Habitat use, preference and utilization distribution of two crane species (Genus: *Grus*) in Huize National Nature Reserve, Yunnan-Guizhou Plateau, China

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Abstract: Understanding habitat use and spatial distribution of wildlife could help conservationists determine high-priority areas and enhance conservation efforts. In this study, we studied habitat use, preference and utilization distribution of two Gruidae species (Black-necked Cranes *Grus nigricollis* and Eurasian Cranes *G. grus*) in Huize National Natural Reserve, Yunnan-Guizhou Plateau, SW China. Line transect method indicated that the anthropogenic habitat of farmland was utilized the most by these two species (>90% of flocks observed for both). But Black-necked Cranes preferred marsh to farmland and grassland while Eurasian Cranes favored grassland in our study. Nearly all the Black-necked Cranes (99.30% of the flocks observed) utilized habitats in the core area of the reserve, covering an area of 283.84 ha close to the common roost. Eurasian Cranes were mostly (55.39% of the flocks observed) distributed in the buffer zone with higher elevation and further distance to the roost, covering an area of 558.73 ha. We believe that our findings could help guide habitat management, functional zoning planning and adjustment in the future. According to our results, we recommended restoration of more wetlands, retain large areas of farmland, and protect the areas that cranes use most frequently.

Keywords: *Grus nigricollis*; *Grus grus*; habitat use; spatial distribution; threatened species; coexistence

Introduction

Understanding ~~the~~ habitat use and spatial distribution of wildlife is important for conservation and management (Morris, 2003; Nina et al., 2008). Conservation planning should be drawn up more carefully for protected area managers when more than one species are taken into consideration. And things are going to be more complicated when the area is surrounded by human beings and anthropogenic habitats (e.g. farmland) are utilized by wildlife (Fujioka et al., 2010; Li et al., 2013), such as wintering crane species.

Black-necked (*Grus nigricollis*, Przevalski, 1876) and Eurasian Cranes (*G. grus*, Linnaeus, 1758) are two large ~~Gruidae~~ waders in the Gruidae family. Black-necked Cranes ~~were~~ are Vulnerable (Vu) species on the IUCN Red List of Threatened Species (BLI, 2016) and Biodiversity Red List of China, while Eurasian Cranes ~~were~~ are recognized as Least Concern (LC) and Near Threatened (NT) species on the Red List of Threatened Species of IUCN and China, respectively.

Both of the species are typical migrators. Eurasian Cranes are vastly distributed across Eurasia. Their breeding range extends from northern and western Europe across Eurasia to northern Mongolia, northern China, and eastern Siberia; and the winter range includes the Mediterranean region of northern Africa, the Persian Gulf, the India Peninsula, as well as southern China to northern Indo-China, Myanmar and Assam (Johnsgard, 1983; Meine and Archibald, 1996). The Black-necked Crane mainly inhabits the alpine wetlands of the Qinghai-Tibet and Yunnan-Guizhou Plateaus of China with a population of 10,000–10,200 individuals (Li and Li, 2005; Li, 2014). Nearly all the Black-necked Crane breeding populations are distributed on the Qinghai-

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Tibet Plateau, China, except for a small number of pairs (maximum 139 birds) in adjacent Ladakh, India (Chandan et al., 2014). The wintering area of Black-necked Cranes includes lower elevations of the Qinghai-Tibet and Yunnan-Guizhou Plateaus of China, Bhutan, with occasional records in Nepal, Myanmar, Vietnam and Kashmir region (Li, 2014; Chandan et al., 2014). These two crane species have a clearly divided breeding range while overlapping on their wintering grounds mainly on the Yunnan-Guizhou Plateau, SW China (Wang and Wang, 2004).

The lake and lakeshore area on the Yunnan-Guizhou Plateau has been regarded as an important wintering place for waterbirds, e.g. geese, ducks, gulls, storks and cranes (Chen, 1998). As a typical mountain area, the majority of lakes on the Yunnan-Guizhou Plateau were formed by faulting (Wang and Dou, 1998) and the lakeside wetland ecosystem are fragile due to ~~its~~ narrow distribution and frequent disturbance by human activities, such as farming, fishery and tourism (Tian et al., 2004; An et al., 2007). The Black-necked Crane and Eurasian Crane are two flagship species of the wetland ecosystem on the Yunnan-Guizhou Plateau. Different from their respective breeding ~~site~~areas, in winter cranes are distributed in ~~the~~ human-dominated areas and mainly forage in anthropogenic habitats (Li, 2014). In order to put forward more rational and effective habitat management measurements and promote sustainable development of the plateau wetland system, we studied the habitat use, preference and utilization distribution (UD, or space use pattern) of two wetland flagship species (Black-necked Cranes & Eurasian Cranes) in the Huize National Nature Reserve (HNNR) on the Yunnan-Guizhou Plateau.

