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ORIGINAL ARTICLE

Wintering ecology of the Black Stork (*Ciconia nigra*) in Beijing

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Abstract The Black Stork (*Ciconia nigra*) is a new winter resident in Beijing due to temperature changes. To understand the wintering ecology of this species better, a field survey covering the number of birds of this population, habitat selection, feeding activity and grouping behavior was conducted at the Shidu Nature Reserve from January 2004 to March 2009. The results show that the Black Stork selected the Juma River at this nature reserve as their new winter habitat. The number of birds in this population decreased from 28 in the 2004/2005 winter to 17 in the 2007/2008 winter with a subsequent recovery to 23 the following year. The wintering flock was formed in mid-November and dispersed in mid-March, but the date changed with seasonal temperature fluctuations. The storks exhibited feeding habitat fidelity and the main food type was fish (> 92.4%). There was no significant variation in food composition between adults and sub-adults (Mann-Whitney U test, $U = 1.00$, $p = 0.44$). Feeding activity occurred in the morning and at noon during early winter, but concentrated in the afternoon during mid winter, divided into dawn and dusk in late winter. Daily fish intake was 538 g for adults and 449 g for sub-adults if the period of foraging reached six hours in the wild, which was similar to the level under artificial feeding. Agonistic behavior among feeding birds was observed among group members in late winter. The main negative factor for wintering Black Stork was a reduced feeding habitat resulting from increased water depth due to damming of the river to benefit tourism and to wetland exploitation.

Keywords Beijing, *Ciconia nigra*, foraging behavior, wintering ecology

Introduction

With global warming the Beijing wetlands are threatened by the overuse of water resources and shrinking of wetlands. Water birds depending on wetlands suffer from loss of suitable habitats. Conservation of the wetland ecosystem and bird diversity has become of primary concern in Beijing (Chen et al., 2007). The Black Stork (*Ciconia nigra*) is listed as a first grade national key protection species. While this bird has a wide distribution throughout China, the number of birds in the population is small with an estimated 1000 individuals according to the China Red Data Book (Zheng and Wang, 1998). The Black Stork was previously recorded as a migrant and summer breeder in Beijing (Cai, 1987). Their nests were found on cliffs near rivers and streams in mountainous areas. Recently, however, many birds became residents under the effect of global warming (Sparks and Mason, 2004; Cano Alonso, 2006). Usually the Black Stork winters in regions south of the Yangtze River in China (Zheng and Wang, 1998). No studies of wintering ecology have been completed for this species despite reports of wintering Black Stork in Shaanxi and Shanxi provinces (Liu et al., 1990a; Wang and Wang, 2003). We have documented a wintering Black Stork

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population in Beijing since 2003 and have made a six-year follow-up study of its demographical ecology and feeding habitat selection (Bao et al., 2006). The objective of our research was to supply information for planning an in-situ protection strategy to maintain a stable wintering Black Stork population in Beijing.

Materials and methods

Study area

Our study area was located at the Shidu Juma River Aquatic Animal Nature Reserve of the Fangshan District in Beijing (39°35′–39°40′N, 115°27′–115°39′E), 800 m above sea level; the Shidu area lies in the middle reaches of the river (Fig. 1). The regional mean annual temperature is 11–12°C with a maximum of 35°C and a minimum of –18°C and the annual precipitation is 687 mm. The karst topography is obvious with cliffs around the Juma River. The riversides are small areas of flatland for cultivation and residential areas. River water originates from mountain springs and the running water never freezes along the river during the winter. The fish source in the river is rich and the main species are Topmouth Minnow (*Pseudorasbora parva*), Blackfin Minnow (*Sarcocheilichthys nigripinnis*), Yellow Catfish (*Pelteobagrus fulvidraco*), Rounded Gudgeon (*Abbottina rivularis*), Mud Fish (*Misgurnus anguillicaudatus*), Crucian Carp (*Carassius carassius*) and Korean Piscivorous Chub (*Opsariichthys bidens*) (Wang, 1984; Yang et al., 2008).

