

Research article

## Activity budget and behaviour of giant otters *Pteronura brasiliensis* at Parken Zoo, Eskilstuna, Sweden

Mélodie Friedmann<sup>1</sup>, Anita Burkevica<sup>2</sup>, Linn Lagerström<sup>2</sup>, Jenny Gustafsson<sup>2</sup>, Julia Johnsson<sup>2</sup>, Peter Lundgren<sup>2</sup> and Marcus Clauss<sup>1</sup>

<sup>1</sup>Clinic for Zoo Animals, Exotic Pets and Wildlife, Vetsuisse Faculty, University of Zurich, Winterthurerstr. 260, 8057 Zurich, Switzerland

<sup>2</sup>Parken Zoo, Flackstavägen 13, 63222 Eskilstuna, Sweden

Correspondence: Marcus Clauss, email; mclauss@vetclinics.uzh.ch

**Keywords:** activity budget behaviour, feeding enrichment, *Pteronura brasiliensis*, welfare, zoos

**Article history:**

Received: 11 Jun 2023

Accepted: 19 Aug 2023

Published online: 31 Oct 2023

**Abstract**

Modern zoos must ensure the welfare and conservation of their captive animals. For this, it is recommended to provide cognitive stimuli ('enrichment'), good habitat management and adequate nutrition amongst other things. Assessment of animal welfare should include behavioural observation. One frequently used approach compares the activity budget of zoo animals with their wild conspecifics, carefully interpreting resulting differences. Here, this method is used for giant otters *Pteronura brasiliensis* on a feeding regime with three fixed feeding times during the keeper's working day, and ice blocks containing fish suspended above the pool, thawing over time and thus releasing fish well into the night. This time-delayed food dispensing was expected to make the subjects spend a large proportion of time foraging. Nevertheless, results show a lower feeding proportion than reported in the literature for this species in the wild (27% versus 64%), likely related to the fact that zoo animals did not have to hunt live prey. The captive otters also spent less time scent-marking (1% versus 9%), possibly due to the absence of other conspecific groups in their vicinity. By contrast, there was a higher proportion of resting (34% versus 21%) and affiliative behaviours (14% versus 1%), suggesting that shifts in the activity budget between natural habitats and zoos need not always be interpreted as indicators of reduced welfare. 'Calling family members to food', reported in the wild, was observed repeatedly when one family member was awake and the rest were asleep at a time that fish fell from the thawing block into the pool. Extending food distribution over time, particularly into the night, might develop behaviours other than increased feeding activity as indicators of welfare in captive giant otters. Further investigations with delayed feeding methods for this and other species are needed.

**Introduction**

The assessment of animal welfare is complex. One approach is to compare the activity budget of zoo animals with that of their free-ranging conspecifics, with a special focus on behaviours considered appropriate for keeping the animals occupied, such as feeding (Melfi and Feistner 2002; Veasey et al. 1996). Some studies on activity budgets focus only on zoo (Azevedo et al. 2015; Bashaw 2011; Bashaw et al. 2003; Brereton et al. 2023; Jenny and Schmid 2002; Ross 2002; Wallgren 2014) or wild individuals (Cortez et al. 2016; Duplaix 1980; Leuchtenberger et al. 2014; Walker et al. 2008), while others directly compare

results from zoo subjects either with pre-existing literature (Melfi and Feistner 2002) or with data recorded during parallel observations in the wild (Inoue and Shimada 2020; Yamanashi and Hayashi 2011). Most of these studies indicate that feeding behaviours like foraging or hunting occur less frequently in zoo individuals than in the wild but might increase when the individuals are exposed to new stimuli ('enrichment'). Nevertheless, Veasey et al. (1996) point out that not all behaviours expressed in the wild need to be replicated in zoos, especially if one assumes that the consequences of the behaviour are more important than the expression of the behaviour itself. More recently, Browning (2020) emphasised

that ‘naturalness’ itself may not be a suitable measure of welfare, while Hill and Broom (2009) had already suggested that ‘natural’ or ‘normal’ as a behavioural category must be assessed critically in each case, and that activity budgets can only be one part of a comprehensive welfare assessment.

Food presentation and feeding frequency are important factors affecting the behaviour of zoo animals (Hosey et al. 2013; Young 1997). This may be particularly relevant for carnivores, as holding conditions may prevent them from performing several natural behaviours, like hunting or moving long distances (Breton and Barrot 2014); this may be an underlying cause for the development of abnormal behaviours (Hosey et al. 2013; Veasey et al. 1996; Young 1997), e.g., ‘pacing’, the most frequent stereotypy in carnivores (Clubb and Mason 2003; note that this should not be confused with anticipatory pacing, Watters 2014). Different regimes of food presentation have successfully reduced stereotypies in various zoo-kept predator species, including varying the food type or composition (Bashaw et al. 2003; Wallgren 2014), changing food management over time by making food less easily obtainable (Kastelein et al. 2007; Ross 2002) and randomising feeding times (Jenny and Schmid 2002). When discussing feeding management for predators, feeding of live prey appears an intuitive solution; however, providing live food has ethical implications and welfare considerations for the prey animal. For this reason it is illegal in many countries including Sweden (Djurskyddslag 1988:534) and Switzerland (Animal Protection Ordinance 2008).

The giant otter *Pteronura brasiliensis*, classified as Endangered (Groenendijk et al. 2022), is the largest of the 13 extant otter species. These semi-aquatic mammals live in streams, rivers and lakes of South America (Carter and Rosas 1997; Duplaix et al. 2015a) with a wide-ranging territory varying greatly in size between the wet and dry seasons (Leuchtenberger et al. 2013). Most of the time, individuals perform the same activities together in a cohesive way as a family group (Carter and Rosas 1997; Duplaix 1980). A high degree of cooperation is highlighted in Chavez-Fontecha et al. (2019), which lists 11 hunting strategies observed in wild giant otters. Their natural diet is composed of several different fish species, depending on availability (Cabral et al. 2010; Carter and Rosas 1997; Carter et al. 1999; Duplaix 1980; Moraes et al. 2021; Rosas et al. 1999), which leads to the description of these predators as opportunistic (Cabral et al. 2010; Duplaix 1980). However, their diet may also include other prey like crustaceans, molluscs, reptiles, birds and small mammals (Cabral et al. 2010; Carter and Rosas 1997; Duplaix 1980) or even mussels (Wallgren 2014).

