

ARTICLE

HOLT-BASED ACTIVITY PATTERNS OF SMOOTH-COATED OTTER (*Lutrogale perspicillata*) IN THE LOWER KINABATANGAN WILDLIFE SANCTUARY, SABAH, MALAYSIA

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ABSTRACT: Despite being one of the most biodiverse regions in the world, not much is known concerning the ecology of the otters on Borneo. We conducted a study to document the activity patterns of the smooth-coated otter, *Lutrogale perspicillata*, in increasingly disturbed and fragmented habitats in the Lower Kinabatangan Wildlife Sanctuary (LKWS), located in the Malaysian state of Sabah, northern Borneo. The aim was to gather ecological information for establishing baseline data and to understand better the otter behavior in this region of Sabah. We deployed camera traps at active otter holts, grooming and sprainting sites for 15 non-consecutive months and utilized the photographs to model the activity patterns of the otter using kernel's density estimate modeling. Results showed that *L. perspicillata* in the LKWS was mainly crepuscular, with otter activity mainly occurring during early morning (0600 h) and late afternoon (1600 h - 1800 h). Grooming activity peaked at 0600 h while sprainting activity peaked at both 0800 h and 1700 h. We suggest that activity patterns of *L. perspicillata* may be influenced by prey availability, human disturbance and environmental temperature.

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INTRODUCTION

A total of 379 species of mammals are known to be found in the island of Borneo (Phillips and Phillips, 2016), including four otter species; *Lutrogale perspicillata* (smooth otter), *Aonyx cinereus* (Asian small-clawed otter), *Lutra sumatrana* (hairy-nosed otter) and *Lutra lutra* (Eurasian otter). In Sabah, *L. perspicillata* and *A. cinereus* are commonly seen, however, no scientific studies have been conducted on otters in the Lower Kinabatangan Wildlife Sanctuary (LKWS). *L. sumatrana* was rediscovered in Sabah in 2010 and *L. lutra* was considered extinct in Borneo during the Borneo Carnivore Symposium in 2011. However, *L. lutra* was rediscovered and photographed in 2015.

The LKWS is a forest corridor along the Kinabatangan River in Sabah and it is an area comprised of a mixture of primary and logged lowland dipterocarp forests

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surrounded mainly by oil palm plantations (Abram et al., 2014; Ancrenaz et al., 2004). Despite being surrounded by human-modified landscapes, the narrow strip of forest corridor remains an important habitat for flora and fauna including otter species. To date, there are two otter species documented in the examined reaches of the LKWS; *L. perspicillata* and *A. cinereus*.

There has been no published research into the activity patterns on *L. perspicillata* in Borneo. In other regions within their range, the species displays diurnal behavior (Hussain, 2013), although others have reported otters will become more nocturnal following increasing levels of human disturbances (Kruuk, 2006). Camera trapping has been widely used in wildlife surveys throughout the region and has been effective in detecting elusive species such as otters (Bernard et al., 2013; Evans et al., 2016; Matsubayashi et al., 2011; Samejima and Semiadi, 2012). In this study, camera traps were used to record the daily activity patterns of *L. perspicillata* at active holts, grooming and sprainting sites situated within the degraded landscape of LKWS. Understanding the daily activity pattern of this species provides a valuable ecological information of *L. perspicillata* within degraded landscape, which will become the baseline for conserving this species in Sabah. This baseline data can be used to protect and conserve otter habitat, as well as managing human-otter conflict in Sabah.

STUDY AREA

The LKWS is located on the east coast of Sabah, Malaysia Borneo (Figure 1), and comprises 27,000 ha of protected forest divided into 10 lots after being gazetted by the Sabah Wildlife Department in 2002 (Ancrenaz et al., 2004). The lowland dipterocarp forests in the Kinabatangan floodplain have undergone drastic human changes since the 1950s, particularly in the form of logging and agriculture, resulting in the extensive conversion of rainforest into oil palm (*Elaeis guineensis*) plantations (Abram et al., 2014; Ancrenaz et al., 2004). Despite the large amount of agriculture along the Kinabatangan River, a seemingly high diversity of Bornean species continues to persist within the floodplain (Abram et al., 2014; Evans et al., 2016). The mean annual rainfall of the region is 3,000 mm and average temperatures range from 21 - 34 °C.

