The functional use of East Dongting Lake, China, by wintering geese

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Abstract

A survey and study of geese wintering at the East Dongting Lake National Nature Reserve, China, in February 2008 revealed internationally important numbers of Lesser White-fronted Geese *Anser erythropus*, Greater White-fronted Geese *Anser albifrons* and Bean Geese *Anser fabilis* using the site, as well as small numbers of Greylag Geese *Anser anser*. Only five Swan Geese *Anser cygnoides* were recorded, compared with several hundreds in the 1990s. Globally important numbers of Lesser White-fronted Geese spend the majority of daylight hours feeding on short grassland and sedge meadows within the core reserve areas of the National Nature Reserve, and also roost there at night. Greater White-fronted Geese were not studied in detail, but showed similar behaviour. Large numbers of Bean Geese of both *serrirostris* and *middendorffi* races showed differing feeding strategies. The small numbers of *serrirostris* tended to roost and feed in or near the reserve on short grassland, as did small proportions of *middendorffi*. However, the majority of *middendorffi* slept within the confines of the reserve by day and flew out at dusk, to nocturnal feeding areas at least 40 km north on the far side of the Yangtze River, returning 40–80 min after first light. In order to safeguard these goose populations, it is essential to optimise the foraging opportunities for geese within the reserve and to understand the feeding habitats exploited by the geese in adjacent and remote areas such as those used by the *middendorffi* birds north of the Yangtze.

Key words: Activity budgets, Bean Goose, East Dongting Lake, Greater White-fronted Goose, Greylag Goose, Lesser White-fronted Goose, Ramsar site management, Swan Goose.

Current knowledge suggests severe declines amongst several goose populations in the East Asian Flyway (Syroechkovskiy 2006; Wetlands International 2006). More precise information on their abundance and distribution is lacking due to the challenges of counting large numbers of wintering sites simultaneously and to the shortage of skilled observer networks, especially in China, although the situation there is improving. China is a key country because of its importance for several wintering goose species; it supports 98% of the global population of Swan Geese *Anser cygnoides,* 100% of the flyway population of the globally threatened Lesser White-fronted Geese *Anser erythropus* (classified as vulnerable; International Union for Conservation of Nature 2001), as well as 80% of the Taiga Bean Goose *Anser fabalis middendorffi* and 25% of Greater White-fronted Goose *Anser albifrons* populations in this flyway (Cao *et al*. 2008).

Despite the difficulty in obtaining accurate counts and thus in quantifying longer-term trends, it is important to understand the causes of declines observed at specific goose wintering resorts in order to implement management actions where these are feasible. China has established a network of National Nature Reserves, several of which are designated because of their importance as wetland ecosystems and to protect wintering waterfowl, including geese (BirdLife International 2004). Many of these reserves remain subject to intensive and often unsustainable human use in the form of agriculture, forestry, fisheries, sand and gravel extraction, and other exploitation such as the commercial harvesting of reedbeds (*Phragmites* sp.). However, before it is possible to consider appropriate conservation management actions in nature reserves to maintain and potentially increase their capacity to support geese at present abundance levels, it is essential to understand how birds utilise different wetland habitats within a wetland complex. Furthermore, it is important to understand for which purposes these habitats are used throughout the diurnal cycle. For example, the presence of geese feeding in the vicinity may enable other birds to sleep and use open waters as a day-time roost in relative safety, because the feeding birds are also vigilant for predators.

In this account, we describe the results of a census of five different goose species using a discrete area of the East Dongting Lake National Nature Reserve, designated by the Chinese Government as a wetland of international importance under the Ramsar Convention in 1992. Since large numbers of geese occur at the site, diurnal activity patterns were studied in further detail for the two most numerous goose species to assess whether their use of the food supply and resting areas on the reserve is competitive or cooperative. By comparing the ways in which the geese utilise habitats within and outwith this major Chinese wetland complex, we aim to describe key features of the site and surrounding area that are critical for the continued presence of each population.

Study Area

The East Dongting Lake National Nature Reserve and Ramsar Site (29.32°N, 112.98°E) in Hunan Province, China, is an extremely large (190,000 ha) area of shallow freshwater

lakes, marshes and seasonally inundated sedge meadows, which receives water from the upper and middle reaches of the Yangtze River (Taylor *et al.* 2005). It forms part of the more extensive Dongting Lake wetlands, an area of 500,000 ha, which is listed as an important bird area (IBA) because of its importance for threatened species (including Swan Goose and Lesser White-fronted Goose) and for waterbirds occurring there in large numbers (including Bean Goose and Greater White-fronted Goose) (BirdLife International 2004, Fig. 1). The IBA also includes West Dongting Lake and South Dongting Lake, designated by the Chinese Government as Ramsar Sites in 2002. Water levels in the lake system rise and fall with those in the Yangtze River to the north, fluctuating 16–18 m each year (Research Institute for Yangtze Water Resources Protection 1999), although in recent years this has reduced to 10–12 m (Y. Jiang pers. comm.). The climate is subtropical monsoon, with an annual rainfall of 1.2–1.33 m per annum and mean temperature of 17°C, with frequent sub-zero temperatures in winter (Taylor *et al.* 2005).

