NOTE FROM THE EDITOR

NOTE FROM THE EDITOR

Dear Friends, Colleagues and Otter Enthusiasts!

We have closed issue 38/3 and immediately start issue 38/4, which again is already complete with 4 four exciting manuscripts to go online in the next weeks. Once this is done, we will have for the first time a 5th regular issue in the same year. So, there is much more to come this year.

I have a few days ago also received the most recent impact factor of the IUCN OSG Bulletin and we have now according to Scimago increased to an IF of 0,34 and have left Q4 and are now a Q3 journal within the category "Animal Science and Zoology". I am very well aware about the ongoing discussion on all the various scientific metrics that exist and their usefulness. I hope you agree we should not be too fixed on this especially when it comes to individual impact. However, for a journal is a bit more stable and less prone to manipulation. As we have seen an increasing number of issues and articles this increase is even more remarkable. The recent increase shows that the strict quality control by our reviewers and the way the authors address the concerns raised are all of high quality.

Lesley uses a lot of time every week not only for getting the manuscripts online. There is much more work done behind the scenes and I am very thankful for the language editing and to double check missing references etc. Lesley, I want to thank you for all your efforts on behalf of the whole otter community!

A R T I C L E

STATUS OF CONSERVATION OF *LONTRA LONGICAUDIS* (Olfers, 1818) (CARNIVORA: MUSTELIDAE) ON SANTA CATARINA ISLAND

Oldemar Carvalho JUNIOR[1], Procássia Maria L. BARBOSA[2], Alesandra Bez BIROLO[1]

[1]Instituto Ekko Brasil, Caixa Postal 10121 - R. Henrique Veras do Nascimento, 82 - Conceição Lagoon - Florianópolis/SC - 88062-970
[2]Departamento de Zootecnia e Desenvolvimento Rural, Universidade Federal de Santa Catarina, Florianópolis, SC, Brasil
Corresponding author: Oldemar Carvalho Junior (ocjunior@ekkobrasil.org.br)



(Received 20th January 2021, accepted 15th January 2021)

Abstract: Neotropical otters (*Lontra longicaudis*) are semi-aquatic mammals classified as "Near threatened" by the International Union for Conservation of Nature (IUCN), facing various threats against their survival, such as habitat fragmentation, water pollution, conflicts with fishermen, or attacks by dogs. A total of 9.531 scats were collected monthly over nine years, covering 14 years, from 2003 to 2017, in six different areas of study in Santa Catarina Island, Brazil. Frequency analysis through non-parametrical statistical tests and a polynomial regression model was applied. A linear model was also used following criteria and standards defined by the IUCN. Both methods were in agreement, showing a significant decrease in the number of Neotropical otter's faeces over this period. Because the modifications of the environment were constant during the last 14 years, the criterion to be adopted, according to the IUCN Red List, is A2. Therefore, the average reduction in the number of otter droppings over the past 14 years, or three generations, suggests that the population is critically endangered (CR).

Citation: **Carvalho Junior, O., Barbosa, P.M.L. and Birolo, A.B. (2021).** Status of Conservation of *Lontra longicaudis* (Olfers, 1818) (Carnivora: Mustelidae) on Santa Catarina Island. *IUCN Otter Spec. Group Bull.* **38** (4): 186 - 201
Key words: Mustelidae, IUCN Red List, population, biodiversity, distribution, shelters.

INTRODUCTION

The present work aims to provide information to update the conservation status of Neotropical otters (*Lontra longicaudis*) in the Brazilian state of Santa Catarina. As the area where this otter species live is quite broad, about 80 km long by 60 km wide (Carvalho Junior, 2016), the results presented here can be considered representative for the Santa Catarina Island. The study area represents 50% (212 km^2) of the Island, which has 424,4 km^2.

The Neotropical otter is considered a threatened species by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), of which Brazil is a signatory. The International Union for Conservation of Nature (IUCN) classifies the species as Near Threatened. According to Rodrigues et al. (2013), the species is vulnerable in the Atlantic Forest, an essential biome of the Brazilian state of Santa Catarina.

The Atlantic Forest used to cover 85% of the area of the Santa Catarina state. Today it occupies only 17% of the original area, indicating a critical situation of this biome. During 2017 and 2018, the state lost 9.05 km^2 of the Atlantic Forest, compared to 5.95 Km^2 from 2016 to 2017, which resulted in an increase of 52% in deforestation for this biome in the period (SOS Mata Atlântica/INPE, 2018).

In Brazil, the Wildlife Protection Law (Law N° 5.197, 3/01/1967) prohibits the use, pursuit, destruction, hunting, or harvesting of wild animals, emphasizing hunting and fishing, without specifying any particular species. The law does not explicitly mention the otter as a protected species. On the other hand, reports indicate that these animals are not popular in some sectors of society. Fishermen and fish farmers, for example, complain that otters are harmful, damaging nets, eating farmed fish, and damaging oyster and shellfish farms.

Due to the top predator role, otters provide an exciting example of biomagnification, making them more sensitive to aquatic ecosystems' negative impacts as water pollution. This biomagnification is useful to warn of the need to protect the various habitats used by otters, such as estuaries, freshwater lakes, rivers, mangroves, bays, marshes, and coastal islands.

In addition to water pollution, living close to anthropogenic activities like agriculture, livestock, or fishing, leads Neotropical otters to face conflicts with human society, mostly with fishermen (Barbieri et al., 2012, Castro et al., 2014) and deal with habitat fragmentation (González and Utrera, 2001). Despite being top predators, attacks on adults and offspring could also occur in the study area, from *Caiman latirostris* (broad-snouted caiman) and feral dogs. In fact, González and Utrera (2001) describe otter deaths caused by dogs in Venezuela.

The loss of habitat in the study area has been shown to be irreversible, giving rise to increasing water extraction for human consumption and increasingly intense mass tourism (Campos, 2004; Gomez et al., 2014; Chaves, 2015; Covello et al., 2017). Also, condominiums multiply, increasing the number of people per square meter and the number of cars on highways built without protective measures for the passage of fauna.

The impact on the otters over the years in the studied areas are mostly of anthropic origin, mainly run over and conflicts with fishermen. At the base of the Ekko Brasil Institute/Otter Project, dead otters were received over nine years in the south of the Island. From this total, 11 otter corpses died due to car accidents, found next to highways (3 animals); physical aggressions, found floating on the waters (2 animals); drowning in fish traps (5 animals), and one animal was the victim of a domestic dog attack. The Neotropical otter can be affected by other causes, such as the accumulation of heavy metals and food reduction in lagoons and rivers, construction of dams, the degradation of riparian forests, and natural disasters.

These different threats may have a more negative impact on *L. Longicaudis* than global warming itself, for which Neotropical otter is a less sensitive otter species (Cianfrani et al., 2018). Threats decrease population size (Pacifici et al., 2013), affecting population genetic diversity (Trinca et al., 2007, 2012). Because they belong to the Brazilian natural heritage, the otter's preservation is a question for academic, economic, and the social development of the country (Carvalho Junior, 2016). To implement efficient conservation strategies, it is mandatory to correctly evaluate the distribution of otter subpopulations and estimate the intensity of the species in the study area.

The term intensity, used here, is different from the definition of frequency. The intensity of the species' presence in the monitored areas is a strategy used in several countries in Europe since the 1960's. This model's importance is due to the difficulty of observing the otter in the wild and the costs and logistics associated with DNA studies. Besides that, the use of intensity comes from previous work on the flow of energy, the species' ecological role, and the species' ecological services (Carvalho Junior, 2016). In this case, the otter's presence is related to the flow of energy in the system and its concentration at the top of the food chain. It is seen from the receiver's point of view, not the sender, as Odum (1996) defined. Therefore, the otter's value to the receiver means how much he is willing to pay, a market value.

On the other hand, the value from the issuer's point of view represents the total amount spent to create the otter, including solar radiation and producers. We opted for the receiver's point of view to better illustrate the differences in values by society attributed to the otter. The otter's value for an ecovolunteer who participates in the Ecovolunteer Program of Projeto Lontra, for example, is much greater than the value attributed by a fisherman. This perception is intrinsic to the feeling that the otter causes within the human being. In this sense, the term intensity is also used here to reflect the energy caused by the species' presence in different social groups.

In other words, the intensity of the otter's presence can indicate the health of the functioning of the different compartments of the ecosystem, responsible for the transformation and transfer of energy. In physics, the intensity is related to the variation in the flow of energy over time. The greater the intensity, the greater the flow of energy in space. It reflects the strength of something that can be measured (https://dictionary.cambridge.org). Therefore, intensity can be seen here due to the frequency, but with a more ecological and applied interpretation for public policy.

Neotropical otters are organized in the form of a metapopulation, small subpopulations separated by geographic and human barriers, but maintaining contact through ecological corridors. On Santa Catarina Island, a preliminary study conducted in the Peri Lagoon (Carvalho Junior, 2007) estimated 5 to 11 individuals, through DNA analysis, in 5 km^2 of water surface and a perimeter of 11 km. However, in terms of seasonal intensity and movements through ecological corridors, the Island's population has not yet been investigated.

The determination of Neotropical otter status is based on studies that have been developed in Europe with the Eurasian otter *Lutra lutra* since the 1970s. These studies are based on Erlinge's (1967) methods, described by Jeffries, as in Strachan and Jefferies (1996). The following works, Chapman and Chapman (1982), Strachan and Jefferies (1996), Green and Green (1997), Hamilton and Rochford (2000), Reuther (2000), Chanin (2003a, 2003b), Bailey and Rochford (2006), were successful in demonstrating the distribution and presence of otter in several habitats, determining the tendency of increase or decline of subpopulations.

The study design consisted of a preliminary survey in the first year, followed by monitoring in the following years. The preliminary survey served as a preparation for the monitoring effort, define the sampling sites, while the monitoring itself consisted of collecting and analyzing the data. This methodology has already been successfully used in other sites (Carvalho Junior. 2016; Carvalho Junior and Birolo, 2019), creating a baseline for future monitoring of otter populations in southern Brazil.

By analyzing the intensity of the species' presence, based on sightings and signs such as faeces, conducted over nine years, covering 14 years, but not in all locations of Santa Catarina Island, this paper seeks to answer three main questions:

1) Are there any favorite places for otters in each location?
2) Is there any seasonal variation in the presence of otters?

3) Is there a significant decrease in the intensity of otter presence on the Island since 2003?

It is hoped that this methodology can be replicated in other federation states, assisting in management plans for the species in Brazil.

STUDY AREA

Santa Catarina Island is the largest island of the Santa Catarina State, located parallel to the mainland and separated by a narrow channel (Figure 1). It has an average length of 54 km and an average width of 18 km. Bays, promontories, smaller islands, and lagoons are standard features in the study area. The most important water bodies in the Santa Catarina Island are the Peri Lake (5.1 km^2) and Conceição Lagoon (19.71 km^2) (Carvalho Junior et al., 2012).

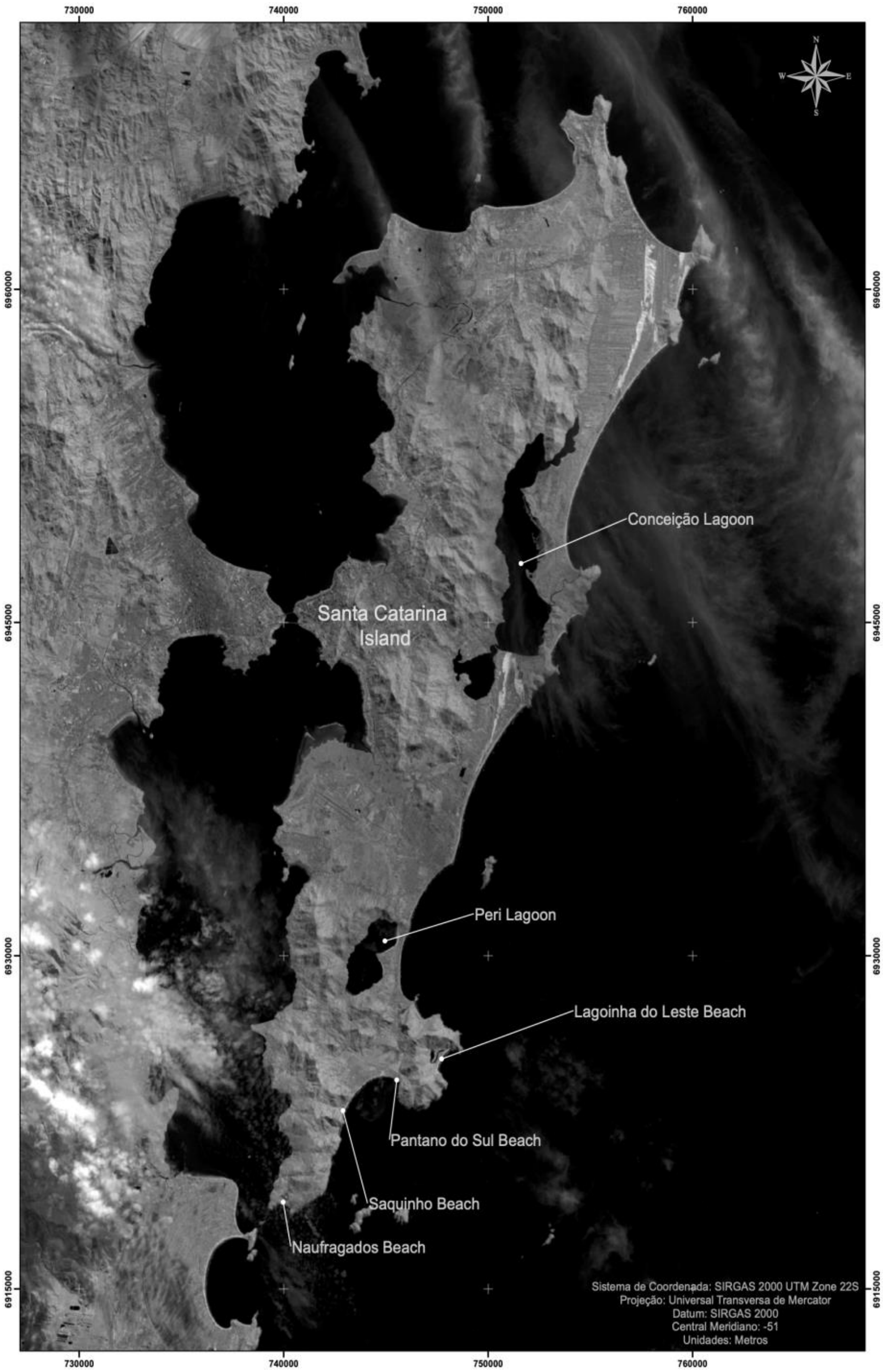

Figure 1. Localization of sampling areas in Santa Catarina Island, Brazil.

