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What artificial wetland configuration host more waterbirds? A case study in the Chongming Dongtan wetlands, China

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Abstract: Background: The Chongming Dongtan wetlands were subjected to loss, deterioration, and fragmentation of coastal wetlands. In recent years, artificial wetlands have been constructed to protect waterbirds in this region. This paper aims to determine whether constructed artificial wetlands used equally by waterbirds and find out the preferred habitats of waterbirds, so as to determine what artificial wetland configuration will host more waterbirds. **Methods:** We quantified the waterbird community composition at three artificial wetlands and on one natural coastal wetland, which served as a reference site, from September 2011 to May 2012 in the Chongming Dongtan wetlands. **Results:** Shorebirds was abundant in spring (preferred site C & D) and autumn (preferred site C); diving birds and dabbling ducks were both abundant in winter, while diving birds preferred site B and followed by site C, but dabbling ducks preferred site C; herons was abundant in autumn (preferred site C) and winter (preferred site B and followed by site C). Each waterbird guilds exhibited unique and complex habitat preferences. Specifically, shorebirds preferred mudflats and shallow water, but were most abundant on mudflats. Diving birds selected open water as the unique habitat. Most dabbling ducks preferred open water, however some ducks were observed on *Scirpus mariqueter* (hereafter *Scirpus*) habitat. Herons exhibited the widest range of habitat preferences (shallow water, mudflats and *Scirpus*). **Conclusions:** The artificial wetlands served as a suitable habitat for waterbirds to some extent, although were not used equally by waterbirds. Multi-functional artificial wetlands could be constructed by incorporating diverse habitats to attract a greater abundance of waterbirds to forage and roost in the coastal wetlands of Yangtze River during their migration from Australia to Siberia.

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Keywords: Chongming Dongtan wetlands; natural wetland; artificial wetlands; habitat heterogeneity; multi-functional wetland; waterbirds

1. Introduction

The Yangtze River Estuary is one of the 50 sensitive ecological regions in the world (Maffi et al. 2000). The Chongming Dongtan wetlands, a critical coastal wetland in the Yangtze River estuary, were included in the Ramsar Convention's List of Wetlands of International Importance in 2002. The annual use of coastal wetlands in Chongming Dongtan by thousands of migratory waterbirds indicates that these habitats are important stopover and wintering sites for birds migrating between Australia and Siberia (Barter and Wang 1990; Ma et al. 2002; Xu and Zhao 2005). The success of bird migration depends on intact migratory routes and stopovers (Moore et al. 2005) because birds generally do not deposit enough fat to enable them to fly between breeding and wintering areas without stopovers (Buler et al. 2007). The Chongming Dongtan wetlands are also a critical area for threatened species, including *Grus monacha*, *Ixobrychus minutus*, and *Platalea minor*; the population of these species in the Chongming Dongtan wetlands accounts for approximately 1% of the total global population

During the past decades, the Chongming Dongtan wetlands have been subjected to loss and deterioration caused by the invasion of Spartina alterniflora (hereafter Spartina) which has gradually replaced native plant communities Scirpus and Phragmites australis (hereafter Phragmites) (Gan et al. 2010; Ma et al. 2011; Wang et al. 2006). Habitat loss and deterioration caused a drastic decline in the abundance of avian populations (Carrete et al. 2009). Hobson and Bayne (2000) recognized that habitat loss and deterioration have significant effects on the abundance of all migratory birds except those that came from short distances. Most waterbirds in the Chongming Dongtan wetlands are long-distance migratory waterbirds coming from Australia and Siberia (Barter and Wang 1990; Ma et al. 2002; Xu and Zhao 2005). Thus, wetlands in Chongming Dongtan must be restored or created to compensate for habitat loss and deterioration. In recent years, artificial wetlands have been constructed to protect waterbirds in the Chongming Dongtan wetlands, particularly the long-distance migratory waterbirds from Australia and Siberia. A wetland park was constructed in 2006 to enhance biological conservation and ecological tourism. In 2008, Spartina communities were removed prior to constructing aquacultural ponds in Beibayao. In 2010, the wetlands in Buyugang were constructed by removing the Spartina communities prior to broadening tidal creeks and constructing mudflat wetlands.

The preference of waterbirds for the constructed artificial wetlands could indicate wetland restoration success (Frederick et al. 2009; Ke et al. 2011; Robledano et al. 2010). However, caution must be taken when dealing with generalist species which may exploit both suitable and unsuitable habitats (Bock and Jones 2004). In the Chongming Dongtan wetlands, migratory waterbirds exhibited habitat preferences which appear to be relatively stable (Ma et al. 2002; Tian et al. 2008; Xu and Zhao 2005). Because these species exhibit very little site fidelity, their habitat preferences can indicate the habitat quality of natural and artificial wetlands (Frederick et al. 2009; Ke et al. 2011; Robledano et al. 2010).

This study aims to (1) determine whether constructed artificial wetlands used equally by waterbirds, focusing specifically on whether waterbird density, diversity, evenness, and richness differ among four study sites (three constructed artificial wetland sites and a natural coastal wetland site), and (2) find out the preferred habitats of waterbirds and determine which wetland configuration will host more waterbirds among different seasons. We expect that this study will encourage the managers to develop an artificial wetland construction strategy to protect migratory waterbirds in the coastal area of the Yangtze River.