The large annual variation in water levels has resulted in vegetation dominated by relatively few species, with common submergents (*Vallisneria spiralis*, *Hydrilla verticillata, Ceratophyllum demeraum* and *Potamogeton malainus*), floating (*Trapa* sp., *Nelumbo mucifera, Euryale ferox* and *Lemna minor*), and emergent aquatic vegetation (*Typha orientalis, T. angustifolia* and *Miscanthus sacchariflorus*) being prevalent at the site (Research Institute for Yangtze Water Resources Protection 1999). In areas of low sedimentation rates away from the main water channels, extensive flats have been deposited, the higher and less frequently inundated of which support extensive meadows dominated by a robust sedge *Carex* sp. In the lower reaches, there are extensive areas of bare mud flats which are progressively exposed in the course of the winter by water level recession and these become colonised by short ephemeral grasses. The reclaimed wetlands that lie outside the dyke surrounding the lake are intensively cultivated with extensive areas of rice, winter wheat and vegetables, and some areas of planted woodland.

The wetlands and surrounding areas are state owned and were designated as a National Nature Reserve in December 1984. Fishing, reed harvesting and grazing (mostly goats and water buffalo) occur throughout the wetlands, but hunting is illegal and strictly controlled.

Methods

Census

Three teams of observers, on foot with binoculars and 20–60x telescopes, attempted to count all the geese present in a geographically defined area within the northwest core area of East Dongting Lake on 16 February 2008. The survey covered Cai Sang Lake (a small lagoon behind the Nature Reserve Management Building but not part of the reserve), and the area visible from the road that runs on top of the dyke confining the major part of the reserve, including Daxi Lake, Xiaoxi Lake and the adjacent areas of sedge beds (Fig. 1). These are also the areas where goose activity budgets were recorded (see page 7).

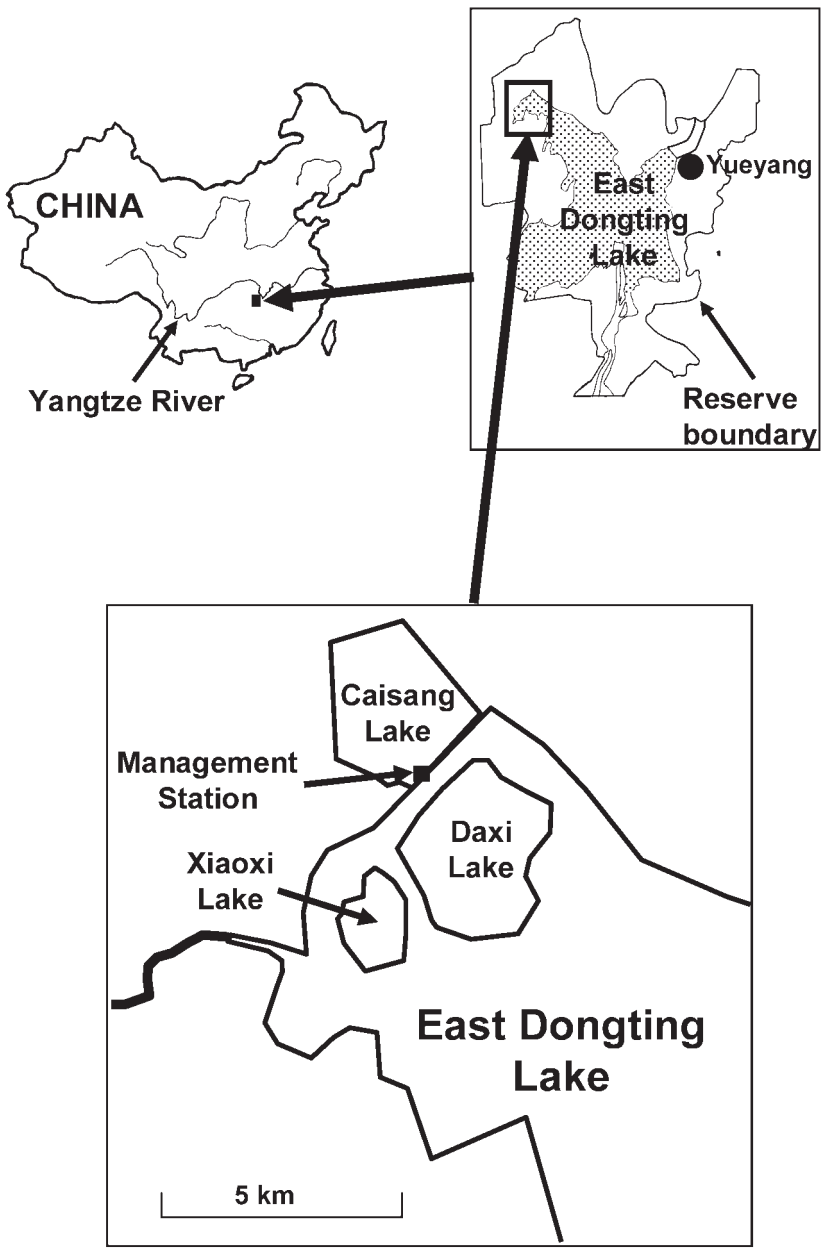

Figure 1. The study area within the East Dongting Lake Nature Reserve, China.

