



## BEHAVIOR AND ACTIVITY PATTERNS OF SMOOTH-COATED OTTERS (*Lutrogale Perspicillata*) IN SHUKLAPHANTA NATIONAL PARK, NEPAL

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### ABSTRACT

Understanding the behavior and activity patterns of Smooth-coated Otters (*Lutrogale perspicillata*) is essential for their conservation and management, particularly within protected areas such as Shuklaphanta National Park, Nepal. Therefore, we employed camera traps to monitor otter behavior and activity patterns in Shuklaphanta National Park. We observed the majority of otter activities during daylight hours, with a peak in activity occurring between 07:00 to 09:00 hours and 11:00 to 13:00 hours. Smooth-coated Otters displayed heightened activity during the early morning, possibly associated with foraging or territorial behaviors. Common behaviors observed included alertness, scent-marking and latrines, and walking. These findings reveal that camera traps offer a novel and effective method for monitoring otter behavior in the wild. Camera traps proved particularly advantageous in river sections with dense vegetation, enabling continuous monitoring and overcoming logistical challenges. Our study underscores the importance of prioritizing behavior, activity patterns, and individual identification research to enhance conservation efforts. Given the threats posed by human-altered landscapes, understanding otter behavior is paramount for formulating effective management and conservation strategies, particularly in protected areas like Shuklaphanta National Park, Nepal.

**Keywords:** Activity pattern, behavior camera traps, conservation management, Shuklaphanta National Park, Smooth-coated Otter

### INTRODUCTION

Otters are semi-aquatic elusive mammals that serve as top predators and keystone species within freshwater ecosystems, making them critical indicators of the health of wetland environments (Kruuk, 2006; IOSF, 2020). Smooth-coated Otters show a preference for shallow waters, riverbanks characterized by soft sand and clay, and abundant riparian vegetation cover (Acharya & Lamsal, 2010; Basak et al., 2021; Jayasura et al., 2022; Awasthi et al., 2024b). They can cover extensive distances while searching for their primary food sources, including insects, fish, crabs, and frogs (Kruuk, 2006; Kafle, 2009; Acharya & Rajbhandari, 2012; Basak et al., 2021). They also have a significant impact on the spatial and temporal dynamics of their ecosystems over extended periods (Durbin, 1998; Prenda et al., 2001). Freshwater ecosystems, comprising only 0.8% of the Earth's surface (Dudgeon et al., 2006; Rai et al., 2019), face substantial threats and are vanishing at a rate three times faster than terrestrial ecosystems (Dudgeon et al., 2006; Gardner & Finlayson, 2018).

Rapid human population growth, climate change, deforestation, wetland degradation, and anthropogenic activities such as habitat fragmentation, overfishing, and ecosystem disturbance have led to the severe endangerment of otters in their native Asian habitats (Hussain, 2002; de Silva et al., 2015; Acharya & Rajbhandari, 2012; Awasthi et al., 2024b). This species is classed as Vulnerable on the IUCN Red List (IUCN, 2023), legally protected in Nepal under the Aquatic Life Protection Act (2002) and listed in Appendix I of the Convention on International Trade in Endangered Species (CITES).

The Smooth-coated Otter (*Lutrogale perspicillata*) occupies a broad geographic range spanning from Indonesia across southwestern China, Bhutan, Nepal, India, and Pakistan (Hussain et al., 2008; Moretti et al., 2017; Raman et al., 2019). It inhabits various habitats including rivers, lakes, estuaries, and coastal mangrove swamps, and shows a preference for undisturbed riparian forests or scrub (Kruuk, 2006; Abdul-Patah et al., 2014; Acharya et al., 2023). In Nepal, large otter populations were once sustained by wetlands in and around the Terai Arc

Landscape (TAL) region (Hodgson, 1841; Acharya & Rajbhandari, 2011; Gwachha et al., 2023, Thapa et al., 2021, Awasthi et al., 2024b)). However, the distribution range of otters is currently restricted to small patches within protected areas and their buffer zones (Acharya & Lamsal, 2010; Acharya & Rajbhandari, 2012; Joshi et al., 2021; Mishra et al., 2022; Gwachha et al., 2023; Thapa et al., 2021). ShNP encompasses a variety of aquatic environments crucial for Smooth-coated Otters, including extensive wetlands, rivers, and associated riparian zones (Thapa et al., 2021; Joshi et al., 2021; Awasthi et al., 2024b). These habitats provide essential resources such as prey and suitable denning sites (Joshi et al., 2021)

