ASSOCIATION OF OTHER WATERBIRD SPECIES WITH WINTERING BLACK-FACED SPOONBILLS *Platalea minor* IN HONG KONG

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EXECUTIVE SUMMARY

An exploratory study was conducted on waterbirds associating with Black-faced Spoonbills in the Deep Bay area in the winter 2007/08. Flocks of spoonbills were scanned and numbers and behaviour were noted of spoonbills and associates. Data of 1,349 scans could be collected; 767 of loafing, 463 of feeding and 119 of flying spoonbills. The number of associates differed significantly being highest in loafing and lowest in flying Black-faced Spoonbills. Ciconiiform birds were the most common among the associates, especially Grey Heron, Great and Little Egrets. Grey Herons and Eurasian Spoonbills were in significantly higher numbers associated with loafing than with feeding Black-faced Spoonbills, while Great Egrets had significantly higher numbers associated with feeding than with loafing Black-faced Spoonbills. Number of associating Little and Intermediate Egrets showed no significant differences between loafing and feeding spoonbills. Great Egrets showed strong numerical relationships to Black-faced Spoonbills in feeding sites; Little Egrets had less strong numerical relationships to spoonbills, but associated in both feeding and loafing activities. Grey Herons were most frequently associated in groups of loafing Black-faced Spoonbills but the numerical relationships were weak. The Eurasian Spoonbill was the only species that associated with flying Black-faced Spoonbills. A total of 51 cases of aggressive interactions (i.e. threatening, attacking and food robbery) were recorded during the scans. All were during feeding, none was seen in loafing Black-faced Spoonbills. Seven species of waterbirds were involved in the aggression interactions: Grey Herons, Great Egrets, Intermediate Egrets, Little Egrets, Black-faced Spoonbills, Eurasian Spoonbills and Great Cormorants. Food robbery from Black-faced Spoonbills was most common by Grey Herons followed by Great Egrets. Black-faced Spoonbills only robbed food from other Black-faced Spoonbills, not from associates.

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Association of other waterbird species with wintering Black-faced Spoonbills *Platalea minor* in Hong Kong

Introduction

Six species of spoonbill (Plataleinae, under Family Threskiornithidae) are present in the world. They have similar body structures, e.g. long and dorso-ventrally flatten spatulate bill, long legs, plain plumage, medium-sized and main differences among them are only colour of bare parts (e.g. bare skin on face, bill and legs) and distributions. Of which, Black-faced Spoonbill *Platalea minor* is the smallest species and also the rarest one (Hancock *et al*. 1992, Matheu and del Hoyo 1992). Only two thousand individuals of the Black-faced Spoonbills were counted in the East Asia region during the annual census conducted in January 2008 (HKBWS unpub. data). Its scarcity triggered some studies to this species recently, especially in its two major wintering grounds: Taiwan and Hong Kong. The studies mainly focused to the feeding and food of this species (e.g. Swennen and Yu 2004, 2005, Ueng *et al*. 2006, Yu and Swennen 2004b) and other parts of the biology of this species have still been relatively little known.

All spoonbills also have similar behaviours due to similar morphological characters. They share similar habitat requirements of relying in the shallow water areas of coastal and freshwater wetlands and feed on similar food items in water column. Besides, all the spoonbills are known to be gregarious in most of their activities in both breeding and non-breeding periods (Hancock *et al*. 1992, Matheu and del Hoyo 1992). They not only form intra-specific congregations, but also mix to other species of waterbirds in many different habitats (e.g. feeding and loafing habitats) and areas (e.g. breeding and wintering grounds). Descriptive notes of mixed flocks between the Black-faced Spoonbills and other waterbirds were made in some literatures such as Hancock *et al*. 1992, Chong *et al*. 1996. However, this aspect of the Black-faced Spoonbill is still not studied in details.

The aim of this study is to make better understanding to the association of waterbirds to the wintering Black-faced Spoonbills in the Deep Bay area, Hong Kong. Behaviours and numbers of the Black-faced Spoonbills and the waterbirds presented nearby were scanned and recorded to bring information of the interactions between the Black-faced Spoonbills and waterbirds. Over 300 individuals of Black-faced Spoonbills and thousands of other waterbirds were regularly presented in the Mai Po Nature Reserve and the nearby Deep Bay area in winter time that provides a good opportunity and condition to conduct this study.

Study area

The Black-faced Spoonbills mainly rely in the Deep Bay area of the northwest New Territories, Hong Kong. This area is a coastal wetland that is suitable for feeding and loafing of the spoonbills. Despite a few young birds present throughout the summer, the wintering individuals usually come to the Deep

Bay area in mid-October and return to the breeding grounds in the north during March. This study was undertaken mainly in the Deep Bay area including the Mai Po Nature Reserve, Tsim Bei Tsui intertidal area, Lok Ma Chau fishponds area (under management by KCRC) and also in the Futian National Nature Reserve, Shenzhen, China.

Methods

Field observations of this study were conducted in the beginning of November 2007 to the end of February 2008. Most of the observations were made in the Mai Po Nature Reserve where the Black-faced Spoonbills are known to present in very regular basis throughout the winter. Tsim Bei Tsui intertidal area was visited during morning low tide where we aimed to find some feeding spoonbills. Fishponds at Lok Ma Chau were also visited when the ponds were drained and stocked with trash fishes for attracting the Black-faced Spoonbills and other ardeids. The later two sites were only visited less frequently in the study period after several visits were made with only few spoonbills (and data) recorded and many observations were done in the Mai Po Nature Reserve.

To find what birds associate with the Black-faced Spoonbills during feeding, loafing and flying, all groups of Black-faced Spoonbills were scanned with associated waterbirds immediately after discovery. During each scan the number of Black-faced Spoonbill and the number of individuals of each associated waterbird species were counted. Each group could be repeatedly scanned every 15 minutes. When the numbers were noted, any inter-specific activities were also noted of both Black-faced Spoonbills and associates. Preliminary observations in the previous winter 2006-07 noted some aggression behaviours between the spoonbills and associated waterbirds. Three activities of the aggression behaviours were also recorded including threatening, attacking and food robbery. Numbers, species and condition (i.e. in feeding, flying or loafing period) were also recorded. In each observation day a minimum of 3-hour observation was made in both period of feeding (i.e. twilight period) and loafing (i.e. mid-day). One week had three observation days. Observations were made with aids of binocular and telescope mounted on a tripod.

Data Analysis

Previous studies of the Black-faced Spoonbills (Yu and Swennen 2004a and 2004b) found that spoonbills spent time on two main activities: loafing and feeding. Habitats of these two activities for the spoonbills are also different and so the numbers and species of associated waterbirds could also be different. Therefore, the data was analysed with grouping the numbers of the Black-faced Spoonbills and their associated waterbirds in different habitats. The Black-faced Spoonbills were found loafing in large numbers in only a few certain sites in the Mai Po Nature Reserve in this study and also all other previous winters. These sites are called 'traditional sites' hereafter. The spoonbills were also located in many temporary sites in tidal area (called 'tidal area') and in drained fishponds and *gei wai* (called 'drained

ponds'). These sites became unavailable again to the spoonbills and the associated waterbirds in short time such as when tide rises at night and refilling of water after drain-down. Some areas were stable in water level and free of disturbances throughout this winter and so some spoonbills could loaf in this winter but there would not be in the same situation in previous winters (called 'other sites'). Feeding spoonbills were also always found in the drained *gei wai* and fishponds (called 'drained ponds'), and also in the shallow water area of fish-stocking *gei wai* and fishpond which were not lowered water level (called 'fish-stocking ponds'). Tidal area is still a key feeding area for spoonbills because it is available all the time during the low-tide period (called 'tidal area'). Besides, spoonbills could also feed in the *gei wai* without stocking any fish and drain-down (called 'normal ponds').

Results

Numbers of Black-faced Spoonbills and associated waterbirds

For this study, 1,349 scans were made of wintering Black-faced Spoonbills between 1 November 2007 and 1 March 2008. There were 767 scans of loafing, 463 scans of feeding and 119 scans of flying Black-faced Spoonbills. Group size was significantly larger in flocks of loafing than in feeding and flying Black-faced Spoonbills (Kruskal-Wallis One Way ANOVA, $H = 217.57$, $df = 2$, $P < 0.001$, table 1). There were also significantly more associated waterbirds in flocks of loafing than in feeding spoonbills (Mann-Whitney Rank Sum Test, $T = 243{,}321.50$, $P < 0.001$). Among flying spoonbills, there was no significant difference in group size with flying heights (high VS low, Mann-Whitney Rank Sum Test, $T = 2096.50$, $P = 0.118$). Flying spoonbills are excluded in the following analysis because there were no associations recored with other waterbirds with the exception of one Eurasian Spoonbill, that was noted once only noted among the flying Black-faced Spoonbills. During loafing there were significantly higher numbers of the Black-faced Spoonbill when associated with other waterbirds than the numbers without association (with associates (mean $\pm$ SD): 28.25 ± 40.00 ($N = 695$), without associates: 19.68 ± 30.94 ($N = 72$), Mann-Whitney Rank Sum Test, $T = 23266.00$, $P = 0.014$). Feeding Black-faced Spoonbills also had a significantly higher number when they were associated with other waterbirds than those without association (with associates (mean $\pm$ SD): 13.97 ± 23.12 ($N = 368$), without associates: 3.92 ± 4.44 ($N = 95$), Mann-Whitney Rank Sum Test, $T = 15070.00$, $P < 0.001$).

