UNIVERSITI PUTRA MALAYSIA

ECOLOGICAL ASSESSMENT OF THE REINTRODUCED MILKY STORK POPULATION IN MALAYSIA

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By

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Throughout time, the deterioration of natural habitat and its quality has driven many wildlife species close to extinction. The Milky stork (*Mycteria cinerea*) is one important example for this worsening trend. Its conservation status was recently up-listed to 'threatened' from 'vulnerable' by the IUCN in 2016. Nevertheless, the country still has a good number of captive-bred populations in its possession which were later re-introduced back into the wild. This study was done in a hope to understand the Milky stork's ecology in Malaysia following the reintroduction programme. It consisted of researches conducted during pre and post-release period which are: 1) understanding the Milky stork's ecology pre-release or in captivity in Zoo Negara using bio-logging technique (and its feasibility to be used in the field); 2) understanding the Milky stork's ecology and adaptability post-release in Kuala Gula; 3) assessment of the Milky stork's habitat quality in relation to heavy metals and glyphosate pollution and last but not least; 4) understanding the risk of exposure of the Milky stork population to the available pollutants particularly heavy metals using Exposure Model Analysis. As for the results, the use of bio-logging technique helped to predict the Milky stork's activity and movement (temporal and spatial movements) following the reintroduction programme. In pre-release study, important sites associated with the Milky storks' breeding, foraging and roosting activities have been identified and their utilization are discussed in the thesis. For the habitat quality study, the risk of the population being exposed to Zn, Cd and Pb was calculated. To compare, the exposure dose for all metals are much lower in water (0.009 - 0.01 mg $kg^{-1}d^{-1}$) compared the foods (0.30 – 1.49 mg $kg^{-1}d^{-1}$). This suggests that the Milky storks are more likely to accumulate higher amount of Zn, Cd and Pb through food intake (> 90% of exposure) although their levels are still within the acceptable limit. Glyphosate from surface sediments in the Milky stork's

foraging areas was found to range between 0.26 and 1.80 mg kg^{-1} which is considered low and thus no immediate threat to the Milky stork's environment. To conclude by objectives: 1) bio-logging technique has been proven to be an effective tool or technique in studying the Milky stork's behavior albeit several modifications to the logger and field testing are still needed before it can be fully employ to study the population in the wild; 2) The reintroduced Milky storks were able to adapt very well to the new environment in Kuala Gula by taking advantage on the different types of habitat available (natural and artificial) particularly during foraging. However, the population still facing difficulty in selecting appropriate nesting or breeding area due to the rapid development of Kuala Gula's coastal environment; 3) The pollutants level in Kuala Gula's environment i.e. heavy metals and glyphosate are still considered as low but the increasing trend of the metals need to be regulated; 4) The Milky stork's population risk of being exposed to heavy metals (through diet) are still low yet again, authority needs to continuously monitor the environment's quality due to the increasing pattern of metals level mentioned in the study. The findings also point towards the need for urgent protection and conservation of the Milky stork's habitats. Several recommendations are also given to help improve the reintroduction programme.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Doktor Falsafah

