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RESEARCH ARTICLE

Time budget and activity rhythm of wild Great Bustard in winter

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Abstract Instantaneous scanning and focal animal sampling methods were used to record the behaviors of nine wild Great Bustards (*Otis tarda*) and their time budget from November 2004 to January 2005. The results indicated that foraging and resting time accounted for as high as 46.40% and 39.12%, respectively, while the rest of the behaviors, such as walking, alerting, preening and flying, only shared 6.83%, 2.03%, 2.64% and 1.84%, respectively. There were significant differences in foraging time, alert time and walking time between males and females ($P < 0.05$). The preening and flying were closely related to males (Pearson's correlation, $r = 0.932$), and it was similar for resting and walking in females (Pearson's correlation, $r = 0.716$). Resting occurred mainly at dawn and dusk, and foraging appeared mostly from 9:30 to 11:30 and from 14:30 to 16:30. Non-parameter testing demonstrates that time budget among resting, flying and others in two temperature intervals (> −5 ℃ and ≤ −5 ℃) was significantly different.

Keywords Great Bustard, wintering period, behaviors, time budget, rhythm

1 Introduction

The Great Bustard (*Otis tardas*) is a ground dwelling, lekking bird that inhabits the Palearctic natural and cultivated grasslands, and it is distributed from Iberia and Morocco in the west to China in the east (Cramp and Simmons, 1980). In China, it breeds mainly in Heilongjiang Province, Jilin Province, Liaoning Province, Inner Mongolia Autonomous Region, and Xinjiang Uygur Autonomous Region, and in the winter in Hebei Province, Henan Province, Shandong Province, Shanxi Province and Jiangxi Province (Zhao, 2001), where it lives in grasslands and sandy areas. Because of the hunting and destruction in grasslands, the Great Bustard is now listed in the CITES appendix II and is regarded as a national first-grade protected wildlife species of China (Zheng and Wang, 1998).

Due to its endangered status, research on Great Bustards have been carried out in China and abroad, including on habitat selection (Lane et al., 2001; Wan et al., 2004; Zhao et al., 2005), migration pattern (Morales et al., 2000), diet (Lane et al., 1999), tissue anatomy (Liu et al., 2002, 2003), energy mechanism (Zhang et al., 2004), breeding ecology (Carranza and Trucios, 1993; Alonso et al, 2000; Tian et al., 2004), molecular biology (Pitra et al., 2000; Lieckfeldt et al., 2001), breeding behavior (Goriup, 1982; Trucios and Carranza, 1991) and wintering behaviors of captive Great Bustards (Tian et al., 2005) .

However, little is known about the time budgets and activity rhythm of wild Great Bustards till now, and which is urgently required for the effective management of this endangered species. Moreover, understanding the relationship between population behaviors and ambient conditions is also important for the conservation of wild Great Bustards.

Therefore, we observed and analyzed the behavior characteristics of Great Bustards in winter during 2004–2005. Our objective was to understand the time budget and activity rhythm of this bird and to know the relationship between behavior and ambient conditions.

2 Study area

All fieldwork was carried out in Pingshan county (113º31′–114º15′E, 38º09′–38º45′N), Hebei province, China. The study areas are characterized by grasslands dominated by *Carex dispalata*, *Cyperus rotundus*, *Setaria viridis*, *Salsola* spp., *Artemisia annua* and *Potentilla chinensis*, but woods and shrubs are scarce in this area. There are also some crops, most of which are corns, jowars, peanuts, sojas, etc.

The altitude of this study site is about 196 m above sea level. The weather is severely dry and windy in spring, whereas it is hot and rainy in summer and cold and less

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snowy in winter. The annual precipitation means 609 mm. Mean temperature in summer ranges from 13℃ to 28.5 ℃, while it ranges from −3.6℃ to 17.7 ℃ in winter.

3 Methods

3.1 Behavior definition

On the basis of field observations and previous research (Zhao et al., 2003; Kong et al., 2004; Tian et al., 2005), the day activities of the wild Great Bustards were roughly classified into six types during winter (Table 1).

