ACTIVITY BUDGET AND FEEDING BEHAVIOUR OF LESSER ADJUTANT (*Leptoptilos javanicus*) IN CENTRAL LOWLAND NEPAL

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Submitted to

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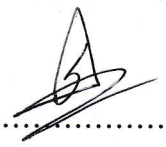
DECLARATION

I hereby declare that the work presented in this thesis has been done by myself and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by the reference to the author(s) or institution(s).

Date: 2023-5-14



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This thesis work submitted by Sabin K.C. entitled **"Activity Budget and Feeding behaviour of Lesser Adjutant (*Leptoptilos javanicus*) in Central Lowland Nepal"** has been accepted as a partial fulfillment for the requirements of Master's degree of Science in Zoology with special paper Ecology and Environment.

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ABSTRACT

An activity budget provides a quantitative description of how animals spend their time engaging in various activities such as foraging, maintenance and reproduction that directly relates to an animal's metabolism, making it a crucial aspect of studying behavioural ecology. Lesser adjutant Stork ((*Leptoptilos javanicus*) is a globally vulnerable species with declining population and increasing threats. Hence, its activity budget and foraging behaviour was studied for two seasons [monsoon (August 2022) and winter season (January 2023)] in Chitwan and Rupandehi-Kapilvastu area to find the seasonal behavioural activities and factors affecting its feeding success. Extensive road survey method was used to collect the LAS behavioural video footage and activity budget was prepared. Lesser Adjutant Stork spent maximum time foraging (mean 9.97 ± 8.25 min) followed by resting, vigilance, maintenance, other and locomotion activity. There was a variation in the time spent by LAS on foraging and resting in between two seasons [foraging behaviour (t-value = 8.203, df = 237, $p < 0.05$) and resting behaviour (t = 8.341, df = 140, $p<0.05$)]. Time spent for foraging was higher in monsoon (1565.56 min, 78% of total time duration) while time spent on resting (751.03 min, 27% of total duration) was higher in winter season. LAS used visual mode (96%) of foraging rather than tactile (4%). The snails (n = 477) was major prey species followed by insects (n = 73), crabs (n = 19), fish (n = 15), frog (n = 8), snake (n = 9), lizard (n = 3), carcasses (n = 2) and mouse (n = 1). Distance to road (Estimate = -0.0022 ± 0.0009, p = 0.0171) and the distance to wetland (Estimate = 0.0013 ± 0.0006, p = 0.0426) are influencing factors for feeding success on LAS.

1. INTRODUCTION

1.1 Background

Activity budget refers to the amount of time that individual animals allocate to different activities, which depends on their interactions with other individuals of the same species and with different species, as well as to different environmental factors (Willmer et al., 2009). It provides a quantitative description on how animals spend their time engaging in activities, such as foraging, maintenance of themselves, and reproduction (Baldassarre & Bolen, 1994). The allocation of time among various daily activities has significant implications for meeting the energy requirements of a particular species, the time allocated to different activities directly relates to an animal's metabolism, making it a crucial aspect of studying behavioural ecology (Halle & Stenseth, 2000). The physical habitat, social organization, and environmental conditions of the individual species can be accessed from extensive time-activity budget they spent (Datta, 2014; Paulus, 1988).

The diurnal activity budget of wetland birds may range dramatically between species, individuals, and the breeding and wintering seasons (Turner, 1982) as a means of adjusting to environmental conditions like varying habitat types, food abundance, and climate (Yang et al., 2007). Additionally, time and energy invested in various activities can affect a bird's ability to survive, and its foraging habits can serve as strong indications of the quality of ecosystems and landscapes (Sundar & Kittur, 2012). In higher-quality settings, wetland birds can find more prey with less effort, which cuts down on the amount of time they spend foraging (Osborn et al., 2017). lowered foraging time in better settings offers fitness-related benefits, such as increased breeding success, indicating that activity budgets are the result of deliberate choice, regardless of environmental factors (Janiszewski et al., 2014;Haig et al., 2019). Wetland birds primary mode of behaviour is foraging (Whitehorne, 2010). A key issue in wetland birds behavioural ecology is understanding their foraging tactics (Sommerfeld et al., 2013). Additionally, it is crucial to investigate the variables impacting the feeding tactics of wetland birds (Whitehorne, 2010).

Among the wetland birds, Storks (Family: Ciconiidae) are a group of wetland birds constituting of total 20 species worldwide, with the majority of their ranges being subtropical or tropical (Gula et al., 2023). They are an important component of

wetland resembling apex of aquatic food chains, thereby effectively serving as flagships (Chavan & Dudhmal, 2016). Storks prefer to stay near wetlands for food sources such as fishes and snails (Pokharel, 1998; Paudyal et al., 2010; Bhattarai, 2012). Activity budget have been carried on several stork species like Black-necked crane (Yang et al., 2007), Black-necked stork (Maheswaran & Rahmani, 2007) Asian Wolly-necked Stork (Ghimire et al., 2022) which has given insight to their diurnal behaviour and different factors affecting those behaviour. However, compared with other wetland birds the foraging ecology of storks has received scant attention (Chavan & Dudhmal, 2016), Lesser Adjutant Stork *(Leptoptilos javanicus)* being one of them.

The Lesser Adjutant Stork (LAS) is the smallest of the three species of storks in the genus Leptoptilos (Gula et al., 2023) measuring about 120-150 cm (47-59 inches) in height, wingspan of approximately 220-250 cm (87-98 inches) and the plumage is predominantly gray with a yellowish neck. The head and upper neck are bare and dark in color, often appearing wrinkled or scaly. It has a massive, thick bill that is yellowish with a dark tip. The legs are long and stout, typically gray or yellowish in color (Henry, 1998; BirdLife International, 2017).

