

Short communication

Changes in Tundra Swan *Cygnus columbianus bewickii* distribution and abundance in the Yangtze River floodplain

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Approximately 75% of the East Asian Flyway Tundra Swan *Cygnus columbianus bewickii* population winters in the Yangtze River floodplain, China. Historically the species was more widely distributed throughout the floodplain but now most of the population is confined to five wetlands in Anhui Province and to Poyang Lake in Jiangxi Province, where the majority (up to 113,000 birds) occur. Within-winter counts suggest that swans congregate at Poyang Lake before dispersing to other sites later in the winter. Counts show large between-year fluctuations, but suggest declines at Shengjin and Fengsha Lakes (both in Anhui) during the last five years. Declines at Shengjin Lake are likely due to decreases in submerged vegetation (particularly tuber-producing *Vallisneria*, a major food item) perhaps linked to eutrophication. Range contractions throughout the floodplain may also be linked to reductions in submerged vegetation coverage elsewhere. Changes in water quality and lake hydrology post-Three Gorges Dam may have adversely affected submerged vegetation productivity. Key information needs for the effective implementation of conservation measures for Tundra Swans include: (1) annual surveys of all major wintering sites throughout each winter to establish the importance of different sites during the non-breeding period; (2) more information on swan diets at important sites; and (3) an assessment of adverse effects of water quality and lake water levels post-Three Gorges Dam on submerged vegetation productivity at Poyang Lake and other important sites.

Introduction

Little is known about the East Asian Flyway Tundra Swan *Cygnus columbianus bewickii* population compared to the North-west European wintering population (Rees 2006). China remains the core wintering area, particularly the Yangtze River floodplain (Barter *et al.* 2004, 2006, Rees 2006, Cao *et al.* 2010), which supported c.81,000 swans (c.75% of the flyway population) during complete surveys in 2004 and 2005, (Cao *et al.* 2008a), most at Poyang Lake in Jiangxi Province, but with important numbers in Anhui Province. It was formerly numerous in Korea, where fewer than 100 birds now occur annually (Moores 2005); c.30,000 winter in Japan (Albertsen and Kanazawa 2002).

Recent counts of the most important wetlands for East Asian Tundra Swans have enabled an assessment of changes in their distribution and abundance in China since 2004/2005, at a time when the North-west European population is declining (Worden *et al.* 2006, Rees and Beekman 2010). We report Tundra Swan numbers at key Yangtze River floodplain wintering sites during 2003/2004–2009/10 inclusive. Here they feed on highly nutritious *Vallisneria* tubers accumulated

in the mud during the summer growing season (Barzen *et al.* 2009, Zhang *et al.* 2010). Evidence suggests *Vallisneria* is declining at some key Tundra Swan sites (Fox *et al.* 2011).

Methods

Study area

The Yangtze River floodplain wetlands are subject to summer monsoonal flooding followed by autumn/winter water level recession (Shankman and Liang 2003), creating c.10,500 km² of numerous shallow, ephemeral, highly productive wetlands (He and Zhang 2001) that support abundant wintering waterbirds (Barter *et al.* 2004, 2006).

Poyang Lake and the Anhui Lakes (Figure S1 in the online Supplementary Material), are internationally important for tuber-feeding birds such as Tundra Swan, Swan Goose *Anser cygnoides*, Hooded Crane *Grus monacha*, Siberian Crane *G. leucogeranus* and White-naped Crane *G. vipio* (Cao 2010).

Poyang Lake (3,300 km²), the largest freshwater lake in China (Wang *et al.* 1993), includes Poyang Lake National Nature Reserve (NNR; 224 km²) and Nanjishan NNR (330 km²). The Anhui Lakes include Shengjin Lake NNR (76 km²) and the Anhui Anqing Yangtze Riverine Wetland Provincial Nature Reserve (ANR), the latter including seven important water bodies: Fengsha (22 km²), Baidang (57 km²), Caizi (167 km²), Wuchang (87 km²), Bo (175 km²), Huang (118 km²) and Dagan Lakes (148 km²).

Data sources

The Yangtze River floodplain was surveyed for waterbirds in February 2004 and February 2005 (Barter *et al.* 2004, 2006), counting all waterbirds present at each site (Cao *et al.* 2008a). Shengjin Lake was also counted approximately fortnightly from October 2009 to April 2010 and all the main Anhui Lakes counted twice in winter 2009/2010 (13–20 December 2009; 5–10 February 2010), using the same techniques.