Field observations and statistical analysis

The field census was conducted to locate Black Storks along the Juma River. The time of day, number of birds, sites, state of activity and habitat characteristics were recorded. Fieldwork was carried out monthly from January to March 2004–2009. In order to avoid duplication, field observers were appointed at six different observation sites along a 20 km river section (Fig. 1). The total number of birds recorded in a single day in a fixed time by all observers was taken as the wintering population of that year. Bird watchers of the Beijing Friends of Nature also reported Black Stork observations to us.

Foraging rhythm and grouping behavior were recorded every 10 days using 8–12× binoculars and a 20–60× telescope from November 2004 to March 2005. Observations occurred from early morning or from noon to evening. Foraging times, sites, feeding habitat, food types and size and grouping behavior were recorded using a focal sampling method on group members. Feeding time allocation was expressed by feeding frequency with a time interval of two hours between 7:00–9:00, 9:00–11:00, 11:00–13:00, 13:00–15:00, 15:00–17:00 and 17:00–19:00. Differences in food types between adults and sub-adults were recorded and compared.

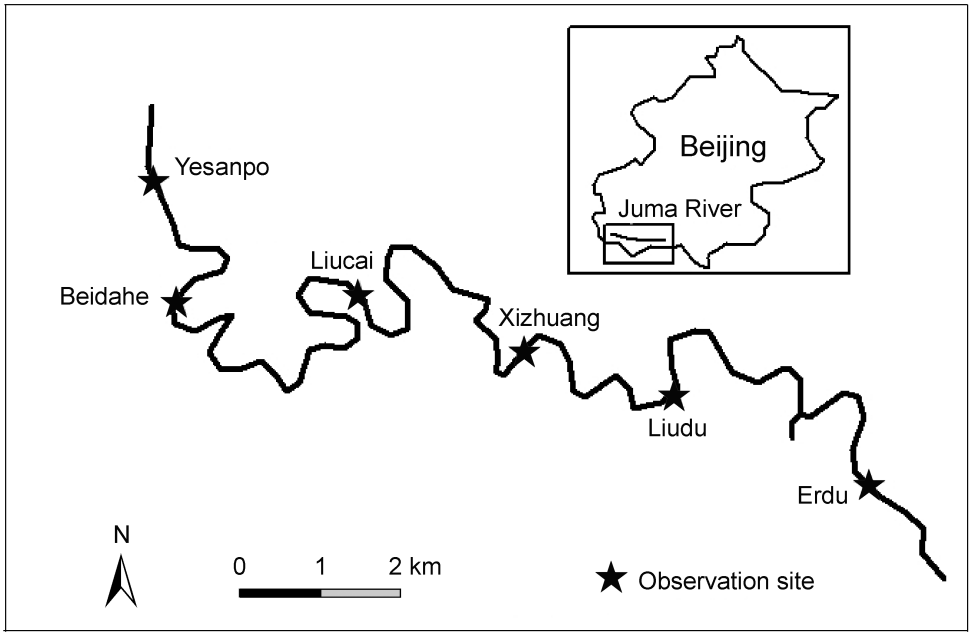

Fig. 1 Observation sites along the Juma River in Beijing

The food types were identified by the shape of fish or whorl. Among food types fish was classified into three groups for ease of field observation using the ratio of fish body length to stork bill length (about 19.0 cm; Zheng, 1997). Fish body length of Group A was below 1/5 of bill length or less than 5 cm in length; that of Group B was from 1/5 to 1/2 of the bill length or 5–10 cm and that of Group C was larger than 1/2 of the bill. Some fish species were collected from catches of local residents to obtain body length and weight. Daily food intake of Black Stork was calculated as a percentage of different size fishes.

The Mann-Whitney *U* test and the Kruskal-Wallis *H* test in SPSS 13.0 (SPSS Inc., Chicago, USA) data processing software were used to compare differences in food composition at different places and between adult and sub-adult Black Storks; $p < 0.05$ was taken as the probability of significant differences.

Results

Number of birds and periods of residency

The largest number of wintering Black Storks was recorded in the 2004/2005 winter with 28 individual birds in the study area. This number remained stable the following years except for the 2006/2007 and 2007/2008 winters (Table 1). The maximum group size in every year was greater than 10 individual birds even in winter years with a small population of 17 birds. Usually groups formed at the end of November, which is the start of winter in Beijing, but in the winter of 2003/2004 a group of 4 was seen in late December. The aggregation group dispersed during mid-March and only paired birds were seen at the end of March, but this occurred earlier in the winter of 2003/2004. The average wintering period lasted 121.5 days while the shortest period occurred in 2003/2004 and the longest in 2004/2005 (Table 1).

