MALAYSIAN PLOVER OCCURRENCE IN RELATION TO CRUSTACEAN PREY ABUNDANCE AT TANJUNG RESANG BEACH, MERSING, JOHOR

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MALAYSIAN PLOVER OCCURRENCE IN RELATION TO CRUSTACEAN PREY ABUNDANCE AT TANJUNG RESANG BEACH, MERSING, JOHOR

By

LIM YEONG SHYA

A Project Report Submitted in Partial Fulfillment of the Requirements for the Degree of Bachelor of Forestry Science in the Faculty of Forestry Universiti Putra Malaysia

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DEDICATION

TO MY BELOVED PARENTS,

LIM SOON HENG & GOH CHAI GUAT

MY BROTHERS,

LIM WEY CHYUAN & LIM WEY NAN

SUPERVISOR,

DR PUAN CHONG LEONG

AND FRIENDS.

ABSTRACT

Sandy beach is an important ecosystem for most coastal and intertidal animals especially for the waders and crustaceans such as crabs. The aim for this study was to identify the species of sand bubbler crabs and to compare the crustacean prey abundance in relation to anthropogenic disturbance level, existence and breeding condition of the Malaysian Plovers. This study was conducted from 6th July to 8th July 2018 in Tanjung Resang beach, Mersing, Johor. In overall, 15 sampling points were set along a transect on the beach. The abundance of crabs was estimated by counting the number of crab burrows within one meter square quadrats. Results showed that the species of sand bubbler crabs found on the beach was most likely *Dotilla wichmanni*. Kruskal-Wallis H test indicated that there was a highly significant difference in the number of crab burrows at different sampling points. A Mann-Whitney U test showed that different anthropogenic disturbance level did affect the number of crab burrows at different points. The points with presence and absence of the Malaysian Plovers had also significant difference in the crab burrow density. However, the Mann-Whitney U test found that the points with breeding-pairs and non-breeding individuals of the plovers had no significant difference in the number of crab burrows. Tourism development and anthropogenic disturbance may affect the crab survival ability and in turn altered the occurrence and feeding behaviour of the Malaysian Plovers.

ABSTRAK

Kawasan pantai berpasir adalah ekosistem yang penting untuk kebanyakan haiwan yang tinggal di situ terutama untuk burung pesisir dan krustasea seperti ketam. Tujuan kajian ini adalah untuk mengenalpasti spesies ketam dan untuk membandingkan kelimpahan mangsa krustasea mengikut tahap gangguan antropogenik, kewujudan dan keadaan pembiakan Rapang Pasir. Kajian ini dijalankan dari 6 Julai hingga 8 Julai 2018 di pantai Tanjung Resang, Mersing, Johor. Sebanyak 15 tapak pensampelan telah ditetapkan sepanjang transek di pantai. Bilangan ketam telah dikira berdasarkan kepada jumlah lubang ketam dalam kuadrat satu meter persegi. Rapang Pasir telah dikenalpasti melalui pemerhatian manakala ketam yang ditangkap dipelihara menggunakan alkohol untuk pengenalpastian selanjutnya. Keputusan menunjukkan bahawa spesies ketam yang terdapat di pantai kemungkinan besar adalah *Dotilla wichmanni*. Ujian Kruskal-Wallis H menunjukkan bahawa terdapat perbezaan yang sangat ketara dalam jumlah lubang ketam pada tapak pensampelan yang berbeza. Ujian Mann-Whitney U menunjukkan bahawa tahap gangguan antropogenik yang berbeza telah mempengaruhi bilangan lubang ketam pada tapak pensampelan yang berbeza. Selain itu, tapak dengan kehadiran dan ketiadaan Rapang Pasir juga mempunyai perbezaan ketara dari segi kepadatan lubang ketam. Walau bagaimanapun, ujian Mann-Whitney U mendapati bahawa tapak yang ada pasangan pembiakan dan individu yang tidak membiak tidak mempunyai perbezaan yang signifikan dalam jumlah lubang ketam. Pembangunan pelancongan dan gangguan antropogenik mempengaruhi kemandirian ketam dan seterusnya mengubah kejadian dan perilaku makan Rapang Pasir.

