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Wintering Behavior of Tundra Swan, *Cygnus columbianus*, at a Small Water-level Controlled Lake in the Middle and Lower Yangtze River Floodplain

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ABSTRACT

The Tundra swan, *Cygnus columbianus,* wintering in the lakes of Yangtze River floodplain are facing wetland degeneration and habitat loss. Daily activity rhythm, time budget and foraging pattern of wintering swans are the important presentation of behavioral strategy in response to habitat variations. We studied the behavior of Tundra Swan wintering in the wetland of Huangpi Lake from November 2012 to February 2013. Wintering individuals and water levels were surveyed every day. Instantaneous scan and focal animal sampling was conducted to collect the behavior data. Foraging behavior is the major behavior in the wintering period, followed by rest behavior and vigilance behavior. In daily activity rhythms, the trough and peaks of foraging behavior appeared in the morning (09:00-10:00 h) and evening(16:00-17:00 h), which is just contrary to the rest behavior. Foraging and rest behaviors showed highly significant differences among all the daily time intervals (P<0.01). During the winter, the foraging and vigilance behaviors declined first, and then increased, which is contrary to the rest behavior. When the water level was lower in mid January, the time budget for vigilance behavior reached the lowest, amounting to 5.19±0.88%. There were significant or highly significant differences except for foraging time budget with the variation of water level. The foraging intensity was affected by water-level fluctuations, and declined with the increase in water level. When water level is low with more available food the swans assemble into a large flock and spend more time foraging, in the meantime the vigilance value declines so as to get enough food supply. Foraging intensity is lower in deep water and higher in shallow water. The small lake could be an alternative suitable foraging habitat for the wintering Tundra Swans when facing the habitat loss.

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Authors' Contribution
LZ conceived and designed the experiments. XW and EY performed the experiments, participated in the field work and analyzed the data. LZ, XW and EY wrote the manuscript.

Key words
Time budget, Activity rhythm, Water level, wintering behavior, Tundra Swan

INTRODUCTION

Daily activity rhythm and time budget are the important presentation of behavioral strategy that is directly related to metabolism and energy requirement of animals (Weathers *et al*., 1984; Halle and Stenaeth, 2000). These behaviors are also influenced by environmental changes. Therefore, the behavioral changes are the result of physiological adaptation, and a response to the environmental changes of animals (Zimmer *et al*., 2011). Food resources are the major factor influencing the bird behavior, especially that of the wintering waterbirds (Davies and Lundberg, 1985; Zhou *et al*., 2010). Food availability is closely related to the water-level fluctuation, as it determines the exposure of resources and hence affects the foraging activity and habitat utilization of water birds (Jiang *et al*., 2007). Moreover, the water level also has an impact on the foraging pattern of wintering waterbirds, and their foraging efficiency (Woodin and Mecot, 2006). The study on the response of animal behavior to habitat factors is of importance for waterbird conservation and wetland management.

Traditionally the larger lakes with plenty of submerged macrophytes and annual hydrological rhythm in the middle and lower Yangtze River floodplain provide important wintering habitats for waterbirds on the East Asian-Australian flyway (Chen *et al*., 2011). Within the last two-decades, wide scale and high density of aquaculture resulted in lake degeneration, and foraging habitat loss for waterbirds (Zhou *et al*., 2010). Some small lakes which

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could provide supplementary foraging habitats attract more wintering waterbirds, as draws more attention to waterbird study (Barter *et al*., 2004).

Tundra swan breeds in eastern Russia and northeast China, wintering in the middle and lower reaches of the Yangtze River (Cheng, 1987). Currently, the number of Tundra swan wintering in the flood plain along the Yangtze River approximately accounts for 75% of the population on its flyway, which means that the wetlands in the middle and lower Yangtze River floodplain have become their important wintering sites (Cao *et al*., 2009; Cong *et al*., 2011a). Recently, with the booming of aquaculture, many wetlands have been lost or degenerated. The wetland vegetation has been destroyed to great extent, and the hydrological conditions have changed, resulting in the suitable habitat loss (Zhu and Zhou, 2010; Fox *et al*., 2013; Cong *et al*., 2011a). In this study, we surveyed the activity rhythm and time budget of the Tundra swan wintering in a small water level-controlled lake in the middle and lower Yangtze River floodplain, and analyzed the influence of water-level variation on the wintering behavior, with the aim to shed light on behavior response to habitat shift, and provide basic knowledge for conservation planning.