Foraging, defecating, and grooming represent daytime behaviors commonly observed in Smooth-coated Otters (Hussain, 2013; Nawab & Hussain 2012). However, due to continuous disturbances like overharvesting of fish, water pollution, extraction of sand and gravel, washing and bathing, these animals exhibit behaviors more typical of nocturnal species (Hussain & Chaudhry, 1997; Kruuk, 2006; Nawab & Hussain 2012). Despite this, they are believed to be social and gregarious animals, cooperating closely while grooming, and foraging (Hussain & Chaudhry, 1997; Anoop & Hussain, 2004; Nawab & Hussain 2012). They typically spend their nights in dens (holts) located in dense foliage, under tree roots, or among stones (Hussain & Chaudhry, 1997). The activity patterns of otter species are influenced by seasonal variations in prey availability and habitat suitability (Kruuk, 2006; Mason & Macdonald, 1986; Nawab & Hussain 2012). When excited, they emit frequent high-pitched screams and are known to be highly vocal (Roberts, 1997; Khan et al., 2010).

In wildlife surveys, camera trapping has been widely utilized and shown to be effective in detecting elusive animals, such as otters (Bernard et al., 2013; Evans et al., 2016; Matsubayashi et al., 2011; Samejima & Semiadi, 2012). Camera traps offer significant advantages, especially in river sections with dense vegetation. They provide essential data for estimating population density and size, as well as demographic parameters like sex ratio and reproduction (Chanin, 2003; Kruuk, 2006; García et al., 2009). Given the elusive and often nocturnal behavior of otters, camera traps are particularly effective compared to direct visual methods (Ruiz-Olmo et al., 2001; Samejima & Semiadi, 2012). This method enhances data collection by capturing the full activity period of otters, reducing logistical challenges, and minimizing disturbance in the field (Gil-Sánchez & Antorán-Pilar, 2020).

To date, research on the behavior and activity patterns of Smooth-coated Otters has not been conducted in Nepal. Furthermore, there is scant research on the status, distribution, and presence of this species in protected areas like Shuklaphanta, Bardia, Chitwan National Parks, Koshi Tappu Wildlife Reserve, (Acharya & Lamsal, 2010; Acharya, 2006, 2017; Gwachha, et al., 2023; Bashyal & Yadav, 2020). To fill this gap, this study aims to assess

the behavior and activity patterns of Smooth-coated Otters in Shuklaphanta National Park; this is the first such study in Nepal and this pioneering research will contribute significant insightful information. This will be vital information for the Ministry of Forest and Environment, the Department of National Park and Wildlife Conservation, Department of Forest and Soil Conservation in the preparation of the Smooth-coated Otter strategy plan and action plan for its conservation which will shortly be prepared. This research will also help to develop long-term monitoring of Smooth-coated Otters in Shuklaphanta National Park, which is essential for their conservation.

## MATERIALS AND METHODS

### Study Area

Shuklaphanta National Park (ShNP) (longitude 80° 06' 04" and 80° 21' 40" E, latitude 28° 45' 16" and 28° 57' 23" N) covers a core area of 305 km<sup>2</sup> and a buffer zone of 243.5 km<sup>2</sup>, with an altitude ranging from 174 to 1,386 m. ShNP has a subtropical monsoonal climate with three distinct seasons: cool-dry (late September to mid-February), hot-dry (February to mid-June), and monsoon (mid-June to late September). The park experiences an average maximum temperature of 37°C and an average minimum temperature of 7°C (DNPWC, 2022). The regional climate is characterized as subtropical monsoonal, with an average annual rainfall ranging from 1,300 to 2,300 mm with a peak in August (Awasthi et al., 2024a).

ShNP encompasses mixed habitats consisting of grasslands, wetlands, and mixed forests, creating a mosaic of wildlife habitats (Rawat et al., 2020; Poudyal et al., 2019). The Park boasts a diverse range of biodiversity, including 665 floral species, 15 amphibian species, 56 reptile species, 456 bird species, and 57 species of mammals, as well as 24 fish species (Rawat et al., 2020; Poudyal et al., 2019). In addition to the Greater one-horned Rhinoceros, the Park is home to more than 3-5 resident and 25-30 migratory Asian Elephants (*Elephas maximus*) (Poudyal et al., 2019; Awasthi et al., 2024a).