More or less simultaneous counts were available for Dongting Lake, Poyang Lake, Shengjin Lake and Shanghai in winters 2005/06–2008/09 (unpublished nature reserve monitoring data). ANR counts were made opportunistically at different periods within and between winters, complicating interpretation of the data but contributing to our knowledge of which sites were important for Tundra Swans.

Results and Discussion

Tundra Swan abundance and distribution in the Yangtze River floodplain

Tundra Swans were abundant in the Yangtze River estuary in the late 19th Century (Styan 1891), and there and at Poyang Lake in the early 20th Century (La Touche 1934). Pre-1996, the Tundra Swan wintered from the Yangtze River floodplain north to Henan and east to inland Jiangsu, and coastal Shanghai and Zhejiang (Cao *et al.* 2008b). In February 2004 and 2005, 90% of all Tundra Swans counted in the Yangtze River floodplain were in Jiangxi and Anhui (Table 1; Figure S1 in the online Supplementary Material) with fewer than 3,000 individuals in Hubei and Hunan provinces, and very few in Jiangsu province and Shanghai (Barter *et al.* 2004, 2006). Hence, since the mid-1990s, the Chinese winter range has contracted markedly to the middle Yangtze River floodplain.

Numbers and distribution of Tundra Swans in Jiangxi province

Most swans in eastern China were counted in Jiangxi (Table 1), the majority at Poyang Lake (90% of the provincial total in 2003/2004, 99% in 2004/2005) where several discrete concentrations

Table 1. Total Tundra Swan numbers counted in the provinces of the Yangtze River floodplain, 2003/2004–2009/10.

Winter	Anhui	Jiangxi	Hunan	Hubei	Jiangsu	Shanghai	Total
2003/2004	13,919	14,446	44	2,516	0	0	30,925
2004/2005	21,568	42,843	408	295	0	0	65,114
2005/2006	10,000 ¹	112,514 ⁶	248 ¹¹	-	-	4 ¹⁸	122,766
2006/2007	4,529 ²	82,364 ⁷	386 ¹²	48 ¹⁶	-	-	87,327
2007/2008	46,057 ³	55,394 ⁸	929 ¹³	76 ¹⁷	-	8 ¹⁹	102,464
2008/2009	18,024 ⁴	49,376 ⁹	823 ¹⁴	-	-	0 ²⁰	68,223
2009/2010	34,247 ⁵	43,326 ¹⁰	545 ¹⁵	-	-	-	78,118

Notes: 2003/2004, 2004/2005 and 2009/2010 counts conducted in early February; italics identify incomplete counts, (numbers were probably higher); - indicates no data available. 1–4: unpubl. data from the Anhui lakes (1 = mid-March; 2 = December–January; 3 = January–February; 4 = December–March); 5: February count (unpubl. data L. Cao); 6–9: data from GEF Siberian Crane Project (6–8 = late December–early January; 9 = 13 February 2009); 10: unpubl. data from “Impact of Poyang Lake Dam on wetlands and waterbirds” project (count on 27 Feb. 2010); 11–15: unpubl. data from Dongting Lake (February counts); 16–17: Hu *et al.* 2008; 18–20: unpubl. data from Chongming Dongtan National Bird Nature Reserve, most important site in Shanghai (February counts).

exceeded 5% of the Eastern Tundra Swan population (estimated at 92,000 birds; Wetlands International 2006), although distributions varied between years (Figure S2 in the online Supplementary Material). In winter 2005/06, the Jiangxi counts exceeded the current eastern Tundra Swan population estimate but more recently the province has held 43,000–82,000 birds (Table 1).

Tundra Swan abundance in the Anhui Lakes

Anhui Lakes supported 33–45% of the total floodplain Tundra Swans counted in February 2004 and 2005 (Table 1); Shengjin, Baidang, Fengsha, Wuchang and Dagan Lakes (Table 2) held internationally important numbers.

Table 2. Tundra Swan numbers counted at the key Anhui Lakes, 2003/2004–2009/10.