2. Material and Methods

This study was conducted in the Chongming Dongtan wetlands, a Ramsar site at the mouth of the Yangtze River Estuary of Eastern China (121°50′–122°05′E, 31°25′–31°38′N) (Figure 1) that covers an area of approximately 326 km^2. Three artificial wetlands (A to C) and a natural wetland (D) were chosen as study sites (Figure 1). Site A was constructed to a wetland park in 2006 for biological conservation and ecological tourism. Site B was constructed in 2008 by removing *Spartina* communities prior to excavating aquacultural ponds. Site C was constructed in 2010 by removing *Spartina* communities prior to broadening tidal creeks and constructing mudflat wetlands. Site D was a natural wetlands which served as a reference site that was compared with the artificial wetlands (A to C). In this site, the main habitat types included *Scirpus* habitat and mudflats and shallow water habitat without any vascular plants.

A total of 17 orders, 50 families, and 288 species of birds have been recorded in the Chongming Dongtan wetlands in the past decades. A number of rare species had also been observed, such as *Ixobrychus minutus*, *Grus monacha*, *Ciconia bigra Linnaeus*, *Platalea minor*, *Platalea leucorodia*, *Cygnus columbianus*, *Aix galericulata*, *Grus grus*, and *Grus vipio.* (Ma et al. 2002; Xu and Zhao 2005). This area was recognized as an important stopover and wintering site for bird migration between Australia and Siberia (Barter and Wang 1990; Ma et al. 2002; Xu and Zhao 2005).

Habitat characteristics were obtained from high-resolution images with a pixel size of 2 m on one side (4 m^2 pixel area). With the help of ENVI and GIS, the habitats were divided into five types, i.e., *Phragmites*, *Scirpus*, mudflats, open water, and other. The percentage of each habitat types in the four study sites was calculated. Similar to Armitage et al. (2007), the Shannon–Wiener diversity index (SHDI) was calculated to describe the habitat diversity in the four study sites, where $SHDI = -\sum (p_i)(\ln p_i)$ where p_i is the percentage of the i^{th} habitat type.

Waterbird surveys were carried out 15 times on each of the four study sites (for a total of 60 times) from September 2011 to May 2012, covering two peak migration periods (spring and autumn) and the wintering period. In each season, surveys were all carried out 5 times on each of the four sites. Waterbird surveys were carried out in 4-5 days, including 2 days before and after the neap tide, respectively. Each survey started 1 hour after sunrise and lasted 4-5 hours every day. Two or three investigators counted waterbirds using 10 × 42 binoculars and 20×–60× spotting scopes by walking at a speed of 1-2 km per hour. The number of waterbird species and their population sizes in the four study sites from September 2011 to May 2012 were counted.

Similar to Armitage et al. (2007), SHDI was calculated to describe the waterbird diversity in the four study sites, where $SHDI = -\sum (p_i)(\ln p_i)$ and p_i is the proportion of the waterbirds that belong to the i^{th} species (Krebs 1994). The Shannon–Wiener evenness index was calculated to describe the waterbird evenness in the four study sites, where $SHEI = SHDI / \ln S$ and S is the total number of observed waterbird species (Krebs 1994). Waterbird species richness is the total number of species observed in each site. Species abundance was estimated using density (individuals per hectare) to allow comparison among four wetlands of different sizes. Dominance species accumulation curves were performed by PRIMER 5.0 version to estimate whether few species were dominated the waterbird communities in the entire study area as well as in the four study sites.

However, analyzing the populations of all waterbird species in the four study sites was difficult. All observed species were grouped into four main guilds: (1) shorebirds (Charadriidae, Scolopacidae and Larinae), (2) diving birds (diving ducks, cormorants and Podicipediformes), (3) dabbling ducks, and (4) herons. Other waterbirds (Gruiformes and terns) were observed occasionally and thus not lumped with these four guilds. These species were only involved in the calculation of SHDI, SHEI and dominance species accumulation curves.

A one-sample Kolmogorov–Smirnov test for waterbird population data and their habitat data indicates that all variables were normally distributed ($p > .05$). Differences in diversity, evenness, richness, and density of all waterbird species and the density (birds per hectare) of each of the four guilds among the four sites were analyzed with One-Way ANOVA, followed by post-hoc Games-Howell multiple comparisons. Data analysis were performed using SPSS for windows (17.0 version).

