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Foraging Activity of the Re-introduced Milky Storks (*Mycteria cinerea*) in Kuala Gula Bird Sanctuary, Perak, Malaysia

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ABSTRACT

The milky stork is an endangered waterbird species that is currently being re-introduced in the Kuala Gula Bird Sanctuary, Perak, Malaysia. However, little information is available on the re-introduced population's adaptation and activity especially of that related to foraging. To fill this gap, a new group of re-introduced population released between 2013 and 2014 was followed and studied. During the early release period (January – February 2013), the population incorporated the natural sites (intertidal areas, mudflats, and riverbeds) and also the shrimp farms almost equally as their foraging sites (~50% each). Later (March – May 2013), a shift from the natural foraging sites to the shrimp farms could be observed with increasing visits made to the latter area. However, the storks incorporated the natural sites again between June and August 2013 most notably during their breeding activity. Nonetheless, there was a significant reliance on the newly built shrimp farms (monthly mean visits =17.6 ± 1.26, p = 0.001) and a high percentage of shrimp consumption (30 - 48%) compared to other prey was recorded in the subsequent period (September - June 2014). Furthermore, the principal component analysis (PCA) indicates that the foraging activity of the waterbirds was more likely tied to the area or size of the foraging sites which were heavily influenced by the anthropogenic activity in Kuala Gula. In addition, there is a concern over the prolonged utilization of the shrimp farms and their resource as the milky storks could be exposed to several hazardous pollutants in the long run.

Keywords: Ecology, endangered species, foraging activity, Kuala Gula Bird Sanctuary, milky stork, principal component analysis

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INTRODUCTION

Waterbirds are often used to monitor environmental variations either temporal or spatial at both species and community levels (Abraham & Sydeman 2004; Rendón-Martos et al., 2000). Their sensitivity to environmental changes can be reflected by their movement or migration activity, making them an excellent bio-indicator of our ecosystem as reviewed by Rahman and Ismail (2018). As such, the availability of suitable habitats for foraging, nesting and roosting are important to the waterbirds' survival. Any disturbances or deterioration in the birds' foraging habitat could cause them to seek a new area for food sources. This would lead to changes in the foragers' diet which often follows the optimal foraging theory. Moreover, the shifting of foraging activity to a new area may occur either temporarily to compensate the low abundance of prey in the original habitat or permanently if its quality further deteriorates. Likewise, the coastal area has been subjected to continuous development throughout the years, causing more problems to the waterbirds population globally due to the alteration of the landscape and their habitats (Ma et al., 2019; Wen et al., 2016).

The Southeast Asia coast, in particular, has been subjected to intense development and urbanization activities (Ramesh et al., 2011; Wong, 1998). The reduction of mudflats and mangroves along its coast is causing many wildlife species to rapidly decline and become endangered. The milky stork, *Mycteria cinerea* (Raffles 1822) is a good example of where the deforestation and development along the coast have driven the population to an endangered status (BirdLife International, 2019; Ismail & Rahman, 2012). The milky stork is a large wading bird from the Ciconiidae family and was once predominantly found along the coast of the Southeast Asia region from Cambodia, southeast Thailand to the west coast of peninsular Malaysia and Indonesia. In Malaysia, the wild population was last observed in 2010 and with the ongoing declining pattern; it is viewed that the wild population may already be extinct (Ismail et al., 2010). The individuals sighted in the country today are most likely to be the ones released in previous re-introduction programs in the Kuala Selangor Nature Park as well as those in the Kuala Gula Bird Sanctuary. The decreasing pattern of the species has also been reported in Indonesia and Cambodia (Iqbal et al., 2012; Naing, 2007). As such, the species has been listed as an endangered species in the IUCN red list (BirdLife International, 2019). Consequently, in 2007 a re-introduction program was carried out in Kuala Gula, Perak, Malaysia to help re-establish the population back into the wild. Nonetheless, little information is available on the milky stork's adaptation and ecology post-release and this could be a hindrance to future conservation efforts for the species and its habitat (Ismail et al., 2012; Ismail & Rahman 2012, 2016). Therefore, this study was conducted to understand the milky stork's foraging activity including the utilization of and preferred foraging areas as well as their diet post-release. There is hope that the findings will provide important information to support the protection of the milky stork's habitat in the future.