METHODS

Naufragados, Saquinho, Pântano do Sul, and Lagoinha do Leste are rocky coastlines, and Conceição Lagoon and Peri Lagoon are salt and freshwater lagoons, respectively. These sampling areas were defined after a systematic evaluation of attractive otter habitats across the Island, selected after direct observations of the animals or indirect evidence of the species' presence such as faeces and footprints.

Data were collected from 2003 to 2017. In 2003, only Peri Lagoon was considered. In 2004, Naufragados, Pântano do Sul, Lagoinha do Leste, and Conceição Lagoon, were added. In 2005, Saquinho joined the other five sampling sites to obtain a total of six different areas. Each year, the data were collected once a month in each area.

The expeditions to otter habitats were conducted on foot by trails or by water using canoes. Otter presence was defined by signs such as faeces and footprints inside the dens and surroundings. During each field trip, the total number of otter faeces was counted for each location. These faeces were collected as not to count them again in the following month.

Statistical analysis

As the number of otter faeces did not follow a normal distribution, non-parametrical statistical tests were applied using the R software (R Studio 1.0). A Kruskal-Wallis test was done across the dataset to investigate any significant difference between the conditions tested. In the case of differences, the paired Wilcoxon test was run to know which conditions were significantly different from the others. Finally, a Loess polynomial regression model was applied to the data's evolution curve, with a Holm adjustment, using R Studio software (RStudio 1.0.44 and "ggplot2" package). The objective was to define if the number of otter faeces was increasing or decreasing over the years. For all statistical analyzes, differences were considered significant at $P < 0.05$.

As for the intensity of the species' presence, the number of faeces is also used to infer if the otter population is declining. The use of indirect data is not uncommon to infer the population of a given species. IUCN suggests using indirect data as long as it is of the same type (IUCN Standards and Petitions Subcommittee, 2019). The objective was to find the population trends of at least three generations. This trend must be justified by characteristics of life history, habitat biology, a pattern of exploitation, or other threatening processes.

A linear model is appropriate when the taxon is threatened, for example, with habitat loss, and a similar-sized area of habitat is lost every year that could lead to a linear decline in the number of individuals. An exponential model should be used in the case of hunting mortality that would result in a proportion of individuals subtracted from the population.

The polynomial regression model shows a regular decrease over the years. The linear model is used in the present case as the otter is not systematically hunted in the study area but subject to retaliation by fishermen and aquaculture farmers, loss habitats, or run over by cars on highways. The analysis follows criteria and standards defined by the IUCN (IUCN Standards and Petitions Subcommittee, 2019) under the official IUCN Red List Categories and Criteria booklet (IUCN 2001, 2012b).

RESULTS

A total of 9,531 scats were collected. There were 3,260 faeces in Conceição Lagoon, from 72 field trips: 2,426 in Peri Lagoon, from 96 excursions in the field; 1,455 in Naufragados, from 84 excursions; 1,252 in Lagoinha do Leste, from 84 excursions;

793 in Saquinho, from 67 excursions; and 335 faeces in Pântano do Sul, from 72 excursions. Figure 2 shows the distribution of Neotropical otter faeces over the years.

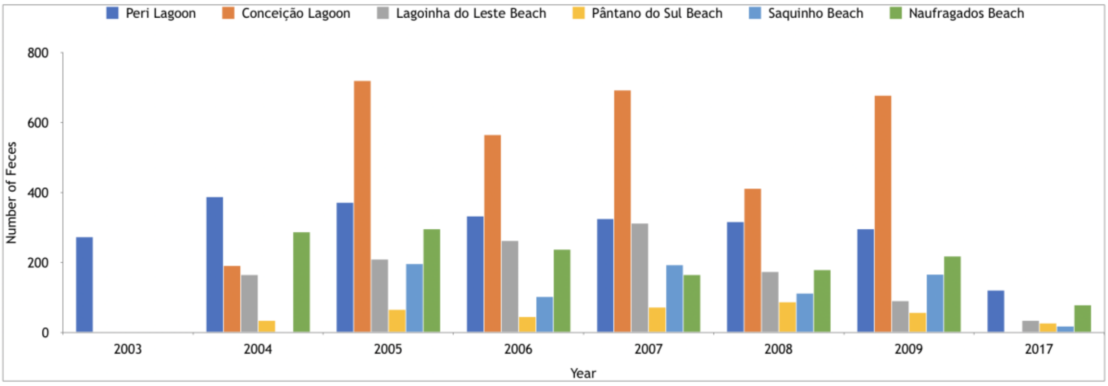

Figure 2. Number of Neotropical otter faeces over the years.

The intensity of otter presence in these areas varied significantly between the sites studied over the years. Conceição Lagoon presented the highest number of otter faeces, followed by Peri Lagoon, but only between 2005 and 2009. In 2004, Peri Lagoon ranked first and Conceição Lagoon second, and in 2017 no data were collected in Conceição Lagoon.

Naufragados, Lagoinha do Leste, and Saquinho always presented smaller numbers of otter faeces than in Conceição Lagoon, and Peri Lagoon, with the position changing over the years (Table 1). Concerning Pântano do Sul, this was always the place with the lowest number of otter faeces between 2004 and 2009. In 2017 Saquinho occupied the last position. Table 1 exhibits the difference in the number of faeces between the different areas and their respective *P*-values.

Table 1. The number of faeces between the different areas and their respective *P*-values.

Year	Greater Number	Smaller Number	*P*-Value
2004	Peri Lagoon (388)	Conceição Lagoon (199)	.0146
		Lagoinha do Leste (166)	.00654
		Pântano do Sul (35)	.00035
	Naufragados (288)	Lagoinha do Leste (166)	.04012
		Pântano do Sul (35)	.00046
	Lagoinha do Leste (166)	Pântano do Sul (35)	.00066
2005	Conceição Lagoon (720)	Peri Lagoon (372)	.03562
		Naufragados (296)	.00071
		Lagoinha do Leste (210)	.00073
		Saquinho (197)	.0006
		Pântano do Sul (66)	.00051
	Peri Lagoon (372)	Lagoinha do Leste (210)	.0006
		Pântano do Sul (66)	.00293

	Naufragados (296)	Pântano do Sul (66)	.00543
2006	Conceição Lagoon (566)	Peri Lagoon (333)	.03016
		Lagoinha do Leste (263)	.01314
		Naufragados (238)	.00173
		Saquinho (103)	.00053
		Pântano do Sul (46)	.00053
	Peri Lagoon (333)	Saquinho (103)	.0015
		Pântano do Sul (46)	.00053
	Lagoinha do Leste (263)	Pântano do Sul (46)	.00102
	Naufragados (238)	Saquinho (103)	.0041
		Pântano do Sul (46)	.00053
	Saquinho (103)	Pântano do Sul (46)	.00905
2007	Conceição Lagoon (693)	Peri Lagoon (325)	.00306
		Lagoinha do Leste (313)	.00421
		Saquinho (194)	.00052
		Naufragados (166)	.00052
		Pântano do Sul (73)	.00052
	Peri Lagoon (325)	Saquinho (194)	.03394
		Naufragados (166)	.00421
		Pântano do Sul (73)	.00052
	Lagoinha do Leste (313)	Naufragados (166)	.02506
		Pântano do Sul (73)	.00052
	Saquinho (194)	Pântano do Sul (73)	.00421
	Naufragados (166)	Pântano do Sul (73)	.01029
2008	Peri Lagoon (317)	Pântano do Sul (88)	.0018
		Lagoinha do Leste (174)	.085
	Saquinho (113)	Pântano do Sul (88)	.029
	Lagoinha do Leste (174)	Pântano do Sul (88)	.04
2009	Conceição Lagoon (678)	Peri Lagoon (296)	.00129
		Naufragados (218)	.00035
		Saquinho (167)	.00035

		Lagoinha do Leste (91)	.00035
	Peri Lagoon (296)	Lagoinha do Leste (91)	.00035
	Saquinho (167)	Lagoinha do Leste (91)	.00305
2017	Peri Lagoon (121)	Lagoinha do Leste (35)	.0023
		Pântano do Sul (27)	.0015
		Saquinho (19)	.001
	Naufragados (79)	Lagoinha do Leste (35)	.0139
		Pântano do Sul (27)	.0026
		Saquinho (19)	.0015

A Kruskal-Wallis test indicated that presence intensity varied significantly between locations (P=8.772e-08; P=3.279e-09; P=1.049e-09; P=5.146e-10; P=0.002995; P=3.919e-08; and P=5,446e-07) and a pairwise Wilcoxon test with a Holm adjustment allowed to underline which ones (*0.01<P<0.05; 0.001<P<0.01; *** P <0.001) (Figure 3).

Conceição Lagoon generally showed the highest number of otter faeces, and Peri Lagoon was the second most preferred site. These positions were constant since 2005, but they were inverted in 2004. Naufragados, Lagoinha do Leste, and Saquinho had fewer otter faeces, and their relative order changed through the years. Finally, Pântano do Sul was always the site with the lowest number of otter faeces since 2004 and significantly equal to Lagoinha do Leste and Saquinho in 2017 (Table 1) (Figure 3).

Considering each year, in a single data set (Figure 4), the intensity of otter presence also varied significantly between sites (*P*<2,2e-16). The number of otter faeces sampled in Conceição Lagoon was significantly higher than in Peri Lagoon (*P*=9,60e-08), Naufragados (*P*=3.70e-12), Lagoinha do Leste (*P*=12), Saquinho (*P*=1.30e-13) and Pântano do Sul (*P*<2e-16). The number in Peri Lagoon was significantly higher than in Naufragados (*P*=0.00075), Lagoinha do Leste (*P*=2.70e-07), Saquinho (*P*=1.00e-09), and Pântano do Sul 2e-16). In Naufragados, the number was significantly higher than in Saquinho (*P*=0.00252), and Pântano do Sul (*P*<2e-16) but was not significantly different from Lagoinha do Leste. In Lagoinha do Leste, the number was significantly higher than in Pântano do Sul (*P*=1.80e-12), but it was not significantly different from Saquinho. Finally, the number of otter faeces sampled in Saquinho was also significantly higher than in Pântano do Sul (*P*=3.70e-08) (see Table 1).

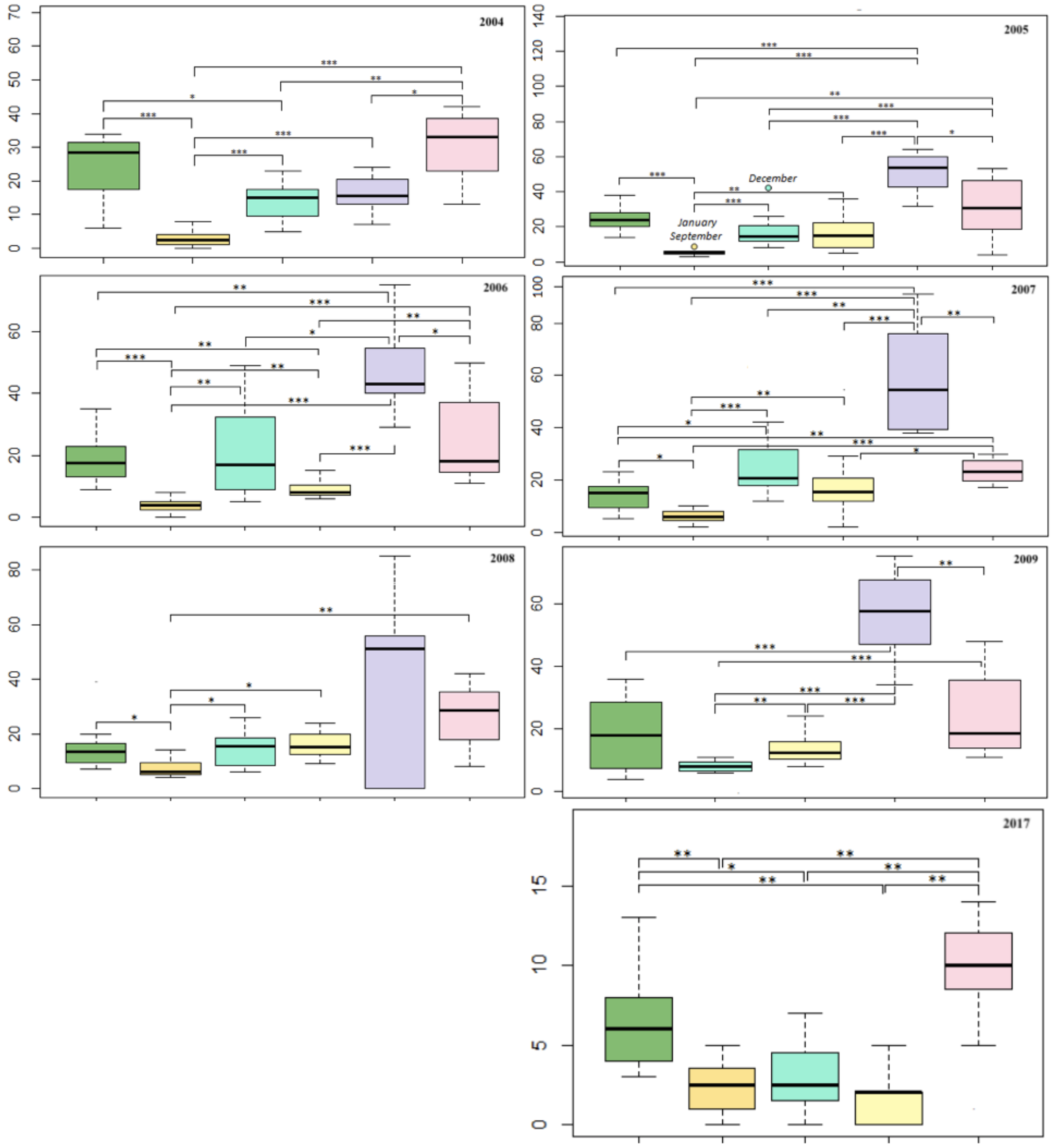

Figure 3. Mean number of otter faeces (Y axis) sampled in Naufragados (green), Pântano do Sul (orange), Lagoinha do Leste (turquoise), Saquinho (yellow), Conceição Lagoon (purple), and Peri Lagoon (pink).

