



Time Budget and Rhythm of Wintering Behaviors of Great Bustard in the Middle Reaches of Yellow River Basin of China

Wu Yi-qun* and Xu Xiu

College of Chemistry and Environment, Weinan Normal University, Weinan, 714099, China

ABSTRACT

During the period from January 26th to February 3rd, 2013, the time budget and rhythm of wintering behaviors of Great Bustard (*Otis tarda*) was studied with instantaneous-scanning method in the intersection area of the Yellow River, the Wei River and the Luo River located at the middle reaches of Yellow River basin of China. The results showed that standing accounts for 32.75 % of wintering behaviors for Great Bustard, followed by the feeding behavior (27.55 %) and walking behavior (16.69 %). Alert and lying behavior account for a small proportion – 8.45 % and 7.49 %, respectively; the rest behaviors take the least proportion. With respect to rhythm, feeding and walking behavior account for a large proportion from 11:30 to 12:00, reach a trough from 13:30 to 14:00 and increase from 14:00. Lying behavior reaches a maximum proportion from 13:30 to 14:00. Correlation analysis on the wintering behaviors shows that there is a significant positive correlation ($P < 0.05$) between feeding and walking, air movement and chasing behavior, and the positive correlation between lying and preening behavior is also significant. The results also showed that weather conditions has obvious influence on wintering behavior, especially on feeding, walking, lying and standing ($P < 0.01$).

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Authors' Contributions

WY and XX analysed the data.

WY wrote the manuscript and XX reviewed the literature.

Key words

Great bustard, Wintering behavior, Time budget, Behavior rhythm, Yellow River Basin of China.

INTRODUCTION

The Great Bustard *Otis tarda* is the heaviest extant flying bird, it ranges across central and southern Europe, Western Russia and some temperate areas of central and eastern Asia to the Pacific, occupying open steppe grasslands and extensively cultivated fields (Del Hoyo *et al.*, 1996). The Great Bustard contains two subspecies, *Otis tarda tarda* and *Otis tarda dybowskii*. Although widely distributed, most populations have suffered large declines and some went extinct in relatively short periods during the last century (Alonso *et al.*, 2003). At present, the main stronghold is found in Spain where 60 – 70% of the world's population (Alonso and Palacin, 2010), and the populations of the nominal subspecies are listed as Vulnerable (VU) worldwide by IUCN at 2012.

The two subspecies of great bustard are isolated distribution in China, *Otis tarda tarda*, disperses in the west of the Xinjiang Autonomous Region while *Otis tarda dybowskii* mainly distribute in central and northeast China, and their distribution areas show no overlaps. With respect to breeding grounds, the Great Bustard breeds in the provinces of Heilongjiang, Jilin, Inner Mongolia and Xinjiang, but in

recently years its breeding range is now much reduced and fragmented. In winter, they occur at many other provinces mostly distributed in the Yellow River basin of central and eastern China. The Great Bustard is a key species in conservation of the lowland grassland ecosystem (Wan *et al.*, 2010). Most of the references regarding great bustards are based on population distribution (Alonso *et al.*, 2003; Palacin and Alonso, 2008; Martínez, 2008; Alonso and Palacin, 2010; Ahmad *et al.*, 2015; Jose *et al.*, 2015), diet (Lane *et al.*, 1999; Bravo *et al.*, 2012; Wu and Xu, 2014), habitat selection (Delibes *et al.*, 2012; Zsolt *et al.*, 2016), Parasitic disease (Du *et al.*, 2014) and ecological studies (Raab *et al.*, 2011; Kessler *et al.*, 2013). Besides, there are some published studies on behavior observation of captive Great Bustard (Tian *et al.*, 2004) but there few references about free-living Great Bustards behaviors especially in wintering period are found. In order to (1) understand the behaviors characteristic of wild Great Bustard in naturally wintering habitat, and (2) provide some scientific suggests for it's protection and management, the time budget and rhythm of bustard's was conducted in the intersection area of the Yellow River, the Wei River and the Luo River, which is the middle reach of Yellow River in China.