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APPROVAL SHEET

I certify that this research project entitled "Malaysian Plover Occurrence in Relation to Crustacean Prey Abundance at Tanjung Resang Beach, Mersing, Johor" by Lim Yeong Shya has been examined and approved as a partial fulfillment of the requirements for the degree of Bachelor of Forestry Science in the Faculty of Forestry, Universiti Putra Malaysia

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Symbol	Description
IUCN	International Union for Conservation of Nature
OFT	Optimal foraging theory
SE	Standard error

CHAPTER ONE

INTRODUCTION

1.1. General Background

Coastal areas are transitional areas between the land and sea which are characterized by a high biodiversity and they include some of the richest and most fragile ecosystems on earth. Like other ecotones, they exhibit a sharp gradient both in biotic and environmental factors, mainly related to substrate coherence and salinity, wind, salt spray and wave regime, which differ with distance from the water and topographic sheltering (Acosta et al., 2007). This steep gradient makes them highly dynamic systems deeply influenced by environmental stressors and drivers (Barbour, 1992), but at the same time, as abiotic patterns change within a short distance, it is responsible for the high level of ecological diversity, environmental heterogeneity and for the coexistence of different communities within a relatively limited space including composition of waders and crustacean communities. (Frederiksen et al., 2006). Waders and crustacean organisms are the main constituents for formation of different communities in the coastal area.

Worldwide, 40 more bird species are now classified as having a higher risk of extinction in the 2015 International Union for Conservation of Nature (IUCN) Red List. Besides the vultures, these include many wading shorebirds, and other iconic species like Helmeted Hornbill, Swift Parrot, Atlantic Puffin, and European Turtle-dove. The Malaysian Plover is one of the endangered shorebird species. Although nearly half of the threatened shorebird species breed in tropical areas, little research has been conducted on the conservation and ecology of these species (Yasué, 2006). The most dominant factor which contributes to the global loss of the species is anthropogenic habitat disturbance (Yasué, 2006). With some of the world's fastest growing economies, high human densities in coastal areas have led to increasing threats to these waders. Coasts offer recreational activities such as swimming, fishing, surfing, boating, and sunbathing for tourists. This leads to destruction and loss of habitat of variety of coastal organisms. Coasts also face many human-induced environmental impacts. The human influence on climate change is thought to contribute to an accelerated trend in sea level rise which threatens coastal habitats.

The Malaysian Plovers are among the wader species which primarily threatened by tourism development on the beach at their breeding habitat and such development affects their habitat selection and breeding success which are linked to the changes in prey abundance. In terms of habitat use, Placyk and Harrington (2004) indicated that densities of foraging waders are highest on intertidal habitats sheltered from coastal wave and at which densities of benthic (burrowing) and epifauna (surface-dwelling) prey are high. The common preys of the shorebirds include crabs. For the Malaysian Plover, sand bubbler crab is its main prey. The crabs which are present in sandy beaches spending most of their time inside their burrows in shifting sand. The location where the sand crabs live is specifically the area of intertidal zone along the sandy beach. Organisms that live in the intertidal zone must be able to live in a wide range of temperature, light and tidal conditions.

The habitat requirements demanded by intertidal organisms and shorebirds are influenced by the negative impacts resulted from tourism activities. Coastal pollution is also a persistent problem. Pollution can occur due to severe natural events such as hurricanes or floods, illegal dumping, accidental oil spills, and solid waste trash left behind by people. Trash and other solid materials that reach rivers, bays, estuaries and oceans may eventually wash up on beaches. Other sources of pollution include trash, fishing nets and lines in the ocean. These plastic, rubber, foam materials, and metals take hundreds of years to break down. Shorebirds and invertebrates are sometimes killed by the ingestion of non-biodegradable materials that they have mistaken for food on the beach. Besides that, some of them even died from entanglement in fishing nets.

Negative impacts resulted from tourism, environmental factors (e.g. climate change, monsoon, hurricanes), human disturbance and other sources are believed to affect the population of crabs which inhabit mostly the intertidal zone on the sandy beach. A decline in the crustacean prey abundance over the beach will in turn influence the distribution and occurrence of predator. The Malaysian Plovers which mainly depend on crustacean organisms on the beach for feeding, may need to change their habitat repeatedly due to paucity of food sources.

1.2 Problem Statement

Many waders around the world are endangered and some are listed as threatened species although they are important contributor to ecosystem goods and functions. As predators of invertebrates, shorebirds have a function in regulation of aquatic, benthic and infaunal communities. Shorebirds are an important part of coastal food webs, as they are major consumers of invertebrates. Shorebirds that feed on benthic invertebrates play an important role in maintaining a balance within benthic communities (Moreira, 1997). Shorebirds also play a significant role in nutrient cycling, by depositing guano and food remains and influencing the growth of plants, especially on island ecosystems. Besides that, shorebirds are important in the transport of seeds from the mainland to islands. Through their role in nutrient deposition and seed transportation, shorebirds are likely to make a contribution in erosion regulation in coastal and island ecosystems.