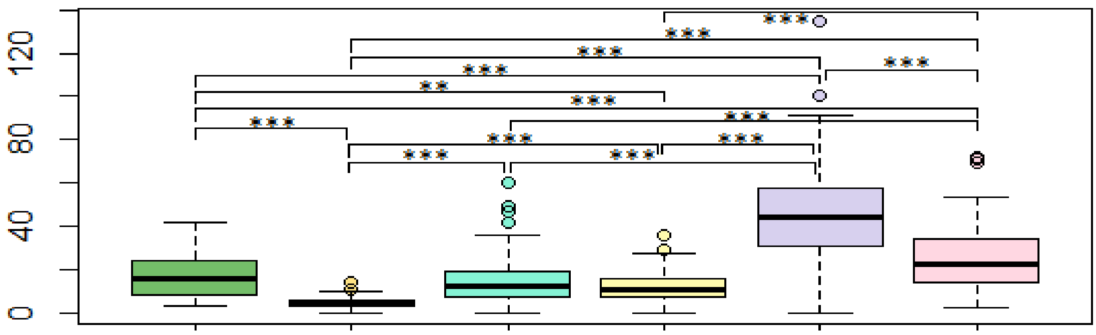

Figure 4. The mean number of otter faeces sampled in each study area over the years 2004, 2005, 2006, 2007, 2008, 2009, and 2017.

A Kruskal-Wallis test indicated that presence intensity varied significantly between locations (*P*<2.2e-16), and a pairwise Wilcoxon test with a Holm adjustment allowed to underline which ones (*0.01<*P*<0.05; 0.001<p<0.01; *** *P*<0.001).

Naufragados (green), Pântano do Sul (orange), Lagoinha do Leste (turquoise), Saquinho (yellow), Conceição Lagoon (purple), and Peri Lagoon (pink).

No difference in the present intensity of otters was shown between the different months, over the years 2004, 2005, 2006, 2007, 2008, 2009, and 2017, so it prevented us from underlining any seasonal variation, either considering each sampling area separately (Figure 5) or all areas in the same dataset (Figure 6).

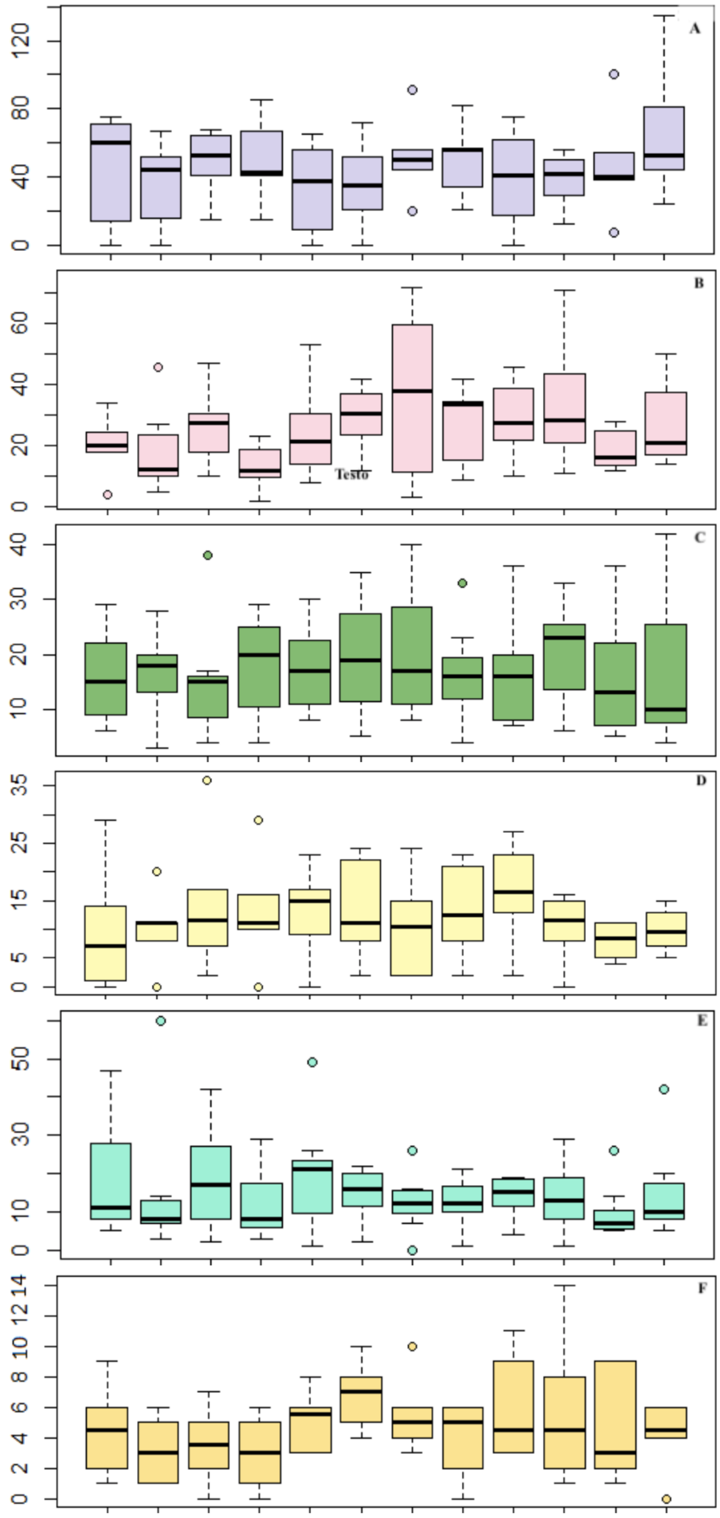

Figure 5. Mean number of otter faeces (Y axis) sampled per month (X axis) over the years 2004, 2005, 2006, 2007, 2008, 2009, and 2017, in (A) Conceição Lagoon, (B) Peri Lagoon, (C) Naufragados, (D) Saquinho, (E) Lagoinha do Leste, and (F) Pântano do Sul. A Kruskal-Wallis test indicated that presence intensity did not vary significantly between months.

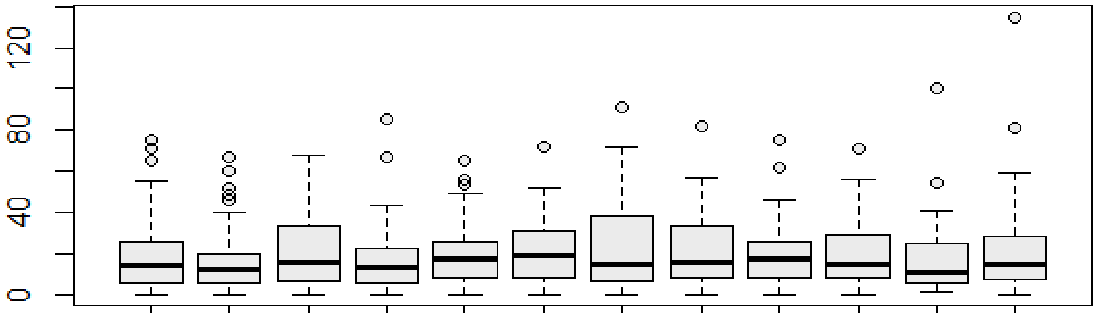

Figure 6. Mean number of otter faeces (Y axis) sampled per month (X axis) over the years 2004, 2005, 2006, 2007, 2008, 2009, and 2017, in all locations. A Kruskal-Wallis test indicated that presence intensity did not vary significantly between months (p=0.8171).

Presence Intensity of Otters through Years

In Conceição Lagoon (Figure 7A), the regression model first showed an increasing number of sampled faeces between 2004 and 2005, then a decrease from 2005 to 2006, and again an increase after 2006 was stabilized in 2009. Since 2009, the lack of data did not allow us to investigate the trend in presence intensity. In Peri Lagoon (Figure 7B), the regression model first showed an increasing number of sampled faeces between 2003 and 2005 and then decreased from 2005 to 2017. In Naufragados (Figure 7C), the regression model showed first an increasing number of sampled faeces between 2004 and 2007, then an increase between 2007 and 2011, followed by a decrease until 2017.

In Saquinho (Figure 7D), the regression model showed first a decreasing number of sampled faeces between 2005 and 2006, then an increase between 2006 and 2007, and a decrease until 2017. In Lagoinha do Leste (Figure 7E), the regression model showed first an increase in the number of sampled faeces between 2004 and 2007, and a decrease until 2017. In Pântano do Sul (Figure 7F), the regression model showed first an increase in the number of sampled faeces between 2004 and 2005. A decrease was observed from 2005 to 2006, followed by an increase between 2006 and 2011, and finally decreased until 2017.

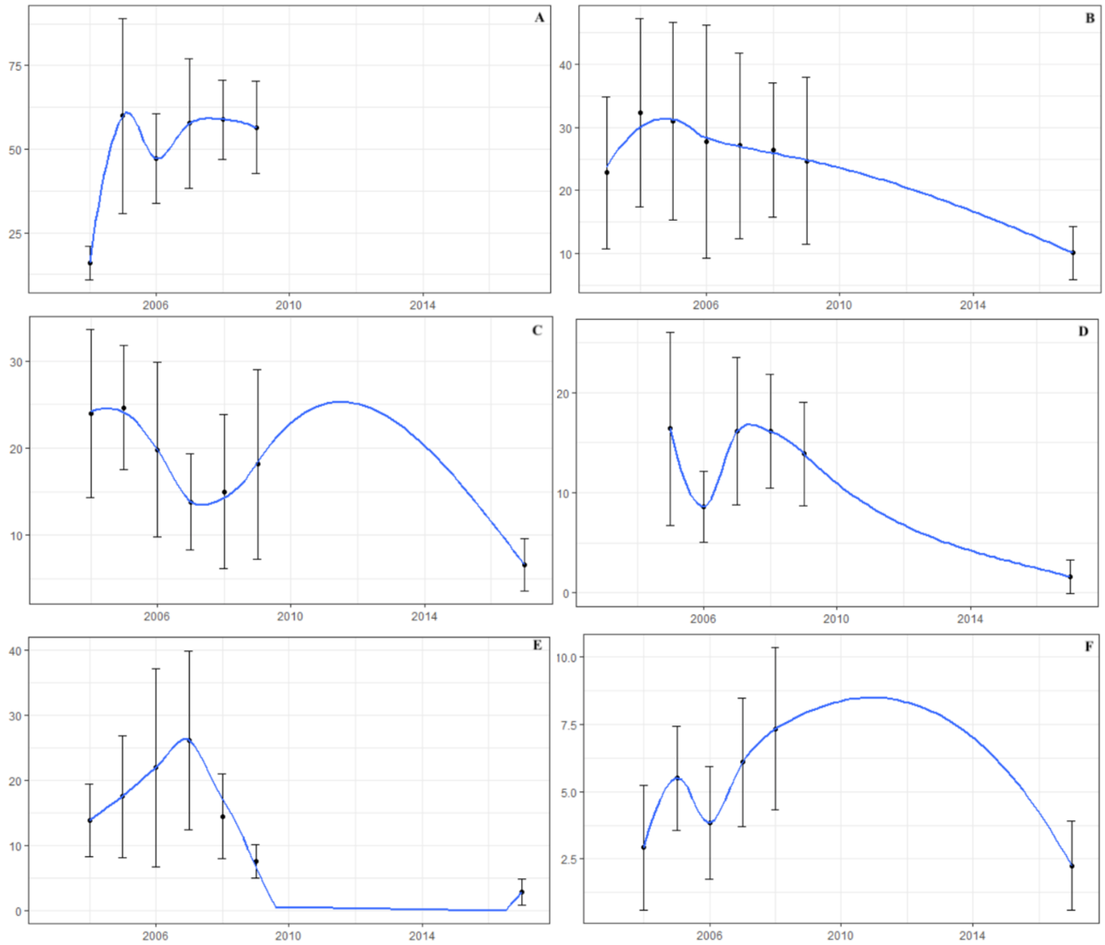

Figure 7. Distribution of the number of otter faeces (Y axis) collected over the years (X axis) in (A) Conceição Lagoon, (B) Peri Lagoon, (C) Naufragados, (D) Saquinho, (E) Lagoinha do Leste, and (F) Pântano do Sul. Blue lines are curves estimated by a Loess polynomial regression model**,** and grey lines are the 95% confident interval added to this smooth line.

The linear model analysis considers a 14-year generation time. The number of faeces in the study area was estimated as 493 in 1983 and 34 in 2025, the triangle markers in Figure 8. It is assumed that the decline does not begin until 1983. As Figure 8 shows, the decline in the number of faeces does not happen before 2004.

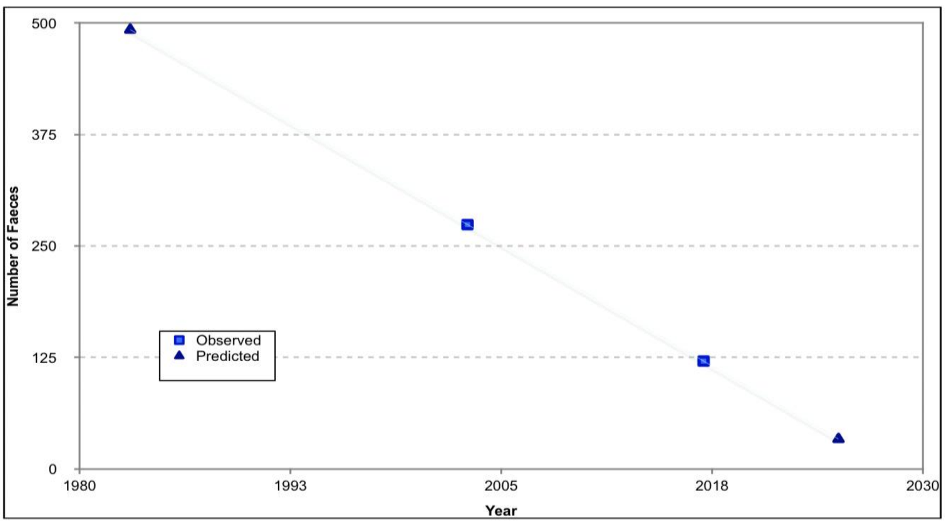

Figure 8. The decline in the number of otter's faeces, observed and forecast, over the years, from 1983 to 2025.