Different levels of association with Black-faced Spoonbills were found with different orders of waterbird. Significantly more individuals of Ciconiiformes were found associated with loafing spoonbills than the feeding spoonbills (Mann-Whitney Rank Sum Test, $T = 243{,}321.50$, $P < 0.001$). Pelicaniiformes (i.e. only Great Cormorants presented, Mann-Whitney Rank Sum Test, $T = 276{,}300.50$, $P = 0.150$), Anseriformes (i.e. ducks, Mann-Whitney Rank Sum Test, $T = 284{,}668.00$, $P = 0.959$) and Charadriiformes (i.e. shorebirds, Mann-Whitney Rank Sum Test, $T = 283{,}505.00$, $P = 0.807$) showed no significant difference in numbers associating with loafing and feeding Black-faced Spoonbills. Other associated waterbirds such as Grebes and Rails were only recorded infrequently and details are summarised in table 2.

Grey Herons and Eurasian Spoonbills were in significantly higher numbers associated with loafing than with feeding Black-faced Spoonbills (Mann-Whitney Rank Sum Test, T = 238531.50, P < 0.001 and T = 265683.50, P = 0.001 respectively), while Great Egrets were in significantly higher numbers associated with feeding than with loafing spoonbills (Mann-Whitney Rank Sum Test, T = 300534.50, P = 0.01). In Little Egrets and Intermediate Egrets no significant differences were found in numbers associating between loafing and feeding spoonbills (Mann-Whitney Rank Sum Test, T = 296667.50, P = 0.053 and T = 289242.50, P = 0.48 respectively). The Chinese Pond Heron and Purple Heron are not discussed below as they were only rarely recorded as associated with Black-faced Spoonbills.

There were significant differences in numbers of both Black-faced Spoonbills and associate waterbirds in different loafing sites (Kruskal-Wallis One Way ANOVA, Black-faced Spoonbills: H = 70.996, df = 3, P < 0.001; associates: H = 24.079, df = 3, P < 0.001) and also in different feeding sites (Kruskal-Wallis One Way ANOVA, Black-faced Spoonbills: H = 18.543, df = 3, P < 0.001; associates: H = 25.337, df = 3, P < 0.001). Drained ponds had the highest numbers of feeding Black-faced Spoonbills and both feeding and loafing associate waterbirds. Loafing Black-faced Spoonbills were present in largest numbers in traditional loafing site (table 3). Mean numbers of both spoonbills and associate waterbirds were much smaller in tidal area than in other habitats. Below, further analyses are made of the relation of the major associate waterbirds with Black-faced Spoonbills in different habitats.

Numerical relationships of Black-faced Spoonbills to Grey Herons, Great and Little Egrets

Regression analyses are made to investigate associations of Grey Heron, Great and Little Egrets with both loafing and feeding Black-faced Spoonbills in different habitats. In loafing sites, the numbers of Grey Herons showed a weak relationship with the numbers of Black-faced Spoonbills in traditional ($P < 0.05$, $r^2 = 0.03$) and other sites ($P < 0.05$, $r^2 = 0.13$) but had a tendency of positive relationship in tidal area ($P < 0.05$, $r^2 = 0.44$) and drained ponds ($P < 0.05$, $r^2 = 0.44$). The numbers of Great Egrets had a strong relationship with loafing Black-faced Spoonbills in drained ponds ($P < 0.05$, $r^2 = 0.63$) but the numerical relationship between loafing Great Egrets and Black-faced Spoonbills in tidal area was undetermined because of insufficient data. The numbers of Little Egrets had a stronger positively relationship with the numbers of loafing spoonbills in other sites ($P < 0.05$, $r^2 = 0.57$) but only showed a tendency in drained ponds ($P < 0.05$, $r^2 = 0.34$).

In feeding sites, the numbers of Grey Herons showed some relationship with the numbers of Black-faced Spoonbills in drained ponds ($P < 0.05$, $r^2 = 0.43$), but only in a little relationship in normal ponds ($P < 0.05$, $r^2 = 0.19$). The numbers of Great Egrets showed a strong relation with the numbers of Black-faced Spoonbills in normal ponds ($P < 0.05$, $r^2 = 0.76$), some relationships in fish-stocking ponds ($P < 0.05$, $r^2 = 0.48$) and tidal area ($P < 0.05$, $r^2 = 0.49$), but only a weak relation in drained ponds ($P < 0.05$, $r^2 = 0.23$). The numbers of Little Egrets showed a strong relation with the numbers of Black-faced Spoonbills in normal ponds ($P < 0.05$, $r^2 = 0.68$) and in tidal area ($P < 0.05$, $r^2 = 0.45$), but weaker in drained ponds ($P < 0.05$, $r^2 = 0.26$) and in fish-stocking ponds ($P < 0.05$, $r^2 = 0.19$). All analyses of these relationships and in different

habitats are listed in table 4 and figures of these regression analyses are shown in figure 1 to 4.

When Black-faced Spoonbills were less numerous than other associated waterbirds, there were always in positive numerical relationships. Data was analysed in feeding and loafing habitats but there were not enough data for subdividing the habitats. During loafing, there was a strong relation to between the numbers of Black-faced Spoonbills and the numbers of Grey Herons ($P < 0.05$, $r^2 = 0.79$), Great Egrets ($P < 0.05$, $r^2 = 0.87$) and Little Egret ($P < 0.05$, $r^2 = 0.61$). In feeding flocks, the numbers of Black-faced Spoonbills had a strong relationships with the numbers of Little Egrets ($P < 0.05$, $r^2 = 0.85$) and Great Egrets ($P < 0.05$, $r^2 = 0.85$) and a weak relationship with the numbers of Grey Herons ($P < 0.05$, $r^2 = 0.21$). Figures 5 and 6, and table 5 are showing these relationships.

Aggression behaviours

A total of 51 cases of the aggression interactions (i.e. threatening, attacking and food robbery) were recorded during this study. All were during feeding period. None was seen in loafing period of the Black-faced Spoonbills. Seven species of waterbirds were involved in these aggression interactions: Grey Herons, Great Egrets, Intermediate Egrets, Little Egrets, Black-faced and Eurasian Spoonbills, and Great Cormorants. No aggressor has been seen attacking more than one waterbird at the same time during this study. However, two or three (maximum: 5, average: 1.6) aggressors were attacking the same bird, which usually was about food robbery. There was a significantly difference in aggression among waterbird species; Grey Herons behaved more often aggressive to others waterbirds than the other species (Kruskal-Wallis One Way ANOVA, $H = 53.879$, $df = 4$, $P < 0.001$, table 6). Conversely, the Black-faced Spoonbills were most frequently attacked by other associated waterbirds (table 7), but their own attacks were only directed to their own species.

Of all the 51 cases of aggression interactions, 30 (59%) was noted as food robbery, 13 (26%) as threatening and 8 (16%) as attacking. Food robbery involved 41 individual waterbirds. The commonest robber was Grey Heron with 19 individuals (46%) recorded and 34 (83%) individuals of Black-faced Spoonbills were robbed. However, of these 34 Black-faced Spoonbills 12 (40%) could still successfully withhold the prey and swallowed it at the end. Food robbery was recorded frequently when different waterbird species were involved, while attacking usually involved the same species. Threatening concerned both same and different waterbird species. There were significantly difference (chi-square = 16.924, $df = 2$, $P < 0.001$, table 8).

Discussion

Numbers of Black-faced Spoonbills and waterbirds in associations

The results show that Black-faced Spoonbills always associated to other waterbirds during loafing and feeding, but almost none during in flight. More spoonbills and associated waterbirds were found during loafing than during feeding (table 1 and 2). There were no significant difference on numbers of both

spoonbills and associated waterbirds in different loafing site, except low numbers in tidal area, while feeding spoonbills and associated waterbirds were mostly attracted to drained ponds (table 3). All associations involved 19 species of waterbirds from six orders (table 2). Ciconiiformes was recorded in highest numbers associating to the Black-faced Spoonbills, while other waterbird orders were in smaller numbers. Grey Herons, Great and Little Egrets were found to have some numerical relationships to the Black-faced Spoonbills in different habitats and more are discussed below.

