Diurnal activity-time budget of the black-necked crane, *Grus nigricollis*, and its behavioral response to human disturbances, in foraging habitats of Bumdeling Gewog & Yangtse Gewog, Bhutan

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Abstract
Focal Sampling method was adopted to study the activity-time budget and behavioral response of *Grus nigricollis* to human disturbances at Bumdeling Gewog and Yangtse Gewog during the winter period, from 29 December 2016 to 20 February 2017. A total number of 1932 of behavioral events, amounting to 9,660 minutes, were recorded (1732 adults and 201 juveniles) during the observation period of 48 days. All observations were carried out between 07:30 a.m. and 06:00 p.m. and observation periods of the day were further divided into early morning (07:30 a.m. to 10:00 a.m.), late morning (10:00 a.m. to 12:00 a.m.), early afternoon (12:00 a.m. to 3:00 p.m.), and late afternoon (03:00 p.m. to 06:00 p.m.). The result showed that *Grus nigricollis* spent more time foraging (42.1±6.3), followed by vigilance (22.8±6.3), locomotion (18.7±6.4), maintenance (13.4 ±6.2), out of sight (2.2 ±6.3), and resting (0.9±6.3). The diurnal rhythm of different behaviors varied according to time, with foraging behavior reaching its peak at 11:00 a.m., 02:00 p.m, and 04:00 p.m. and resting behavior peaking at noon. The study revealed that Maidung constituted a higher set of threats as compared to Khabretsey and Bategang, with significantly high percent frequency of people and vehicular movement, unregulated tourists and visitors, and disturbances by dogs and livestock. Disturbances were categorized based on the types of disturbances recorded in these regions during the field survey. *Grus nigricollis* spent more time scanning in the presence of non-lethal human disturbances, however, flight initiation probability increased when approached more directly and closely (<50m). Based on the result of the study, conservation management should initiate public education to reduce unnecessary disturbances by people and initiate community co-management of its site to provide better foraging grounds for the vulnerable *Grus nigricollis*.

Keywords: *Grus nigricollis*, migratory bird, winter habitat, activity-time budget, foraging, vigilance, human disturbances

1. Introduction

Cranes are among the most ancient and unique families of birds on Earth, and fly thousands of kilometres without caring for the political boundaries of countries created by humans (Meine & Archibald, 1996). From their loud and high-pitched trumpeting notes to intricate dances, cranes have enchanted mankind for centuries. *Grus nigricollis*, (henceforth, referred to as *G.nigricollis*) is the only member of the family Gruidae residing almost exclusively at an altitude of 1,900 to 4,900 masl and the only species of cranes endemic to China, Bhutan, and India (Li & Bishop, 1999, RSPN, 2013). *G.nigricollis* with an estimated global population of 11,000 individuals is classified by IUCN as a vulnerable species globally (Bishop & Dolma, 2007; Farrington & Xiulei, 2013, Birdlife International, 2017).

Widespread loss and degradation of habitats are the main threats faced by *G.nigricollis*, which has the most restricted range of all cranes, after the Blue Cranes (Harris & Mirande, 2013). These problems are most serious in the winter habitats, where unregulated anthropogenic activities such as economic development, peat mining, overgrazing, mechanized farming, etc., have led to the reduction in overall wetland size and the fragmentation of wetlands, resulting in less suitable habitats and increased human disturbances (Meine & Archibald, 1996). The shrinkage of wetland in northeast Yunnan province, China, have declined the number of *G.nigricollis* from more than 20 in the 1990s (Li, 1996) to less than 12 in 2002 (Li & Yang, 2003), and some existing wintering sites harbor an unstable population of fewer than 10 cranes except the Napahai and Bata Hai wetlands. Napahai and Bata Hai wetlands are the last refuges for the central population of *G.nigricollis*, with the former having the largest number (Wei & Wu, 1994; Han 1995; Li, 1996; Yang, 2005).