LAS is distributed globally across South and South-East Asian countries like Cambodia, India, Nepal, Indonesia, Malaysia, Sri Lanka, Bangladesh, Myanmar (BirdLife International, 2017). The population in Nepal is distributed mainly in the central tarai region with few population being scattered along other regions of tarai (Sundar et al., 2016; Katuwal et al., 2023). Its population is believed to be rapidly declining as a result of numerous challenges, such as hunting pressure, loss of nesting habitat, conversion and degradation of wetlands, and agricultural changes and intensification and thus has been categorized as vulnerable species (Birdlife International, 2017).

LAS is found foraging alone widely dispersed across foraging grounds, in groups of three to four, but at distances of between 10 and 100 m (Sailda & Bhattacharjee, 1990). Prey is detected either visually or by touching as the probed up to two-thirds deep into the soft surface. The LAS stalks the edges of marshes, primarily consuming fish, frogs, reptiles, big invertebrates, rodents, small mammals, and occasionally carrion (Subaraj & Lok, 2009). LAS needs fresh water for drinking, they also use

water to remove foreign body stock in the internal nostril, which is critical to their long term health (Oehler, 2017).

In Nepal, there are numerous studies focusing on LAS breeding, distribution and factors related to it, while studies related to its general behavioural and factors affecting those behaviour is lacking, so this study has been carried out to address those gaps.

1.2 Objectives

1.2.1General objective

The general objective of this study was to find the seasonal (breeding and post breeding) activity budget and foraging behaviour of Lesser Adjutant Stork (LAS).

1.2.2 Specific objective

i. To identify the seasonal behavioral activities of LAS in the central lowlands of Nepal.
ii. To assess the factors affecting the feeding success of LAS.

1.3 Rationale of the study

Activity budgeting has been identified as a vital tool to know about habitat use as well as niche separation (Rave & Baldassarre, 1989) and thus it can be utilized as an important tool for the management of bird's habitat (Bensaci et al., 2015). Time budgets can be adapted to differing environments and is also the response to the factors that influence the activities as well (Yang & Yang, 1996). Human interference in a man-made landscape can be seen as a sort of predation risk, which has an impact on foragers survival and behaviour. LAS is a globally vulnerable species with declining population and increasing threats (Birdlife International, 2017). LAS plays an important role in ecosystem services from preying on frogs, snakes, rodents and even carrion and helps farmers. However, they are indirectly threatened by agricultural intensification, increased pesticide use, and invasive alien species (Poudyal & Nepal, 2010). Further, the species is also hunted for their body parts, especially beaks and feathers (Baral, 2010). Despite such threats studies focusing on its foraging behaviour are very rare with little to no focus on understanding the species ecology. A lot of information about the species can be gained through its

behavioural study and knowledge about the daily behaviour pattern is essential to conserve it. Thus, this study identified the behavioural activity of LAS in the Chitwan and Rupandehi-Kapilvastu of Nepal, and the findings of this will be useful for the conservation of this species by developing site and species specific conservation action and management plan.

2. LITERATURE REVIEW

2.1 Waterbird and activity budget

Wetland birds are a group of birds that have adapted to aquatic environments, making them ideal targets for studying activity budgets related to their specific ecological niches and adaptations (Morrie & McNeil, 1991). Studies on wetland birds activity budgets have provided valuable insights into their behaviour and ecology (Mason et al., 2013; Rose et al., 2022; Mukherjee et al., 2023). They typically spend their time in activities, such as foraging, resting, grooming, displaying courtship, and parenting. These activity patterns can vary seasonally, daily, and depending on habitat availability (Ali, 2019).

2.2 Distribution of LAS

The Lesser Adjutant Stork (LAS), a globally vulnerable wetland or waterbird species, predominantly inhabits the lowlands of Nepal (Katuwal et al., 2023). This avian species holds a crucial ecological role within wetland ecosystems. LAS is distributed globally across South and South-East Asian countries like Cambodia, India, Nepal, Indonesia, Malaysia, Sri Lanka, Bangladesh, Myanmar (BirdLife International, 2017). Nepal has a diverse array of wetland ecosystems, ranging from lowland oxbow lakes and rivers to swamps, marshes, paddy fields, reservoirs, and ponds. These wetlands play a crucial role in supporting a variety wetland dependent bird. As such, Nepal provides a rich and suitable environment for the Lesser Adjutant (Poudyal & Nepal, 2010). The population in Nepal is distributed mainly in the central and eastern terai region with few population being scattered along other regions of tarai (Sundar et al., 2016; Katuwal et al., 2023). Lesser Adjutant are uniformly distributed and higher densities from Jhapa to Kapilvastu, and west of kapilvastu is sporadically distributed (Katuwal et al., 2023).

LAS is known to inhabit a variety of natural habitats within Nepal, including the riverbeds, paddy fields, swamps, floodplains, lakes, and forest pools of various Protected Areas and outside the protected areas. These magnificent birds can also be found in Bardia National Park and Chitwan National Park, as well as their buffer zones, Suklaphanta, Parsa, and Koshi Tappu Wildlife Reserves and their buffer zones, as well as Farmlands in Lumbini Area, Jagadishpur Reservoir, Ghodaghodi Lake, and the Mai Valley, Barandabhar, Beeshajari Lake, Nawalparasi, Janakinagar, Murtiya

and Nadiman of Sarlahi district, Dang Deukhuri, and Urlabari forests (Baral, 2005; Sharma, 2005; Poudyal & Nepal, 2010; Bajagain & Pradhan, 2019: Katuwal et al. 2023).