DISCUSSION

The present study is based on direct observations, represented by the average variation in the number of faeces found over eight years (2003, 2004, 2005, 2006, 2007, 2008, 2009, and 2017), covering 14 years, or three otter generations. It does not present the size of the population but the intensity of the species' presence in the monitored areas, a strategy used in several countries in Europe since the 1960s. The importance of this model is due to the difficulty of observing the otter in the wild, and the costs and logistics associated with DNA studies.

The large number of faeces, collected over a long period of time, made it possible to analyze the presence of otter subpopulations on Santa Catarina Island. The number of droppings varies among the different study sites. The Neotropical otter's intensity of presence revealed that the favorite places for the species are Peri Lagoon and Conceição Lagoon.

Conceição Lagoon presented the highest number of otter faeces, followed by Peri Lagoon, but only between 2005 and 2009. In 2004, Peri Lagoon ranked first and Conceição Lagoon second. Naufragados, Lagoinha do Leste, and Saquinho always presented smaller numbers of otter faeces than in Conceição and Peri Lagoons, with the position changing over the years.

It is important to note that the otter showed a strong presence in marine waters such as Conceição Lagoon, Lagoinha do Leste, Naufragados, Saquinho, and Pântano do Sul. Carvalho Junior et al. (2012) demonstrated the otter's presence in coastal islands along the coast of the state of Santa Catarina, Brazil.

Two statistical analyses were used. One was based on non-parametric tests associated with a polynomial regression model. According to the criteria and standards defined by the IUCN Standards and Petitions Subcommittee, the other follows a linear model. Both methods indicate a drastic reduction in the number of otters in the studied region. The results show that by 2030, the otter's intensity on the Santa Catarina Island should reach an imperceptible average value.

The loss of habitat in the study area, the increasing extraction of water for human consumption, and the intense mass tourism gets worse every year. Consequently, an increase in the number of people is observed, as well as in the number of cars on highways that are built without protective measures for the passage of fauna.

As an example, Palhoça, a municipality neighboring Florianópolis, experienced a population increase of 60.52% from 2000 to 2017; today it occupies the tenth position among the most populous cities in the state of Santa Catarina, with 164,926 inhabitants, while Florianópolis occupies the second position, with 485,838 inhabitants (Will, 2020). A study on the projection of population growth for Conceição Lagoon, a key area for the Neotropical otter on Santa Catarina Island, shows that of the 62,596 people today, an increase of about 45% can be expected in 2040 (Machado, 2019). For a species like the *Lontra longicaudis*, organized in a metapopulation form, in constant movement from one ecosystem to another, this situation can produce their local extinction.

With the results obtained, the best scenario would be the category A1 (CR) (from IUCN 2001; 2012a; 2012b), which is still alarming. For that, it would be necessary to have concrete evidence that the impacts caused by the loss of suitable habitat, retaliation, and being run over on highways could be reversible. However, this does not seem to be the case.

Considering the probability that the environmental degradation will not cease but, on the contrary, get worse, the criterion to be adopted, according to the IUCN Red List, is the A2. Therefore, the average reduction in the number of otter droppings over the past 14 years, or three generations, suggests that the population is critically endangered (CR) in the area. We hope that this methodology can be applied to other areas of Brazil to know the status of the different populations of Neotropical otters.

Acknowledgements - We would like to acknowledge Marcelo Tosatti for helping with the fieldwork. Grateful to Caroline Cosnard for the statistical analysis on R Statistics.

REFERENCES

Bailey, M., Rochford J. (2006). Otter Survey of Ireland 2004/2005. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin.

Barbieri F., Machado R., Zappes C.A., Oliveira L.R. (2012). Interactions between the Neotropical otter (*Lontra longicaudis*) and gillnet fishery in the southern Brazilian coast. *Ocean & Coastal Management* **63**: 16–23. https://doi.org/10.1016/j.ocecoaman.2012.03.007.

Campos, É.T. (2004). A gestão territorial urbana no município de Florianópolis: uma abordagem sobre a expansão imobiliária e seus impactos ambientais. (Dissertação de Mestrado). Universidade Federal de Santa Catarina, Florianópolis.

Carvalho Junior, O. (2007). No rastro da lontra brasileira. 1st ed. Bernúncia Editora, 103 pp.

Carvalho Junior, O., Birolo, A.B., Macedo-Soares, L. (2010). Ecological Aspects of Neotropical Otter (*Lontra longicaudis*) in Peri Lagoon, South Brazil. *IUCN Otter Spec. Group Bull*. **27**: 105–115.

Carvalho Junior, O., Fillipini, A.; Salvador, C. (2012). Distribution of Neotropical otter, *Lontra longicaudis* (Olfers, 1818) (Mustelidae) in coastal islands of Santa Catarina, Southern Brazil. *IUCN Otter Spec. Group Bull.*, **29**(2): 95–108.

Carvalho Junior, O. (2016). Emergy Analysis of the Peri Lake System and the Role of the Neotropical Otter. *IJRRAS* **29**: 31–54.

Carvalho Junior, O., Birolo, A.B. (2019). Projeto Lontra. Turismo de Conservação como Interface Social em Projetos de Pesquisa. 1st ed. Bambu, São Paulo, 160 pp.

Castro, F.R., Stutz-Reis, S., Reis, S.S., Nakano-Oliveira, E., Andriolo, A. (2014). Fishermen's perception of Neotropical otters (*Lontra longicaudis*) and their attacks on artisanal fixed fence traps: The case of caiçara communities. *Ocean & Coastal Management* **92**: 19–27.

Chanin, P. (2003a). Monitoring the Otter *Lutra lutra*. English Nature, Peterborough.

Chanin, P. (2003b). Ecology of the European Otter. Peterborough, Peterborough.

Chapman, P.J., Chapman, L.L. (1982). Otter Survey of Ireland 1980-81. The Vincent Wildlife Trust, London.

Chaves, T.F. (2016). Uma análise dos principais impactos ambientais verificados no estado de Santa Catarina. *Revista Gestão & Sustentabilidade Ambiental* **5**: 611–634. http://dx.doi.org/10.19177/rgsa.v5e22016611-634

Cianfrani, C., Guisan, A., Loy, A., Broennimann, O. (2018). More than range exposure: Global otter vulnerability to climate change. Biological Conservation. https://doi.org/10.1016/j.biocon.2018.02.031.

Colares, E.P., Waldemarin, H.F. (2000). Feeding of the Neotropical River otter (*Lontra longicaudis*) in the coastal region of the Rio Grande do Sul state, southern Brazil. I*UCN Otter Spec. Group Bull*. **17**: 6–13.

Covello, C., Filho, N.O.H., Brilha, J. (2017). The Geodiversity of the Municipality of Florianópolis, Santa Catarina, Brazil: Values and Threats. Revista do Departamento de Geografia Universidade de São Paulo Volume Especial-Eixo 6, 104–111.

Erlinge, S. (1967). Home range of the otter *Lutra lutra* L. in Southern Sweden. *Oikos* **18**: 186–209.

Gomez, J.J., Túnez, J.I., Fracassi, N., Cassini, M.H. (2014). Habitat suitability and anthropogenic correlates of Neotropical river otter (*Lontra longicaudis*) distribution. *Journal of Mammalogy* **95**: 824–833. https://doi.org/10.1644/13-MAMM-A-265.

González, I., Utrera, A. (2001). Distribution of the Neotropical otter *Lontra longicaudis* in the Venezuelan Andes: habitat and status of its population. *IUCN Otter Spec. Group Bull*. **18**: 86–92.

Green, R., Green, J. (1997). Otter Survey of Scotland 1991-1994. The Vincent Wildlife Trust, London.

Hamilton, G., Rochford, J. (2000). The Distribution of the Otter *Lutra lutra* in relation to Water Quality and other factors in three Hydrometric Areas in the East of Ireland. Heritage Council, Kilkenny.

IUCN. (2001). IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, U.K.

IUCN. (2012a). Guidelines for application of IUCN Red List Criteria at Regional Levels: Version 4.0. Gland, Switzerland and Cambridge, U.K. Available at https://www.iucnredlist.org/resources/categories-and-criteria.

IUCN. (2012b). IUCN Red List Categories and Criteria: Version 3.1. Second edition. Gland, Switzerland and Cambridge, U.K. Available at https://www.iucnredlist.org/resources/categories-and-criteria.

IUCN Standards and Petitions Committee. (2019). Guidelines for Using the IUCN Red List Categories and Criteria. Version 14. Prepared by the Standards and Petitions Committee. Downloadable from https://www.iucnredlist.org/resources/redlistguidelines

Lenton, E.J., Chanin, P.R.F., Jefferies, D.J. (1980). Otter Survey of England 1977-79. Nature Conservancy Council, London.

Machado, M.A. (2019). Avaliação da influência do crescimento populacional na balneabilidade da Conceição Lagoon, Florianópolis - SC (Trabalho Conclusão do Curso de Graduação em Engenharia Sanitária e Ambiental do Centro Tecnológico da Universidade Federal de Santa Catarina). Universidade Federal de Santa Catarina, Florianópolis.

Odum, H. T. (1996). Environmental accounting: Emergy and environmental decision making. New York: Wiley.

Pacifici, M., Santini, L., Marco, M.D., Baisero, D., Francucci, L., Marasini, G.G., Visconti, P., Rondinini, C. (2013). Generation length for mammals. *Nature Conservation* **5**: 89–94. https://doi.org/10.3897/natureconservation.5.5734.

Reuther, C. (2000). Surveying and Monitoring Distribution and Population Trends of the Eurasian Otter (*Lutra Lutra*): Guidelines and Evaluation of the Standard Method for Surveys as Recommended by the European Section of the IUCN/SSC Otter Specialist Group. Gruppe Naturschutz, 148 pp.

Rodrigues, L.A., Leuchtenberger, C., Kasper, C.B., Carvalho Junior, O., Silva, V.F. (2013). Avaliação do risco de extinção da Lontra Neotropical *Lontra longicaudis* (Olfers, 1818) no Brasil. *Biodiversidade Brasileira* **3**: 216–227.

SOS Mata Atlântica/INPE. (2018). Atlas dos Remanescentes Florestais da Mata Atlântica. Mapeamento dos Sistemas Costeiros. SOS Mata Atlântica/INPE, São Paulo.

Strachan, R., Jefferies, D.J. (1996). Otter Survey of England 1991- 1994: a Report on the Decline and Recovery of the Otter in England and on its Distribution, Status and Conservation in 1991- 1994. The Vincent Wildlife Trust, London.

Trinca, C.S., Waldemarin, H.F., Eizirik, E. (2007). Genetic diversity of the Neotropical otter (*Lontra longicaudis* Olfers, 1818) in Southern and Southeastern Brazil. *Brazilian Journal of Biology* **67**: 813–818. https://doi.org/10.1590/S1519-69842007000500003.

Trinca, C.S., Thoisy, B., Rosas, F.C.W., Waldemarin, H.F., Koepfli, K.P., Vianna, J.A., Eizirik, E. (2012). Phylogeography and Demographic History of the Neotropical Otter (*Lontra longicaudis*). *Journal of Heredity* **103**: 479–492. https://doi.org/10.1093/jhered/ess001.

Will, M. (2020). Transformações socioespaciais na região metropolitana de Florianópolis: o caso do município de Palhoça - SC (Dissertação de Mestrado). Universidade Federal de Santa Catarina, Florianópolis.

RÉSUMÉ

STATUT DE CONSERVATION DE LA LOUTRE À LA LONGUE QUEUE *Lontra longicaudis* (Olfers, 1818) (CARNIVORES : MUSTÉLIDÉS) DANS L'ÎLE DE SANTA CATARINA

Les loutres à longue queue (*Lontra longicaudis*) sont des mammifères semi-aquatiques classés comme «quasi menacés» par l'Union Internationale pour la Conservation de la Nature (UICN), confrontés à diverses menaces pour leur survie, telles que la fragmentation de l'habitat, la pollution de l'eau, les conflits avec les pêcheurs ou les attaques par des chiens. Un total de 9.531 épreintes a été collectées mensuellement durant 9 ans, sur une période 14 ans, de 2003 à 2017, dans 6 aires d'étude différentes sur l'île de Santa Catarina, au Brésil. Nous avons appliqué une analyse de fréquence par tests statistiques non paramétriques et un modèle de régression polynomiale. Un modèle linéaire a également été utilisé suivant les critères et normes définis par l'UICN. Les deux méthodes concordaient, montrant une diminution significative du nombre d'épreintes de loutres à longue queue durant cette période. Parce que les modifications de l'environnement ont été constantes au cours des 14 dernières années, le critère à adopter, selon la Liste rouge de l'UICN, est A2. Par conséquent, la réduction moyenne du nombre d'épreintes de loutres au cours des 14 dernières années, ou trois générations, suggère que la population est en danger critique d'extinction (CR).

RESUMEN

STATUS DE CONSERVACIÓN DE *Lontra longicaudis* (Olfers, 1818) (CARNIVORA: MUSTELIDAE) EN LA ISLA DE SANTA CATARINA

Las Nutrias neotropicales (*Lontra longicaudis*) son mamíferos semi-acuáticos clasificados como "Casi amenazados" por la Unión Internacional para la Conservación de la Naturaleza (UICN), y enfrentan varias amenazas a su supervivencia, como fragmentación del hábitat, contaminación del agua, conflictos con pescadores, o ataques por perros. Colectamos un total de 9.531 fecas, en forma mensual durante nueve años, cubriendo 14 años, desde 2003 hasta 2017, en seis diferentes áreas de estudio en la Isla de Santa Catarina, Brasil. Aplicamos análisis de frecuencias a través de tests estadísticos no-paramétricos, y un modelo de regresión polinómica. También usamos un modelo lineal, siguiendo los criterios y estándares definidos por la UICN. Ambos métodos coincidieron en mostrar un descenso significativo en el número de fecas de Nutria Neotropical a lo largo de este período. Como las modificaciones del ambiente fueron constantes durante los últimos 14 años, el criterio a ser adoptado, de acuerdo a la Lista Roja de la UICN, es el A2. Por lo tanto, la reducción promedio en el número de deposiciones de nutria a lo largo de los últimos 14 años, ó tres generaciones, sugiere que la población está críticamente amenazada (CR).

