

Time budgets and habitat use of White-naped Cranes *Grus vipio* in the Ulz river valley, north-eastern Mongolia during the breeding season

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Summary

Habitat loss and degradation are critical threats for the globally threatened White-naped Crane *Grus vipio*. We estimated the size of the area used per day and the time budgets of parental and non-parental White-naped Crane pairs in north-eastern Mongolia during 2000 and 2001. Six parental crane pairs used an area of 11–155 ha per day. The maximum distance of a focal parental crane from the roosting-site was 3,030 m. Habitat conservation measures for breeding White-naped Cranes need to be targeted to within at least 3 km of the roosting-site or nest-site. Parental cranes spent $79.6 \pm 4.8\%$ of the daylight period foraging and had reduced preening and resting behaviour to $4.4 \pm 1.9\%$. Pairs without juveniles showed a pronounced period of resting and preening behaviour during midday, which was absent in parental cranes. This indicates that parental cranes may be time-stressed. We conclude that increases in feeding-related activities (e.g. caused by a decrease in food availability) are likely to be at the expense of parental vigilance. Conversely, increases in vigilance (due to e.g. increased disturbance) may have a negative impact on feeding-related activities. Both increases can potentially negatively affect reproductive success in this Vulnerable species.

Introduction

The White-naped Crane *Grus vipio* is globally threatened (Vulnerable fulfilling criteria A2c+3c; IUCN 2006). Mongolia is an important breeding area for the species (Goroshko and Tseveenmyadag 2001, 2002, Gombobaatar 2002a, b, Bradter *et al.* 2005). In Mongolia, White-naped Cranes nest in river valleys, along lake edges and in other wetlands, often in the vicinity of pastoral families. Habitat loss and degradation throughout the breeding range are critical threats to the species (Meine and Archibald 1996, BirdLife International 2001). In Mongolia, plans for large-scale agricultural, industrial and infrastructural development and overgrazing by livestock are particularly likely to be detrimental to the breeding population (BirdLife International 2003).

For effective conservation measures, a sound understanding of the biology and ecology of the species is paramount. Studies carried out in China (e.g. Li Chunyuan *et al.* 1991, Li Peixun *et al.* 1991, Su *et al.* 1991, Yuan and Li 1991), Russia and Mongolia (e.g. Fujita *et al.* 1994, Bold *et al.* 1995, Dugintsov and Pankin 1995, Gombobaatar and Sumiya 1998, Smirenski 1999, Tseveenmyadag and Goroshko 2001, Goroshko and Tseveenmyadag 2001, 2002, Gombobaatar 2002a, b, Goroshko 2002, Bradter *et al.* 2005) have provided valuable information on numbers and distribution of White-naped Cranes during the breeding season as well as on breeding behaviour, breeding success and nest-site locations. However, much basic information, for example on foraging habitats, is still not available.

To allow targeting of conservation measures, it is important to know the spatial requirements of White-naped Crane pairs. Very few attempts to estimate the size of White-naped Crane territories have been made (e.g. Su *et al.* 1991, Li Peixun *et al.* 1991). To our knowledge there is no estimate of the size of the daily foraging area or information on its position in relation to the roosting-site available. Neither are habitat requirements of White-naped Cranes on their daily foraging area known. Time budget studies are also an appropriate tool to assess the quality of a particular area and can indicate factors limiting a population (e.g. Exo 1992). They can indicate whether time, food availability and/or predation pressure are limiting factors and in doing so can provide information facilitating the development of conservation strategies.

Time budget studies on Eurasian Cranes *Grus grus* have shown a bimodal activity pattern. A foraging peak in the morning and afternoon separated by a period of preening behaviour during midday has been found in summering (Wilkening 1999) and wintering Eurasian Cranes (Alonso and Alonso 1992). However, during a more demanding winter of scarce food supply, this pattern almost disappeared (Melo *et al.* 1999). Parental cranes spend more time being vigilant than non-parental cranes (Nowald 2001) even whilst in the wintering area (Alonso and Alonso 1993). A comparison of the time spent foraging by parental and non-parental birds may indicate whether parental birds are likely to be able to tolerate or compensate for additional pressures (e.g. increased disturbance, decreased food availability) without affecting reproductive success.