2.3 Nesting behaviour

The LAS shows a preference for nesting in farmlands and wetlands, typically choosing tall trees located either within or adjacent to wetland areas (Bhattarai et al., 2021). Research indicates that LAS breeding density and reproductive success are notably higher in agricultural land compared to wetland colonies, likely due to reduced predation in the latter (Katuwal et al., 2022, 2023). Both parents actively contribute to nest construction, breeding activities, and chick development (Katuwal et al., 2022). Successful breeding outcomes are closely tied to the availability of suitable habitats for breeding, as well as the abundance and fluctuation of prey species throughout the breeding season (Karki & Thapa, 2013). Generally, the population dynamics and foraging behaviour of colonial-breeding species like the LAS are closely tied to the quality of natural wetland habitats (Frederick et al., 2009; Sundar et al., 2016).

2.4 Diet

The LAS exhibits diverse dietary habits, preying on a wide variety of organisms. DeSilva (2015) and Subaraj (2009) documented their consumption of various prey, such as different fish species (e.g., gobies, catfish, *Oreochromis*, *Chana*, Cyprinidae), eels, snakes (*Xenochrophis asperrimus* and *Ptyas mucosa*), bullfrogs, small and medium-sized lizards, insects, crustaceans, grasshoppers, mice, and carrion. Choudary (2012) reported that LAS adults fed their chicks primarily Indian bullfrogs (*Hoplabatrachus tigerinus*) (70%) and non-venomous water snakes (*Xenochrophis piscator*) (30%) during feeding events.

2.5 Foraging behaviour

The foraging behaviour of the LAS is complexly linked to wetland ecosystems. They employ various techniques, including slow creeping, motionless standing, and rapid beak movements, to capture prey (Ramli & Norazlimi, 2017; Fauzi & Norazlimi, 2021). Their foraging activities and prey selection are influenced by seasonal variations in water levels and fish abundance. Notably, LAS, characterized by longer beaks and legs compared to other birds, are observed to forage in close proximity to

water, in deeper mud, and within deeper waters, emphasizing the relationship between their morphological traits and foraging behaviour (Norazlimi & Ramli, 2015).

2.6 Factors affecting foraging behaviour

The foraging success of waterbirds, including the LAS, is influenced by multiple factors, including prey availability, habitat characteristics, anthropogenic disturbances, and interactions with other species (Sundar et al., 2016). Prey abundance, seasonal changes, and alterations in aquatic habitats directly impact foraging success. Habitat degradation, loss of foraging grounds, and changes in water quality can adversely affect prey availability and accessibility (Rogan & Lacher, 2018). Additionally, competition for food resources with other wetland species, such as herons, egrets, and other storks, can negatively impact foraging success. Studies have revealed varying levels of tolerance to human presence in LAS populations (Samia et al., 2015). Proximity to habitats influences foraging behaviour, leading birds to adjust activity patterns and alter foraging strategies to minimize disturbances and maximize access to food resources (Ghimire et al., 2022). The presence of predators or potential threats can prompt waterbirds to shift from energy-gathering behaviours, such as foraging, to energy-consuming behaviours like vigilance and flight, thereby reducing foraging time (Schummer & Eddleman, 2003; Zimmer et al., 2011; Li et al., 2017; Middleton et al., 2018). Seasonality also plays a significant role in influencing behaviour, with waterbirds adjusting their foraging activities based on changes in prey availability and quality during different climatic periods (Davoren, 2000; Ye et al., 2013). In agricultural landscapes, seasonal variations in crop planting result in substantial changes in the landscape, which, in turn, dramatically affect the seasonal conditions for waterbirds on a large spatial scale (Sundar et al., 2016; Koli et al., 2019). Water resources also play a vital role in the nutritional ecology of LAS. The presence of suitable water bodies, such as rivers, lakes, marshes, and ponds, affects the availability and accessibility of prey. Waterbirds select foraging areas close to water sources as these habitats are essential for meeting their nutritional needs. Alterations in water availability caused by habitat changes and climatic factors can impact the foraging success of waterfowl species (Lecomte et al., 2009). Human activities can directly and indirectly affect feeding success (Guevara, 2019). The breeding patterns and ecological behaviour of wetland birds are contingent upon prey availability and the potential threats arising from human activities, such as wetland

alterations and excessive pesticide use in agricultural areas (Tozer et al., 2010; Bennett et al., 2018). Furthermore, those activities can directly impact the availability and accessibility of LAS prey, potentially altering foraging behaviour, reducing feeding efficiency, and ultimately diminishing feeding success.

Various studies were found on different wetland birds from ducks to cranes regarding their breeding and time budget activity Although many studies have been conducted on LAS about their distribution, nest site selection, breeding and nesting behaviour, research on their activity budget is lacking. So, this study is the first attempt to examine the activity budget of LAS.

3.MATERIALS AND METHOD

3.1 Study area

This study was carried out in wetland and farmland of Chitwan and Rupandehi-Kapilvastu districts of central lowlands Nepal.

Chitwan consists of Chitwan National Park which comprises of a diversity of ecosystems-including the Churia hills, Ox-bow lakes, and the flood plains of the Rapti, Reu and Narayani Rivers. The Churia hills rise slowly towards the east from 150 m. to more than 800 m. The western portion is comprised of the lower but more rugged Someshwor hill. The valley consists of tropical and subtropical forests. Sal forests cover 70 percent of the park. Sal leaves are used locally for plates in festivals and religious offerings. Grasslands cover 20 percent of the park. This area is home to more than 50 mammal species, over 525 birds, and 55 amphibians and reptiles. The endangered fauna found in this area are: One-horned rhinoceros (*Rhinoceros unicornis*), Gaur (*Bos gaurus*). Royal Bengal tiger (*Panthera tigris tigris*). Wild elephant (*Elephas maximus*), Four-horned antelope (*Tetracerus quadricornis*), Pangolin (Manis pentadactyla), Golden monitor lizard (Varanus flavescens) and Chitwan is a crucial location for Nepal's endangered bird species with approximately two-thirds of them being documented here like Bengal florican (*Houbaropsis bengalensis*), Lesser florican (*Sypheotides indicus*), Giant hornbill (*Buceros bicornis*), Black stork (*Ciconia nigra*), Lesser adjutant stork (*Leptoptilos javanicus*) are also found here (DNPWC, 2023).