Assessments of the activity budget of giant otters in zoos are scarce (Brereton et al. 2023; Londoño and Muñoz 2006; Wallgren 2014). Initially thought to be strictly diurnal in the wild (Carter and Rosas 1997; Duplaix 1980), Leuchtenberger et al. (2014) observed with camera traps that 31% of giant otters’ activities are nocturnal, with the highest peak of activity during the crepuscular period before daylight. Fishing accounted for 64% of the behaviours recorded in that study. In ex-situ settings, assessments specifically focused on the effect of new enrichment on behaviour are also extremely rare (Wallgren 2014), although Duplaix et al. (2015b) suggest food items that may stimulate giant otters: fish juice, feed balls stuffed with fish, ice blocks of frozen fish or of different fruits, large fish heads, (water) melons, pumpkins and hollowed-out coconuts. The Parken Zoo in Eskilstuna (Sweden) usually feeds its giant otters three times a day, adding a block of ice with 1 kg of frozen fish at the last meal of the day, which then thaws over the following hours. This theoretically prompts the otters to remain alert to catch any fish that would fall in the pool, and the anecdotal impression of the responsible staff was that this measure led to additional activity. This study aimed to report the activity budget of each of the three adult giant otters when using this randomised

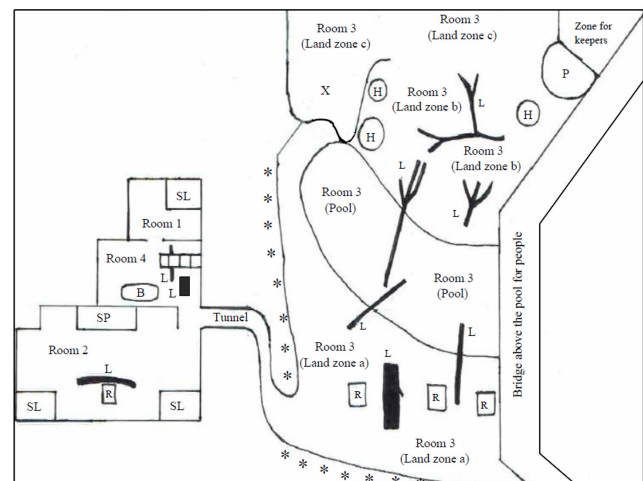
feeding method, and to compare the results with those for wild giant otters in Leuchtenberger et al. (2014).

## Methods

The subjects were three adult giant otters housed at Parken Zoo in Eskilstuna (Sweden): a breeding pair (Yumbo, M and Alua, F), both born in 2009 having been captive-bred in different parks, who had had previous litters before (Wallgren 2014), and a young adult (Paraná, F) born in April 2019 from this breeding pair. A litter of two cubs, four months old at the time of the study, were also present. The observations and video recordings took place between 8 and 21 November 2021.

The otters had access to four internal areas (Figure 1): a small sleeping area (room 1), a larger sleeping and latrine area with an empty little pool, sand, rocks and trunks (room 2), the exhibit with one big pool, vegetation and substrate (room 3) and a passage area between rooms 1 and 2 (room 4). The outdoor enclosure to which the animals have access during summertime was closed because the study took place during the cold season. Room 3 was the only internal exhibit zone, but there were no visitors during the study period because Parken Zoo is closed to the public from November to April. Only the zoo staff came by to feed the animals.

Three meals a day were set for giant otters at about 0800 (range 0750–0822), 1220 (range 1141–1235) and 1530 (range 1526–1541). The zookeepers threw fish from the bridge into



**Figure 1.** Diagram of the enclosure areas accessible to the giant otters during the observations. Room 1: Small sleeping area. Room 2: Large sleeping and elimination (defecation/urination) area. Room 3: Exhibit area called ‘Amazonas’ with one big pool and land differentiated in three zones: Land zone a), part of the room with a hard floor, Land zone b), a floor with substrate and vegetation like bushes and trees and Land zone c), a floor with sand. There was also vegetation up against the walls around this room (\*). Room 4: Passage area between rooms 1 and 2. SL: sleeping boxes; B: bathtub, empty; L: logs, some of which dipped into the pool; R: rocks; SP: small deep pool, empty or filled with a little water; H: holes dug in the ground by the giant otters; P: a pit with sand in it; X: hollow space towards the back of the room with sand, out of sight of the observer and cameras. The hiding spot for direct observation is not visible in the diagram; it was behind the vegetation at the very bottom of the figure.

**Table 1.** Distribution of the daily diet of giant otters during the observation period

Date	Morning	Noon	Evening
8 November 2021	3.5 kg fish	4 kg fish	4.5 kg fish+2×1 kg frozen fish
9–14 November 2021	4.5 kg fish	3 kg fish	4.5 kg fish+2×1 kg frozen fish
15–21 November 2021	4 kg fish+1 kg frozen fish	3 kg fish	4 kg fish+2×1 kg frozen fish

room 3, and at the last feeding time of the day, one small and one larger ice block, each containing 1 kg of frozen fish, were suspended with ropes above the pool. To compare a potential difference in the otters when this feeding method was managed differently, another small ice block was additionally suspended in the morning during the second week of observations (resulting in a total of three ice blocks). The daily ration was regularly adapted to the growth of the cubs but remained constant during the two study weeks at approximately 14 kg of fish for the whole group (including the three meals and the ice blocks) (Table 1).

Food distribution always took place in the exhibit area with the giant otters consuming food at the water's edge. The only exception was during enclosure cleaning times when, in order to empty the exhibit area, the otters received the first part of their morning meal as bait in room 4. Then, the rest was given in room 3 to clean rooms 1, 2 and 4. Cleaning happened twice a week around the morning feeding time.

The ice blocks were produced by adding water to 1 kg of frozen fish, placing a piece of rope that had two looped ends and a large knot in its middle into the water, and placing the whole into a freezer. The actual weights of the blocks produced during the study period are given in Table 2. The freezing water created an attachment to the rope knot, whereas the looped ends, kept out of the water, served to hang the block on a hook from the bridge. From the ice blocks, fish randomly dropped into the pool as the blocks thawed over time. Recording the thawing time was part of the observation protocol, as well as recording the corresponding temperature and humidity.

Data were acquired by a combination of direct observations (from a hide) and later analysis of video recordings of the same period. Cameras with an infrared function for nighttime observations recorded continuously. Three were already installed and used by Parken Zoo for routine monitoring of the animals

(one in each of rooms 1, 2 and 3) (Axis P3375-LV cameras, Axis Communications, Lund, Sweden; connected to the zoo's in-house server). An additional eight cameras (AHWVSE, Hangzhou Xiongmai Technology, Hangzhou, China) were set up to cover blind spots (one in each of rooms 1 and 4, two in room 2 and four in room 3) and connected to a digital video recorder (ADVR-8, Hiseeu, Shenzhen, China) placed with a screen above the tunnel between rooms 2 and 3. Direct observations took place from a hiding spot behind the vegetation in room 3, out of reach of the animals, to give a view of most of the large area and opportunities to better distinguish each individual without disturbing them. Direct observations were performed for approximately four hours per day in the morning (from about 0800 to 1200).