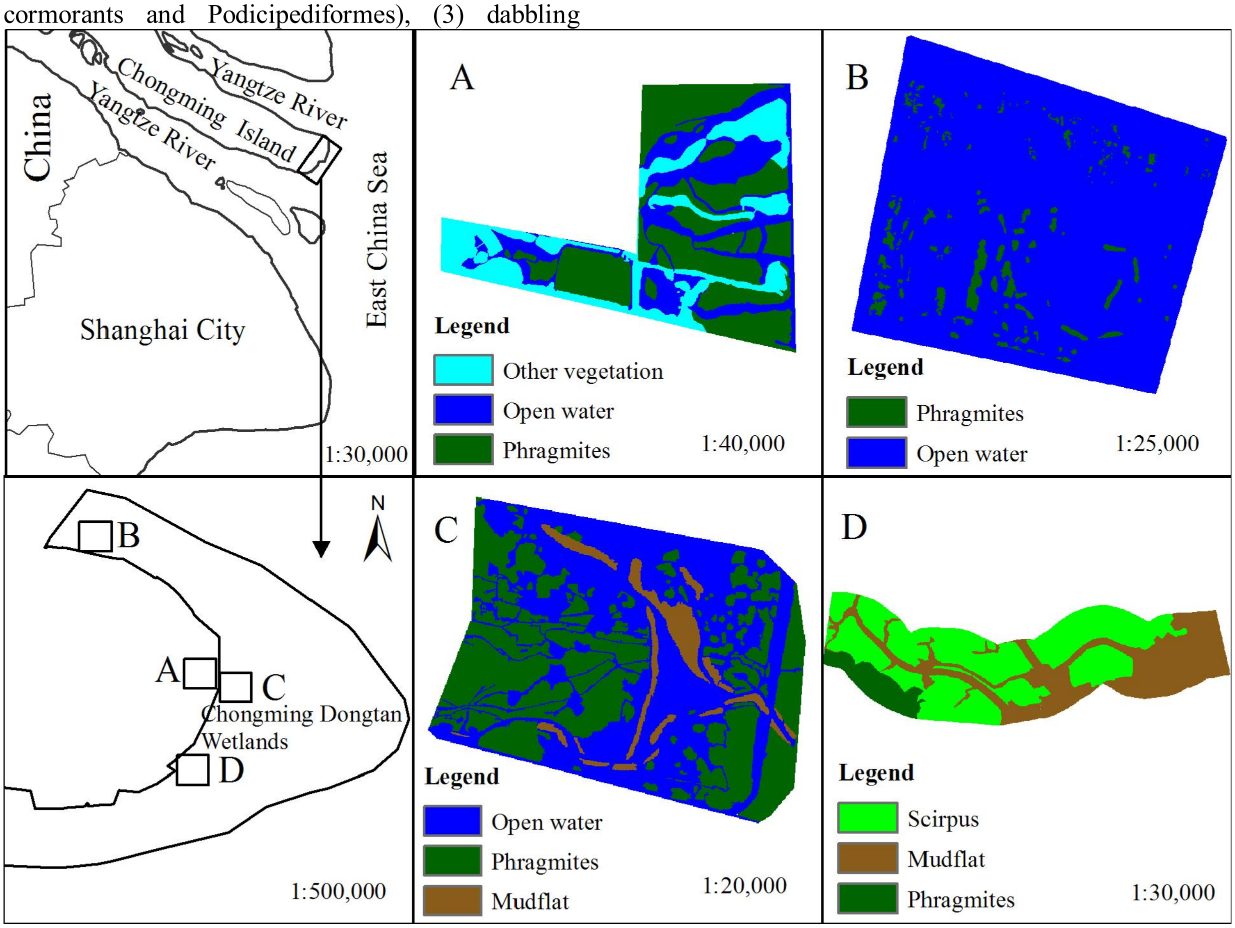

Figure 1. Location of the study sites (A–D).

3. Results

T The areas of the four selected study sites ranged from 56.04 ha (site D) to 139.85 ha (site A). In site A, the dominant habitat type was *Phragmites* (45.56%), followed by open water (28.1%), and other vegetation (26.34%). In site B, the dominant habitat type was open water (94.2%), followed by *Phragmites* (5.8%). In site C, the dominant habitat types were open water (49.11%) and *Phragmites* (44.21%), followed by mudflats (6.68%). In site D, the dominant habitat types were *Scirpus* (52.82%) and mudflats (39.96%), followed by *Phragmites* (7.22%). Among the four sites, site C had higher habitat heterogeneity (SHDI=2.44), with a mix of open water, *Phragmites*, and mudflat. Site B had lower habitat heterogeneity (SHDI=0.47), with open water dominating.

Table 1. Habitat characteristics of each site (A, B, C, and D) based on remote sensing images.

	A*	B*	C	D
Total area (ha)	139.85	105.34	61.38	56.04
Phragmites (% total area)	45.56	5.8	44.21	7.22
Scirpus (% total area)	N/A	N/A	N/A	52.82
Mudflat (% total area)	N/A	N/A	6.68	39.96
Other vegetation (% total area)	26.34	N/A	N/A	N/A
Open water (% total area)	28.1	94.2	49.11	N/A
SHDI	2.07	0.47	2.44	1.98

*Shallow water is another habitat where shorebirds and herons foraged. It represents the area in the edge of the sites A and B. Shallow water habitat was not included in Table 1, because it is difficult to extract such habitat from open water habitat in these sites.
N/A denotes not applicable.

A total of 35,593 individuals, which correspond to 62 species, were recorded during the 60 waterbird surveys. Shorebirds (28 species), dabbling ducks (11 species), diving birds (10 species) and herons (6 species) accounted for 87.1% of all species. Overall, dabbling ducks (23,819), shorebirds (6,735), diving birds (2,187), and herons (1,013), dominated the waterbird community in the four study sites, which accounted for 93.31% of all recorded individuals. Nine rare species (listed by IUCN) were observed Oriental White Stork (*Ixobrychus minutus*) and Swan Goose (*Anser cygnoides*) were listed as endangered Hooded crane (*Grus monacha*), Chinese Egret (*Egretta eulophotes*), Baikal Teal (*Anas formosa*), Far Eastern Curlew (*Numenius madagascariensis*), and Saunders's Gull (*Larus saundersi*) were vulnerable. Falcated duck (*Anas falcate*) and Black-tailed Godwit (*Limosa limosa*) were near-threatened. Ninety individuals of Hooded crane were observed in a single survey in site D in December 2011, which is six times the 1% threshold (species of global conservation importance for which population size was >1% of their estimated global flyway population).

Significant differences in species group diversity, richness, and waterbird density were observed in the four study sites (ANOVA, all $p < 0.01$), but a significant difference among three seasons (autumn, winter, and spring) was observed only in the waterbird density (ANOVA, $p < 0.01$) (Table 2).

The least significant difference obtained during post hoc comparisons indicated higher species group diversity and richness in sites B and C than in sites A and D (all $p < 0.01$) (Figure 2a & 2c). The waterbird density was higher in site C than in the other three sites (all $p < 0.01$) and was higher in winter than in autumn and spring (both $p < 0.01$) (Figure 2d). No significant difference in species group evenness was observed in the four study sites ($p > 0.05$) or in the three seasons ($p > 0.05$) (Figure 2b).