Numbers of associations in different habitats

Numbers of the Black-faced Spoonbills and the associated waterbirds were found similar in many loafing habitats because Black-faced Spoonbills and their associated waterbirds could actually loaf in several types of habitats. All these loafing sites are available permanently (i.e. traditional site, see details below) or temporary (such as drained ponds). So, the loafing habitats of the Black-faced Spoonbills are extensive but must be free of predators (Yu and Swennen 2004a). In Mai Po several areas such as Pond 6 near the Rocky outcrop near the border fence, the Scrape (i.e. Pond 16/17) and open shallow water area in front of tower hide in Pond 8 are managed to provide suitable habitats for the Black-faced Spoonbills. Water level and vegetation of these sites are controlled to maintain the sites as an open area. All these management activities help the Black-faced Spoonbills to congregate in these sites and also their associates.

Feeding habitats of the Black-faced Spoonbills are restricted to shallow water area with flat bottom and free of obstacles and high turbidity (Yu and Swennen 2004a), but high concentration of prey from draining down the fishponds and *gei wai* can also attract large numbers of Black-faced Spoonbills and many associated waterbirds feeding in these habitats. In recent years fish-stocking also in Mai Po that aimed to attract Great Cormorants feeding in the Mai Po Nature Reserve also catches the attention of these long-legged waterbirds because they could feed these fishes in the shallow water area in the same pond. In some occasion, feeding association of waterbirds could also be noted in normal ponds where no draining or fish-stocking took place. It was assumed that the association was formed when certain waterbirds were attracted by the other when some birds could have good feeding success.

Tidal area had significantly lower numbers of the Black-faced Spoonbills and associated waterbirds. Tidal area is a dynamic environment with changing water level all the time. Intertidal mudflat is suitable to the spoonbills and associated waterbirds during low tide. Food of the spoonbills and waterbirds could not be largely concentrated in certain area that also could not attract large numbers of waterbirds. During high tide only small numbers of the Black-faced Spoonbills and associated waterbirds could stay on top of mangrove trees and many prefer to go loafing inside the Mai Po Nature Reserve (i.e. the traditional loafing site).

Numbers of associated waterbirds in different orders

Members of Ciconiiformes (i.e. ardeids and spoonbills) have similar body structure, i.e. long bill, neck and legs, medium to big body size and plumage colour of some species to the Black-faced Spoonbill.

Therefore, it is likely that they could share similar habitats too. On the contrary, waterbirds of other orders have different body structure and behaviours and so they did not make strong association to the Black-faced Spoonbills. Anseriforms (i.e. ducks) has short legs and bill, and bulkier body and they are good swimmers. They could spend long time to float on water surface regardless to water depth and so they mainly loaf in deep water area in the bay throughout the day because the area is usually free of human disturbance comparing to those shallow water areas. They could spend shorter time in the Mai Po area where the Black-faced Spoonbills usually loaf in a long time. Gruiformes (i.e. rails and waterhens) are usually small-sized with a shorter bill and they are usually secretive. They prefer staying inside vegetation to feed and loaf but the Black-faced Spoonbill always loafs in open areas. Charadriiformes (i.e. shorebirds) also has a long bill and legs and they utilise shallow water area with following the tide, but their body sizes are considerably smaller than the Black-faced Spoonbills. Hence, the shallow water area used by the spoonbills is too deep for the shorebirds. Also, shorebirds feed on benthic invertebrate while Black-faced Spoonbills feed on fish and shrimp in water column. Shorebirds usually spend long time on tidal flat when the flat is not covered by water, while Black-faced Spoonbills use mudflat mainly for feeding and would spend about 4 hours per day for feeding (Yu and Swennen 2004b).

Great Cormorant is also known as gregarious and always present in flocks. Numbers of Great Cormorants exceeded 10,000 individuals in Mai Po and nearby in recent winters. They also gather together in night roosting sites and density of birds in these roost sites is high. Most of the birds perch on the bare branches and keep a distance to the companions and birds become aggressive when companions get closer. Cormorant has a sharp beak and so it is actually dangerous to mix with a large flock of Great Cormorants. Very few other waterbirds had seen mixed with the roosting cormorants. The Black-faced Spoonbill does not have sharp claws or bill for defence and so the spoonbills were usually found staying away from the dense cormorant groups. However, when small groups (not exceeding 100 individuals) of Cormorants gather to loaf in daytime, some Black-faced Spoonbills could still stay in the surrounding and occasionally could stay inside the group of the cormorants because cormorants provided adequate protection to the spoonbills. Numbers of waterbirds in the main roost site of the Great Cormorants in daytime were also recorded during this study for comparison. There were only 1.8 (SD $\pm$ 1.5, N = 13) ardeids found associating on average 731 (SD $\pm$ 496, N = 13) Great Cormorants (unpublished data) and no spoonbill was seen inside this site.

Numerical relationships of Black-faced Spoonbills to Grey Herons, Great and Little Egrets

Numerical relationships between Black-faced Spoonbills and Grey Herons, Great and Little Egrets were found in this study. They differed between habitats and also differed between species (table 4, figure 1-4). Grey Herons had higher numbers associating to Black-faced Spoonbills during loafing but the numbers of Grey Herons varied considerably. Great Egrets showed higher numbers associated to the Black-faced Spoonbills in feeding habitats than in the loafing habitats. Little Egrets also could have some numerical relationships to the Black-faced Spoonbills in both loafing and feeding habitats.

Grey Heron had the highest number associating to the Black-faced Spoonbill in this study among all other waterbirds (table 2). There were also significant numerical relationships to the Black-faced Spoonbills in all loafing habitats but these numerical relationships are not so strong (table 4). Grey Heron is noticeably bigger than the Black-faced Spoonbill in body size (table 10) and hence Grey Herons is capable to loaf with fewer companions. Some Grey Herons preferred to loaf with the large congregation of spoonbills, indicating that they might feel safer from being in the group. In addition, the Black-faced Spoonbills could not attack to the Grey Herons because of smaller in size and without a sharp beak. Feeding Grey Herons could stalk the prey in a deeper water area where other ardeids or Black-faced Spoonbills could not reach. Moreover, the feeding Grey Herons are more territorial during feeding and they often expel other nearby feeding waterbirds (Cramp and Simmons 1977). This caused low numbers of association between Grey Herons and the Black-faced Spoonbills during feeding.

Great Egrets significantly associated to the Black-faced Spoonbills in all feeding habitats (table 2 and 4, figure 3 and 4). They are less different in size (table 10) and so they would feed in similar water depth. The Black-faced Spoonbills is a tactile feeder (Swennen and Yu 2004, 2005) and they feed in turbid water by wading through water and sensing the movement of fish and shrimp in water column and hence to catch them. Great Egret (and other ardeids as well) is a visual feeder which depend on eyes to locate and catch the prey. Therefore, the feeding habitat of the Black-faced Spoonbill is primarily unsuitable to the Great Egrets. However, many observations and picture 2 showed that the Great Egrets could feed closely and even followed to the Black-faced Spoonbills. While feeding spoonbills walked around the shallow water, the fish could be disturbed and so moved away that make fishes visible to the Great Egrets. Therefore, Great Egrets would get benefits from the feeding behaviour of the Black-faced Spoonbills. Robbing big fishes from the Black-faced Spoonbills could sometimes add extra benefits from this association.

In contrast, Little Egret is much smaller than the Black-faced Spoonbills (table 10) and so it is reasonably believed that they use quite different areas regarding to the water depth. The results also indicate there were not strong relationships of their numbers in the main loafing habitat (i.e. the traditional site) of the spoonbills (table 4, figure 1). In feeding habitats the Little Egrets usually feed in the surrounding or shallower area (picture 2). Similar to Great Egrets, the Little Egrets could get prey items which were disturbed by the feeding Black-faced Spoonbills and jumped out from water and therefore there are significant relationships between the Little Egrets and the Black-faced Spoonbills in all feeding habitats (table 4, figure 3 and 4).

Which is the commonest species associating to the Black-faced Spoonbills?

Extent of these associations could also be expressed from their numbers presented in the Deep Bay area within the study period and their presences in the scans of the association with the spoonbills. Peak count of Grey Heron, Great Egret and Little Egret recorded in this period was 930, 712 and 1366 (Anon. 2008) and so the percentages of these species to the sum of these peak counts was 31%, 24% and 45%

respectively. In the loafing period of the Black-faced Spoonbills the total number of scans is 769, of which Grey Herons were recorded in 522 scans (68% of the total), Great Egrets in 224 scans (29%) and Little Egrets in 155 scans (17%) (table 1 and 4). The ratio of Grey Herons in association with Black-faced Spoonbills to total number of three ardeids present in the Deep Bay area is 2.2 (i.e. 68%/31%). Same calculation is used to find the ratio for Great and Little Egrets which is 1.21 and 0.44 respectively. In all the feeding associations the total number of scans is 463, while Grey Herons were recorded in 231 scans (50%), Great Egrets in 196 scans (42%) and Little Egrets in 141 scans (30%) (table 1 and 4). Hence, the ratio of Grey Heron, Great Egret and Little Egret in association to feeding Black-faced Spoonbills is 1.61, 1.75 and 0.66 respectively. These ratios also reflect Grey Herons often associated to loafing Black-faced Spoonbills and Great Egrets associated more to the feeding spoonbills.