Foraging and resting sites

Foraging sites could be found along the Juma River, where the main feeding places were at Erdu, Liudu and Qidu. Feeding sites were usually located at shallow water 50 to 100 m away from roads and villages. The Black Stork occasionally searched for food in river mud. The water depth of foraging places was less than 35 cm which, at most, reached to the belly of the stork.

Resting places during foraging bouts were generally shallow water, river banks and high rocks in the water near the feeding sites, whereas the storks flew onto a cliff nearby for longer rests at noon. When night approached storks left the feeding sites and returned to their night roosts. One roosting place was located at Liudu, a cliff platform that storks use annually. A flock was found twice standing in the river after 20:00 hours; one stork was located at the same place the following morning demonstrating that it had spent the night there.

Activity rhythm

Activity and feeding behavior observations lasted 16 whole days and 10 half days for a total of 246 hours.

Activities consisted mainly of feeding and resting. Feeding usually started at dawn and lasted to late morning. Storks then rested at the riverside if not disturbed and continued to forage from 13:00 at the same place to 16:00 when they finished their daily feeding activity. We also found some flocks resting from dawn to noon that started feeding after 12:00. During early winter (November and December) feeding bouts were concentrated in late morning and at noon with a small peak at dusk. However, during mid winter (January and February) the feeding peak was in the afternoon and in late winter (March) it was divided into two peaks, early morning (7:00–9:00) and late afternoon (17:00–19:00) (Table 2).

Table 1 Number of wintering Black Storks at Juma River Nature Reserve in Beijing

Years	Population size	Maximum group size	Date of first seen and group size ≥ 4	Date of last seen and group size ≤ 4	Wintering days
2003/2004	15	13	22 Dec 2003, 4	29 Feb 2004, 4	69
2004/2005	28	16	18 Oct 2004, 8	27 Mar 2005, 3	160
2005/2006	23	13	20 Nov 2005, 7	18 Mar 2006, 4	118
2006/2007	17	10	19 Nov 2006, 5	18 Mar 2007, 2	119
2007/2008	17	12	24 Nov 2007, 8	22 Mar 2008, 1	120
2008/2009	23	12	07 Nov 2008, 8	21 Mar 2009, 2	143

Food types and daily amount of intake

Fish and whorls were the only observed food for wintering Black Stork, where fish was the dominant food. There was no significant variation in food composition at Erdu and Yesanpo (Mann-Whitney U test, $U = 2.00$, $p = 1.00$) and between adult and sub-adult (Mann-Whitney U test, $U = 1.00$, $p = 0.44$) (Table 3).

According to local fish collections and field observations of fish shape, color and size, the fish preyed upon by Black Storks were mainly Crucian Carp (*Carasius carasius*), Top-mouth Minnow (*Pseudorasbora parva*), Mud Fish (*Misgurnus anguillicaudatus*) and Korean Piscivorous Chub (*Opsariichthys bidens*). Fish weight of the three size groups were 2.8 ± 1.1 (SD) g for group A, 4.2 ± 2.9 g for group B, and 22.9 ± 7.0 g for group C, respectively.

Fish Group A (shorter than 5 cm) represented the highest percentage and Group C (longer than 10 cm) was the least (Table 4). This pattern was the same for adult and sub-adult Black Storks (Mann-Whitney U test, $U = 3.00$, $p = 0.51$).

During the 3322 min of recorded feeding periods adult storks caught 1012 fish at a feeding frequency of 18.27 ± 8.18 (SD) fish per hour. The catch frequency for sub-adults was 20.15 ± 6.50 fish per hour during the 2412 min feeding periods. Based on the catch rate of different fish sizes (Table 4) and weights of the three groups, the food intake for adults and sub-adults was 89.74 g and 74.84 g per hour.

Foraging and grouping behavior

After catching a fish the Black Stork had to adjust its swallow position to eat the fish head first. Usually the stork made several attempts before swallowing the fish. When a fish is large, it takes a longer time to adjust and the fish may slip away. On a day following a severe temperature drop, we observed that almost all storks shortened their processing time by throwing the fish into the air and quickly gobbling it with a wide opened gape as the fish fell. When the air temperature rose three days later the storks resumed their normal processing behavior.