### Camera trapping

Camera trapping was carried out at 37 stations set up along riverbanks and wetlands in 2020 and 2021 (Fig. 1). The location of the stations was determined based on otter signs like spraints (scats), pugmarks, and scratch marks to increase the chances of capturing Smooth-coated Otters. Initially, 23 cameras were deployed in Shuklaphanta National Park, resulting in 308 camera-trap days from October 10 to December 24, 2020. Later, 14 additional cameras were installed, contributing 201 camera-trap days from March 3 to March 29, 2021 (Fig 1). The selection criteria for these stations involved ensuring a distance ranging from greater than 0.6 km to 1.5 km between camera locations and verifying the presence of fresh otter tracks. At each station, a single automated camera trap, chosen from Cuddeback, Stealth Cam, and Campark T-45 Camera models, was set up approximately 2-3 m away from the water's edge and

mounted 10-25 cm above the ground. The GPS coordinates of each camera station were recorded using Garmin Etrex devices.

The camera traps were configured to record 30-second videos with a five-second interval between triggers and operated continuously for periods ranging from four to twenty-four days, running nonstop, 24 hours a day. Each camera boasted a detection range of at least 20 m. However, occasional issues such as wildlife interference or other disruptions sometimes truncated the observation duration. To ensure continuous operation, the cameras underwent regular inspections every five to seven days, during which their batteries and SD cards were replaced, and they were relocated to different positions. To maintain the independence of observations, any sequence of images capturing Smooth-coated Otters with intervals exceeding 30 minutes was treated as distinct events (Wai et al., 2020).

The analysis involved assessing the frequency of otters seen in recorded videos per operational day of the camera to estimate visit rates. Each instance of a Smooth-coated Otter appearing in a single video clip of

the camera trap was counted as one visit. The duration of each visit was calculated by timing how long either a single otter or a group of otters remained in the area. This was determined by recording the number of seconds the otters remained visible within the camera's field of vision, from their initial appearance until they disappeared. Notably, the visit duration could not be computed during periods when the Smooth-coated Otters were not observable in the video footage.

To identify the predominant behavior, we conducted a comprehensive analysis by first tallying the total number of instances for each behavior type. Subsequently, we calculated the percentage of behavior events by dividing the total number of events by the corresponding number of observations. Our ethogram behaviors were categorized into two distinct groups: "activity" and "walking." Instances where otters traversed the camera's field of view without pausing for any other activity during the video footage were classified as "walking." Conversely, if otters halted and became involved in any of the ethogram-defined activities at the latrine location, these behaviors were categorized as "activity (Table 1)."

**Table 1. Ethogram of behaviors observed from camera trap footage for Smooth-coated Otters (Green et al., 2015)**

<b>Visits</b>	
Solitary	Single individual
Group	Two or more than two individuals
<b>Activity behaviors</b>	
<b>Activity behaviors</b>	<b>Definition</b>
Alert	Perched and/or vigilant
Walking	If the otter(s) moved through the camera without stopping or doing anything else during the whole video
Grooming	Licking their own body, licking paws and then rubbing them on the face, scratching their fur with forepaws or hind paws, ruffling the fur, or washing
Investigating	Animals sniff and inquisitively move around the environment.
Sniffing	Nose to the ground with head moving back and forth, whether the animal is standing still or walking; or nose touching another Smooth-coated Otter.
Resting	Rest
Sleeping	Sleep on the ground
Run	Running
Foraging	Searching in water for food
Body rub	Rubbing the head and neck on the ground or dragging the belly on the ground
Allogrooming	Licking or scratching with forepaws or hind paws the fur of another Smooth-coated Otter
Standing	Stationary, no walking or running movement
Mount	When one Smooth-coated Otter mounts another to mate, it might bite the nape of the other's neck during this activity.
Poop dance	Dancing after defecation
Defecating/ sprainting/urinating	Otters sprainting, defecating, and any excremental discharges from any animals

## DATA ANALYSIS

We analyzed the frequency and time duration of visits between solitary (single otter visits) and social (group otter visits) behaviors across 37 camera trapping stations using the BORIS program v. 8.20.3 2023-06-04 (Friard & Gamba, 2016). Notably, none of the otters were individually tagged or identifiable due to a lack of distinctive physical characteristics for repeated recognition. Otter behavior classification relies on the

occurrence of specific actions, including grooming, playing, walking, urination, and defecation. Furthermore, we documented the presence of otters that exhibited no observable behaviors, whether directly or indirectly.