MATERIALS AND METHODS

Study area

The study site was chosen at Huangpi Lake (117°20′-117°25′E, 31°09′-31°13′N), a small shallow lake in the Yangtze River floodplain, generally at or near 9 m above sea level, located in the southeast Lujiang County, Anhui Province, which narrows from east to west with an area of 24.45km^2. The distance from the northwest to the southeast is about 8.8 km, while the distance from the southwest to the northeast is only about 2.4 km (Fig. 1).

This lake is located in humid monsoon climate of northern subtropical region, has four distinct reasons with annual mean temperature of 16°C and annual precipitation of 1190 mm. The lowering of water level in the dry season usually results in a large number of mudflat wetlands. The water level is controlled for aquaculture. The water is usually drained for fish harvest from November to December. The water level is the lowest in January, and the lake is filled again for aquaculture in early February. During the fish harvest period, water level of the lake is relatively low, and food resources in the mudflat such as *Vallisneria spiralis* are exposed, providing a good habitat for waterbirds to forage. Vegetation at the study site is mainly dominated by *Phragmites australis,* secondarily by *Trapa bispinosa* and *Salvinia natans,* lesser submerged macrophytes, which provide food for wintering waterbirds were destroyed by fishing, increased water levels, and pollution, such as *Vallisineria spinulosa* and *Potamogeton crispus*. The average biomass of *Vallisneria spinulosa* in the culture area at Huangpi Lake was 77.50±21.30 (n=6) g/m^2 wet weight, and 40.17±12.65 (n=6) g/m^2 dry weight, buried depth 13.90±8.45 (n=6) cm.

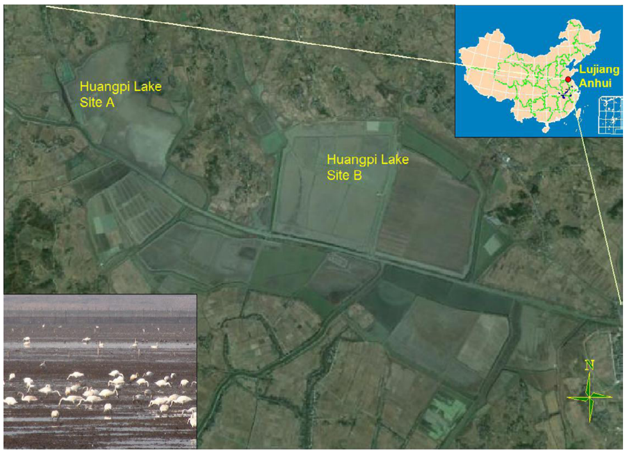

Fig. 1. The study areas at Huangpi Lake. A, B, the study sites.

Data collection

Instantaneous scan and focal animal sampling were carried out to observe the wintering behavior of Tundra swan with monocular telescope (SWAROVSKI, (20-60)×80mm) and binocular telescope (BOSMA, 8×42mm) from November 26, 2011 to February 25, 2012. The interval of instantaneous scan sampling was 15 minutes, that is, the observation and recording was done four times every hour. The sampling time was from 07:00 to 17:00 h. The effective data were 171 h in total with 75,550 individuals scanned. The foraging efficiency of swans was studied by focal animal sampling. Some foraging individuals were focused on, and their foraging bouts were observed. The action of head submerging into water and then raising was counted as one foraging bout. The time used for foraging alone in ten bouts was recorded as well as the time of each bout and the total time (the intervals between bouts included). The individuals were randomly chosen from the left to the right so as to ensure that each individual was recorded only once a day at the most. During the whole wintering period, 230 groups of data were obtained. According to previous description (Cong *et al*., 2011b) and field observation, the wintering behavior of swans was divided into six types: foraging (searching, excavating, swallowing and drinking), rest (sleeping, gliding), maintenance (bathing, pluming, stretching), vigilance (raising head and watching, calling, escaping), translocation (walking, running, swimming, flying) and social behavior (frolicking, fighting, crying). The adult and juvenile swans were discriminated according to their morphological characteristics. The most significant difference in juveniles was their dust-coloured body feathers. In addition, the beak was pale flesh-color and the legs and feet were also dust-coloured. The water level of the lake and the activity sites was also investigated every day. The water level was determined by arranging uniformly spaced measuring spots. The biomass of winter tubers of *Vallisneria spinulosa* was determined by quadrat sampling method, 1 meter × 1 meter quadrts were laid in foraging habitats for the wet and dry food biomass, and the buried depth to the tubers.