The Kapilvastu-Rupandehi district consists of Lumbini area which is holy pilgrim site. It is the birthplace of Lord Gautam Buddha who is regarded as the father of Buddhism. A famous IBA (Jagadishpur reservoir) lies there. The habitat of the reservoir and its surroundings is important for resident, wintering and migrating wetland birds, comprising 105 different bird species, five of these are globally threatened species. The surrounding cultivated land also provides habitat for a large number of birds (Baral, 2008). Some of the common wetland birds of this area are Sarus crane (*Gyrus antigone*), Lesser Adjutant Stork (*Leptoptilos javanicus*), Asian Wolly-necked Stork (*Ciconia episcopus*), Whistling duck (*Dendrocygninae*), little cormorant (*Microcarbo niger*)

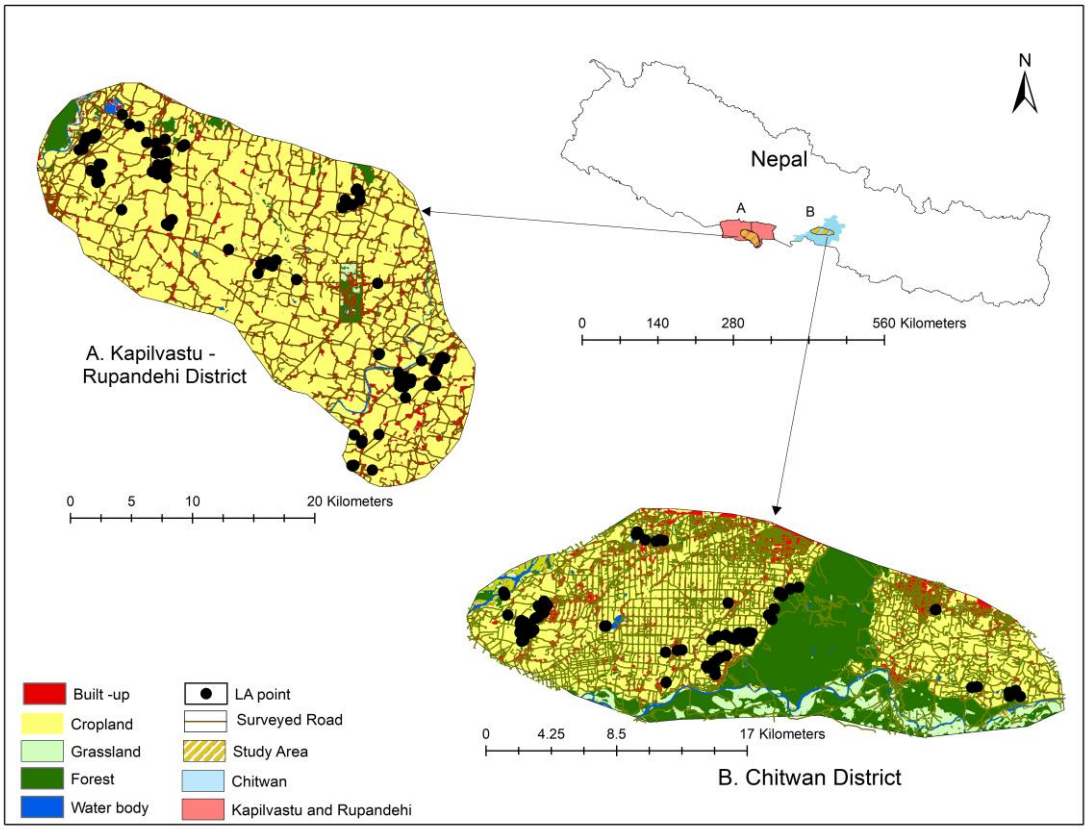

Figure 1. Map of study area for recording videos; A (Rupandehi-kapilvastu districts), B (Chitwan area)

3.2 Materials

The different materials that were used in this research are:

1) Binoculars (Vixen 10x42)
2) Global Positioning System (Garmin etrex 10)
3) Range Finder (Apresys Powerline660)
4) Cameras (Nikon 5600D with Nikon 200-500mm zoom lens and Nikon P950)

3.3 Method

3.3.1 Field survey

The field survey was carried out in breeding (Monsoon: August-September) and post-breeding (Winter: December-January) seasons in the Chitwan and Lumbini area for a total of 30 days (15 days on each season). Those areas were chosen as they have higher densities of the LAS than other area (Bhattarai et al., 2021; Hem B. Katuwal et

al., 2022). Based on the literature reviews and discussions with the local bird experts, all the potential habitat for LAS in those districts were surveyed.

An extensive road survey method (surveying all the feasible roads) using bike was used to collect the data at a constant speed of 15 -20 Km/hr (Sundar et al., 2016). After spotting LAS, the video was recorded using a camera (Nikon P950) from a distance either handheld or by using a tripod. The recording was only stopped if the individual was out of sight or when it flew away or when it exceeded the 30-minute time limit. The 30 min limit was kept avoiding the bias towards recording only the specific individual behaviour.

The road survey was conducted in the morning (7:00 am to 11:00 am) and in the evening (2:00 pm to 6:00 pm), excluding days with rain and fog. Same roads were sampled more than once in each season, but the sampling was done on an average of six days apart.

After detecting LAS, GPS coordinates were recorded from that point, along with aspect and distance of LAS, which were later used to exact GPS points using QGIS (QGIS Development Team, 2016). Habitat type (wetland/forest/farmland) and crop type of LAS presence point was noted by observing through binocular. Variables like distance to humans, distance to settlements, distance to roads, and distance to farmland, distance to wetland were all measured using a rangefinder and if the distance was greater than 400 m the variables were measured using Open Street Map (OSM) in QGIS software (QGIS Development Team, 2016).