METHODS

Camera trapping

A total of 40 kilometers of the Kinabatangan River (see Figure 2) were surveyed and two active otter holts, one grooming and one sprainting site were encountered. Reconyx HyperFire Professional Infrared camera traps (Models HD500 and PC800) in protective iron casings were deployed directly in front of the two active holts, an additional unit was placed at the holt grooming site, while one more was set up at the sprainting site (see Figure 2). The camera traps were set up for a period of 15 non-consecutive months (April 2016 - June 2017); monitoring was non-consecutive due to flooding events in the region, as cameras were removed to avoid damage. Camera traps took a series of three images at 1-second intervals when triggered, and during low lighting conditions, an infrared flash was used for successful and minimal stressful nocturnal imaging. Batteries and memory cards were changed and data were retrieved every 30 days

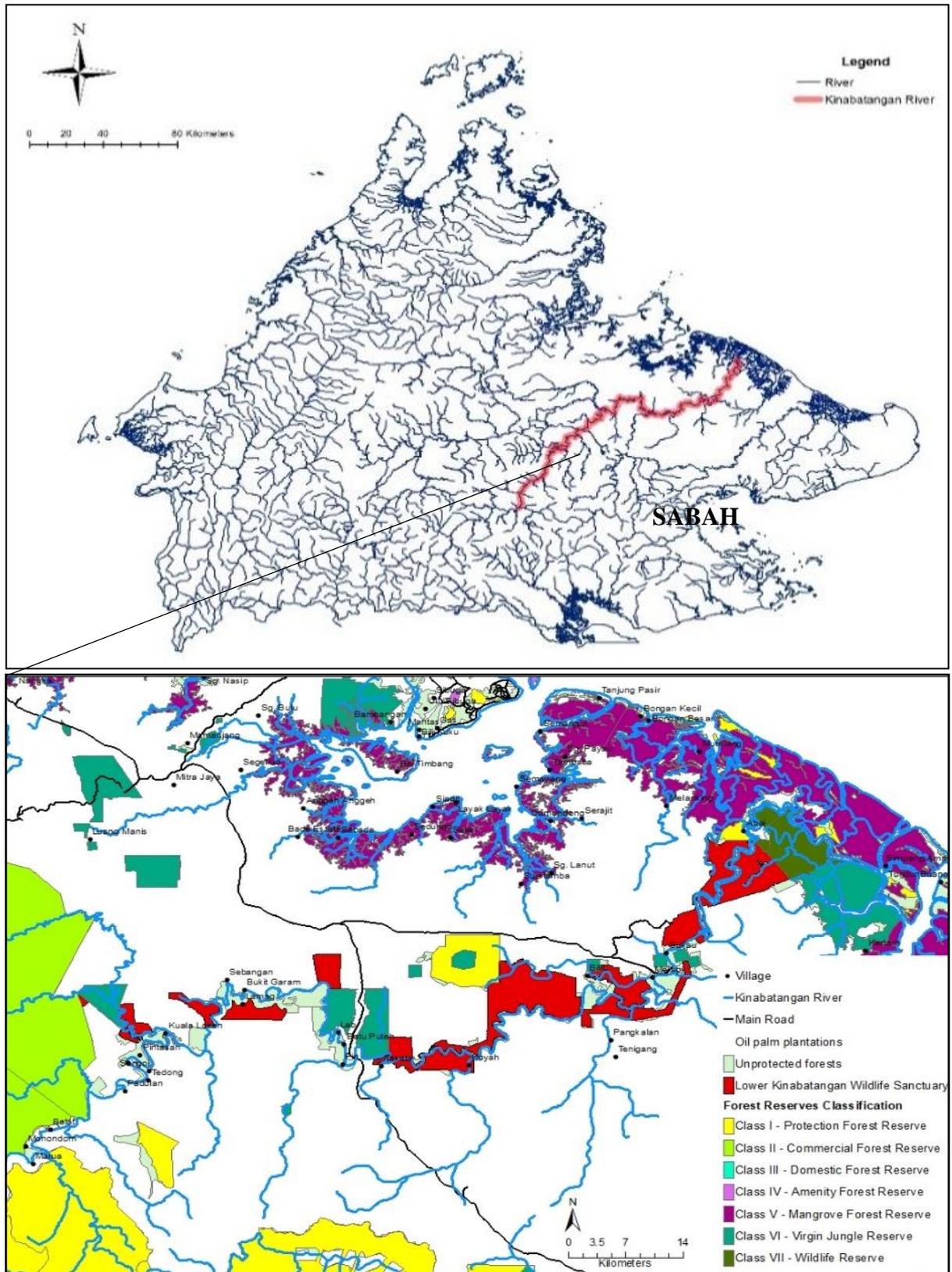


Figure 1: Location of the LKWS and surrounding protected forest in Sabah, Malaysia. Red line denotes the Kinabatangan River in large extent map.