Images and videos were organized based on locations and specific dates, and a filtering process was implemented to identify images of different animals. Using RENAMER software, the captured mammal

photos and videos were renamed along with the corresponding timestamps. To ensure event independence, the filtering process was repeated, with criteria for determining each photo as an independent event including consecutive images of similar or dissimilar animals, alternate photos of the same animal, and consecutive photos taken more than 30 minutes apart. Subsequently, data specifically related to otters were segregated from the overall records for further analysis.

We categorized nocturnal activity as occurring from 19:00 to 05:00 hours, diurnal activity from 07:00 to 17:00 hours, and crepuscular activity from 05:00 to 07:00 hours and 17:00 to 19:00 hours (Ross et al., 2013; Wai et al., 2020). Otter activity patterns were analyzed using kernel density estimates with the “overlap” package (Ridout & Linkie, 2009; Meredith & Ridout, 2023). Statistical analyses were conducted using RStudio (v. 4.1.3, R Core Team, 2023) to visualize the species’ activity patterns.

## RESULTS

### Distribution of Smooth-coated Otters in Shuklaphanta National Park

To assess the distribution and behavior of Smooth-coated Otters in Shuklaphanta National Park, a total of 509 camera-trap nights were conducted across multiple habitats. This effort resulted in the capture of 9,963 videos and 6,190 photographs. Among the videos captured during the study conducted in 2020 and 2021, a total of 3,492 videos recorded animal activity, with 2,629 videos captured in 2020 and 1,823 videos in 2021. Only seven camera trapping stations yielded footage of otters (Fig. 1), predominantly at the Chaudhar River and Hattikunda sites. Remarkably, no otters were recorded at Rani Taal throughout the study period. From these seven camera stations, a total of 28 independent otter visits were obtained. Interestingly, group visits ( $n = 24$ ) outnumbered solitary visits ( $n = 4$ ), with a mean of  $2.64 \pm 2.28$  individuals per visit reflecting the social nature of the species in this region.