Activity budgets

Behavioural observations were made of the two most numerous goose species at the site, namely the Lesser White-fronted Goose and the Taiga Bean Goose, from 12–19 February 2008. All birds in a flock were scanned using a telescope, and the behaviour of each individual on first being encountered in the field of view was recorded (Altmann 1974). The behaviour categories were as follows: walk, feed, stand, preen (including wing flap and other plumage care), alert (standing with the body and bill held slightly above the horizontal), drink, loaf (on water), swim, fly, sit, sleep (both sitting and standing) and agonistic interactions (both given and received). Scans were undertaken every 15 min from dawn until dusk, although occasionally one scan was dropped within each hour when birds were disturbed or the flock was too large to complete a scan within 15 min. For Lesser White-fronted Geese, we compiled such data from four different areas and for Taiga Bean Goose from two different sites. The data gathered were amalgamated and summarised as hourly means; 95% confidence intervals were calculated from all scans made within each hour for each species, rather than from the hourly mean values.

Flights to and from feeding areas

The arrival and departure patterns for geese moving into and out of the reserve was determined by counting the number of birds in flight, from various vantage points at least 2 km apart along the main bank to the north and south of the Management Station. The dawn watches were carried out from two locations on 15 February and from three locations on 18 February, from before first light (*c.* 06:00 h) until 08:30 h. Evening flight was observed at or near the Management Station on the evenings of 13, 14 and 17 February, from 16:30 h until after darkness (usually after 18:30 h). Because of the dispersed nature of these flights, the objective was to gather data on the timing and direction of these flights, rather than to determine the total number of birds involved. For this reason, the data are presented as the cumulative percentage of arrivals or departures per minute.

Results

Lesser White-fronted Goose

A total of 18,949 birds was counted at East Dongting Lake during the census, confirming that the site continues to be of international importance for the population and the species (Table 1). Although the geese were frequently seen departing the reserve in small parties of 2–56 individuals, the vast majority of up to 11,169 counted in the northwest core area of the reserve remained there throughout the day. This species was seen grazing on short swards in sedge meadows, as well as on the very sparse and even shorter grass swards typical of newly exposed mudflats caused by receding water levels.

Behavioural observations found that Lesser White-fronted Geese spent most of the day feeding intensively at the site, with more comfort activities occurring during the middle part of the day. The latter included

Table 1. Counts of geese at the East Dongting Lake Nature Reserve. Sources are: [a]Waterbird Specialist Group of the Chinese Ornithological Association 1994; [b]Xu 1998 (Nov 18); [c]Xu 1998 (March 5); [d]Lei 1999; [e]Markkola *et al.* 2000; [f]Lei Gang pers. comm. [g]China Ornithological Society 2004; [h]Barter *et al.* 2004; [i]Barter *et al.* 2006; [j]China Ornithological Society 2006; [k]this paper.

Blanks indicate no data. Shaded values indicates counts >1% of the biogeographical populations for the year concerned, population size being based on Wetlands International's Waterbird Population Estimates (Wetlands International 2006).

	1989/90 (Jan[a])	1990/91 (Jan[a])	1991/92 (Jan[a])	1996/97 (Nov[b])	1996/97 (Mar[c])	1998/99 (Dec[d])	1998/99 (Feb[e])
Swan Goose	250	4,800	288			1,000	1,002
Bean Goose		3,875	5,693			6,000	3,942
Greater White-fronted Goose		700	34			50,000	5,443
Lesser White-fronted Goose	1200?	675	46	2,161	20,000	9,860	11,800
Greylag Goose	1,600	6,300	288			17	157

	2002/03 (Jan[f])	2003/04 (Dec[g])	2003/04 (Jan[h])	2004/05 (Feb[i])	2005/06 (Dec[j])	2007/08 (Feb[k])
Swan Goose	4	234	51	48		5
Bean Goose	17,840	5,977	25,821	25,166	5,000	6,853
Greater White-fronted Goose	4,417	260	12,575	9,495		4,645
Lesser White-fronted Goose	16,550	11,771	16,923	8,636	2,000	18,949
Greylag Goose	80	231	213	195		97

conspicuous flights to drink 2.5–3 h after coming off the roost and a similar time before returning to the roost, as well as much drinking, loafing, sleeping and plumage care during the middle part of the day (Fig. 2).

A few pedestrians were seen on the sedge beds and mudflats that provide the main feeding area for the geese, mostly farmers checking livestock (water buffalo) but also people using the area for recreation, including a wildlife photographer. Additionally, there was considerable pedestrian and vehicular activity along the road on the dyke surrounding the lake, and frequent noise from firecrackers celebrating the Chinese New Year. The effect of human activity on goose behaviour was not monitored in the present study, but it was noted that although the birds were generally tolerant of visits by the farmers, they would fly to water if humans approached to within 200m of where they were feeding.