EKOLOGI DAN HABITAT KUALITI BURUNG UPEH YANG DIPERKENALKAN SEMULA DI MALAYSIA

Oleh

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Kemerosotan habitat semula jadi dan kualiti yang berterusan telah mendorong banyak spesies hidupan liar menjadi hampir pupus. Burung Upeh (*Mycteria cinerea*) adalah salah satu contoh penting yang turut mengikuti arah aliran ini. Status pemuliharaannya telah disenaraikan sebagai 'terancam' oleh IUCN pada tahun 2016. Walau bagaimanapun, negara ini masih mempunyai sebilangan burung dalam kurungan yang kemudiannya telah diperkenalkan semula ke habitat semulajadi mereka. Kajian ini dilakukan dengan harapan untuk memahami ekologi Burung Upeh di Malaysia sempena program pelepasan semula yang dijalankan. Ia melibatkan kajian-kajian semasa tempoh pra dan juga pasca-pelepasan iaitu: 1) memahami ekologi Burung Upeh semasa pra-pelepasan atau ketika dalam kurungan di Zoo Negara menggunakan teknik ‘bio-logging’ (dan kesesuaiannya untuk digunakan di lapangan); 2) memahami ekologi Burung Upeh dan penyesuaiannya pasca-pelepasan di Kuala Gula; 3) penilaian habitat kualiti Burung Upeh yang berkaitan dengan pencemaran logam berat dan ‘glyphosate’ dan; 4) memahami risiko Burung Upeh terdedah pada bahan pencemar terutamanya logam berat menggunakan Analisis Model Pendedahan. Hasil kajian menunjukkan penggunaan teknik ‘bio-logging’ dapat membantu meramal aktiviti dan pergerakan Burung Upeh di lapangan. Dalam kajian pasca-pelepasan pula, kawasan-kawasan penting berkaitan dengan pembiakan, mencari makan dan berehat telah dikenalpasti dan penggunaannya turut dibincangkan di dalam tesis ini. Bagi kajian kualiti habitat, risiko populasi Burung Upeh terdedah kepada Zn, Cd dan Pb menunjukkan dos pendedahan untuk semua logam jauh lebih rendah dalam air (0.009 - 0.01 mg kg-1d-1) berbanding makanan (0.30 - 1.49 mg kg-1d-1). Ini menunjukkan Burung Upeh lebih berkemungkinan untuk mengumpul Zn, Cd dan Pb dengn lebih tinggi melalui pengambilan makanan (> 90% pendedahan). Walaubagaimanapun tahap logam berat

sedia ada masih berada dalam had yang selamat atau rendah. 'Glyphosate' di dalam sedimen di kawasan Burung Upeh mencari makan pula didapati berada di antara 0.26 dan 1.80 mg kg-1 dan masih dianggap rendah dan ianya tidak memberi ancaman terhadap persekitaran Burung Upeh. Sebagai kesimpulan, berdasarkan objektif: 1) teknik 'bio-logging' telah terbukti menjadi suatu teknik yang berkesan dalam mengkaji tingkah laku Burung Upeh walaupun 'logger' yang digunakan masih perlu diubahsuai disamping tempoh kajian yang lebih lanjut diperlukan sebelum dapat digunakan sepenuhnya di lapangan; 2) Burung Upeh yang diperkenalkan semula dapat menyesuaikan diri dengan persekitaran baru di Kuala Gula dengan menggunakan pelbagai jenis habitat yang ada (termasuk habitat semula jadi dan buatan) khususnya untuk mencari makanan. Walau bagaimanapun, populasi tersebut masih menghadapi kesukaran dalam memilih kawasan bersarang atau pembiakan yang sesuai kerana pembangunan persekitaran pesisir Kuala Gula yang pesat; 3) Tahap pencemaran di persekitaran Kuala Gula khusunya logam berat dan 'glyphosate' masih dianggap rendah tetapi arah aliran logam berat yang semakin meningkat seperti plumbum perlu dikawal; 4) Risiko populasi Burung Upeh terdedah kepada logam berat (khususnya melalui diet) masih rendah, namun begitu, pihak berkuasa perlu terus memantau kualiti alam sekitar disebabkan peningkatan logam berat yang ditunjukkan dalam kajian ini. Hasil kajian ini juga menunjukkan kepada keperluan memberi perlindungan dan pemuliharaan segera terhadap habitat Burung Upeh. Beberapa cadangan turut diberikan sebagai panduan untuk memperbaiki program pelepasan Burung Upeh.