Wintering Black Storks usually group together while feeding, but agonistic behavior was found among group members; when larger adults approached sub-adults and other adults the latter would walk away. Furthermore, this threatening behavior by some adults was obvious in late winter.

Discussion

To date studies of the Black Stork in China mainly focused on breeding (Liu et al., 1989; Su et al., 1989; Ma et al., 1993; Li et al., 1994; Bai et al., 1998; Guo et al., 2002), food habits (Liu et al., 1990b), habitat selection (Sun, 2006) and field population surveys (Qiu et al., 2001; Yao et al., 2009). A large flock of wintering Black Storks was found with 93 individual birds which fed at a fishpond after a fish harvest in the Weinan Region of Shaanxi Province in 2002 (Wang and Wang, 2003). Here we have shown a stable wintering population of Black Stork near Beijing during 2004–2009.

The first report of Black Stork wintering at the Shidu Nature Reserve in Beijing was from birdwatchers in January 2003 (http://www.cnbirder.com/reportview.asp). There was a group of 14 storks, but they did not report total population size. We started field surveys in the winter of 2003/2004 and confirmed that there was a stable wintering population of around 20 storks in this region with the exception of the 2006/2007 and 2007/2008 winter seasons when 17 birds were sighted. We did not know the reason for this decrease, but some birdwatchers said the number of other wintering water bird species also dropped for those two years. We propose that this may be related to unpredictable climate changes, especially the severe

Table 2 Feeding time allocation (%) of wintering Black Storks in 2004–2005

Time	November ($n = 4$)	December ($n = 22$)	January ($n = 30$)	February ($n = 9$)	March ($n = 22$)
7:00–9:00	0	4.8	4.8	0	29.4
9:00–11:00	31.4	36.6	7.1	0	13.7
11:00–13:00	68.6	25.9	4.5	0	0
13:00–15:00	0	8.6	41.7	100	0
15:00–17:00	0	24.1	42.0	0	10.2
17:00–19:00	0	0	0	0	46.7

Note: n means the number of observed Black Storks.

Table 3 Food components of adult and sub-adult Black Storks at two locations

Food	Location		Age group	
	Erdu	Yesanpo	Adult	Sub-adult
Fish (%)	98.5 (580)	96.9 (349)	92.4 (500)	97.3 (429)
Whorl (%)	1.5 (13)	3.1 (19)	7.6 (19)	2.7 (13)

Note: The numbers in brackets are the observed feeding time (min).

Table 4 Catch rate of different fish sizes by Black Storks (unit: %)

Age groups	Fish size		
	Group A (< 5 cm)	Group B (5–10 cm)	Group C (> 10 cm)
Adult	62.7 (281)	28.8 (129)	8.5 (38)
Sub-adult	68.1 (218)	29.4 (94)	2.5 (8)

Note: The numbers in brackets are the observed feeding time (min).

snow and frost in southern China during the spring of 2008. Black stork started grouping at the Juma River from mid-November and dispersed from mid-March, which is similar to the migration date of breeding Black Storks at Ningwu County in Shanxi Province (Qiu et al., 2001).

Studies on the impact of climate on changes in bird migration status suggest that increasing temperature is the most significant factor (Crick, 2004; Sutherland, 2004; Møller et al., 2009). Black storks were recorded as a summer breeders in northern China (Liu et al., 1985; Zheng and Wang, 1998) and a wintering population was only observed recently (Wang and Wang, 2003). We thought the changes in the residency of Black Storks may be caused by the impact of a warming climate. According to weather forecasts the low temperatures were –10°C in December 2004 and –11°C in January 2005 which were much higher than earlier recorded low temperatures. The rich fish resource could maintain the energy balance of Black Stork in warmer winters. Wetlands lost in southern winter habitats may also be a reason Black Storks were forced to choose this high latitude winter area. Based on our findings that there was a group of 6–12 members using a single site as their overnight roost every year, the suggestion is that this group already established site fidelity and maintained the Juma River as their wintering habitat. This is similar to the Black Stork in Spain where a group of storks repeatedly maintained winter site fidelity (Cano Alonso, 2006).