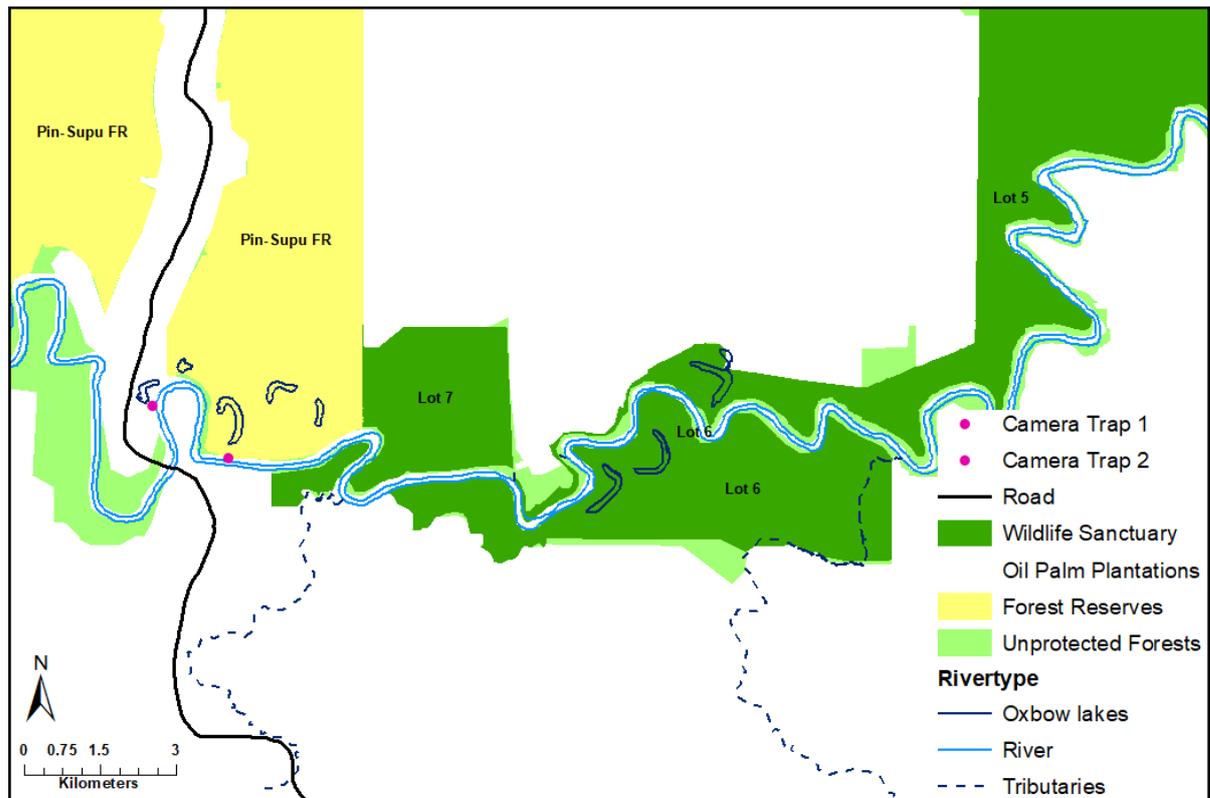


Figure 2: Location of camera trap stations within Lots 5, 6 and 7 in LKWS.

Data entry and analysis

Camera trap images were manually selected and photos not containing otters were excluded from statistical analysis. Metadata extraction was completed using ExifTool (version 9.6.8.0), which included the file name, time, date, moon phase and temperature from each selected photograph. Each burst of three images was considered a single capture, and capture events were further separated using an interval of >30 minutes between photos to avoid pseudoreplication (Vickers et al., 2017; Yasuda and Tsuyuki, 2012). Group size was disregarded for activity pattern determination; as such a photograph containing more than one otter was considered a single event. As a methodology, it is important to note that the resulting activity pattern model generated from these otter photographs represents holt-based behaviours; other activities outside the camera trap view such as hunting activity are not presented. The day-night cycle remains constant throughout the year within the study site, as sunrise occurs at 0600 h and sunset 1800 h, local time (GMT +8). Nocturnal wildlife activity in Borneo can be categorized as 1900 h - 0500 h, diurnal activity between 0700 h - 1700 h and the remaining time; 0500 h - 0700 h and 1700 h - 1900 h was categorized as crepuscular activity (Ross et al., 2013). Following the methodology of Ridout and Linkie (2009), otter activity pattern was modelled using kernel density estimates and the package ‘overlap’ (Meredith and Ridout, 2014). Statistical analyses were conducted in RStudio software (v. 3.3.3, R Core Development Team, 2018).

RESULTS

A total of 46,245 images of otters were collected from the four camera traps across 916 camera trap-nights. Based on the combined images from all four camera traps, regardless of exact position, *L. perspicillata* demonstrated two activity peaks; 0600 h and between 1600 h - 1800 h, which indicates that otters were most likely to be captured by the camera traps during dawn and dusk (Figure 3(a)). Moderate otter activity was recorded at 1200 h and between 1900 h - 2400 h, while the lowest activity

was recorded during the night between 0000 h - 0500 h. Grooming activity pattern was generated using the same modelling parameters (see Figure 3(b)) and grooming activity peaked at 0600 h, while the lowest grooming activity recorded was between 0000 h - 0300 h. Using the same model, a sprainting site activity pattern was also generated (see Figure 3(a)). Based on the result obtained, two temporal peaks in sprainting behaviours were recorded; the first peak occurred at 0800 h and the second peaked at 1700 h. The lowest sprainting activity recorded was at 0300 h and 1200 h.