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This thesis was submitted to the Senate of the Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

Cd	Cadmium
ERL	Effective range low
ERM	Effective range medium
mg/kg / mg kg^{-1}	Milligram per kilogram
mg/L / mg L^{-1}	Milligram per litre
mm	Millimeter
N	North
n	Sample size
C	Celsius
Pb	Lead
ppm	Parts per million
SD	Standard deviation
Zn	Zinc

CHAPTER 1

INTRODUCTION

1.1 Malaysia's biodiversity and its threats

Malaysia is on the 12th list among the seventeen mega-biodiversity countries that possess a unique and important biodiversity in the world. Together, these countries accommodate about 60 – 70 % of the world's important biodiversity resources. Coastal area plays an important part in the list too and is equally sensitive to anthropogenic activity as its land's counterpart. In Malaysia almost 60% of the population is situated in the coastal districts (Malaysia Economic Planning Unit, 1999). Historically, coastal area has been subjected to continuous development since early civilization as it provides ample of natural resources as food and ease of access between places. The mangrove in particular, is one of the world's major productive ecosystems because they are key ecological habitats that link terrestrial and marine environments (Vane *et al*., 2009). Its intertidal mudflat for example, sustain a good diversity of marine organisms like mudskippers, crabs, mussels, etc. that serve as important food sources for both human and waterbirds.

Nowadays, development continues to be an unending quest to support growing human population and their needs. Naturally, increasing demand for coastal resources from fish and crustacean to seaweed and the minerals that it possesses always put us in conflict between protecting and developing it. However, knowing that at least sixty percents of urbanization and human population are concentrated in the coastal area, it is clear that only more developments will be sought after and prioritized in the future compared to the protection and conservation of our natural habitats. Therefore, there is a constant need for the scientists especially environmentalist and conservationist, to highlights the unique characteristics and components of the coastal ecosystem as well as their interactions within it in to ensure that their protection will continues and stay relevant in the future.

With the recent advances in environmental engineering, some profess that we can engineer a new, better ecosystem to replace the natural and degrading one. However, one must understand that even the ecologist themselves who studied how the ecosystem works, lack the comprehensive understanding to make completely reliable predictions about ecosystem behavior (Haflon, 1983). This point still valid to date as we are still facing unexpected losses and even extinction of many flora and fauna species at an accelerated pace, and we just enters the sixth mass extinction phase in the world's history (Ceballos *et al*., 2015). In addition, wildlife population will only relies on artificial habitats when the natural one is no longer available or of poor quality (Ma *et al*., 2004). Although it cannot be deny that artificial

habitat has become increasingly important to certain species due to accelerated destruction of its natural counterpart, the complexity and sustainability of the natural ecosystem cannot be simplified let alone underestimated. Hence, for the purpose of conservation, it is important to conserve existing natural habitat rather than degrading one in a hope that later such habitat can be re-engineered back to its normal function.

Habitat degradation is negatively affecting the wildlife population that depends on it. Throughout time, the deterioration of natural habitat and its quality has driven many wildlife species to close to extinction. According to IUCN (2015a) of the 77,340 species of conservation concern in its database, 22,784 species are currently threatened with extinction. At least 85% of the threats are the results of habitat loss and degradation which still continue to this day. As for the waterbirds, 44% of the known global species are still decreasing (SCBD, 2014) and 213 species of birds in general are facing an extremely high risk of being extinct in the near future (BirdLife International, 2013a). Additionally, the loss of intertidal habitat through land-reclamation is one of the major threats to the bird population and still continues in many parts of Asia according to the report.

Our coastal area particularly the mangroves have been subjected to intense anthropogenic activity since past decades as a result of rapid development, over logging and clear-cutting of mangroves along the coastlines (Hashim *et al*., 2010). In Malaysia, the mangroves occupy at least 564, 606 ha of area with nearly 16% of them can be found along the west coast area (Shamsudin and Nasir, 2005). The declination trend is increasing rapidly due to the increased reliance on mangroves for aquaculture and wood products (Alongi *et al*., 2004). Hence, we are losing more wildlife species every few years including those that we barely have information about.

