aspects of the study. Shorebird count was conducted during all tidal states and the count was also conducted whenever sources of disturbance approach the sampling plots. The type and frequencies of disturbance were recorded. All shorebird present in each plot can be easily identified and counted because the intertidal mudflat area of Jeram and Remis Beach was relatively open and unvegetated. Flying forward birds were excluded from counting and only those feeding and flying within the sampling area were recorded [25]. Extreme care were practiced to locate all bird present within the sampling plots and to minimize multiple counting. Based on the assumption that same bird's individual will forages on the same habitats for 2 days, each sampling site was visited in alternate day to reduce the bias of multiple counting. During sampling, shorebirds are counted from at least 100 m away to ensure the researcher's presence did not affect bird numbers [26]. Counting of shorebirds under extreme weather conditions (windy and/or rainy days) was not conducted due to possible adverse effects on bird activity and density [27].

C. Data Analysis

The univariate measure of species diversity was calculated using Shannon-Weiner Diversity Index and Shannon Evenness Index [28]. Shorebird densities were calculated as number of bird per hectare. Mann-Whitney 2 sample t-test was used to test differences in abundance of shorebird during migratory and non-migratory seasons, the effects of tidal condition on shorebirds distribution, and the effects of disturbance on shorebirds density. In addition, Chi-Square analysis (χ^2) was also used to determine monthly variation in shorebird abundance. Analysis of data was conducted using STATISTICA version 8.0.

III. Results

A. Bird Population Survey

A total of 32 species of shorebird were recorded during both migratory and non-migratory seasons (Table I). Of these, only 23 species were used for further analysis. Nine species of shorebird were excluded from further analysis due to lower abundance (less than 10 individuals were recorded throughout sampling periods). These species were White-bellied sea-eagle (*Haliaeetus leucogaster*), Chinese egret (*Egretta eulophotes*), Grey plover (*Pluvialis squatarola*), Pacific golden plover (*Pluvialis fulva*), Long-billed plover (*Charadrius placidus*), Malaysian plover (*Charadrius peronii*), Rudy turnstone (*Arenaria interpres*), Little stint (*Calidris minuta*) and Sooty tern (*Onychoprion fuscatus*). Overall, total number of individual recorded is 19,044 individuals. Eleven species (48%) are migrants, six species (26%) have both migrant and resident populations, four species (17%) are vagrants, and two species (9%) are residents (Fig. 3). The compositions of birds differed significantly in all months ($\chi^2 = 84.35$, $p < 0.001$). Bird densities were highest in January and lowest in July (Fig. 4). The abundance of bird was higher during migratory periods compared to non-migratory period (Figs. 5 (a)-(c)). Mann-Whitney analysis shows that bird's abundance is significant difference between migratory and non-migratory seasons ($t = 2.39$, $p = 0.036$). The avian abundance were differed significantly in Jeram and Remis Beaches during migratory period ($t = 4.39$, $p = 0.001$) but not during non-migratory period ($t = 0.78$, $p = 0.456$). Bird's density was significantly difference between high tide and low tide (Mann-Whitney, $t = 78.0$, $p < 0.005$). Shorebirds distribution was affected by frequency of disturbance (Mann-Whitney, $t = 57.0$, $p = 0.0134$).

The most abundant species is Common redshank (*Tringa totanus*) which consists 27.2% of total individual recorded (Table I). The values diversity indices, i.e. Shannon-Weiner, Shannon evenness, and density were highest during migratory periods than non-migratory period (Table II). A declining trend in abundance was recorded in migrant and both migrant and resident populations after migratory season. On contrary, the abundance of the residents species was increased (Figs. 6 (a)-(d)).