Data analysis

The field data such as the number of swans, behavior samples, water level were analyzed employing Excel according to the time sequence of investigation. The average of the data of four groups in each hour was used as the time budget of every period of time. Foraging intensity=total time of 10 foraging bouts/10; Foraging efficiency =time used for foraging alone in 10 foraging bouts/total time from the 1st bout to the 10th bout. The Kolmogorov-Smirnov test was performed for the data of each behavior type for goodness of fit. This performs a test of the distribution G(x) of an observed random variable against a given distribution F(x). Under the null hypothesis the two distributions are identical, G(x)=F(x). If the data accorded with the normal distribution, One-Way ANOVA or the Independent Samples T Test was employed. Otherwise, Kruskal-Wallis H Test or Mann-Whitney U Test was employed. These tests were used to determine the differences between the wintering behavior of adults and that of juveniles in different time periods and months. Moreover, Spearman's correlation analysis was performed to test the correlations of wintering behavior with temperature and water level.

RESULTS

Flock size and water level shift

The Tundra swans began to assemble into Huangpi Lake to forage when the fishery company drained the water for fish harvest in mid- to late November (Figs. 1 and 2). The wintering flocks of Tundra swan numbering 1240±671.37 (220-2512) (n=27) assembled in Huangpi Lake from November 26, 2012 to February 25, 2013. The largest flock included 2512 individuals in mid January, when the water level was lower.

Daily activity rhythm

Of all activities and behaviors of Tundra swans in one day, foraging behavior showed significantly negative correlation with the behavior of rest (R=-0.891, df=169, P=0.000). The trough of foraging behavior was 09:00-10:00 h, amounting to 26.21±2.32% of total activity time. After this period, the foraging behavior became frequent and reached the peak at 16:00-17:00 h, amounting to 72.89±3.46% of total activity time. However, the rest behaviors gradually increased from 7:00 h, and reached the peak at 09:00-10:00 h, accounting to 52.57±3.15% of total activity time. After that, it declined continuously and maintained a lower level at 12:00-16:00 h. The trough of rest behavior occurred at 16:00-17:00 h, amounting to 8.23±1.27% of total activity time. Vigilance and maintenance behavior were reduced over time, and the peak of vigilance appeared at 12:00-13:00 h, accounting to 12.87±2.14% of total activity time. The other behaviors showed no obvious difference within a day (Fig. 3). Among all the daily time intervals, highly significant difference existed only in the foraging and rest behaviors (Kruskal Wallis Test, foraging: C^2=56.42, df=9, P<0.01; rest: C^2=49.76, df=9, P<0.01, n=172).

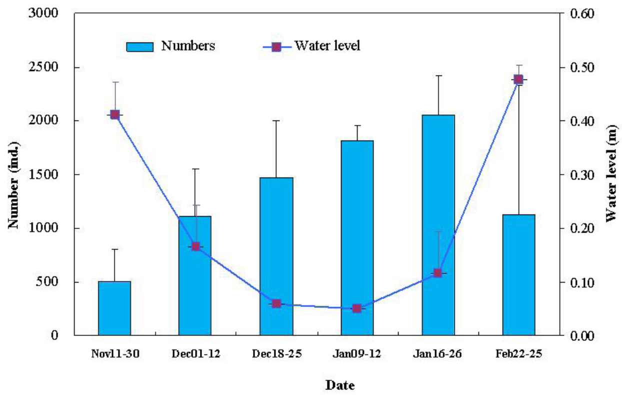

Fig. 2. The wintering Tundra Swan at Huangpi Lake.