ARTICLE

DIETARY ADAPTABILITY OF THE GIANT OTTER, *Pteronura brasiliensis* (MAMMALIA: MUSTELIDAE), IN TWO FLOODPLAIN SYSTEMS IN THE PANTANAL WETLAND, MATO GROSSO STATE, BRAZIL

Júnio de Souza DAMASCENO[1,2], Júlio César DALPONTE[3,4],
Marília Couto Silva SHIRAIWA[2]

[1]Pontifícia Universidade Católica de Minas Gerais (PUC Minas), Programa de Pós-Graduação em Biologia de Vertebrados. Av. Dom José Gaspar, 500, Coração Eucarístico, CEP: 30535-901, Belo Horizonte, MG, Brazil. Corresponding author: jdamascenobh@gmail.com
[2]Universidade Federal de Mato Grosso (UFMT), Programa de Pós Graduação em Ecologia e Conservação da Biodiversidade. Av. Fernando Correa da Costa, 2367, Coxipó, CEP: 78060-900, Cuiabá, MT, Brazil
[3]Universidade Federal de Mato Grosso (UFMT), Campus de Sinop. Av. Alexandre Ferronato, 1.200, Bairro: Setor Industrial, CEP: 78550-000 – Sinop, MT, Brazil
[4]Instituto Pró-Carnívoros, Av. Horácio Netto, 1030 - Chácaras Interlagos, Atibaia - SP, 12945-010



(Received 6th July 2020, accepted 23rd February 2021)

Abstract: The giant otter, *Pteronura brasiliensis*, is an almost exclusively piscivorous mammal of the family Mustelidae, and an endangered species. The present study compared the diet of the giant otter in two floodplain systems of the Pantanal wetland, a permanent lake and a river branch, in the Poconé and Barão de Melgaço wetlands in the Brazilian state of Mato Grosso. Samples were collected during the dry seasons, with 43 spraints being collected from the lake and 31 from the river branch. The fish species present in the samples were identified based on the comparison of bone fragments found in the spraints with specimens of fish collected from the two floodplain systems. The diets were composed primarily of fish of the families Erythrinidae (94.6%), Cichlidae (91.9%), Pimelodidae (70.3%), Callichthyidae (63.5%), and Doradidae (60.8%). Catfish (Siluriformes) were more abundant in the samples from the lake, while characins (Characiformes) were well represented in the river branch. While the siluriform family Callichthyidae was a prominent component of the otter diet in both study areas, it has been rarely recorded in previous studies of *P. brasiliensis* in either the Amazon or Pantanal regions. Most of the fish recorded in the diet of the otter are not targeted by commercial fisheries in Mato Grosso. The varying characteristics of different aquatic systems are important determinants of the composition of the local fish fauna and are thus relevant to the feeding ecology of the giant otter in the Pantanal wetland.

Citation: Damasceno, J. de S., Delponte, J.C. and Shiralwa, M.C.S. (2021). Dietary Adaptability of the Giant Otter, *Pteronura brasiliensis* (Mammalia: Mustelidae), in two Floodplain Systems in the Pantanal Wetland, Mato Grosso State, Brazil. *IUCN Otter Spec. Group Bull.* **38** (4): 202 - 216

Keywords: Neotropical biodiversity, Pantanal, *Pteronura brasiliensis*, latrine, feeding ecology, ichthyofauna

INTRODUCTION

The giant otter, *Pteronura brasiliensis* (Gmelin, 1788), is a predominantly piscivorous mammal, which feeds opportunistically on the most abundant fish found near the margins of rivers and lakes (Duplaix, 1980; Schweizer, 1992; Carter and Rosas, 1997; Paglia et al., 2012; Duplaix et al., 2015). These otters rarely consume other types of prey (Cabral et al., 2010; Silva et al., 2013). Most studies of the feeding ecology of the giant otter are based on the identification and quantification of the hard parts of prey species found in spraints (Laidler, 1984; Rosas et al., 1999; Rosas-Ribeiro et al., 2012), although some direct observations have been possible (Duplaix, 1980). However, direct observation is logistically more complex and costly than fecal analysis (Carter et al., 1999).

Excessive hunting for the fur trade has had a fundamental impact on giant otter numbers (Carter and Rosas, 1997), and in 2000, the conservation status of *P. brasiliensis* was upgraded from “Vulnerable” to “Endangered” by the International Union for Conservation of Nature (Duplaix et al., 2008), and the species has remained in this category ever since (Groenendijk et al., 2015). The ongoing accumulation of human pressures and habitat loss in South America is the principal threat to this species (Groenendijk et al., 2015). Tourism and conflicts with fishers have also had an important impact on the species in the Pantanal wetland of Brazil (Rosas et al., 2008). In Brazil, *P. brasiliensis* is classified as “Vulnerable” in the Official List of Species of Brazil Threatened with Extinction (MMA, 2018).

This degree of threat reinforces the need for ecological studies that consolidate the understanding of the ecology of *P. brasiliensis* and provide an important database for the conservation of the giant otter. While the giant otter populations persist within the historical range of the species, the illegal fur trade, conflicts with fisheries, mining, the construction of dams, tourism, deforestation, and climate change have all intensified the pressures on the populations remaining in the wild (Duplaix et al. 2015).

Giant otter populations in the Pantanal wetland have been the focus of a number of important studies, including genetics and conservation (Garcia et al., 2007; Pickles et al., 2012), habitat characteristics (Camilo-Alves and Desbiez 2005), contamination by mercury (Fonseca et al., 2005), and ethology (Leuchtenberger and Mourão, 2008; Leuchtenberger et al., 2013). Schweizer (1992), Rosas et al. (1999) and Leuchtenberger et al., (2020) have provided some data on the diet of the giant otter in the southern Pantanal, but systematic studies of the species’ diet and other aspects of its ecology in the northern Pantanal are scarce. In addition, the relative contribution of lakes and creeks to the diet of *P. brasiliensis* has been poorly documented, not only in the Pantanal, but also in other regions.

The present study compares the diets of *P. brasiliensis* in two different types of aquatic system that are common in the northern Pantanal wetland in the state of Mato Grosso, Brazil. One type of system is the permanent lakes, known locally as “*baías*”, while the other is branches of rivers, known as “*corixos*”. The study analyzes differences between these systems in the taxonomic composition of the *P. brasiliensis* diet in these two systems during the dry season. The data were also compared with those collected in previous studies of the diet of giant otters in the Amazon regions (Cabral et al., 2010); Rosas-Ribeiro et al., 2012; Silva et al., 2013) and Pantanal (Rosas et al., 1999; Leuchtenberger et al., 2020).

MATERIAL AND METHODS

Study area

The present study was conducted in the northern Pantanal, in the southwestern extreme of the Brazilian state of Mato Grosso, which covers a total area of 147,574 km^2 of wetland habitats, formed by the Paraguay River and its tributaries (15º30'–22º30' S, 54º45'–58º30' W). The Pantanal encompasses an enormous diversity of riparian habitats and forest fragments that are flooded either permanently or over the course of the annual flood cycle (Alho et al., 2008). The drainage capacity of the floodplain is greatly reduced, with water accumulating in depressions, forming lakes (*baías*) or being flooded permanently. During the flood period, the water flows slowly through channels known locally as "*corixos*" or along shallow runoffs, known as "*vazantes*" (Alho and Sabino 2012).

The annual flood pulse of the Pantanal floodplain is the principal driver of changes in the composition of the local fish communities, with a high level of species turnover occurring between the flood and dry seasons. This marked temporal gradient in the hydrological cycle provokes a large-scale response in the local fish communities to the annual flood pulse (Pains da Silva et al., 2010).

The study was conducted in two distinct types of habitat, a permanent lake and a river branch. While small drainage channels or river branches (*corixos*) persist on the floodplain during the dry season, connecting rivers and lakes, in general, the permanent lakes (*baías*) only receive an inflow of water during the flood season and remain isolated from other bodies of water in the dry season (Nunes da Cunha and Junk, 2004).

Baía das Pedras (16º24'36.7" S, 56º21'08.6" W) is one of the lakes found in a locality known as Pirizal, in the Poconé wetland, in the municipality of Nossa Senhora do Livramento. This lake is connected to the Piraim River, a right-margin tributary of the Cuiabá River, during the flood season, when it receives an increased load of organic matter, which has a considerable impact on the structure of the ecosystem (Nogueira et al., 2002). Baía das Pedras Lake has a surface area of 2.08 ha and a perimeter of 10,750 m, with a maximum depth of 6.2 m, mean depth of 1.04 m, maximum effective width of 100 m, and maximum effective length of 274 m (Nogueira et al., 2002).

The *Corixo* Espírito Santo is part of the SESC Private Natural Heritage Reserve, which, in turn, is located within the SESC–Pantanal Ecological Station (16–17º S, 56–57º W), with a total area of 106,588 ha, located in the northern Pantanal wetland (Antas et al., 2011). The length of this *corixo* is regulated by the flood pulse. In the dry season of 2002, the *corixo* had a length of 13 kilometers (16º31' S, 56º17' W to 16º34' S, 56º21' W), with two small branches of one kilometer in length (16º33'53" S, 56º20' W and 16º33' S, 56º20' W). This *corixo* is 100–200 m wide during the dry season, with gently sloping margins covered predominantly by dense arboreal and shrubby vegetation. In some stretches, there are sandy beaches and flat sandbanks covered with grass as far as the waterline (Figure 1).

A giant otter group has been observed in Baía das Pedras Lake (Pinho, JB., personal communication). In addition, recent sightings of active giant otter dens and individuals have been found in Corixo Espírito Santo (Neves, C.C. personnal communication), and thus they are relevent to conservation of *P. brasiliensis* in the Pantanal This biome has been affected by progressive loss of natural habitat through deforestation and fires. More than 20,000 fire alerts were registered in 2020; three times the historical average (1998-2020) (INPE, 2020). From 1988 to 2019, Mato Grosso state had already deforested 146,140 km^2 of natural habitat (Shimabukuro et al., 2020), a lost natural cover area equivalent to Pantanal along the last 30 years.

The vegetation cover of the study area is predominantly savannah, with diverse phytophysiognomies in both floodable and non-flooded areas. The fauna is diverse and abundant and includes a number of endangered species (Alho et al., 2019). The flood-pulse reflects the cycle of rainy and dry seasons typical of the Pantanal wetland (Ivory et al., 2019). Therefore, extreme climatic events (Thielen et al., 2020) and conversion of natural ecosystems (Colman et al. 2019) are altering patterns of the hydrological and sediment dynamics, disrupting local ecology and the socioeconomic relationships of the basin (Schulz et al., 2019). Two larger rivers, the Cuiabá River and the São Lourenço River, are found in the marginal areas of the Natural Heritage Private Reserve (Antas et al., 2016).

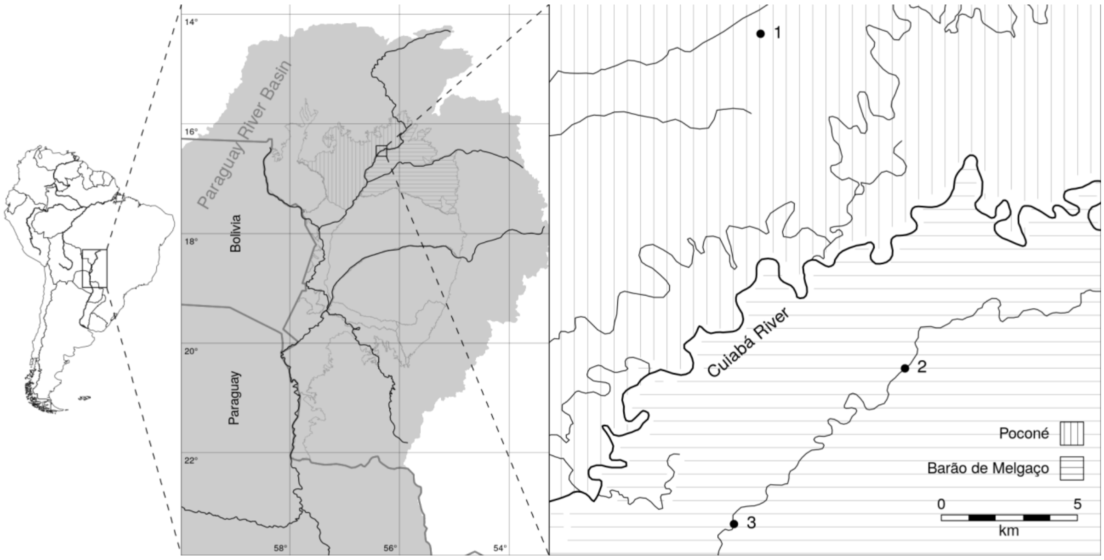

Figure 1. Map of the study area showing the subdivisions of the Pantanal and location of the study localities at Baía das Pedras (1), in the Pantanal of Poconé, and *Corixo* Espírito Santo (2 e 3), in the Pantanal of Barão de Melgaço. Source: Adapted from Silva and Abdon, (1998).

Spraint collection and analysis

The diet of the giant otter was compared between sites based on the analysis of spraints collected from otter latrines during the dry seasons (July to December) of 2002 and 2003. Each sample was placed in a numbered plastic bag, and then washed and dried for the identification of the components (animal fragments), following Rosas et al. (1999). Only fresh spraints, recognized by their characteristic color and odor, were collected, with a total of 74 samples being accumulated over the study period.

In Baía das Pedras Lake spraints were collected from a group of eight giant otters (four adults and four cubs) in four communal latrines. In *Corixo* Espírito Santo spraints were collected from groups, being a group of eight individuals (five adults and three cubs) and other group consisted five adult individuals from 14 giant otter communal latrines.

The fragments of fish found in the spraints were sorted and analyzed, with the species being identified using taxonomic keys (Britski et al., 1999), comparisons with fish specimens collected from the study area, and consultation with specialists.

The fragments analyzed for identification were divided into five types of structure: scales, opercula, mandibles, vertebrae, and miscellaneous bone structures (vertebrae, skull and fin bones, and carapaces). The molluscs (*Pomacea*) were identified from their carapaces, and the crustaceans from their appendages (Magalhães, 2000). Only fragments longer than 1 cm were considered, in order to minimize the probability of overestimating the number of items present in each sample. The fragments of fish bones identified in this analysis were deposited in a reference collection at the vertebrate collection of the Bioscience Institute of the Federal University of Mato Grosso in Cuiabá (Brazil).