During its annual migration, more than 500 *G.nigricollis* overwinters in Bhutan every winter, for five months across different wintering sites in the country (RSPN, 2008). Although the overall population of *G.nigricollis* visiting Bhutan has been on the rise over the last two and half decades, the number of *G.nigricollis* visiting Bumdeling, in particular, has been steadily declining (RSPN, 2008), and this is of great concern. *G.nigricollis* population in Bumdeling has never exceeded 200 individuals since 1992; instead, the population trend has been on a decline (Sherub, 2008). *G.nigricollis* population in Bumdeling has fluctuated (1987-2017) between 91-203 individuals, and the winter of 2016-2017 recorded the lowest *G.nigricollis* population.

Bumdeling faces higher sets of threats as compared to other wintering sites in the country (Lhendup & Webb, 2009). Though the specific cause of the decline of *G.nigricollis* population in Bumdeling lacks in-depth studies, it is largely attributed to the loss of paddy fields caused by the seasonal floods, economic development, especially in and around the site. The problem may be further aggravated by increasing human disturbances such as the frequent movements of vehicles and people, domestic dogs, unregulated visitors coming to watch cranes, and machinery in the agricultural fields near foraging sites (Sherub, 2008, Lhendup, 2007).

Literature shows that many extrinsic factors such as predation risk, food density, group size and intrinsic factors such as sex, reproductive status, social rank, affect vigilance in animals (Li et al., 2012). However, the factor that has attracted the most attention is human disturbances as a form of predation risk (Frid & Dill, 2002). Factor such as age also affects vigilance; for instance, adults are much more vigilant than juveniles. According to Frid & Dill, (2002), non-lethal disturbance stimuli caused by humans can be viewed as a form of predation risk as human disturbances in artificial wetland such as paddy fields could induce behavioral response similar to those associated with predation risk. The risk-disturbance hypothesis predicts that animals exposed to human disturbances will elicit anti-predator behaviors that divert time and energy from fitness-enhancing activities, which can potentially exceed the impact of natural enemies on wildlife behavior.

Studies have documented behavioral responses, such as vigilance, avoidance, and flight, to human disturbances for a variety of animals (Frid & Dill, 2002). *G.nigricollis* foraging in agricultural fields may coordinate their vigilance to increase detection ability by increasing vigilance to scan their surroundings leaving less time to forage (Luo et al., 2012). Furthermore, increased vigilance may also force *G.nigricollis* to feed at disturbed sites, or take more risk to feed (Luo et al., 2012). The human activities of the communities residing within the vicinity of crane habitat had a direct impact on the foraging pattern of the *G.nigricollis* population. The cranes may spend significantly less time foraging, and more time in vigilance in highly disturbed agricultural fields. Alternatively, it may not exhibit any significant response if species are habituated to the disturbances because the behavioral response of animals also depends on tolerance level and availability of alternative foraging sites (Bechet et al., 2004). The non-availability of suitable alternative habitat may attract cranes to disturbed foraging habitats (Frid & Dill, 2002).

G.nigricollis in Bumdeling is almost solely dependent on agricultural wetlands (Sherub, 2008) but cranes in paddy fields can be intentionally or unintentionally disturbed by normal farming activities (Elphick, 2010; Czech & Parsons, 2002). Although *G.nigricollis* is quite tolerant of people, if they are approached more directly or closely, then they may respond by spending more time scanning or fleeing or initiating flight (Frid & Dill, 2002). In order to survive and reproduce, *G.nigricollis* must effectively carry out activities, each requiring an expenditure of time (Verner, 1965). Each activity performed by an individual either requires energy or is directed to gain energy (Goldstein, 1988; Khan et al., 2010). Winters are a critical period in the annual cycle of migratory cranes as sufficient energy supplement in this period are critical to their migration, reproduction, and survival (Morrison et al., 2007). Therefore, activity-time budget studies can be an appropriate tool to understand the activity rhythm and proportion of time spent in behavioral activities (Khan et al., 2010) and behavioral response of *G.nigricollis* to human disturbances as winter habitats of cranes in Bumdeling and Yangtse are in close proximity to human settlements. Although several authors reported a general concern about the adverse impacts of human disturbances on *G.nigricollis*, no study has been conducted to observe the behavioral response of *G.nigricollis* to human disturbance.