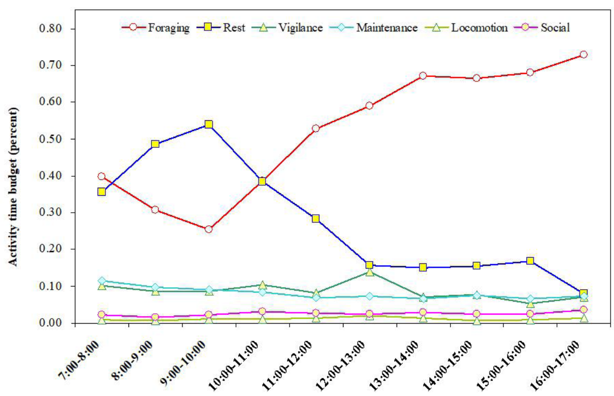

Fig. 3. Daily activity rhythm of wintering Tundra Swan at Huangpi Lake.

Table I. Activity time budget of wintering Tundra swan in four months. n, observation time (hours).

Behaviors	**November (n=23)**	**December (n=91)**	**January (n=47)**	**February (n=10)**	χ^2 **/ *F***	***P***
Foraging	56.21±4.72	49.09±3.44	51.52±3.43	70.31±2.99	4.89 a	0.180
Rest	15.33±2.66	30.521±3.46	31.93±3.29	9.23±1.73	11.30 a	0.010
Vigilance	15.50±3.09	8.83±1.05	5.19±0.88	9.17±0.50	26.43 a	0.000
Maintenance	8.90±1.44	8.29±0.64	7.54±0.58	5.77±0.90	1.50 a	0.683
Locomotion	2.70±0.25	2.02±0.17	2.99±0.23	4.54±0.49	10.05 b	0.000
Social	1.35±0.22	1.26±0.17	0.82±0.09	0.99±0.16	4.68 a	0.197

a, indicates the values from Kruskal Wallis H and b, indicates the value from One-way ANOVA.

Table II. Activity time budget between adult and juvenile. n, observation time (hours).

	Foraging (n=342)	**Rest (n=342)**	**Vigilance (n=342)**	**Maintenance (n=342)**	**Locomotion (n=342)**	**Social (n=342)**
Juvenile	53.59±5.26	26.17±4.83	8.07±0.69	8.40±0.54	3.03±0.19	0.73±0.10
Adult	51.09±5.46	28.16±5.05	9.13±0.77	7.98±0.50	2.33±0.17	1.31±0.14
Z	-1.022	-0.627	-1.026	-0.121	-2.249	-4.746
P	0.307	0.530	0.305	0.903	0.024	0.000

The daily activity rhythm indicated that the juveniles and adults showed similar behavior pattern, that is, foraging was the major behavior, followed by rest, and the proportions of each behavior type showed consistent fluctuation in the ten time intervals of the day.

Activity time budget

The major behavior of Tundra swans at Huangpi Lake was foraging (51.09±5.46%), followed by rest (28.16±5.05%) and vigilance (9.13±0.77%). However, the behavior patterns were not consistent across the months. During the winter, the foraging and vigilance behavior declined first, and then increased, which was contrary to the rest behavior (Table I). Foraging behavior was the major behavior in November, accounting for 56.21±4.72% of activity time, and rest (15.33±2.66%) and vigilance (15.50±3.09%) also showed higher proportions. Compared with November, the proportions of foraging behavior in December and January was unchanged basically, while the rest time increased considerably and vigilance time declined. In February, the time budget for rest declined significantly, accounting for 9.23±1.73% of total activity time; it declined by more than 1/3 compared with that in December and January; the time budget for foraging increased to 70.31±2.99% of total activity time. Moreover, the vigilance time also increased compared with December and January, reaching 9.17±0.50% (Fig. 4). Among the six behavior types, the rest behavior showed significant differences in the four months ($P<0.05$), and vigilance and translocation behaviors showed highly significant differences ($P<0.01$).

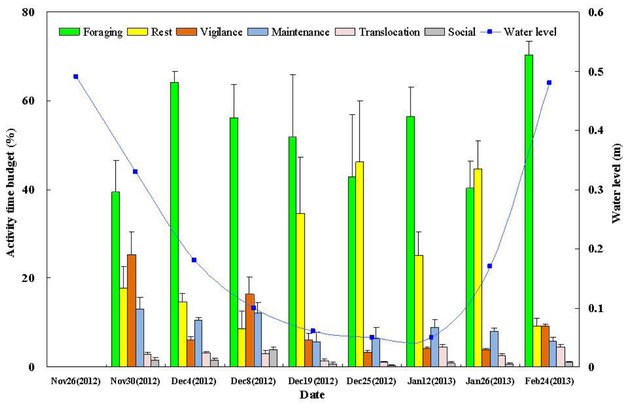

Fig. 4. Activity time budget of wintering Tundra swan and water level at Huangpi Lake.