Table 2. Results from two-factor ANOVA of site and season on waterbird species group diversity, species group evenness, species group richness, and waterbird density and four dominant waterbird density.

		df	F	*p*
Diversity	Site	3	7.31	<0.01
	Season	2	0.15	0.86
	Season × Site	6	3.24	<0.01
Evenness	Site	3	0.13	0.94
	Season	2	0.37	0.69
	Season × Site	6	0.98	0.45
Richness	Site	3	21.34	<0.01
	Season	2	1.78	0.18
	Season × Site	6	2.79	0.02
Density	Site	3	23.81	<0.01
	Season	2	10.03	<0.01
	Season × Site	6	4.2	<0.01

Significant interactions were noted between site and season for species group diversity ($p < 0.01$), richness ($p = 0.02$), and waterbird density ($p < 0.01$) (Table 2). Specifically, species group diversity was higher in site B than in sites A ($p < 0.05$), C ($p < 0.01$), and D ($p < 0.01$) in winter, and higher in sites B and C than in sites A ($p < 0.01$) and D ($p < 0.05$) in spring (Figure 2a). Species group diversity was higher in winter and spring than in autumn in site B (both $p < 0.01$), and higher in winter than in autumn and spring in site C (both $p < 0.05$) (Figure 2a). Richness was higher in site C than in the other three sites in autumn (all $p < 0.01$), higher in sites B and C than in sites A and D both in winter and spring (all $p < 0.01$), and higher in site A than in site D in winter ($p < 0.05$) (Figure 2c). Richness was higher in winter and spring than in autumn in site B (both $p < 0.01$) (Figure 2c). Waterbird density was higher in site C than in other three sites in winter (all $p < 0.01$), and higher in site C than in sites A ($p < 0.01$) and B ($p < 0.05$) in spring (Figure 2d). Waterbird density was higher in winter than in autumn and spring in sites A and B (all $p < 0.01$), and higher in winter than in spring in site C ($p < 0.01$) (Figure 2d).

In the entire study period, site C hold the highest species richness (Figs. 2a &3a), yet contributing to the species diversity. The species cumulative dominance curve was higher in site A and lower in site D than in other sites (Figure 3a), indicating that waterbird community in site A was dominated with few species, but it was opposite in site D. Spot-billed Duck (*Anas poecilorhyncha*) and Mallard (*Anas platyrhynchos*) were most abundant in site A, accounting for 73.27% of the total waterbirds observed. In autumn, site C hold the highest species richness (Figs. 2a &3b). The species cumulative dominance curve was lower in site C than in other sites (Figure 3b). Mallard, Little Grebe (*Tachybaptus ruficollis*) and Spot-billed Duck were, respectively, most abundant in sites A, B and D, accounting for 68.82%, 60.09% and 62.99% of the total waterbirds recorded in these sites. In winter, the cumulative curves were closer to each other (Figure 3c). However, Mallard, Spot-billed Duck and Northern Pintail (*Anas acuta*) were most abundant in site C, accounting for 94.02% of the total waterbirds. In spring, the cumulative curve was higher in site A than in other sites (Figure 3d). Mallard and Spot-billed Duck were most abundant in site A, accounting for 78.58% of the total waterbirds.

