Activity patterns of otters (*Lutra lutra*) in De Onlanden Nature Reserve, the Netherlands

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Abstract: The otter (*Lutra lutra*) population in the De Onlanden Nature Reserve (Province of Groningen, the Netherlands) has been monitored for four years using seven cameras placed at locations where otters regularly passed. Analyses of the recordings of these cameras showed that otters were present and active throughout the year and were mainly active in the dark period of the day. Males were found to be most active in the late summer months, while family groups were seen mostly in the winter months and were absent in the summer period. During the long winter nights, activity was spread out over the whole night and family groups and 'other' otters continued to be active at a low level in the daytime hours. Males were not active in daylight. Both males and family groups seemed to have short breaks during their night time activity. In the short summer nights the otters started being active a little (1-2 hours) before sunset and were most active at the start of the dark period. Activities diminished gradually during the night, continuing until approximately one hour after sunrise. Almost no activity was recorded during the long daytime period in summer. Comparison of locations with and without human disturbance (i.e. traffic) showed that in the absence of human disturbance the otters (especially families) were significantly more active during the daytime period.

Keywords: otter, *Lutra lutra*, De Onlanden, monitoring, camera, activity patterns, disturbance.

Introduction

Between 2002 and 2008 otters (*Lutra lutra*) were successfully reintroduced in the Netherlands with the release of 31 individuals in de Weerribben-Wieden National Park (Kuiters et al. 2011). Migration from this new and rapidly growing population brought otters into the De Onlanden Nature Reserve in 2013, where they flourished, due to the favourable environment, that offers plenty of food and is relatively undisturbed by human presence. In a few years the population in De Onlanden had grown to a more or less stable size of one to three males and five to eight females with their cubs (van Boekel 2016-2020). Yearly DNA-analysis of otter spraint samples showed that one dominant male was present in the largest, central part of De Onlanden, while the other males were living on the outskirts of the reserve (Kuiters et al. 2015-2020). The dominant male remained the same individual (labelled NB351 by Kuiters et al.) in all the years between 2014-2020, but the other males were often replaced by newcomers. DNA-analysis and monitoring with cameras showed that the females had their territories throughout the reserve, although most of them lived in the central part. Each year three to five females had litters of one to (exceptionally) four cubs. Some females were present over longer periods, as shown by DNA-analysis, but some changes in the female population occurred over the course of time too (for full details on the development of otter population in De Onlanden, see van Boekel 2016-2020).

Monitoring of the otters in De Onlanden was started in 2014 with one wildlife camera. By 2016 seven cameras were in use permanently throughout the year. The primary purposes of the monitoring were to follow the development of the otter population and the distribution of the individuals over the reserve. However, the large dataset that was collected over the years can also be used to try to answer some questions on otter activity patterns in De Onlanden. At what part(s) of the day are otters most active? Are there differences in activity patterns between sexes and/or other subgroups? Do activity patterns change over the seasons? Does human presence influence otter activity patterns? This study uses the dataset of recordings of otter activity in De Onlanden to address these questions.

Methods

Study area

The De Onlanden Nature Reserve is situated in the northern part of the Netherlands (figure 1). It consists of approximately 3000 ha of marshlands and grasslands with a large system of interconnected small rivers, canals and other water courses (for a full description of the origin and structure of De Onlanden, see van Boekel 2015). Surface water levels are high and fluctuate continuously in a natural way, depending on rainfall and transport downstream. Water levels are lowest in the summer period and can be up to 50 cm higher in the winter period. Fish can migrate freely both within as well as towards and from De Onlanden and find good spawning grounds in the large shallow water areas in the reserve. They are thus abundant in all the waters in

Figure 1. Location of De Onlanden Nature Reserve, which is situated in the northern part of the Netherlands (inset), also showing the positions of the permanent wildlife cameras (numbered 1-6).

the reserve (R. van Hezel, aquatic ecologist, Noorderzijlvest Regional Water Authority, personal communication). Wherever main roads in De Onlanden, with a high density of motorised vehicles, cyclists and/or pedestrians, cross the main water courses, the safe migration of otters (and other water-connected large animals) is secured by large sandy banks under the bridges (fauna passages, see figure 2). Human presence in the reserve is largely restricted to the roads and a few paths that run through it. Activities such as fishing, canoeing or swimming are prohibited in most watercourses. Maintenance activity is restricted to a small part of the reserve where cattle graze and the grasslands are mown once a year. Because of these restrictions, human activity and disturbance is minimal throughout the year in the most of the reserve.

