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Feeding Rate and Success Rate of Foraging Waders in Tropical Intertidal Areas

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Abstract: A serious deduction in waders population worldwide has led to several study on ecology of waders in their stop-over migratory routes. Extensive study on wader's habitat used especially on their feeding ground is needed to establish a framework that channels to the conservation of waders species. Therefore, this study was aimed to determine the feeding and success rates of foraging in selected species of waders at Jeram and Remis Beaches of Selangor, Malaysia. Direct observation techniques were used in this study. Kruskal-Wallis Analysis test shows that there was significant difference in feeding rates ($H= 139.58$, $p < 0.001$) and success rates between the species ($H = 11.18$, $p = 0.011$). Pairwise comparisons analysis proved that the differences of feeding rates occurred between Little heron and Lesser adjutant ($z = 107.39$, $p < 0.0001$); Little heron and Whimbrel ($z = -159.31$, $p < 0.001$); and Lesser adjutant and Common Redshank ($z = 80.3$, $p < 0.001$). Meanwhile, Mann-Whitney test shows that the differences lie between Little heron and Common redshank ($W = 5743$, $p = 0.0114$) and also between Lesser adjutant and Common redshank ($W = 9353$, $p = 0.012$). Spearman correlation shows that a significant correlation was found between both feeding and success rates ($R = -0.293$, $p < 0.001$). This study concluded that the feeding rates and success rates were differed between different species of waders utilizing similar feeding ground due to the differences in foraging techniques used while foraging.

Keywords: Shorebirds, feeding rates, success rates, foraging techniques, tropical mudflats

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1. Introduction

The rate at which foraging animal consumes its food forms the basis of innumerable studies in ecology. Measuring the intake rates of feeding animals lead to study of fundamental basis of the animals, such as studies of energy budgets, predator-prey interactions, foraging theory, the quality of feeding grounds, the trade-off between consuming food and other factors that may affect fitness, such as the risk of being taken by a predator, and food-related reproductive success [1].

Waders are highly mobile group of animals that migrate annually from wintering to breeding grounds [2]. Waders encounter variable and unpredictable food resources at stopover sites [3][4][5]. In order to complete the successful journey of migration, waders should forage opportunistically [6] and effectively. Adopting an opportunistic foraging strategy provide migrant waders with a flexible strategy that allows them to increase their probability of being able to replenish energy and nutrient reserves for continuing their migration to breeding and wintering grounds as well as arriving on the breeding grounds in good conditions [4].

Therefo re, the objective of this study was to determine the feeding and success rates of foraging in selected species of waders utilizing the intertidal tropical mudflats in Selangor, Peninsular Malaysia.

2. Methodology

2.1 Study Area

The Jeram and Remis Beaches are located on the West Coast of Peninsular Malaysia (3o13’27”N, 101o18’13”E) (Fig. 1). The mudflat area of the beaches was fringed by a mangrove stand of stunted Avicennia alba Blume and few scattered Sonneratia sp. [7]. The distance between Jeram Beach and Remis Beach is approximately 2 km. The selected study areas comprise approximately 55 ha of intertidal mudflats. The selection of these sites was based on past waders counts reported by Wetland Internationals from 1999–2004 [8], which shows that these areas were previously known to be important stopover sites for waders [9]. Three plots were constructed in Jeram Beach (27 ha) while two plots were setup in Remis Beach (28 ha).