Of all these associated waterbirds, Eurasian Spoonbill is the most closely related to the Black-faced Spoonbills both in behaviour and morphology because they belong to the same genus. Both spoonbills are well documented to inhabit together in many sites during non-breeding period (e.g. Kennerley 1987, Hancock *et al*. 1992, Yu and Swennen 2005). In the present study, the Eurasian Spoonbill was apparently found weakly associated to the Black-faced Spoonbills. There was only three Eurasian Spoonbills among a total of 369 Black-faced Spoonbills in the Deep Bay area during the study period. The chance to have one in a small group was low, and in large groups they are easily overlooked during scanning.

Reasons of association

All above gives some explanations to different waterbird species (or groups) on how they associate to the Black-faced Spoonbills. In fact, the Black-faced Spoonbills also need such associations that are important for their survivals. In loafing the spoonbills put their bills and heads low on the back and bend their necks, and some could also fall asleep. Spoonbills in this posture could be susceptible to predators from their sudden approaches. Hence, they tend to gather in a large flock and so risk of being attacked of each individual could be diluted, but some individuals loafing on the edge of the group still have higher risk. In contrast, loafing ardeids have a posture with head pointing forward and straight or bended neck. So, with the same body orientation in the group the loafing ardeids look to the opposite direction that Black-faced Spoonbills do (Yu and Swennen pers. obs). As a result, the spoonbills would need some ardeids to join in the group because it can help to enhance observations for the safety in the loafing site.

The ardeids make responses quicker to any sudden disturbance and need shorter distance to escape into the air (Yu and Swennen pers. obs.). Therefore the ardeids have a higher adaptability to loaf in less open area and they can settle in wider area in the Deep Bay area than the Black-faced Spoonbills. Situation is similar in feeding birds. Feeding Black-faced Spoonbill also put the head down and the bill into the water to search the food item in water column (Swennen and Yu 2005). Hence, the spoonbills also could not scan the environment for any approaching predator. Ardeids could feed in the aggregation of waterbirds and walked in upright posture. Apparently they could watch both the water and other birds (Kushlan 1978). The numerical relationships are even stronger in the situation that the Black-faced Spoonbills were

in minority with the associated waterbirds (table 5, figure 5 and 6). More ardeids present in an area that attracts more spoonbills to join the flock. Therefore, the Black-faced Spoonbill depends on the associated waterbirds for safety in both loafing and feeding habitats.

Aggression behaviour

In this study the aggression behaviour was only recorded during feeding and none during loafing. Grey Herons undertook significantly more aggressions to other waterbirds and robbed food from other waterbirds, but received no militant activities from other species (table 6 to 9). Great Egrets also made attacks to other species but less frequent as Grey Herons did and received militant activities only from the Grey Herons (table 6 to 9). Other species such as Little Egret and Great Cormorant which are both smaller than the Grey Heron and the Great Egret also made militant activities but in very few cases. Situation was different from the Black-faced Spoonbills which were only aggressive toward the other Black-faced Spoonbills but often attacked and robbed by other waterbirds (table 6 to 9). Therefore, size hierarchy is present in the militant activities.

Food robbery only involves to big prey items because the large prey needs longer handling time from the bill and that enhances the chances for robbery. The Black-faced Spoonbill makes 'catch-and-throw' action to transport the prey from bill tip to mouth. The spoonbills take several 'catch-and-throw' actions to bring a big fish (5-20cm) to the mouth but only one throw of small prey items (<5cm) (Swennen and Yu 2005). Therefore, the large prey becomes visible to other feeding waterbirds when it was captured and transported in the bill. In the meanwhile, Grey Herons could have time to harass the spoonbill which has a large prey in bill and might eventually get the prey. This food robbery was not recorded with small prey because small prey could be transported to the mouth too fast and energetic cost is not beneficial to rob a small prey. In addition, the spoonbills can still deny some robbing from the associated waterbirds and the robbing itself is in lower successful rate, greater time expenditure and so to obtain a lower gross energy intake (Kushlan 1978). Therefore, the food robbery is not always profitable to the robber and it would happen only opportunistically.

Conclusion

Previous studies of the Black-faced Spoonbill focused to find out basic information of the habitats, food and feeding of the wintering Black-faced Spoonbill in Hong Kong and other sites in the spoonbill's range state (e.g. Choi *et al.* 2007, Swennen and Yu 2004, 2005, Wei *et al*. 2005, Ueng *et al*. 2007, Yu and Swennen 2004a and b, Zhang *et al*. 2006). Only brief notes was made for describing associated waterbirds to the Black-faced Spoonbills (e.g. Hancock *et al*. 1992, Chong *et al*. 1996) and these lacked of quantitative measurement of the relationships between the spoonbills and associated waterbirds. This study not only found numbers of waterbirds associating to the Black-faced Spoonbills, but also some numerical relationships of some important ardeids to the spoonbills. This is a first attempt of such study to the Black-faced Spoonbills and in this region.

To conclude, this study focused to some basic information about association among the Black-faced Spoonbills and waterbirds utilising the same areas as the spoonbills. The commonest associate in loafing and feeding habitats of the Black-faced Spoonbills is Grey Heron and Great Egret respectively. Black-faced Spoonbills were always robbed by other waterbird species and Black-faced Spoonbill individuals, but they just could not rob the others. Grey Herons and Great Cormorants are dominant over the Black-faced Spoonbills in some situations but the results could not show strong indication that spoonbills and other waterbirds do suffer from associations under the situation as occurs now. However, the Grey Herons and Great Cormorants could occupy the area for the Black-faced Spoonbills. Situation could become less favourable to the Black-faced Spoonbills when the Deep Bay area has fewer areas for feeding and resting sites to all these waterbirds temporarily or permanently. Therefore, management exercises in the Ramsar site could focus to provide different habitats (e.g. both deep and shallow water areas) to reduce or avoid direct competition and aggression of these waterbirds.

Some aspects of the whole content about the association or aggregation of waterbirds are still not studied, discussed and explained so far. Further studies could be focused on several finer questions, e.g, how the association form, attractiveness of different waterbirds species in the association of the species, feeding success or efficiency between associated and solitary waterbirds, and effects of prey density in different feeding habitats to numbers of waterbird present etc. Mai Po Nature Reserve and the nearby Deep Bay area holds thousands of waterbirds in the winter time and some areas are under active management for the wildlife. It is an ideal place to carry out further similar studies later on.

Acknowledgements

We thank Asia Ecological Consultant Ltd. (AEC) for facilitating field observations of this project in Lok Ma Chau KCRC mitigation ponds. We also thank World Wide Fund for Nature (HK) to provide schedule of *gei wai* draining and so the field observations could be arranged. We are grateful to ECF to grant fund for this project and otherwise this study could not be undertaken.

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Association of other waterbird species with wintering Black-faced Spoonbills in Hong Kong

Tables

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Environment and Conservation Fund

Table 1. Numbers of Black-faced Spoonbills scanned in different behaviours in Deep Bay area, winter 2007-08.

	No. of scans	Mean	Median	SD	Max.
Loafing	767	27.4	11	39.3	254
Feeding	463	11.9	5	21.1	165
Flying	119	4.6	1	15.5	158

Table 2. Mean (with SD) and species of associated waterbirds to loafing and feeding Black-faced Spoonbills in the Mai Po area.

