Postprint: Spatiotemporal Variation in Flocking Characteristics and Adult-Juvenile Composition of Four Crane Species at Poyang Lake

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Date: 2017-04-11T00:00:00+00:00

Abstract

From October 2014 to April 2015, the flock size, flock type, and adult/juvenile composition of Siberian Cranes (Grus leucogeranus), Hooded Cranes (G. monacha), White-naped Cranes (G. vipio), and Common Cranes (G. grus) were investigated at 45 sample points in Poyang Lake using the point count method. The results showed that the average flock size was (23.86±10.26) individuals (N=104 flocks) for Siberian Cranes, (6.42±1.63) individuals (N=98) for Hooded Cranes, (6.09±2.55) individuals (N=105) for White-naped Cranes, and (5.55±1.26) individuals (N=246) for Common Cranes. Only the Hooded Crane showed a significantly smaller flock size in the mid-period compared to the late period; the differences in flock size among periods for the remaining crane species and among regions for Common Cranes were not significant. The flock sizes of cranes in Poyang Lake did not conform to predictions from vigilance behavior regarding flock size; differences in habitat quality may be one of the main factors influencing the flock sizes of cranes in Poyang Lake. All four crane species exhibited the highest frequency in small flocks of 1-5 individuals. Siberian Cranes had the highest proportion of individuals in flocks >35 individuals, whereas Hooded Cranes, White-naped Cranes, and Common Cranes had relatively high proportions of individuals in both 1-5 individual flocks and >35 individual flocks. Siberian Cranes, Hooded Cranes, White-naped Cranes, and Common Cranes all primarily formed family groups, with proportions of (64.29%, total flocks N=98), (71.91%, N=89), (70.77%, N=65), and (63.11%, N=206), respectively. The predominance of family groups among cranes in Poyang Lake suggests that ensuring adequate food supply may be more important than spending more time foraging. Siberian Crane family groups were dominated by 2 adults and 1 juvenile (65.08%), whereas Hooded Cranes (51.56%), White-naped Cranes (52.17%), and Common Cranes (47.69%) were dominated by 2 adults. The juvenile proportions in flocks of Siberian Cranes, Hooded Cranes, White-naped Cranes, and Common Cranes

were 12.27% (N=1695 individuals), 14.42% (N=416), 16.59% (N=229), and 20.46% (N=655), respectively. The extremely low proportion of 2 adults and 2 juveniles flocks indicates that the difficulty for Siberian Crane families to successfully raise two juveniles simultaneously is greater than that for the other three crane species. There were no significant differences in juvenile proportions among periods for the four crane species. Among the three regions with larger numbers of Common Crane individuals, the juvenile proportions at Duchang Migratory Bird Provincial Nature Reserve (25.25%) and East Poyang Lake National Wetland Park (25.14%) were significantly and highly significantly higher, respectively, than that at Poyang Lake National Nature Reserve (14.24%). The juvenile proportion of Siberian Cranes in Poyang Lake has remained at a low level for many years; the juvenile proportion of Hooded Cranes has decreased significantly compared to the winter of 2012–2013; the Common Crane and White-naped Crane populations may be in a stable or increasing state.

Full Text

Temporal and Spatial Variations in Group Characteristics and Adult-Juvenile Composition of Four Crane Species in Poyang Lake, China

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Abstract

Poyang Lake is the largest freshwater lake in China, providing critical wintering habitat for numerous waterbirds, including four endangered crane species each year. While feeding and resting are the primary behaviors exhibited by wintering waterbirds, comprehensive data on the wintering ecology of these crane species remain limited. From October 2014 to April 2015, we investigated group sizes and adult-juvenile compositions of Siberian cranes (*Grus leucogeranus*), hooded cranes (*G. monacha*), white-naped cranes (*G. vipio*), and common cranes (*G. grus*) at 45 survey sites in Poyang Lake using point count methods.

