



UNIVERSITI PUTRA MALAYSIA

**DIVERSITY OF MIGRATORY SHOREBIRDS AND THEIR HABITAT
CHARACTERISTICS IN KUALA GULA BIRD SANCTUARY, PERAK,
MALAYSIA**

ROMEO M. LOMOLJO

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By

ROMEO M. LOMOLJO

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia in
Fulfilment of the Requirements for the Degree of Doctor of Philosophy**

January 2011

DEDICATION

*To my daughters En-En, Barbie and my wife Evangelina
for the love and understanding*



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

DIVERSITY OF MIGRATORY SHOREBIRDS AND THEIR HABITAT CHARACTERISTICS IN KUALA GULA BIRD SANCTUARY, PERAK, MALAYSIA

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Chairman: Prof. Dr. Ahmad Ismail, PhD

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The research study was conducted in one of the primary corridors and stopover sites of the migratory shorebirds during annual migrations in Kuala Gula Bird Sanctuary, Perak in the west coast of Peninsular Malaysia. The objective were to determine the diversity of migratory shorebirds and to assess the habitat quality, prey availability, environmental conditions, heavy metal concentrations in the sediments, macrobenthic organisms, fish and shrimps from October 2006-September 2007. Two sampling stations each covering an area of 100 x 100 m, were established to represent the whole Kuala Gula Bird Sanctuary between 04°55.185'N, 100°27.8'E and 100°27.761'E. Survey of shorebirds was carried out through direct count and identification to species level. Sixty-one migratory shorebird species from 12 families were identified in both stations. The overall

total of shorebirds density was found to be higher in northward migration (7913 individual/ha) than southward migration (4396 individual/ha). Similarly, the species diversity index ($H' = 3.20$; $p < 0.05$) and the species richness ($d' = 6.19$; $p < 0.05$) were also higher in northward migration. However, no significant ($p > 0.05$) differences were found in species evenness, between southward and northward migration throughout the study period. Meanwhile, 28 species of macrobenthos in both stations were recorded and identified representing 15 families throughout the study period. The species diversity index of macrobenthos were higher ($p < 0.05$) in station 2 ($H' = 3.24$) compared to station 1 ($H' = 3.13$). Similarly, the species richness was higher ($p < 0.05$) in station 2 ($d' = 6.22$) compared to station 1 ($d' = 6.11$). Among the macrobenthos, polychaetes were found to be the most abundant (204.3 ± 6.84 individual/ m^2), followed by molluscs (156.8 ± 6.3 individual/ m^2), fishes (132.8 ± 6.6 individual/ m^3), and shrimps (135.3 ± 4.1 individual/ m^3). The overall total macrobenthos density and biomass revealed a positive ($r = 0.920$; $p < 0.05$) correlation with bird density, suggesting the importance of food resources to the distribution of migratory shorebirds in the area.

The environmental quality in the area in terms of water quality and nutrients were maintained in healthy levels. No significant variations in the *in situ* water quality parameters (salinity, pH, temperature and dissolved oxygen) were observed in both sampling stations throughout the study period. In addition, nitrate nitrogen (NO_3-N), total ammonia nitrogen (TAN) and soluble reactive phosphorus (SRP) in the water surface were all in safe levels and maintained at minimum (SRP = 55.92 ± 7.88 $\mu g/L$; nitrate-N = 85.68 ± 24.33 $\mu g/L$; TAN = 85.91 ± 6.54 $\mu g/L$) throughout the study period. The total

geochemical fractionation analysis of sediments in Station 1 and Station 2 ranged from 80.4 - 91.3%, 61.9 - 86.4%, 49.4 - 72.4%, 61.3 - 96% and 63 - 95% of the total Cd, Cu, Ni, Pb and Zn were accumulated in the 'resistant' fractions throughout the sampling period which indicated that the mobility of these metals in Kuala Gula coastal water were low in terms of contribution or contamination from anthropogenic sources. Significant ($p < 0.05$) and positive correlation were detected between ($r = 0.578$) birds density and Pb metal concentration of sediments in station 2. However, the total fraction of Cu ($r = -0.591$ and Ni ($r = -0.513$) in sediments had significant $p < 0.05$) negative correlation with crabs density in station 1. Similarly, the Pb ($r = 0.657$) metal concentrations in sediments was significantly $p < 0.05$) correlated to shrimp density in station 1. Meanwhile, positive correlation, with lesser confidence ($p < 0.05$) was also detected between mollusc density and Cd ($r = 0.492$) metal concentrations in station 2.

Overall, this study revealed that Kuala Gula ecosystems are still pristine with low anthropogenic sources, abundant food supply and ideal habitat for migratory shorebirds. Therefore, Kuala Gula coastal water is still in healthy condition but continuous environmental monitoring program should be implemented before it reaches alarming level as the ever increasing human activities and rapid developments in many infrastructures and industry sectors are continuously expanding. At present, the results of the study will provide important baseline data as reference for future studies on migratory shorebirds.