Therefore, the objectives of this research are:

i. To develop activity- time budgets of *G.nigricollis*
ii. To investigate how *G.nigricollis* show behavioral response to local human disturbances in its foraging sites.
iii. To recommend conservation activities to provide suitable habitats for *G.nigricollis*

1.4 Research Questions

i. How does *G.nigricollis* allocate their time between different behavioral acts?
ii. On average, do adults spend more time of the day in vigilance activity than juveniles?
iii. What is the relationship between different disturbance factors and vigilance factors?

2. Materials and methods

The study sites fall within the Bumdeling Wildlife Sanctuary (BWS lies at 27º 47’ 50” N - 27º 79’ 72” N and 91º 26’ 79” E - 91º 43’ 77” E) in Trashiyangtse. The main foraging grounds of *G.nigricollis* are spread across Bumdeling and Yangtse gewog, while the only roosting area, Dowaling (27º 40’ 31” N, 091º 26’ 24” E), is in Bumdeling (Namgay & Wangchuk, 2016). The overwintering ground of Bumdeling is located at the lowest elevation (1900m) and has a narrower valley than other wintering sites in Bhutan.

The habitat types used by *G.nigricollis* are agricultural wetlands and dry farmlands, riverbeds, sandy and cobble singles along the Kholong Chu River. However, cranes in these regions are almost solely dependent on agriculture farmlands and paddy terraces. A result of a household survey conducted by Sherub, (2008) also concluded that paddy wetlands were the most preferred forage habitat of *G.nigricollis* (Sherub, 2008). According to Sherub (2008), 28 foraging sites have been identified and all these areas are scattered within 11.5 km stretches along the Kulong Chu River. Patches that were relatively smaller in size were occupied by family pairs or sub-adult feeding flocks and maintained as their feeding territory, while social groups occupied larger sites and the crane’s flocks moved from one feeding sites to the other in search of food. Maidung (27º 39’ 51” N, 091º 26’ 37” E) in Bumdeling gewog and Khabretsey (27º 37’ 87” N, 091º 29’ 50” E), and Bategang (27º 36’ 35” N, 091º 30’43” E) in Yangtse gewog were visited for regular behavioral observations because paddy fields of these areas were visited by larger flocks of *G.nigricollis* every year.

The cranes foraged within the radial distance of 5-10 km from their roosting site. Subsistence agriculture farming and livestock rearing are the main sources of livelihood for the local communities. Farmers are dependent on the cultivation of maize, rice, finger millet, and potatoes.

Khabretsey and Bategang are in close proximity to human settlement (although not densely populated) except Maidung, which is closest to the roosting area. The wide arrays of paddy lands in Maidung are located next to the flood plains of Kulong Chu River and because of its proximity to the river and the opportunity to watch *G.nigricollis* (during the winter), it has become one of the favorite destinations for visitors and tourists. A small farm road meanders through the paddy fields and is used by people and vehicles alike. The BWS has taken initiatives to keep disturbance factors at bay by constructing a wooden gate to bar people from using this farm road without much success. The BWS prohibits people from engaging in any recreational activities in close proximity to these sites in the winter.

2.1. Field equipment and materials

A Binocular (6×8) was used to observe *G.nigricollis* at foraging sites. Observation sheets, stopwatch, pencils, and eraser were used for recording data and information in the field. Global Positioning System (GPS) coordinates of observation points of the foraging areas and roosting sites were recorded using a Garmin Etrex 20.

2.2 Behavioral observation

The field data collection was carried out from 29th December 2016 to 20th February 2017. A preliminary survey was carried out to locate the birds’ potential foraging areas prior to the start of the fieldwork. A total of 48 days were spent in the field, daily observing *G.nigricollis* behavior from 07.30 a.m. in the morning till 6 p.m. or till the time the birds left for their roosting area. Observations were made on different periods of the day: early morning (07:30 a.m. to 10:00 a.m.); late morning (10:00 a.m. to 12:00 a.m.); early afternoon (12:00 a.m. to 3:00 p.m.); and late afternoon (03:00 p.m. to 06:00 p.m.). Days with strong winds, rain, snow, or heavy fogs were avoided to minimize bias caused by the effects of extreme weather (Yang et al., 2007). Behavioral observations were obtained in all three foraging grounds and a minimum of one- or two-nights' interval was maintained before it was observed again. Observations were carried 100 m away from the crane's flocks to reduce potential disturbances by the observer.