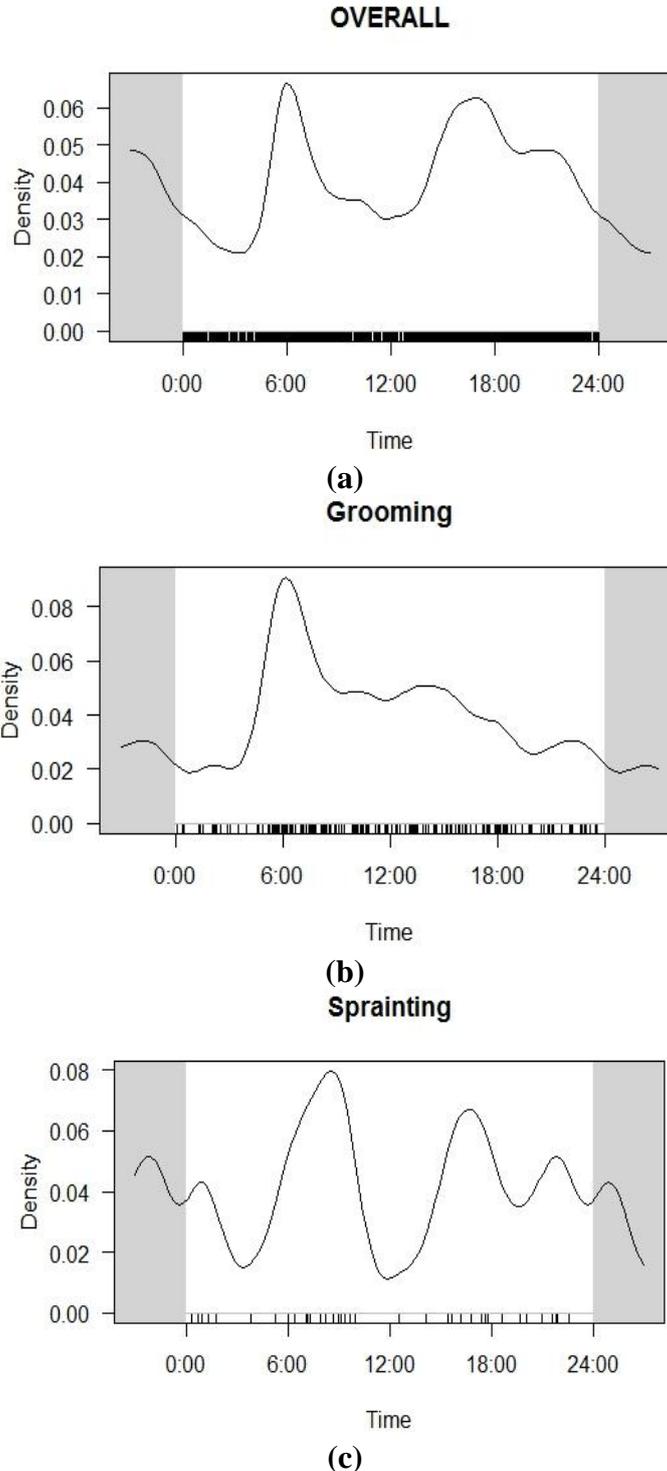


Figure 3: Daily activity patterns for *L. perspicillata* in LKWS based on photographs collected from: (a) all camera traps, (b) a grooming site (1 camera trap) and, (c) a sprainting site (1 camera trap). The grey areas represent an extension of the diel given its circular nature, black marks along the horizontal axes indicates individual camera trap events containing otters.

DISCUSSION

This study has produced the first documented model of the activity pattern of *L. perspicillata* in Sabah, Malaysian Borneo and this information will help to understand better otter behaviour in this region. The findings indicate that the holt-based activity patterns of *L. perspicillata* in LKWS was mainly crepuscular and this study broadly agree with Hussain (2013), who studied the same otter species in India using radio telemetry. However, these findings are in direct contrast with other *L. perspicillata* studies, which suggests that this species is mainly diurnal (Foster-Turley, 1992; Khan et al., 2010; Kruuk, 2006; Payne et al., 2007).

The crepuscular behavior of the Kinabatangan otters in contrast to other regions could be influenced by the differences in the availability of prey, human disturbances or ambient temperatures (Hussain, 2013). Our recorded moderate otter activity at noon might be associated with the high tropical temperatures in Sabah. High ambient temperatures will increase otter energy expenditure, directly affecting otter physiology (Anoop and Hussain, 2004; Foster-Turley, 1992; Hussain, 2013). During these temperature spikes, otters could be resting inside the holts, and therefore were not visible in front of the camera trap. Mean annual temperature in Sabah range from 25 - 30°C, and maximum temperatures are reached at midday and could exceed 32°C (Malaysian Metrological Department, 2017). However, lower temperatures (18 - 20°C) are recorded throughout the night and early morning (Malaysian Metrological Department, 2017), which could help explain our recorded otter activity peaks in the early morning. Moreover, fish, the main prey source for *L. perspicillata*, activity may also be affected by the high afternoon temperatures in Sabah; perhaps fish hide in cooler environments during these times and become active again when temperature is more tolerable (Hussain, 2013; Kruuk, 1995).