3.3.2 Activity budget

A total of 240 video samples (60 from Chitwan and 60 from Lumbini in each season excluding video samples that didn't show any distinctive behaviour) were collected, and these videos had an average length of 17.5 ± 8.175 minutes.

The collected video footage was observed visually, and the LAS behaviour was classified into five categories (Table1) and their respective duration for these activities were noted. These five behaviours were chosen as LAS showed those more distinctively than other behaviours.

Table 2. Ethograms recorded for Lesser Adjutant Stork

SN	Behaviour	Description
1	Foraging	LAS bowing its head and scanning the area.
2	Vigilant	LAS examination of its surrounding by stretching its neck and looking around.
3	Maintenance	LAS actions related to body surface maintenance including preening with the beak, shivering.
4	Locomotion	LAS moving by keeping its head upright.
5	Other	Any other activities than those mentioned above like sun basking excretion, calls.

3.3.3 For foraging behaviour

Similarly, the footage was observed, and different parameters were noted as Table 2. Also, the prey items consumed by LAS were noted and classified based on their common type like snails, crabs, lizards, snakes, mouse and other.

Table 2: Different parameters used for data collection.

SN	Parameters	Description
1	Mode of prey capture	Either visual or tactile
2	Type of Prey	Species consumed my LAS
3	Number of prey species	Number of prey individuals consumed
4	Number of Pecks	Counting the number of pecks (biting something with beak)
5	Prey handling time	Time duration after capturing to swallowing of prey
6	Feeding success	Successfully capturing and swallowing of prey

3.4 Data Analysis

The sampled video footage was observed, and data was recorded. The Chi-square test was done to see the variation within behaviour of total activity budget, two sample t-tests were done to compare the each behaviour in different seasons.

GLM was used to understand the factors affecting the feeding success. Before that correlation test was performed between independent variables (distance to road, distance to settlement, distance to animal, distance to human, distance to wetland, number of pecks). The predictive variables were not correlated ($|r|<0.7$; Figure 2), therefore, all variables were used for Generalized Linear Model (GLM). The response variable was binomial (success, and unsuccess) while the predictors variables were distance to road, distance to farmer/human, distance to settlement, number of pecks. All the analysis were done in R software (R Core Team, 2022) using packages like Corrplot, tidyverse and stats (function: chisq.test, t.test, glm).

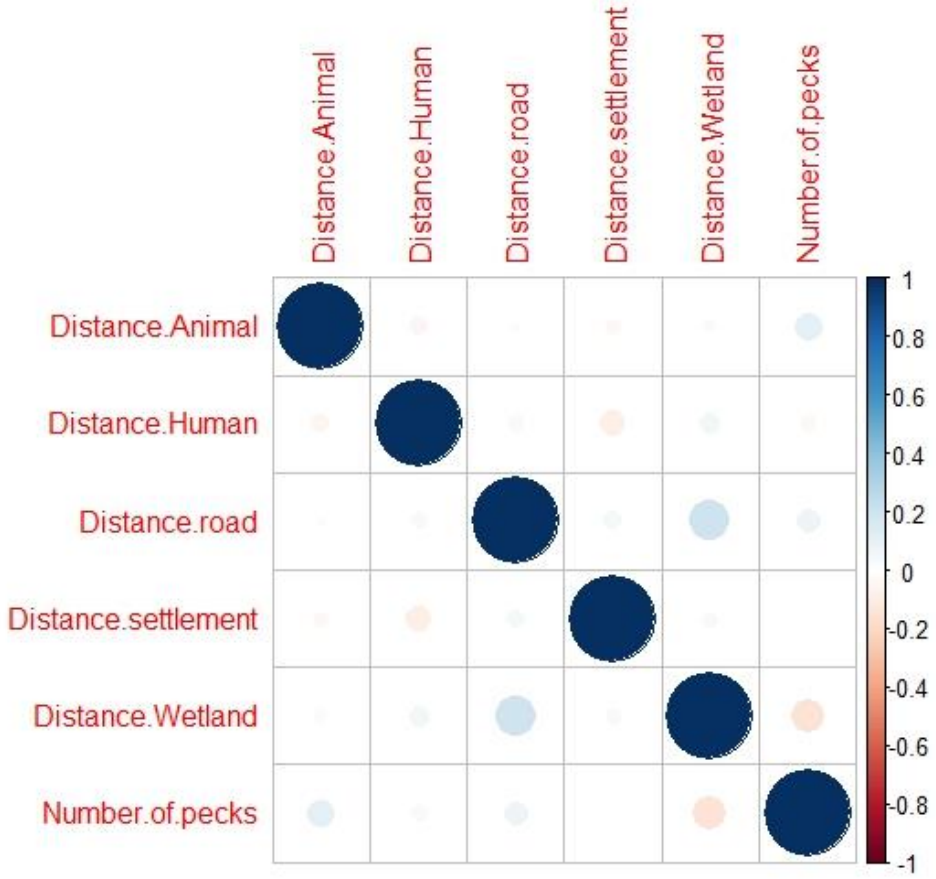

Figure 2: Correlation test between the different variables (distance to human, distance to animal, distance to road, distance to settlement, distance to wetland and number of pecks)**.**

4 RESULTS

4.1 Overall Activity Budget of LAS

A total of 4,215.07 minutes (70.25 hrs) of video footage of LAS behaviour was recorded from both seasons. Based on the footage, LAS spent most of their time for foraging (mean ± sd 9.97 ± 8.25 min per video sample, 56.8% of total duration), followed by resting (mean 3.25 ± 6.12 min,18.5% of total duration), whereas it spent least time for locomotion (mean 0.21 ± 0.77 min, 1.2%) followed by other (mean 0.20 ± 1.13 min, 1.2%) behaviour (Figure 3). The species showed a significant difference between the time spent among different behaviour types ($\chi^2 = 5788$, df = 5, $p < 0.05$).