MATERIALS AND METHODS

Study Area

The study was conducted in the Kuala Gula Bird Sanctuary in Perak (4°56'00" N; 100°28'00" E) which is part of the larger Matang Mangrove Forest in Malaysia (Figure 1). Elevation of the area averages at 2-3 meters above sea level with average annual rainfall of 3500-4800 mm. It consists of several small fishing villages along the mangroves, covering approximately 10 kilometers of the Kuala Gula coast. Its inland areas have been mostly developed for agricultural activity particularly oil palm plantations. The aquaculture industry is also a booming industry in Kuala Gula. This has led to the increasing number of reclaimed mangroves in recent years (Ismail & Rahman, 2016). Nonetheless, Kuala Gula and its mudflat areas are still regarded as one of the important stopovers in the East Asia-Australia flyway. Between 4,000 and 8,000 individual migratory shorebirds have been recorded to stop and refuel in the area (Lomoljo, 2011). Kuala Gula is also home to important endangered waterbird species such as the wild milky stork (*Mycteria cinerea*) and lesser adjutant (*Leptoptilos javanicus*). Currently, Kuala Gula is the center of the milky stork re-introduction program in Malaysia. According to Ismail and Rahman (2016), Zoo Negara under the management of the Malaysian Zoological Society has agreed to supply a total of 150 captive-bred milky stork individuals to reestablish the population in Kuala Gula. Meanwhile, the Department of Wildlife and Parks (DWNP) has been tasked with monitoring and protecting the re-introduced

Figure 1. Map of the study sites in Kuala Gula Bird Sanctuary, Perak, Malaysia

population under existing legislation and acts. The captive-bred individuals will be continuously supplied in small batches, between 5-8 individuals, to the release center, the DWNP office. To date, at least 50 captive-bred individuals have been released in Kuala Gula.

Sampling Activity

A newly released group of milky storks obtained from Zoo Negara was followed to its respective foraging sites in the Kuala Gula Bird Sanctuary between January 2013 and December 2014 (2 years). The flight directions of the milky storks from the release center were observed and monitored using the vanishing bearing method (Kenyon, 2006). This method employed a bearing compass to accurately determine the storks' flight directions, assuming that to minimize energy cost, the storks would fly a direct route between its colony (in this case the release center) and their foraging sites. In addition, like other colonial waterbirds, the milky storks are known to congregate while foraging and roosting. Accordingly, the newly released storks congregated with the more experienced individuals from the older groups or batches sent. These individuals can be distinguished by the color and condition of the rings attached to their legs; the new ones are more vivid and unstained compared to individuals from the older groups. No effort was made to distinguish between the age one and two years old individuals as they were observed as one group. In total, eight individuals were observed from the new group. A study done by Ismail et al. (2012) suggested that the species particularly the captive ones were not very active as they spent most of their time roosting (45%) followed by foraging (30%). As such, sampling activity is straightforward as researchers could monitor them without missing any of the released individuals for the above reasons highlighted. A five-day observation between 0700 and 1900 hours was conducted every two weeks for each month between the periods of January 2013 and December 2014. A binocular (Nikon Egret II 8x40CF), a digital SLR camera (80-300mm lenses) and a video recorder (Sony HDR-PJ340) were used during the observations. The number of visits made by the milky storks, distance from the release center, height of trees in foraging areas, disturbances and the prey captured were also recorded. The storks foraging activity could last for several hours hence several recording sessions were taken during each sampling activity with 1-2 hours recorded for each session. No classification or categorization was made for the foraging activity in this study. The preys captured by the storks were identified up to the species level whenever possible and unknown food items taken were classified as 'unidentified' in this study. Observation distances were maintained between 10 and 100 meters. The descriptions of the foraging sites utilized by the storks are shown in Table 1. These sites include both the natural and artificial habitats. The later's hydrology and biotic components have been altered mainly for economic activity. Tree heights were measured using trigonometry method