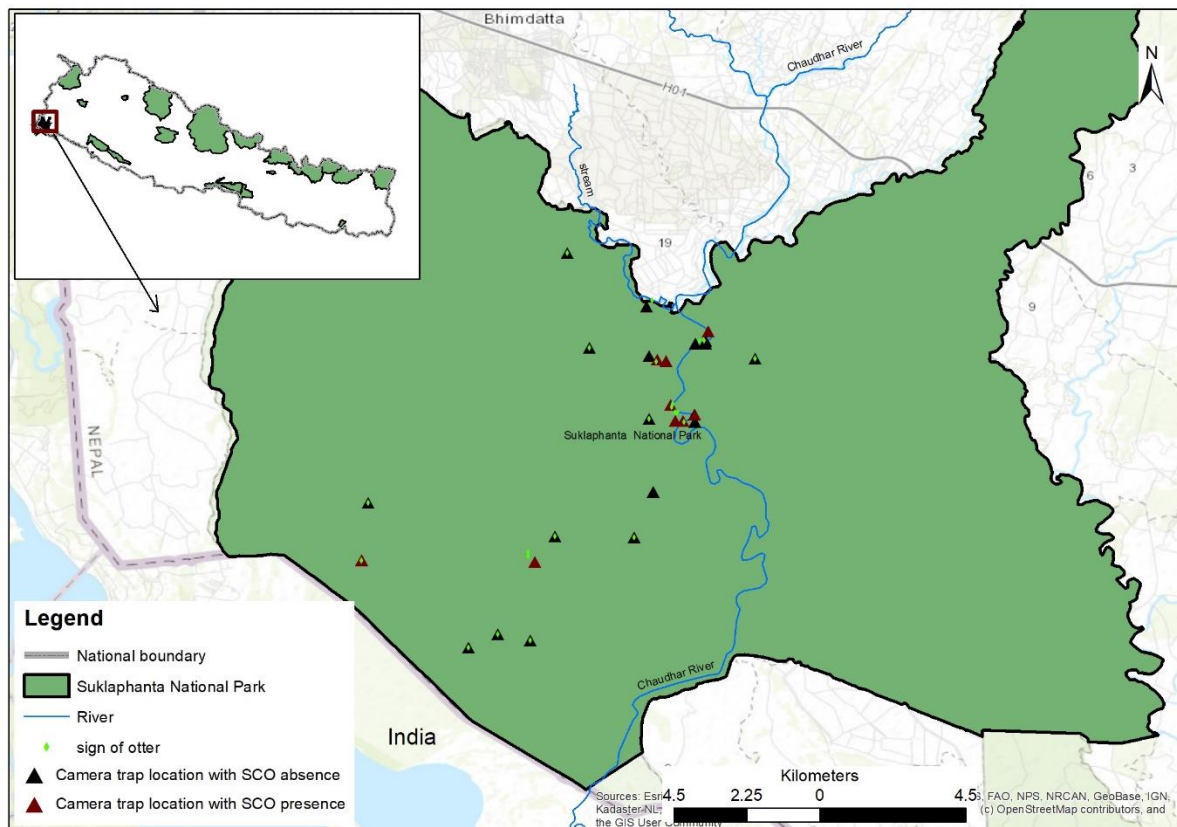


Figure 1. Map showing the distribution of Smooth-coated Otters based on direct, indirect, and camera trap records in Shuklaphanta National Park

### Habitat preference

Footprint signs and other evidence of otter presence were found in 37 camera trapping stations, which were primarily situated in wetlands and riverbanks surrounded by tall grasses of 1-4 meters in height, such as *Phragmites karka* and *Saccharum spontaneum*. The specific stations

where otters were recorded, along with their corresponding habitats, are presented in Table 2. These findings suggest that Smooth-coated Otters prefer habitats with minimal human disturbance and dense vegetation, particularly in wetland areas (Fig. 2).

Table 2. The preferred habitat of Smooth-coated Otter based on camera trapping and direct observation

Location	Type of water point	Habitat type	Dominant vegetation	Average grass height	Human disturbances	Evidence of presence
Haati Kunda	Wetland	Tall grass	<i>Phragmites karka</i> , <i>Saccharum spontaneum</i>	> 3m	Absence	CT-photo capture, footprint sign, spraint presence
Bahuni Khola	Wetland	Riverbank mixed forest	<i>Syzygium cumini</i>	-	Absence	CT-photo capture footprint sign, spraint presence
Salgaudi Tal	Wetland	Tall grass	<i>Phragmites karka</i>	> 3.5m	Absence	CT-photo capture
Chaudhar river (Gohikunda)	River	Riverbank tall grass	<i>Phragmites karka</i> <i>Saccharum spontaneum</i>	> 3.5m	Absence	Direct observation
Chaudhar river (Harayasirani)	River	Riverbank	-	-	Absence	CT-photo capture



Figure 2. Smooth-coated Otters (*Lutrogale perspicillata*) captured by camera traps at Shuklaphanta National Park (ShNP). The images illustrate the species' activity in their natural habitat, providing evidence of their presence in the park's wetlands and riverbank areas.

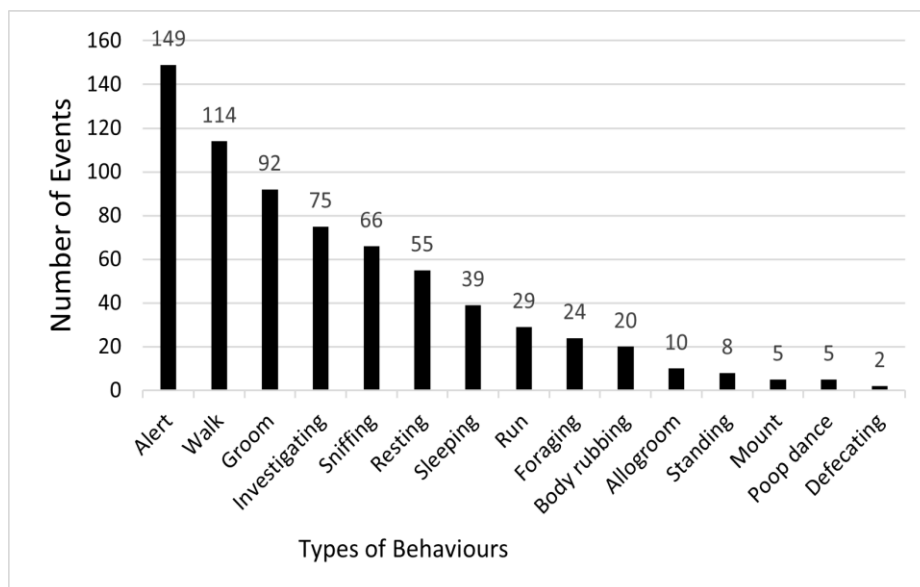


Figure 3. Types and event records of Smooth-coated Otter behaviors

**Behavior assessment**

A total of 172 otter video recordings were documented across various locations, including 143 group visits and

29 solitary visits. Analyzing 5,106 seconds of video footage, we recorded 679 distinct behavioral observations (see Supplementary Table S1). The

ethogram employed to categorize these behaviors indicated that alertness (149 observations) and walking (114 observations) were the most frequently exhibited behaviors in riverine habitats (Fig 3).