MATERIALS AND METHODS

Study area

The study area of the study area reach 1200 km²,

* Corresponding author: wuyq-05@163.com

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which is located in eastern Guanzhong Plain, Shaanxi Province ($110^{\circ} 10' - 110^{\circ} 36' E$, $34^{\circ} 36' - 35^{\circ} 40' N$) (Fig. 1). This land, with its elevation below 400m, is a semi-arid continental monsoon area of temperate zone with sufficient sunshine and appropriate rainfall—mostly from July to September; The annual average temperature is $13.5^{\circ}C$, annual precipitation ranged from 529 mm to 574 mm; frost period ranges from 160 to 167 days (Wu and Xu, 2014). The intersection area of the Yellow, Wei and Luo River in the Shaanxi Yellow River wetland, has open and wide topography and less human interference. Great Bustards are omnivorous, eating mainly green plant material and secondarily insects, with grains (wheat, barley, etc.) and some other seeds also being common foods (Alonso and Palacín, 2009). The main crop here are wheat and beans providing food resource for wintering Great Bustard, thus this land has become one of the major wintering habitats for Great Bustard in China. Each year, Great Bustard migrates here from northern Mongolia from mid to late octoer and returns back to their breeding grounds in mid-March to early-April of the next year (Kessler *et al.*, 2013). So far, as many as 300 wintering Great Bustard are found every year (Wu, 2012).

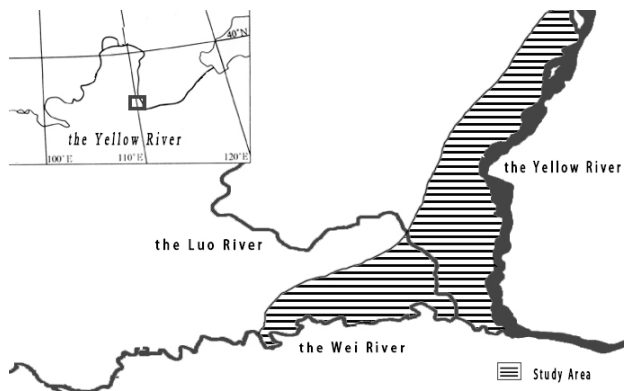


Fig. 1. The study area in the intersection area of the Yellow, Wei and Luo River.

Data collection

From 9:00 to 18:00, January 26 – February 3rd, 2013, the wintering behavior of Great Bustard was daily observed through instantaneous-scanning method from left to right every two minutes. Binoculars (Nikula 8×42) and monocular telescope (Bosma $20 - 60 \times 80$) were used to observe. The distance was about 300 – 400 m far from Great Bustard groups. During this work, one staff was in charge of individual behavior observation, while the other staff was responsible for data recording. This study lasted nine days, with 6,469 behavior data obtained. Meanwhile, human interference on the wintering Great Bustard and weather conditions in study period was also recorded.

Additionally, interviews with local people were carried out to obtain information on the former and current occurrence of Great Bustards.

In this study, the wintering behaviors of Great Bustard were divided into eleven types shown in Table I.

Data analysis

Day behavior rhythm of Great Bustard was analyzed utilizing bivariate Pearson Correlation. The weather was divided into two types – sunny and cloudy with snow. Various behaviors in sunny day (five days) and cloudy days with snow (four days) were combined for comparative analysis. Non-parametric Mann – Whitney U testing was utilized to determine whether there was a significant difference on the same behaviors of Great Bustard under different weather conditions. All data were processed by Excel 2007 and SPSS 18.0 for statistical analysis.

RESULTS

Time budget

Standing accounts for the largest proportion (32.75 %) among time budget of wintering behaviors of Great Bustard, followed by the feeding behavior (27.55 %) and walking behavior (16.69 %); alert behavior and lying behavior account for a small proportion -8.45 % and 7.49 %, respectively; air movement, stretching wings, fighting, chasing and shaking feathers are in the minimum proportions.

Correlation analysis on the wintering behaviors of Great Bustard shows that there is a particularly significant positive correlation ($P < 0.01$) between feeding and walking, and between lying and preening behavior; air movement and chasing behavior have a significant positive correlation ($P < 0.05$); feeding behavior has a significant negative correlation ($P < 0.01$) with preening, lying and standing behavior; walking behavior has a significant negative correlation ($P < 0.01$) with preening, lying and standing behavior; standing has a significant negative correlation ($P < 0.01$) with lying, alert and air-movement behavior; walking behavior has a significant negative correlation ($P < 0.01$) with air movement and shaking-feathers behavior (Table I).

The feeding, walking, lying and standing behaviors of Great Bustards show significant differences ($P < 0.01$) under different weathers. The proportion of lying behavior, in sunny days, is significantly greater than that in cloudy days with snow; the proportion of feeding, walking behavior and standing, in cloudy days with snow, is significantly greater than that in sunny days. There is no significant difference ($P > 0.05$) between preening, alert, air movement, stretching wings, chasing, shaking feathers and fighting behaviors under different weathers (Table II).