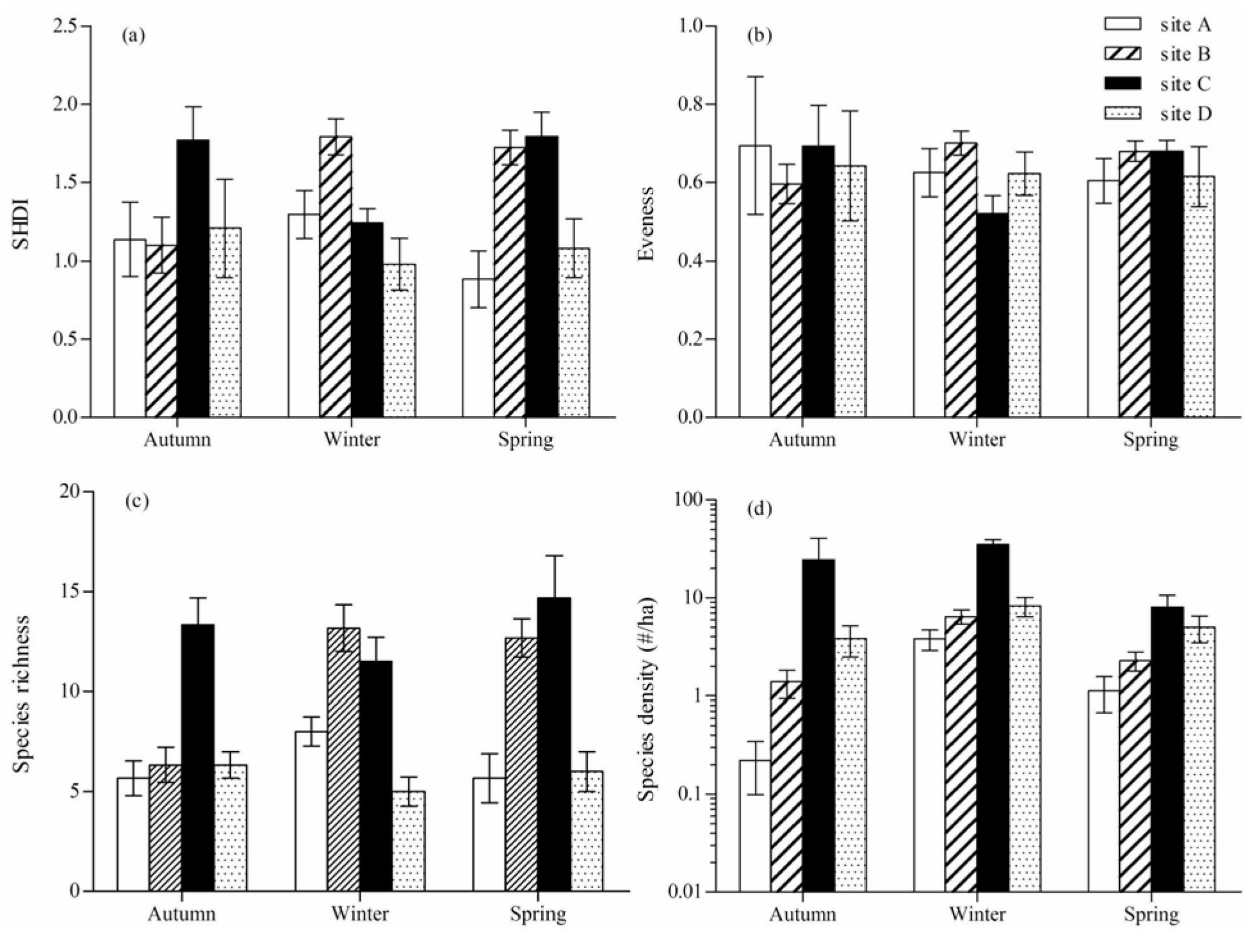

Figure 2. Seasonal variation in waterbird species diversity (a), eveness (b), richness (c) and density (d) in four types of wetlands from September 2011 to May 2012. Sample sizes were all 5 for four sites in each season.

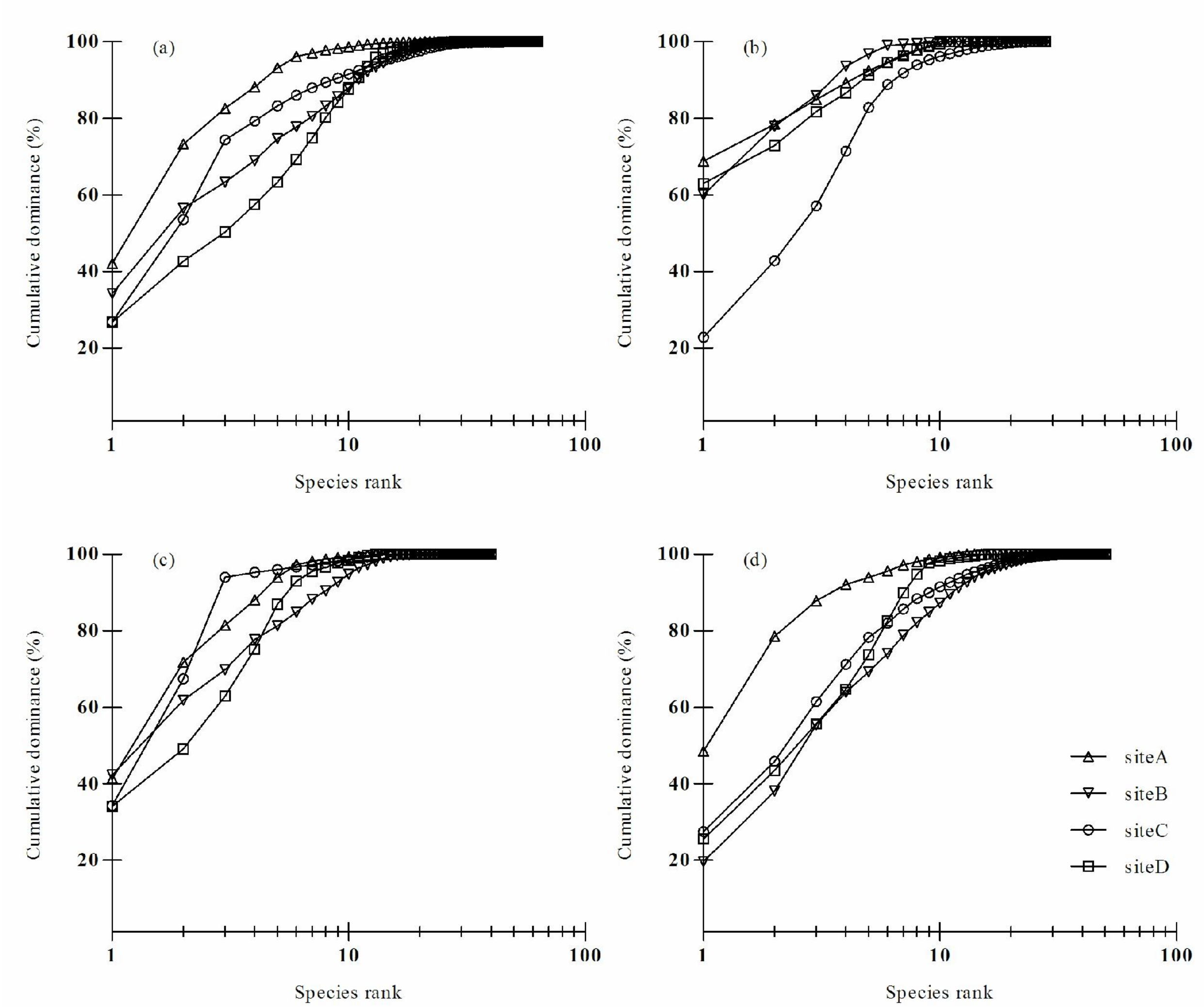

Figure 3. Waterbird species cumulative dominance curve over the study period (a) and in autumn (b), winter (c) and spring (d).

