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## Impact of habitat management on waterbirds in a degraded coastal wetland

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## ABSTRACT

The loss of coastal wetlands in Hong Kong Mai Po Nature Reserve adversely affected wetland-dependent species. To mitigate this impact, *gei wai* ponds were reconstructed according to a set of biodiversity management zones (BMZs). This study, based on Canonical Correspondence Analysis (CCA), investigated if waterbird distribution was related to BMZ characteristics. Based on habitat characteristics, ponds in the same BMZ generally clumped in the same quadrant or within a short distance on CCA scatter plots, indicating that a BMZ zone produced common habitat traits. Ponds in a close distance on the plot had similar bird abundance or community structure. Significant correlations were noted between the abundance of cormorants and tall tree, and between waders and bare ground areas within study ponds. This study indicated that the control of key habitat factors was important for the success of reconstruction of *gei wais* and management of waterbirds in Mai Po.

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## 1. Introduction

Coastal wetlands and associated estuarine systems provide feeding and nesting sites for birds, in particular waterbirds (Weller, 1999; Bamford et al., 2008; Yang et al., 2011). The loss and degradation of coastal wetlands, caused by sea level rise, land-use changes and other anthropogenic activities (Nicholls, 2004; Ferrati et al., 2005; Kevin, 2009), have adversely affected waterbirds and other wetland-dependent species (Ma et al., 2010). With the aim of mitigating the adverse influences, many wetland construction and restoration projects have been conducted in recent decades (Broome et al., 1988; Dennis, 1999; de Jonge and de Jong, 2002; Rafael and Juan, 2015) according to the known relations between habitat characteristics and waterbirds. However, the simple creation of wetland alone is not enough to improve or even maintain its ecological function and quality, particularly as an important wetland for waterbirds. It is important to have proper management such as keep stable water level to attract dabbling duck and remove emergent plant regularly to make wetlands suitable for foraging of waders (Ma et al., 2010). More, wetland management does not always result as expected (Rafael and Juan, 2015). It has been reported that foraging rates of waterbirds in managed habitats are not as high as those observed in natural sites (Mander et al., 2013; Choi et al.,

2014). The managed or restored habitats are not used by the same species as natural habitats (Dias et al., 2014) and constructed habitat can only host the species of concern for a short period of time as vegetation succession changes the habitat characteristics later (Francesco et al., 2013). Therefore, the impacts of habitat management on waterbirds need to be further understood to design a better strategy for wetland and waterbird conservation.

Mai Po Nature Reserve was originally a mangrove marsh and valuable habitat for endangered and migratory birds. From early 1920s to early 1980s, the land use of Mai Po marsh underwent a series of changes. In early 1920s, Mai Po Nature Reserve area was swamps and mangrove marshes. From early 1940s to early 1970s, this area was changed to intertidal shrimp ponds (locally known as *gei wais*), and a characteristic feature of *gei wai* is having a shallow platform in the centre of the pond. Starting from mid 1970s, some of the *gei wais* were converted to modified *gei wai* and fish ponds (WWF HK, 2003). As a result, the ecological function of this Reserve area has decreased drastically, in particular as roosting and feeding habitats for waterbirds. To mitigate the potential adverse impact, *gei wai* ponds in Mai Po Nature Reserve have been reconstructed and managed according to a series of biodiversity management zones (BMZs), which are designed for conservation and protection of different groups of wetland-dependent species, from 1990s onwards. However, there is a lack of information about the importance of habitat management on the distribution of waterbirds in Mai Po, except the studies on habitat utilization and abundance of endangered or threatened water bird species (Yu and Swennen, 2004; Stanton et al., 2014; Stanton et al., 2015).

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The present study therefore aims to analyze if the distribution of current birds in Mai Po Nature Reserve relates to the BMZ characteristics, and reveal the relationship between the distribution of waterbirds and the characteristics of wetland habitats. The waterbirds which just flying through the *gei wai* were not counted. The study also attempts to evaluate whether the BMZ mode of operation in Mai Po is successful in habitat reconstruction and management for coastal waterbirds or not.

## 2. Study site

Mai Po Nature Reserve (113°59' –114°03'E, 22°29' –22°31'N) is situated in Northwest New Territories, Hong Kong Special Administrative Region, China (Fig. 1). It is part of the 1500 ha Mai Po Marshes and Inner Deep Bay Ramsar Site, which is the important stop of East Asia-Australasian Flyway Network (Richard and Brain, 1998). This Ramsar site supported an average 83,034 waterbirds in mid-winter during 2007–2012, and regularly provides habitat for 23 globally threatened bird species, such as *Fregata andrewsi*, *Aythya baeri*, *Eurynorhynchus pygmeus*, *Tringa guttifer*, *Acrocephalus tangorum*, according to the 2012 IUCN Red List (<http://www.iucnredlist.org>). It also regularly holds over 20% of the global population of Black-faced Spoonbill (*Platalea minor*) in 2007–2012, and there are another 26 species (e.g. *Phalacrocorax carbo*, *Ardea alba*, *Podiceps cristatus*, *Anas acuta*, *Anas clypeata*) in Mai Po having >1% of threshold population of Eastern Asia (<http://www.ramsar.org>).