Focal Sampling Method (Altmann, 1974) was employed to collect data on behavioral acts every five minutes at the aforementioned time intervals. Focal individuals were randomly selected from the flock and were followed visually for 5 minutes and all the behavioral acts observed during the sampling were recorded irrespective to what the crane was doing earlier or later. An observation session that lasted less than 5 minutes was neglected and not included and it seldom happened. With this random procedure, it was estimated that all individuals had the same probability of being sampled. However, due to the small population size, an individual might have been observed more than once on the same day since marking individuals was not possible.

Direct-counting Method was employed to record the number of individual cranes, including adults and juveniles in a group (comprising of several flocks). The habitat type, age (adult or juvenile), disturbance types, and distance to disturbances were noted before each behavioral session began. Additionally, GPS coordinates of a site were recorded. Disturbances were defined as human activities occurring within the range of 150 m of the cranes and later, it was quantified as the frequency of occurrences per hour. During the presence of disturbances, cranes were selected opportunistically from the flock to measure the scanning duration (minutes) or its effect on its behavior and concurrently, time spent alert was noted down with the help of the second watch. Activities of both adults and juveniles were observed in order to detect the behavioral response of juvenile in the presence of disturbance. Juveniles were easily distinguished from adults by their smaller body size and plumage color. The behaviors of *G.nigricollis* were divided into six categories (Zhou et al., 2010).

2. 3 Data analysis

Data collected from the field observations were computed and managed in Microsoft Excel spreadsheet 2013 and one set of data was converted to CSV data frame to be analyzed by R 10.2 software program (R Core Team 2013). Frequency of occurrence of each behavior was summed hourly and daily from every five minutes behavioral sample across observation time. Data was then quantified as the percentage of frequency of each behavioral category to analyze overall time budget and diurnal rhythm of *G.nigricollis*. The distribution of the time budget for each behavioral activity were tested using a program Oriana 4, from Kovach Computer Services, while excel 2013 was used for creating overall time budget graphs. The time budget data were entered in a spreadsheet like data editor with time (in hourly) as the circular data and percent frequency of behaviors as an associated linear variable and then plotted an arrow graph. Rayleigh's

Uniformity Test was calculated to test whether samples are uniformly distributed or not.

Scan rates were defined as the time spent vigilant per five minutes. Data was subjected to Shapiro-Wilk test, qqnorm and qqline (p-value = 0.01, weight = 0.10) for normality in distribution prior to conducting further statistical analysis. The dependent scan rate data was transformed (square root) to fit the normal distribution assumption and reduce right skewness. Generalized Linear Mixed Models (GLMM) were used to account for the relationships between predictor (scan rates) and categorical data (such as proximity of cranes to disturbance types (*people on foot, plying vehicles, tourists or visitors, agricultural activities, livestock and dogs*) across three sites, and group size. The main focus was to find the best-fit candidate models and therefore, following packages such as Multi-Model Inference (MuMIn*)* (Barton, 2015), Model Selection and Multi-model Inferences Based on (AICc modavg*)* (Mazerolle, 2016), Linear mixed-effects model (lme4) (Bateset al., 2017), Effects displays for Linear, Generalized Linear, and other Models *(*Effects*)* (Fox et al., 2016) and Modern Applied Statistics with S" (MASS*) (*Ripley, 2017) from Program R Package version 10.2 were used for multi-model selection. The collection of functions from MuMIn packages such as dredge*,* (which performs automated model selection enabling to generate all possible combinations of independent variables), model.sel, (that creates a model selection table from hand-picked models) and AIC_c (used as sample size was small in comparison to the number of estimated parameter) were used to formulate and compare 63 models to identify the best model before plotting an effect plots for a series of combination of predictors using the function effect from effect package (see appendixes). The functions from *lme4* such as residual, coefficient, fitted, fixed effects and random effects were used to extract some of its components. All variables that showed any significant influence ($P<0.05$) on the response variable were included in the final model. Variables were classified into three data types as given below in Table 2. The model best-predicting scan rates in focal individuals were identified by minimum AIC_c (Akaike Information Criterion adjusted for small sample size); model ranking and finally best model with the lowest AIC values (delta $AIC_c \leq 3$) were considered for variables interactions (Burnham et al., 2002). The statistical comparisons were performed with these average values using analysis-of-variance (ANOVA), rejecting the null hypothesis at $P<0.05$.