The percentage of occurrence of each prey group was determined for all the spraints. A contingency table (*G* test) was used to test the hypothesis that the composition of the diet (prey categories) is independent of the environment (lake *vs.* river branch). The *G* test, with Williams' correction (Zar, 1996), was chosen for this analysis because some cells of the contingency table had expected frequencies of 5 or less. This procedure was complemented with an analysis of the residuals, to determine the probabilistic contribution of each cell (i.e., the prey categories).

The frequencies of items of the three orders of fish (Characiformes, Siluriformes and Perciformes) found in the spraints collected in the present study were also compared with the corresponding frequencies recorded in the Amazon (Rosas et al., 1999; Cabral et al., 2010; Rosas-Ribeiro et al., 2012; Silva et al., 2013) and Pantanal regions (Rosas et al., 1999; Leuchtenberger et al., 2020). This analysis was also based on the *G* test, as described above following a calculate *p*-value partitioning chi-square test. The analyses were run in BioEstat 5.0 (Ayres et al., 2007).

RESULTS

Seventy-four giant otter spraints (43 from Baía das Pedras Lake and 31 from the *Corixo* Espírito Santo) were analyzed here (Table 1). In both areas, the diet was composed of fish, crustaceans, and molluscs. Fish were present in 100% of the samples at both sites. Crustaceans were found in four samples (9.3%) from Baía das Pedras, and molluscs were found in nine samples (20.9%). At *Corixo* Espírito Santo, crustaceans and molluscs were each found in only a single sample (3.2%).

The five most frequent families of fish recorded at both sites were the Erythrinidae (found in 94.6% of the spraints), Cichlidae (91.9%), Pimelodidae (70.3%), Callicthyidae (63.5%), and Doradidae (60.8%). The contributions of the different taxa to the otter diet varied between sites, however. At Baía das Pedras, three fish orders (Characiformes, Siluriformes and Perciformes) were recorded in the spraints. In the case of the Characiformes, the family Erythrinidae, represented primarily by *Hoplias malabaricus* (Bloch, 1794), was present in 95.3% of the samples, followed by the family Serrasalmidae (67.4%). The order Siluriformes was well represented by three families, the Callicthyidae (97.7% of the samples), Doradidae (95.3%), and Pimelodidae (93.0%), while the order Perciformes was represented only by the family Cichlidae, which was present in 100% of the samples and was the most frequent prey category in the Baía das Pedras samples.

At *Corixo* Espírito Santo, characiforms were recorded in all 31 samples and this order was represented primarily by the family Erythrinidae (93.5% of the samples), followed by the Serrasalmidae (48.4%). In contrast with Baía das Pedras, siluriforms were present in only 54.8% of the samples, with pimelodids being found in 38.7%. of the spraints, while the Doradidae and Callicthyidae were each present in 12.9% of the samples. The only perciform family recorded at this site was the Cichlidae, present in 25 samples (80.6%).

Table 1. Frequency of the different food items identified in the spraints of the giant otter (*P. brasiliensis*) collected from a lake, Baía das Pedras (BPS), and river branch, *Corixo* Espírito Santo (CES), in the SESC-Pantanal Natural Heritage Private Reserve in the Pantanal wetland, Mato Grosso state, Brazil, during the dry seasons of 2002 and 2003. The classification and nomenclature of the fish are based on Britski et al., (1999). In parenthesis the percentage of spraints containing each item.

Food item	BPS 43 (x%)	CES 31 (x%)
Fish		
Characiformes		
Characidae	1 (2.3)	1 (3.2)
Bryconinae	1 (2.3)	1 (3.2)
Triportheinae	-	2 (6.4)
Cynopotaminae	-	3(9.7)
Characinae	-	1 (3.2)
Acestrorhychinae	3 (7.0)	3 (9.7)
Serrasalmidae	29 (67.4)	15 (48.4)
Prochilodontidae	-	1 (3.2)
Curimatidae	1 (2.3)	2 (6.4)
Anostomidae	1 (2.3)	1 (3.2)
Erythrinidae	41 (95.3)	29 (93.5)
Siluriformes		
Pimelodidae	40 (93.0)	12 (38.7)
Auchenipteridae	19 (44.2)	-
Doradidae	41 (95.3)	4 (12.9)
Callicthyidae	42 (97.7)	4 (12.9)
Loricariidae	26 (60.5)	1 (3.2)
Perciformes		
Cichlidae	43 (100.0)	25 (80.6)
Crustaceans		
Trichodactylidae	4 (9.3)	1 (3.2)
Molluscs		
Ampullaridae	9 (20.9)	1 (3.2)

Significant differences were found between the lake and *corixo* in the numbers of the principal items found in the spraints (*G* test, 14 x 2 contingency table; $G = 52.919$; $P < 0.0001$). The results of the residual analysis indicate that the spraints from the lake had a higher frequency of siluriforms and relatively lower frequency of perciforms and erythrinids (Characiformes) than the *corixo* (Table 2). The frequencies of the other characiforms were similar at the two sites (Table 3).

In the inter-study comparison, characiforms were commonly found in all eight study areas, being present more than 77 percent of the spraints analyzed. Perciforms were also common in the present study, and at Xixuaú Creek, Balbina reservoir, Jaú National Park and in the Corumbá Pantanal, although this order was relatively uncommon in the samples from the Aquidauana River and Juruá River. The differences among sites were highly significant (*G* test 3 x 8 contingency table; $G = 191.5082$;

P<0.0001). The spraints from Baia das Pedras had proportionally more siluriforms than those from all the other study areas (residuals significant at *P*<0.01). By contrast, *Corixo* Espirito Santo had a significantly lower proportion of siluriforms than others Pantanal regions (residuals significant at *P*<0.05).

Table 2. Results of the residual analysis of the comparison of the individual contributions of each type of prey to the diet of the giant otter between the two study between two environments (lake *vs.* river branch) in the Pantanal wetland, Mato Grosso, Brazil.

Item			Residual		*p*	Conclusion
			Lake	River Branch		
Fish	Characiformes	Characidae	-1.435	1.435	ns	Lake = River branch
		Serrasalmidae	-1.499	1.499	ns	Lake = River branch
		Prochilodontidae	-1.740	1.740	ns	Lake = River branch
		Curimatidae	-1.681	1.681	ns	Lake = River branch
		Anostomidae	-0.824	0.824	ns	Lake = River branch
		Erythrinidae	**-3.529**	**3.529**	**	**Lake < River branch**
	Siluriformes	Pimelodidae	0.322	-0.322	ns	Lake = River branch
		Auchenipteridae	**2.570**	**-2.570**	*	**Lake > River branch**
		Doradidae	**2.634**	**-2.634**	**	**Lake > River branch**
		Callichthyidae	**2.699**	**-2.699**	**	**Lake > River branch**
		Loricaridae	**2.635**	**-2.635**	**	**Lake > River branch**
	Perciformes	**Cichlidae**	**-2.491**	**2.491**	*	**Lake < River branch**
Crustaceans		Trichodactylidae	**0.254**	**-0.254**	**ns**	Lake = River branch
Molluscs		Ampullaridae	**1.102**	**-1.102**	**ns**	Lake = River branch

Significant results are highlighted in bold script: $P< 0.05$* = residual ≥ 1.96; $P< 0.01$** = residual ≥ 2.576; ns (non-significant = residual < 1.96.

Table 3. Frequency of occurrence (number of times a prey item was recorded in the spraints) of the three principal orders of fish consumed by the giant otter (*Pteronura brasiliensis*) at eight Brazilian study localities: Baía das Pedras and *Corixo* Espírito Santo (present study); Xixuaú Creek and Aquidauana River (Rosas et al. 1999), Balbina reservoir (Cabral et al., 2010); Juruá River (Rosas-Ribeiro, et al., 2012), the PARNA Jaú (Silva et al., 2013) and Corumbá Pantanal (Leuchtenberger et al., 2020). The percentage of spraints containing each item is shown in parentheses.

Site	**Taxonomic order of fish**			**Study**
	Characiformes	**Perciformes**	**Siluriformes**	
Xixuaú Cove (RR)	32 (100)	36 (97.3)	2 (20.0)	Rosas et al., (1999)
Aquidauana River (MS)	6 (100)	4 (33.3)	2 (66.6)	Rosas et al., (1999)
Balbina Dam (AM)	197 (77.5)	236 (92.9)	16 (6.3)	Cabral et al., (2010)
Juruá River (AM)	92 (86.6)	25 (23.6)	31 (29.1)	Rosas-Ribeiro et al., (2012)
Jaú National Park (AM)	69 (84.1)	75 (91.5)	18 (22.0)	Silva et al., (2013)
Corumbá Pantanal (MS)	136 (100)	126 (92.9)	97 (71.4)	Leuchtenberger et al. (2020)
Corixo Espírito Santo (MT)	29 (95.3)	25 (80.6)	12 (38.7)	Present study
Baía das Pedras Lake (MT)	41 (95.3)	43 (100)	42 (97.7)	Present study

The chi-square analysis showed that Baía das Pedras Lake and the *Corix*o Espírito Santo are significantly distinct to Characiformes and Siluriformes order (χ^2 = 17.1301; *P*<0.0001). We also observed statistically significant findings on the relationship among the order of fish and other studies in the Pantanal region (χ^2 = 24.4962; *P*<0.0001). In the integrated data analysis for all studies in the Amazon and Pantanal regions, there was variation in frequency of occurrence of taxonomic orders with highly significant chi-square value (χ^2 = 174.4825; *P*<0.0001).

DISCUSSION

The results of the present study on two floodplain systems of Pantanal (lake and river branch) indicate that fish is the main source of food for the giant otter, as reported in the previous study of Carter and Rosas (1997), Silva et al. (2013) and Leuchtenberger et al. (2020). The analyses also confirmed the occasional predation of crustaceans and molluscs (Rosas et al., 2008; Silva et al., 2013; Leuchtenberger et al., 2020).

As in previous studies (Duplaix, 1980; Schweizer, 1992; Rosas et al., 1999; Cabral et al., 2010; Silva et al., 2013; Leuchtenberger et al., 2020), the findings of the present study indicate that the diet of the *P. brasiliensis* populations is composed primarily of fish belonging to the orders Characiformes, Perciformes, and Siluriformes. Cichlids were the principal category of prey at Baía das Pedras, while erythrinids predominated at *Corixo* Espírito Santo. Previous studies have also emphasized the importance of the erythrinid genus *Hoplias* (Duplaix, 1980; Laidler, 1984; Schweizer, 1992; Cabral et al., 2010; Rosas-Ribeiro et al., 2012; Silva et al., 2013; Becerra-Cardona et al., 2015; Trujillo et al., 2015, Leuchtenberger et al., 2020) and cichlids (Laidler, 1984; Rosas et al., 1999; Cabral et al., 2010; Silva et al., 2013; Trujillo et al., 2015, Leuchtenberger et al., 2020) in the diet of the giant otter.

The principal difference in the prey categories between Baía das Pedras and *Corixo* Espírito Santo was the greater frequency of the siluriform families Auchenipteridae, Callicthyidae, Doradidae and Loricariidae in the former environment. Siluriforms are nocturnal and seek refuge on the bottom or in crevices during the day (Kirchheim and Goulart, 2010), although Britski et al. (1999) found that many species are active during the day, especially in turbid waters.

The turbidity of the water has differential effects on the abundance of different fish groups, with the abundance of siluriforms and gymnotiforms increasing in more turbid waters, whereas characiforms and cichlids are more common in more transparent water (Castro et al., 2018). Fish species with sensorial adaptions for conditions of reduced luminosity will tend to predominate in more turbid waters, while visually-oriented species will be more dominant in clearer water, which benefit their foraging strategies (Rodríguez and Lewis Jr., 1997; Kirchheim and Goulart, 2010). At Baía das Pedras, the more restricted lacustrine environment is associated with the accumulation of feces and decomposition of organic matter derived from the high density of fish, waterbirds, and caiman, *Caiman yacare* (Daudin, 1802) (Nogueira et al., 2002), what connected to an exacerbated decline in the level of the water over the course of the dry season, contribute to the turbidity of the aquatic environment and may be driven the differences observed in the giant otter diet between the different floodplain systems.

Although relatively common in the Pantanal, callichthyids were not consumed frequently at *Corixo* Espírito Santo (12.4%). On the other hand, this group of fish has been found in 50% of the spraints collected from Corumbá Pantanal (Leuchtenberger et al., 2020) and was the second most common fish family from Baía das Pedras (97.7%). The different habitat characteristics probably influenced the occurrence of callicthyids between *Corixo* Espírito Santo and Baía das Pedras. However, it is difficult to determine, from the fecal analyses, to what extent feeding preferences or specializations, or the relative availability of prey, influence the composition of the giant otter diet (Rosas et al., 1999), in particular considering that callicthyids are much less common (Rosas-Ribeiro et al., 2012; Silva et al., 2013) or even absent (Cabral et al., 2010) from the giant otter diet in some Amazonian environments. The sedentary and slow swimming behavior of the callicthyids (Britski et al., 1999), associated with the unique rocky substrates of the Baía das Pedras site (Nogueira et al. 2002), may facilitate the capture of these fish at this site, in contrast with the conditions found at the *Corixo* Espírito Santo. Overall, then, the relative importance of callicthyids in the diet of the giant otters in the present study, in comparison with other localities, may reflect the greater availability of these fish in the shallower parts of the Baía das Pedras, a scenario reinforced by the limnological intensification of the water turbidity during the dry season. More detailed studies will be required to determine the depletion of the availability of other prey taxa in this habitat.

The tendency for an increase in the consumption of loricariid catfish with the intensification of the dry season at Baía das Pedras, may be related to the predominance in this lake of limnophilic taxa, which are tolerant of low oxygen concentrations, and are forced to retreat into remnant pools as the water level decreases during the dry season (Junk et al., 2006). It is important to note that, during the dry season, isolated habitats become increasingly subject to distinct selective pressures that exacerbate the heterogeneity of the remaining aquatic habitats (Thomaz et al., 2007). The morphological differences found in distinct fish species permit their differential exploitation of both feeding resources and physical habitats, which permits the coexistence of the different species (Agostinho et al., 2007; Shibatta et al., 2007). The fish species composition may also vary among the different phases of the flood pulse, depending on the duration and intensity of the hydrological cycle (Alho et al., 2008).