**The proportion of time spent on different behaviors**  
The greatest proportion of time spent by Smooth-coated Otters was in mounting (30.52%) and foraging (15.18%), with eight instances of defecating at latrines (Fig 4).

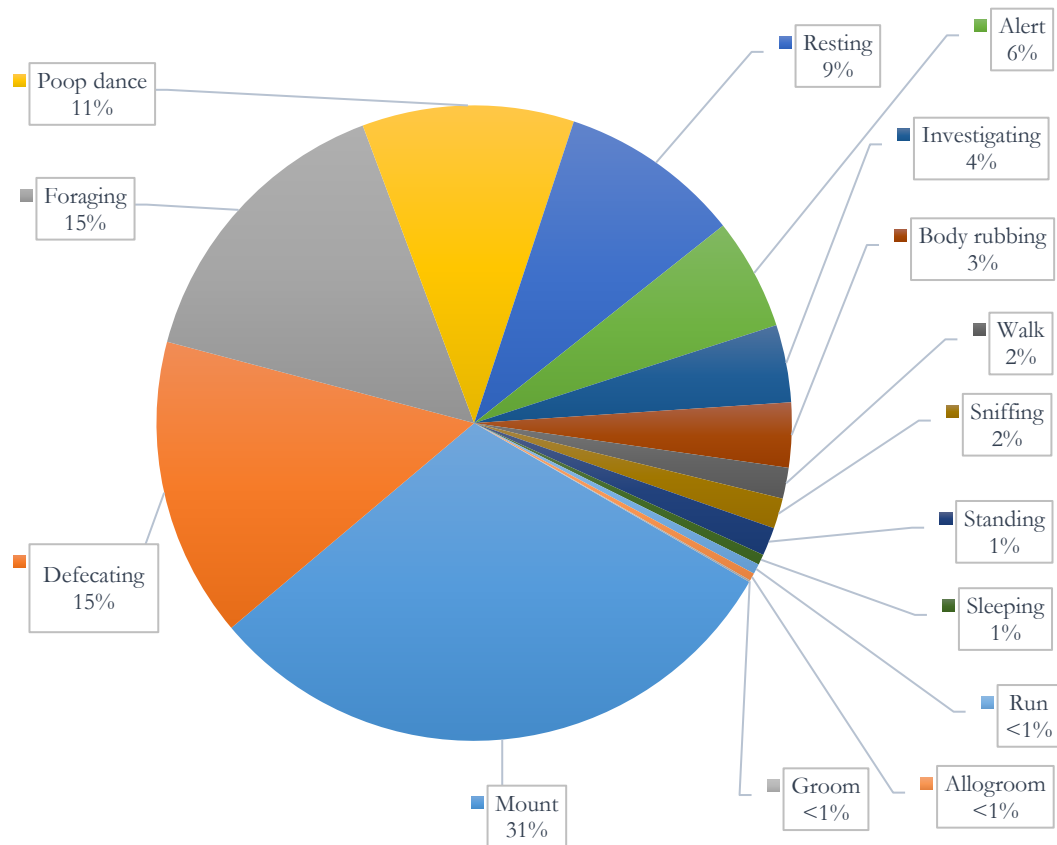


Figure 4. The percentage of time spent on different behaviors

### Daily activity pattern

The study revealed that otter activity was predominantly diurnal, with most behaviors occurring between 07:00 and 17:00 hours, particularly around midday. In wetland habitats (Figure 5a), activity peaks were also observed during the crepuscular periods (05:00 to 07:00 hours and 17:00 to 19:00 hours) and persisted throughout daylight hours. In river habitats (Figure 5b), activity patterns varied, reflecting habitat-specific behaviors. When data from both wetlands and rivers were combined (Figure 5c), the overall activity pattern exhibited consistent diurnal peaks. A comparison between wetlands and rivers (Figure 5d) highlighted differences in the timing of activities, suggesting adaptations specific to each habitat.