The Juma River is the only site with wintering Black Storks in Beijing, although we do not know the origin of this wintering population. According to field surveys of the population size in the breeding season, there were 91 birds in Beijing and 31 at Shidu in 2008 (G. Wu, personal communication), but the winter population was only 23 during the winter of 2008/2009. This wintering group may be from the Siberian region of Russia, similar to wintering storks in Spain which arrived from northern Europe with some local residents (Cano Alonso, 2006). This statement needs further verification through banding studies.

Group living may supply more time for members to forage in the face of predation, allowing young storks to find feeding sites easily by following adults. But when the fish resource was reduced in late winter, adults exhibited agonistic behavior towards sub-adults and smaller conspecies, evidenced by wing flapping and beak jabbing. Sub-adults usually took the fish away from adults to eat. However, whether this agonistic behavior exhibits differences among group members still needs to be confirmed.

Allocation of foraging time was largely affected by air temperature. Feeding activity occurred in the morning or at noon during early winter when the temperature was relatively high. When it became colder in mid winter storks concentrated their feeding activity in the afternoon allowing for more energy for the cold night, in accordance with stork feeding dynamics at Fanshi County, Shanxi Province (Liu et al., 1990a). Feeding bouts, calculated over six hours (Table 2), indicate that an adult stork would consume 538 g of fish, which is similar to the minimum amount of the daily feedings of 500–750 g for pre-breeding storks in zoos (Bai et al., 1998). The intake of sub-adults was 449 g, similar to the lower limit of 400 g for 12-week-old storks (Li et al., 1994). During all winter surveys we did not see any hint of starvation in the form of thin or dead storks in the field, so the food intake was apparently sufficient to satisfy energy needs for survival. If foraging activity was disturbed for several days, the stork could not have adequate foraging time, which would push the stork to the verge of starvation. We observed that when storks were forced to shorten feeding time due to human presence, they would forage in the stream very early the next morning to compensate for feeding shortage experienced the previous day. Feeding bouts separated into morning and near evening during late winter, which resulted from human disturbance as local residents began clearing up the riverside for spring tourism.

There are many mountain springs along the Juma River. The water does not freeze in winter and submerged plants supply good shelter for wintering fish. The rich food provision and the shallow river provided the Black Stork a high quality wintering habitat. This may be the reason that the Black Stork chose the Juma River as their new wintering place in Beijing. The Juma River area is one of the most famous scenic spots in Beijing. With the increasing dam-

ming activity along the river for tourism the water depth is becoming less suitable for Black Stork foraging. Some local residents even netted small fish in winter, which increases the negative impacts on stork feeding activity and fish supply. An urgent conservation plan is needed to protect Black Stork foraging habitats and to maintain a stable wintering population of Black Storks in Beijing.

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北京地区居留黑鹳的越冬生态学

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摘要：由于气温的变化，原来属于夏季繁殖鸟的国家一级保护鸟类黑鹳(*Ciconia nigra*)，在北京市出现了越冬群体。为了解黑鹳的越冬生态特点，从2004年1月到2009年3月，在北京十渡水生动物自然保护区，对其种群数量、生境选择、取食规律和集群行为进行了实地调查。结果显示，黑鹳选择该保护区的拒马河作为其越冬地，种群数量从2004–2005年冬季的28只下降到2007–2008年的17只，但随后恢复到了23只。越冬群体于11月中旬形成，次年3月中旬分散，但群体形成受到温度变化的影响。黑鹳对取食生境具有依赖性，主要食物为鱼类（> 92.4%）。成年和亚成年黑鹳的食物构成没有差异(Mann-Whitney U test，$U = 1.00$，$p = 0.44$)。在越冬初期，取食活动主要发生在早晨和中午，越冬中期则集中于下午，而在越冬后期，分为清晨和傍晚两个取食阶段。按照每日取食6 h计算，成年黑鹳的每日进食量约538 g，亚成年个体约449 g，与人工饲养条件下黑鹳的饲喂量相近。在越冬后期，观察到取食过程中群体内部存在争斗行为。对越冬黑鹳的干扰主要来自旅游活动对取食生境的改变、人为筑坝提高水位、在滩涂开辟新的旅游场地减少了适于黑鹳取食的空间。

关键词：北京，黑鹳，取食行为，越冬生态