Sandy tropical beaches are significant habitats for a variety of marine species but at the same time these beaches also have economic value. This value causes increased industrial development occurring in the coastal area, the most crucial habitats for shorebirds are being degraded and sometimes removed altogether. Beaches are rapidly being converted into resorts, restaurants and seawalls to meet the demands of international and domestic tourism (Yasué & Dearden, 2006). Shorebirds are vulnerable to a range of threats result from the increased industrial development including degradation and loss of habitats across their entire distributional range. Beach degradation resulted from tourism development not only causes a decline in waders population but also crustacean organisms living along the sandy beaches. Despite the tourism industry is growing in coastal areas, there are only a few studies examined the potential impacts of human disturbance on habitat of shorebirds in the tropics. During the breeding season, many resident shorebirds are beach-nesters, they are susceptible to considerable human disturbance impacts, predation and disturbance by domestic, feral and wild animals.

As geographically located along the east coast of Peninsular Malaysia, Tanjung Resang beach in Mersing, Johor is being developed to become an attractive area to tourists. Although not as well-known as other east coast seaside areas, Tanjung Resang still draws a huge number of tourists. Tourism development in the area may influence habitat selection of the Malaysian Plover. This is because such development can lead to disturbance and alterations of habitat structure that may threaten not only the beach-nesting waders but also the crustacean organisms living on the beaches. In areas with high concentrations of tourist activities, waste disposal is a serious problem and improper disposal can be a major despoiler of the natural environment including rivers, ocean, scenic areas and sandy beach. Litters such as bottles and plastic sacks can create harmful environment to the intertidal crab species. Plastic poses threat to the crabs by depleting their nutrients and blocking their stomachs and intestines. Crabs may also crawl into the bottles looking for food and water and become stuck thereby slowly die from starvation and illness.

Intertidal crabs occupy and live inside the burrows in the intertidal zone. Frequent use of trail and trampling of the sand particles can eventually cause damage to small crustaceans and their habitat. Such damage can be even more extensive when visitors frequently stray off established trails. Trampling by visitors has been perceived to have a greatest impact on local crustacean populations. Consequently, increased tourism activities on the sandy beach area is expected to give impacts on Malaysian Plovers with respect to decrease in crustacean prey abundance.

1.3 Objectives

The objectives of this study were:

a) To compare the crustacean prey abundance at sites with different anthropogenic disturbance level at Tanjung Resang, Johor.
b) To compare the crustacean prey abundance among sites with breeding pairs and non-breeding individuals of the Malaysian Plover.
c) To identify the species of sand bubbler crabs which were present on the beach.

REFERENCES

Acosta, A., Ercole, S., Stanisci, A., De Patta Pillar, V. & Blasi, C. (2007). Coastal vegetation zonation and dune morphology in some Mediterranean ecosystems. *Journal of Coastal Research, 23*, 1518-1524.

Allen, K. R. (1941). Studies on the biology of the early stages of the salmon (*Salmo salar*) 2. Feeding habits. *Journal Animal Ecology, 10*, 47-76.

Allen, J. (2012). *A field guide to the birds of Peninsular Malaysia and Singapore*. Oxford: Oxford University Press.

Allen, C. J. (2010). Ecology of the intertidal crab *Dotilla Intermedia* from tsunami-impacted beaches in Thailand. University of Southampton, PhD Thesis, 2-97.

Amat, J. A., Fraga, R. M., & Arroyo, G. M. (1999a). Brood desertion and polygamous breeding in the Kentish Plover *Charadrius alexandrinus*. *Ibis, 14,* 596-607.

Ansell, D. A. (1988). *Migration or shelter? Behavioural options for deposit feeding crabs on tropical sandy shores. In: Chelazzi G, Vannini M (eds) Behavioural adaptations for life.* New York and London: Plenum Press, 15-26.

Baillie, J. E. M., Hilton-Tayler, C., & Stuart, S. N. (2004). *List of threatened species: A global species assessment*. Cambridge: International Union for Conservation of Nature.

Barbour, M. G. (1992). *Life at the leading edge: The beach plant syndrome, In: Coastal plant communities of Latin America, Seeliger U*. (Edision.). San Diego: California: Academic.