Order	Species	Associated with loafing BFS. Mean (with SD, N = 767)	Associated with feeding BFS. Mean (with SD, N = 463)
Order Podicipediformes	Little Grebe	Nil	0.00 (0.05)
Order Pelicaniformes	Great Cormorant	1.52 (8.93)	0.07 (0.56)
Order Ciconiiformes	Grey Heron	5.06 (12.09)	2.03 (4.48)
	Purple Heron	0.00 (0.04)	Nil
	Great Egret	1.44 (6.36)	1.93 (6.17)
	Intermediate Egret	0.07 (0.36)	0.12 (0.71)
	Little Egret	0.79 (2.89)	1.05 (4.64)
	Chinese Pond Heron	Nil	0.00 (0.05)
	Eurasian Spoonbill	0.19 (0.45)	0.05 (0.26)
	All ciconiiformes	7.54 (16.83)	5.19 (12.54)
Order Anseriformes	Eurasian Wigeon	0.08 (1.84)	0.01 (0.10)
	Common Teal	0.01 (0.14)	0.01 (0.14)
	Spot-billed Duck	Nil	0.01 (0.14)
	Northern Pintail	0.38 (3.31)	0.07 (0.89)
	Northern Shoveler	0.39 (2.17)	0.54 (5.75)
	Unidentified Duck	0.71 (6.14)	0.29 (4.76)
	All Anseriformes	1.57 (9.90)	0.93 (8.29)
Order Gruiformes	White-breasted Waterhen	0.00 (0.04)	Nil
	Common Moorhen	0.06 (0.41)	0.01 (0.15)
	All Gruiformes	0.06 (0.41)	0.01 (0.15)
Order Charadriiformes	Pied Avocet	1.12 (19.33)	0.02 (0.46)

	Grey Plover	0.03 (0.72)	Nil
	Black-tailed Godwit	0.04 (0.81)	Nil
	Eurasian Curlew	1.37 (16.44)	Nil
	Spotted Redshank	0.00 (0.05)	0.00 (0.05)
	Common Greenshank	0.15 (3.64)	0.03 (0.65)
	All Charadriiformes	2.71 (35.59)	0.05 (1.16)
Total	*All species*	13.41 (32.91)	6.26 (14.43)
	Positively identified species	19	17

Table 3. Mean numbers (and SD) of Black-faced Spoonbills and their associates in different loafing and feeding habitats.

	Black-faced Spoonbills	Associated waterbirds
Loafing		
Traditional site (N = 472)	30.83 (39.63)[1]	8.95 (17.63)[2]
Drained ponds (N = 122)	29.83 (46.07)[1]	23.89 (50.04)[2]
Tidal area (N = 39)	3.74 (4.72)[1]	6.64 (24.20)[2]
Other (N = 117)	19.45 (35.57)[1]	15.85 (49.76)[2]
Feeding		
Drained ponds (N = 190)	16.08 (25.66)[3]	8.11 (17.20)[4]
Tidal area (N = 40)	4.18 (4.04)[3]	1.80 (2.52)[4]
Fish-stocking ponds (N = 110)	9.94 (17.34)[3]	4.65 (7.48)[4]
Normal ponds (N = 123)	9.74 (18.37)[3]	6.28 (16.26)[4]

1) The numbers of loafing Black-faced Spoonbill differed significantly in loafing habitats (Kruskal-Wallis One Way ANOVA, $H = 70.966$, $P < 0.05$), except those in traditional and drained ponds sites.
2) The numbers of associated waterbirds differed significantly between the loafing habitats of the Black-faced Spoonbills (Kruskal-Wallis One Way ANOVA, $H = 24.079$, $P < 0.05$), except those in other sites comparing to the numbers of traditional and drained ponds sites.
3) The numbers of feeding Black-faced Spoonbills were significantly higher in drained ponds than in tidal area and fish-stocking ponds (Kruskal-Wallis One Way ANOVA, $H = 18.543$, $P< 0.05$).
4) There were significantly higher numbers of associated waterbirds in drained ponds than in tidal area and normal ponds (Kruskal-Wallis One Way ANOVA, $H = 25.337$, $P < 0.05$).

Table 4. Regression analyses of numerically important Ciconiiformes associated with Black-faced Spoonbills in different loafing and feeding habitats.

Loafing habitats	Associate waterbird	Regression line	P	r^2	N
Traditional sites	Grey Heron	y = 3.299 + 0.023x	0.004	0.028	288
	Great Egret	y = 2.630 + 0.0008x	0.934	0.000	110
	Little Egret	y = 1.877 + 0.001x	0.844	0.000	82
Tidal area	Grey Heron	y = 0.649 + 0.206x	0.007	0.437	15
	Great Egret	undetermined	-	-	4
	Little Egret	y = 1.159 + 0.018x	0.744	0.756	8
Drained ponds	Grey Heron	y = 0.683 + 0.284x	<0.001	0.444	76
	Great Egret	y = -0.778 + 0.181x	<0.001	0.632	53
	Little Egret	y = 1.559 + 0.054x	<0.001	0.335	36
Other sites	Grey Heron	y = 2.376 + 0.030x	0.004	0.129	64
	Great Egret	y = 1.506 + 0.001x	0.754	0.003	33
	Little Egret	y = 1.110 + 0.032x	<0.001	0.569	20
Feeding habitats	Associate waterbird	Regression line	P	r^2	N
Drained ponds	Grey Heron	y = 1.510 + 0.135x	<0.001	0.426	102
	Great Egret	y = 1.527 + 0.111x	<0.001	0.234	86
	Little Egret	y = 1.498 + 0.051x	<0.001	0.261	57
Fish-stocking ponds	Grey Heron	y = 1.810 + 0.019x	0.251	0.024	55
	Great Egret	y = 0.766 + 0.103x	<0.001	0.476	35
	Little Egret	y = 1.196 + 0.014x	0.036	0.185	24
Tidal area	Grey Heron	y = 0.925 + 0.035x	0.12	0.247	11
	Great Egret	y = 0.228 + 0.237x	0.005	0.494	14
	Little Egret	y = 0.796 + 0.079x	0.005	0.446	16
Normal ponds	Grey Heron	y = 1.832 + 0.041x	0.006	0.185	39
	Great Egret	y = -1.256 + 0.219x	<0.001	0.756	26
	Little Egret	y = 0.898 + 0.077x	<0.001	0.679	20

Table 5. Regression analyses of numerically important Ciconiiformes associated with the number of Black-faced Spoonbills in cases of the numbers of Black-faced Spoonbills which were less than the numbers of associates in loafing and feeding habitats.

Habitats	Associate waterbird	Regression line	P	r^2	N
Loafing	Grey Heron	y = -1.330 + 0.594x	<0.001	0.787	79
	Great Egret	y = 1.200 + 0.274x	<0.001	0.871	24
	Little Egret	y = 1.326 + 0.155x	0.013	0.612	9
Feeding	Grey Heron	y = -1.337 + 0.133x	0.024	0.211	24
	Great Egret	y = -1.667 + 0.551x	<0.001	0.847	35

	Little Egret	y = -0.993 + 0.512x	<0.001	0.853	24

Table 6. Average numbers(with SD) of waterbirds showing aggressions to others. The numbers of aggressions from different waterbird species were tested by Kruskal-Wallis One Way ANOVA.

	Threatening (N = 13)	Attacking (N = 8)	Food robbery (N = 30)	Total (N = 51)
Grey Heron	0.5 (0.5)	0.4 (0.7)	1.0 (1.0)	0.8 (0.9)
Great Egret	0.2 (0.4)	0.3 (0.5)	0.6 (0.8)	0.5 (0.7)
Little Egret	0.2 (0.4)	0	0.1 (0.6)	0.1 (0.5)
Black-faced Spoonbill	0.1 (0.3)	0.4 (0.5)	0.2 (0.4)	0.2 (0.4)
Great Cormorant	0	0	0.1 (0.3)	0.0 (0.2)
Total	1.0 (0.0)	1.1 (0.4)	2.0 (1.2)	1.6 (1.0)
P	< 0.01	0.20	< 0.01	<0.01

Table 7. Numbers (and percentages) of cases of waterbirds suffering of aggression.

	Militant action by same species	Militant action by other species	Militant action by both same and other species in the same time	Total
Grey Heron	5 (10%)	0	0	5 (10%)
Great Egret	4 (8%)	4 (8%)	1 (2%)	9 (18%)
Intermediate Egret	1 (2%)	1 (2%)	0	2 (4%)
Little Egret	0	2 (4%)	0	2 (4%)
Black-faced Spoonbill	7 (14%)	25 (49%)	1 (2%)	33 (65%)
Total	17 (33%)	32 (63%)	2 (4%)	51 (100%)

Table 8. Militant activities within same species and between different species among associated waterbirds.

	Same species	Different species	Total
Threatening	6 (12%)	7 (14%)	13 (25%)
Attacking	7 (14%)	1 (2%)	8 (16%)
Food robbery	4 (8%)	26 (51%)	30 (59%)
Total	17 (33%)	34 (67%)	51 (100%)

Table 9. Frequency of food robbery among associated waterbirds in Deep Bay area.

	Robbed					
Robber	GH	GE	GC	BFS	LE	Total
Grey Heron (GH)	0	3	0	15	1	19 (46%)
Great Egret (GE)	0	2	0	11	0	13 (32%)
Great Cormorant (GC)	0	0	0	2	0	2 (5%)
Black-faced Spoonbill (BFS)	0	0	0	5	0	5 (12%)
Little Egret (LE)	0	0	0	1	1	2 (5%)
Total	0	5 (12%)	0	34 (83%)	2 (5%)	41 (100%)

Table 10. Body and tarsus lengths, and weight of Black-faced Spoonbill, Grey Heron, Great and Little Egret.