The adults and juveniles of wintering Tundra swans had similar behavior patterns, of which foraging behavior occupied the largest proportion, followed by rest behavior and social behavior. A comparison indicated that the time of foraging behavior of juveniles was longer than that in adults, while the vigilance behavior was slightly shorter. Kruskal Wallis H Test showed that except for translocation and social behavior, there were no significant differences in other behavior (P>0.05, Table II).

Activity and water level

From the middle of November, water in Huangpi Lake was drained for fish harvest. By the middle of December, the water level was very low and the average depth was only about 6 cm. This water level was maintained more than 60 days. The lake was filled again starting by the end of January of the next year, which resulted in the rising of water level. During the four months, there were obvious variations in time budget for each behavior (Fig. 4). The linear regression analysis indicated that there was no correlation between each behavior type and water level (P>0.05). However, One-Way ANOVA indicates that the translocation behavior showed highly significant difference over time with the variation of water level ($F_{7,72}$=7.33, P=0.000). Kruskal Wallis H Test showed that there were highly significant differences in rest, vigilance, maintenance and social behavior (rest: $\chi2$=20.20, df=7, P=0.005; vigilance: $\chi2$=48.15, df=7, P=0.000; maintenance: $\chi2$=27.10, df=7, P=0.000; social behavior: $\chi2$=26.28, df=7, P=0.000. n=80). Foraging behavior showed no significant correlation with water level (P>0.05).

Foraging efficiency and water level

During the whole wintering period, foraging intensity of Tundra swan i.e. the duration of one foraging bout, increased first and then decreased (Fig. 5). It was recorded on December 11, 2012 that the foraging intensity of adults and juveniles was 11.83±0.52 s and 10.48±0.80 s respectively, and the foraging efficiency gradually increased over time. On January 15, 2013, the foraging intensity of adults and juveniles reached the peaks of 23.87±2.15 s and 28.82±2.69 s, respectively. Then the foraging intensity began to decline. The foraging intensity of adults and juveniles was 14.56±1.08 s and 13.93±0.67 s respectively, on February 24. Nonparametric test shows that there were highly significant differences between the foraging intensity in different wintering periods (adults: χ^2=21.406, df=4, P=0.000; juveniles: χ^2=20.036, df=4, P=0.000).

During the whole wintering period, the foraging efficiency initially increased and then decreased, but the variation was not obvious (Fig. 6). The One-Way ANOVA indicates that there was no significant difference in the foraging efficiency of adults in different wintering periods (P>0.05), while there was significant difference in the foraging time of juveniles (F=2.622, df=4, P=0.043). Moreover, neither the adults nor the juveniles showed significant difference in foraging efficiency in different periods (P>0.05).

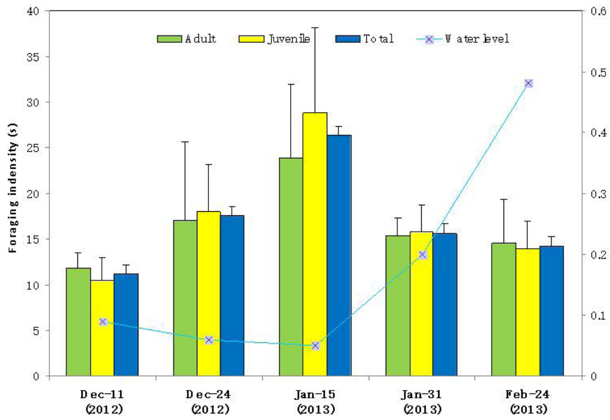

Fig. 5. Foraging intensity efficiency of adult and juvenile Tundra swan at different water levels.

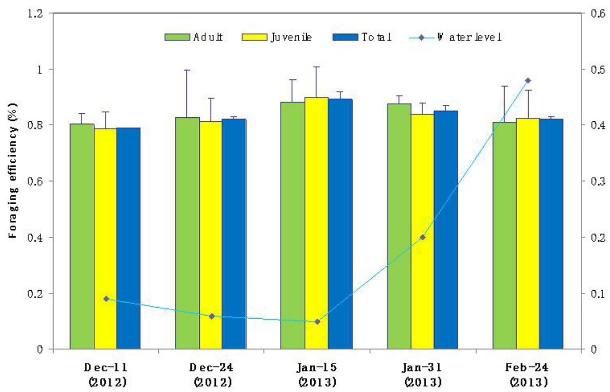

Fig. 6. Foraging efficiency of adult and juvenile Tundra swan at different water levels.