Materials & Methods

Study area

This study was conducted between November 2010 and March 2011 in the HNNR, north-eastern Yunnan Province (Fig. 1). The reserve was first established in 1990 as a county level reserve and upgraded to a national reserve in 2006 to protect wintering waterfowl and their habitats (Qiou, 2012). Black-necked Cranes and Eurasian Cranes ~~were~~ are known as the flagship species of this plateau wetland ecosystem. There ~~were~~ are 64 water bird species wintering at HNNR including about 400 Black-necked Cranes and 350 Eurasian Cranes (Yang and Zhang, 2014). The elevation of HNNR, which is located on the Yunnan-Guizhou Plateau, is 2,470–3,092 m above the sea level (Qiou, 2012).

HNNR has two discrete sites about 30 km apart named the Daqiao and Zhehai. Our study was conducted in the Daqiao site, which covers an area of 9076.28 ha (N26°38'00"–26°44'24", E103°12'06"–103°22'02") (Fig. 1). The Daqiao site contains 470.50 ha of reservoir named Yuejin, 149.36 ha of marsh, 3966.53 ha of farmland, 178.19 ha of grassland, 302.11 ha of residential areas, and 4009.58 ha of woodlands (Qiou, 2012). The Yuejin Reservoir supplies shallow water roosting and foraging habitat for wading birds, as well as marsh, farmland and grassland, which serve as foraging habitats for the cranes, and woodland, which is considered unsuitable habitat

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for cranes (Kong et al., 2011). As a typical anthropogenic habitat, farmlands have more human activities during the harvest (from October to November) and planting season (from February to March). Food grown by farmers, includ~~e~~ing grains and potatoes, ~~is~~ which are the primary forage~~ily~~ consumed by cranes in winter (Dong et al., 2016). During the course of our study, there were about 340 Eurasian and 80 Black-necked Cranes in the Daqiao site, as well as several thousands of other waterfowl, such as Bar-headed Goose *Anser indicu*, Ruddy Shelduck *Tadorna ferruginea*, Grey Heron *Ardea cinerea*, and many other species. Wildlife in HNNR is facing intensive human disturbance due to the 12250 people residing in the study area. The mean annual temperature at Daqiao is 9.6°C, and there are 40 days of snowfall, 50 days with snow on the ground, and 45 days of frozen ice annually (Qiou, 2012).

Field surveys

Wintering cranes are gregarious and share communal roosting sites; they depart~~ed~~ ~~for~~ to ~~foraging~~ forage ~~during~~ in the morning (06:30–08:00) and return~~ed~~ at night (18:00–20:00) typically (Kong et al., 2008). The line transect~~s~~ survey method was used to record bird distributions and habitat use while they fed on clear days (no rain, snow or fog) during 08:00—18:00. In general, three spatially ~~relatively~~ separated areas comprising villages of Yangmeishan-Bajiacun-Lijiawan (YBL), Maanshan (MAS) and Daqiao-Dideka (DD) were included along the line transect (Fig.1). The line transect~~s~~ covered 16.6 km and could be fully inspected in two days. Every day of field studies, we started off from the protecting station located in Yangmeishan village. The end point along the line transect of the previous day was used as the start point of the second day. The continuous two days' survey was considered as a whole survey or one independent sampling and we switched direction of travel in the next whole survey. In consideration of relatively constant activity ~~area for~~ of cranes in concentrated area in a short time (Qian et al 2009); little probability existed for recording a flock repeatedly during one sampling period (two days). Therefore we considered the 12 ~~whole~~ surveys conducted during the study period as 12 independent replicate. Crane flocks ~~could be~~were easily detected along the transect with 10×42 binoculars; nearly 100% of the Black-necked Crane population (mean=78, n=12) and about 80% of the Eurasian Crane population (mean=263, n=12) could be sighted during each whole survey. We defined flocks as being discrete if they were 500m apart. Each flock was considered a sample unit and one GPS point was recorded for every flock due to non-independence of individuals in a flock (Thomas and Taylor 1990). For each crane flock, we recorded detailed information including date, time, habitat type, GPS location, elevation, distance to roost (DTR), flock size and flock composition. DTR was defined as the distance from the location of each flock to the communal roosting site (N26°42′05.6″, E103°16′00.6″) and was calculated in ArcGIS 10.2 software.