Table 1
Coordinates and description of the study sites in Kuala Gula

Site	Coordinates (Latitude, Longitude)	Area description
I	4° 56' 2.47" N, 100° 29' 16.41" E	Newly developed shrimp farms surrounded by mangrove forest
II	4° 56' 26.38" N, 100° 28' 7.60" E	A small strip of mangrove forest with heavy anthropogenic activity i.e. boating
III	4° 57' 18.13" N, 100° 29' 19.37" E	Mangrove forest turned into shrimp farm
IV	4° 55' 30.47" N, 100° 27' 42.32" E	Mangrove forest turned into shrimp farm
V	4° 56' 14.84" N, 100° 28' 5.016" E	Intertidal mudflat surrounded by residential, jetties and fishery activity

(Beals et al., 2000), while distances from the release center and the size of the milky storks' foraging grounds were estimated using the GEPath software for areas less than 1000 hectares (Rahman, 2017).

Statistical Analysis

One-way ANOVA with Tukey as post-hoc test was used to differentiate the number of visits made between foraging sites. All statistical tests were done at 95% level of significance using the Statistical Package for Social Science (SPSS) software version 17. Principal component analysis (PCA) using XLSTAT (version 2014.3.02) was also employed to classify recorded variables i.e. tree height, distant from release center, number of other waterbirds, number of milky storks and the size of the foraging areas into meaningful components to better understand the pattern of the milky storks' foraging activity. Variables that failed to meet the minimum criteria of having a primary factor loading of 0.4 or above were excluded from the analysis.

RESULTS

There was a statistically significant difference between groups (i.e. number of visits recorded between available sites) as determined by one-way ANOVA ($F(4,50) = 36.33$, $p = 0.001$). The Tukey post-hoc test revealed that the number of visits made was highest in site I (17.6 ± 1.26, p = 0.001). There were no statistically significant differences between visits made between site V and site IV (12.5 ± 4.0 and 8.9 ± 6.02 respectively with p = 0.865) as well as site III and II (3.0 ± 0.7 and 2.2 ± 0.45 respectively with p = 0.988). Based on the percentage of foraging visits made by the milky storks (Figure 2), the population's foraging activity as recorded was almost equal between the natural sites (i.e. intertidal mudflat and mangroves) and the shrimp farms between January and February 2013 (approximately 50% each). However, starting from March until May 2013, the population had moved to existing shrimp farms in Kuala Gula (Site III and Site IV). Later, between June and August 2013, the

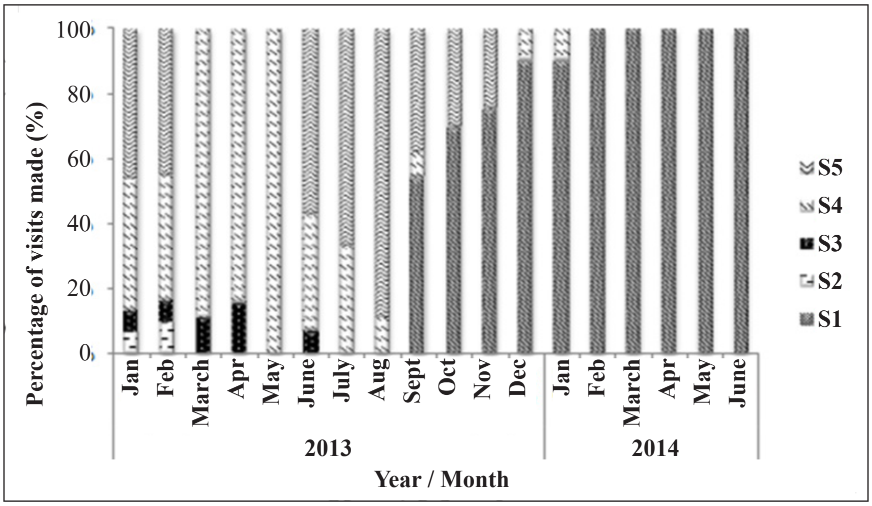

Figure 2. Percentage of foraging visits made by the milky stork in the study

population started to incorporate back the natural sites as their foraging area (57% – 88%), most notably because they were located in the same area as their nesting site. However, between September 2013 and June 2014, the storks had shifted most of their foraging activity to a newly built shrimp farm (Site I). In general, the size of their foraging area had increased up to 20% (30 ha) between 2013 and 2014.