Therefore, the main aims of our study were: (a) to obtain time budgets and behaviour patterns for White-naped Crane pairs during the chick-rearing period to assess whether or not parental cranes are time-stressed; (b) to provide data on the size and habitat structure of the daily used area to determine which areas need to be targeted for conservation measures for the species.

Study area and methods

Study area

The study area covers 270 km of the Ulz river basin and the nearby lake Galuut Nuur ($48^{\circ}51' N$, $112^{\circ}6' E - 49^{\circ}41' N$, $115^{\circ}19' E$) (Figure 1). The Ulz river basin is listed as a key breeding area for the White-naped Crane (Meine and Archibald 1996). It is located in Khentii and Dornod Aimag (Provinces) of north-eastern Mongolia. Altitude of the study area varies between 640 m and 1,000 m. The river basin is mostly open with only a few willow trees (*Salix* sp.). It is largely dominated by typical wetland vegetation (Cyperaceae, Juncaceae and reed *Phragmites australis* syn *communis*) interspersed with seasonal and permanent water bodies (flooded areas and ponds). Scattered along the river basin are the winter and summer as well as year-round homes of pastoral families. Cattle, horses and camels graze both the river basin and the adjacent steppe while sheep and goats keep to the steppe. Two villages, Bayan-Uul ($49^{\circ}7' N$, $112^{\circ}41' E$) and Dashbalbar ($49^{\circ}33' N$, $114^{\circ}24' E$) are situated in the study area. Parts of Mongol Daguur Strictly Protected Area and Ugtam Nature Reserve are also included. Mongol Daguur Strictly Protected Area is an IBA (BirdLife International 2004), Ramsar site, North East Asian Crane Network site and part of the trilateral Dauria International Reserve of China, Russia and Mongolia (Anonymous 1998). The Ulz river basin has localized high concentrations of breeding pairs. In 2001, 42 territorial pairs were recorded in the study area (Bradter *et al.* 2005). Fieldwork was carried out from May to August in 2000 and 2001.

Selection of focal pairs

Locations of pairs were determined by searching the river basin with telescopes and binoculars from nearby hills (see Bradter *et al.* 2005). Focal pairs were selected in areas allowing the observation of daytime activities simultaneously from two hill observation points. Bird locations obtained by triangulation are most accurate for angles close to 90° and we tried to select pairs in areas that allowed this. Chick age was estimated by assessing chick size in comparison with