Greater White-fronted Goose

This species was seen in small numbers (<50 birds) on most days but, on the one day when 4,600 were observed on the reserve (Table 1), they all associated with smaller numbers of Lesser White-fronted Geese. Substantial within- and between-winter variation in numbers has also been recorded in previous years; counts have ranged from just 34 birds in January 1992 (Chinese Ornithological Society Waterbird Specialist Group 1994) to 50,000 birds in December 1998 (Lei 1999), and during the 2003/04 winter, 260 were counted in December but 12,575 in January (Table 1).

Although not subject to flock scans, the Greater White-fronted Geese followed the Lesser White-fronts' behaviour of intensive feeding especially in the early morning and late afternoon, and returning to the water to drink and bathe with increased frequency during the middle part of the day.

Whether present in small or large numbers, Greater White-fronted Geese fed on sedge meadows with the Lesser White-fronted Geese. The large numbers seen during the census fed in an area of much higher vegetation biomass within the same sedge beds than those exploited by Lesser White-fronted Geese. The small number of Lesser White-fronted Geese seen associating with the Greater White-fronted Geese on that day were conspicuously at the edge of the flock.

Tundra Bean Goose

This species was only occasionally encountered, and always in groups of less than 39 individuals. Small flocks were found grazing by day on very short (< 5 cm) grass swards at Cai Sang Lake, on slightly longer (< 10 cm) grass swards south of Xiaoxi Lake, amongst areas of burnt reed in both areas and in emergent Lotus *Nelumbo mucifera* stands where these occurred on the reserve. These birds resorted to nearby open water to roost at night and, although not subject to activity scans, most likely remained on the reserve.

Taiga Bean Goose

A total of 5,593 were found in the core area of the reserve in 6,853 counted during the census (Table 1). Although *c.* 500 geese fed on nearby farmland, the majority (*c.* 90%) roosted on the exposed bare mudflats of the Cai Sang, Daxi and Xiaoxi Lakes during the

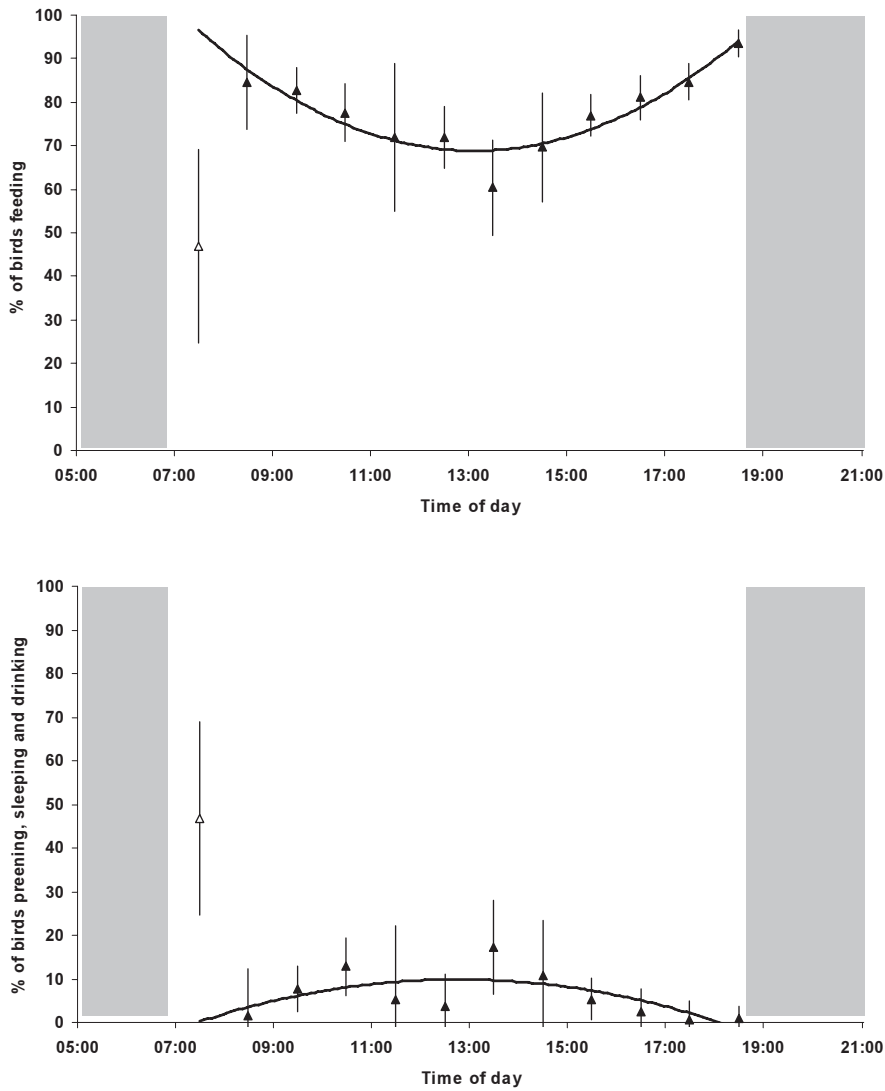

Figure 2. Daily activity patterns of Lesser White-fronted Geese within the East Dongting Lake Nature Reserve, showing the mean (± 95% confidence intervals) hourly percentage of scan samples with birds feeding (upper) and drinking and comfort behaviours (loaf, swim, drink and preen combined; lower). Open symbols represent the period of movements from the roost in the morning, delayed by frost on one of the sampled mornings. Shaded areas indicate period of darkness at the time of the study. Second order polynomial least squared regression models are shown simply to illustrate general patterns in behaviours.