Data were collected every day using focal animal sampling (Altmann 1974) with an instantaneous scan every 15 minutes for each animal. Only the three adult animals were recorded, and interactions between adults and cubs were noted as part of the adult animals' budgets. As there were seven 24-hour sessions per week, this resulted in 672 behavioural recordings per animal per feeding management regime. The ethogram (Table 3) used for data collection was inspired by Duplaix (1980), Leuchtenberger and Mourão (2009), Leuchtenberger et al. (2014), Metrione et al. (2018), Parken Zoo keepers' knowledge about the subjects and personal observations during an acclimatisation and habituation week preceding the two observation weeks. During this acclimatisation week, the observer took the same position, for the same periods during the day, as during the observation periods. During this time, a rubbing behaviour in the younger adult was observed that had not been part of the original ethogram but was included at this stage.

Behaviours were classified immediately during direct observations. By contrast, video observations required viewing footage one minute before and after the instantaneous 15 min

**Table 2.** Average water volume in litres (with range) in the different blocks used during the two study phases

	Morning small block	Afternoon small block	Afternoon large block
Phase 1	-	1.5 (1.3–1.6)	4.2 (3.9–4.4)
Phase 2	1.5 (1.4–1.6)	1.5 (1.3–1.7)	4.2 (4.2–4.3)

**Table 3.** Ethogram describing behaviours grouped in categories for analysis, inspired by Duplaix (1980), Leuchtenberger and Mourão (2009), Leuchtenberger et al. (2014), Metrione et al. (2018), Parken Zoo keepers' knowledge about the subjects and personal observations during an acclimatisation and habituation week preceding the two observation weeks

Category (code)	Behaviour (code)	Description
Feeding (F)	Eating (Eat)	Ingestion of food, food transport with the aim to ingest it or first to give it to a cub who finally does not want it and so the adult ends up ingesting it.
	Active (A)	Transporting fish in the intention to give it to a cub and this one takes it. Giving up its food to an insistent cub.
	Foraging (FO)	Swimming in direction of accessible food, looking up towards the bridge or the ice block (both food sources), screaming in direction of the bridge, waiting under an ice block, sleeping or swimming at night at the edge of the pool waiting for food to drop from the ice blocks.
Active (A)	Elimination/Scent-marking process(Eli/SM)	Sniffing the elimination zone, defecation and/or urination, scent-marking the around the elimination zone by rubbing sand with the forepaws and/or stepping on trunks or rocks around with the hindpaws.
	Investigate (Inv)	Standing up vertically on the ground or on the water surface to look around, quick paw scraping on the ground or on the walls of the sleeping box.
	Locomotion (Lo)	Walking, running, swimming without showing clear behaviour of interest or waiting for food.
	Maintenance (M)	Fur nibbling with the incisors, forepaws licking, face rubbing with the forepaws, body or head scratching with a hindpaw, body rolling and rubbing on substrate.
	Contact with cubs (Cubs)	Active physical contact with the cubs except feeding the cubs (allogrooming, playing, hugging, snout touching, carrying cubs, etc.).
	Rubbing walls (Rub)*	Vigorous rubbing of the head and/or the body by propulsion and retraction against the walls and edges of the pool.
	Positive activity (A+)	Active positive physical contact between the adults (allogrooming, playing, hugging, snout touch).
Inactive (Ina)	Negative activity (A-)	Fighting with hard bites, hitting, being aggressive with screams and teeth exposition.
		Sleeping, resting with the body lying down and showing no other behaviour of the ethogram, standing or lying still for at least one minute.
Stereotypies (St)		Head-rolling, tail-chasing.
Other (O)		Other behaviour observed than those above listed.
Invisible (X)		Out of sight of the observer and the cameras.

\*This behaviour has to the authors' knowledge not been described in the literature but was evident during the acclimatisation week and therefore is included in the ethogram

timepoints to ensure correct interpretation of the frame (to decide e.g., whether an animal was just swimming—locomotion— or swimming while focussing on the ice block—foraging). From all observations made during this 2-minute period, the behaviour that would most easily be overlooked during scan sampling was noted as follows in descending priority: feeding the cubs, eating, foraging and locomotion. Based on nocturnal fishing events observed in the wild (Leuchtenberger et al. 2014), swimming during the night was also counted as a foraging behaviour: waiting for fish to drop was the only reason apparent to the observer for the otters to come into the pool at night.

Each behaviour of interest (eating, feeding the cubs, foraging, the sum of eating, cub feeding and foraging, inactive and rubbing walls) was summed for each individual separately every day. Then, results for the two experimental conditions were compared for each otter with a linear mixed model, using each behaviour as a response variable and the feeding treatment as an explanatory variable. Statistical analyses were performed using R 4.2.0 software with the packages readexcel, lme4, lmerTest and MASS and a probability significance level of 0.05.

Additionally, behavioural proportion means were calculated hourly for each feeding management regime and depicted as stacked histograms for the whole group. This comparison could not be statistically analysed because of the small size of the dataset.

## Results

### Thawing period

The period over which food might be delivered by the ice blocks was determined in hours from the time of suspension until the last fish item dropped, hung at the fixed morning or afternoon feeding times (Table 4). Thus, in the first phase of the study, a small and a large ice block were hung at approximately 1535 (range 1530–1542), with the small block lasting until 0354 (range 0019–0459), and the large block lasting until 0601 (range 0458–0733) the following day. During the second study phase, an additional small block was given in the morning at 0805 (range 0755–0831) in addition to the two afternoon blocks at 1543 (range 1528–1540). The morning block lasted until 1733 (range 1526–2114) on the day of its suspension, while the little afternoon block lasted until 0253 (range 2342–0448) and the large afternoon block until 0717 (0518–0826) on the following day. Thus, in the second feeding management regime, the period of food delivery was extended to almost 24 hours a day and the thawing period of the three blocks overlapped in the afternoon for about 2.02 hours (range 0.00–5.73), but never in the early morning.

### Daily behavioural frequency

By including all behaviours listed in the ethogram, 96 behavioural data points were collected every day for each giant otter,

**Table 4.** Average thawing period (with range) of each differently organised ice block from the time it is suspended until its last fish item drops, with the average temperature and relative humidity during this period and for each study phase

	Morning small block	Afternoon small block	Afternoon large block
Phase 1			
Thawing time (hr)	-	11.8 (8.8–13.5)	14.4 (13.3–15.9)
T (°C)	-	17.2 (15.4–18.2)	17.2 (15.4–18.2)
Rel. hum. (%)	-	12.4 (12.0–14.1)	12.9 (12.0–16.6)
Phase 2			
Thawing time (hr)	9.5 (7.5–13.2)	11.3 (8.1–13.6)	15.7 (13.8–16.8)
T (°C)	17.9 (16.0–19.2)	17.3 (15.0–18.6)	17.1 (14.7–18.4)
Rel. hum. (%)	12.1 (11.9–12.2)	12.1 (11.9–12.2)	12.1 (12.1–12.2)