3. Results

The following in-depth findings include overall diurnal activity, rhythms, and behavioral response of *G.nigricollis* to disturbances in three foraging sites viz. Maidung, Kabretsey, and Bategang.

3.1 Overall activity pattern of the G.nigricollis

A total of 1932 behavioral events, amounting to 9,660 minutes, were recorded (1732 adults and 201 juveniles) during the entire observation period of 48 days. The predominant diurnal behaviors observed in *G.nigricollis* were foraging, vigilance, locomotion, and maintenance, and the least occurrence of behavior was resting and out of sight. Of the total observations (n=1932), the percent frequency of foraging behavior was most prevalent, accounting for (42.1%) of their diurnal time budget, followed by vigilance (22.8%), locomotion (18.7%), maintenance (13.4%), out of sight (2.2%) and resting (0.9%) respectively. Figure 3 provides a percentage breakdown of the overall activity of *G.nigricollis* wintering at Bumdeling and Yangtse gewog.

The overall activity-time budget showed that both adults and juvenile spent most of their daytime foraging but the foraging time-budget for juveniles (70.48 %) was greater than for adults (39.31%). While both adult and juvenile devoted a small proportion of their time to maintenance and locomotion, some notable differences were also observed between them. Adult (23.56 %) devoted a significant proportion of their time to vigilance behavior than juvenile (5.9 ± 0.042). Adult spent more time vigilant at Maidung (56.5%), which constitutes higher sets of threats as compared to Khabretsey (26%) and Bategang (17.5%), while no significant changes were observed in juvenile's vigilance pattern across three sites. Adult cranes had been observed resting during the study period while juvenile individuals seldom engaged themselves in activities such as maintenance and resting. The result may be biased because the sample size of the juvenile was very low (generally 5 to 6 numbers present in a social group) as compared to adult (ranges from 20 to 65 individuals).

3.2 Diurnal rhythms

The circular linear graphs showed a great variation in the diurnal pattern of *G.nigricollis*, displaying noticeable peaks and lows with respect to different periods of the day, with the lowest level of activity occurring just before sunrise. *G.nigricollis* upon reaching the foraging sites in the early morning (07:30 a.m.) directs their activity budget to forage. The time spent on foraging activity gradually increased and reached its peak at 11:00 a.m. in the late morning as depicted by the high mean vector (0.1). After a trough of two hours, the rhythm of the feeding behavior rose again and reached yet another two peaks in the late afternoon, one at 02:00 p.m. and another at 04:00 p.m. Foraging occupied a large part of the day but the distribution of time spent on this activity varies throughout the day. With the increase in temperature, foraging showed a downward trend while resting behavior showed an obvious rhythm with the temperature. The resting behavior remained insignificant throughout the day but reached its peaks usually when the temperature of the day was high.

Similarly, peaks of diurnal patterns of out of sight behavior may be correlated to the presence of high stimuli of disturbances in their foraging sites that usually flushed cranes away from the site. Maintenance or preening behavior was focused frequently from 9:45 a.m. to 11 a.m., noon to 01:00 p.m. and 03:00 p.m. Behaviors such as locomotion and vigilance showed almost similar rhythm with each of them having at least one peak before and afternoon. *G.nigricollis* respond to high stimuli of human disturbances by either spending more time in scanning or flying away from the site and returning back when the level of the disturbance subsided.