1.2 Problem Statement

The Milky stork or the *Mycteria cinerea* (Raffles, 1882) is one close example of the worsening trend. The species has been rapidly decline throughout its ranges, worldwide. Like other large waterbirds, it is a top predator species that is associated with a unique coastal ecosystem, the mangrove. As such, the species is highly sensitive to changes and disturbance and its rapid decline signals us the deterioration of our mangroves. To help alleviate this issue, a reintroduction programme was conducted to help the species repopulate in Kuala Gula, Perak, Malaysia. Although this is not the first effort to repopulate the species back into the wild, it can be considered as the first direct attempt that tries to reintroduce the species into the natural environment. The first attempt conducted in 1998 was more of a breeding trial in a large aviary without allowing the birds to move freely outside their enclosure-albeit that the birds were later being released accidentally due to a storm-damage being inflicted on the aviary. However, no detailed study

was ever conducted to the released birds. Therefore, the current reintroduction can be considered as the first of its kind and there are many unknown challenges that need to be identified and resolved to ensure its success.

1.2.1 The Milky stork reintroduction and its challenges

The Milky stork's conservation status was recently up-listed to 'threatened' from 'vulnerable' by the IUCN in 2016. The review is deemed appropriate due to the rapid and ongoing decline of the population in its stronghold in Sumatera, the only place in the world with large number of Milky storks left, with an estimation of less than 1600 individuals (BirdLife International, 2013b). In Malaysia, the population has undergone constant decline since the 1980s (Li *et al.*, 2006). According to Ismail *et al*. (2010), there are less than five wild individuals recorded in 2009 and with the continuous declining pattern, the wild population in Malaysia is expected to become extinct soon.

Nevertheless, the country still has a good number of captive-bred populations in its possession that can be re-introduce back into the wild. The Malaysian Government through the work of Department of Wildlife and National Parks (DWNP) and with the combined effort of Zoo Negara, have taken the initiative to repopulate the species by exercising a releasing programme. Captive bred population from Zoo Negara was released into the wild habitat of Kuala Gula in Perak. The challenges associated with the Milky stork re-introduction programme are plenty (Li *et al*. 2016). From restraining budget to inadequate expertise to train the Milky storks, as well as availability of suitable habitat, these are some of the main challenges facing by previous and possibly current efforts to conserve the species. Other challenges include the need to identify the stork's behavior and routine activity post-release. Due to the large home-range of the species, monitoring the reintroduced population can be difficult at times especially in a new habitat like the one in Kuala Gula.

Understanding the species' response in the new environment is equally important so that future re-introduction can be improved. Information like home-range, movement, distribution and breeding activity, etc. is fundamental for monitoring and to evaluate the success of the re-introduction programme. Past studies focus mostly on the Milky stork's distribution and brief account/ short-term activity and habitat utilization of the population (Swennen and Marteijn, 1987; Silvius and Verheugt, 1989; Yatim, 1989; Verheugt et al. 1993). However, none has conducted a long-term study to understand their responses and adaptation to habitat changes and anthropogenic activity in the wild. In addition, the knowledge that we have on the wild population is still inadequate which led to the uncertainty of the exact cause of their rapid decline in the country. This has also been demonstrated

in the first re-introduction programme in Kuala Selangor that failed to meet its objective.

1.2.2 Pollution and its impact on the population

Development and pollution can never be separated. Anthropogenic activity not only disrupt coastal habitat but also increases pollutants availability and levels. Kuala Gula is regarded as pristine and unpolluted in terms of toxic pollutants levels in its aquatic environment (Lomoljo *et al*., 2010). However, with the current development of aquacultures, residential and heavy boating activity in Kuala Gula, the levels of toxic pollutants like the heavy metals could increase in the area. In addition, the extensive palm oil industry in the inland would also increase the levels of pesticide in the aquatic environment with continuous input from the industry. These pollutants will eventually accumulate in sediments and later bio-magnify along the food chain. In addition, these pollutants may cause adverse effect to Milky storks' health as they affect their physiological and biological processes. The well-known effects of toxic pollutants on waterbirds include among others are thinning of eggshells, premature hatching, and deformities in their young (De Luca-Abbot *et al*., 2004; Horai *et al*., 2006; Ayas, 2007; Kim and Koo, 2007).