day, where they spent most of the daylight hours asleep after a preliminary period of plumage care (Fig. 3). These birds departed every evening, gaining height and flying to the north, with more than 70% of all departures occurring between 17:30 and 18:30 h. They returned every morning after first light, 80% of the arrivals being between 07:25 and 08:00 h (Fig. 4).

Unfortunately, we were unable to find the precise feeding areas of these birds, although we followed them north as far as 29.74°N 112.80°E on the evening of 13 February, when it was clear they were crossing two ranges of hills and continuing over the Yangtze River to feeding areas beyond. On 15 February, we travelled to the north side of the Yangtze at 29.89°N 112.77°E and watched *c.* 50 birds in 4 flocks continue northwards, witnessing two groups, one of ten individuals dropping into lakes at 29.85°N 112.78°E, *c.* 43 km N of the daytime roosting site. These lakes were clearly heavily subject to fishing activity by day, but we were unable to confirm whether the geese were feeding on the lake, or merely drank there before continuing out to feed on abundant rice paddy fields and associated grasslands in the vicinity.

Small groups of 20–30 Taiga Bean Geese were seen feeding in different parts of the reserve and adjacent farmland during the day, in the burnt reed beds of Cai Sang Lake, on spilt rice and emerging grasses in harvested paddy fields northwest of Xiaoxi Lake, on small fields of winter wheat, oilseed rape and cultivated vegetables, also to northwest of Xiaoxi Lake, and upending in emergent Lotus stands across the reserve. Some were also seen standing and digging with their bills in wetland habitats such as the vegetated areas of Cai Sang Lake, apparently seeking food in the substrate.

Greylag Goose

This species was encountered in very small numbers (up to 41 birds counted) and was therefore the least common of the geese regularly seen at the site. They were seen most days, however, usually at the western end of Xiaoxi Lake quite close to the dyke.

Swan Goose

Alarmingly, only five Swan Geese were seen during the duration of the study, loafing briefly on Cai Sang Lake. This compares with much higher counts recorded in earlier years, including 4,800 in 1990 (Chinese Ornithological Society Waterbird Specialist Group 1994) and 1,000 in 1999 (Lei 1999; Markkola *et al.* 2000), though only 51 were present during 2004 and 48 in 2005 (Table 1). The species seems to have undergone a very dramatic decline at this site.

Discussion

This study confirmed the outstanding significance of East Dongting Lake for its internationally important concentrations of three Eastern Palearctic flyway goose species (see Miyabayashi & Mundkur 1999). The sustained importance for the species concerned (with the exception of the Greylag Goose which has fallen below threshold levels in recent years) underlines the importance of the site and the efficacy of current reserve management at least in the short term to sustain these wintering