Table 1 Definition of Great Bustard activities

Behavior	Definition
Resting	Standing and lying
Foraging	Seeking，Proceeding and swallowing
Alert	Alert to the surrounding environment and disturbance
Walking	Walking slowly and quickly
Flying	Flying
Preening	Combing feather
Others	Scaring, combating and shaking

3.2 Behavior observation

The Great Bustard is a typical grassland bird, and it is an ideal subject to study bird behaviors because of its big body and unique characters for females and males. The key positions, about 220 m from the Great Bustard active site, were set, and the behaviors of the Great Bustards were observed and recorded using a single-tube telescope (LEICA APO TELEVID77) and binoculars (Bushnell Legend, 10 × 42). The instantaneous scanning sampling method (Xu and Zhang, 1998) was combined with focal animal sampling method (Altman, 1974) to gain time sampling records. The scanning sampling intervals were 5 minutes, and the temperatures were recorded every six times, namely once every 30 minutes. Meanwhile, two or three Great Bustards were selected randomly for continuous observation everyday. Data were collected from 7:30 to 17:30 in days as following: 22−24 and 28−30 Nov., 7−9, 13−15, 19−21 and 25−27 Dec., 2004, and 9−11 and 20−23 Jan., 2005.

3.3 Data analysis

The Mann-Whitney *U*-test was used to determine the difference between the sexes, as well as the difference among different temperatures.

The correlation among behaviors was analyzed using hierarchal cluster analysis, the degree of which was defined by Pearson's correlation coefficient.

In all statistical tests, a probability of 0.05 or less was accepted as significant. Unless specially mentioned, means were given as mean ± SE.

All statistical procedures were carried out using SPSS 12.0 for Windows (SPSS Inc., 2003).

4 Results

In total, nine Great Bustards were observed, including four males and five females. The observation time added up to about 240 hours, and 7,584 valid data were collected.

4.1 Time budget of behaviors

Great Bustards spent their time mostly in foraging, accounting for about 46.40 ± 1.98% in daytime in winter (Fig. 1), followed by resting representing approximately 39.12 ± 1.50%, but the resting activities mainly took place at night. Furthermore, the foraging and resting times added up to 85% in daytime in winter. The rest were as follows: walking time accounted for merely 6.83 ± 0.54% of the total, alert time 2.03 ± 0.39%, flying time 1.83 ± 0.21%, preening time 2.64 ± 0.40%, and others accounted for only 1.14 ± 0.23%.

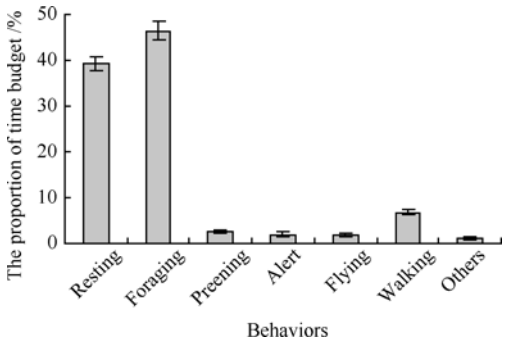

Fig. 1 Time budget of Great Bustards in daytime

4.2 Relationship among behaviors

In males, preening and flying were highly correlated (Pearson's correlation, r = 0. 932), followed by resting and alert (Pearson's correlation, r = 0.562). However, in females, resting and walking were greatly related (Pearson's correlation, r = 0.716), followed by alert and flying (Pearson's correlation, r = 0. 552) (Fig. 2).

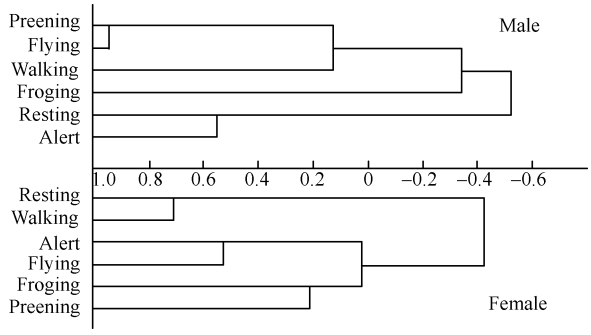

Fig. 2 Results of cluster analysis for Great Bustard behaviors

4.3 Activity rhythm in daytime

Two activity peaks occurred during daytime, i.e. 9:30−11:30 and 13:30−16:30 (Fig. 3). Resting exceeded other activities before 8:30 and after 16:30. Foraging happened primarily in two peaks which occurred during 9:30−11:30 and 14:30−16:30. Walking occurred mostly in 10: 30−11: 30 and 13: 30−14: 30. Preening was focused frequently during 11:30−12:30. Alert behaviors occurred mostly during 8:30−9:30 and 12:30−13:30, and flying time was distributed evenly during daytime.