As for the sediment, its quality is viewed as an important indicator of water pollution due to the fact that they act as pool for pollutants (Santos *et al*., 2003). The sediments which act as a primary sink for many pollutants will leach them back into the environment under favorable conditions. These pollutants will then travel along the food chains and through bio-magnification process, reach higher trophic level organism like the Milk stork. Thus, understanding the speciation of the metals in the sediment is important as it would allow us to predict the risk of contamination of the metals to the population.

For instance, heavy metals like cadmium (Cd) and lead (Pb) may cause extreme toxicity even at low levels making it necessary to monitor sensitive aquatic environments (Cohen *et al*., 2001). Other metals like zinc (Zn) and iron (Fe) metals are essential for biological processes but will become toxic if it is found above their threshold values. In addition, there is a concern over the level of glyphosate in Kuala Gula environment due to the existence of massive oil palm plantation in the area. Glyphosate is the most widely used herbicide in the world since its first introduction in the 1970s (Allegrini *et al.*, 2015). This herbicide is widely used in the country's palm oil plantations and other major crops to control weed. Prolong usage of glyphosate-based herbicide will affect not just the biotic communities but also the ecosystem that support them.

According to Cuhra *et al.* (2013) even the ambient concentration of this herbicide can adversely affect aquatic invertebrate ecology that will eventually disrupt the entire food chain, affecting top predators like the waterbirds. Currently, there are no studies that highlight glyphosate accumulation in Kuala Gula's environment. Thus, it is equally important to analyze its level particularly in the sediment in the Milky stork foraging areas to highlight the background levels of the pollutant. With the increasing anthropogenic activity in Kuala Gula, some of these pollutants are expected to increase and if not studied, would affect not only the wildlife population but also the human in the area.

1.3 Research Objectives

In general, the main objective of this work is to study the ecology of the Milky stork in Malaysia. The specific objectives are:

1. To investigate the Milky stork's ecology pre-release or in captivity in Zoo Negara using bio-logging technique.

2. To investigate the Milky stork's ecology post-release in Kuala Gula including home-range, movement pattern, foraging and breeding activity and its success.

3. To evaluate the habitat quality of the Milky stork i.e. input of heavy metals (Zn, Cu, Cd and Pb) in water, sediment and the Milky stork diet as well as glyphosate background level the in sediment.

4. To identify the risk of exposure of the Milky stork population to the available pollutants particularly heavy metals using Exposure Model Analysis.

1.4 Significance of Study

Considering the lack of detailed reports on past Milky stork re-introduction programme, this study is viewed as one of the important components in the Milky stork's management as it follows the Milky stork's activity in both captivity and reintroduced statuses. The study also evaluates the changing environment particularly one that is related to heavy metals and glyphosate pollution in Kuala Gula's aquatic environment. In addition, this study tries to understand the re-introduced Milky stork adaptability after release such as foraging and breeding activities. Moreover, the risk of the population being exposed to available pollutants particularly heavy metals (in relation to the increasing anthropogenic activity in Kuala Gula) is also a critical issue that need to be assessed. It is a hope that the findings from this study can be used to guide and improve the current re-introduction programme.

1.5 Thesis Organization

The thesis is organized following the specific objectives of this study. Hence, the flow of the methodology, results and discussion as well as the conclusion made are presented in that manner i.e. investigation of Milky stork's ecology pre-release using bio-logging technique > investigation of post-release ecology > habitat quality study > identification of the risk of exposure of metals on the Milky stork population.

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