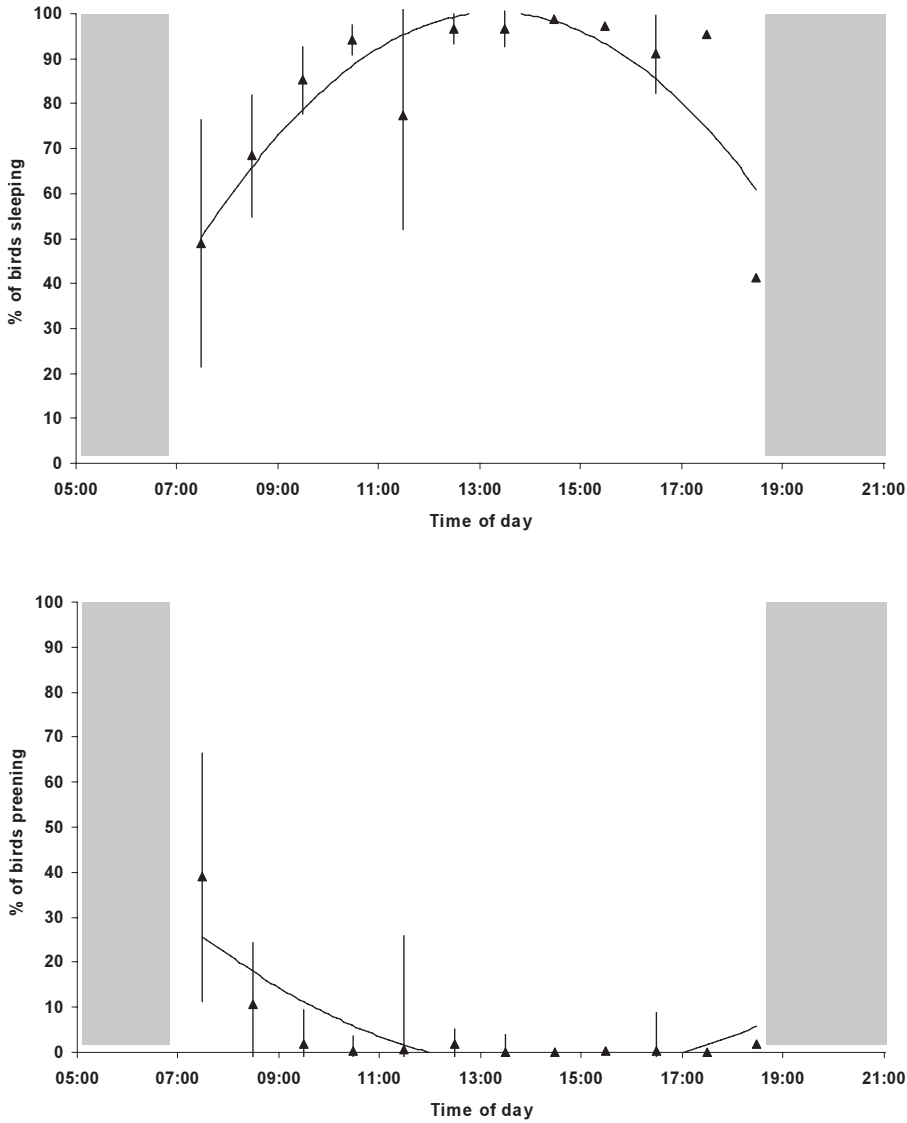

Figure 3. Daily activity patterns of Taiga Bean Geese within the East Dongting Lake Nature Reserve, showing the mean (± 95% confidence intervals) hourly percentage of scan samples with birds sleeping (upper) and preening (lower). Shaded areas indicate period of darkness at the time of the study. Second order polynomial least squared regression models are shown simply to illustrate general patterns in behaviours.