	Body length (cm)	Tarsus length (mm)	Weight (g)
Black-faced Spoonbill	60-78.5[a]	All sex: 129-152[c], 113-124[d]	1470-1900[c]
Grey Heron	90-98[a], 93-100[d]	Male: 151 (136-172)[b], 148-159[d]; Female: 141 (132-153)b, 165[b]	1020-2073[a], 1310-1900[d]
Great Egret	80-104[a], 94.2-178[d]	Male: 169-200[d], Female: 172[d]	700-1500[a], 1200-1850[d]
Little Egret	55-65[a], 51.0-64.2[d]	Male: 101 (78-112)[b], 90-104[d]; Female: 97.3 (88-110)[b], 88-96[d]	280-638[a], 350-500[d]

a) Matheu, E and del Hoyo, J. 1992. Family Threskiornithidae (Ibises and Spoonbills). Page 472-506 in Handbook of birds of the world (del Hoyo, J., Elliott, A. and Sargatal, J. eds.) Volume 1. Lynx Edicions, Barcelona.

b) Cramp, S. and Simmons, K. (eds.) 1977. Handbook of the Birds of Europe, the Middle East and North Africa; the birds of the Western Palearctic, Volume 1. Oxford University Press. Oxford.

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Association of other waterbird species with wintering Black-faced Spoonbills in Hong Kong

Figures

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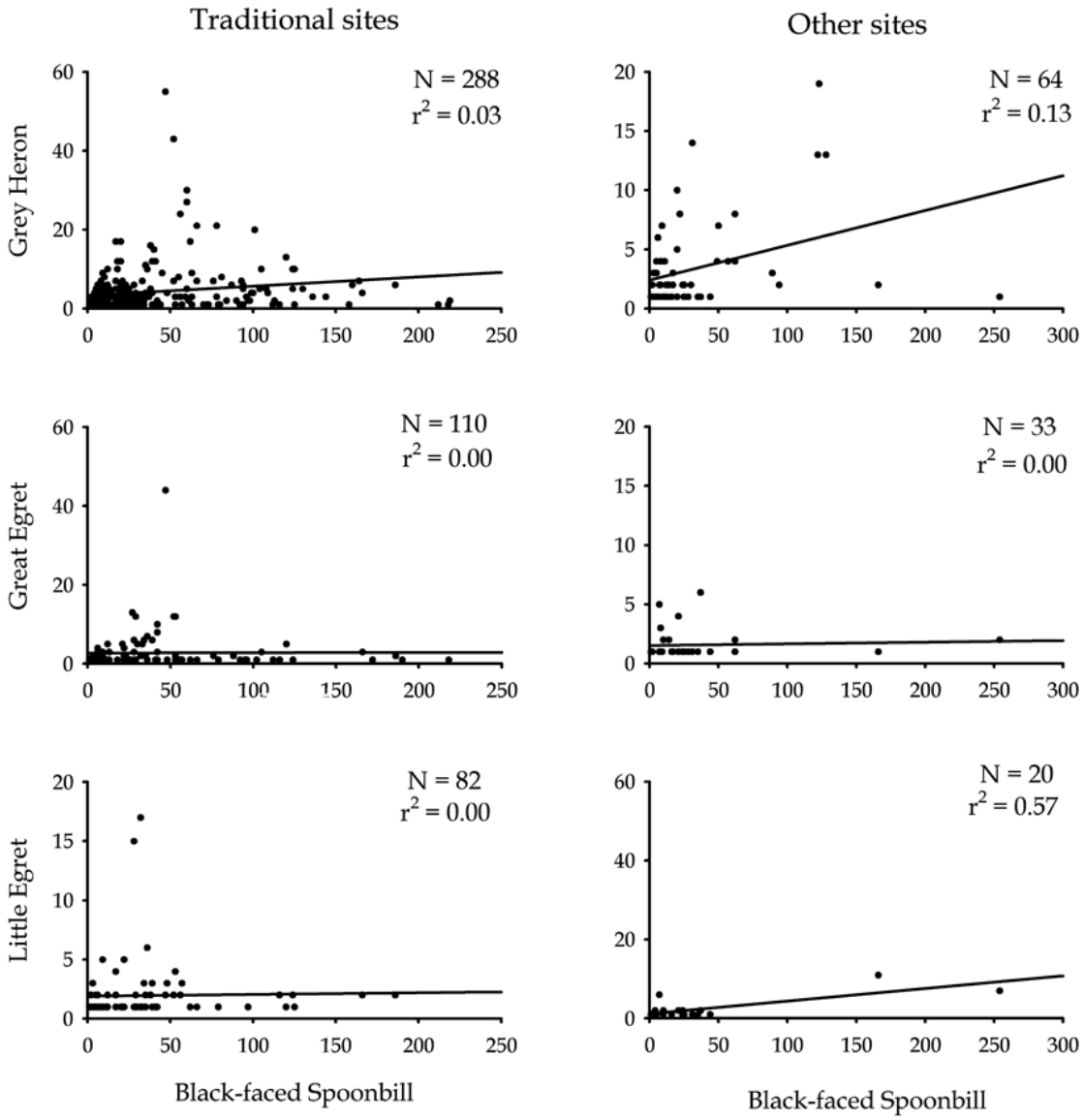

Figure 1. Linear regressions of numbers of Black-faced Spoonbills and Grey Heron, Great and Little Egret in traditional and temporary loafing sites (see table 5).

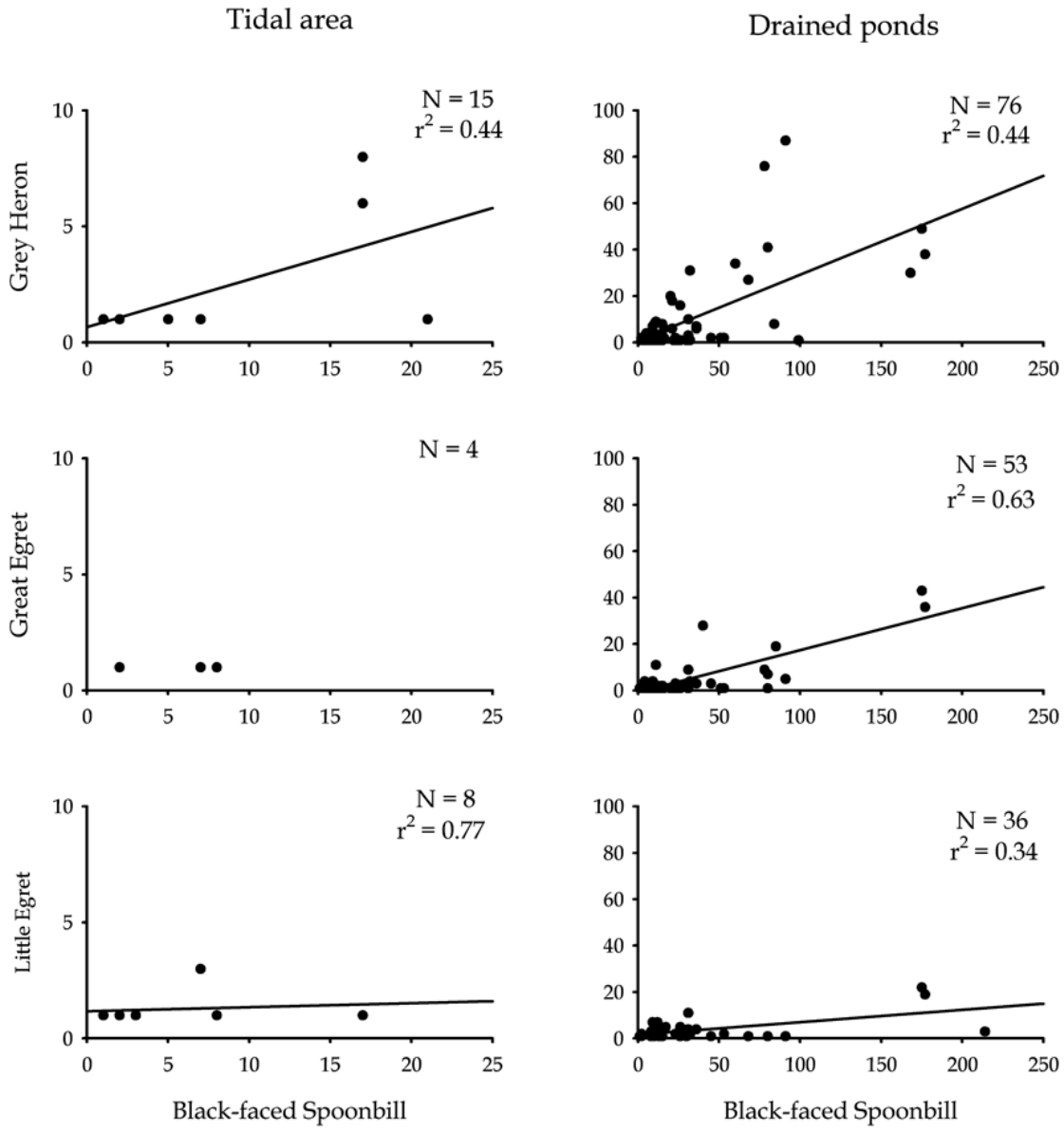

Figure 2. Linear regressions of numbers of Black-faced Spoonbills and Grey Herons, Great and Little Egrets in tidal area and drained ponds during loafing (see table 5).