4.4 Difference in time budget between males and females

Foraging time of males was significantly less than that of females, but alert and walking time were significantly more. However, there were no significant differences in the times for resting, flying, preening and other behaviors between males and females (Table 2).

4.5 Effects of temperature on time budget

The temperature recorded was divided into two intervals, i.e. > -5℃ and $\leqslant -5$℃, and the time budget was significantly different for resting, flying and other behaviors ($P < 0.05$), while there was no significant difference among foraging, preening, alert and walking behaviors ($P > 0.05$) (Table 3).

5 Discussion

Time budget of bird behaviors is not only adapted to the ambient conditions, but also to the comprehensive performances of all factors affecting their activities (Yang and Yang, 1996). Time budget and distribution rhythmicity are the adaptive mechanisms to natural selection, which is beneficial to the evolution process in nature (Verbeek, 1972; Coroco, 1979; Davies and Lundberg, 1985). Our study proved that time budget of Great Bustard behaviors results from their requirements in winter, which is similar to that of breeding behaviors in captive or wild conditions (Zhao et al., 2003; Kong et al., 2004; Tian et al., 2005). Some behaviors such as resting, foraging, preening, flying and walking account for more than 90% during daytime, whereas alert and combating take less time. Furthermore, food is one of the crucial factors that has some influences on time sharing in birds (Coroco, 1979), and foraging time is closely related with food density (Enoksson, 1990). Therefore, it is very difficult for wild Great Bustards to get enough food in winter, leading to an increase in the foraging time.

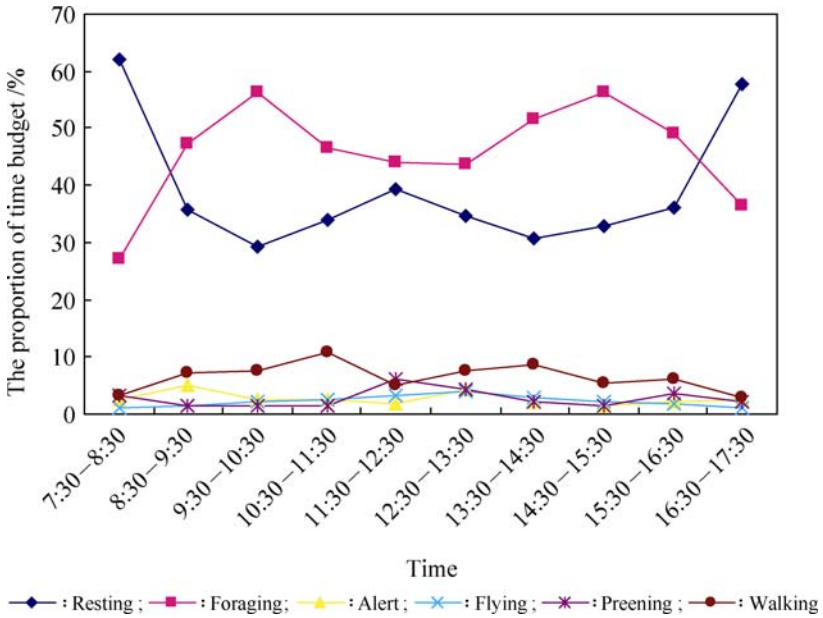

Fig. 3 Daily rhythm of Great Bustard behaviors in winter

Table 2 Time budget of male and female Great Bustards

Sex	Quantity	Resting	Foraging	Alert	Time budget /% Walking	Flying	Preening	Others
Male	4	40.04±1.22	44.71±1.01	2.38±0.28	7.32±0.22	1.90±0.21	2.48±0.53	1.17±0.28
Female	5	38.39±1.37	47.74±1.40	1.75±0.17	6.44±0.36	1.78±0.283	2.76±0.24	1.11±0.21
Z	—	−1.599	−2.449	−2.337	−2.440	−0.490	−1.225	−0.477
P	—	0.110	0.014	0.019	0.015	0.624	0.221	0.624