Bartelt, G. A., Rolley, R. E., & Vine, L. E. (2001). *Evaluation of abundance indices for striped skunks, common raccoons and Virginia opossums in southern Wisconsin (Research report (Wisconsin. Dept. of Natural Resources).* Madison, Wisconsin: Wisconsin Dept. of Natural Resources, Bureau of Integrated Science Services.

Beasy, K. M., & Ellison, J. C. (2013). Comparison of three methods for the quantification of sediment organic carbon in salt marshes of the Rubicon Estuary, Tasmania, Australia. *International Journal of Biology, 5*(4), 1-13.

Benes, K. M., & Bracken, M. E. (2016). Nitrate uptake varies with tide height and nutrient availability in the intertidal seaweed *Fucus vesiculosus*. *Journal Phycology, 52*(5), 863-876.

Bergamaschi, B. A., Tsamakis, E., Keil, R. G., Eglinton, T. I., Montluçon, D. B., & Hedges, J. I. (1997). The effect of grain size and surface area on organic matter, lignin and carbohydrate concentration, and molecular compositions in Peru Margin sediments. *Geochimica et Cosmochimica Acta, 61*(6), 1247-1260.

Bradshaw, C., & Scoffin, P. (1999). Factors limiting distribution and activity patterns of the soldier crab *Dotilla myctiroides* in Phuket, South Thailand. *Marine Biology, 135*(1), 83-87.

Camarda, D., & Grassin, L. (2003). *Local resources and global trades: Environments and agriculture in the Mediterranean region*. Bari: CIHEAM, 263-270.

Clark, R. (2001). *Marine pollution*. Oxford: Oxford University Press.

Clark, J. R. (1997). Coastal zone management for the new century. *Ocean and Coastal Management, 37*, 191-216.

Creel, S. (2005). Elk alter habitat selection as an antipredator response to wolves. *Ecology, 86*, 3387-3397.

David, J. T. D., & James, W. P. H. (2014). Relative importance of prey abundance and habitat structure as drivers of shorebird breeding success and abundance. *Journal of Animal Conservation, 17*, 535-543.

Effendy, K., & Natin, P. (2016). The effect of soil particle size on the soil organic matter and the abundance of sand bubbler crab *Scopimera globosa* at Tanjung Aru Beach, Kota Kinabalu, Sabah. *Transactions on Science and Technology, 3*(1-2), 209-217.

Elliott, A., Hoyo, J., Sargatal, J., Christie, D. A., & Juana, E. (2015). Handbook of the Birds of the World Alive.

Ens, B. J., Kersten, M., Brenninkmeijer, A., & Hulscher, J. B. (1992). Territorial quality, parental effort and reproductive success of oystercatchers (*Haematopus ostralegus*). *Journal Animal Ecology, 61*, 703-715.

Frederiksen, L., Kollmann, J., Vestergaard, P., & Bruun, H. H. (2006). A multivariate approach to plant community distribution in the coastal dune zonation of NW Denmark. *Phytocoenologia, 36*, 321-342.

Gall, S. C., & Thompson, R. C. (2015). The impact of debris on marine life. *Marine Pollution Bulletin, 92*, 170-179.

Gherardi, F., Russo, S., & Anyona, D. (1999). Burrow-orientated activity in the ocypodid crab, *Dotilla fenestrata*, living in a mangrove swamp. *Journal Marine Biology Ass UK, 79*, 281-293.

Godvik, I. (2009). Time scale, tradeoffs and functional responses in red deer habitat selection. *Ecology, 90*, 699-710.

Griffiths, D. (1973). The food of animals in an acid moorland pond. *Journal Animal Ecology, 42*, 285-293.

Griffiths, D. (1975). Prey availability and the food of predators. *Ecology, 56*, 1209-1214.

Hall, C. M. (2001). *Trends in ocean and coastal tourism: the end of the last frontier?* Dunedin: Elsevier Science Limited.

Hess, A. D., & Swartz. A. (1940). The forage ratio and its use in determining the food grade of streams, p. 162-164. In Trans. 5th N. Am. Wildlife. Conf.

Howes, J. R., Hawkins, A. F. A., & Parish, D. (1986). Preliminary survey of wetlands and shorebirds along the east coast of Peninsular Malaysia. *Interwader Publication, 14*, 10-27.

Johnsgard, P. A. (1981). *The plovers, sandpipers and snipes of the world*. London: University of Nebraska Press.