Mai Po Nature Reserve covers an area of 380 ha, including 24 *gei wai* ponds, which account for about 70% area of the Reserve. Among these *gei wai* ponds, 21 are managed as a series of Biodiversity Management Zones (BMZs) for different target species under the operation by World Wide Fund Hong Kong (WWF HK), the other three were leased to local citizen for fish farming. These 21 *gei wai* ponds managed by WWF HK are divided into seven types, which include Black-face Spoonbill habitat (BMZ1), reed bed habitat (BMZ2), traditionally managed production *gei wai* with mangrove (BMZ3), education centre and its associated waterfowl collection (BMZ4), secure high-tide roost for wintering waterfowls (BMZ5), open freshwater roosting area (BMZ6) and open high-tide roosting site (BMZ7, which was classified as BMZ5 before 2010) as an alternative to BMZ5 (WWF HK, 2013). Each BMZ type has its own management intention (Table 1). Different management work has been carried out in BMZs to create different habitat characteristics, for instance, rising water level in summer to prevent reed growing in BMZ1, desilting to lower the reedbed floor in summer to prevent reed from drying out in BMZ2, cleaning climbers particularly from mangrove to promote their health and growth in BMZ3, removing mangrove and reed from the inner islands (shallow platform) and creating shingle inner islands in BMZs 5, 6 and 7 (WWF HK, 2006, 2013). A total of 12 *gei wai* ponds (ponds 1 to 12) covering all seven BMZ types were selected in this study (Fig. 1): Pond 1 in BMZ1, pond 2 in BMZ2, ponds 3, 4, 7 and 8 in BMZ3, pond 5 in BMZ4, pond 6 in BMZ5, ponds 9, 11 and 12 in

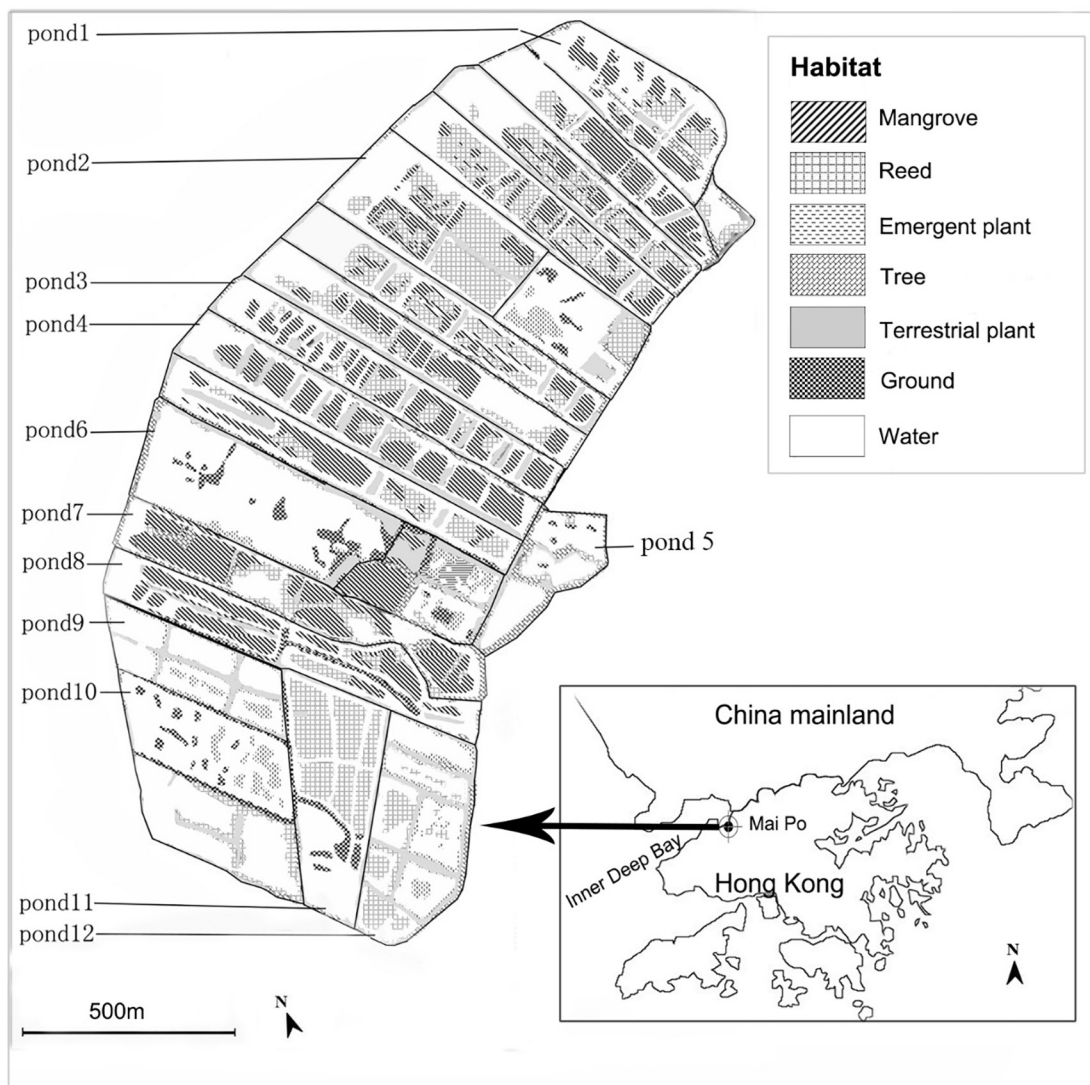


Fig. 1. Map of study area and the 12 ponds selected in the present study.

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