Winter	Shengjin Lake	Baidang Lake	Fengsha Lake	Wuchang Lake	Dagan Lake	Caizi Lake
2003/2004	4,333	4,400	987	3,980	83	8
Date	28-1-2004	9-2-2004	9-2-2004	6-2-2004	3-2-2004	31-1-2004
2004/2005	5,429	8,760	2,056	2,447	2,405	438
Date	19-2-2005	16-2-2005	16-2-2005	17-2-2005	23-2-2005	21-2-2005
2005/2006	-	10,000	-	-	-	-
Date	-	11-3-2006	-	-	-	-
2006/2007	-	33	1,800	350	-	2,164
Date	-	8-1-2007	25-12-2006	27-12-2006	-	6-1-2007
2007/2008	1,007	21	15,000	29	-	30,000
Date	25-2-2008	18-2-2008	18-2-2008	9-1-2008	-	14-2-2008
2008/2009	1,778	-	11,000	4,286	-	960
Date	2-2-2009	-	14-3-2009	25-12-2008	-	7-1-2009
2009/2010a	660	0	0	2,249	-	767
Date	19-12-2009	13-12-2009	13-12-2009	17-12-2009	-	15-12-2009
2009/2010b	2,443	28,450	468	2,521	-	365
Date	16-2-2010	10-2-2010	10-2-2010	5-2-2010	-	8-2-2010

Note: italics identify incomplete counts.

Although swan numbers at the Anhui Lakes have remained high, their distribution has changed. Shengjin Lake supported c.5% of the eastern Tundra Swan population in winters 2003/2004 and 2004/2005, but numbers there have declined since winter 2007/2008 (Table 2), although they are still of international importance (mean peak count of 1,743 from 2007/08 to 2009/10 inclusive). Numbers at Wuchang Lake have changed little since winter 2007/2008, whilst the smallest lakes (Baidang and Fengsha Lakes) have erratically supported much larger numbers of swans than in the 2003/2004 and 2004/2005 winters (Table 2). Caizi Lake, which normally holds < 1,000 swans, supported > 30,000 in 2007/2008.

Potential causes for changes in Tundra Swan numbers and distribution in the Yangtze River floodplain

Poyang and Anhui Lakes are now the major Chinese strongholds of Tundra Swans, with widely fluctuating numbers showing no trend since 2003/2004 (Cao 2010). Swan numbers declined at Shengjin Lake, where other tuber-feeding species (e.g. Swan Goose and Hooded Crane; Cheng *et al.* 2009, Zhang *et al.* 2010) have also decreased, but where numbers of ducks and other goose species have increased. These changes are thought to reflect the disappearance of *Vallisneria* since the early 2000s, perhaps the result of eutrophication (Fox *et al.* 2011).

Tundra Swans recently aggregated at two small Anhui lakes: Baidang (57km²) and Fengsha Lakes (22km²). Baidang is the only lake now retaining extensive *Vallisneria* stands in Anhui, perhaps explaining its importance. According to local fishermen, formerly abundant *Vallisneria* has recently largely disappeared at Fengsha Lake, potentially explaining the collapse of swans and other tuber-feeding waterbirds in winter 2009/2010. Plans to exchange water in the next 1–2 years between Baidang or Caizi Lake and Chao Lake, a 755 km² highly polluted wetland (Anon. 2008), to improve the water quality supplied to Hefei city and adjacent agricultural land in the vicinity, is likely to impact seriously on both lakes.

It is suggested that elevated nitrogen and phosphate levels in lake water have contributed to the collapse of *Vallisneria* at Shengjin Lake, affecting the tuber-feeding guild of wintering waterbirds there, including Tundra Swans (Fox *et al.* 2011). It is therefore vital to understand the relationships between water level management, water quality and fishery management that affect the distribution and abundance of submerged plants in these lakes, in order to recommend ways to maintain the very high productivity of these ephemeral lake systems and the ecosystem services they supply to the human population, as well as ensuring they continue to support internationally significant numbers of swans in this increasingly important part of their wintering range.