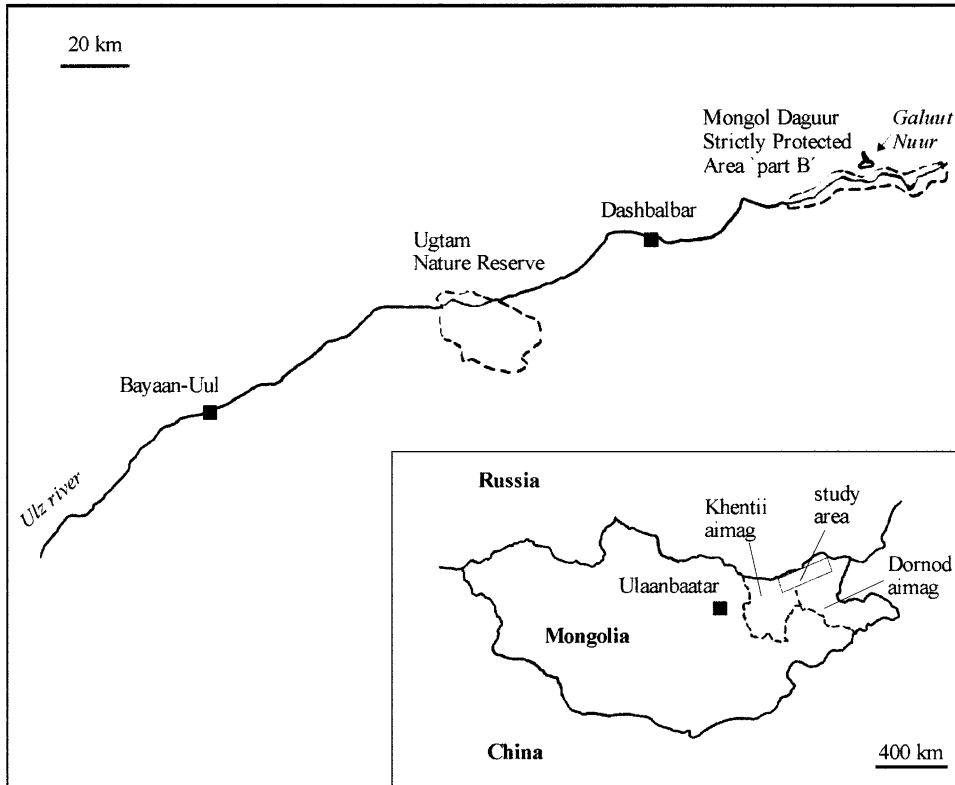


Figure 1. The study area at the Ulz river and its location in north-eastern Mongolia. Broken lines denote protected areas.

estimated hatching date obtained from egg flotation tests based on data from Florida Sandhill Cranes *Grus canadensis pratensis* (Fisher and Swengel 1991). Five pairs with chicks were selected in both years and six pairs without chicks in 2000. In 2001, observations of four focal pairs were carried out at an approximate chick age of 15 days and (after the death of the offspring of one pair) of three pairs at an approximate chick age of 30, 55 and 65 days.

Focal pair observation

Behaviour and location of both adults of a pair were recorded every 10 minutes throughout a full observation day (focal sampling, instantaneous time sampling; Martin and Bateson 1986). In 2001, continuous observations were carried out from dawn to dusk. In 2000, observations were allowed to start at any time of day and were continued at dawn on a following day, until a full observation day was covered. If visibility allowed, we recorded the time difference to sunrise and sunset of the first pair partner leaving from or arriving at the roosting-site.

Behaviour was recorded in the following categories: foraging, preening, resting, locomotion, standing, other (alarm, brooding, aggression), and as 'out of sight' when a focal bird was hidden from view. During foraging, cranes interrupt feeding bouts with short vigilance bouts (standing and scanning the surroundings) of only a few seconds (e.g. Alonso and Alonso 1993) and short bouts of walking while searching for food (for a description of foraging behaviour see e.g. Johnsgard 1983, Meine and Archibald 1996). Therefore, we recorded focal birds as foraging when

they were recorded picking or digging at the sample point or within an estimated 15 seconds after standing or walking (for behaviour classes in studies on cranes, see e.g. Alonso *et al.* 1986, Eguchi *et al.* 1991, Alonso and Alonso 1992, 1993, Pae and Won 1994, Fox *et al.* 1995, Nowald 1995, Melo *et al.* 1999, Wilkening 1999).

Location of a bird was determined by taking a compass bearing of the focal bird simultaneously from two observation points. Accuracy of the compasses was $\pm 1^\circ$ to $\pm 2^\circ$. Bearings were corrected for magnetic deviation with data obtained from Sukhbaatar *et al.* (2002). GPS coordinates of observation points were recorded and locations of focal birds determined by triangulation in the software program Tracker 1.1 (Tracker Radio Location System, Stockholm, Sweden).

Habitat recording

Habitat characteristics of areas used by three pairs during focal bird observations were recorded in August at sampling points on a 100–200 m grid (depending on the size of the area sampled). We recorded vegetation height (averaged over three samples), ground condition (dry, moist or height of standing water) and whether or not the area was dominated by wetland vegetation (Cyperaceae, Juncaceae, reed). Later, vegetation height was grouped into two categories, 20–50 cm and >50 cm. Ground condition was grouped into the categories dry or moist/flooded.