Table I.- The correlation among wintering behavior of great bustard.

Types	Feeding	Walking	Preening	Lying	Standing	Alert	Air movement	Fighting	Shaking feathers	Chasing
Walking	0.45**	1								
Preening	-0.22**	-0.28**	1							
Lying	-0.45**	-0.34**	0.18**	1						
Standing	-0.41**	-0.41**	-0.02	-0.16**	1					
Alert	-0.12*	-0.1	-0.05	-0.14*	-0.22**	1				
Air movement	-0.18**	-0.11*	-0.09	-0.04	-0.17**	-0.09	1			
Fighting	0	0.05	-0.03	-0.02	0.03	-0.06	-0.04	1		
Shaking feathers	0.09	0.11*	-0.02	-0.07	-0.12*	0.09	-0.04	-0.03	1	
Chasing	0.04	0.03	-0.04	-0.05	-0.03	-0.07	0.13*	0.1	-0.01	1
Stretch wings	-0.07	-0.04	-0.04	0	0.04	0.04	-0.05	0.05	0	0

*, P < 0.01; **, P < 0.01.

Feeding, foraging with head down while standing and walking; Walking, walking with eyes looking forward or looking around spontaneously; Preening, pecking feathers at various parts of their body and making the feathers neatly; Lying, lying on the ground with legs curled up, including flat-head resting, sink-head resting and resting with the head retracted into feathers on the back; Standing, standing still with retracted head; Alert, stretching their necks and looking around unnaturally; Air movement, short jump and spontaneous cluster air-movement after being disturbed; Fighting, two or more Great Bustards attacking each other with beaking; Shaking feather, shaking their body violently, letting debris out of feathers and losing feathers; Chasing, two or more Great Bustards chasing after each other; Stretch wings, opening or gently patting two wings while standing.

Table II.- The comparison of wintering behavior of Great Bustard under different weather conditions.

Types	Sunny day %	Cloudy day with snow %	Z value	P value
Feeding	24.09±19.45	27.94±17.27	-2.9063	0.0037**
Walking	12.94±12.43	17.22±12.67	-4.2058	0.0000**
Preening	4.13±5.66	4.71±7.41	-0.3075	0.7585
Lying	13.53±21.87	1.64±3.27	-6.2733	0.0000**
Standing	32.41±20.93	37.41±20.87	-2.7367	0.0062**
Alert	6.57±12.35	8.18±12.20	-1.9132	0.0557
Air movement	3.29±15.31	0.63±4.15	-1.5172	0.1292
Fighting	0.06±0.44	0.06±0.40	-0.4229	0.6724
Shaking feathers	0.01±0.11	0.03±0.18	-1.4844	0.1377
Chasing	0.00±0.00	0.01±0.17	-1.3291	0.1838
Stretch wings	0.45±1.26	0.32±1.39	-1.9257	0.0541

*, P < 0.01; **, P < 0.01.

Behavior rhythm

Figure 2 shows the first standing peak of Great Bustard appears at 9:00-9:30, reaching a trough at 10:30-11:00 and the second peak at 12:30-13:00. Feeding and

walking behavior account for a large proportion at 11:30-12:00, reaching a trough 13:30-14:00 and increase from 14:00. Lying behavior reaches a maximum proportion at 13:30-14:00.

The proportion of alert has two peaks in one day, 12:00 - 12:30 and 15:30 - 17:00, respectively. The proportion of preening behavior has a peak at 12:30 - 13:00. The proportion of air-movement behavior is relatively small, reaching a peak at 10:00 - 10:30. Behaviors of fighting, shaking feathers, chasing and stretching wings account for the least proportion, less than 1 %.

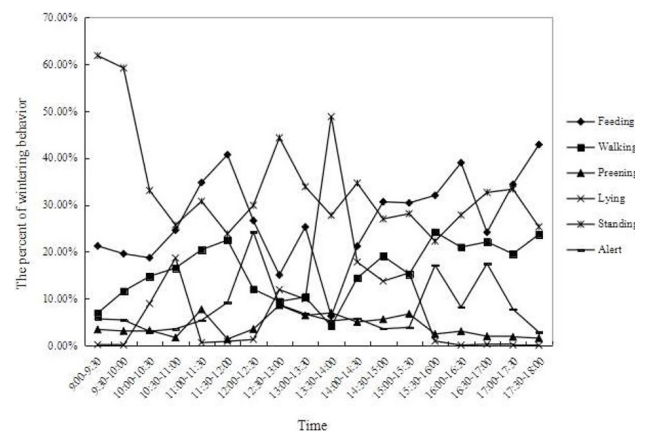


Fig. 2. The rhythm of major behavior Great Bustard in winter period.