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

KEPELBAGAIAN BURUNG HIJRAH PANTAI DAN CIRI-CIRI HABITAT DI SANTUARI BURUNG, KUALA GULA PERAK, MALAYSIA

Oleh

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Fakulti: Sains

Kajian ini telah dijalankan di salah sebuah laluan persinggahan utama bagi burung-burung hijrah pantai semasa migrasi tahunan di Sanctuary Burung Kuala Gula, Perak di pantai barat Semenanjung Malaysia bagi mengenalpasti kepelbagaian burung hijrah pantai di Kuala Gula, menguji kualiti habitat, kebolehdapatan sumber makanan, keadaan persekitaran, kepekatan logam berat di dalam sedimen, organisma makrobentik, ikan dan udang bermula dari Oktober 2006-September 2007. Dua stesen persampelan telah dipilih yang merangkumi kawasan seluas 100 x 100 meter untuk setiap stesen di santuari burung Kuala Gula yang terletak di antara 04° 55.185'N, 100° 27.840'E dan 04° 55.00'N, 100° 27.761'E. Burung-burung telah dienumerasi dan dikenalpasti sehingga ke peringkat spesies secara langsung sewaktu tinjauan dijalankan. Sejumlah 61 spesies burung hijrah pantai yang terdiri daripada 12 famili telah dikenalpasti dikedua-dua stesen kajian. Jumlah keseluruhan kepadatan burung hijrah pantai semasa penghijrahan ke arah utara (7913 individu/ha) didapati lebih tinggi berbanding penghijrahan ke arah selatan (4396

individu/ha). Begitu juga, indeks kepelbagaian ($H = 3.20$; $p < 0.05$) dan kekayaan spesies ($d = 6.19$; $p < 0.05$) semasa penghijrahan ke arah utara didapati ternyata lebih tinggi. Walaubagaimanapun, tiada perbezaan signifikan bagi kesamarataan sebaran spesies ($p > 0.05$), di antara penghijrahan ke arah selatan dan utara di sepanjang tempoh pengajian. Sementara itu, sepanjang kajian dijalankan, sejumlah 28 spesies makrobentos daripada 15 famili telah direkodkan dan dikenalpasti di kedua-dua stesen kajian. Index kepelbagaian spesies di stesen 2 ($H' = 3.24$) didapati lebih tinggi ($p < 0.05$) berbanding stesen 1 ($H' = 3.13$). Begitu juga dengan kekayaan spesies dimana stesen 2 ($d' = 6.22$) didapati mempunyai nilai yang lebih tinggi ($p < 0.05$) berbanding stesen 1 ($d' = 6.11$). Polichaete (204.3 ± 6.84 individu/ m^3) merupakan kumpulan makrobentos yang paling kerap ditemui dikalangan makrobenthos, diikuti oleh molluska (156.8 ± 6.3 individu/ m^3), ikan (132.8 ± 6.6 individu/ m^3) dan udang (135.3 ± 4.1 individu/ m^3). Secara keseluruhan, didapati bahawa kepadatan serta biomass makrobentos adalah berkorelasi secara positif ($r = 0.920$; $p < 0.05$) dengan kepadatan burung yang ditemui. Oleh itu, sumber makanan boleh dikatakan sebagai faktor penting yang mempengaruhi sebaran burung hijrah pantai di kawasan persisiran Kuala Gula.

Kualiti air dan nutrien di Kuala Gula didapati masih kekal di paras yang sihat. Parameter kualiti air *in situ* (suhu, saliniti, oksigen terlarut, pH dan konduktiviti) didapati tidak menunjukkan sebarang variasi signifikan dari segi bulanan sepanjang tempoh kajian dijalankan di kedua-dua stesen. Kepekatan nitrat nitrogen (NO_3-N), ammonia nitrogen total (TAN), dan fosforus reaktif terlarut (SRP) didalam air di kedua-dua stesen didapati berada pada paras yang selamat dan kekal pada paras yang minimum ($SRP = 55.92 \pm$

7.88 $\mu\text{g/L}$, $\text{NO}_3\text{-N} = 85.68 \pm 24.33 \mu\text{g/L}$, $\text{TAN} = 85.91 \pm 6.54 \mu\text{g/L}$) di sepanjang tempoh kajian.