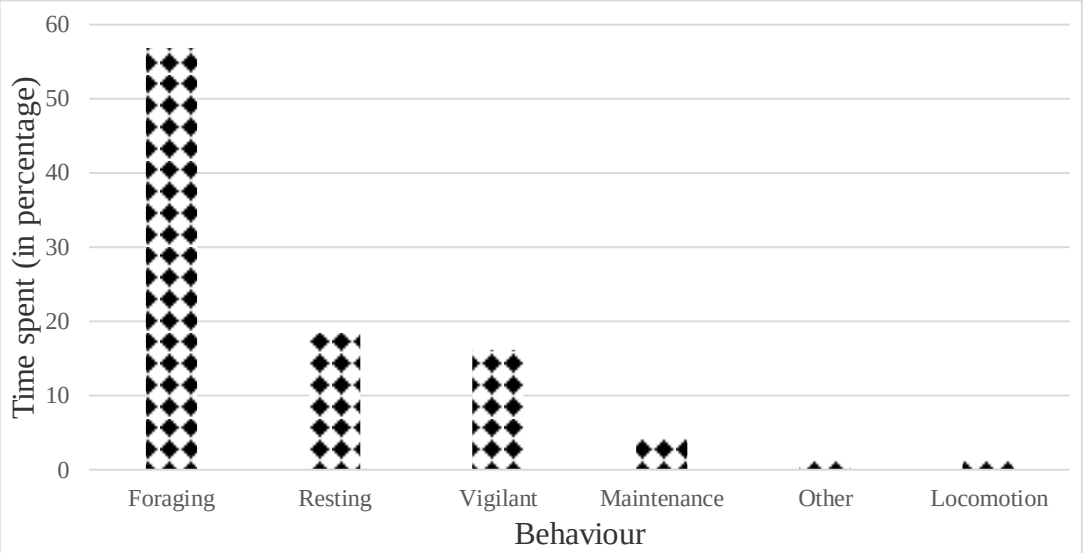

Figure 3:Different behaviour shown by LAS in moonson and winter seasons.

4.1.1 Seasonal budget of LAS

In seasonal analysis, a significant variation was observed in foraging behaviour (t-value = 8.203, df = 237, $p < 0.05$) and resting behaviour (t = 8.341, df = 140, $p<0.05$: Annex 3) of LAS between the winter and monsoon season. The species spent more time in foraging (1565.56 min, 78% of total time duration) during monsoon season while it was for resting (751.03 min, 27% of total duration) in the winter season (Figure 4). However, behavioural time (time spent carrying out particular behaviour) was almost similar to other behaviours (vigilant, maintenance, location and others) (Figure 4).

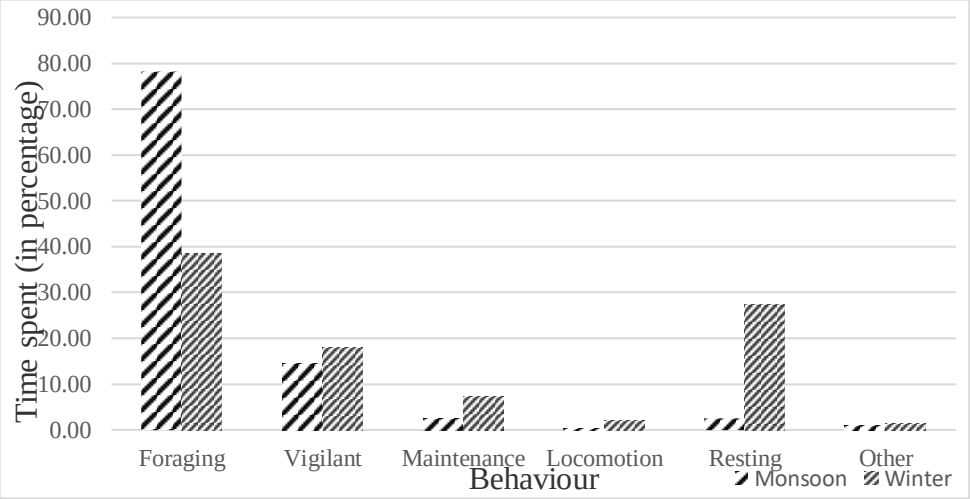

Figure 4: Different behaviour shown by LAS in monsoon and winter season.

4.2 Foraging

4.2.1 Diet Composition

LAS was primarily observed to use visual search method for foraging and was observed to feed on range of species including snails, insects, crabs, fishes, frogs, lizards, snakes, and sometimes mouse. During the study, LAS caught a total of 577 prey belonging to eight prey types. Snail (n = 477) was the major prey species for LAS followed by insects (n = 73), whereas other items like crabs, fish, frog, lizard, snake, mouse, and carcass are less consumed (Figure 5).