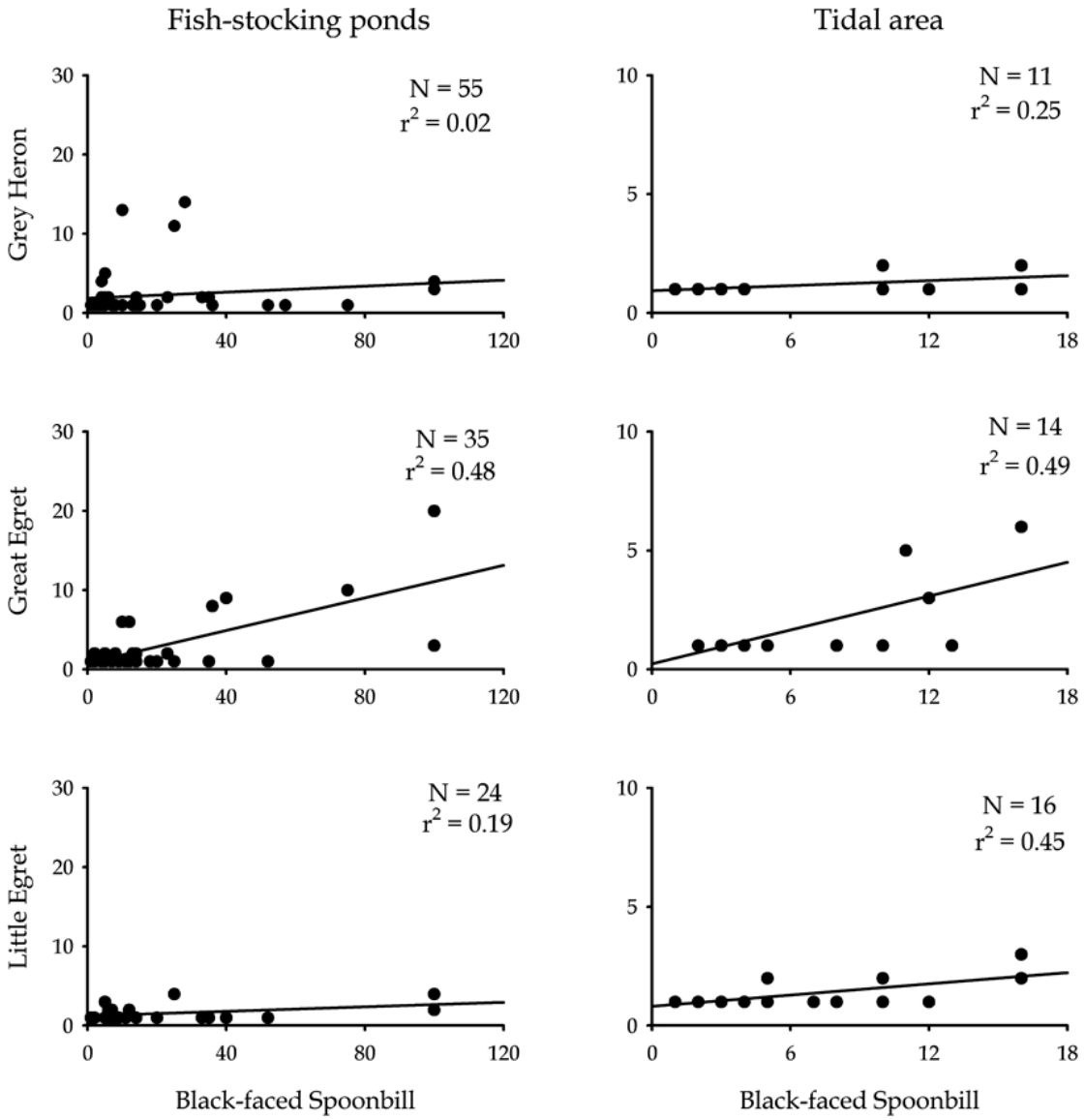

Figure 3. Linear regressions of numbers of Black-faced Spoonbills and Grey Herons, Great and Little Egrets in fish-stocking ponds and tidal area during feeding (see table 5).

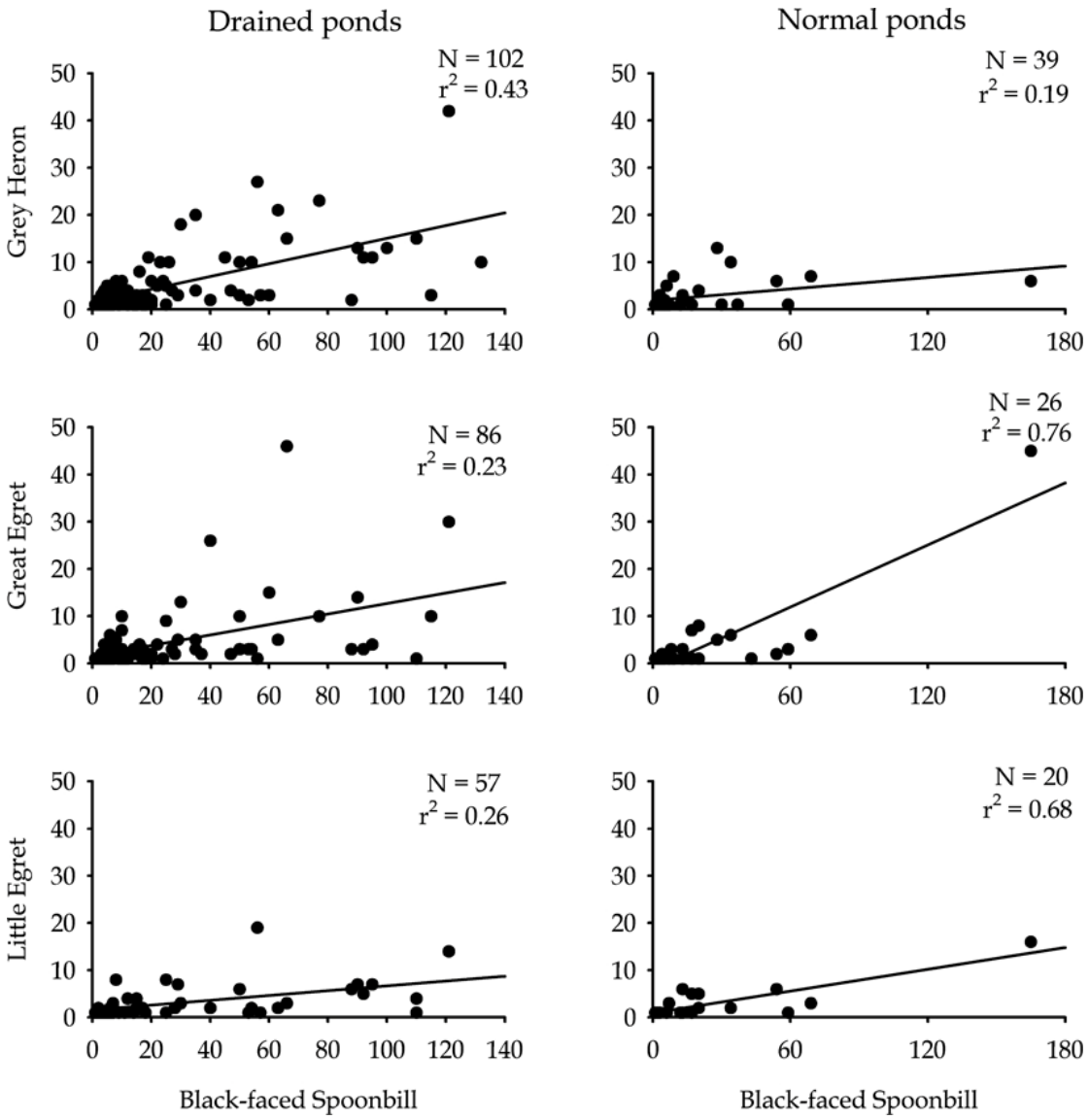

Figure 4. Linear regressions of numbers of Black-faced Spoonbills and Grey Herons, Great and Little Egrets in drained and normal ponds during feeding (see table 5).