Monitoring

The monitoring of otter abundancy and activity in De Onlanden was done with wildlife cameras at six fixed locations. The cameras were placed at locations with high level of otter activity (i.e. where many fresh spraints were found) in different parts of De Onlanden (the locations are shown in figure 1). Three of these locations were situated at fauna passages under road bridges with much traffic (locations 1-3 in figure 1), the other three fixed locations were situated far from human disturbances along water courses and at a dam in a watercourse (locations 4-6 in figure 1). Another (seventh) camera was placed in succession at changing locations in the reserve where new or a higher level of otter activity (visible as spraints or other traces) was found. Bushnell cameras of different types were used. All were so-called 'no glow' cameras, with special filters to reduce the visibility of the infrared light of the camera for animals. All cameras made 30 second video films at a 'normal' sensor level, with a reactivation time of 1 second after each recording. The batteries and SD cards of all cameras were replaced every two weeks. No measures were used to encourage the otters to visit the camera sites more often (such as spreading fish oil), so all the behaviour of the animals can be considered natural.

For this study all the data of otter activity gathered between 1 January 2016 and 31 January 2020 were used. For each occurrence of one or more otters at a camera site, the date, time of day, number of otters and (if possible) sex of the animal was recorded. All time-data from the summer season were adjusted to Dutch winter time. For the comparison of activity in winter and summer the data from the months November–January (winter) and May–July (summer) in all years were combined. In the dataset three otter subgroups were distinguished: 'male', 'family' (mother with one or more cubs), and 'other'. The sex of the animal could only be recorded with certainty for males with clearly visible genitals as the size of individuals was found to be an unreliable criterion for distinguishing between male and female otters. Families were defined as two or more otters, appearing in the record together and clearly being a mother with cubs, i.e. a large otter with one or more clearly smaller otters and/or showing the typical behaviour of family groups (much harmonious and playful interaction, frequent communication sounds, swimming side by side, etc.). All otters that could not be identified as either male or family were defined as 'other' otters. This group thus included single females and solitary youngsters, but also males and families that could not be identified as such. Often the quality of the camera recordings was not good enough (due to weather conditions or only partly visible animals) to derive detailed information. Otters on these recordings were also classified as 'other'. On the rare occasions that two adult otters were visible at the same time (distinguishable from a family by their size and, often aggressive, behaviour), they were recorded as two sepa-

Figure 2. A. View of the fauna passage at location 2 (see figure 1) in April 2012, shortly after it was constructed. In later years the vegetation around the passage became much higher. B. The sandy bank on the northern shore of the fauna passage at location 1 in April 2020, with clear signs of otter activity such as the scraped heaps of sand used for spraining.

rate individuals. During the research period data from cameras that were placed temporarily in De Onlanden by other persons were sometimes added to the dataset, but only after review by the author of the recordings made by these cameras. These data make up less than 4% of the total.

To demonstrate the degree of similarity between two rankings, Spearman's rank correlation coefficient was used to assess the significance of the relation between them. To determine if two categorical variables from the same population have a significant correlation, the Chi-square test was used. For both tests a Bonferroni correction for repeated tests was applied and the probability of obtaining a difference by chance was set at $P<0.01$.

Results

Number of recordings per year/ subgroup

In the research period (January 2016-January 2020) a total of 6092 unique recordings of one or more otters were registered with the cameras. Of these, 626 recordings were of families (female with one or more cubs) and 761 recordings were of otters that could be identified as males. The largest part of the recordings (5140 in total) were made at the fauna passages (locations 1-3 in figure 1) that were often used by the otters not only for passing safely under the roads, but also for leaving their scent marks and sometimes for hunting, grooming or even sleeping. At location 1, in the central area of the reserve, the camera registered otters almost every night during the research period and sometimes up to five recordings of passing otters were made in one night.