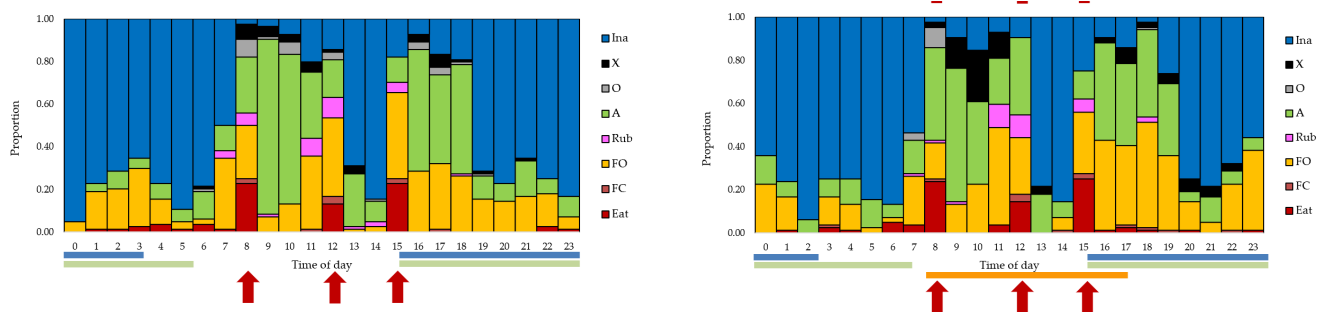
which corresponds to 672 recordings per individual per feeding management regime. However, for analysis, the following specific behaviours were of interest: feeding behaviours (eating, feeding the cubs and foraging), rubbing the walls and inactive. Proportional means for these behaviours are compared for each giant otter between the two feeding treatments (two blocks and three blocks) in Table 5. A significant difference appeared only for Paraná's foraging behaviour which increased during the three blocks treatment ( $P=0.007$ ), consequently increasing her 'feeding' behaviour in general ( $P=0.005$ ) as foraging was by far the most frequent occurrence recorded from the feeding category. All other behaviours showed no statistically significant change for any of the subjects. Still, despite this increased tendency, Paraná invested less time daily foraging than her parents (Table 5). The low figures in F values and effect sizes confirm that variations between the samples are small and that the explanatory variables have a very small, negligible impact on the response variables.

#### Hourly activity budget

To obtain a global view of a whole day in each condition, all behaviours of the ethogram were taken into account in order to create two 100%-filled stacked histograms. Behaviours listed in the activity category were grouped as 'active behaviours' (A) (Figure 2). As 672 behavioural scans were recorded for each adult otter per study condition, each of these histograms included 2016 datapoints with every time of the day indicated under a bar.

Each of these times had the same sample size of 84 scans. The following behaviours are ranked from the most to least frequent proportion according to the two ice blocks management regime: 51.6% inactive ( $n=1041$ ), 22.1% active ( $n=446$ ), 18.1% foraging ( $n=365$ ), 3.2% eating ( $n=64$ ), 1.6% invisible ( $n=33$ ), 1.6% rubbing walls ( $n=32$ ), 1.3% other behaviour ( $n=26$ ) and 0.5% feeding the cubs ( $n=9$ ). The ranking hardly changed with the three ice blocks management regime: 48.9% inactive ( $n=985$ ), 21% active ( $n=424$ ), 20.3% foraging ( $n=409$ ), 3.6% eating and invisible ( $n=73$  each), 1.4% rubbing walls ( $n=28$ ), 0.6% feeding the cubs and 0.6% other behaviour ( $n=12$  each).

In both situations, three eating peaks occurred during the feeding times around 0800, 1200 and 1530. Smaller peaks around 0700 and 1100 were the rare times that the fixed meal distribution happened earlier than normal or because some fish had fallen from a previous block. All other eating behaviour was spread out over the day in reaction to the food items dropping from the thawing ice blocks. The adults shared their food with the cubs mainly during the fixed feeding times, either by giving it spontaneously or letting it go when the cubs were insistent. Even though feeding the cubs was the rarest feeding-related behaviour observed (two blocks=2.1%, three blocks=2.4%), feeding the cubs occurred at feeding times as well as sometimes when the fish fell from a block. On the other hand, foraging was the most frequent feeding behaviour recorded in both treatments (two blocks=83.3%; three blocks=82.8%) peaking around 0700, 0800, 1100, 1200 and 1530



**Figure 2.** Hourly activity budgets of the giant otters. One stacked histogram during the 2-ice blocks (left) and the other one during the 3-ice blocks management (right). (Ina) inactive; (X) invisible; (O) other behaviour; (A) active; (Rub) rubbing walls; (FO) foraging; (FC) feeding the cubs; (Eat) eating. Red arrows represent feeding times (on average 805, 1221, and 1533). Horizontal lines underneath the times of day represent food distribution period of the afternoon little (blue), afternoon large (green) and morning (orange) blocks.



during the first week, and around 1100 and 1200 and from 1530 to 2000 during the second week. A possible reason for this shift towards the evening in the second week may be the small morning ice block slowly coming to the end of its thawing, thus depositing its last food items during the hours following the last feeding time (range 1526–2114). Between 2000 and 0800 the majority of foraging was recorded for Yumbo (week 1: 51%, week 2: 40%) followed by Alua (week 1: 30.3%, week 2: 29.3%) and Paraná (week 1: 18.6%, week 2: 30.7%). All occurrences of rubbing walls were performed by Paraná, nearly always before food distribution and on rare occasions afterwards. During the first week, the periods of time when inactive behaviours occurred in at least 50% of the scans for all three individuals were at night (0000–0800 and 1900–0000) and just after lunchtime (1300–1500) but not during the period when the observer was positioned in the hide; this was similar during the second week with an exception at 1900 where the inactivity proportion was reduced by approximately 45%.

The periods when active behaviours occurred more frequently than other behavioural categories were 0800–1100 and 1600–1900 when two ice blocks were presented and 0800–1100, around 1200 and 1600–1800 with three blocks; note that these periods included the time of observer presence in the hide. The most frequent behaviours recorded in the active category during the whole study were either interaction with cubs, especially playing or allogrooming (week 1=36.1%, week 2=37.5%), or locomotion (week 1=29.8%, week 2=28.8%). All the behaviours in the ‘other’ category occupied a nearly negligible part of the day and characterised, for example, times when the otters were handling straw, sniffing the territory or scanning the surroundings. Finally, the frequency of scans where the giant otters were invisible more than doubled between the two weeks due to two of the adults spending time in a hollow space towards the back of room 3 out of sight. Indeed, during the second week, Yumbo went to this space two to three times more often and Paraná five times more often than in the first week. The increase is particularly noticeable between 0900 and 1200, i.e., during the time of observer presence in the hide. Due to several consecutive scans that took place while the animals were in this space, in addition to personal observations in between, it is speculated that the animals were mainly resting there. However, they could have been digging a hole, rubbing the ground or pursuing any other activity.