3.3 Frequency of occurrence of disturbances

The percent frequency of occurrence of disturbances such as people on foot was significantly high, accounting for (25.5%), followed by constant vehicular movement (12%), unregulated tourist and visitors (7%), livestock specifically cattle and calves (7%), and agricultural activities (1%) across the three foraging sites viz. Maidung, Khabretsey, and Bategang. Maidung constitutes a higher set of threats as compared to Khabretsey and Bategang. The disturbance factors such as the frequent movement of local people and vehicles, tourist and visitors approaching cranes closer to take better photographs, livestock and dogs were significantly high in Maidung, followed closely by Khabretsey and Bategang. The unregulated tourists and visitors, who approached the cranes directly and moved closer for clearer photographs, were responsible (3%) for causing maximum flight initiation in cranes, followed by people on foot (2%), who sometimes walked closer or when they moved closer to take good photographs. Livestock animals (2%) particularly cattle and calves that usually shared the same foraging site often tried and chased the cranes away or more often calves playfully engaged in chasing away *G.nigricollis.*

3.4 Effects of disturbances on the scan rate

The best model explained approximately 55% (weight) of the variability of scan rate and according to predictions, the predicted scan rate of *G.nigricollis* increased as the proximity of cranes to the disturbance types decreased. A model did not find any significant effect of group size on overall vigilance pattern of *G.nigricollis* and similarly, time of the day too had no significant effect on the vigilance pattern. The proportion of cranes that spent vigilant was greatest when the disturbances were at the ranges of 0-50m and 51-100m. For instance, the scan rate of the crane was significantly high when the disturbances factors were at <50m than <51-100m to *G.nigricollis*. When the distance between *G.nigricollis* and disturbance factors such as livestock were <50m, the scan rate was 0.60 minutes, but as the proximity of *G.nigricollis* to disturbances increased (<51-100m), the scan rate decreased to 0.45 minutes.

4. Discussion

4.1 Activity-time budget

The strategy of any avian winter flock is to accumulate sufficient energy to survive till the next breeding season (Caraco, 1979) and as migratory species, allocating more time to foraging behavior often increases its survival by accumulating energy reserves to meet migration cost for long perilous journeys, and for improved reproduction on breeding grounds (Khan et al, 2010). Besides, wintering cranes do not have to devote time to reproduction. The result obtained from the present study indicated that Foraging was the predominant behavior in wintering *G.nigricollis* and represents a higher proportion of activity-time budget at Bumdeling and Yangtse gewog. The result is also consistent with the time budget studies carried on for other crane species, such as hooded cranes (*Grus monacha*) (Zhou et al., 2009), Red-crowned cranes (*Grus japonensis*) (Liet al., 2013), and common cranes (*Grus grus*) (Alonso & Alonso, 1993), where feeding were seen as one of the predominant behaviors of *G.nigricollis***.** However, the wintering population of *G.nigricollis* at Bumdeling and Yangtse spent less time (42.1±6.3) foraging **as** compared to wintering *G.nigricollis* (53.05±4.93) of Dashanbao National Nature Reserve, (Kong et al., 2008), breeding *G.nigricollis* at Ruoergai Wetland National Reserve, in China (45%) (Yang et al., 2007) and Changthang in Ladakh (50%) (Khan et al., 2010). The increased disturbances at its foraging sites may have reduced their foraging time and increased their scanning time (22.8±6.3). Threats from human disturbances at the Huize Nature Reserve in China have forced wintering *G.nigricollis* to retreat to fewer roosting sites despite abundant food available from traditionally cultivated fields (Zhou et al., 2010).

The study revealed that compared to an adult, juvenile individuals often have different time budgets due to lack of experience in foraging. Juveniles spent more time foraging because the energy requirements of the juvenile are greater than adults and their inept foraging proficiency decreases their net intake; therefore they devote more time to compensate for it. On the other hand, adults are more efficient in food-handling proficiency, hence they spent less time foraging (Li et al., 2013). The parental care for offspring becomes even more important in disturbed habitat. Alonso & Alonso (1993) have shown that the size of flocks or the social context of birds did not change the foraging and vigilance effort of juveniles and rely on parental vigilance effort to detect predators. However, the presence of juvenile individuals may benefit other flock members of the group and in particular parent-adult since it provides a dilution effect by increasing the flock size Alonso & Alonso, 1993).