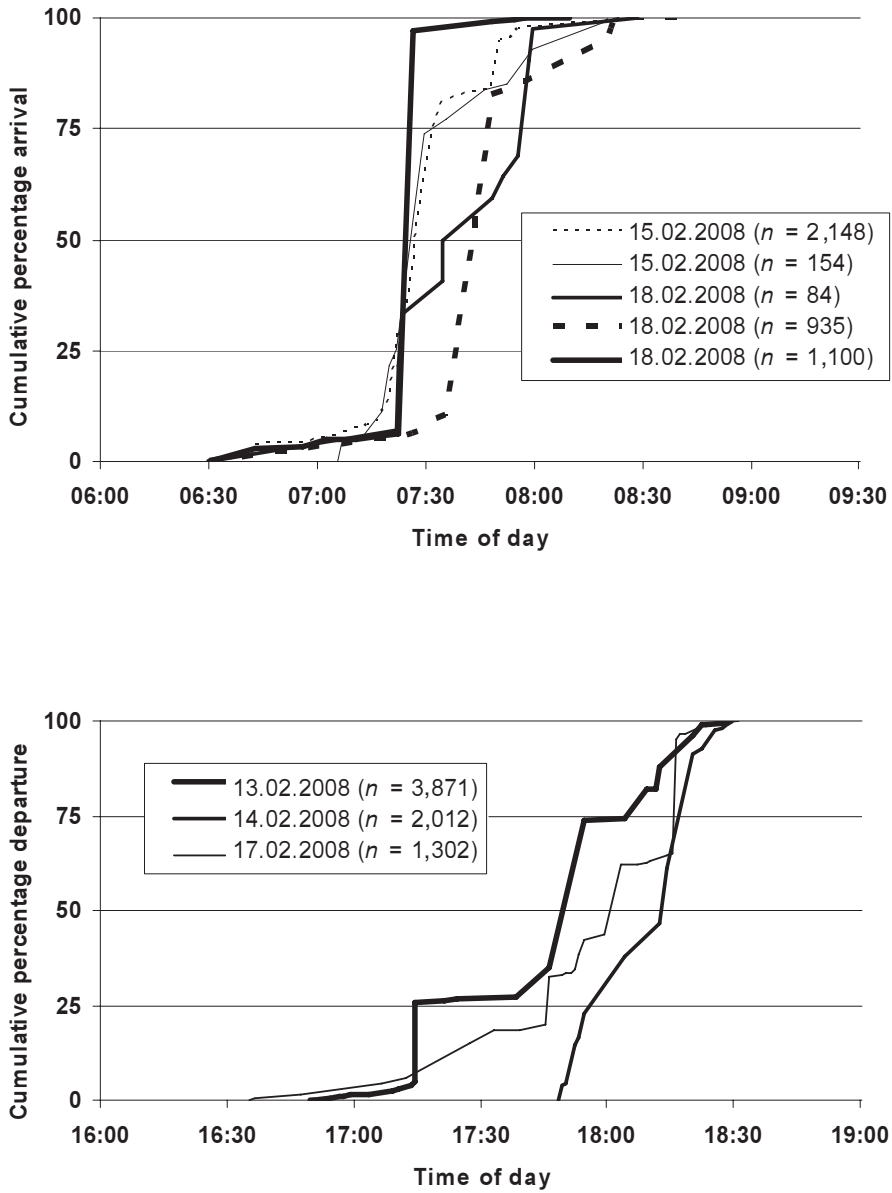

Figure 4. Cumulative daily morning arrival of Taiga Bean Geese to East Dongting Lake (upper), showing data from different observation points and dates. The lower graph shows the same data for evening departures. *n* = total number of geese counted in each case.

waterbird concentrations. However, the variation in goose numbers counted at the reserve (see Table 1) underlines the need for continued consistent surveillance at the site, using standardised counts and monitoring of the hydrological conditions that affect feeding conditions and therefore affect the distribution and abundance of the key species. The studies also reinforce the vital role of East Dongting Lake for its wintering Lesser White-fronted Geese. With a global population 28,000–33,000 birds, of which 20,000 follow the eastern flyway (Wetlands International 2006), the count of 18,949 geese (*c.* 60% of the global population and *c.* 95% of the East Asian population) shows that this site remains the single most important wintering resort for the species in the world.

At the time of the visit, the vast majority (>95%) of all birds fed, drank and roosted overnight within the confines of the northwest core area of the reserve and the adjacent Cai Sang Lake (currently not protected). Whilst the concentration of 95% of geese in the eastern flyway at a single site makes them vulnerable to extinction, that the birds frequent a protected area in winter gives some cause for optimism for safeguarding the population. There has in the past been problems with illegal poisoning (using the pesticide Funandan and the narcotic Alphachloralose) and hunting at the site (Lei 2000; Markkola *et al.* 2000), but improved control has hopefully reduced such practices. There remain considerable human activities in the area, not least from the daily visits of the cattle herders that take their water buffalo out onto the marshes to graze each morning, returning at night. Despite flushing at close approach (< 200 m), the Lesser White-fronted Geese generally seemed tolerant of these activities, perhaps because they have habituated to this regular predictable intrusion to some degree. Generally, they do not permit close approach by humans, with the result that an individual hunter or fisherman (or in one case a wildlife photographer) can have a highly disruptive effect on a flock of birds that spends a high proportion of its day feeding. Although only a few pedestrians were seen on the sedge beds and mudflats that provide the main food source for the geese during our visit, quantifying the frequency and impact of human access to the feeding and roosting areas at the site, and assessing the extent to which such disturbances impinge on the birds' foraging efficiency and energy budgets throughout the winter, remains a high priority for the species.

The other key issue dictating the ability of the reserve to support the present densities of Lesser White-fronted Geese relates to the suitability of the vegetation. East Dongting Lake is a seasonally inundated wetland subject to massive annual water level fluctuations which inhibit colonisation of mudflats by dense vegetation. Indeed it is the vast contributions of nutrients and sediments that result from these annual inundations that make the site so biologically productive and the huge quantities of water involved that make the wetlands difficult to claim for conventional agriculture. However, the instability that results from changes in water level has hereto followed a predictable pattern of water level recession which has

undoubtedly provided predictable habitats for exploitation by the geese. This is now being compromised by further water table drawdown to enhance fishing catches, although members of staff at the National Nature Reserve have attained the right to manage and maintain water levels within the major core areas and this will protect the most important feeding areas against such change. The effects of the Three Gorges Dam upstream will maintain higher water levels in the Yangtze later in the winter and lower levels in the summer than was formerly the case. This means there will be potentially lower flood levels but higher dry season water levels which are likely to have adverse consequences for the extent and availability of recessional grassland and mudflats in suitable condition for the Lesser White-fronted Geese.

There is a more general need, given the reserve's outstanding importance for the population, to understand the feeding ecology of the species, and to determine how best to maximise the extent and quality of the habitat available for the geese. In material to be presented elsewhere, we found evidence that scything and removal of sedge (for feeding to farmed fish) in areas away from those used by buffalo enhanced goose usage. Lesser White-fronted Geese avoided sections of sedge beds with high biomass, and in this respect it seems very likely that the geese benefit from the less selective grazing by cattle to maintain a suitably short and open sward. In this respect, it may be that these two sustainable aspects of human exploitation at the site may actually benefit the geese in maintaining suitable habitat, which would otherwise develop into longer ranker swards quite unsuitable for the Lesser White-fronted Geese; however, we need to understand the dynamics of these systems to be able to attain the optimal management options for maintaining goose abundance.