It is hard and even meaningless to detect the differences of the species numbers and densities of the four waterbird guilds in four study sites in various seasons. So we first analyzed the species numbers and densities of the four guilds in various seasons to find out the season(s) which host more waterbirds. Only the mean frequency of species numbers of shorebirds exhibited significant differences in the three seasons ($F_{(2, 12)}$=8.83, p <0.01), which was higher in spring than in autumn (post hoc p <0.05) and winter (post hoc p<0.01) (Figure 4a). The densities of shorebirds ($F_{(2, 12)}$=11.95, p <0.01), diving birds ($F_{(2, 12)}$=10.63, p <0.01), dabbling ducks ($F_{(2, 12)}$=18.41, p <0.01) and herons ($F_{(2, 12)}$=7.03, p <0.05) all exhibited distinct differences in the three seasons. Specifically, the density of shorebirds was higher in spring (post hoc p<0.01) and autumn (post hoc p<0.05) than in winter; the density of diving birds was higher in winter than in spring (post hoc p<0.01) and autumn (post hoc p<0.05); the density of dabbling ducks was higher in winter than in autumn and spring (post hoc both p<0.01); the density of herons was higher in autumn and winter than in spring (post hoc both p<0.01) (Figure 4b).

Then differences in the densities of the four waterbird guilds in four study sites in such season(s) were assessed with one-way ANOVA. The densities of shorebirds in autumn ($F_{(3, 18)}$=4.21, p <0.05) and spring ($F_{(3, 18)}$=4.49, p <0.05), diving birds in winter ($F_{(3, 18)}$=24.79, p <0.01), dabbling ducks in winter ($F_{(3, 18)}$=47.49, p <0.01), and herons in autumn ($F_{(3, 18)}$=4.62, p <0.05) and winter ($F_{(3, 18)}$=16.26, p <0.01) all exhibited distinct differences in the four sites. Specifically, shorebirds preferred site C in autumn and sites C & D in spring, indicating by the higher densities of shorebirds in such sites than others;

diving birds preferred site B and followed by site C in winter; dabbling ducks preferred site C rather than others in winter; and herons preferred site C rather than site A in autumn, while preferred site B and followed by site C in winter (Figure 5).

Each waterbird guilds exhibited unique and complex habitat preferences (Figure 6). Specifically, shorebirds preferred mudflats and shallow water rather than other habitats, but were most abundant on mudflats. Diving birds selected open water as the unique habitat. Most dabbling ducks preferred open water, however some ducks were observed on *Scirpus* habitat. Herons exhibited the widest range of habitat preferences among the waterbird examined. Herons were observed in shallow water, mudflats and *Scirpus*, whereas most herons were observed in shallow water in winter.

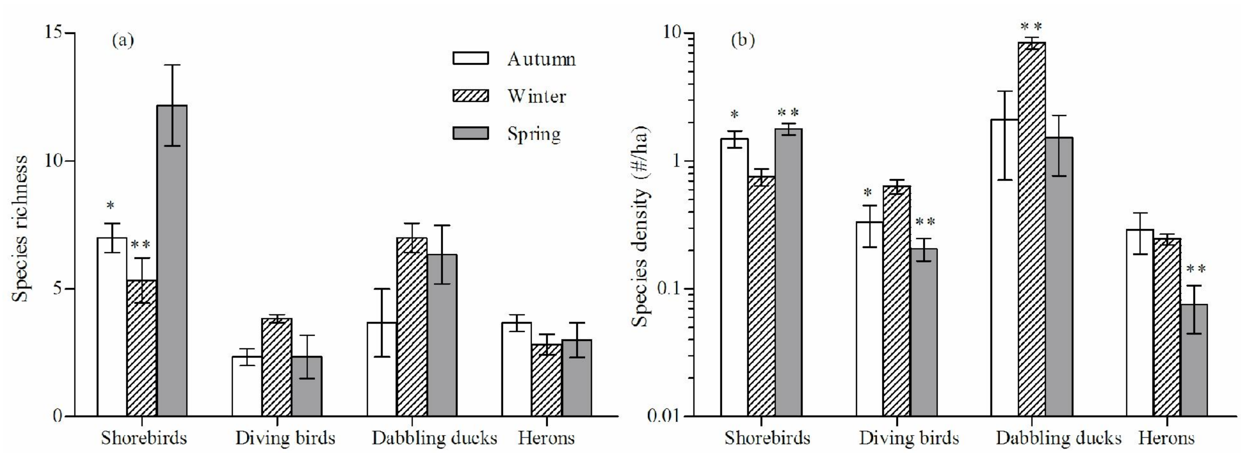

Figure 4. Mean frequency of waterbird species numbers (a) and densities of waterbird individuals (b) of four waterbird guilds in the three seasons. The error bars represent standard error (SE). For each guild, sample sizes were all 5 in each season and bars with * ($p < .05$) or ** ($p < .01$) are significantly different.