Bagi analisis keseluruhan pecahan geokimia bagi logam berat Cd, Cu, Pb and Zn di dalam sedimen di stesen 1 dan 2, pecahan 'resistant' telah didapati mendominasi nilai keseluruhan logam berat di sepanjang tempoh kajian dijalankan dengan julat di antara 80.4 - 91.3%, 61.9 - 86.4%, 49.4 - 72.4%, 61.3 - 96% dan 63 - 95% telah menggambarkan bahawa mobiliti metal yang berpunca daripada sumber anthropogenik di perairan Kuala Gula adalah masih rendah. Terdapat kolerasi secara positif ($r = 0.578$; $p < 0.05$) di antara kepadatan burung dengan kepekatan Pb di dalam sedimen di stesen 2. Walaubagaimanapun, terdapat kolerasi secara negatif ($p < 0.05$) diantara pecahan keseluruhan logam berat bagi Cu ($r = -0.591$ dan Ni ($r = -0.513$) di dalam sedimen dengan kepadatan populasi ketam di stesen 1. Begitu juga dengan kepekatan Pb ($r = 0.657$) di dalam sedimen di stesen 1 dimana terdapat kolerasi secara positive dengan kepadatan udang telah diperhatikan. Sementara itu, kolerasi positif ($p < 0.05$) yang lemah juga dapat diperhatikan di antara kepadatan moluska dengan kepekatan Cd ($r = 0.492$) di stesen 2.

Secara keseluruhannya, kajian ini menunjukkan bahawa ekosistem Kuala Gula masih berada ditahap yang bersih dengan sumber antropogenik yang minimal, kebolehdapatan sumber makanan yang banyak dan habitat yang ideal untuk burung-burung hijrah pantai. Walaubagaimanapun, pemantauan yang berterusan di kawasan ini perlu dilaksanakan bagi memastikan sebarang gangguan atau perubahan ekosistem akibat aktiviti manusia

dan pembangunan pesat dalam sektor infrastruktur dan industri yang dijalankan dapat dikesan diperingkat awal lagi bagi mengelakkan kesan yang lebih buruk terhadap kepelbagaian serta habitat hidupan liar dikawasan ini. Maka, diharapkan hasil kajian ini dapat dijadikan sebagai rujukan dan memberi panduan asas untuk kajian di masa hadapan.



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I certify that an Examination committee has met 6th January 2011 to conduct the final examination of Romeo M. Lomoljo on his Doctor of Philosophy thesis entitled “Diversity of Migratory Shorebirds and Their Habitat Characteristics in Kuala Gula Bird Sanctuary Perak, Malaysia” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980. The Committee recommends that the student be awarded the doctor of Philosophy Degree.

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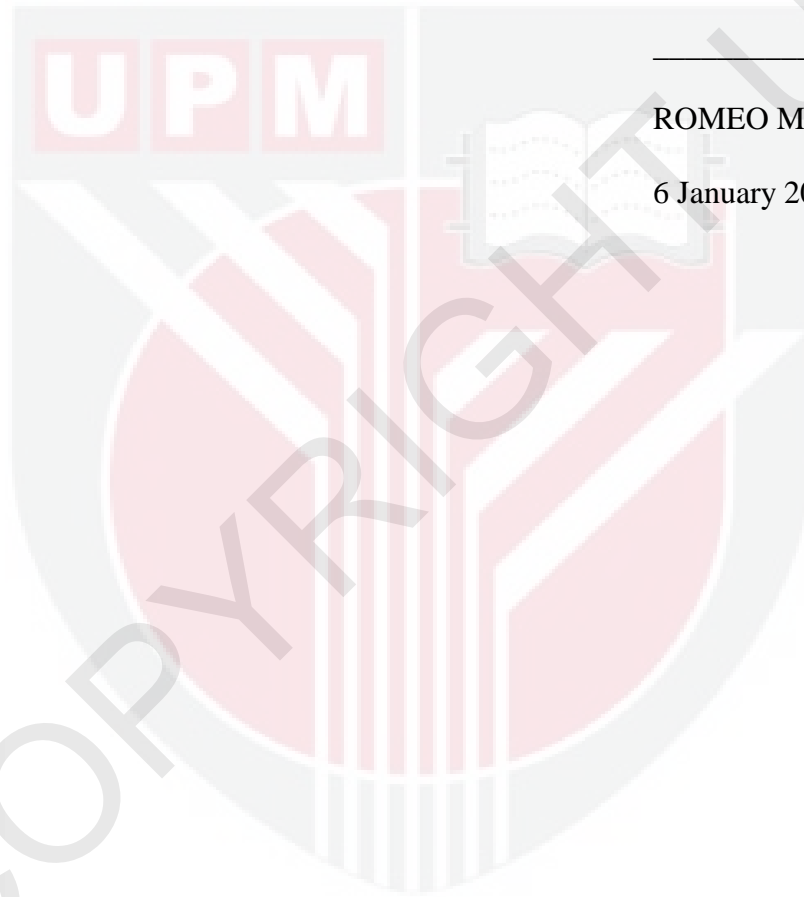
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DECLARATION

I declare that the thesis is my original work except for quotation and citations which have been duly acknowledge. I also declare that it has not been previously, or concurrently, submitted for any other degree at Universiti Putra Malaysia at any institutions.



ROMEO M. LOMOLJO

6 January 2011

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