Contrastingly, low nocturnal temperatures may increase otter activity. However, in this study, otter activity was moderately low during the night. Perrin and Carranza (2000) reported spot-necked otter (*Hydrictis maculicollis*) activity was positively correlated with the detection of prey, such that low detection of fish during the night caused the otters to become less nocturnally active. The above statement suggests that *L. perspicillata* in the study area might be actively hunting on the river during the day when their visibility is at the best, however, hunting activities were not detected due to the location of our camera trap.

Another possible explanation that affects the otter activity pattern is the presence of saltwater crocodiles (*Crocodylus porosus*) in the study site. Otters may display behavioural changes to adapt with their surroundings, and this could include adapting their activity patterns to avoid predation risk from *C. porosus* or to minimize interspecific competition for fish. Saltwater crocodiles were documented actively hunting at night in the study area, although some satellite-tracked individuals displayed elevated activity peaks at crepuscular times (Evans, 2016). It is suggested that the increases in holt-based activity by *L. perspicillata* may be in response to the presence of saltwater crocodiles. Indeed, Hussain (1993) reported avoidance of mugger crocodile (*Crocodylus palustris*) basking sites. In other regions, otter species co-occur with a range of crocodylian species (Hussain, 2013; Kruuk, 2006; Reed-Smith et al., 2015; Ribas et al., 2012), but little is known concerning the interactions between these two river predators.

Grooming site utilisation of *L. perspicillata* in the LKWS was mostly recorded in the morning, and this may be associated with otter's natural behaviour; otters groom themselves after hunting bouts. After diving under water, otters need to dry their fur to maintain its insulating ability (Hussain, 2013; Kruuk, 2006). Foraging sessions of *L. perspicillata* have been observed and recorded mostly in the morning and evening (Hussain, 2013; Kruuk, 1992). Therefore, our recorded increase in morning grooming

activity might relate to morning hunting activity. Even though *L. perspicillata* have previously been reported to actively hunt during the evening, we recorded low grooming activity in the evening. The findings may suggest that *L. perspicillata* in the region may have multiple grooming sites and they were grooming at other sites in the evening, outside of the camera trap view.

Results from the modelled sprainting activity pattern presented sprainting peaks in the morning and evening. Similar to grooming behavior, sprainting has also been related to hunting bouts (Kruuk, 1992), which could explain the high sprainting activity in the morning and evening. Our modelled sprainting activity pattern presents as a bimodal wave across the diel except noon, which indicates that otters are constantly sprainting throughout the day. Otters are territorial mammals and often mark their territory with repetitive sprainting (Brzeziński and Romanowski, 2006; Kruuk, 1992; Shenoy et al., 2006; White et al., 2003). Our reported decrease in afternoon sprainting activity may be also due to the increase of grooming activity during that time. Other studies (Anoop and Hussain, 2004; Shenoy et al., 2006) have reported that smooth-coated otter may spraint at their grooming site. However, in this study, no spraint was detected at the grooming site, suggesting differences in behaviour of the same species in other regions.