Data analysis

Locations of focal birds were plotted using the software program Tracker and the area used per pair and per observation day calculated using a minimum convex polygon (White and Garrot 1990). When two distinct areas were used, two minimum convex polygons were constructed and their respective areas summed. Sample points for which we could not plot a location of a focal bird did occur (e.g. focal bird hidden behind some willow bushes). When the focal bird was located inside the area covered by the minimum convex polygon (e.g. an area hidden by willow bushes known to be inside the polygon), the observation day was retained. Otherwise the observation day was omitted. When the angle between the two bearings was small ($<30^\circ$), the triangulated location of the focal bird was considered to be not sufficiently accurate and the observation day was also omitted. Sixteen observation days of six pairs with juveniles and three observation days of three pairs without juveniles were retained in the analysis. The furthest distance from the roosting-site to any location of a focal pair or pair partner during an observation day was also calculated.

Weather conditions strongly influenced the length of time over which we were able to observe crane behaviour during dawn and dusk. We defined the daylight period of an observation day as the period between sunrise and sunset (as recorded in the field) and time budget is given as a percentage of the daylight period. Preening and resting as well as “out of sight” recordings during the daylight period in which the focal birds were known to be at the roosting-site were grouped into preening/resting. Observation days with more than 5% “out of sight” recordings during the daylight period were omitted from the time budget analysis. In 2000, 12 and, in 2001, 17 observation days of five pairs with juveniles were retained. Three observation days of three pairs without juveniles in 2000 were retained. In contrast, behaviour patterns are presented including recordings during dawn and dusk and including observation days of pairs with more than 5% ‘out of sight’ recordings. Behaviour patterns are presented for ten parental and six non-parental pairs.

To avoid problems of statistical independence of proportional data (unit-sum constraint), time budget data were analysed using compositional analysis (Aebischer and Robertson 1992, Aebischer *et al.* 1993). Zero proportions were replaced with values an order of magnitude less (0.0001) than the lowest observed proportions (Aebischer *et al.* 1993) and log-ratios calculated. GLM was used to test for year differences in time budget (Quinn and Keough 2002).

Results

Time budgets

The main behaviour category recorded during the daylight period was foraging (Table 1, Figure 2). Parental cranes spent $79.6 \pm 4.8\%$ (10 pairs, 2000 and 2001) of the daylight period foraging whereas pairs without juveniles spent only $60.3 \pm 14.0\%$ (three observation days of three pairs) of the daylight period foraging. We found no difference in time budget for parental cranes between 2000 and 2001 (Wilk's lambda, $F = 0.16$, $P = 0.96$). Foraging time shows a slight but non-significant increase with chick age during the second and third week ($r_s = 0.40$, $P = 0.58$) (Figure 3). Preening/resting was recorded during $4.4 \pm 1.9\%$ of the daylight period for parental pairs and during $24.3 \pm 11.1\%$ of the daylight period for non-parental cranes.

Foraging behaviour also determined the overall daylight activity pattern (Figure 2). Whereas pairs without chicks showed a bimodal foraging activity pattern, we did not find any distinct diurnal patterns of behaviour for pairs with chicks. Pairs without juveniles sometimes went to a shallow water body during midday for a period of resting and preening which we did not observe in parental cranes. With shorter days and older juveniles, pairs increasingly left the roosting-site before sunrise ($r_s = 0.78$, $P < 0.001$) and returned after sunset ($r_s = 0.53$, $P = 0.006$) (Figure 4).

Habitat use

The size of the area used by crane families ranged from 11 to 155 ha per day (Table 2). Pairs rearing juveniles used on average 65 ± 31 ha per day, pairs without juveniles 111 ± 35 ha per day.

Two pairs used a composite area of 165 and 379 ha, respectively, during observation days with chicks aged *c.* 15, 30, 55 and 65 days (see Figure 5 for an example of one pair). Maximum recorded distance of a focal parental bird from the roosting-site was 3,030 m.

Start and finish of daily movements was always the roosting-site. Five pairs retained their nest-site at the periphery of their minimum convex polygon (e.g. Figure 5). The sixth pair permanently moved to another wetland about 2 km from the nest-site, probably because the wetland adjacent to the nest-site was too small to provide enough foraging habitat for the family.

The habitat grids sampled (72 points) covered more than 80% of the minimum convex polygon of five observation days of three pairs. The majority of grid points were dominated by wetland vegetation (76–100%) in the 20–50 cm height class (72–94%). The majority of habitat points for two pairs were dry (83% and 94%, $n = 45$) while only 33% of habitat points of the third pair were dry ($n = 27$).