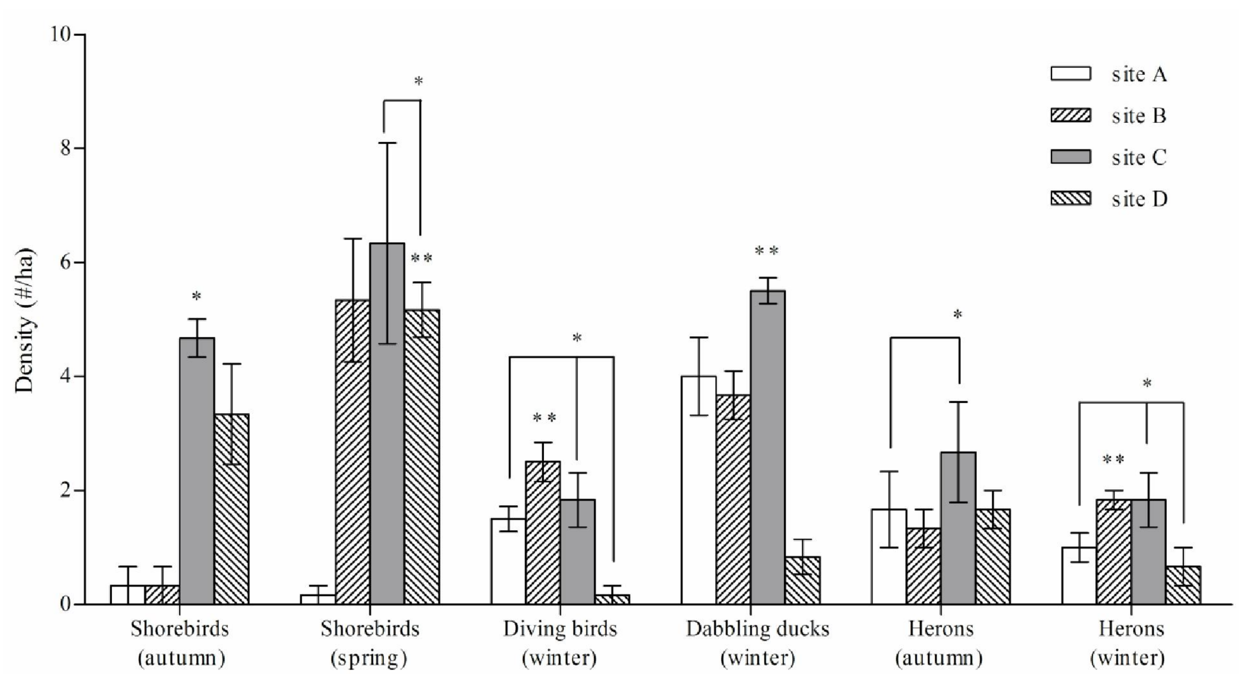

Figure 5. Species richness of shorebirds, diving birds, dabbling ducks and herons among seasons in four types of wetlands. Error bars represent ± 1 SE. * denotes not observed. Sample sizes were all 5 for four sites in each season.

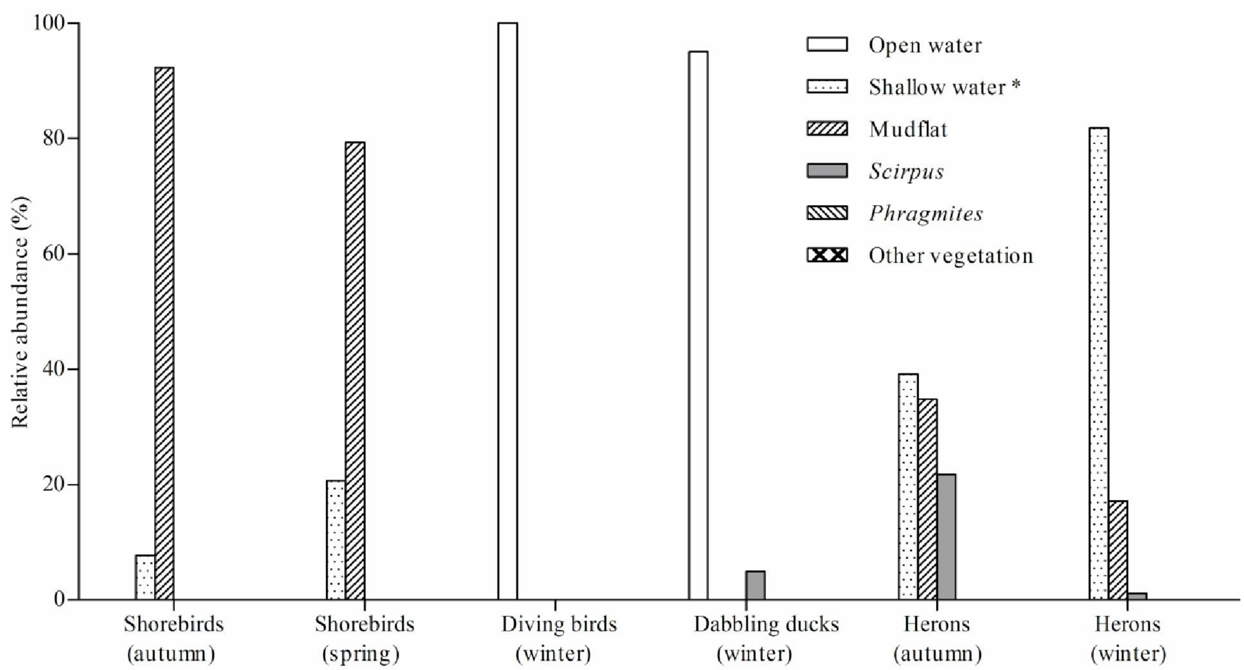

Figure 6. Habitat preferences of four waterbird guilds. *Shallow water habitats represent the area in the edge of the sites A and B, where shorebirds and herons foraged. Shallow water habitats were not extract from open water in these sites, because it is difficult.

Feeding was the most common activity of most waterbirds across all their preferred habitats, with most of the observed shorebirds, diving birds and herons foraging when we observed them. However, most dabbling ducks were observed resting in open water. Only few dabbling ducks were observed foraging on *Scirpus* habitat. The probably reason is that dabbling ducks are constantly foraging in *Scirpus* habitats before sunrise and after sunset, and resting in open water in daytime, while our survey were carried out in daytime.

In conclusion, differences in habitat preferences and use among waterbird guilds further illustrate the importance of incorporating diver habitat types into both artificial and natural wetlands.