The variation in the frequency of occurrence of the fish of the three principal study orders (Characiformes, Siluriformes, and Perciformes) among the different Brazilian sites (Baía das Pedras, *Corixo* Espírito Santo, Aquidauana River, Xixuaú Creek, Balbina reservoir, Juruá River and the Jaú National Park) may reflect differences in the availability of these prey groups in the different habitats, in particular where lotic and lentic systems favor the predominance of distinct groups of fish. The seasonal variation in the limnological conditions found in different aquatic environments may also influence the diversity and abundance of fish species, with the conditions prevailing in specific habitats favoring certain fish groups (Castro et al., 2018). The composition of the fish community may also vary seasonally, depending on the duration and intensity of the flood pulse (Alho et al., 2008).

The giant otter will also adapt to the local availability of fish, and its food sources typically correspond to both the relative abundance of different fish taxa and their behavioral characteristics.

The fish families that were most common in the giant otter spraints collected in the present study (Erythrinidae, Cichlidae, Pimelodidae, Callicthyidae, and Doradidae) contrast broadly with the principal families exploited the commercial fishing in Mato Grosso, that is, the Pimelodidae, Characidae, Prochilodontidae, and Anostomidae (Mateus et al., 2004; Catella et al., 2008).

The results of the present study indicate that the distinct characteristics of the environment at Baía das Pedras and *Corixo* Espírito Santo may have a significant influence on the otter diet, even within a local area and during the same period, which reinforces the considerable adaptability and versatility of the giant otter under varying environmental conditions. The diversity and abundance of fish species is also influenced by the flood pulse, which determines the availability of habitats favorable for foraging, feeding, and taking shelter (Moura and Val, 2019). In this context, seasonal oscillations in hydrological conditions derived from human activities, such as hydroelectric dams, the modification of river channels or climate change, may also impact the patterns of fish abundance and diversity, by reducing conditions favorable for the local ichthyofauna (Leite et al., 2018).

The adaptability of giant otters to extreme seasonal and environmental conditions reflects the ecological flexibility of *P. brasiliensis*, although Duplaix et al. (2015) concluded that giant otters prefer aquatic environments with more transparent water, which favors their visually-oriented foraging behavior. This means that, *a priori*, they will normally avoid environments with more turbid waters, which may nevertheless be exploited as a seasonal alternative.

In the Pantanal, fishery resources are fundamental components of the ecosystem and its genetic heritage, while also providing important sources of subsistence and income for the local human population, as well as supporting sports fishing activities and the trade in ornamental fish (Alho and Sabino, 2012). These multiple interests imply that humans and giant otters are potential competitors (Leuchtenberger et al., 2020), even though little evidence of direct interactions between fishers and otters was found in the present study. However, giant otters do consume some species that are important subsistence resources (*Hoplias malabaricus*) and will adapt to the availability of different species in a given environment or period, and may, in particular, target bait fish in some areas, overlapping with local economic interests. While commercial and sports fisheries are selective of their target species, the negative impact of these activities on fish stocks is a conservation concern (Junk et al., 2006), and will accentuate the potential threats to the conservation of the giant otter in the Pantanal, which is already under pressure from cattle ranching, the construction of hydroelectric dams, the expansion of the agricultural frontier in the Cerrado, the contamination of aquatic systems, and climate change.

The current occurrence of the giant otters that encompasses the area of study demonstrates the importance of local habitat features as present in the Baía das Pedras Lake and *Corixo* Espírito Santo for conservation of *Pteronura brasiliensis* in the Pantanal biome, particularly in perceived face threat scenario related to deforestation, fires and change of extreme events in regional climate.

ACKNOWLEDGMENTS - The authors are grateful to the researchers Dr. Mário de Pinna of the Ichthyology Sector at the USP Zoology Museum, Dr. Mauro Triques of the Ichthyology Laboratory at UFMG, Dr. Francisco Langeani Neto of the Ichthyology Laboratory at UNESP and Dr. Rosenil Oliveira of the vertebrate collection at the UFMT Biosciences Institute, who provided invaluable input for the fish taxa. We are also grateful to Dr. Adriano Chiarello for his contributions to the manuscript. The authors are also grateful to the Brazilian funding agencies, the Coordination for Higher Education Personnel Training (CAPES), for a graduate stipend, the National Council for Scientific and Technological Development (CNPq), PELD/CNPq site 12 Pantanal Norte Project for funding the present study and the Natural Heritage Private Reserve of SESC Pantanal (RPPN SESC Pantanal) for logistics support and fieldwork related research. The authors wish to express particular thanks to Assis Rondon for invaluable contribution in the field and to Dr. João Batista de Pinho (PPG-ECB/UFMT) and Cristina Cuiabália Neves (SESC Pantanal) for news information about giant otters.

REFERENCES

Agostinho, A.A., Pelicice, F.M., Petry, A.C., Gomes, L.C., Júlio Jr., H.F. (2007). Fish diversity in the upper Paraná River basin: habitats, fisheries, management and conservation. *Aquat. Ecosyst. Health.* **10(2)**: 174–186

Alho, C.J.R. (2008). Biodiversity of the Pantanal: response to seasonal flooding regime and to environmental degradation. *Braz. J. Biol.* **68(4, Suppl.)**: 957–966.

Alho, C.J.R., Sabino, J. (2012). Seasonal Pantanal Flood Pulse: Implications for Biodiversity Conservation – A Review. *Oecol. Aust.* **16(4)**: 958–978.

Alho, C.J.R., Mamede, S.B., Benites, M., Andrade, B.S., Sepúlveda, J.J.O. (2019). Ameaças à Biodiversidade do Pantanal Brasileiro pelo Uso e Ocupação da Terra. *Ambient. Soc.*, **22**: e01891.

Antas, P.T.Z., Oliveira, L.F.B., Pádua, M.T.J., Pereira, N.C., Vanutky, W.W. (2011). *Plano de Manejo da Reserva Particular do Patrimônio Natural do SESC Pantanal* (Conhecendo o Pantanal 3) / Brandão, L.G. (Coordenação); 2. ed. Rio de Janeiro : SESC, Departamento Nacional, 2011. 148 p.

Antas, P.T.Z.; Carrara, L.A.; Ubaid, F.K.; Oliveira Júnior, S.B. & Ferreira, L.P. (2016). *Aves coloniais das praias da Reserva Particular Natural SESC Pantanal*. (Conhecendo o Pantanal 10). Rio de Janeiro: SESC, Departamento Nacional, 2016. 236p.

Ayres, M., Ayres Jr., M., Ayres, D.L., Santos, A.A.S. (2007). *BioEstat 5.0*: Aplicações Estatísticas nas Áreas das Ciências Bio-Médicas. Sociedade Civil Mamirauá; Belém/PA, Brasil. 364p.

Baginski, L.J., Florentino, A.C., Fernandes, I.M., Penha, J.M.F., Mateus, L.A.F.M. (2007). A dimensão espacial e temporal da diversidade de peixes da zona litoral vegetada de lagoas marginais da planície de inundação do rio Cuiabá, Pantanal, Brasil. *Biota Neotrop.* **7(3)**: 233–238.

Becerra-Cardona, M.P., Mallea-Cárdenas, H.A. and Van Damme, P.A. (2015). The use of premaxillary bones of six fish species in giant otter (*Pteronura brasiliensis*) diet analysis. *LATAM* **10(2)**: 131–142.

Britski, H.A. Keve, Z.S.S., Lopes, B.S. (1999). *Peixes do Pantanal*. Manual de Identificação. Brasília/DF: Embrapa-SPI; Corumbá/MS: Embrapa-CPAP. 184p.

Cabral, M.M.M., Zuanon, J., Mattos, G.E., Rosas, F.C.W. (2010). Feeding habits of Giant Otters *Pteronura brasiliensis* (Carnívora: Mustelidae) in the Balbina Hydroelectric Reservoir, Central Brazilian Amazon. *Zoologia* **27(1)**: 47–53.

Camilo-Alves, C. & Desbiez, A. (2005) The Use Of A Natural Cave For Breeding By Giant Otters In The Brazilian Pantanal: Observations And New Insights On Giant Otter Behavior. *IUCN Otter Spec. Group Bull*. **18**(1): 21 – 24

Carter, S.K., Rosas, F.C.W. (1997). Biology and conservation of the giant otter, *Pteronura brasiliensis*. *Mammal Rev.* **27(1)**: 1–26.

Carter, S.K., Rosas, F.C.W., Cooper, 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. *Aquat. Mamm.* **25(2)**: 79–90.

Castro, R.J., Henry, R., Ferragut, C., Casartelli, M. (2018). Comparing lacustrine environments: the importance of the kind of habitat on the structure of fishes. *Acta Limnol. Bras.* **30**: e303.

Catella, A.C., Mascarenhas, R.O., Albuquerque, S.P., Albuquerque, F.F., Theodoro, E.R.M. (2008). Sistemas de estatísticas pesqueiras no Pantanal, Brasil: aspectos técnicos e políticos. *Panam. J. Aquat. Sci.* **3(3)**: 174–192.

Colman, C.B., Oliveira, P.T.S., Almagro, A., Soares-Filho, B.S., Rodrigues (2019). Effects of Climate and Land-Cover Changes on Soil Erosion in Brazilian Pantanal. Sustainability, **11**: 7053.

Duplaix, N. (1980). Observations on the ecology and behaviour of the giant river otter *Pteronura brasiliensis* in Suriname. *Rev. Ecol. - Terre Vie* **34**: 495–620.

Duplaix, N., Waldemarin, H.F., Groenekijk, J., Evangelista, E., Munis, M., Valesco, V., Botello, J.C. (2008). *Pteronura brasiliensis*. In: IUCN 2011. *IUCN Red List of Threatened Species*. Version 2011.2. <www.iucnredlist.org>. DOI https://dx.doi.org/10.2305/IUCN.UK.2015-2.RLTS.T18711A21938411.en. Downloaded on 25 May 2012.

Duplaix, N., Evangelista, E., Rosas, F.C.W. (2015). Advances in the study of giant otter (*Pteronura brasiliensis*) ecology, behavior, and conservation: a review. *LAJAM* 10(2): 75–98.

Fernandes, A.H.B.M., Catella, A.C.,Soriano, B.M.A., Urbanetz, C., Cardoso, E.L., Fernandes, F.A., Bergier, I., Comastri, J.A., Salis, S.M., Tomas, W.M. (2019). BIOMA PANTANAL: oportunidades e desafios de pesquisa para o desenvolvimento sustentável. In: **Vilela, E.F., Callegaro, G.M., Fernandes, G.W.** Biomas e agricultura. Edition: 1, Chapter 6. Publisher: Vertente Edições pp. 99-121.

FIOCRUZ (2020). Incêndios Florestais no Pantanal 2020. Fundação Oswaldo Cruz (Ministério da Saúde) Nota Técnica **01**: 1– 11. (Accessed: 16 Feb 21) https://agencia.fiocruz.br/sites/agencia.fiocruz.br/files/u34/nt_01_pantanal_final1.pdf

Fonseca, F.R.D., Malm, O., Waldemarin (2005). Mercury levels in tissues of Giant otters (*Pteronura brasiliensis*) from the Rio Negro, Pantanal, Brazil. *Environ. Res.* **98**: 368–371.

Garcia, D.M., Marmontel, M., Rosas, F.C.W., Santos, F.R. (2007). Conservation genetics of the giant otter (*Pteronura brasiliensis*) (Zimmermann, 1780) (Carnivora, Mustelidae). *Braz. J. Biol.* **67(4, Suppl.)**: 819–827.

Gómez, J.R., Jorgenson, J.P. (1999). An Overview to the Giant Otter – Fisherman Problem in the Orinoco Basin of Colômbia. *IUCN Otter Spec. Group Bull.* **16(2)**: 90–96.

Groenendijk, J., Duplaix, N., Marmontel, M., Van Damme, P. & Schenck, C. (2015). *Pteronura brasiliensis*. The IUCN Red List of Threatened Species 2015: e.T18711A21938411. https://dx.doi.org/10.2305/IUCN.UK.2015-2.RLTS.T18711A21938411.en Downloaded on 02 September 2021.

INPE (2020). Monitoramento dos Focos Ativos por Bioma (Queimadas). Programa Queimadas – Instituto Nacional de Pesquisas Espaciais. (Accessed: 16 Feb 21) http://queimadas.dgi.inpe.br/queimadas/portal-static/estatisticas_estados.

Ivory, S.J., McGlue, M.M., Spera, S., Silva, A., Bergier, I. (2019). Vegetation, rainfall, and pulsing hydrology in the Pantanal, the world's largest tropical wetland. *Environ. Res. Lett.* **14**: 124017.

Junk, W.J., Cunha, C.N., Wantzen, K.M., Petermann, P., Strüssmann, C., Marques, M.I., Adis, J. (2006). Biodiversity and its conservation in the Pantanal of Mato Grosso, Brazil. *Aquat. Sci.* **68**: 278–309.

Kirchheim, P.D.; Goulart, E. (2010). Ecomorfologia de Predação e Antipredação em Siluriformes (Osteichthyes). *Oecol. Aust.* **14(2)**: 550–568.

Laidler, P.E. (1984). *The Behavioural Ecology of the Giant Otter in Guyana*. Dissertation for the Degree of Doctor of Philosophy. University of Cambridge. 296p.

Leite, G.F.M., Rezende, R.S., Silva, H.P., Muniz, C.C. (2018). Effects of Flood Pulse on the Community of Loricariidae (Pisces, Siluriformes) in Oxbow Lakes of the Pantanal, Brazil. *Bol. Inst. Pesca* **44(1)**: 35–43.

Leuchtenberger, C., Mourão, G. (2008). Social Organization and Territoriality of Giant Otters (Carnivora: Mustelidae) in a Seasonally Flooded Savana in Brazil. *Sociobiology* **52(2)**: 257–270.

Leuchtenberger, C., Oliveira-Santos, G.R., Magnusson, W., Mourão, G. (2013). Space use by giant otter groups in the Brazilian Pantanal. *J. Mammal.* **94(2)**: 320–330.

Leuchtenberger, C., Rheigantz, M.L., Zucco, C.A., Catella, A.C., Magnusson W.E., Mourão, G. (2020). Giant otter diet differs between habitats and from fisheries offtake in a large Neotropical floodplain. *J. Mammal.*, **101(6)**:1650–1659.

Magalhães, C. (2000). *Caracterização da comunidade de crustáceos Decápodos do Pantanal*. Mato Grosso do Sul. RAP, 2000. P. 175–182 (Boletim de Avaliação Biológicas).

MMA (2018). *Livro Vermelho da Fauna Brasileira Ameaçada de Extinção*: Volume II – Mamíferos / 1. ed. Brasília, DF : ICMBio/MMA (Ministério do Meio Ambiente), 2018. (622 p.)