TABLE I
RELATIVE ABUNDANCES AND DISTRIBUTION STATUS OF SHOREBIRD'S SPECIES ENCOUNTERED IN JERAM AND REMIS BEACHES, SELANGOR, MALAYSIA

English Name	Scientific Name	Relative abundance (%)	Distribution Status
Common sandpiper	*Actitis hypoleucos*	1.5	M
Great egret	*Ardea alba*	3.7	R, M
Grey heron	*Ardea cinerea*	3.8	R
Purple heron	*Ardea purpurea*	0.1	R, M
Rudy turnstone	*Arenaria interpres*	-	M
Little/striated heron	*Butorides striata*	4.3	R, M
Little stint	*Calidris minuta*	-	V
Red necked stint	*Calidris ruficollis*	6.4	M
Common ringed plover	*Charadrius hiaticula*	0.3	V
Greater sand plover	*Charadrius leschenaultii*	3.5	M
Lesser sand plover	*Charadrius mongolus*	17.2	M
Malaysian plover	*Charadrius peronii*	-	R
Long-billed plover	*Charadrius placidus*	-	V
Chinese Egret	*Egretta eulophotes*	-	M
Little egret	*Egretta garzetta*	6.4	R, M
White-bellied sea-eagle	*Haliaeetus leucogaster*	-	R
Laughing gull	*Larus atricilla*	1.6	V
Lesser adjutant	*Leptoptilos javanicus*	3.0	R
Bar-tailed godwit	*Limosa lapponica*	4.1	M
Far eastern curlew	*Numenius madagascariensis*	2.7	M
Little curlew	*Numenius minutus*	0.5	V
Whimbrel	*Numenius phaeopus*	1.9	M
Sooty tern	*Onychoprion fuscatus*	-	R,M
Osprey	*Pandion haliaetus*	0.1	M
Pacific golden plover	*Pluvialis fulva*	-	M
Grey plover	*Pluvialis squatarola*	-	M
Black-legged kittiwake	*Rissa tridactyla*	0.2	V
Little tern	*Sternula albifrons*	0.4	R, M
Collared kingfisher	*Todiramphus chloris*	0.8	R, M
Marsh sandpiper	*Tringa stagnatilis*	0.8	M
Common redshank	*Tringa totanus*	27.2	M
Terek sandpiper	*Xenus cinereus*	9.4	M

R = Resident, M = Migrant and V = Vagrant

TABLE II
ESTIMATION OF SHOREBIRD COMMUNITY METRICS VALUES DURING MIGRATORY AND NON-MIGRATORY SEASONS AT JERAM AND REMIS BEACHES

Indices	Migratory	Non-migratory
H'	5.68	4.07
H_E	0.74	0.58
D	240	97
S	13,683	5,331

H' = Shannon-Weiner Diversity Index = $-\sum p_i \ln p_i$, H_E = Shannon Evenness = H'/ln S, D = Density = individual/hectare, S = Total number of individual