Table 1. Time budget of White-naped Crane pairs in north-eastern Mongolia between sunrise and sunset.

Behaviour category	2000				2001	
	Without juveniles		With juveniles		With juveniles	
	Mean \pm SD ($n = 3$ pairs)	Min.–Max. ($n = 3$ obs-d)	Mean \pm SD ($n = 5$ pairs)	Min.–Max. ($n = 12$ obs-d)	Mean \pm SD ($n = 5$ pairs)	Min.–Max. ($n = 17$ obs-d)
Foraging (%)	60.3 ± 14.0	41.0–73.6	81.1 ± 4.5	63.2–93.7	78.1 ± 4.8	63.9–88.2
Standing (%)	5.8 ± 3.5	2.3–10.7	5.1 ± 2.7	0.6–16.8	7.3 ± 2.4	0.0–14.7
Preening/resting (%)	24.3 ± 11.1	14.6–39.9	5.0 ± 2.0	0.0–12.9	3.7 ± 1.5	0.5–6.4
Locomotion (%)	7.3 ± 2.8	4.6–11.2	6.3 ± 1.7	0.5–14.3	6.2 ± 1.8	1.6–11.8
Other (%)	2.3 ± 0.9	1.1–3.4	0.8 ± 0.4	0.0–2.4	4.3 ± 1.4	0.0–9.8
Out of sight (%)	0.0 ± 0.0	0.0–0.0	1.7 ± 0.8	0.0–4.7	0.4 ± 0.5	0.0–4.1

Mean \pm SD are percentages of the daylight period for pairs with juveniles and pairs without juveniles. obs-d number of observation days.