The recordings of males showed a clear peak during the late summer period, while recordings of families peaked during the winter period. The recordings of 'other' otters were distributed fairly evenly over the months of the year (figure 3). These patterns were the same every year and were not correlated with each other, Spearman rank correlation; $n=12$; male–family: -0.343 (n.s.); male–other: -0.021 (n.s.); family–other: -0.028 (n.s.), so the peaks of recordings found for males and families in summer and winter respectively can be considered to be realistic.

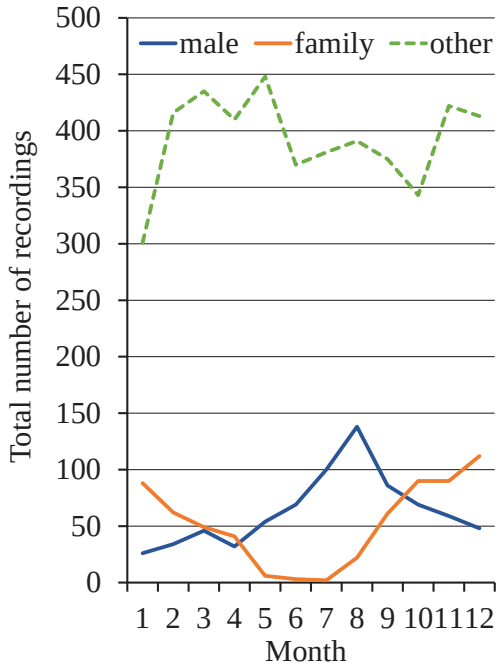

Figure 3. Distribution of unique recordings per month (as total recordings for each month over the research period) for male otters, families and other otters.

Daily patterns

In general, the otters were most active in the dark. This resulted in a clear difference in activity patterns of the otters between seasons. In the short summer nights (figure 4A) the otters became active approximately one - two hours before sunset and were most active at the start of the dark period. The activity level fell gradually during the rest of the night until approximately one hour after sunrise. Daytime activity was very low. There was