Mendoza, J. C. Z. (2018). Lecturer of Faculty of Science, National University of Singapore. Personal communication.

Kemp, S. K. (1919). *Notes on crustacea decapoda in the Indian museum*. Rec Ind Mus XVI (V), 305-348.

Leo, Z., Jan, V. D. K., Bruno, E., & Theunis, P. (2004). *Shorebirds-An illustrated behavioural ecology*. Netherlands: KNNV Publishers.

Lloyd, P. (2008). Adult survival, dispersal and mate fidelity in the White-fronted Plover *Charadrius marginatus*. *Ibis, 150*, 182-187.

Lord, A., Waas, J. R., Innes, J., & Whittingham, M. J. (2001). Effects of human approaches to nests of northern New Zealand dotterels. *Biological Conservation, 98*, 233-240.

Low, P. S. (2005). *Climate Change and Africa*. Cambridge: Cambridge University Press.

Martin, T. E. (1996). Life history evolution in tropical and south temperate birds: what do we really know? *Journal Avian Biology, 27*, 263-272.

Medway, Lord, & Wells, D. R. (1976). *The birds of the Malay Peninsula*. Kuala Lumpur: Witherly and Sons/ Universiti Malaya,

Melvin, S. M., Hecht, A., & Griffin, C. R. (1994). Piping plover mortalities caused by off-road vehicles on Atlantic coast beaches. *Wildlife Society Bulletin, 22*, 409-414.

Moody, A. L., & Houston, A. I. (1995). Interference and the ideal free distribution. *Animal Behaviour, 49*, 1065-1072.

Moody, A. L., & Ruxton, G. D. (1996). The intensity of interference varies with food density: support for behaviour-based models of interference. *Oecologia, 108*, 446- 449.

Moreira, F. (1997). Importance of shorebirds to energy fluxes in a food web of a south European estuary, Estuarine. *Coastal and Shelf Science, 44*, 67-78.

Neill, R. M. (1938). The food and feeding of the brown trout (*Salmo trutta* L.) in relation to the organic environment. *Trans. R. Soc. Edinb, 59*, 481-520.

Nobbs. M., & Mcguinness, K. A. (1999). Developing methods for quantifying the apparent abundance of fiddler crabs (Ocypodidae: *Uca*) in mangrove habitats. *Journal of Ecology, 24*, 43-49.

Nur Atiqah Norazlimi & Rosli Ramli (2015). *The relationship between morphological characteristics and feeding behavior in four selected species of shorebirds and waterbirds utilising tropical mudflats.* The Scientific World Journal, Vol. 2015, Hindawi Publishing Corporation.

Ono, Y. (1965). On the ecological distribution of Ocypodid crabs in the estuary. *Mem Faculty Science Kyushu University Ser E (Biol), 4*, 1-60.

Parish, D., & Wells, D. R. (1985). *Interwader Annual Report 1984*. Kuala Lumpur: Interwader Publication No. 2.

Peter, H., John, M., & Tony, P. (2011). *An identification guide to the waders of the world.* London: Christopher Helm Publisher.

Placyk, J. S., & Harrington, B. A. (2004). Prey abundance and habitat use by migratory shorebirds at coastal stopover points in Connecticut. *Journal Field Ornithol, 75*(3), 223-231.

Plaster, E. J. (2002). Soil science & management (4^{th} edition.). Delmar Cengage Learning.

Pombo, M., & Turra, A. (2013). Issues to be considered in counting burrows as a measure of atlantic ghost crab populations, an important bioindicator of sandy beaches. *PLoS One, 8*, 1-7.

Richard, C. (2009). *Shorebirds of the northern hemisphere*. London: Christopher Helm.

Robinson, W., Schlacher. T. A., & Lucrezi, S. (2008). Human disturbance as a cause of bias in ecological indicators for sandy beaches: Experimental evidence for the effects of human trampling on ghost crabs (*Ocypode* spp.). *Ecological indicator, 9,* 913-921.

Roner, M., D'Alpaos, A., Ghinassi, M., Marani, M., Silvestri, S., Franceschinis, E., & Realdon, N. (2015). *Spatial variation of salt-marsh organic and inorganic deposition and organic carbon accumulation: Inferences from the Venice lagoon, Italy.* Advances in Water Resources - In press.

Ruttanadakul, N., & Ardseungnurn, S. (1986). *Evaluation of Coastal Wetlands in South Thailand: Evaluation of Shorebird Hunting in Pattani Province, South Thailand*. Kuala Lumpur: Interim Report for WWF-US. INTERWADER/PSU Report No.2.