The results showed that mean group sizes were (23.86 ± 10.26) for Siberian cranes (n = 104), (6.42 ± 1.63) for hooded cranes (n = 98), (6.09 ± 2.55) for white-naped cranes (n = 105), and (5.55 ± 1.26) for common cranes (n = 246). Crane group sizes in Poyang Lake did not conform to predictions based on vigilance behavior alone; however, habitat quality may explain this discrepancy. Hooded crane group sizes during mid-winter were significantly smaller than during late winter, whereas other crane species showed no significant differences

across the three wintering stages. Common crane group sizes also showed no significant regional differences.

All four crane species most frequently appeared in groups of 1–5 individuals. Most Siberian crane individuals occurred in groups of 35 or more, whereas other cranes were found in groups of 1–5 or more than 35 individuals. Siberian cranes (64.29%, total group number N = 98), hooded cranes (71.91%, N = 89), white-naped cranes (70.77%, N = 65), and common cranes (63.11%, N = 206) appeared mainly in family groups, suggesting that ensuring adequate food supply was more important than increasing foraging time. The highest percentage of Siberian crane family group types was two adults with one offspring (65.08%), while two adults predominated in hooded crane (51.56%), white-naped crane (52.17%), and common crane (47.69%) populations. The lower percentage of family types with two adults and two offspring indicated that Siberian crane families found it more difficult than families of the other three cranes to raise two offspring simultaneously.

The percentage of juvenile Siberian cranes was 12.27% (individual number N = 1695), 14.42% (N = 416) for hooded cranes, 16.59% (N = 229) for white-naped cranes, and 20.46% (N = 655) for common cranes. There was no significant difference in juvenile percentages across the three wintering stages for any crane species. Duchang Provincial Migratory Birds Nature Reserve and East Poyang Lake National Wetland Park contained significantly and extremely significantly more common cranes (25.25% and 25.14%, respectively) than Poyang Lake National Nature Reserve (14.24%). The percentage of juvenile Siberian cranes remained low in Poyang Lake, whereas that of hooded cranes significantly decreased between 2014 and 2015 from the corresponding percentage of the population in 2012–13. The populations of common cranes and white-naped cranes remained stable or increased, suggesting that Poyang Lake is able to maintain and develop healthy populations of these cranes.

Keywords: group; adult-juvenile ratio; Siberian crane; hooded crane; white-naped crane; common crane

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Introduction

Group formation represents an animal' s response to environmental conditions that facilitates predator detection and escape, thereby enhancing individual fitness. However, excessively large groups can attract predator attention, increase competition among individuals, and elevate disease transmission risk, consequently reducing individual fitness [1-2]. Animals in specific environments exhibit an optimal group size, which varies both across species in the same region and within species across different habitats [1,3-5]. Different group types provide individuals with varying benefits, leading to diverse grouping strategies [5]. Studies of group characteristics help elucidate avian survival status and adaptive strategies.

The proportion of newly added individuals to the total population, commonly termed the juvenile ratio, reflects annual population growth and serves as an indicator of habitat quality. Since juvenile individuals are difficult to observe during the breeding season, this information is typically collected during winter or autumn [6-7]. Understanding adult-juvenile composition enables preliminary prediction of population trends and reflects habitat quality, providing a foundation for sustainable population management and appropriate conservation strategies [6,8].