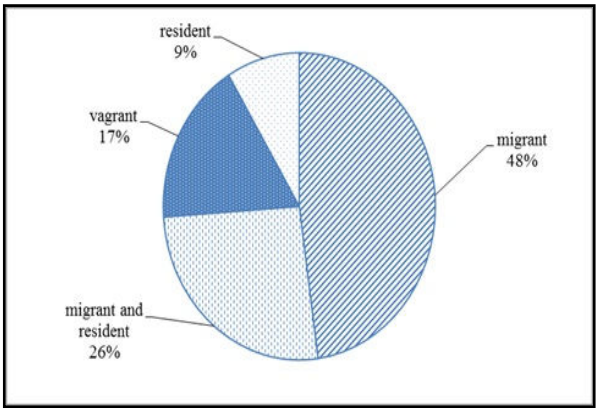

Fig. 3 Percentage of shorebirds species according to distribution status

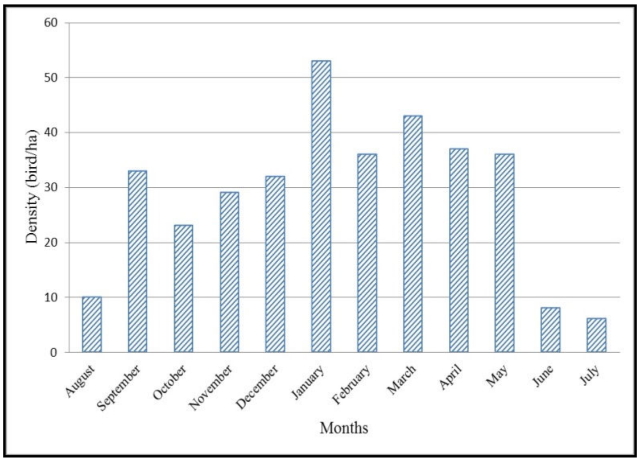

Fig. 4 Fluctuation of shorebirds density in Jeram and Remis Beaches recorded during study period

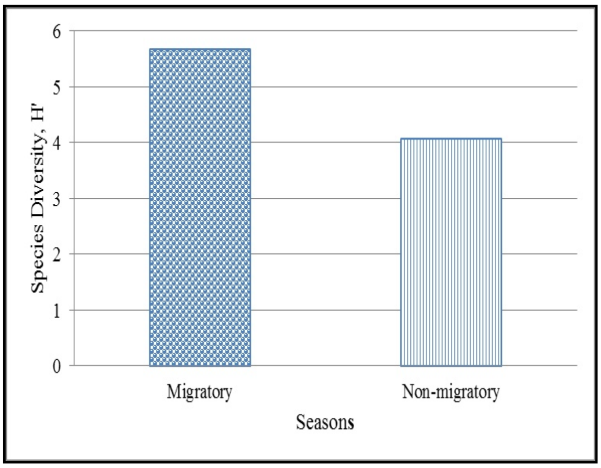

Fig. 5 (a) Diversity of shorebirds in Jeram and Remis Beaches during migratory and non-migratory seasons

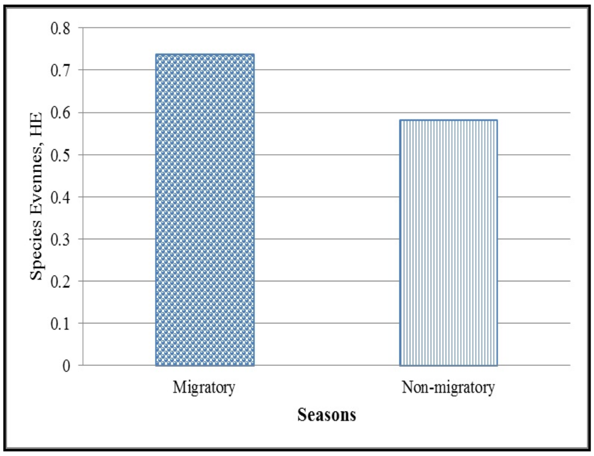

Fig. 5 (b) Species richness of shorebirds in Jeram and Remis Beaches during migratory and non-migratory seasons

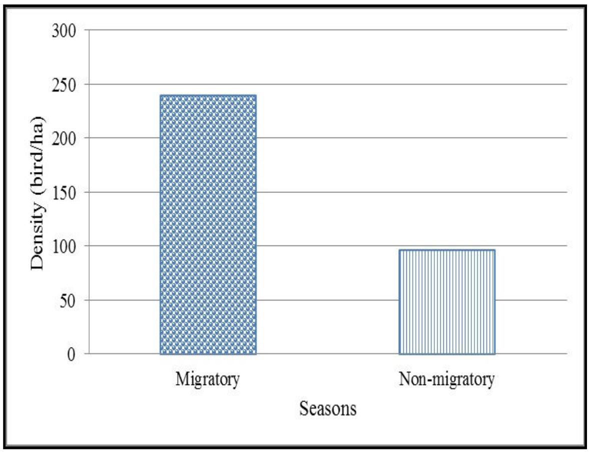

Fig. 5 (c) Density of shorebirds in Jeram and Remis Beaches during migratory and non-migratory seasons