Ruxton, G. D., Gurney, W. S. C., & De Roos, A. M. (1992) Interference and generation cycles. *Theoretical Population Biology, 42*, 235-253.

Saher, N. U., & Qureshi, N. A. (2010). Zonal distribution and population biology of *Ilyoplax frater* (Brachyura : Ocypodoidea: Dotillidae) in a coastal mudflat of Pakistan. *Current Zoology, 56*(2), 244-251.

Saher, N. U., Qureshi, N. A., & Siddiqui, A. S. (2017). Influence of sediment characteristics on density and distribution of *Ocypodoid* crab burrows (superfamily: Ocypodoidea) along the coastal areas of Pakistan. *Acta Ecological Sinica*, 1-8.

Sarno, Mohd Rasyid Ridho & Hanifa Marisa. (2016). Pantai pasir padi (paddy sand beach) of Bangka Island; crabs (*Scopimera* sp) population, feeding behaviour and their bird predator. *Biological Research Journal, 2*, 88-93.

Schlacher, T., & Lucrezi, S. (2014). "The ecology of ghost crabs." Oceanography and marine biology - An Annual Review, 201-256.

Silva, W. T. F., & Calado, T. C. S. (2013). Number of ghost crab burrows does not correspond to population size. Cent. Eur. *Journal Biology, 8*, 843-847.

Stanton, M. L. (1982). Searching in a patchy environment: foodplant selection by *Coliasp eriphyle* butterflies. *Ecology, 63*, 839-853.

Stillman, R. A., Goss-Custard, J. D., & Caldow, R. W. D. (1997) Modelling interference from basic foraging behaviour. *Journal of Animal Ecology, 66*, 692-703.

Swennen, C., & Marteijn, E. (1985). *Wader Feeding Ecology Studies in the Malay Peninsula.* Kuala Lumpur: In Parish and Wells (eds) INTERWADER Annual Report 1984, INTERWADER.

Takahashi, M., Suzuki, N., & Koga, T. (2001). Burrow defense behaviors in a sand-bubbler crab, *Scopimera globosa*, in relation to body size and prior residence*. Japan Ethological Society and Springer-Verlag Tokyo, 19*, 93-96.

Triplet. P, Stillman. R. A., & Goss-Custard. J. D. (1999). Prey abundance and the strength of interference in a foraging shorebird. *Journal of Animal Ecology, 68*, 254-265.

Vernberg, F., & Vernberg, W. (2001). The Coastal Zone: Past, Present, and Future. *Nature*, 161-182.

Vogel, F. (1983). A redescription of *Dotilla malabarica* Nobili, 1983 (Decapoda, Brachyura, Ocypodidae). *Crustaceana, 46*, 157-163.

Vogel, F. (1984). Comparative and functional morphology of the spoon-tipped setae on the second maxillipeds in *Dotilla Stimpson*, 1858 (Decapoda, Brachyura, Ocypodidae). *Crustaceana 47*, 225-234.

Ward, N. D., Krusche, A. V., Sawakuchi, H. O., Brito, D. C., Cunha, A. C., Moura, J. M. S., & Richey, J. E. (2015). The compositional evolution of dissolved and particulate organic matter along the lower Amazon River - Óbidos to the ocean. *Marine Chemistry, 177*, 244-256.

Watts, A. J. R., Urbina, M. A., Corr, S., Lewis, C., & Galloway, T. S. (2015). Ingestion of plastic microfibers by the crab *Carcinus maenas* and its effect on food consumption and energy balance. *Environmental Science & Technology, 49* (24), 14597-14604.

Yasué, M. (2006). The Breeding Ecology and Potential Impacts of Habitat Change on the Malaysian Plover (*Charadrius peronii*) in the Gulf of Thailand. PhD Dissertation, University of Victoria, Victoria.

Yasué, M., & Dearden, P. (2006). The potential impact of tourism development on habitat availability and productivity of Malaysian plovers *Charadrius peronii. Journal Application Ecology, 43,* 978-989.

Yasué, M., & Dearden, P. (2008). *Methods to measure and mitigate the impacts of tourism development on tropical beach-breeding shorebirds: the Malaysian plover in Thailand.* Tourism Mar. Environ. In press.

Yasué, M., & Dearden, P. (2008). Replacement nesting and double-brooding in Malaysian Plovers *Charadrius peronii*: effects of season and food availability. *Ardea, 96*(1), 59-72.