Supplementary Materials

The supplementary materials for this article can be found online at journals.cambridge.org/bci

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References

- Albertsen, J. O. and Kanazawa, Y. (2002) Numbers and ecology of swans wintering in Japan. *Waterbirds* 25 (Special Publication): 74–85.
- Anon. 2008. North Water Diversion Project Proposal. <http://www.zongyang.net/zybbs/simple/?t35389.html>
- Barter, M., Chen, L., Cao, L. and Lei, G. (2004) *Waterbird survey of the middle and lower Yangtze River floodplain in late January and early February 2004*. Beijing, China: China Forestry Publishing House.
- Barter, M., Lei, G. and Cao, L. (2006) *Waterbird survey of the middle and lower Yangtze River floodplain (February 2005)*. Beijing, China: China Forestry Publishing House.
- Barzen, J., Engels, M., Burnham, J., Harris, J. and Wu, G. F. (2009) *Potential impacts of a water control structure on the abundance and distribution of wintering waterbirds at Poyang Lake*. Unpublished report submitted to Hydro-Ecology Institute of the Yangtze Water Resources Commission. Baraboo, Wisconsin: International Crane Foundation.
- Cao, L. (2010) Impact of Three Gorges Dam on waterbirds in the Yangtze floodplain. Unpublished report submitted to WWF China. Hefei, China: University of Science and Technology of China.
- Cao, L., Barter, M. and Lei, G. (2008a) New Anatidae population estimates for eastern China: implications for flyway population sizes. *Biol. Conserv.* 141: 2301–2309.
- Cao, L., Wang, X., Wang, Q. S. and Barter, M. (2008b) Wintering Anatidae in China – a preliminary analysis. *Casarca* 11: 161–180.
- Cao, L., Zhang, Y., Barter, M. and Lei, G. (2010) Anatidae in eastern China during the non-breeding season: geographical distributions and protection status. *Biol. Conserv.* 143: 650–659.
- Cheng, Y. Q., Cao, L., Barter, M. and Xu, W. B. (2009) *Wintering waterbirds at the Anhui Shengjin Hu National Nature Reserve, China*. Hefei, China: University of Science and Technology of China Press. (In Chinese and English).
- Fox, A. D., Cao, L., Zhang, Y., Barter, M., Zhao, M. J., Meng, F. J. and Wang, S. L. (2011) Declines in the tuber-feeding waterbird guild at Shengjin Lake National Nature Reserve, China – a barometer of submerged macrophyte collapse. *Aquatic Conservation*. 21: 82–91.
- He, Y. and Zhang, M. X. (2001) Study on wetland loss and its reasons in China. *Chi. Geogr. Sci.* 11: 241–245.
- La Touche, J. D. (1934) *Handbook of the birds of eastern China Vol.2*. London, UK: Taylor and Francis.
- Moore, N. (2005) *Key species: South Korea's most urgent priorities for conservation*. Birds Korea. Accessible at: http://www.birdskorea.org/Birds/Key_Species/BK-KS-Key-Korean-Species.shtml (last accessed 16 February 2010).
- Rees, E. (2006) *The Bewick's Swan*. London, UK: T. & A.D. Poyser.
- Rees, E. C. and Beekman, J. H. (2010) North-west European Bewick's Swans: a population in decline. *British Birds* 103: 640–650.
- Shankman, D. and Liang, Q. (2003) Landscape changes and increasing flood frequency in China's Poyang Lake region. *The Professional Geographer* 55: 434–445.
- Styan, F. W. (1891) On the birds of the lower Yangtze basin – Part II. *Ibis* 6: 481–510.
- Wang, J. B., Wang, B. H., Song, X. J., Melville, D. S. and Mackinnon, J. (1993) *Management plan for Jiangxi Poyang Lake National Nature Reserve*. Beijing, China: China Forestry Publishing House.
- Wetlands International (2006) *Waterbird population estimates*. Fourth edition. Wageningen, The Netherlands: Wetlands International.
- Worden, J., Cranswick, P. A., Crowe, O., McElwaine, G. and Rees, E. C. (2006) Numbers and distribution of Bewick's Swan *Cygnus columbianus bewickii* wintering in Britain and Ireland: results of international censuses, January 1995, 2000 and 2005. *Wildfowl* 56: 3–22.
- Zhang, Y., Cao, L., Barter, M., Fox, A. D., Zhao, M. J., Meng, F. J., Jiang, Y. and Zhu,

W. Z. (2010) Changing distribution and abundance of Swan Geese in the Yangtze

River floodplain: the likely loss of a very important site. *Bird Conserv. Int.* 21: 36–48.

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