#### **Calling family members to food**

A surprising interactive event was noted four times in the giant otters between scan times in the observation period. The initial situation started with one parent waiting for food in the big pool while the rest of the family were sleeping in rooms 1 or 2. When a fish finally fell down from a block, the parent took it to the sleeping otters, not giving it away but luring either the two other adults (two observations) or the whole family (two observations) with it into room 3 to stay for a while, waiting for the next fish to fall. This happened with Alua on 8 November at 2236 (Figure 3), and with Yumbo on 15, 16 and 19 November, respectively at 0313, 0325 and 0433. In the end, the fish used for luring was always left to the offspring, once to Paraná and three times to one or both of the cubs.

#### **Discussion**

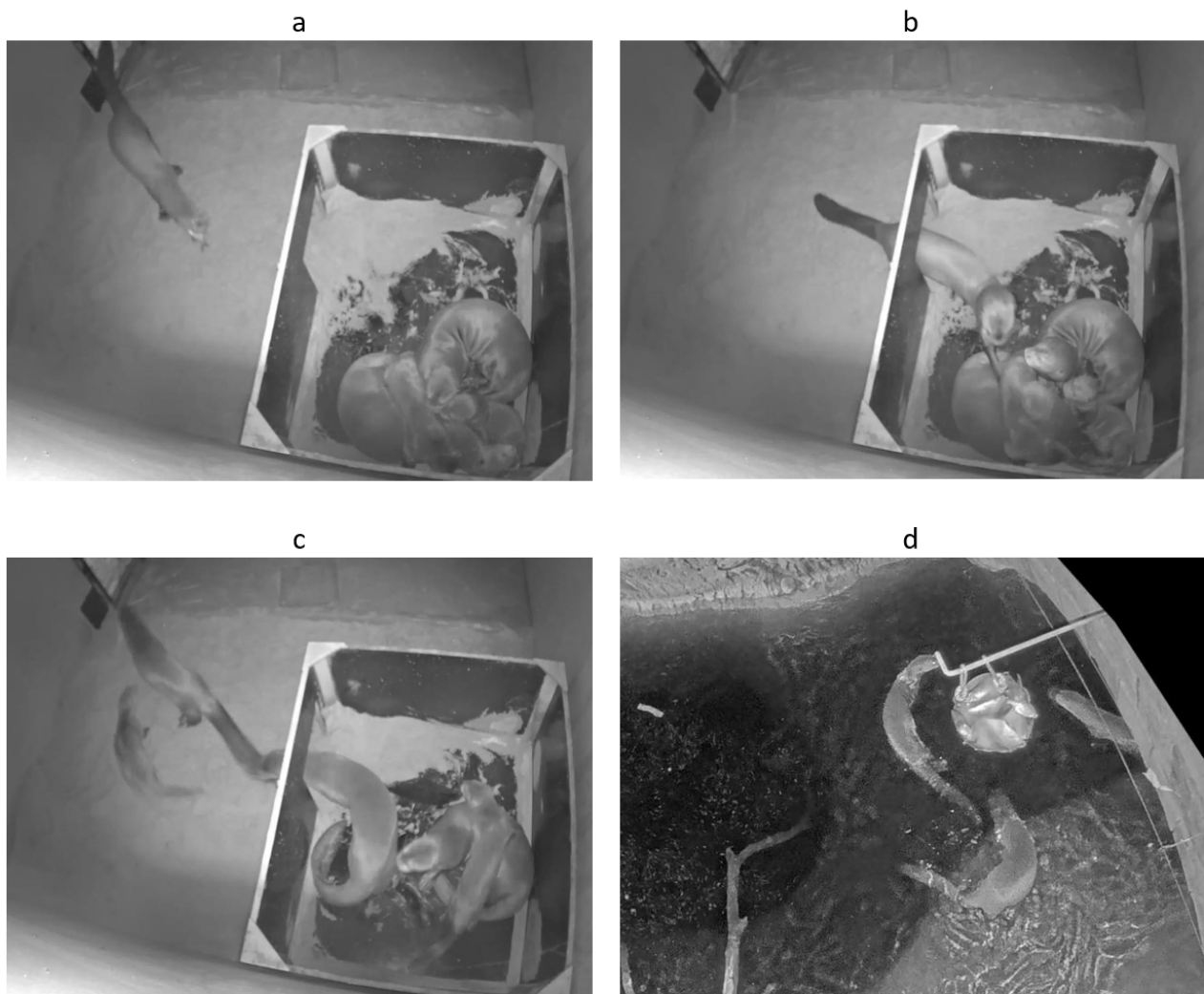
This study provided a daily activity budget of the three adult giant otters at Parken Zoo partly fed with fish in ice blocks thawing over time above the pool. During the whole experiment, on average 50.3% of the otters’ daily time was spent sleeping or resting (inactive), 3.4% eating, 0.5% feeding the cubs and 19.2% foraging. Although the duration of randomised food availability was extended, the results revealed no significant difference in the

proportion of these behavioural scans, except for the daughter (Paraná) whose foraging increased by half during the second test phase. She also took part in feeding the cubs, although the breeding pair remained the main food providers (Alua: 38.1%, Yumbo: 33.3%, Paraná: 28.6%). This corroborates the statement that every member of the group takes part in cub-rearing (Davenport 2008; Evangelista and Rosas 2011; Londoño and Muñoz 2006). A previously unknown behaviour, called here ‘rubbing the walls’, was recorded in Paraná on average in 1.5% of her scans. The exact purpose of this behaviour is still unclear, but because it mainly occurred before fixed feeding times, it is suspected to be an anticipatory behaviour. No clear stereotypical behaviour was noted.

It was recently reported that giant otters may be disturbed by the presence of an observer at their enclosure and show reduced activity, even if the actual effect size determined when comparing observer-made and camera-made observations is small (Brereton et al. 2023). In the present study, the effect of the observer in the hide during the morning hours was not evaluated. Given that otters were mainly active during this specific time of day could be an indication they were not particularly disturbed by the observer—possibly because the observer was in a hide and because the animals had been habituated to being observed during an acclimatisation week prior to the actual observations. By contrast, the fact that the animals increased the time that they were invisible particularly during the morning hours of the second observation week could be considered an indication that they reacted to the observer’s presence. Ideally, judging the effect of observer presence should be part of observational studies, even though this may not always be feasible. Additionally, it should be noted that this particular zoo is not open to visitors during the winter months when the study took place. To what degree the behaviour of the animals would be different with visitors present cannot be estimated.