Four crane species winter sympatrically in Poyang Lake, with the Siberian crane population representing over 95% of the global population [3-5,9-10]. Siberian and hooded cranes are Class I nationally protected species in China, classified as Critically Endangered (CR) and Vulnerable (VU), respectively. White-naped and common cranes are Class II nationally protected species, with white-naped cranes also listed as Vulnerable (VU) [3-5]. Previous research on these species in Poyang Lake has focused on population distribution [3-5,11], behavioral time budgets [12-13], foraging ecology [12,14-16], and habitat utilization [11,17]. Preliminary statistics on family groups and adult-juvenile composition exist for Siberian, hooded, and common cranes [3-5,9], revealing that family groups predominate, with hooded cranes showing the highest juvenile ratios. Both Siberian and hooded cranes exhibit increasing juvenile ratios during late winter stages. However, these studies were limited by small sample sizes and few survey points, preventing comprehensive characterization of temporal and spatial variation in grouping patterns and age composition across Poyang Lake. White-naped crane family groups and juvenile ratios remain particularly understudied. This study aims to investigate the spatiotemporal dynamics of group characteristics and adult-juvenile composition for these four crane species to predict population trends.

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1. Study Area

Poyang Lake, China' s largest freshwater lake, is located in northern Jiangxi Province at the junction of the middle and lower Yangtze River (28°24 -29°46 N, 115°49 -116°46 E). The Gan, Fu, Rao, and Xiu Rivers flow into the lake from the south before draining into the Yangtze [4,18]. The region experiences a mid-subtropical monsoon climate with mean annual temperatures of 16.5-17.8°C, prevailing northerly winds in winter and southwesterly or easterly winds in summer, mean annual precipitation of 1450–1550 mm, and 1885 hours of annual sunshine [19-20]. Winter water levels recede to expose extensive mudflats, creating important waterbird wintering habitat that supports approximately 400,000 migratory birds annually, including over 95% of the world' s Oriental storks (*Ciconia boyciana*) [10].

We selected 45 lake survey sites across Poyang Lake, covering: Poyang Lake National Nature Reserve (PYH-NNR) including Dahuchi and Shahu lakes; Nanji

Wetland National Nature Reserve (NJ-NNR) including Changhu and Nanshen lakes; Duchang Provincial Migratory Birds Nature Reserve (DC-NNR); East Poyang Lake National Wetland Park (PYH-WP) including 11 sites such as Chemen in Poyang County; and Poyang Lake Silver Fish Spawning Ground Provincial Nature Reserve (YY-NNR) including Dalianzihu and Rongqicun areas.

2. Methods

2.1 Data Collection This study aimed to investigate group size, group types, and adult-juvenile composition of four crane species wintering in Poyang Lake. Survey efforts totaled 1–3 days per region, conducted primarily during daytime hours (9:30–15:30). We used SWAROVSKI spotting scopes (20–60×) to record crane group sizes and identify adult and juvenile numbers. Each region' s lake sites were surveyed sequentially during each survey period.

A group was defined as individuals showing coordinated activity with relatively independent movement and consistent pacing among members, with >30 m separation from other groups [11,21]. Juveniles were distinguished from adults by tawny feathers on the head, neck, or back [11]. Cranes began arriving in mid-October, gradually increasing to peak numbers in early January, then declining from late March with most departing by early April [10]. Based on these migration dynamics, we divided the wintering period into early (October–November), middle (December–January), and late (February–March) stages.

Survey frequency varied by region: PYH-NNR (3 surveys), NJ-NNR (2 surveys), YY-NNR (3 surveys), PYH-WP (2 surveys), and DC-NNR (1–2 surveys per protected area). Each survey lasted 1–2 days.

2.2 Data Processing We compiled group size and juvenile ratio data, classifying crane groups into three types based on individual numbers and composition: family groups (parents with offspring), collective groups (>5 individuals), and solitary individuals [4]. We first tested data normality using Kolmogorov-Smirnov tests. For normally distributed data, we applied one-way ANOVA; for non-normal data, we used independent samples t-tests. Chi-square tests assessed differences in family group composition and juvenile ratios. Data are presented as mean ± SE. Significance level was set at $= 0.05$. All statistical analyses were conducted using Excel 2007 and SPSS 21.0.

Since Siberian cranes, hooded cranes, and white-naped cranes were primarily distributed in Poyang Lake National Nature Reserve, we only tested regional differences in group characteristics and juvenile ratios for common cranes.