As for their diet, the milky storks' prey predominantly consisted of brackish and coastal water species. In this study, we identified at least seven different species consumed by the reintroduced population. These include the *Mystus* sp., *Oreochromis* sp., *Penaeus* sp., *Periophthalmus minutus*, *Valamugil* sp. and also mollusks commonly found in the Kuala Gula coastal area. Figure 3 highlights the storks' diet which varies

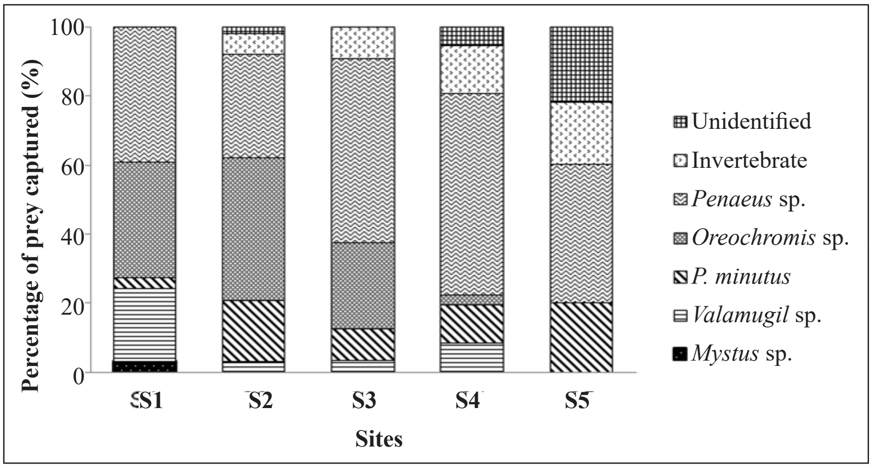

Figure 3. Percentage of preys captured by the storks in the study

according to available foraging sites. In general, the *Penaeus* sp. consumption was the highest (30 - 58%), followed by *Oreochromis* sp. (3 - 41%), *P. minutus* (3 - 20%), mollusk (6 – 18%), unidentified (2 - 22%), *Valamugil* sp. (3 - 21%), and *Mystus* sp. (2%). In addition, the consumption of *Periophthalmus minutus* by the milky stork is the first to be reported by this study.

For the principal component analysis results, the variables can be separated into two groups with the number of waterbirds foraging and area in one group, while tree height and distances from the release center in another (Table 2). Furthermore, the first two principal components account for 89.28% of the explained variances in this study. Axis 1 has strong positive loadings for the waterbirds population number, distances, tree height and area. This may reflect the general characteristic of the foraging habitats preferred by the re-introduced population. On the contrary, axis 2 has strong negative loading for the milky stork population and positive loading with tree height. This reflects the less foraged areas by the milky storks in Kuala Gula. The two components can be categorized into 'disturbed' and 'undisturbed' areas where the former primarily consists of reclaimed mangrove areas while the latter has no anthropogenic activity presence in it. Overall, the biplot (Figure 4) indicates that the foraging activity of the milky storks is more likely to be tied to the size of the foraging site.

DISCUSSION

It is believed that in the early stages of establishment, birds tend to select high quality habitat that offers enhanced cover and foraging opportunities (Michele et al., 2010). In this study, the milky stork population had been relying on both natural and developed or disturbed areas for food and the latter was being utilized mostly towards the end of this study. This alternating or shifting of foraging area could be related to the changes in prey abundance and also the shrimp harvesting

Table 2
Results of the principal analysis performed on the correlation matrix of the five variables describing the milky stork's foraging site characteristics

Variables	Abbreviation	PCA Axes	
		1	2
Number of milky storks	Ms	0.8	
Number of other waterbirds	Other	0.9	
Distance from the release center (km)	Dist	0.9	
Tree height (m)	TH		0.7
Size of foraging area (ha)	Area	0.8	
Eigenvalue		3.8	0.7
Explained Variance		75.0	14.2
Summation of Explained Variance		75.0	89.3