Documentation of stereotypies specific to giant otters is still scarce, and the 15-minute interval between the instantaneous scans made stereotypies more difficult to identify than continuous observations would have. Wild giant otters live in a large home range (Leuchtenberger et al. 2013), which means they should be prone to developing stereotypies like swim-pacing (repetitive swimming back and forth) (Duplaix et al. 2015b) as are other wide-ranging carnivores when their space for locomotion is limited (Clubb and Mason 2003). During the current study, the otters showed movement back and forth between the ends of the pool that accelerated before the fixed feeding times. During this behaviour the bridge (from where the keepers would dispense the fish) was always kept in sight, and Paraná sometimes displayed the behaviour of rubbing herself along the walls. Here, the intensification of pacing always happened either before food distribution or on the rare occasions keepers passed on the bridge for other reasons. This resembles a food anticipatory behaviour rather than a stereotypy (Watters 2014). Such anticipatory behaviour need not always be considered negative (Clegg et al. 2018; Watters 2014). To what degree this anticipatory behaviour could be modified by a randomisation of feeding times—whether the animals would display anticipation more or less under variable schedules—remains to be investigated.

To the authors’ knowledge, the most recent study on the activity budget of wild giant otters was recorded at 30-minute intervals from 0500 to 1900, for a total of 153 days between November 2009 and June 2011 (Leuchtenberger et al. 2014). These results indicate that 64% of observed time was devoted to fishing (including foraging and eating,  $n=1477$ ) and 21% to resting (18% in dens and 3% outside,  $n=492$ ) by recording 2323 behaviours from three different groups (Leuchtenberger et al. 2014). In the current study, observations were made during two weeks with 15-minute



**Figure 3.** Calling to food: (a) Alua arrives in the small sleeping area (room 1) with a fish that had just fallen from the large block in Amazonas (room 3) while the rest of the family is sleeping in the box; (b) Alua wakes up one of her cubs, while the father (Yumbo) watches; (c) the whole family gradually emerges from the room, in order: Alua, the cub she woke up, Paraná, the second cub and finally Yumbo; (d) Yumbo, Alua and Paraná are swimming in the big pool of Amazonas, glancing at the block above them, while the cubs only went to the passage (room 4), where the cub that was woken up ate the fish and then returned to room 1 with its sibling. Photographed with the cameras of Parken Zoo.

intervals for the full 24 hours per day. So, when percentages are calculated at the same hours for 14 days by keeping the 15-minute intervals, feeding behaviours (eating, feeding the cubs and foraging) account for over a quarter of the daily activity budget (25.8%,  $n_1=303$ ; 28.8%,  $n_2=339$ ) and the inactive behaviours one third (34.3%,  $n_1=403$ ; 34.6%,  $n_2=407$ ) of the activity budget (Figure 4). Even with a reduced interval between the scans, this remains quite below the results of observations in the wild. The most parsimonious explanation is that dead fish were used as food at the zoo (which corresponds to good welfare practice for the prey animals), i.e., the otters did not have to hunt evading

prey. Replacing the time spent hunting with activities of similar duration, cognitive complexity and the option of failure remains an important challenge for carnivore husbandry.

Similarly, the otters in the current study also performed distinctively less scent marking than reported for the free-ranging animals (1.2% with the blocks,  $n_1=n_2=14$ ; 8.9% in the wild,  $n=206$ ) (Figure 4). Since one of the main roles of scent-marking in giant otters is territorial defence (Duplaix 1980; Leuchtenberger et al. 2013), having only one family in the enclosure might explain the lower occurrence of this behaviour, and hence eventually the fact that there is more time for social interactions, encouraged here

**Table 5.** Mean daily percentage of scans engaged in behaviours of interest in each adult giant otter separately and statistical results of the comparison between the two feeding managements.

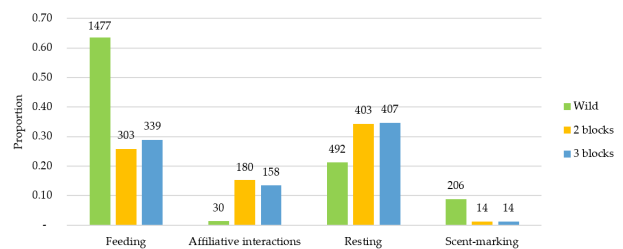
Species	Phase 1 (2 blocks)	Phase 2 (3 blocks)	F (coeff)	z (effect size)	P
<b>Yumbo (Y)</b>					
Eating	3.27	4.17	1.000	0.53	0.337
Feeding the cubs	0.60	0.45	0.158	-0.22	0.698
Foraging	22.32	19.49	0.559	-0.41	0.469
Feeding behaviours	26.19	24.11	0.301	-0.30	0.593
Rubbing the walls	0.00	0.00	-	0.00	-
Inactive	49.11	49.70	0.018	0.07	0.896
<b>Alua (A)</b>					
Eating	3.42	3.42	0.000	-0.00	1.000
Feeding the cubs	0.45	0.74	0.480	0.38	0.502
Foraging	19.20	22.17	0.881	0.50	0.366
Feeding behaviours	23.07	26.34	0.917	0.51	0.357
Rubbing the walls	0.00	0.00	-	0.00	-
Inactive	50.74	47.62	1.291	-0.60	0.278
<b>Paraná (P)</b>					
Eating	2.83	3.27	0.931	0.52	0.354
Feeding the cubs	0.30	0.60	1.091	0.56	0.317
Foraging *	12.80	19.20	10.626	1.32	0.007
Feeding behaviours *	15.92	23.07	12.021	1.36	0.005
Rubbing the walls	4.76	4.17	0.197	-0.24	0.665
Inactive	55.06	49.26	2.011	-0.73	0.182

\*Significant difference when phase 2 is compared to phase 1 ( $P < 0.05$ )

by the cubs.

Affiliative interactions (positive activity and contact with cubs) appeared more frequently in observations than reported in the wild (15.3%,  $n_1=180$ ; 13.4%,  $n_2=158$ ; 1% in the wild,  $n=30$ ). This higher proportion of affiliative behaviours (playing, allogrooming) compared to the wild, and the parents' tendency to feed the cubs before consuming food during fixed meals (this was not counted, just observed) suggest a different social dynamic in the observed group, and could be an indicator of positive welfare. The lack of the necessity to hunt potentially evasive prey, or to defend a territory against conspecifics, may set free a certain part of the time budget for more affiliative behaviours than otters might be able to perform in the wild. These observations remind of those in chimpanzees *Pan troglodytes* from Tama Zoological Park (Japan), who received various environmental enrichments, including artificial feeders, and spent more time in mutual grooming than their wild conspecifics from Mahale Mountains National Park (Tanzania) (Inoue and Shimada 2020). Similarly, the observations that socially compatible tigers *Panthera tigris*, when kept in pairs, will perform prosocial behaviours has been interpreted as a sign of positive welfare in a state that is not natural for this usually solitary species (De Rouck et al. 2005).