3. Results

3.1 Group Size Mean group sizes were (23.86 ± 10.26) for Siberian cranes (range 1–270, n = 104), (6.42 ± 1.63) for hooded cranes (range 1–123, n = 98), (6.09 ± 2.55) for white-naped cranes (range 1–300, n = 105), and (5.55 ± 1.26) for common cranes (range 1–30, n = 246). No significant differences existed across wintering stages for Siberian, white-naped, or common cranes. Hooded crane group sizes were significantly smaller in mid-winter than late winter (t = -2.209, P = 0.034). Common cranes showed no significant regional or temporal differences in group size (F = 3.426, P = 0.09).

Table 1 shows group sizes of Siberian, hooded, and white-naped cranes across wintering stages. **Table 2** presents spatial and temporal variation in common crane group sizes.

3.2 Family vs. Collective Group Sizes Mean family group sizes were similar across all four crane species (2.5–2.7 individuals) with no significant differences. For collective groups, Siberian cranes had larger mean group sizes (84.56 ± 37.64) compared to hooded cranes (21.35 ± 7.18), white-naped cranes (26.86 ± 18.72), and common cranes (14.97 ± 5.17), though differences were not statistically significant.

3.3 Frequency Distribution and Individual Proportions White-naped cranes and common cranes showed highest frequency in small groups of 1–5 individuals, representing 75.96% and 81.63% of total groups, respectively. These small groups contained 88.57% and 84.96% of total individuals. Hooded cranes and white-naped cranes also showed high individual proportions in groups of 1–5 (44.10%, 32.38%) and >35 individuals (42.72%, 42.25%). **Figure 2 [Figure 2: see original paper]** illustrates the frequency distribution of group sizes and individual proportions.

3.4 Group Types All four crane species predominantly formed family groups (60–70% of groups), with collective groups comprising 20–30% and solitary individuals 4–8%. Siberian crane family group proportions were 64.29% (N = 98), hooded cranes 71.91% (N = 89), white-naped cranes 70.77% (N = 65), and common cranes 63.11% (N = 206). Siberian and hooded cranes showed significant temporal variation in group type allocation (^{2} = 22.753, P < 0.001; ^{2} = 8.533, P = 0.003). Siberian crane family group proportions declined significantly from early to late winter, while collective groups increased correspondingly. Hooded crane family groups increased significantly from mid to late winter.

Figure 3 [Figure 3: see original paper] shows group type distributions across wintering stages.

3.5 Family Group Composition Siberian crane families predominantly consisted of two adults with one offspring (65.08%), while hooded cranes (51.56%),

white-naped cranes (52.17%), and common cranes (47.69%) were dominated by two-adult groups. No Siberian crane groups with two adults and two offspring were recorded, indicating greater difficulty raising two chicks simultaneously compared to other species. All crane species showed some solitary individuals (4–8% of groups), primarily adults appearing during mid-winter.

Figure 4 [Figure 4: see original paper] displays family group composition patterns.

3.6 Adult-Juvenile Composition We observed 1695 Siberian cranes with identifiable age classes, yielding a juvenile ratio of 12.27% with no significant temporal variation. Hooded cranes (N = 416) had 14.42% juveniles, while white-naped cranes (N = 229) had 16.59% juveniles, both showing stable proportions across wintering stages. Common cranes (N = 655) had 20.46% juveniles overall, with significantly higher proportions in Duchang Provincial Nature Reserve (25.25%) and East Poyang Lake National Wetland Park (25.14%) compared to Poyang Lake National Nature Reserve (14.24%) (^{2} = 9.012, P = 0.011; ^{2} = 6.495, P = 0.003).

Table 4 and **Table 5** detail adult-juvenile ratios across species and regions.