Table 3 Time budget of Great Bustards in different temperatures

Temperature	Resting	Forging	Alert	Time budget /% Flying	Preening	Walking	Others
≤ −5℃	47.78±13.94	39.94±10.28	3.02±1.41	1.36±0.35	2.69±1.01	4.80±2.11	0.95±0.15
> −5℃	33.46±3.58	49.76±5.83	2.46±1.06	2.77±0.80	2.69±1.96	7.57±2.14	1.29±0.23
Z	−2.132	−1.279	−0.853	−2.558	−0.640	−1.706	−2.245
P	0.033	0.201	0.394	0.011	0.522	0.088	0.025

The relationships between flying and preening, resting and alert are closer than that of the others in male Great Bustards. Flying is usually followed by temporal preening, and resting is accompanied with alert in males. In females, alert and flying are highly correlated, but the relationship between walking and resting is the closest as a result of the short distance among rest sites. It was found that the females would immediately fly off if they were disturbed by humans, indicating females are extremely sensitive to external disturbances.

The activity rhythm of the wild Great Bustards in winter was characterized by the fact that resting was predominant during dawn and dusk, and foraging and walking behaviors appeared mostly in the middle periods of mornings and afternoons, which differed from that of other birds such as *Grus monacha*, *Anser indicus*, *Grus nigricollis* and *Lophophorus lhuysii* (Wu and Li, 1985; Lu et al.,1986; Jing et al., 2002; Liu and Li, 2004) as well as that of the captive ones. Great Bustards have to forage to meet energy requirements because of adverse circumstances, and it may be harmful to them if energy lost during foraging is more than that obtained from foraging. Therefore, our result suggests that there should be no good food resources in the study area, and less activity may prevent the loss of energy and heat, and maintain normal body temperature.

Generally, the time budget of all behaviors displays a certain difference between males and females of either captive or wild birds (Siegfried, 1974; East, 1980; Bryant and Tatner, 1988; Yang et al., 1995; Tian et al., 1996; Yang and Yang, 1996), and this was also reflected in our results.

Temperature has certain effects on the behavior time distribution in birds (Verbeek, 1972; Coroco, 1979; Zhou et al., 2002; Zhou et al., 2004; Tian et al., 2005). The research stated that activities of Great Bustards sharply decreased to conserve energy and heat under lower temperature conditions. Some behaviors, such as resting, flying and others, are significantly affected by temperature, but foraging, preening, walking and alert are less impacted, which shows that temperature has an uneven effect on different behaviors of Great Bustards.

Tian et al. (2005) have studied the behavior characteristics of captive Great Bustards in winter. Compared with captive birds, foraging time of wild ones is far less, but the resting time is significantly more. Wild birds have two foraging peak stages in the day, but foraging just occurs during 11:00−12:00 for captive ones. Compared with captive Great Bustards, it is difficult for wild ones to find adequate food because of unfavorable factors such as inferior habitats, shortage of food etc., which directly functions on time budget pattern of behaviors. In addition, the physiological differences between wild birds and captive ones maybe contribute to the time budget difference.

6 Management implications

Food plays a very important role for Great Bustards in winter, as the main source of food is crop seeds. Thus, guaranteeing a sufficient amount of crops and decreased human activity is necessary for increasing food sources for Great Bustards; in particular, periodic food should be supplied during days of snowing. Field investigation suggests time budget pattern is different in different temperature conditions. It indicates that the activities of Great Bustards are highly restricted to ambient conditions; on the other hand, it also demonstrates that Great Bustards have great adaptive ability to environmental changes. Further research on the relationship between behaviors and environment factors should be carried out to accomplish species persistence and population development.

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