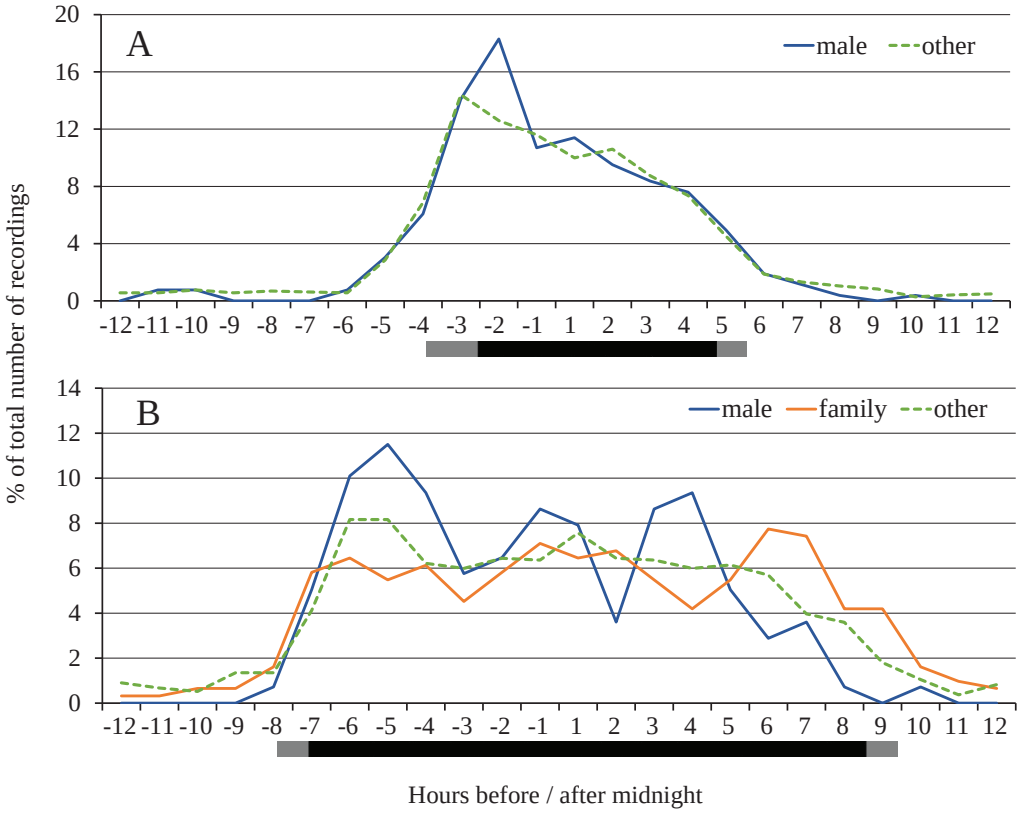

Figure 4. Distribution of recordings per hour (as % of total recordings over this part of the research period) in: A. The summer period (May-July) for male and other otters. B. The winter period (November-January) for males, families and other otters. Black and grey bars on the X-axis respectively show the minimum length and the maximum length of the dark period during the summer (A) and winter (B) period.

no clear difference in the daily activity pattern between males and other otters (Spearman rank correlation 0.905, $P<0.01$). The total number of recordings of family groups in the summer period was too low to analyse. During the long winter nights (figure 4B) all otters (males, families, and others) became active at sunset and remained active during the whole dark period. The heterogenous 'other'-group showed no distinctive pattern in activity during the night. The male otters seemed to have periods with higher activity interspersed by periods of low activity. This pattern suggests that the males took breaks between hunting sessions for grooming and/or sleeping. Families also showed this pattern of alternating higher and lower activity, although not as distinctly as the males. Both the males and families displayed this high-low activity pattern each winter, but the variation in these patterns between winters was large and the number of recordings for males and families was too small to confirm any statistically significant pattern of high and low activity in the data. In winter, males stopped activity well before sunrise and were not active during daytime hours. Families remained highly active for some time into the light period. Both families and the other otters were active at a low level during the light period.

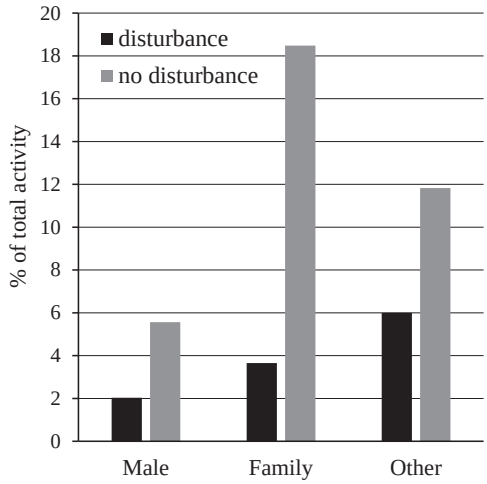

Figure 5. Daytime activity (as % of total activity at the given locations in the research period) of males, families and other otters at locations with human disturbance and with no human disturbance.

Relation with disturbance

The influence of disturbance by human presence (in the form of vehicle, bicycle and pedestrian traffic) on the activity patterns of the otters was analysed by comparing the daytime activity of the animals between sites with relatively high disturbance levels (locations 1-3 in figure 1) and undisturbed sites (locations 4-6 in figure 1). Figure 5 shows that all groups of otters were clearly more active during daytime at locations without human disturbance. This difference proved to be significant for families and other otters, but not for the male group (family χ^2 (df=1): 29.095, $P<0.01$; male χ^2 (df=1): 3.516, $P=0.061$ (n.s.); other χ^2 (df=1): 24.87, $P<0.01$).

Discussion

The large dataset of camera recordings of otters in De Onlanden showed the clear preference of this species for night-time activity. This nocturnal way of life has also been found in studies of otters in Portugal (Beja 1996, Quaglietta et al. 2018) and Scotland (Garcia de Leaniz et al. 2006), although Kruuk (2006) mentioned that otters living on the shores of the Shetland islands were active during the daytime. Here otters foraged for fish in the seawater around the islands. These fish were sleeping on the ocean floor during the day, so otters could easily catch them. In fresh water, the many fish species show no clear or uniform patterns of daily activity (Reebs 2003). For most fresh water fish species the preference for day or night time activity depends on other variables such as water temperature, the time of year, food conditions and/or predator activity and abundance. Otter activity patterns in fresh water therefore cannot easily be linked to the activity of their prey. In De Onlanden there is a great variety and abundance of prey available for the otters throughout the reserve, ranging from many different fish species, occurring often in large numbers, to amphibians, crayfish and waterbirds (personal observations). The otters were often seen hunting and catching fish, seemingly without effort, in front of the cameras. It can well be assumed that food availability was not the key factor determining their preference for night time activity.