* Only the highly significant loading factors of the variables in the PCA axes are shown

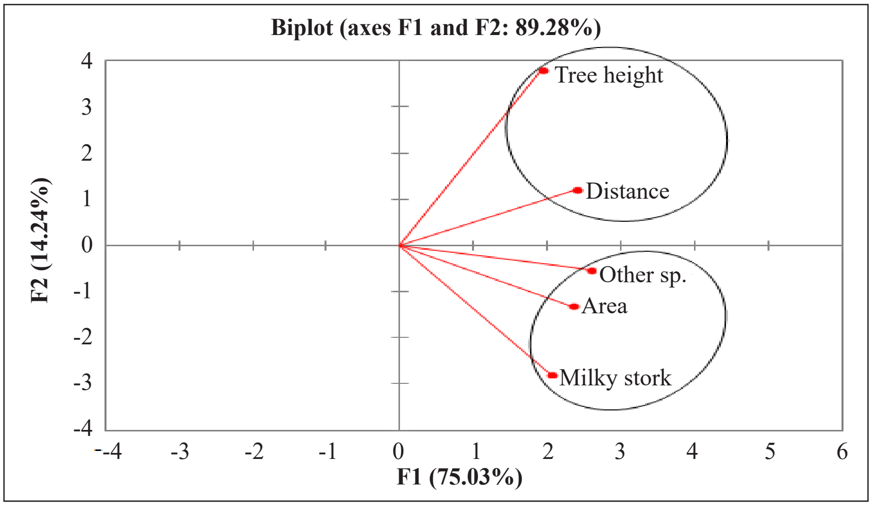

Figure 4. PCA results, the variables and their relationships as analyzed in the study

period in which the milky storks and other opportunist waterbirds often take advantage of (Marquiss, 1993). The development of a massive shrimp farm in Pulau Gula or Site 1 (approximately 340 ha) further led the milky storks to incorporate this area as their main foraging site (September 2013 - June 2014). Field observations suggest that the alteration of the landscape and its hydrology throughout the farms' development had trapped many wild fish and shrimps in the area. This presented an opportunity for both the milky storks and other waterbirds to feed on the prey easily.

The results from the principal component analysis are also in agreement with the shifting foraging pattern observed in the study. The milky storks have been increasingly incorporating existing and newly built shrimp farms as their foraging areas. However, the pattern becomes more prominent starting from the middle until the late period of this study (September 2013 to June 2014). The storks were given a fixed amount of fish (average of two kilograms daily) during their captivity and conditioning phases and the practice still continued post-release. Ismail et al. (2012) stated that the captive milky storks were not very active as they spent most of their time roosting. This was probably true due to the nature of the storks' enclosure which restricted the subjects' movement. However, as the milky storks were re-introduced into the wild, they became more active. Therefore, the amount of food given may have no longer been sufficient to support the increasing energy requirements of the free roaming storks. Thus, the storks' strategy of incorporating the shrimp farms could be a way for them to compensate for the extra energy required to sustain themselves (Kloskowski et al., 2009). Field observation in South Sumatera showed that the population had taken milkfish (*Chanos chanos*), elongate mudskipper (*Pseudapocryptes elongatus*), mullet fish and even giant mudskipper (*Periaptholomodon schlosserii*) as part of their diet (Iqbal et al., 2009). However, the milky storks in Kuala Gula were only recorded to prey on *P. minutus* although several other species of the mudskipper were available. The shifting in foraging areas utilization by the milky storks showed that they relied heavily on shrimp farms for food. The high consumption of *Penaeus* sp. recorded (up to 58%) was in line with the high number of visits made to the shrimp farms as it made up the bulk of the population's diet. Other preys captured in lower percentages (21% and less) like the *Mystus* sp. and *Valamugil* sp. were mostly taken opportunistically as they were trapped in the canals during the farms' development and operation. In addition, some species remain separated spatially from the brackish and estuary communities following the changes in the area's hydrology. As for the unidentified food items, we believe that they consisted of decomposed plant materials that were taken by younger individuals between the ages of one and two years (based on the identification rings or tags on their legs).