We divided the foraging habitat into three categories of farmland, marsh and grassland. Farmland included plowed and unplowed lands used for crops, including *Solanum tuberosum*, *Rassica campestris*, and *Zea mays*. Marsh was near the reservoir where the ground was covered with shallow water (≤50 cm) throughout the winter. The

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most dominant vegetation in the marsh was *Ranunculus japonicus*, *Juncus effuses* and *Poa annua*. Grassland included meadows without water covered during winter, and predominately occupied by *Leontopodium andersonii*, *Prinula malacoides* and *Trifolium repens*. All of these habitats were scattered around the Yuejin Reservoir.

Habitat use and preference

Jones (2001) reviewed that habitat use refers to the way in which an individual or species uses habitats to meet its life history needs, while habitat preference ~~that~~ takes into account habitat availability, resulting in the disproportional use of some resources over others (Krausman, 1999). Both habitat use and preference are consequences of habitat selection, which refers to a hierarchical process of behavioral responses that may result in the disproportionate use of habitats (Block and Brennan, 1993).

Habitat use was calculated by the number of crane flocks occurring in each habitat type as the percentage of all crane flocks observed. Compositional analysis was used to determine habitat preference rank of the birds by considering the relative magnitude between utilization and availability of every two habitat categories. Log-transformed ratio value of habitat was used instead of the absolute value for avoiding the unit-sum constraint of available habitat types (only the farmland, marsh and grassland were regarded as available foraging habitat as mentioned above) (Bingham and Brennan, 2004). The equation of $d_{ij} = \ln(\chi_{Ui} / \chi_{Uj}) - \ln(\chi_{Ai} / \chi_{Aj})$ were used to construct a ranking matrix of habitat preference, where *i* and *j* ~~means~~ are defined as the *i*th and *j*th habitat type and $i \neq j$; χ_U and χ_A are habitat proportion utilized and available, respectively (Aebischer et al., 1993). If $d_{ij} > 0$ habitat *i* is utilized more than expected relative to habitat *j*, otherwise habitat *i* is utilized less than expected.

Utilization distribution

The utilization distribution (UD) provides a useful global representation of space use pattern of animals by defining the relative frequency of occurrence of animals (Benhamou and Riotte-Lambert, 2012). We calculated utilization distributions using the nonparametric kernel method called the "LoCoH" local convex hull method to assess space use by the cranes (Getz and Wilmers, 2004; Getz et al., 2007). This method is more appropriate than a parametric kernel method for constructing UDs and can capture hard boundaries (e.g., rivers and cliff edges) and process a large sample size (Getz et al., 2007). This method is also very powerful in processing aggregated and clustered data (Getz and Wilmers, 2004) on population level (Liu et al., 2010). We constructed kernels with the *r*-LoCoH method (available at http://locoh.cnr.berkeley.edu), using data of flock locations within a fixed radius of 500 m, which was sufficient to distinguish two crane flocks. Shapefiles obtained from this implementation was imported to ArcGIS 10.2 to construct the UD map. We considered the 90%, 70% and 50% UD isopleths of cranes in our study in order to ~~determining~~ determine areas with high conservation priority. We considered the 90% isopleths instead of 100% isopleths as the overall distribution range of the cranes by omitting outlying points representing exploratory animal movement rather than those necessary

for survival. And the 90% UD isopleths could reflect actual spatial distribution pattern of animals faithfully (Luca et al., 2006).

Statistical analysis

We used parametric and non-parametric tests, as appropriate after the *Kolmogorov–Smirnov* test was conducted for each data set. For comparing mean of flock size, elevation and distance to the roost of two crane species, the nonparametric test of Mann-Whitney U was selected as the normality violation of our data. Statistical analysis were completed with IBM SPSS Statistics 19.0 and the difference between two variables was considered statistically significant when the two-sided *p*-values of significant probability < 0.05.

Results

Habitat use and preference

We observed 287 and 399 flocks for Black-necked Cranes (BNC) and Eurasian Cranes (CC), respectively during the 12 whole surveys. In winter, both of the two crane species showed similar habitat use patterns with the most utilized proportion of farmland (BNC: 90.94%; CC: 93.73%). For the other two habitat types, more Black-necked Cranes utilized marsh and more Eurasian Cranes selected grassland (Table 1).