4. Discussions

The coastal wetlands at Chongming Dongtan have undergone drastic changes over the last two decades. *Spartina* is the invasive vegetation that has colonized the area since the mid-1990s and has rapidly spread throughout Chongming Dongtan (Gan et al. 2010; Ma et al. 2011; Wang et al. 2006). It gradually replaced the native plant communities (i.e., *Scirpus*, and *Phragmites*) and has become one of the most dominant plants on the intertidal flats. *Spartina* habitats, which are characterized by short and dense vegetation and reduced diversity and abundance of food resources, are unavailable for shorebird and other saltmarsh bird specialists (Gan et al. 2010; Guntenspergen and Nordby 2006; Ma et al. 2011; Wang et al. 2006). During the last decade, several artificial wetlands were constructed by removing *Spartina* and incorporating native habitat types (mudflats, open water, and *Phragmites*) to attract a diverse group of waterbirds.

Migratory waterbirds exhibit relatively little site fidelity, and as a result, their preferences for foraging and roosting locations can indicate the habitat quality of natural and artificial wetlands (Frederick et al. 2009; Ke et al. 2011; Robledano et al. 2010). Previous studies indicated that waterbirds could colonize artificial wetlands rapidly (Armitage et al. 2007; Passell 2000). In this study, a total of 35,593 individuals, corresponding to 62 species, were observed, including 11 rare species (listed by IUCN) were also noted. Numerous artificial wetlands had a similar or higher waterbird species diversity, richness, and density as the natural wetland (Figs. 2 & 3), which revealed that waterbirds could colonize artificial wetlands rapidly, and the artificial wetlands served as a suitable habitat for waterbirds to some extent.

High habitat heterogeneity can increase species diversity, richness, and density, although some waterbirds may prefer homogeneous habitats

(Armitage et al. 2007; Danufsky and Colwell 2003). In our study, habitat heterogeneity was higher in site C (SHDI = 2.44), with a mix of open water, *Phragmites*, and mudflat (Table 1). Each waterbird guilds exhibited unique and complex habitat preferences (Figure 6). These were probably the proximate causes of the higher species diversity, richness, and waterbird density in site C than in other sites (Figure 2). On the other hand, the higher species diversity and richness and lower SHDI in site B was probably due to sufficient food resources for diving birds, shorebirds and herons.

Artificial wetlands were not used equally by different waterbirds (Armitage et al. 2007; Brawley et al. 1998; O'Neal et al. 2008; Snell-Rood and Cristol 2003). Shorebirds preferred sites C (roosting) and D (foraging) which have more mudflats. Diving birds preferred sites A, B and C which have more open water. Dabbling ducks preferred site C (roosting) which has a mix of open water and *Phragmites* (site C). Herons preferred site B (foraging) which has sufficient food resources and site C (roosting) which has a mix of open water, *Phragmites*, and mudflat. Similar to previous studies (Armitage et al. 2007; Danufsky and Colwell 2003), differences in habitat preference among species illustrated that artificial wetlands should be constructed by incorporating diverse habitat types (Armitage et al. 2007; Danufsky and Colwell 2003). Mudflats and shallow water are important foraging and roosting habitats for shorebirds (Fan et al. 2011; Ma et al. 2002; Tian et al. 2008; Xu and Zhao 2005). Open water, particularly the mix of open water and *Phragmites*, could serve as roosting habitat for dabbling ducks (Yu et al. 1995), while *Scirpus* could serve as foraging habitat (Fan et al. 2011; Ma et al. 2002; Tian et al. 2008; Xu and Zhao 2005).

Different characteristics of artificial wetlands should be constructed by incorporating different habitat types among different seasons to meet the needs of various waterbirds, e.g., a larger area of mudflat for roosting should be constructed for shorebirds by lowering water depth during migration season (spring and autumn), but a larger area of open water mixed with *Phragmites* for roosting should be constructed for dabbling ducks by increasing water depth during wintering season (winter).

Furthermore, artificial wetlands were used by most waterbirds as roosting sites (except site B). However, natural wetlands should not be replaced by artificial wetlands because natural wetlands, particularly *Scirpus*, mudflats, and shallow water habitats, are important foraging habitats for waterbirds (Fan and Zhang 2012; Ma et al. 2004; Tian et al. 2008; Tourenq et al. 2001; Yu et al. 1995). Similar studies also indicated that artificial wetlands could not serve as a full ecosystem replacement for natural wetlands (Snell-Rood and Cristol 2003). We expect that multi-functional artificial wetlands could be created, including roosting (similar to site C) and foraging habitats. The foraging habitat for waterbirds can be effectively accomplished via the reestablishment of *Scirpus* and the reintroduction of tidal flow.

5. Conclusions

Based on waterbird surveys and high-resolution remote sensing images of the study area (three artificial wetlands and a natural wetland), the waterbird community in four study sites was examined to evaluate what artificial wetland configuration host more waterbirds in the Chongming Dongtan wetlands. The results revealed that waterbirds could use artificial wetlands, and the artificial wetlands served as a suitable habitat for waterbirds to some extent. However, not all artificial wetlands were used equally by waterbirds, as they exhibited unique and complex habitat preferences. Artificial wetlands with diverse preferred habitats (site C) host more waterbirds. However, artificial wetlands with single preferred habitat (site A) was dominated by few waterbirds. Artificial wetlands were almost used by waterbirds as roosting sites. However, natural wetlands should not be replaced by artificial wetlands because natural wetlands, particularly *Scirpus*, mudflats, and shallow water habitats, are important foraging habitats for waterbirds. We expect that artificial wetlands host more waterbird species by incorporating diverse preferred habitats and involve multi-functional habitats, including roosting and foraging habitats.

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