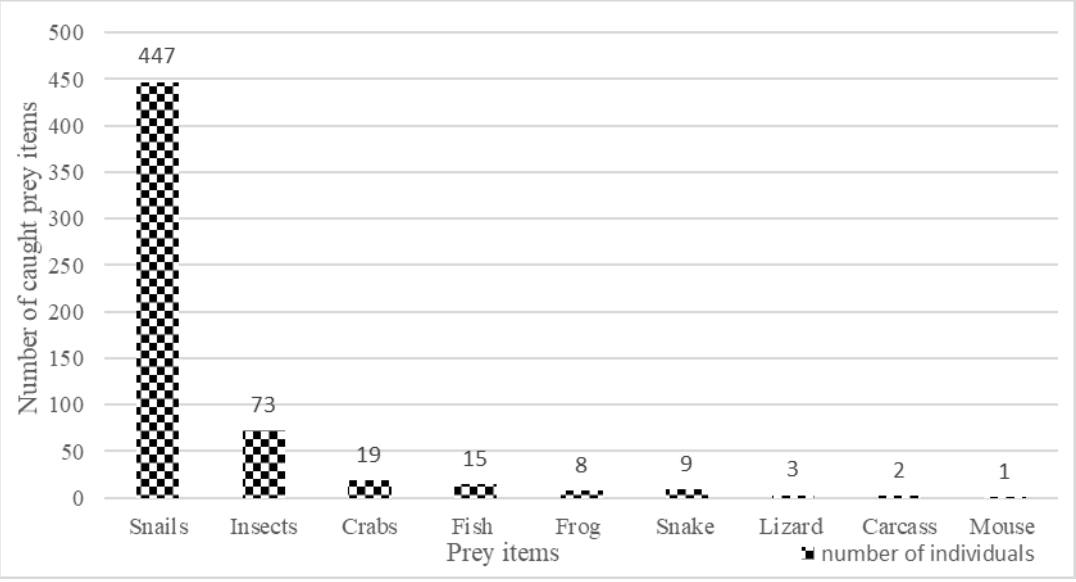

Figure 5: Different prey items caught by Lesser Adjutant Stork.

4.2.2 Factors affecting the feeding success of LAS.

Multiple factors were observed to the feeding success of LAS differently. The significant impact was observed for distance to road [-0.0022 ± 0.00091(Estimate ± SE), p = 0.0171] and distance to wetland (0.0013 ± 0.0006, p = 0.0426) (Table 4). Distance to wetland had positive impact on feeding success as the distance to wetland increases, it was likely that LAS feeding success increased (Figure 9a), Although, there was no significant impact for number of pecks during foraging, it was found to have positive impact on the feeding success (0.1280 ± 0.0798, p >0.05) as pecking number increases the chances of prey capture. The distance to road had negative impacts on feeding success as the distance to road increased the feeding success decreased (Figure 9b). Here, the distance to human (0.0050 ± 0.0037, p = 0.1812), distance to settlement (estimate <0.001, p = 0.346) and number of pecks (0.1280 ± 0.0798, p = 0.1104) did not show any statistically significant associations (Table 3).

Table 3: Generalized Linear Model (GLM) analysis of feeding success (response variable) with predictors variable (Distance to road, Distance to wetland, Number of pecks, Distance to human, Distance to settlement). Bold value indicates significance (p<0.05).

Variables	**Estimate**	**SE**	**z**	**p**
Intercept	-0.6564	0.2073	3.1540	0.0016
Distance to road	-0.0022	0.0009	2.3850	**0.0171**
Distance to wetland	0.0013	0.0006	2.0280	**0.0426**
Number of pecks	0.1280	0.0798	1.5960	0.1104
Distance to human	0.0050	0.0037	1.3370	0.1812
Distance to settlement	<0.0001	<0.0001	0.9410	0.3465

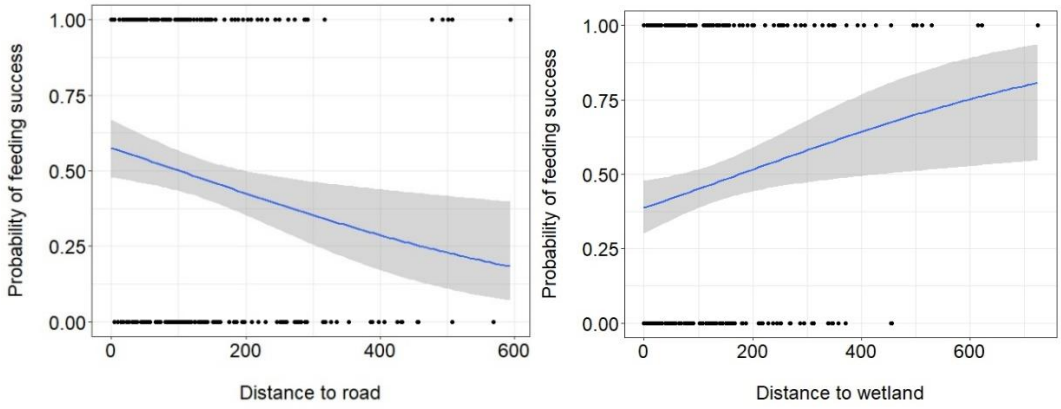

Figure 6: Relation between distance to road and feeding success (Left) and Relation between distance to wetland and feeding success (Right).

5. DISCUSSION

Activity budget

The study on the activity budget indicates that the LAS spent most of their time feeding, and the time spent for this activity was higher during monsoon season. This might be due to the breeding season of the LAS. In breeding season, they need more energy for nest building and carrying out reproduction activities including mating and egg laying (Yang et al., 2007) similar case was also observed in Wattled Crane (*Grus carunculata*) spending 39.3% of total duration foraging (Tadele et al., 2022). LAS spent more time resting in winter season which might be due to cold temperature to preserve its body heat as it require more thermal for movement similar finding was found on study of Black-necked Crane (*Grus nigricollis*) (Kong et al., 2008) Time spent foraging decreased from monsoon to winter season this might be due to LAS entering post breeding phase, while other behaviour remained similar in both season.