DISCUSSION

Main wintering behaviors

Great Bustard's activities during wintering period mainly include standing, feeding and walking accounting for 76.99 % of all the behaviors. Studies on Scaly-sided Merganser *Mergus squamatus* (Fang *et al.*, 2009), Black-necked Crane *Grus nigricollis* (Li, 2011) and Black Stork *Ciconia nigra* (Feng, 2008) show that feeding behavior accounts for the largest proportion among all the behaviors during wintering period, indicating feeding behavior is an important wintering behavior for most birds. Wintering Great Bustards need a lot of food to maintain metabolism and resist the cold weather. Great Bustards needs to keep walking to seek food while feeding, so the proportion of walking behavior is high, showing a significant positive correlation ($P < 0.01$) between walking and feeding behavior. Studies have shown that Black-faced Spoonbill *Platalea minor* (Zhang *et al.*, 2006), American Black Duck *Anas rubripes* (Morton *et al.*, 1989) and Sandhill Crane *Grus canadensis* (Fox *et al.*, 1995) have high proportion of resting behavior in daytime (including standing and lying). The proportion of standing and lying behavior for Great Bustard was 40.24 % in this work, indicating that birds can cut down their energy consumption by reducing activities in cold winter.

Impact of weather on wintering behavior

Different weather conditions have a significant impact on Great Bustard's wintering behaviors. In sunny days, feeding and walking behaviors of Great Bustard account for a small proportion due to the sufficient sunshine and suitable temperature, significantly less than that in cloudy days with snow ($P < 0.01$); however, lying behavior accounts for a large proportion, significantly greater than the proportion in cloudy days with snow ($P < 0.01$). It is difficult for Great Bustard to seek food in cloudy days with snow, thus, increasing the proportion of walking behavior to seek the food resource. In addition, temperature among all the environmental factors has a significant impact on Great Bustard's activities. In the morning, Great Bustard rarely does any activities from 9:00 to 9:30 due to the low temperatures, and standing quietly can be effective reduce energy consumption. At noon, the proportion of feeding and walking behaviors reach a peak at 11:30-12:00 with the rising temperature while the proportion of standing behavior declines.

Wintering status and protection

For wintering birds, a suitable habitat needs to provide appropriate foraging grounds to ensure that the nutritional

requirements of wintering. This is especially important in steppe birds inhabiting farmland areas, and particularly relevant in the Great Bustard, a primarily ground-dwelling species (Martín *et al.*, 2007). Great Bustard is extremely sensitive to human interference and environmental changes, and the minimum area of their habitat should also meet certain requirements. The minimum area of most suitable habitat for Great Bustard is 16.5 km²; the minimum area of relatively suitable habitat for Great Bustard is 10.8 km². Habitats with the area less than 8km² are unsuitable for Great Bustard to seek food (Lane *et al.*, 2001; Martín *et al.*, 2002). In study area, the rural road networks along with the Wei River and the Yellow River divides original complete and continuous wintering habitat into many small areas, exacerbating the fragmentation of Great Bustard's habitat, thus the activity scope of this Bustard is limited, and foraging is difficult. Habitat fragmentation is pervasive threats to great bustard conservation.

Collisions with overhead power lines are currently the most significant mortality factor for Great Bustards in several countries. A study on radio-tagged Great Bustards in Spain documented mortality caused by collision with power lines of 54.5% for birds during the second year of life (Martín *et al.*, 2007). The complex set of transmission lines put more risks to the air flight of Great Bustards. From 2004 to 2012, twelve Great Bustards have been rescued by local farmer in Shaanxi province, and ten Great Bustards' wings injured from the collision with transmission line (Liu *et al.*, 2013). The intersection area of Yellow River, Wei River and Luo River is the artillery-targeting ground of a subordinate unit of the PLA, thus the wintering behavior of Great Bustard is disturbed. Local farmers often place corn grains mixed with pesticides on farmland preventing birds and rodents from pecking and chewing wheat seedling. The Great Bustards may be poisoned by toxic corn grains. Therefore, agriculture departments should strengthen agricultural management and improve people's understanding and consciousness of animal protection to ensure the safety of wintering Great Bustard.

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Conflict of interest statement

We declare that we have no conflict of interest.

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