Another explanation for their nocturnal life could be the avoidance of human presence. Otters are known to be shy animals, that flee immediately if disturbed by human activity. Only a few other otter studies have considered the influence of human presence on otter behaviour, possibly because most studies were done in areas with very limited human presence. Beja (1996) found that human activity had an influence on the selection of resting places by the otters living on the coast of Portugal, but not on their daily activity pattern. Kruuk (2006) found no relation between human activity and the location of the daytime resting places of otters living in Scottish fresh water lochs. He also mentioned examples of otters living and hunting in close proximity to humans, even in cities, and sug-

Wildlife camera view of an otter on the bank of the fauna passage under the main road at location 2 in De Onlanden during daytime, looking up at cyclists passing over the adjacent cyclists bridge.

gested that abundance of food is the key factor for the presence (or absence) of otters in any area. In the city of Groningen, close to De Onlanden, two different male otters were found living in the canals in the centre of the city in wintertime (H. Jansma, personal observation). DNA monitoring showed that one of these otters relocated to De Onlanden in the following two years (van Boekel 2020, Kuiters et al. 2020). Possibly, the otters in the city were young males without territory that preferred to follow their fish prey into the warmer waters and accept human presence. These city-otters were also only active during the night, probably to avoid the attention of humans. In De Onlanden, otter families and 'other' otters were significantly more active during daytime hours at locations without human disturbance compared to locations with regular human disturbance (motorcars, cyclists and pedestrians passing over the bridges). For the male otters this difference in daytime activity was found to be (just) not significant, but possibly this is an effect of the relatively small number of recordings for this group in the statistical analysis. Human disturbance may be a factor influencing the daily activity pattern of the otters in De Onlanden, resulting in the animals being most active in the dark period when human presence is minimal, but more research is needed to determine the extent of this influence.

Most recordings of male otters in De Onlanden were made during the late summer period, and they were rarely seen during the winter months. The recordings of otter families showed an almost opposite pattern. Although Eurasian otters have no strict reproductive season (Kruuk 2006), in De Onlanden most females had their litters at approximately the same time. The mothers and cubs started to appear on camera in late autumn and were seen all winter. In the next spring the young otters appeared progressively more solitary on the camera recordings and eventually they were no longer present in the area or could at least no longer be distinguished as youngsters in the recordings. The peak of male otter recordings in late summer may partly be explained as the appearance of young solitary male otters in the area, originating both from within and outside (migrat-

Wildlife camera view of an otter at location 5 on the bank of the main small river (Peizerdiep) in De Onlanden during daytime.

ing youngsters) De Onlanden. Possibly the dominant male also expanded and intensified his activity at that time in reaction to the presence of these young males in his territory.

During the short summer nights in De Onlanden, with only seven hours of darkness, the otters apparently were able to find enough food to help them through the long period of inactivity during the day. Their activities started before it was getting dark, possibly because human disturbance was already low at that late hour and the otters were eager to catch food after the long daylight period. After sunset the otters immediately showed a high activity level that gradually diminished towards the end of the night. There was no significant difference in this pattern between males and other otters, although the males seemed to be more active at the start of the night. In the long winter nights the otters were active during the whole dark period of approximately 16 hours. Males became less active at the end of the dark period, possibly because they had caught enough food to get them through the day. Families remained highly active well into the light period, possibly because a mother with cubs needs more time to catch enough food. The relatively large (but statistically not significant) differences in activity found during the night for both males and families suggests that the otters alternated periods of high activity with short periods of less or no activity. Kruuk (2006) described the necessity for otters to take breaks between feeding sessions in order to restore their body temperature after cooling down in the water. For the otters in De Onlanden this could also be an explanation for the apparent pattern of alternating activity and resting during the nights in the cold winter months. In Portugal, otters fitted with radio transmitters were also found to have an activity pattern with two peaks during the night time in the winter period (Quaglietta et al. 2018). Their activity continued at a low level into the light period. In the summer period Quaglietta et al. found one activity peak in the night and almost no activity in the daytime period. The authors explain the absence of daytime activity in the summer as avoidance of the period with high temperatures by the otters. In the Netherlands, with a more temperate climate, high