### DISCUSSION

Through the utilization of camera traps and subsequent analysis of video data, we gained valuable insights into the behavioral dynamics of Smooth-coated Otters. A key

finding from our study was the frequency of otter visits: out of 28 independent visits, the majority involved multiple individuals, indicating a strong tendency towards social behavior over solitary visits. Being part of a social group allows for cooperation in tasks like foraging and defense (Smith et al., 2012). Supporting the "ecological constraints hypothesis," Smith et al., (2008) demonstrated that cooperation could increase individual benefits in obtaining trophic resources and protecting against threats. Our findings indicate that otters are predominantly active during daylight hours, which may be associated with foraging or territorial behaviors (Hussain, 2013; Wai et al., 2020; Lélías et al., 2021).

Moreover, through the analysis of over 5,106 seconds of video data, we documented 679 instances of otter behavior. The ethogram used for behavior classification revealed intriguing patterns, with 'alert' and 'walking' being the most prevalent behaviors, recorded 149 and

114 times, respectively. The frequent occurrence of alert behavior suggests that otters remain vigilant and attentive to their surroundings, which is crucial for detecting potential threats such as predators or competitors. This vigilance underscores the adaptive

nature of otters as they continuously monitor their environment for changes or disturbances, which plays a significant role in their survival and defense strategies (Barocas et al., 2022).

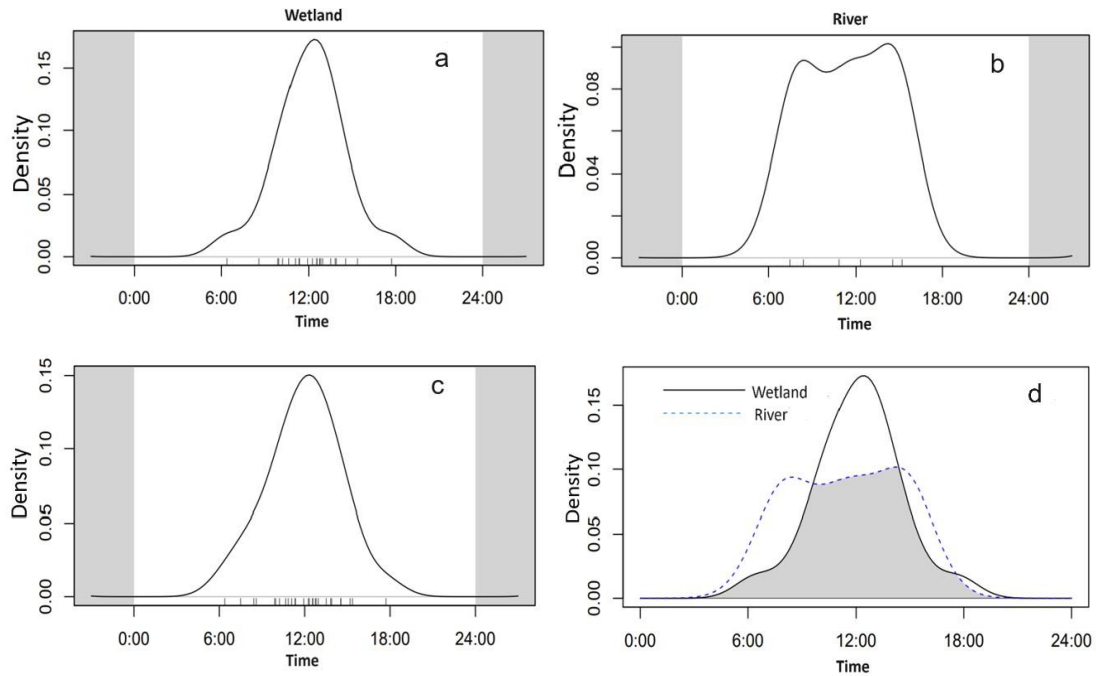


Figure 5. 5a). Activity curves for otters in wetlands; 5b). Activity curves for otters in rivers; 5c). Activity curves for otters in ShNP (both habitats); 5d). Activity curves for otters in wetlands and rivers in ShNP

One notable finding of the study is the occurrence of defecating/sprainting behaviors, which play crucial roles in communication, social bonding, and territory establishment within otter populations (Wai et al., 2020). This behavior suggests that otters may collect olfactory information about conspecifics at these sites (Kean et al., 2015).