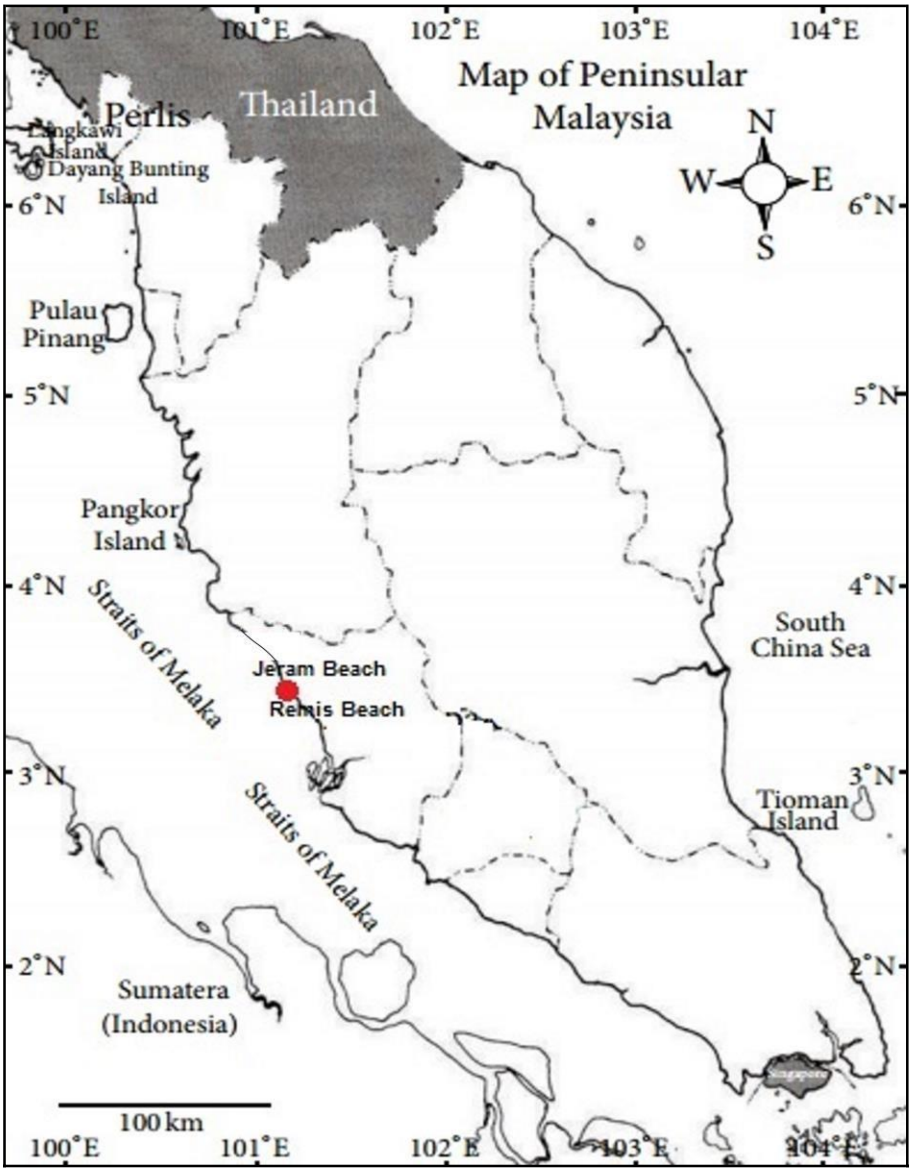

Fig. 1 - Location of Jeram and Remis Beaches in Selangor, Malaysia

2.2 Field Survey

The study was conducted from August 2013 to July 2014 by using direct observation techniques. Four species of waders (Lesser adjutant (*Leptoptilos javanicus*), Common redshank (*Tringa totanus*), Little heron (*Butorides striata*), and Whimbrel (*Numenius phaeopus*)) were chosen for this study due to differences in size and foraging techniques as well as because they are easily distinguished from one another. Selected focal birds were observed by using binoculars (12 × 42 magnifications), stopwatches, and video recorders. The selected focal bird must be actively foraging (each individual was observed until they were done foraging, i.e., starting from the time the bird began actively searching for prey until the prey was completely swallowed); if the bird left within 30 seconds, it was eliminated from the study [10][11]. The focal observation of each individuals was recorded for at least 30 seconds for up to a maximum of five minutes. The data recorded from the different sites and months were pooled to increase replications [11][12] so that the data was strong enough to be analyzed. The focal observations were done only during low tide period (i.e., during ebbing tide, low tide peak, and rising tide) so that birds of all sizes (either with longer or shorter legs) can use the mudflats area for foraging at the same time. The observations were conducted during four-interval period (i.e. 0800–1000 hours, 1000–1200 hours, 1400–1600 hours, and 1600–1800 hours). The selected focal individual for observation must be located at least 10 meters away from the previously observed bird to avoid multiple observations of the same individual [11]. The data, such as the frequency of pecks or probes per minutes, prey items captured per minutes were recorded. The obtained data was then used to calculate the feeding rates, the success rates and the percentage of successful attempts by the bird species. Feeding rates was obtained by totaling the number of feeding attempts (pecks or probes) made by bird per minutes while prey items captured by birds per minutes was used to determine the success rates. Meanwhile, the percentage of successful attempts was calculated based on formula:

$$\text{Percentage of successful attempts (\%)} = \frac{\text{Number of successful strike (pecks or probes)}}{\text{Total number of pecks or probes}} \times 100\%$$

2.3 Data Analysis

Data has been analysed using STATISTICA software. In preparation for statistical testing, all data sets were tested with Shapiro Wilke’s W test and Anderson’s Darling test for normality [13]. For all cases, $\alpha = 0.05$ were used. Non–parametric Kruskal-Wallis test was used to determine the feeding rates and success rates between the wader species. Besides that, analyses by using pairwise comparisons and Mann-Whitney test were used to prove the differences in feeding and success rates occurred between which species. Spearman correlation analysis test was used to determine the relationship between feeding and success rates of waders.