summer temperatures cannot be assumed to have a relevant influence on otter behaviour. It seems more likely that the abundance of fish and other prey provided the otters with enough food in both summer and winter to be able to stay in their resting places for most of the daytime period. Comparison of the results presented here with activity patterns of otters living in temperate climate environments with less available food would be welcome, but no relevant data are available yet from such locations.

Monitoring otters with the use of strategically placed wildlife cameras over a period of several years proved to be a relatively easy method to collect a large dataset on otter activity that can be used to show and compare the activity patterns of otters living in different environments. If, in future studies, this method can be combined with techniques to identify the individual otters in the images (i.e. computerised identification) much more could be learned about the behaviour of this elusive species.

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Samenvatting

Activiteitspatronen van otters in natuurgebied De Onlanden

In natuurgebied De Onlanden werd de otterpopulatie (*Lutra lutra*) gedurende vier jaar gevolgd door middel van zeven wildcamera's. Drie camera's waren geplaatst bij bruggen met faunapassages onder wegen waar jaarrond veel verkeer (auto's, fietsers, wandelaars) pas-

seerde. Drie andere camera's stonden op locaties langs waterwegen waar juist geen mensen in de omgeving kwamen. Eén camera werd op steeds wisselende plekken met veel (nieuwe) otteractiviteit geplaatst. Van elke cameraopname van één of meerdere otters werden datum, tijdstip en aantal otters genoteerd. Ook werd genoteerd of het een mannetje betrof (genitaliën zichtbaar) of dat het om een familiegroep ging (moederotter met één of meer jongen). Vaak liet de kwaliteit van de opname niet meer toe dan de vaststelling dat het om een otter ging. Deze groep wordt hier 'overige otters' genoemd. De monitoring leverde in totaal 6092 afzonderlijke opnames op, waarvan er 761 van een herkenbaar mannetje waren en 626 van families. De opnames van de overige otters waren redelijk gelijk verdeeld over de maanden van het jaar, maar bij de mannetjes piekte het aantal opnames in de late zomerperiode terwijl in de wintermaanden relatief weinig opnames werden gemaakt. Families werden juist veel in de wintermaanden gezien en vrijwel niet in de zomermaanden. Alle otters waren gedurende het hele jaar vooral in het donker actief, maar in de (korte) zomernachten begon de activiteit al ruim (1-2 uur) voor zonsondergang, waarna direct aan het begin van de nacht een activiteitspiek bereikt werd. De activiteit nam daarna geleidelijk af tot een uur na zonsopkomst. Tijdens de lange winternachten werden de otters pas in het donker actief en ging de activiteit het grootste deel van de nacht in wisselende mate en zonder duidelijke piek door. Families bleven na zonsopkomst nog enige tijd actief, maar mannetjes stopten hun activiteit al ruim voordat het licht werd. Op de locaties met veel verstoring door verkeer waren alle otters significant minder vaak actief in de lichtperiode dan op de locaties zonder menselijke activiteit in de buurt. Vooral otterfamilies waren op de locaties zonder verstoring veel vaker overdag te zien op de camerabeelden. De otters in De Onlanden lieten activiteitspatronen zien die ook al bij otters in andere leefgebieden gevonden werden. De seizoenspatronen in de waarnemingen van zowel mannetjes als families zijn, voor zover bekend, nog niet eerder gemeld. De voorkeur voor nachtelijke activiteit wordt soms verklaard als een nachtelijk voordeel voor de otters bij de jacht op vis, maar deze koppeling kan in De Onlanden niet met zekerheid gemaakt worden. De resultaten tonen wel aan dat otters in De Onlanden overdag meer actief zijn op plaatsen waar verstoring door menselijke activiteit ontbreekt. Of dit ook in andere leefgebieden van otters zo is zou onderzocht moeten worden.

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