Unfortunately, we were unable to study the behaviour of the Greater White-fronted Geese at the site. The large numbers encountered during the census were associated with sedge beds of much higher biomass than those exploited by Lesser White-fronted Geese, even though the smaller goose species associated with the larger birds on the periphery of the flock where the sward length was conspicuously shorter. It seems likely that these two species do avoid direct feeding interactions to some extent by their exploitation of differing sward lengths (as also suggested by Markkola *et al.* 2000), which in turn may be due to differences in bill size. However, given that both consume *Carex* biomass from the extensive sedge beds, management of the sward may achieve improved foraging for one species at cost to the other. This complex interaction offers a fertile line of research that, hopefully, may provide recommendations on how best to manage sedge beds for geese in general. Certainly the complications presented by such interactions strengthens the need for management planning at the site, to agree and prioritise actions for the more critical species over those of lesser conservation status should conflict arise.

Previous accounts suggested that the Bean Geese of East Dongting belong to the tundra form *serrirostris* (e.g. Markkola *et al.* 2000), yet we were confident that the

majority of the Bean Geese encountered in February 2008 were of the taiga form *middendorffi*. As well as the difference in bill length, depth and shape, the tundra form was markedly darker and more uniformly coloured on the body, neck and head, making diagnosis at distance relatively easy. Identification was reinforced by observations made (over two weeks immediately following the study at East Dongting) of many *serrirostris* at two lakes further east in Anhui Province, where all individuals closely inspected in *c.* 27,500 Bean Geese counted were of the tundra form. On this basis, we found the tundra form relatively uncommon and encountered typically in small groups, mostly grazing short turf grassland and generally within the reserve. It remains a priority to establish the relative abundance of the two types of Bean Geese, their distribution and habitat use throughout the Yangtze floodplain before we can make an adequate assessment of their true abundance, status and conservation needs.

The vast majority (*c.* 90%) of the more numerous *middendorffi* Bean Geese used the reserve only as a daytime roost and flew out long distances to forage well away from the immediate vicinity of the reserve. Quite why they should do this was obscure, especially because this flight entailed a >80 km round trip every 24 hours. Taiga Bean Geese *A. fabalis fabalis* in Sweden never flew more than 10 km from the roost to feed in winter, and, in spring, the distance was less than 3.2 km (Nilsson & Persson 1984). Pink-footed Geese *Anser brachyrhynchus* and Greylag Geese wintering in Scotland flew median distances of 3.6–12.7 km between feeding areas and nighttime roosts, most less than 10 km and never more than 22 km (Newton & Campbell 1973; Bell 1988; Patterson *et al.* 1989). Similarly in England, Brent Geese (< 5 km), Pink-footed Geese (< 8 km) and Greater White-fronted Geese (< 8 km) commuted much shorter distances between daytime feeding areas and night-time resting places (Vickery *et al.* 1997). This rather suggests that, for the Bean Geese at East Dongting Lake, there is a rich food resource to which they can only gain access at night, which rather implies that human activity (probably associated with intense patterns of daylight land-use activity) could be responsible for this unusual reversal of feeding/sleeping during the diurnal cycle.

Wintering geese in the Northern Hemisphere feed habitually by night to supplement daytime feeding (McNeil *et al.* 1992), especially during the shortest days, and most often under the influence of the strongest moonlight, for instance Barnacle Geese *Branta leucopsis* in the Netherlands and Scotland (Ebbinge *et al.* 1975) and Greenland White-fronted Geese *Anser albifrons flavirostris* in Scotland and Ireland (McKay 1992; Alyn Walsh pers. comm.). This was not the case for the roosting Taiga Bean Geese at East Dongting Lake, where the geese made no attempt to feed during the daylight hours. This is one of the few instances to our knowledge of geese sleeping throughout the day and then flying long distances at dusk to feed away from the roost throughout the night. Such behaviour is well known amongst many duck species, most spectacularly amongst Baikal Teal *Anas formosa*, which resort to reservoirs by day (Allport *et al.*

1991), feeding on dry harvested rice paddies by night in Korea. The nature of their feeding resource, the profitability of the available food and the causes of night feeding should be a priority for future research.

That said, some Taiga Bean Geese (<750 birds) remained in the immediate vicinity of the lake, although the majority of these flew off the reserve to adjacent fields, where they were found to be feeding on winter wheat, gleaning rice from harvested paddy fields, but most frequently grazing the established and emerging grasses in the rice paddies, rape fields and between cultivated vegetables on arable land. Some were also seen feeding, apparently in amalgamated family groups of 20–30 birds, on short turf in fields to the south of Xiaoxi Lake; yet others fed in wetland habitats, where they were seen digging in the substrate for food, perhaps including the fruits of water chestnut *Trapa* sp. which were abundant there and can constitute an important part of the diet (Wantanabe *et al.* 2003). The within-species variation in habitat use, involving contrasting transit costs, warrants future investigation, not least because the majority of the *middendorffi* wintering at East Dongting Lake appear to be reliant on food resources well outside the jurisdiction of the reserve staff and management programme.

Overall, the great diversity of feeding strategies shown by geese wintering at East Dongting Lake, demonstrates that, although the birds have similar food requirements, they are able to use the site in different way. Although this paper provides an initial overview of the situation at the site, longer-term and more systematic study is required to determine sustainable management practices for the reserve.

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