Although Carter and Rosas (1997) mentioned food sharing as a common behaviour among captive giant otters, this behaviour



**Figure 4.** Behavioural frequency proportions compared between wild giant otters (Leuchtenberger et al. 2014) and giant otters from Park Zoo during the two study phases. Feeding in the wild category (green) counts 'eating' and 'foraging', while the two blocks (yellow) and three blocks (blue) phases include 'feeding the cubs' as well. The inactive behaviours in this study are compared with both categories of resting (in and outside the den) of the study in the wild. For the ice blocks categories, affiliative interactions include 'positive activity' and 'cubs' from the ethogram, while it considers any affiliative interaction between members of the same group in the wild study (grooming, cub caring, playing). Scent-marking/elimination in both treatments with blocks is compared with scent-marking and/or latrine use at latrines distant from the den and at the den in the literature. The numbers above each column indicate the sample size of recordings.



was also observed in the wild (Evangelista and Rosas 2011), even from young individuals to the older matriarch (Davenport 2008). At Parken Zoo, the parents held the role of main food providers considering their experience with previous litters and the young age of the offspring (Davenport 2008). However, beyond the notion of food sharing, when Yumbo or Alua used a fish item at night to lure the other otters into the pool, they clearly demonstrated an intention to involve the group in anticipating the next fish to drop, while they could have simply kept it to themselves as the rest of the family was sleeping (Figure 3). A similar 'calling to food' event was noted in the wild at dusk with one individual that remained outside of the den and vocalised at the entrance to make its kin come out and hunt a passing fish shoal (Leuchtenberger et al. 2014). Nevertheless, it was unexpected to see the breeding pair in the current study performing such incitation with a fish lure. This is especially because a recent social-cognitive study showed giant otters being less successful in solving a cooperative task to get access to food when they had to wait for another individual rather than when they were already together (Schmelz et al. 2017). Possibly, calling family members to prey is a more intuitive social behaviour for giant otters than handling a cooperative task device where two individuals have to pull simultaneously on different strings to release food. This observation is an important example of zoo animals displaying behaviours that indicate (and require) positive social competence, and this could only happen because of the delayed feeding method. This kind of enrichment thus not only serves to increase activity, but also facilitates behaviours that are not elicited by few, lumped-feeding events.

To conclude, even with reduced feeding activity (likely related to the absence of live prey) compared to that of their wild conspecifics, giant otters from Parken Zoo showed various signs that may indicate some positive welfare or at least a reduced level of stress. Moreover, the extension of foraging in the youngest female suggests some degree of effectiveness in the use of ice blocks. This leads to the question: what other welfare indicators may exist in this and other species when using delayed feeding methods?

## Acknowledgments

Special thanks go to Maude Vernet and Luca Gallo for their support in data analysis, and two anonymous reviewers for their comments.

## References

- Altmann J. (1974) Observational study of behavior: Sampling methods. *Behaviour* 49(3–4): 227–266. doi:10.1163/156853974X00534
- Animal Protection Ordinance (2008) 455.1 (Swiss Confederation). Available at: <https://www.blv.admin.ch/dam/blv/en/dokumente/tiere/rechts-und-vollzugsgrundlagen/tschv-en.pdf.download.pdf/Animal%20Protection%20Ordinance%20455.1.pdf>.
- Azevedo O.M., Correia A.M., Magalhães A.I., de Sousa L.M. (2015) How do common otters (*Lutra lutra*) interact? Behavioral study on a pair of otters in captivity. *Animal Behavior and Cognition* 2(2): 124–131.
- Bashaw M.J. (2011) Consistency of captive giraffe behavior under two different management regimes. *Zoo Biology* 30(4): 371–378. doi:10.1002/zoo.20338
- Bashaw M.J., Bloomsmith M.A., Marr M.J., Maple T.L. (2003) To hunt or not to hunt? A feeding enrichment experiment with captive large felids. *Zoo Biology* 22(2): 189–198. doi:10.1002/zoo.10065
- Brereton J.E., Jones E.M.L., McMillan C., Perkins K. (2023) Visitors and observers otter-ly influence the behavior and enclosure use of zoo-housed giant otters. *Zoo Biology* 42(4): 509–521. doi:10.1002/zoo.21755
- Breton G., Barrot S. (2014) Influence of enclosure size on the distances covered and paced by captive tigers (*Panthera tigris*). *Applied Animal Behaviour Science* 154: 66–75. doi:10.1016/j.applanim.2014.02.007
- Browning H. (2020) The natural behavior debate: Two conceptions of animal welfare. *Journal of Applied Animal Welfare Science* 23(3): 325–337. doi:10.1080/10888705.2019.1672552
- Cabral M.M., Zuanon J., de Mattos G.E., Rosas F.C. (2010) Feeding habits of giant otters *Pteronura brasiliensis* (Carnivora: Mustelidae) in the Balbina hydroelectric reservoir, Central Brazilian Amazon. *Zoologia (Curitiba)* 27(1): 47–53. doi:10.1590/S1984-46702010000100008
- Carter S.K., Fernando C.W., Copper A.B., Cordeiro-Duarte A.C. (1999) Consumption rate, food preferences and transit time of captive giant otters *Pteronura brasiliensis*: Implications for the study of wild populations. *Aquatic Mammals* 25: 79–90.
- Carter S.K., Rosas F.C.W. (1997) Biology and conservation of the giant otter *Pteronura brasiliensis*. *Mammal Review* 27(1): 1–26. doi:10.1111/j.1365-2907.1997.tb00370.x
- Chavez-Fontecha E., Torres M.J.O., Romero J.C.T. (2019) Comportamiento de forrajeo en nutrias gigantes (*Pteronura brasiliensis*) estudio de caso en Santa Rosa de Sapuara, departamento de Guainía, Colombia. *Revista de Investigación Agraria y Ambiental* 10: 75–88.
- Clegg I.L.K., Rödel H.G., Boivin X., Delfour F. (2018) Looking forward to interacting with their caretakers: Dolphins' anticipatory behaviour indicates motivation to participate in specific events. *Applied Animal Behaviour Science* 202: 85–93. doi:10.1016/j.applanim.2018.01.015
- Clubb R., Mason G. (2003) Captivity effects on wide-ranging carnivores. *Nature* 425: 473–474. doi:10.1038/425473a
- Cortez M., Wolt R., Gelwick F., Osterrieder S.K., Davis R.W. (2016) Development of an altricial mammal at sea: I. Activity budgets of female sea otters and their pups in Simpson Bay, Alaska. *Journal of Experimental Marine Biology and Ecology* 481: 71–80. doi:10.1016/j.jembe.2015.05.020
- Davenport L.C. (2008) Behavior and ecology of the giant otter (*Pteronura brasiliensis*) in oxbow lakes of the Manú Biosphere Reserve, Peru. University of North Carolina, Chapel Hill: Doctoral dissertation.
- De Rouck M., Kitchener A.C., Law G., Nelissen M. (2005) A comparative study of the influence of social housing conditions on the behaviour of captive tigers (*Panthera tigris*). *Animal Welfare* 14(3): 229–238. doi:10.1017/S0962728600029390
- Djurskyddslag (1988:534) (Sveriges Riksdag) Available at: [https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/djurskyddslag-1988534\\_sfs-1988-534](https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/djurskyddslag-1988534_sfs-1988-534).
- Duplax N. (1980) Observations on the ecology and behavior of the giant river otter *Pteronura brasiliensis* in Suriname. *Revue d'Écologie (La Terre et La Vie)* 34(4): 495–620.
- Duplax N., Evangelista E., Rosas F.C.W. (2015a) Advances in the study of giant otter (*Pteronura brasiliensis*): Ecology, behavior, and conservation: A review. *Latin American Journal of Aquatic Mammals* 10(2): 75–98. doi:10.5597/lajam00200
- Duplax N., Heap C.J., Schmidt T., Schikora T., Carvalho J., Rubiano I., Ialeggio D., Rivera S. (2015b) *Summary of Husbandry Guidelines for Giant Otters (Pteronura brasiliensis) in Zoos, Aquariums and Wildlife Sanctuaries*. IUCN/SSC Otter Specialist Group, OZ Task Force.
- Evangelista E., Rosas F.C. (2011) Breeding behavior of giant otter (*Pteronura brasiliensis*) in the Xixuáú Reserve, Roraima, Brazil. *IUCN Otter Specialist Group Bulletin* 28(A): 5–10.
- Groenendijk J., Leuchtenberger C., Marmontel M., Van Damme P., Wallace R., Schenck C. (2022) *Pteronura brasiliensis* (amended version of 2021 assessment). The IUCN Red List of Threatened Species 2022: e.T18711A222719180. doi:10.2305/IUCN.UK.2022-2.RLTS.T18711A222719180.en
- Hill S.P., Broom D.M. (2009) Measuring zoo animal welfare: Theory and practice. *Zoo Biology* 28(6): 531–544. doi:10.1002/zoo.20276
- Hosey G., Melfi V., Pankhurst S. (2013) *Zoo Animals: Behaviour, Management, and Welfare*. Oxford, UK: Oxford University Press.
- Inoue N., Shimada M. (2020) Comparisons of activity budgets, interactions, and social structures in captive and wild chimpanzees (*Pan troglodytes*). *Animals* 10(6): 1063. doi:10.3390/ani10061063
- Jenny S., Schmid H. (2002) Effect of feeding boxes on the behavior of stereotyping Amur tigers (*Panthera tigris altaica*) in the Zurich Zoo, Zurich, Switzerland. *Zoo Biology* 21(6): 573–584. doi:10.1002/zoo.10061
- Kastelein R.A., Jennings N., Postma J. (2007) Feeding enrichment methods for Pacific walrus calves. *Zoo Biology* 26(3): 175–186.
- Leuchtenberger C., Mourão G. (2009) Scent-marking of giant otter in the southern Pantanal, Brazil. *Ethology* 115(3): 210–216.
- Leuchtenberger C., Oliveira-Santos L.G.R., Magnusson W., Mourão G. (2013) Space use by giant otter groups in the Brazilian Pantanal. *Journal of Mammalogy* 94(2): 320–330. doi:10.1644/12-MAMM-A-210.1
- Leuchtenberger C., Zucco C.A., Ribas C., Magnusson W., Mourão G. (2014) Activity patterns of giant otters recorded by telemetry and camera traps. *Ethology Ecology and Evolution* 26(1): 19–28. doi:10.1080/03949370.2013.821673