Although camera traps have been widely used to record wildlife behaviour, there were several limitations intrinsic to the usage of this methodology in this study. Camera traps were removed several times due to flooding. It would be interesting to record otters' behaviour and activity patterns outside their holts and associated sites during the flooding season; a waterproof camera trap could be used for such future monitoring work. In addition, activity data were limited to the behaviour that occurred within the camera trap view, and activity beyond this view was not recorded, and thus, not included in these preliminary activity models. For future work, other methods such as habituation observation studies, satellite tracking or radio telemetry, as per Hussain (2013), could be incorporated together with camera trapping to provide more detailed activity patterns for this species. Moreover, setting up the camera traps for a longer period could be useful for monitoring otter group demographics, group health and reproduction cycles over the years. Camera trapping can be easily adopted to study this species in the future, however, targeted questions and an awareness of the methodological limitations of the technology are required for effective future research. These preliminary activity patterns determined by this study serve as valuable baseline knowledge on how this species persists in Borneo, specifically in a degraded and human-modified landscape.

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RÉSUMÉ

MODÈLES D'ACTIVITÉ DE LA LOUTRE A PELAGE LISSE (*Lutrogale perspicillata*) LIÉS A LA CATICHE, DANS LE SANCTUAIRE DE LA FAUNE SAUVAGE DU KINABATANGAN INFÉRIEUR, SABAH, MALAISIE

Bien qu'elle soit l'une des régions les plus riches en biodiversité du monde, on sait peu de chose sur l'écologie des loutres à Bornéo. Nous avons mené une étude pour documenter les schémas d'activité de la loutre à pelage lisse, *Lutrogale perspicillata*, dans des habitats de plus en plus perturbés et fragmentés de la réserve faunique inférieure de Kinabatangan (LKWS), située dans l'État malaisien du Sabah, au nord de Bornéo. L'objectif était de rassembler des informations écologiques pour avoir des données de base et mieux comprendre le comportement de la loutre dans cette région du Sabah. Nous avons installé des pièges photos à proximité des catiches, des sites de toilettage et d'épreintes fréquentés par la loutre pendant 15 mois non consécutifs et avons utilisé les photos pour modéliser les schémas d'activité de la loutre à l'aide d'un modèle d'estimation de la densité du noyau. Les résultats ont montré que *L. perspicillata* dans le LKWS était principalement crépusculaire, l'activité de la loutre se situant principalement tôt le matin (600 h) et en fin d'après-midi (1600 h à 1800 h). Les activités de toilettage ont culminé à 600 h, tandis que les activités d'épreintes ont atteint leur pic à 800 h et à 1700 h. Nous suggérons que les schémas d'activité de *L. perspicillata* pourraient être influencés par la disponibilité en proies, les perturbations humaines et la pollution de l'environnement.

RESUMEN

PATRONES DE ACTIVIDAD EN LA MADRIGUERA, DE NUTRIAS LISAS (*Lutrogale perspicillata*) EN EL SANTUARIO DE VIDA SILVESTRE DE KINABATANGAN INFERIOR, SABAH, MALASIA

A pesar de ser una de las regiones más biodiversas del mundo, no se sabe mucho sobre la ecología de las nutrias en Borneo. Condujimos un estudio para documentar los patrones de actividad de la nutria lisa, *Lutrogale perspicillata*, en hábitats con disturbio y fragmentación creciente en el Santuario de Vida Silvestre de Kinabatangan Inferior, ubicado en el estado malayo de Sabah, Borneo del norte. El objetivo fue obtener información ecológica para establecer datos de base para entender mejor el comportamiento de las nutrias en esta región de Sabah. Desplegamos cámaras-trampa en madrigueras activas de nutria, y sitios de marcación y acicalamiento, durante 15 meses no-consecutivos, y utilizamos las fotos para modelar los patrones de actividad de las nutrias en base a modelado de densidad estimada de núcleos (kernel). Los resultados mostraron que *L. perspicillata* en Kinabatangan es principalmente crepuscular, concentrándose la actividad de las nutrias principalmente durante la primera mañana (0600 h) y el final de la tarde (1600 h – 1800 h). La actividad de acicalamiento tuvo un pico a las 0600 h, y la de marcación (fecas) tanto a las 0800 h como a las 1700 h. Sugerimos que los patrones de actividad de *L. perspicillata* pueden estar influenciados por la disponibilidad de presas, el disturbio humano y la temperatura ambiente.