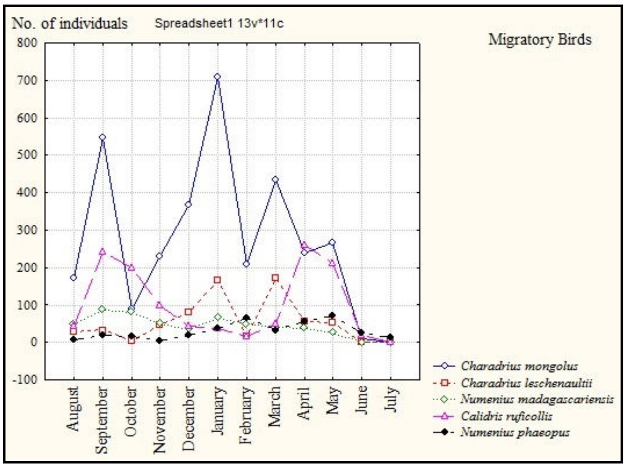

Fig. 6 (a) The fluctuation in population size of migratory species of shorebirds in all months

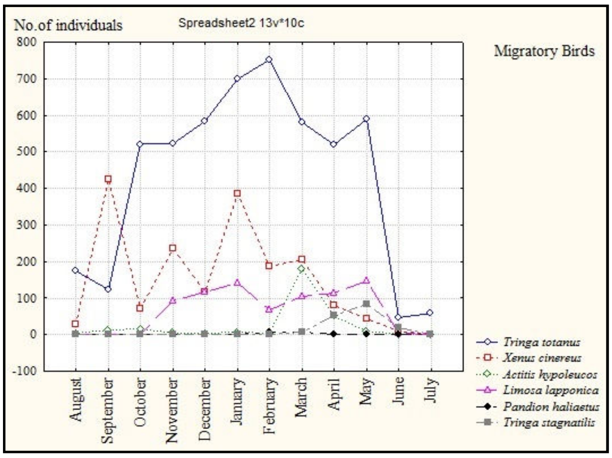

Fig. 6 (b) The fluctuation in population size of migratory species of shorebirds in all months

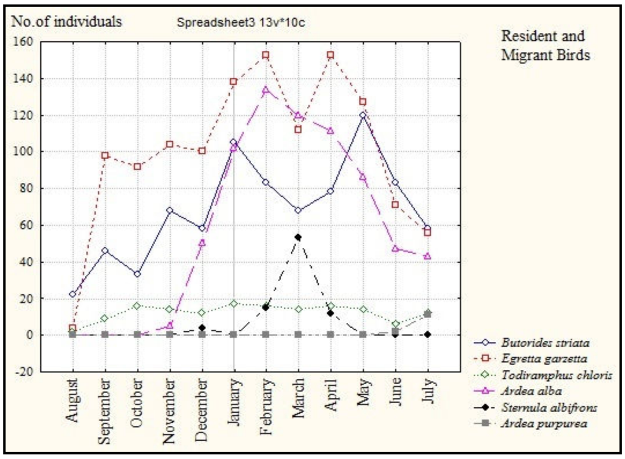

Fig. 6 (c) The fluctuation in population sizes of migrant and resident shorebird in all months

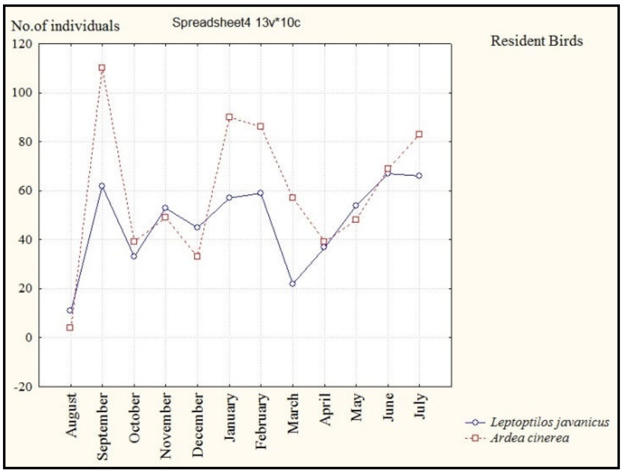

Fig. 6 (d) The fluctuation in population size of resident species shorebirds in all months