The majority of activities in wild birds exhibit a regular daily pattern with regard to their behavior, which might be modified by external factors such as, food supply. *G.nigricollis* breeding at Ruoergai Wetland spent more time in locomotion because *G.nigricollis* in their summer habitat appears to feed more on animal food items that were usually more widely scattered and required more walking (Yang et al., 2007). While, *G.nigricollis* in their winter habitats do not have to expend more energy on searching for food as they were more vegetarian and therefore, depend on agricultural wastes in farmland and tubers in wetlands, which were usually abundant in supply (Bishop, 1996; Li et.al 1997, Yang et al., 2007). Similarly, the time budget of locomotion behavior varied between *G.nigricollis* at Flower Lake and Cao Hai Lake in China. Cranes spent more time walking to search for food, at Flower Lake, where the food supply was greatly reduced due to wetland degradation that has resulted due to drainage for pastureland and overgrazing (Yang, 1991; Yang et al., 2007). On the other hand, the cranes at Cao Hai Lake did not spend much on locomotion behavior due to ample supply of natural and cultivated plants (Li et.al., 1997; Yang et al., 2007).

In this study, wintering *G.nigricollis* were found to spend much of their time walking in search of food, causing some differences in the time budget of locomotion as compared to the previous studies carried out in China. It may be because it had to move from one series of successively receding platforms to another paddy terraces on the sloppy terrain. Studies have also shown that predation risk was one factor that influenced the time budget of birds. The relatively higher human disturbances from direct approach by visitors, chasing by dogs and cattle, upland burning of litter falls, frequent movement of people and vehicles have caused *G.nigricollis* to engage in locomotion to keep them away from predation risk or fly away in response to high stimuli disturbances.

4.2 Diurnal rhythms

Time budget and the variation of diurnal rhythms of behavioral activities during the day may result from strategies to adapt to environmental factors such as predation level and temperature (Verbeek, 1972). The activity rhythm of the *G.nigricollis* in winter was characterized by a gradual increase of its feeding time from the early morning and reaching its peak in the late morning and late afternoon. The daily activity pattern of breeding *G.nigricollis* of Ruoergai Wetlands National Nature Reserve (Yang et al. 2007) and *G.nigricollis* wintering at Napahai Lake, (Wang et al., 2009) also displayed similar foraging peaks in the late morning and late afternoon. Wang et al (2009) mentioned that the postponing of higher feeding peaks is a behavioral adjustment in response to the cold and frigid temperature of the morning.

And when the temperature of the day was high, *G.nigricollis* in Bumdeling and Yangtse either moved to the roosting area or they spent more time in preening or resting behaviors. The winter strategy used increased the rest time at high temperatures, while foraging time increased at low temperatures. This survival strategy of *G.nigricollis* enables it to adapt to the harsh climatic condition of its habitats (Kong et al., 2008). A similar daily variation in this pattern of maintenance and resting behavior was observed at its summer habitat at the Ruoergai Wetland in China and the wintering Common cranes (Alonso & Alonso, 1993) while the behavior of breeding *G.nigricollis* at Changthang, Ladakh, showed a peak in the early morning, just after waking up and another slight peak at noon (Khan et al., 2015).

4.3 Behavioral response of cranes to disturbances

No natural predator of *G.nigricollis* was observed during the study period, but the predation risk to *G.nigricollis* in Bumdeling and Yangtse are largely from human disturbances. According to the result of the current study, *G.nigricollis* wintering at Maidung, Khabretsey, and Bategang in Bumdeling and Yangtse were faced with significantly high anthropogenic disturbances that frequently interrupted their foraging behavior and increased vigilance level and leading to less time for foraging. This can have subsequent effects on energy re-fuelling to increase fitness levels before birds leave these sites. Similarly, human disturbance were found to influence the allocation of time to vigilance in other large birds such as Red-crowned cranes (*G. japonensis*) (Li et al., 2013), Hooded Crane, Sandhill crane (*G. canaderns is*) (Li et al., 2014), and Greater Flamingos (*Phoenicopterus*) (Jihen et al., 2006). According to Li et al., (2013), Red-crowned cranes were more vigilant in farmland (located at buffer zone) where the level of human disturbances are high as compared to grassland where disturbances level are low (located in the core of the reserve). Similarly, *G.nigricollis* were found to spend more time in vigilance at highly disturbed areas in Cao Hai Lake, China, where the density of people was high (Yang, 2007; Li & Bishop, 1999).