DISCUSSION

Activity rhythm and time budget are the basic aspects of behavior, usually adopted by animals in the whole overwintering period as the behavioral strategy. Animals respond to environmental changes, such as food resources, habitat changes and survival risks by resorting to various behavioral strategies (Paracuellos, 2006; Villamagna *et al*., 2010; Li *et al*., 2013). The activity time and energy can be allocated flexibly by animals to respond to environmental changes, and animals have their own optimal activity rhythm and time budget (Caraco, 1979).

It can be seen from the time budget of behavior that the foraging and rest behavior accounted for 80% of total activity time, i.e. Tundra swans spent much time on acquiring and accumulating energy in the overwintering period to prepare for migration and reproduction. The time of foraging behavior accounted for over 50% of total activity time, which is common in herbivorous birds with developed digestive system (Drent *et al.*, 1978; Jónsson and Afton., 2009; Cong *et al.*, 2011b). The proportion of vigilance behavior was 8.68% in swans wintering at Huangpi Lake, which is much higher than that (0.20%) at Shengjin Lake (Cong *et al.*, 2011b). Disturbance can induce the vigilance in birds and influence their vigilance intensity (Hamilton *et al.*, 2002; Rees *et al.*, 2005). The swans at Huangpi Lake mainly feed on the tubers of *Vallisneria spinulosa*, which are also the food resource cultivated artificially for fishery. Therefore, frequent disturbance from human beings compels swans to spend more time on vigilance. Parental care usually plays an important role in juvenile survival (Scott, 1980). In order to ensure the increase of energy intake by the juveniles, the adults would keep vigilance on various risks in the environment. Although their foraging time is less than that of juveniles, adults can acquire enough food due to rich experience. As seen from the activity behavior of wintering Tundra swans, the time of foraging behavior of juveniles was longer than that of adults, while the time of rest and vigilance behavior was less. This is consistent with the previous researches on geese and ducks (Jónsson *et al.*, 2009; Cong *et al.*, 2011b).

In the daily rhythm of behavior, foraging and rest were the major behavior of Tundra swans in a day, and there was significantly negative correlation between the two behavior types. Other behavior accounted for similar proportions in each period of the day. To store energy for the consumption at night and to supply energy for the activity in the next morning, higher foraging intensity in the morning and evening is a common foraging pattern of migratory birds (Hamilton *et al.*, 2002). A consistent result was obtained in this study. The trough of foraging behavior occurred at 10:00 h, which was the peak of rest behavior, as might have resulted from the lower temperature during this period. The waterbirds decrease energy consumption by reducing movements (Yang *et al.*, 2012).

The hydrological variation affects the number and distribution of waterbirds (Hua *et al.*, 2009) and their wintering behavior, especially foraging and swimming. Thus, water level is an important influencing factor (Woodin and Michot, 2006). Since the variation of water level affects bathing, pluming and translocation of Tundra swans, the behavior of translocation and maintenance showed obvious changes with the water level in this study. The water-level variation had significant influence on the foraging intensity, while the influence on the proportion of time of foraging was non-significant.

The bird foraging in deep water usually increases the frequency of vigilance and reduces the duration of vigilance, thereby decreasing the foraging time (Guillemain *et al.*, 2001). This is also supported by our study results. With the water-level variations in the overwintering period, the foraging intensity was lower in deep water and higher in shallow water. Thus, water-level variation had effects on the foraging activity of Tundra swans.

CONCLUSION

Water level in the small lake in the middle and lower Yangtz River floodplain is easily controlled. Huangpi Lake could be an alternative foraging habitat for the wintering waterbirds. Tundra swans facing the habitat loss assemble into a large flock and spend more time foraging when water level is low with more available food for swans in this lake, in the meantime the vigilance value declines so as to get enough food supply. Foraging intensity is lower in deep water and higher in shallow water. The small lake could be an alternative suitable foraging habitat for the wintering Tundra swans.

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Statement of Conflict of interest

The authors have declared no conflict of interest.

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