Mann-Whitney U test indicated that Eurasian Cranes usually selected habitat with higher elevations (Z_{686} = -12.046, P = 0.000), further distance to the roost (Z_{686} = -14.164, P = 0.000) and aggregated in bigger flock (Z_{686} = -9.913, P = 0.000) than Black-necked Cranes (Table 2, Fig. 2). Eurasian Cranes utilized habitat at higher elevations than that of Black-necked Cranes at the areas of YBL (Z_{262} = -5.556, P = 0.000) and DD (Z_{262} = -2.141, P = 0.032). Moreover, Eurasian Cranes distributed further away from the roost than those of Black-necked Cranes in the area of YBL (Z_{262} = -4.616, P = 0.000) and MAS (Z_{201} = -2.008, P = 0.045) (Fig. 2).

Compositional analysis indicated that these two species had different habitat preferences. The habitat preference rank of Black-necked Cranes was Marsh > Farmland > Grassland, while Eurasian Cranes preferred Grassland to Farmland and Marsh (Table 3).

Utilization distribution

Nearly all Black-necked Cranes (99.30%) were distributed in the core area close to the roosting sites encompassing YBL and MAS, whereas Eurasian Cranes scattered in the whole region with over half of flocks (55.39%) in the peripheral area of DD (Fig. 1, Table 2). For Eurasian Cranes, the utilization distribution covered a larger area of 558.73 ha (90% isopleths of the UD, or UD_{90}) than that of Black-necked Cranes (UD_{90} = 283.84 ha). UD_{70} of Eurasian Cranes scattered in three discrete areas occupying 380.46 ha, whereas Black-necked Cranes concentrated in the area near the roost covering 165.58 ha. The UD_{50} of Black-necked Cranes was rather small (92.89 ha) at

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YBL area, but the UD_{50} of Eurasian Cranes was situated in YBL and DD with an area of 224.81 ha (Fig. 3).

Discussion

As two large wader species of Gruidae, Black-necked Cranes and Eurasian Cranes were recognized as the flagship species of wetlands on the Yunnan-Guizhou Plateau. Due to their close phylogenetic relationship and similar morphologies, the birds have quite a similar wintering ecology. We found wintering crane species exhibited extremely high dependency on the anthropogenic habitat of farmland in winter, which was understandable, considering that farmland was the predominant available habitat (92.37%) in our study area. Wintering Black-necked Cranes usually forage in cultivated lands and marshes not only at two other wintering sites like Dashanbao National Nature Reserve (Kong et al., 2011) and Yongshan County (Lu and Yang, 2014) on the Yunnan-Guizhou Plateau, but also in the Lhasa river valley Tibet on the Qinghai-Tibet Plateau (Tsamchu and Bishop, 2005), possibly due to plenty of food storage in farmland than other habitats. For example, the residue potato *Solanum tuberosu* and grains like oat *Avena sativa*, buckwheat *Fagopyrum tataricum*, and corn *Zea mays* on the farmland supplied over 80% wintering food for Black-necked Cranes (Li et al 2009; Dong et al 2016). During the whole winter, marsh and farmland rather than grassland were favored by Black-necked Cranes in Huize reserve. Other studies conducted on the Yunnan-Guizhou Plateau also indicated that Black-necked Cranes preferred marsh to other habitats (Li, 1999; Kong et al., 2011). Habitat use is the result~~s~~ of the behavioral response of animals to the local environment (Block and Brennan, 1993; Jones, 2001), while habitat preference reflects the biological characteristics of animals (Hall et al., 1997). In our study area, farmland occupies an extremely high proportion of the available habitat, e.g., about 26 times more than marsh in size. Although Black-necked Cranes prefer marsh, the limited area of marsh cannot support all the birds, which may explain the significant difference between habitat use and preference observed in our study.