Responses of cranes are determined by the type of human disturbances, the direction of approach, the proximity of cranes to disturbances types, etc. Vigilance is an important part of the decision-making process related to predation risk effects (Frid & Dill, 2002). The flocks that are faced with a potential predator risk may have to make an optimal flee or flight decision that balances the benefits of reducing capture probability against the costs of abandoning a foraging site (usually where availability of food resource is high) and expending energy on locomotion such as flying away from the site (Frid & Dill, 2002). *G.nigricollis* exhibited some tolerance level to disturbances of low stimuli, such as a mere presence of local people on foot, vehicular movement or horse grazing closely by remaining alert, alarm calling, however, out-of-vehicle activity, visitors or any person approaching the cranes more closely and directly was strong enough to displace the cranes from their foraging sites.

5. Conclusion and recommendation

5.1 Conclusion/Summary

The cranes spent a maximum of their time foraging, indicating the importance of this activity for migratory foragers to maximize energy gain during non-breeding seasons. *G.nigricollis* appeared to be quite tolerant to people and responded to low stimuli disturbances by remaining more vigilant. However, high stimuli of disturbances such as *G.nigricollis* being approached directly and closely, elicited behavioral responses such as reduced foraging and flying away from foraging sites. Activity-time budget studies provide beneficial information on how *G.nigricollis* balances their trade-off between vigilance and other crucial activities to localized human disturbances (Li et al., 1991, Su et al., 1991, Yuan & Li, 1991, Li et al., 2015). This is important in terms of conservation efforts because any increase in vigilance may be costly if it results in decreased fitness-enhancing activities such as foraging, and displacement or flight may expend valuable amounts of energy, which would be detrimental in the long run.

Therefore, reducing disturbance levels at its foraging sites is paramount for *G.nigricollis* population wintering in Bumdeling and Yangtse gewog, Bhutan. The scope of this research is limited due to the fact that the study was time bound with no financial support. This study is, however, the first of its kind in Bhutan and it is expected to fill the current gap in literature by providing baseline data and information essential for effective management and strategies to provide suitable habitats to *G.nigricollis.*

5.2 Recommendation

Given that Bumdeling supports the second highest population of *G.nigricollis* in the country, the need for effective conservation initiatives are paramount to ensure its survival during its migratory winter visits. Based on the findings from the study, the following recommendations are made for conservation actions. Conservation managers should consider ways to regulate human activity to lessen or strictly limit human disturbances in foraging habitat for wintering *G.nigricollis.* Decreased disturbances may result in increased foraging time for *G.nigricollis* (Li et al., 2013).

G.nigricollis wintering in Bumdeling solely depends on farmlands for foraging and, therefore, the fate of *G.nigricollis* is directly intertwined with that of humans. Conserving these artificial wetlands provides better feeding habitat for the cranes and therefore, farmers of these regions should be encouraged to continue to practice wetland farming and dryland farming (Sherub, 2008). In addition, paddy fields should be kept unplowed until the cranes leave in the first week of April. Grains left after harvest are an important part of *G.nigricollis* diet. Furthermore, a study conducted in Korea has showed that unplowed farmlands can provide more food for the cranes (Lee et al., 2007).

Thirdly, unregulated tourist and visitors and frequent movement of people seem to be a major factor causing disturbances to the cranes. Therefore, initiating public education among locals and importantly, tourists and visitors, who are the main stress causers, is crucial. Effective visitor education should focus on the co-existence of humans and *G.nigricollis* and their role in reducing access to foraging habitats. People will be more likely to support restriction if they understand how the incidence of people approaching cranes on foot more closely could cause cranes to fly away, hence reducing its feeding opportunities. The conservation managers could provide observation and photography blinds that would reduce the perceived need for approach (Klein, 1993).

This study is the first of its kind for Bhutan and the results presented are from data collected over a period of two months; this is to serve as baseline information for future researches. More in-depth studies to establish the fitness costs associated with human disturbances in *G. nigricollis* is needed for better informed recommendations that conservationists could use to reduce these costs.

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