- Londoño G.C., Muñoz N.T. (2006) Reproduction, behaviour and biology of the giant river otter *Pteronura brasiliensis* at Cali Zoo. *International Zoo Yearbook* 40(1): 360–371. doi:10.1111/j.1748-1090.2006.00360.x
- Melfi V.A., Feistner A.T.C. (2002) A comparison of the activity budgets of wild and captive Sulawesi crested black macaques (*Macaca nigra*). *Animal Welfare* 11(2): 213–222. doi:10.1017/S0962728600028165
- Metrione L.C., Bateman H.L., Swanson W.F., Penfold L.M. (2018) Characterization of the behavior and reproductive endocrinology of giant river otters (*Pteronura brasiliensis*) in managed care. *Zoo Biology* 37(5): 300–309. doi:10.1002/zoo.21441
- Moraes C.G., Hegg J., Giarrizzo T., Andrade M.C. (2021) Feeding behavior and trophic niche partitioning between co-existing river otter species. *Hydrobiologia* 848: 4167–4177. doi:10.1007/s10750-021-04614-w
- Rosas F.C.W., Zuanon J.A.S., Carter S.K. (1999) Feeding ecology of the giant otter, *Pteronura brasiliensis*. *Biotropica* 31(3): 502–506. doi:10.1111/j.1744-7429.1999.tb00393.x
- Ross S.R. (2002) The effect of a simple feeding enrichment strategy on the behaviour of two Asian small-clawed otters (*Aonyx cinerea*). *Aquatic Mammals* 28(2): 113–120.
- Schmelz M., Duguid S., Bohn M., Völter C.J. (2017) Cooperative problem solving in giant otters (*Pteronura brasiliensis*) and Asian small-clawed otters (*Aonyx cinerea*). *Animal Cognition* 20: 1107–1114. doi:10.1007/s10071-017-1126-2
- Veasey J.S., Waran N.K., Young R.J. (1996) On comparing the behaviour of zoo housed animals with wild conspecifics as a welfare indicator, using the giraffe (*Giraffa camelopardalis*) as a model. *Animal Welfare* 5(2): 139–154. doi:10.1017/S0962728600018571
- Walker K.A., Davis J.W., Duffield D.A. (2008) Activity budgets and prey consumption of sea otters (*Enhydra lutris kenyoni*) in Washington. *Aquatic Mammals* 34(4): 393–401. doi:10.1578/AM.34.4.2008.393
- Wallgren B. (2014) *Captive Giant Otter Behaviour When Given Mussels*. Student Report No. 552. Uppsala, Sweden: Department of Animal Environment and Health, Swedish University of Agricultural Sciences.
- Watters J.V. (2014) Searching for behavioral indicators of welfare in zoos: Uncovering anticipatory behavior. *Zoo Biology* 33(4): 251–256. doi:10.1002/zoo.21144
- Yamanashi Y., Hayashi M. (2011) Assessing the effects of cognitive experiments on the welfare of captive chimpanzees (*Pan troglodytes*) by direct comparison of activity budget between wild and captive chimpanzees. *American Journal of Primatology* 73(12): 1231–1238. doi:10.1002/ajp.20995
- Young R.J. (1997) The importance of food presentation for animal welfare and conservation. *Proceedings of the Nutrition Society* 56(3): 1095–1104. doi:10.1079/PNS19970113