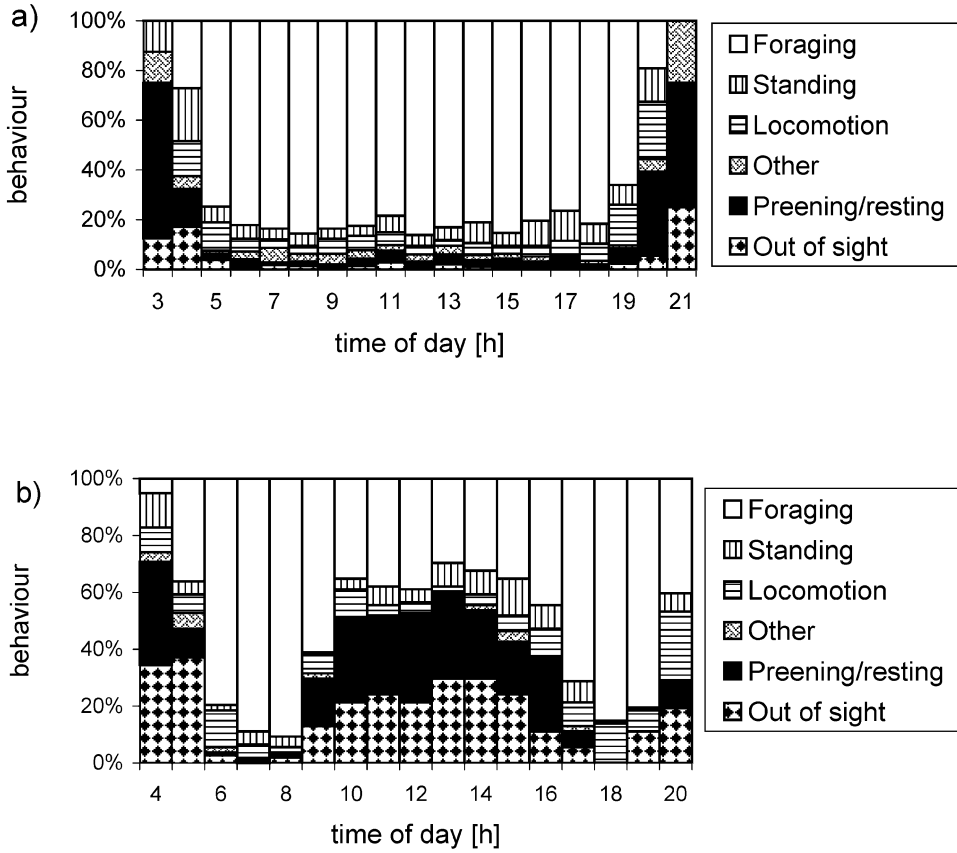


Figure 2. Diurnal behaviour patterns of White-naped Cranes in north-eastern Mongolia. (a) Pairs with chicks in 2000 and 2001 (10 pairs, 29 observation days); (b) pairs without chicks in 2000 (six pairs, 9 observation days). Time is GMT + 8 hours.

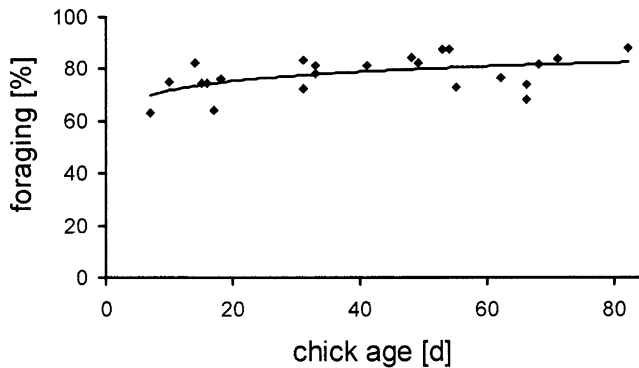


Figure 3. Foraging as a percentage of the daylight period (between sunrise and sunset) for pairs with chicks of known ages (six observation days of two pairs in 2000, 17 observation days of five pairs in 2001).

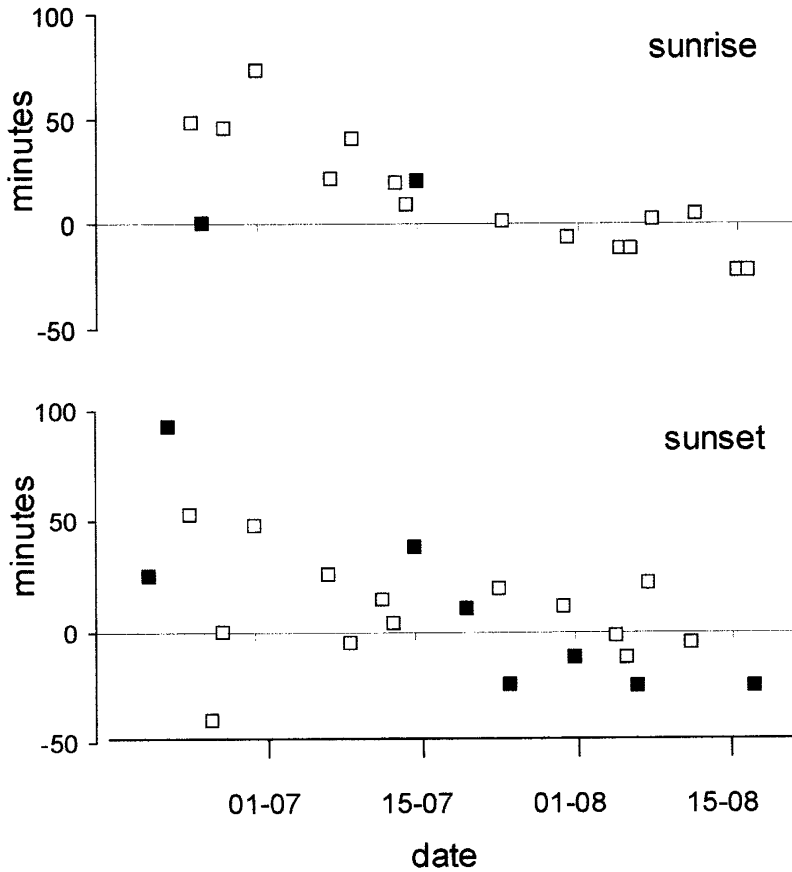


Figure 4. Departure and arrival of parental White-naped Crane pairs from and at the roosting-site in relation to sunrise ($r_s = 0.78, P < 0.001$) and sunset ($r_s = 0.53, P = 0.006$). Filled squares, 2000; unfilled squares, 2001.