3. Result

A total of 205 focal observations were recorded for Common redshank, 75 observations for Lesser adjutant, 53 observations for Little heron, and 38 observations for Whimbrel (Table 1). Due to differences in number of focal observations recorded, all data taken were divided into 12 months (i.e., from August 2013 until July 2014) to obtain the average or mean of each data.

The feeding rates were differed between the species. Kruskal-Wallis Analysis test showed that there was significant difference in feeding rates values between species ($H = 139.58$, $p < 0.001$). Analysis by using pairwise comparisons supported the previous statement by proving that the differences occurred between Little heron and Lesser adjutant ($z = 107.39$, $p < 0.0001$); Little heron and Whimbrel ($z = -159.31$, $p < 0.001$); and Lesser adjutant and Common Redshank ($z = 80.3$, $p < 0.001$). Table 2 summarized the obtained values.

The success rates were differed between species (Table 3). Non-parametric Kruskal-Wallis Analysis test supported that there was significant difference in success rates between the species ($H = 11.18$, $p = 0.011$). The test differences were further analyzed by using Mann-Whitney test which showed that the differences lied between Little heron and Common redshank ($W = 5743$, $p = 0.0114$) and also between Lesser adjutant and Common redshank ($W = 9353$, $p = 0.012$). Spearman correlation analysis was then conducted to test the relationship between feeding rates and success rates. A significant correlation was found between both feeding and success rates ($R = -0.293$, $p < 0.001$).

Table 1 - Summary of frequency of wader species observed (n) from August 2013 until July 2014

	Species (n)			
Months	**Lesser adjutant**	**Common redshank**	**Little heron**	**Whimbrel**
August	6	4	8	4
September	10	20	2	3
October	11	42	2	2
November	3	23	4	2
December	7	33	7	4
January	9	19	5	4
February	5	17	3	4
March	5	17	5	3
April	5	11	5	3
May	6	10	5	3
June	4	5	4	3
July	4	4	3	3
Total	75	205	53	38

Table 2 – Summarized of obtained values for feeding rate and percent of successful attempts between species

Species	Feeding rate		SE	Percent attempts successful (%)
	n	mean		
Little heron	53	1.396	0.197	73
Common redshank	210	14.881	0.768	7.3
Lesser adjutant	76	7.99	1.06	13
Whimbrel	34	11.21	1.36	8.9

Table 3 - The summarized value of number of prey taken, average minutes and success foraging rates between species

Species	No. of prey taken	Average minutes	Success rate
Little heron	54	36.95	1.46
Common redshank	227	111.95	2.03
Lesser adjutant	79	51.16	1.54
Whimbrel	34	17.46	1.95

4. Discussion

The foraging success is crucial for waders for maintaining healthy body condition and fuelling-up before long-distance migration and breeding [14][15][16][17][18]. The success rates combine the feeding rates and the percent of successful feeding attempts [17]. In this study, the feeding rates were differed between the species. The feeding rates of Little heron was the lowest compared to the other species because the total number of feeding attempts (which are pecks or probes) was lower in this species. This happened because Little heron was observed to practise Pause-travel technique that required more time of searching or scanning for the prey items before capturing it. Therefore, less feeding attempts was made by this species, which in turns led to the lower feeding rates. However, in compensate of lower feeding rate, Little heron has the highest percentage of successful attempts compared to other waders. They spent much of the time scanning for available prey instead of randomly foraging in particular area. In consequence, the percentage of successful feeding attempts were also increases. Previous study by [19], suggested that feeding rates differed with feeding techniques.

Moreover, the success rates were also differed between species. Common redshank recorded the highest success rates compared to the other species because of the number of prey taken per minute was the highest in this species. Common redshank consumed smaller prey items compared to Lesser adjutant and Little heron. Smaller prey items required less time to be consumed and also less profitable compare to larger prey items. Therefore, more prey need to be consumed in less time in order to fulfil the energy required by the species. In addition, a significant correlation was found between feeding and success rates. Higher feeding rates will lead to higher success rates. However, previous study by [17] recorded different result. He found that the high feeding rates offered a low success rates and vice versa. Success rates alone can be a poor indicator for intake rate, especially when comparing different habitats and prey types [17][20][21][22][23]. This is because waders may capture and consume items at a higher rate when preys are small than when they are large (due to greater handling time of larger prey) and larger prey had a greater biomass value. Intake rates have the potential to be much higher when waders consume large prey, even though the feeding rate may be lower [20]. Other opinions suggest that intake rates may be low because of physiological constraints on the time require to digest large prey. A previous study by [24] showed that Long-billed Curlews occasionally stopped feeding and either rested or preened for up to 10 minutes after ingesting large prey. It can be concluded that the feeding rates and success rates were differed between different species of waders utilizing the similar feeding ground due to differences in foraging techniques used while foraging.

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