Diet

This study showed that LAS used visual method of prey capture than tactile one that is different from Greater Adjutant Stork and Painted Stork which are efficient tactile foragers (Kalam & Urfi, 2008), this might be because LAS prefer to forage on shallow water which are mostly found on farmlands. LAS was found to prey on smaller species (mostly snails spp,) that might be due to snails being abundant in farmland and canals which contradict with Norazlimi & Ramli (2015) that highlighted LAS preyed on larger species due to its larger bill size. LAS was also found feeding on chicken carcasses, amphibians, reptiles, mammals, which shows opportunistic nature while feeding. Also, on visual observation LAS was found competing with Steppe Eagle, Large-billed Crow and Golden Jackal for carcass which highlights dominance nature in them. Furthermore, the fact that LAS consume prey of different sizes in its diet may lead to the need for more time to find sufficient prey. This could be a significant factor contributing to their high level of foraging activity (56.8% of total duration). In contrast, the Black-necked Stork, which is also carnivorous, feeds on much larger prey and spends less time foraging in a protected reserve (Maheswaran & Rahmani, 2007). The Oriental White Stork and the Woolly-necked Stork both feed on prey of various sizes and spend approximately 35% of their time

foraging, as seen in a protected reserve and in lowland Nepal respectively (Shao et al., 2015).

Factors affecting feeding success

The feeding success of LAS was affected by distance to road, their feeding success increased as the distance to road decreased. Generally, large numbers of food such as snails, snakes, crabs are available near to road due to presence of water canal (Gopi Sundar, 2011). Therefore, they prefer to forage near to the road, even though their activities are disturbed by traffic. Also, road possess a major threat to LAS from being killed by vehicle while crossing and being hunted down, still LAS has been using that habitat signifies their tradeoff for food. In the personal observation, they avoid shortly to the foraging ground nearer to road during the movement of large vehicle. Also, under pressure, LAS might increase pace of foraging that ultimately increases their overall efficiency.

However, the feeding success of LAS was affected by the distance to wetland, their feeding activities increased when the distance from the wetland increased. This means LAS likes to forage more on farmlands than wetlands. Farmlands contains variety of prey items as varieties of crops attracts different prey species, also farmland provides lower competition, lower predation risk due to human presence and on personal observation LAS was found foraging in freshly irrigated fields where the soil was disturbed making it easier to find prey. LAS is found more often in farmlands than other habtiats (Katuwal et al., 2023). This finding is similar to the study done by Li et al (2015) on Hooded Cranes (*Grus monachal*) which prefers to forage on artificial ponds that is nutrient rich but risk on predation than low quality natural wetlands and Ghimire et al (2022) also reported the use of farmlands more than the wetlands by Wolly-necked Stork. Additionally LAS was found to be alert and stop foraging near the human presence which is contrary to the result of Ghimire et al. (2022) where the Wolly-necked Stork did not show vigilant behaviour and continued to feed.

Also, LAS was observed to be more tolerant to humans and was found foraging very close to settlements (based on visual observation).

6 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

From this study on activity budget and foraging behaviour, LAS was found to spend most of their time foraging followed by resting, vigilance, maintenance, and other behaviour. There was a variation in the time spent by LAS in monsoon and winter season. Time spent foraging was higher in monsoon season while the time spent resting was comparatively higher in winter season while time spent in other behaviours were similar. Snails and insect were found to be the primary diet. LAS was found to avoid foraging in wetlands and prefer roadside canals for foraging.

6.2 Recommendation

This study provides information on seasonal activity budget and foraging behaviour in farmland. The next step could be to increase the sample size from wetland and also to compare variables between different seasons. The different wetland threats should be minimized. The prey items of LAS in water canal were excavated by locals which might decrease the prey availability for it so, a managed harvesting should be followed ensuring the prey for future. Furthermore, the local people should be made aware regarding pesticides, insecticides, hunting, carcass poisoning and road safety so that there will not be any consequence in the future.

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APPENDICES

Appendix 1: t.test between behaviour in monsoon and winter season

Behaviour	**t value**	**df**	**p-value**	**95%confidence interval**		**mean x**	**mean y**
Foraging	8.203	237.190	**<0.001**	6.245	10.193	14.496	6.277
Vigilant	0.792	234.440	0.429	-0.511	1.198	3.020	2.676
Maintenance	-0.788	237.430	0.432	-0.591	0.253	0.653	0.822
Locomotion	-0.591	216.770	0.555	-0.245	0.122	0.178	0.235
Resting	-8.341	140.120	**<0.001**	-6.701	-4.133	0.273	5.690
Other	0.977	208.570	0.330	-0.138	0.409	0.292	0.156

Appendix 2: Different behaviour shown by LAS with duration range of each behaviour.

Behaviour	**Overall**					**Monsoon**					**Winter**				
	Duration					**Duration**					**Duration**				
	Total	**Min**	**Max**	**Mean**	**SD**	**Total**	**Min**	**Max**	**Mean**	**SD**	**Total**	**Min**	**Max**	**Mean**	**SD**
Foraging	2394.15	0.07	28.37	9.98	8.25	1565.57	0.88	28.37	14.50	7.20	828.58	0.67	27.02	6.28	8.31
Vigilant	679.48	0.10	20.20	2.83	3.37	326.18	0.10	18.47	3.02	3.22	353.30	0.13	20.20	2.68	3.49
Maintenance	179.10	0.03	10.00	0.75	1.68	70.56	0.03	8.10	0.65	1.53	108.53	0.03	10.00	0.82	1.79
Locomotion	50.27	0.05	9.00	0.21	0.77	19.27	0.05	3.93	0.18	0.54	31.00	0.05	9.00	0.23	0.92
Resting	780.47	0.05	25.00	3.25	6.12	29.43	0.50	8.57	0.27	1.24	75.03	0.05	25.00	0.57	7.33
Other	52.18	0.03	15.70	0.22	1.13	31.53	0.03	4.58	0.29	0.74	20.65	0.03	15.70	0.16	1.37

PHOTOPLATE

LAS different behaviour

Foraging

Maintenance

Resting

Vigilant

Sun-basking

LAS competition with other bird species

LAS Prey items

LAS with snake kill

LAS with fish

LAS with insect

LAS with small snail

LAS with large snail

Data collection

LAS observing passing by farmer