Table 2. Size of area used, and maximum distances between feeding and roosting sites, of White-naped Crane pairs with and without juveniles in north-eastern Mongolia.

	Mean \pm SD	Min.-Max.
Size of area		
Pairs with juveniles (14-c. 80 days)	65 \pm 31 ha (6 pairs)	11-155 ha (16 obs-d)
Pairs without juveniles	111 \pm 35 ha (3 pairs)	62-144 ha (3 obs-d)
Maximum distance		
Pairs with juveniles (14-c. 80 days)	1209 \pm 442 m (6 pairs)	360-3,030 m (16 obs-d)
Pairs without juveniles	2,033 \pm 353 m (3 pairs)	1,630-2,490 m (3 obs-d)

obs-d number of observation days.

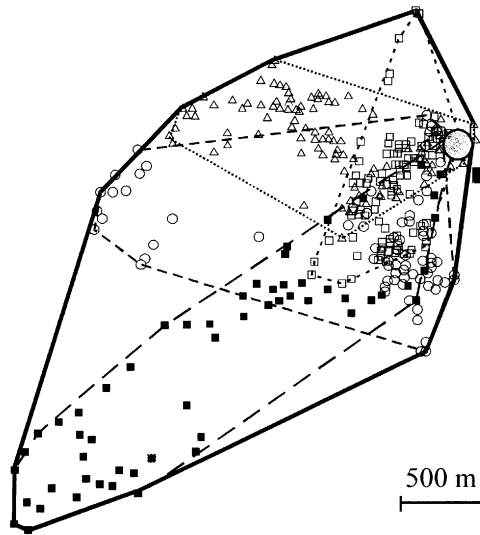


Figure 5. Typical example of the area used by a White-naped Crane family during four observation days in north-eastern Mongolia with one chick aged 17 days (unfilled squares), 33 days (filled squares), 55 days (circles) and 66 days (triangles). Respective minimum convex polygons and a composite minimum polygon are shown. Circle: roosting-site; large square: nest-site.

Discussion

Time budgets

Behaviour patterns of non-parental White-naped Crane pairs in the Ulz river valley show a typical bimodal activity pattern with two foraging peaks, in the morning and in the afternoon (Figure 2). Foraging times are separated by a quite pronounced peak in preening and resting activity during midday. The peak in 'out of sight' recordings at midday reflects the fact that pairs often chose a hidden place in a shallow water body for the midday break. Both the time budgets – in total 24% of preening and resting activity – and the behaviour patterns indicate that White-naped Cranes without chicks were not time-stressed to meet their daily energy demands. Oversummering Eurasian Cranes in Germany show a very similar pattern in feeding activities (Wilkening 1999). Preening was 17% in oversummering Eurasian Cranes (Wilkening 1999), 17% in birds overwintering in Portugal (Melo *et al.* 1999), 10% in parental wintering birds and 15% in non-parental wintering birds in Spain (Alonso and Alonso 1993).

In contrast, a period of comfort behaviour between sunrise and sunset was totally absent in parental White-naped Cranes (Figure 2). Preening and resting behaviour was reduced to only $4.4 \pm 1.9\%$. Nowald (2001) found a similar value of 4.8–6.9% preening behaviour in Eurasian Crane families during the breeding period. Foraging as recorded in this study (see Methods) encompasses all activities related to feeding (searching, handling and eating food) and also short vigilance (standing) bouts. Alonso and Alonso (1993) and Nowald (2001) found higher vigilance levels in parental than in non-parental Eurasian Cranes. High foraging levels by parental birds (80%) in our study are therefore likely to be caused partly by high vigilance levels.

Focal parent birds in our study had reduced comfort behaviour between sunrise and sunset to a minimum. They might be able to expand their foraging time by making increased use of dawn and dusk. However, during the later stages of the chick-rearing period, focal parent birds already

made use of dawn and dusk (Figure 4) and it is unlikely that a significant further increase could be achieved. A further increase in feeding-related activities could probably only be achieved by reducing parental vigilance. Conversely, increased levels of vigilance due to disturbance could probably only be achieved at the expense of feeding-related activities.