The study provides valuable insights into Smooth-coated Otter activity patterns across different habitats within Shuklaphanta National Park. Our findings indicate that otters are predominantly diurnal, with peak activity observed during daylight hours, particularly around midday, suggesting optimal foraging times and predator avoidance. This aligns with previous research which also showed that otters exhibit a preference for daytime activities (Hussain, 2013; Wai et al., 2020), possibly influenced by factors such as prey availability and optimal foraging conditions (Shenoy et al., 2006; Hussain, 2013; Dias et al., 2022). In wetland habitats, otters are active during both daylight and crepuscular periods (05:00 to 07:00 hours and 17:00 to 19:00 hours), indicating optimal times for foraging and avoiding predators. In contrast, otters in river habitats exhibit different activity patterns, which may be influenced by varying environmental factors such as prey availability and water flow (Hussain, 2013; Dias et al., 2022).

By combining data from both wetlands and rivers, the study provides a comprehensive view of otter behavior in Shuklaphanta National Park, highlighting the species' ability to adapt to different habitats. These findings enhance our understanding of Smooth-coated Otter ecology and emphasize the need to consider habitat-specific behaviors in conservation strategies. This study provides the first camera trap-based data on the behavior and activity patterns of Smooth-coated Otters in Nepal, which contributes to our understanding of otter behavior and ecology. However, there is still a great need for further research in this field.

## CONCLUSIONS

In conclusion, the study provides valuable insights into the activity patterns and behaviors of Smooth-coated Otters, revealing a preference for diurnal activity with peaks around midday. The observed patterns highlight the otters' adaptation to different habitats, with distinct behaviors in wetlands and river environments. Looking ahead, future research should prioritize evaluating otter behavior and the recognition of individual animals. It is essential to look further at additional aspects of otter behavior, such as communication, social behavior, reproductive behavior, aggression, territorial behavior, aquatic ability, hunting and feeding behavior. Furthermore, investigating the influence of environmental factors like habitat quality and human

disturbances on otter behavior would enhance our understanding of their ecology and aid in species conservation. Additionally, expanding the research to cover more potential otter sites could improve the accuracy of the findings and enhance our understanding of otter ecology and habitat preferences. This study lays a solid foundation for understanding otter behavior, guiding future research directions, and informing conservation strategies.

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#### AUTHOR CONTRIBUTIONS

BA: Conceptualization, Methodology, Project administration, Resource, Field work, Data curation, Analysis, Writing original draft, Review and editing; KU: Data curation, Writing – review and editing; PMS: Methodology, Writing – review & editing; BRB: Writing – review & editing; GMY: Writing – review & editing; AK: Analysis, Writing – original draft, Review and editing. All authors contributed to the drafts and gave final approval for publication.

#### CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

#### DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

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**Supplementary Table S1. Activities of Smooth-coated Otter and duration of time spent in each behavior.**

Activities of SCO	Hattikunda		Bahunikhola		Gohikunda		Haraya		Total Events	TS	percentage time spent
	Events	TS	Events	TS	Events	TS	Events	TS			
Alert	145	280.64	0	0	0	0	4	9.80	149	290.44	5.69
Body Rubbing	20	80.33	0	0	0	0	0	0	20	80.33	3.30
Defecating	2	4.35	0	0	0	0	0	0	2	4.352	15.27
Foraging	21	150.73	1	14.66	0	0	2	35.94	24	201.35	15.18
Allogrooming	10	78.94	0	0	0	0	0	0	10	78.94	0.39
Investigating	75	472.06	0	0	0	0	0	0	75	472.06	3.94
Mounting	5	27.09	0	0	0	0	0	0	5	27.09	30.52
Poop dance	5	26.33	0	0	0	0	0	0	5	26.33	10.78
Resting	54	772.42	0	0	0	0	1	2.58	55	775.01	9.24
Sniffing	64	153.87	1	11.26	0	0	1	3.16	66	168.29	1.55
Standing	8	20.045	0	0	0	0	0	0	8	20.04	1.44
Running	27	70.43	0	0	1	1.15	1	1.9	29	73.49	0.52
Grooming	92	1558.39	0	0	0	0	0	0	92	1558.39	0.09
Walking	112	521.77	1	26.8	0	0	1	2.16	114	550.73	1.57
Sleeping	39	779.76	0	0	0	0	0	0	39	779.76	0.53

Note: Time in seconds=TS