IV. Discussion

Shorebirds are capable of long-distance migrations, covering thousands of kilometres between breeding and non-breeding sites [29]. During this long journey, birds utilize profitable foraging grounds available along its migratory route to replenish their depleted reserves [30]. The abundance of birds in study sites during migratory season explained the importance of Jeram and Remis Beaches as a stopover sites for migrant shorebirds.

This study, had recorded large numbers of migrant and resident birds assembled in the sampling sites during migratory periods. This had resulted in the seasonal variation of shorebird's abundance. In January, shorebird abundance was at peak because due to the presence of migrant shorebird during migratory periods while in July, most migrant species were already departed from sampling sites to their breeding grounds. Similar results were recorded in Pulicat Lake, India [31]. This result was contributed by less rainfall or less feeding grounds for the birds caused by flooding that was occurring in June and July. The shorebird diversity and richness were highest in the northward migration (January to May) than southward migration (August to December) [11]. High diversity of shorebirds recorded during northward migration might be related to high diversity and abundance of their preferred macrobenthic prey available in the mudflat habitat. However, previous studied at Kapar, Selangor found that shorebird abundance was significantly higher during southward migration than northward migration [22]. This high abundance may be due to the longer period of stay and overwintering at Kapar. Increased shorebird population was observed in this study compared to the previous study conducted in the coastal mudflat area of Jeram in 2001 and Remis in 2004 [23].

The assemblages of big flocks of migrant birds in the sampling sites have a significant effect on resident birds. The presence of migrant species was observed to displace members of resident bird species. Although resident birds were presence throughout the study periods, the decreased in population size was observed during migratory season. These happened maybe due to competition between resident and migrant species. Coexistence with competitors usually results in fitness costs that can be due to direct interactions such as resource competition [32], [33]. Seventy-percent of interspecific aggression initiated by migrant waders was directed at resident bird during the summer. Similarly, 79% of all aggressive encounters initiated by resident bird were directed at migrant bird [34]. Morphologically similar individuals are likely to utilize similar food resources or foraging microhabitats, thus more likely to be involved in aggressive encounters over these resources. Fights were quite common between conspecifics but did not occur between interspecific. This is because birds are more aggressive in defending their personal space to conspecifics than others [35].

Tide is the major factor influencing the distribution, abundance and behavior of shorebirds [36]. In this study, the distribution of shorebird was higher during low tide periods compared to high tide periods. Environmental factors, principally tides constrain food availability on a relatively predictable daily and seasonal basis by limiting access to invertebrate prey [19]. Feeding activity was highest during few hours of bracketing low tide. The highest concentrations of birds occurred shortly after low tide on both the mudflat and the outer beach [37].

There is considerable debate into the effects of human disturbance on animal populations [38]. This study found that the abundance of shorebird was decreased as the frequencies of disturbance increased. The same result was recorded by reference [39] and reference [40]. In this study, the frequency of disturbance was highest in Remis Beach than Jeram Beach. There is higher intensity of human activities on Remis beach. People are more frequently visiting the mudflat area for mussel collection which consequently disturbed foraging shorebirds. When human density increases, shorebirds forage less than 40% of their time while the rest of their time is spent avoiding people, thus some of them were flush away from the sampling sites. Various studies have indicated 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 [41]–[43]. A negative correlation between Sanderling, *Calidris alba* abundance and vehicle numbers was also recorded in previous study [44].

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