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THE NORTHWARD MIGRATION STOPOVER ECOLOGY OF BAR-TAILED GODWITS AND GREAT KNOTS IN THE YALU JIANG ESTUARY NATIONAL NATURE RESERVE, CHINA

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To my family and friends,

whose understanding, patience and continual selfless support

have allowed me to soar with the birds

ABSTRACT

Stopover ecology is the scientific study of the behaviour of migrants, the interrelationships among migrants, and between migrants and their environment, at stopping sites. Many shorebird species are long-distance migrants and require high quality stopping sites to rest and refuel during migration. The suitability of a stopping site depends mostly on food availability, level of competition, and predation or disturbance pressure. Events at stopover may not only affect migration performance, but also the subsequent reproduction or survival, and therefore become the limiting factor for the population sizes of migrants. The stopping sites in the Yellow Sea along the East Asian-Australasian Flyway are used extensively by long-distance migratory shorebirds along the flyway, but very little is known about the stopover ecology of these birds. Moreover, the stopping sites within the Yellow Sea region are under serious threats; some of them are being lost before their importance to shorebirds is fully understood.

In this thesis, my aim was to study the stopover ecology of Bar-tailed Godwits *Limosa lapponica* and Great Knots *Calidris tenuirostris* at an important stopping site in the northern Yellow Sea, the Yalu Jiang coastal wetland, during northward migration between 2010 and 2012. I estimated the number of these shorebirds transiting and their passage dates using repeated counts incorporated with Thompson's modelling approach. I described the type, abundance and characteristics of their benthos resources by benthos sampling. I investigated their dietary compositions, foraging patterns and mechanisms of coexistence by behaviour scans, focal bird observations and faecal dropping analysis. Finally, I studied their predation impact on their main bivalve prey, *Potamocorbula laevis*, using exclosures.

My results indicated that at least 42% of the East Asian-Australasian Flyway's northward migrating *L. l. baueri* godwits, 19% of *L. l. menzbieri* godwits, and 22% of the Great Knots used Yalu Jiang coastal wetland, thereby indicating the importance of the study area to these species. Polychaetes and bivalves numerically dominated the benthic communities, while one bivalve species, *P. laevis*, constituted more than three quarters of total macrobenthic biomass during the study period. Great Knots, Red Knots *Calidris canutus* and Far Eastern Oystercatchers *Haematopus ostralegus osculans* selected mostly the bivalve *P. laevis* while Bar-tailed Godwits had a broader diet and selected mostly polychaetes, even though most of their intake was of *P. laevis*. Moreover, the size of *P. laevis* preferred by godwits and Great Knots overlapped. Their coexistence seems to be enabled by high resource availability rather than niche separation. The different dietary

selections between godwits and knots possibly led to different foraging patterns on the tidal flats. There was clear behavioural evidence that a digestive bottleneck existed in the bivalve-feeding shorebirds. Such digestive constraints of hard-shelled prey, decreased prey quality (amount of energy per dry mass of shell taken), and increased handling and searching time were potential reasons behind a decline in total biomass intake rate in godwits and Great Knots from 2011 to 2012, despite similar numerical and biomass density of their main prey in both years. Finally, there was evidence that predation by shorebirds had a significant impact on the number of *P. laevis* in one of the years studied.

My thesis showed the importance of Yalu Jiang coastal wetland to Bar-tailed Godwits and Great Knots during northward migration. These two species competed for the same bivalve prey and their coexistence in the years of study was enhanced by ample food resources rather than niche differentiation. The lack of young *P. laevis* recruitment in the final year of study and the significant predation impact detected indicated a potential decline in food resources after my study. Long-term monitoring will reveal how these species respond to the changes in prey availability. My study provided important scientific information on the numbers of birds using Yalu Jiang coastal wetland, their prey resource availability, their dietary compositions, and behaviours that are crucial for their conservation management in the reserve and potentially in other stopping sites in the Yellow Sea.

PREFACE

Ecology is the science which says what everyone knows in language that no one understands. (Elton 1927)

This quote captured precisely how I saw scientific research when I was in the planning stage of my project. Scientific stories on popular science magazines are often well written and capture readers' attention successfully. In contrast, a PhD thesis on the same topic can sometimes be so difficult to understand that it easily deter even the most enthusiastic readers. I remember reading the PhD thesis written by one of the most influential scientists in my field and I kept falling asleep time after time. It was not until I had done all my fieldwork, laboratory measurements, and statistical analyses that I was finally able to appreciate and relate my work to that brilliant scientist's. The most enjoyable way to read ecological research work is perhaps through reading some ecology textbooks that are not only easy to read, but also provide a more general perspective that allows readers to grasp the significance of such work.

Perhaps the other reason why I kept falling asleep was because I had not finalised my research topic at that stage, which meant I did not have the right questions in mind before reading. There were a few potential projects that I might have undertaken. These included the stopover ecology of Bar-tailed Godwits at the Yalu Jiang coastal wetland, stopover ecology of Red Knots at the Gulf of Carpentaria, and the foraging ecology of Wrybills in New Zealand. These are all interesting topics but logistics were extremely difficult at the Gulf of Carpentaria and there were more crocodiles than people living there. Wrybills are adorable but there was more urgency to understand shorebirds' stopover ecology in the Yellow Sea that may contribute to the conservation of shorebirds that have been declining along the whole flyway. Before the start of my PhD project, only two stopping sites in the Yellow Sea (Chongming Dongtan and Bohai Bay) were studied and many stopping sites were shrinking rapidly due to coastal development. Yalu Jiang coastal wetland has been shown to support a significant proportion of shorebirds along the flyway, but we knew nothing about the basic questions such as the function of this place to shorebirds, what food resources are available to the birds, why is it so attractive to shorebirds and what are the threats in this site.

My adventures at the Yalu Jiang coastal wetland were an eye-opening experience, at least for me, who had only seen shorebirds in flocks of hundreds or a few thousand before visiting Yalu Jiang. This thesis will describe the life of some of the hundred thousand shorebirds during their one and a half month stopover at Yalu Jiang, using the language that most, if not everyone, understands (*hopefully*!).

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Before the start of my first field season, I benefited greatly from the knowledge of the study site shared by the Miranda Naturalists' Trust, especially Adrian Riegen and Keith Woodley, and also from local birdwatcher Qingquan Bai.

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