Slow-moving herds of grazing animals did not cause visible alarm unless approaching the roosting-site while cranes were there. Focal birds were usually not recorded near grazing livestock herds and we assume that cranes avoided their close proximity. This could potentially exclude them from good foraging habitat and be a considerable problem in areas with many herds or if livestock numbers in Mongolia increase further (e.g. Oyun-Erdene 1998). Identified causes for alarm of parent cranes were horsemen, carts, cars, fast-moving livestock herds, dogs, Grey Wolves (*Canis lupus*) and Eurasian Cranes or other White-naped Cranes. Considerable alarm was caused by horsemen who passed close to White-naped Crane families. In one family, chick and parents were separated for up to 1.5 h by a passing horseman. Some of the lowest proportions of foraging time were recorded for this family in an area frequented by horsemen. Repeated disturbance of this level could lead to insufficient energy intake and consequently to reduced reproductive success. Effects of time-constrained feeding activities on reproductive success need not necessarily become obvious in the breeding areas. Juveniles in better body condition might have higher chances of surviving migration (e.g. Cam *et al.* 2003).

Habitat use

Parental White-naped Cranes in the Ulz river valley used a daily area of 65 ± 31 ha and two pairs used a composite area of 165 and 379 ha, respectively, during four observation days. For a Eurasian Crane family, Nowald (1999) gives 68.9 and 38 ha as the maximum area used per day by a family during two breeding seasons and 103 and 77 ha, respectively, for the composite area. McMillen (in Baker *et al.* 1995) found an average home range for Sandhill Crane chicks of 157.9 ha with a core area of 55 ha.

Fujita *et al.* (1994) found that White-naped Cranes prefer wet steppe areas (of which the Ulz river valley is part). Within this climate type, foraging areas of White-naped Cranes include wetlands, adjacent grasslands and cropland (Meine and Archibald 1996). Our observations show that foraging largely took place in wetland; however, large parts of the daily area used by two out of three pairs were dry. Although a few wet microhabitat features were present in these areas, the plots of focal bird locations (Figure 5) do show a widespread use of the area rather than concentrations of points. This indicates that the wide areas of dry habitats were used for foraging. However, the study took place during years of severe droughts occurring in consecutive summers from 1999 onwards (Iwao and Takahashi 2006) and many temporarily flooded areas had already disappeared by the time the chicks had hatched (pers. obs.). If shallow flooded areas had been available to a greater extent, then they might possibly be preferred for foraging by White-naped Cranes (e.g. during an observation day of an incubating pair, a shallow flooded area of only <0.25 ha was used during 42% of the time the focal bird was visible).

Management implications

Many herdsmen can identify White-naped Cranes and know if they have a pair or family in the vicinity. White-naped Cranes can usually be seen from a distance when on horseback. It would require relatively little effort for horsemen to avoid getting too close to a White-naped Crane family and they might willingly do so if made aware of the disturbance caused.

White-naped Cranes prefer wet areas with high nest concealment and low grazing pressure as nest-sites (Bradter *et al.* 2005) and grazing animals should therefore be kept out of potential nest-sites (i.e. flooded areas and ponds within the breeding area). In foraging areas, White-naped Cranes avoided the proximity of livestock herds and the presence of many herds might leave

them with insufficient foraging habitat. Slow-moving herds did not visibly alarm the cranes and livestock grazing up to a certain stocking density might not be detrimental, and might even be beneficial. We do not know whether livestock grazing itself has a positive or negative effect on food availability or accessibility (e.g. by reducing vegetation height) and these questions need to be answered before recommendations on grazing in White-naped Crane foraging areas can be given. Maximum distance of a focal animal from the roosting-site was 3,030 m. If targeted measures for the protection of the White-naped Crane are to be implemented, they should be focused within c. 3 km of the roosting-site and nest-site. If roosting and nest-sites are not known or if management is to be extended to areas which are presently unoccupied, measures should be focused within c. 3 km of flooded areas as flooded areas are potential nest- and roosting-sites.

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