The Eurasian Crane are found in farmland both in our study and other studies from Asia to Europe (Avilés et al., 2003; Zhan et al., 2007). Eurasian Cranes mainly prefer grassland in this study, whereas farmland and marsh are favored habitats for Eurasian Cranes in Yeyahu wetland, Beijing (Zhan et al, 2007) and Spain (Avilés et al., 2003), where Black-necked Cranes are absent. Although habitat preference reflects the biological characteristics determined by a series of innate and learned behavioral decisions (Hall et al., 1997), this is not invariable. When wintering with Black-necked Cranes in a sympatric area ~~in our study~~, Eurasian Cranes preferred grassland to farmland and marsh. We inferred that this may be caused by the presence of Black-necked Cranes whose larger body size gives them an advantage in competing for resources (Smith and Brown, 1986), and as a result they exclude the smaller Eurasian Cranes from their favored habitats. Thus, the difference in habitat preference between this study and the others may be partly explained by the inter-species competition.

In consideration of the same habitat use pattern of these two cranes, inter-specific

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competition could be expected. However, coexistence has occurred for similar species when niche divergence is present (Schoener, 1974), although we found that the two crane species seem to avoid inter-species competition by moderately segregating of habitat preference as mentioned above. At the same time, we found significant segregating in spatial distribution between these two species. The two crane species seemed to avoid foraging together during the winter by distributing in different areas. Nearly all of black-necked cranes (99.3%) located in the area of YBL and MAS while over half of Eurasian Cranes (55.39%) distributed in the buffer zone of DD. That is why less than 3% of mixed flocks were recorded in our study. Previous empirical observations also indicated that Black-necked and Eurasian Cranes share roosts, although they forage at different sites (Yang et al., 1992) and often compete for foraging sites when wintering in sympatry (Li and Li, 2005).

Our result showed that Black-necked Cranes concentrated for foraging in the central area near the common roost, while Eurasian Cranes scattered throughout the region on a wider scale. This could explain that larger populations of Eurasian Cranes occupy more expansive areas. We found that Eurasian Cranes usually selected habitats 2.55 km farther away from the roost and 55 m higher along the elevation gradient than the Black-necked Cranes. Earlier studies pointed out that foraging near the roost is a strategy of reducing energy expenditures for the cranes (Alonso et al., 1992; Kong et al., 2011), and undoubtedly only the dominate species could occupy the optimal habitat, e.g. close to the roost or with plenty of food. Although we occasionally detected the larger Black-necked Cranes repelling smaller Eurasian Cranes from their foraging farmland habitat, we do not have strong evidence demonstrating that it is the inter-species competition resulting in spatial separation of these two crane species in our study, in spite of a similar distribution pattern documented by Yang et al. (1992). An observation carried out in the Caohai National Nature Reserve of Guizhou Province on the Yunnan-Guizhou Plateau, reported that Black-necked Cranes mostly forage in places near their roosting site, whereas smaller Eurasian Cranes forage in peripheral areas 10–20 km away on the hill (Yang et al., 1992).

Taking into consideration our and earlier habitat studies, we inferred that cranes use different habitats in different ways (Kong et al., 2011; Dong et al 2016). Marsh could be recognized as the optimal foraging habitat for cranes because of the highest amount of food resources (including underground tubers and insect larvae), the softest ground surface for cranes to dig the food and the difficult access for humans (Li et al. 2009; Kong et al., 2011). Farmland is considered as the suboptimal habitat with the largest amounts of underground tubers and medium amounts of insects, but with higher human disturbance (Li et al., 2009). On the other hand, farmland is utilized the most by cranes (especially for Black-necked Cranes) across the Yunnan-Guizhou Plateau to Qianghai-Tibet Plateau (Tsamchu and Bishop, 2005; Kong et al., 2011; Lu and Yang, 2014), and could be regarded as ~~the~~ vital foraging habitat for wintering cranes. Grassland with scarcest food resources and hardest ground surface represent the worst habitat quality (Li et al., 2009).

Although this case study was carried out in one reserve, our study could also shed light on the mountain area on the Yunnnan-Guizhou Plateau and suggest habitat

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conservation and management lessons for ~~the~~ other protected areas. Our results indicated that effective and sustainable conservation measures, such as maintaining plenty of farmland, restoring wetlands, and prohibiting humans and livestock entering the core area inhabited by cranes, could benefit the wintering crane species. We believe the conservation of flagship crane species could also enhance conservation efforts of other waterbirds in the wetland system.

Conclusions

As two close related species, Black-necked and Eurasian Cranes showed high similarity in habitat use patterns. However, they were inclined to utilize habitats in different areas, and Black-necked Cranes kept to the core area while Eurasian Cranes inhabited larger areas. We argue that spatial separation could mitigate interspecies competition and facilitate coexistence. We recommended protection of ~~the~~ farmlands utilized the most by cranes, and restore more wetlands.

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