Fundamentally, the study found that the milky stork population's foraging movement and pattern could be tied to: 1) the availability of aquaculture activity i.e. shrimp farms, and 2) the opportunistic strategy adopted by the population to support the increase in energy required by post-release activity. Accordingly, there are several benefits gained by the milky stork which include but are not limited to: a) utilizing the shrimp farms as a relief and also as an important complementary foraging area to the population (Navedo et al., 2015), b) the conversion of mangroves to build new shrimp farms has led to an increase in area for them to forage on, and c) the selection or utilization of existing and new resources could indicate favorable conditions for its long-term survival (Manly et al., 2002). For a major habitat shift to happen, it can either be the result of a negative factor i.e. the deterioration of a previous habitat (Morris & Dupuch, 2012) or a positive one i.e. having flexibility as a strategy to survive adverse conditions (Bystrom et al., 2003). In the case of the milky stork, both factors could contribute to the findings and need to be monitored in the long run as the long-term impact such a pattern may have upon the milky stork is unknown. In addition, potential conflict is bound to happen as the storks continue to forage in shrimp farms. Although the waterbirds in general are regarded as pest or threat to the aquaculture industry as they prey on aquaculture products, the losses are actually relatively low compared to other causes of mortality such as diseases, accidents, and poor water quality (Kushlan & Hafner, 2000). As such, there is a need to raise awareness and support from the public as well as owners of the local industry to help protect the endangered population (Ismail & Rahman, 2016).

The continuous input of pollutants from existing and new anthropogenic activities could also have a negative impact on the population. As shrimp farms in Malaysia are generally established along the coastal mangroves, a high concentration of such activity in Kuala Gula could result in an increase of pollution input to the surrounding area (Rahman et al., 2013; Vandergeest, 2007). Intense shrimp farming activity has been shown to have dire consequence to wildlife and their habitats. According to Anantanasuwong (2001), massive pollution of the coastal waters at rates that far exceed the natural systems regenerative capacity occurs when shrimp farms dispose their untreated water during and after harvesting periods. As a result, sectors that are dependent on coastal resources including their inhabitants have suffered from the pollution. A recent study done by Rahman et al. (2017) showed that the milky stork population could potentially accumulate high levels of heavy metals through their diet obtained near the common water canals. As such, the current foraging pattern observed could expose the milky storks to higher levels of hazardous pollutants in the long run. The sediment in particular serves as a reservoir for the residues of many hazardous pollutants including drugs, heavy metals and other pollutants (Ismail & Ramli, 1997; Rahman et al., 2013; Sather et al., 2006; Weston, 2000). Under certain conditions, they can re-enter the aquatic environment causing negative influence to the food webs through bio-accumulation and bio-magnification processes. Therefore, further study is required to highlight and monitor the level of hazardous pollutants in the milky storks' foraging areas and how they could affect the population in the long run. This is important in order to understand the risk that could be faced by this endangered species as well as their future in Kuala Gula.

CONCLUSION

It is concluded that the reintroduced milky storks are well adapted to the new habitat in Kuala Gula. However, the findings also suggest that anthropogenic activity and landscape-alteration have had both positive and negative influence on the milky storks' foraging activity. The positive influence includes the use of such an area as an alternative foraging site which acts as a relief during food scarcity or when higher energy demand is required. It also allows for easy monitoring and studies to be conducted in the wild due to its being highly accessible. On the negative side, the quality of the mudflats, intertidal areas and rivers in Kuala Gula would be compromised in the long run due to pollution inputs. This will have a negative impact on the re-introduction program and the milky storks' conservation in general. The continuous success of the re-introduction program will very much depend on the quality of Kuala Gula's natural habitat. Protecting key environmental components that help sustain the population in the long run as well as incorporating them in the future planning and development of Kuala Gula is a must. Therefore, the future biodiversity and conservation planning of a similar scale should be critically assessed and account for the conflicting interests that may arise i.e. between protecting the natural habitat for conservation purpose versus the need for aggressive economic development in the area.

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