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4. Discussion

4.1 Group Size Definitions of crane groups vary considerably across literature, with inter-group distances ranging from 30 m to 200 m [23-25]. We selected 30 m as our threshold because distances exceeding this result in poor activity coordination among individuals [21]. Cranes exhibit strong mobility and unstable wintering groups, making consistent classification challenging [26]. Compared to 2012-13 surveys, our expanded survey range identified several large Siberian crane aggregations at new sites (e.g., Dalianzihu, Dahuichi North Gate), increasing mean collective group size from (21.75 ± 13.53) to (84.56 ± 37.64). Hooded crane mean family group size decreased from 3.09 to 2.56 individuals, corresponding to reduced juvenile ratios (29.22% vs. 14.42%).

Except for hooded cranes showing significant late-winter group size increases, other species exhibited stable grouping strategies across wintering stages, similar to patterns observed in Yellow River wetlands [11]. Hooded and common cranes frequently formed small groups but were observed in large aggregations before migration, likely preparing for collective departure [28].

Group size is influenced by multiple factors including habitat type and quality [11,29-31]. Poor foraging environments can reduce group sizes [30]. All groups >30 individuals were found in Poyang Lake National Nature Reserve, the primary concentration area for crane populations, indicating high-quality foraging and roosting habitat. Resource abundance reduces niche competition [17], allowing cranes to form larger wintering groups. We also documented two

mixed-species aggregations: one containing hooded cranes and another with white-naped cranes.

Small groups of 1–5 individuals represented the most frequent and proportionally important group size for most species, likely representing optimal group sizes. When group size exceeds this threshold, individual vigilance no longer decreases while adult vigilance duration increases [26]. Groups of 20–30 individuals showed low frequency (<2%) across all species, suggesting that vigilance behavior alone cannot accurately predict group size variation.

4.2 Group Types Cranes obtain different benefits from different group types. Collective groups allow individuals to spend less time vigilant and more time foraging, while family groups, though energetically costly in territory defense, ensure adequate food supply [5]. All four species predominantly formed family groups (60–70%), with collective groups comprising 20–30% and solitary individuals 4–8%.

Siberian crane family group proportions (64.29%) were higher than in Yellow River wetlands (55.54%), with correspondingly lower collective groups (25.77% vs. 41.07%) [11]. Hooded and white-naped crane patterns were similar to previous surveys [3-5]. Hooded crane family group proportions exceeded those at Chongming Island (71.91% vs. 29.14%), suggesting that for Poyang Lake cranes, ensuring adequate food supply may be more important than maximizing foraging time [5,32-33].

The absence of Siberian crane groups with two adults and two offspring indicates greater difficulty raising two chicks simultaneously compared to other species, consistent with breeding studies showing Siberian cranes often produce two eggs but typically raise zero or one chick [34]. All species showed some solitary individuals (4–8%), primarily adults during mid-winter. Except for four solitary juvenile common cranes, all solitary individuals were adults, consistent with observations that solitary cranes are typically older or physically compromised individuals that have left family groups [35]. The low proportion of solitary individuals suggests Poyang Lake' s crane population maintains youth and vitality.

4.3 Adult-Juvenile Composition Adult-juvenile composition provides insight into future population dynamics. As a relatively less endangered species, common cranes in China show juvenile ratios of 8.57–27.2% (mean 16.86%), indicating stable or increasing populations [11,36]. Central European common crane populations show similar patterns (16.81% juveniles) [36].

Among the four species, Siberian cranes maintained low juvenile ratios (12.27%), similar to 2012-13 surveys (12.48%), suggesting a declining population trend [3-5]. Hooded crane juvenile ratios (14.42%) were lower than in 2012-13 (29.22%), warranting continued monitoring. White-naped (16.59%) and common cranes (20.46%) showed relatively high juvenile ratios, suggesting stable or potentially increasing populations. The significantly higher juvenile ratios of common

cranes in Duchang Reserve and East Poyang Lake Park compared to the National Nature Reserve may reflect regional habitat quality differences.

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Note: Figure translations are in progress. See original paper for figures.