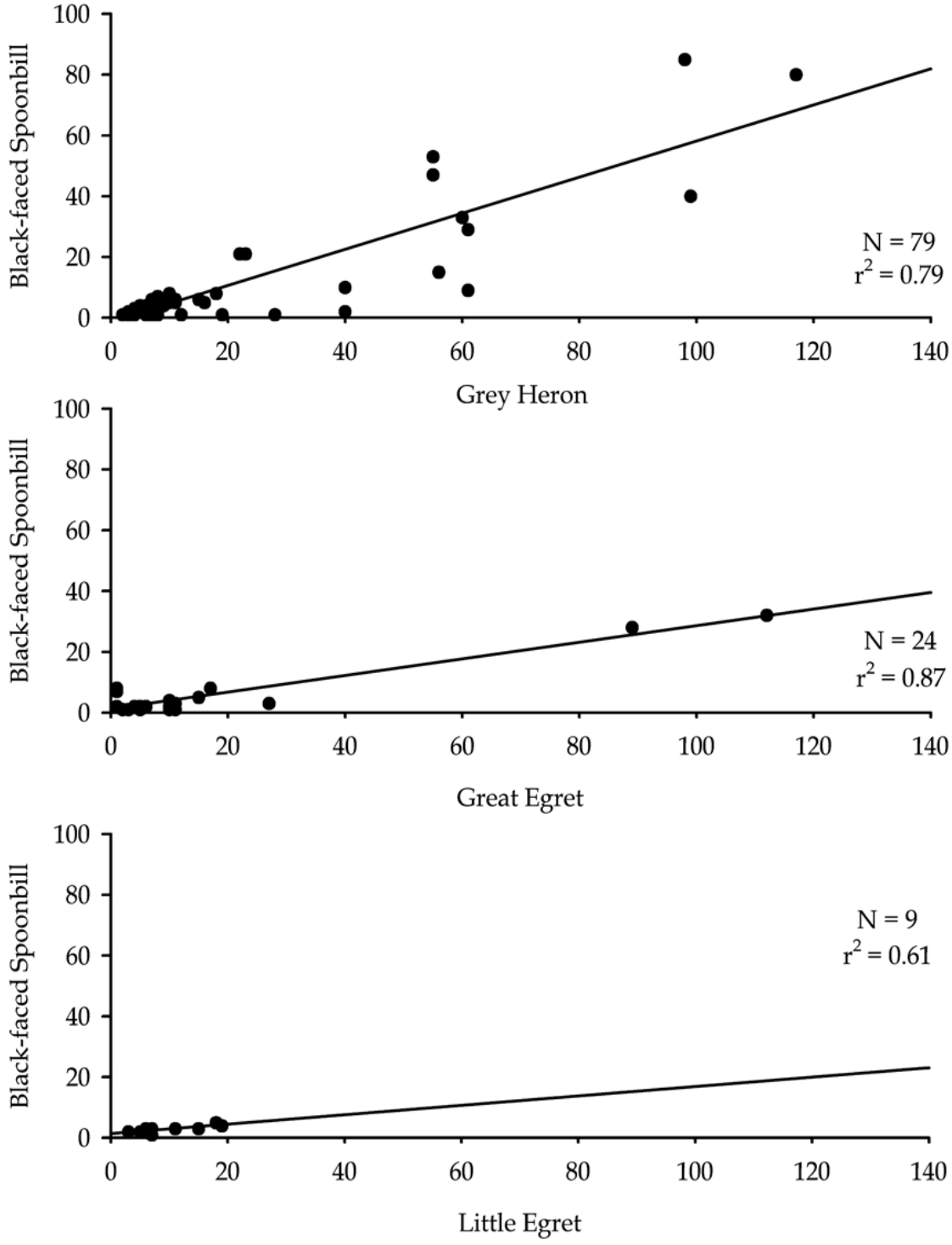

Figure 5. Linear regressions of Black-faced Spoonbills in smaller numbers and Grey Herons, Great and Little Egrets during loafing.

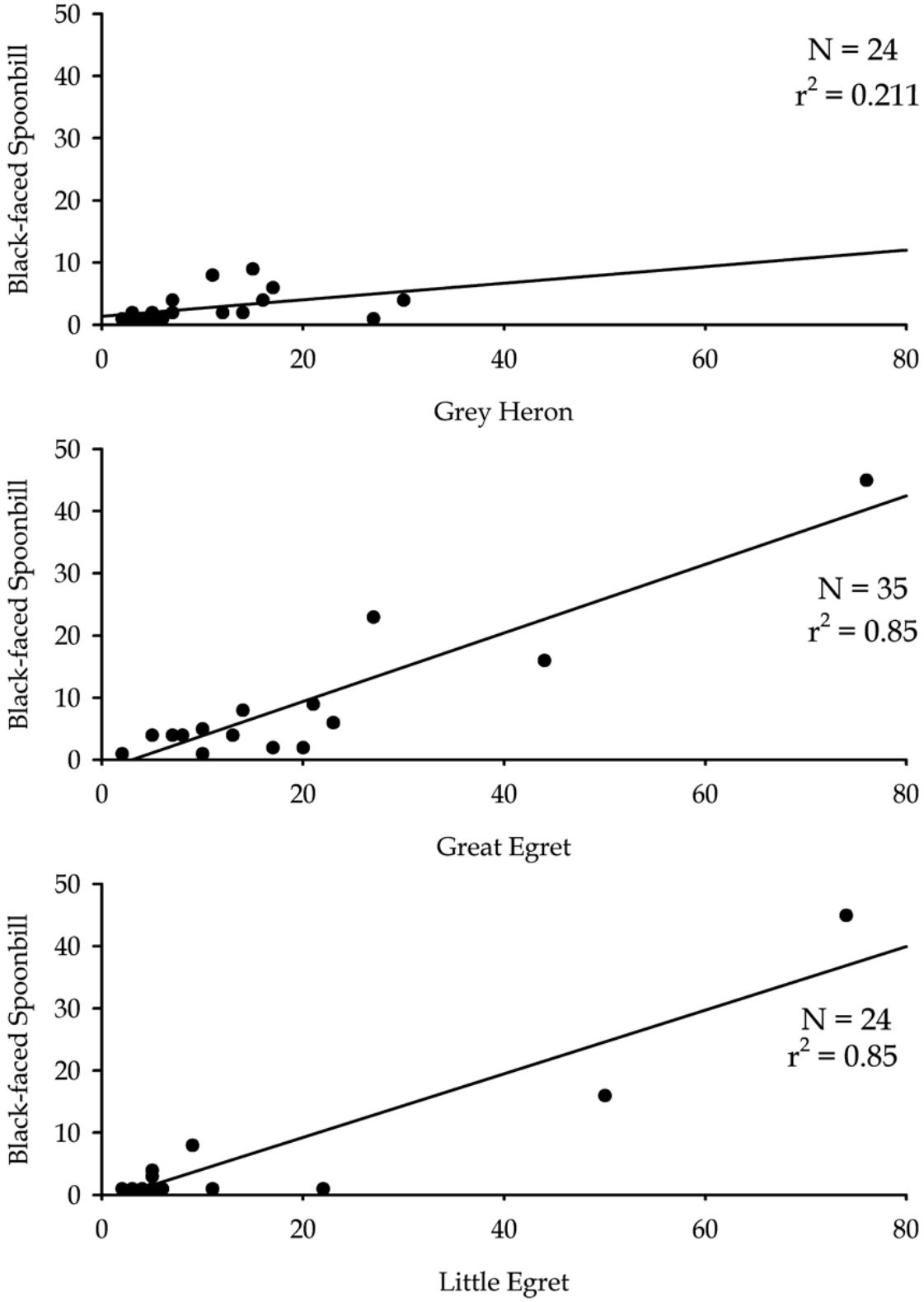

Figure 6. Linear regressions of Black-faced Spoonbills in smaller numbers and Grey Herons, Great and Little Egrets during feeding.

Association of other waterbird species with wintering Black-faced Spoonbills in Hong Kong

Pictures

The Hong Kong Bird Watching Society

Environment and Conservation Fund

Picture 1. Flock of feeding Black-faced Spoonbills, Little, Intermediate and Great Egrets, and Grey Herons in a draining *gei wai* at Mai Po, 15 Jan 2008. Food robbery was regularly observed.

Picture 2. A closer look on the feeding waterbirds in the draining *gei wai*. In the centre of this picture, four Black-faced Spoonbills fed very close to each other. A Great Egret followed or walked toward the feeding Black-faced Spoonbills. A Grey Heron stood still near the feeding spoonbills, while Little Egrets could only stand in some distance away because they cannot reach that area due to shorter legs, 15 Jan 2008.

Picture 3. A part of loafing flock of Black-faced Spoonbills in water with a Great Egret landing in the middle and a Grey Heron standing in the periphery, 4 Dec 2007.

Picture 4. A loafing flock of Black-faced Spoonbills with two Grey Herons in the middle, 14 Feb 2008.

Picture 5. A flock of flying Black-faced Spoonbills. Although this only shows a small flock of flying spoonbills, no other birds were found associating to the spoonbills in flight during this study.