Mateus, L.A.F., Penha, J.M.F., Petrere, M. (2004). Fishing resources in the rio Cuiabá basin, Pantanal do Mato Grosso, Brazil. *Neotrop. Ichthyol.*, **2(4)**: 217–227.

Moura, N.A., Val, A.L. (2019). Migração Lateral de Peixes e a Vulnerabilidade da Baía do Chacororé. Pantanal de Barão de Melgaço, Mato Grosso, Brasil. *Rev. Biol. Neotrop. / J. Neotrop. Biol.* **16(1)**: 1–8.

Nogueira, F., Silva, R.L. Silva, A.J. Souza, M.D., Bachega, I. (2002). Seasonal and diel limnological differences in a tropical floodplain lake (Pantanal of Mato Grosso, Brazil). *Acta Limnol. Bras.* **14(3)**: 17–25.

Nunes da Cunha, C., Junk, W.J. (2004). Year-to-year changes in water level drive the invasion of *Vochysia divergens* in Pantanal grasslands. *Appl. Veg. Sci.* **7**: 103–110.

Paglia, A.P., Fonseca, G.A.B., Rylands, A.B., Herrmann, G., Aguiar, L.M.S., Chiarello, A.G., Leite, Y.L.R., Costa, L.P., Siciliano, S., Kierulff, M.C.M., Mendes, S.L., Tavares, V.C., Mittermeier, R.A., Patton, J.L. (2012). *Lista Anotada dos Mamíferos do Brasil / Annotated Checklist of Brazilian Mammals*. 2ª Edição / 2nd Edition. Occasional Papers in Conservation Biology, No. 6. Conservation International, Arlington, VA. 76p.

Pains da Silva, H., Petry, A.C., da Silva, C.J. (2010). Fish communities of the Pantanal wetland in Brazil: evaluating the effects of the upper Paraguay river flood pulse on baı´a Caic¸ara fish fauna. *Aquat Ecol.* **44**: 275–288.

Pickles, R.S.A., Groombridge, J.J., Zambrana-Rojas, V.D., Van Damme, P., Gottelli, D., Ariani, C.V., Jordan, W.C. (2012). Genetic diversity and population structure in the endangered giant otter, *Pteronura brasiliensis*. *Conserv. Genet.* **13**: 235–245.

Rodriguez, M.A., Lewis Junior, W.M. (1997). Structure of fish assemblages along environmental gradients in floodplain lakes of the Orinoco River. *Ecol. Monogr.* **67(1)**: 109–128.

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.

Rosas, F.C.W., Waldemarin, H.F., de Mattos, G.E. (2008). *Ariranha, Pteronura brasiliensis (Zimmermann, 1780)*. In: **Machado, A.B.M., Drummond, G.M. and Paglia, A.P.** (Eds). Livro Vermelho da Fauna Brasileira Ameaçada de Extinção. Belo Horizonte, MMA, Fundação Biodiversitas, p. 800–801. 1420p.

Rosas-Ribeiro, P.F., Rosas, F.C.W., Zuanon, J.A.S. (2012). Conflict between fishermen and giant otters *Pteronura brasiliensis* in Western Brazilian Amazon. *Biotropica*. **44**: 437–444.

Schulz, C., Whitney, B.S., Rosseto, O.C., Neves, D.M., Crabb, L., Oliveira, E.C., Lima, P.L.T., Afzal, M., Laing, A.F., Fernandes, L.C.S., Silva, C.A., Steinke, V.A., Steinke, E.T., Saito, C.H. (2019). Physical, ecological and human dimensions of environmental change in Brazil's Pantanal wetland: Synthesis and research agenda. *Sci. Total Environ.* **687**: 1011–1027.

Schweizer, J. (1992). *Ariranhas no Pantanal. Ecologia e Comportamento da Pteronura brasiliensis*. Editora Brasil Natureza (EDIBRAN), Curitiba, Brasil. 200p.

Shibatta, O.A., Gealh, A.M., Bennemann, S.T. (2007). Ichthyofauna from the middle and upper stretches of rio Tibagi basin, Paraná, Brazil. *Biota Neotrop.* **7(2)**: 125–134.

Shimabukuro, Y.E., Dutra, A.C., Arai, E., Duarte, V., Cassol, H.L.G., Pereira, G., Cardozo, F.S. (2020). Mapping Burned Areas of Mato Grosso State Brazilian Amazon Using Multisensor Datasets. *Remote Sens.* **12**: 3827.

Silva, R.E., Rosas, F.C.W., Zuanon, J. (2013). Feeding ecology of the giant otter (*Pteronura brasiliensis*) and the Neotropical otter (*Lontra longicaudis*) in Jaú National Park, Amazon, Brazil, *J. Nat. Hist.* **48(7-8)**: 465–479.

Silva, J.S.V., Abdon, M.M. (1998). Delimitação do Pantanal Brasileiro e suas sub-regiões. *Pesqui. Agropecu. Bras.* **33**: 1703–1711.

Silva-Junior, C.A., Teodoro, P.E., Delgado, R.C., Teodoro, L.P.R., Lima, M., Pantaleão, A.A., Baio, F.H.R., Azevedo, G.B., Azevedo, G.T.O.S., Capristo-Silva, G.F., Arvor, D., Facco, C.U. (2020). Persistent fire foci in all biomes undermine the Paris Agreement. in Brazil. *Sci Rep* **10**: 16246.

Tejerina-Garro, F.L.,; Fortin, R., Rodriguez, M.A. (1998). Fish Community structure in relation to environmental variation in floodplain lakes of the Araguaia river, Amazon Basin. *Env. Biol. Fishes* **51(4)**: 399–410.

Thielen, D, Schuchmann, K-L., Ramoni-Perazzi, P., Marquez, M., Rojas, W., Quintero, J.I., Marques, M.I. (2020). Quo vadis Pantanal? Expected precipitation extremes and drought dynamics from changing sea surface temperature. *PLoS ONE* **15(1)**: e0227437. https://doi.org/10.1371/journal.pone.0227437

Thomaz, S.M., Bini, L.M., Bozelli, R.L. (2007). Floods increase similarity among aquatic habitats in river-floodplain systems. *Hydrobiologia* **579**: 1–13

Trujillo, F., Caro, A., Martínez, S., Rodríguez-Maldonado, M.V. (2015). Negative interactions between giant otters (*Pteronura brasiliensis*) and local fisheries in the Amazon and Orinoco basins in Colombia. *LATAM* **10(2)**: 122–130.

Zar, J.H. (1996). *Biostatistical Analysis*. 3ª ed. Prentice Hall International. New Jersey.

RÉSUMÉ

ADAPTABILITÉ ALIMENTAIRE DE LA LOUTRE GÉANTE, *Pteronura brasiliensis,* (MAMMIFÈRES: MUSTÉLIDÉS), DANS DEUX RESEAUX DE PLAINES INONDABLES DE LA ZONE HUMIDE DU PANTANAL, DANS L'ÉTAT DU MATO GROSSO, AU BRÉSIL

La loutre géante, *Pteronura brasiliensis*, est un mammifère presque exclusivement piscivore de la famille des Mustélidés, et une espèce en voie de disparition. La présente étude compare le régime alimentaire de la loutre géante dans deux réseaux de plaines inondables de la zone humide du Pantanal, un lac permanent et un méandre de la rivière, dans les zones humides de Poconé et Barão de Melgaço dans l'État brésilien du Mato Grosso. Des échantillons ont été collectés pendant la saison sèche, avec 43 épreintes prélevées dans le lac et 31 dans le méandre de la rivière. Les espèces de poissons présentes dans les échantillons ont été identifiées sur base de la comparaison de fragments d'os trouvés dans les épreintes avec des spécimens de poissons collectés dans les deux réseaux de plaines inondables. Les régimes alimentaires étaient composés principalement de poissons des familles d'Erythrinidés (94,6%), de Cichlidés (91,9%), de Pimelodidés (70,3%), de Callichthyidés (63,5%), et de Doradidés (60,8%). Les poissons-chats (Siluriformes) étaient plus abondants dans les échantillons du lac, tandis que les characins (Characiformes) étaient bien représentés dans le méandre de la rivière. Alors que la famille des Callichthyidés (siluriformes) était une composante importante du régime alimentaire des loutres dans les deux zones d'étude, elle a rarement été signalée dans des études antérieures sur *P. brasiliensis* dans les régions de l'Amazone ou du Pantanal. La plupart des poissons signalés dans le régime alimentaire de la loutre ne sont pas ciblés par les pêcheries commerciales du Mato Grosso. Les caractéristiques variables des différents systèmes aquatiques sont des déterminants importants de la composition de la faune piscicole locale et sont donc pertinentes pour l'écologie alimentaire de la loutre géante dans la zone humide du Pantanal.

RESUMEN

ADAPTIBILIDAD DIETARIA DE LA NUTRIA GIGANTE, *Pteronura brasiliensis* (MAMMALIA: MUSTELIDAE), EN DOS SISTEMAS DE PLANICIES DE INUNDACIÓN EN EL PANTANAL, ESTADO DE MATOGROSSO, BRASIL

La Nutria Gigante, *Pteronura brasiliensis*, es un mamífero casi exclusivamente piscívoro de la Familia Mustelidae, y una especie en peligro de extinción. El presente estudio comparó la dieta de las nutrias gigantes en dos sistemas de planicies inundables del Pantanal, un lago permanente y un brazo del rio, en los humedales Poconé y Barão de Melgaço, en el estado brasileño de Mato Grosso. Las muestras se recolectaron durante las estaciones secas, con 43 heces recolectadas del lago y 31 del brazo del río. Las especies de peces en las muestras de heces se identificaron en base a la comparación de fragmentos de huesos con los especímenes de peces recolectados en los dos sistemas de planicies de inundación. Las dietas estuvieron compuestas principalmente por peces de la familia Erythrinidae (94.6%), Cichlidae (91.9%), Pimelodidae (70.3%), Callichthyidae (63.5%) y Doradidae (60.8%). Los bagres (Siluriformes) fueron más abundantes en las muestras del lago, mientras que los Characiformes estaban bien representados en el brazo del río. Si bien la família Callichthyidae fue un componente destacado de la dieta de las nutrias gigantes en las dos áreas de estudio, rara vez se había registrado en estudios previos de *P. brasiliensis* en las regiones de la Amazonia o del Pantanal. La mayoría de los peces registrados en la dieta no son de interés de las pesquerías comerciales en Mato Grosso. Las distintas características de los diferentes sistemas acuáticos son importantes determinantes de la composición de la fauna íctica local y, por lo tanto, son relevantes para la ecología alimentaria de las nutrias gigantes en el Pantanal.

RESUMO

ADAPTABILIDADE NA DIETA DE ARIRANHAS, *Pteronura brasiliensis* (MAMMALIA: MUSTELIDAE), EM DOIS SISTEMAS DA PLANÍCIE DE INUNDAÇÃO DO PANTANAL, MATO GROSSO, BRASIL

A ariranha, *Pteronura brasiliensis*, é um mamífero quase exclusivamente piscívoro da Família Mustelidae e uma espécie em perigo de extinção. O presente estudo comparou a dieta das ariranhas em dois sistemas hídricos da planície inundável do Pantanal, uma lagoa permanente (baía) e um canal de rio (corixo), nos pantanais de Poconé e Barão de Melgaço, no estado de Mato Grosso. As amostras foram coletadas durante a estação de seca, com 43 fezes sendo registradas na baía e 31 no corixo. As espécies de peixes nos restos fecais foram identificadas com base na comparação de fragmentos ósseos dos espécimes de peixes coletados nos sistemas pantaneiros. As dietas foram representadas principalmente por peixes das famílias Erythrinidae (94.6%), Cichlidae (91.9%), Pimelodidae (70.3%), Callichthyidae (63.5%) e Doradidae (60.8%). Os Siluriformes foram mais abundantes nas amostras da baía, enquanto os Characiformes mais representados no corixo. A família Callichthyidae foi um item importante na dieta das ariranhas nas áreas de estudo, especialmente na baía, apesar de raramente ser registrada em outros estudos na região Amazônica e do Pantanal. A maioria dos peixes registrados na dieta das ariranhas não é alvo da pesca comercial no Mato Grosso. As distintas características dos sistemas aquáticos são importantes determinantes da composição da ictiofauna local e, portanto, relevantes para ecologia alimentar das ariranhas na planície do Pantanal.

REPORT

HABITAT USE BY THE EURASIAN OTTER (*Lutra lutra* LINNAEUS 1758) IN A NON-PROTECTED AREA OF MADHYA PRADESH, INDIA

Rahul TALEGAONKAR[1], Saloni SALARIA[1], Dhirendra BHARGAVA[2], Jyotirmay JENA[1], Snehit Kumar RAHUL[1], Aniruddha DHAMORIKAR[1], Pranav CHANCHANI[1]

[1]WWF-India, 172 B Lodi Estate, New Delhi 110 003, India. Email: rtalegaonkar@wwfindia.net
[2]Madhya Pradesh Forest Department, Bhopal 462 004, India.







(Received 24th November 2020, accepted 25rd February 2021)

Abstract: Eurasian otter is one of the three otters found in India. In Central India, it was recently photo-captured in Balaghat district. We studied habitat use of Eurasian otters (*Lutra lutra*) by sampling 57 stream segments along the Wainganga River and Uskal stream in a reserve (non-protected) forest of Balaghat Forest Division in the months of March-April 2018 using sign surveys. We used an occupancy-based approach to determine the influence of habitat covariates on otter occupancy. Bank substrate had a significant positive impact on detection probability of otters. The probability of habitat use by otters strongly decreased as the bank width increased. Future studies should focus to better understand the impact of human activities on the distribution, demography, and behaviour of otters.

Citation: Talegaonkar, R., Salaria, S., Bhargava, D., Jena, J., Rahul, S.K., Dhamorikar, A. and Chanchani, P. (2021). Habitat Use by the Eurasian Otter (*Lutra lutra* Linnaeus 1758) in a Non-Protected Area of Madhya Pradesh, India. *IUCN Otter Spec. Group Bull.* **38** (4): 217 - 227

Keywords: *Lutra lutra*, habitat use modeling, Central India, riverine ecosystem

INTRODUCTION

India is home to three species of otters - the Smooth-coated (*Lutrogale perspicillata*), the Asian small-clawed (*Aonyx cinerea*), and the Eurasian otter (*Lutra lutra*). The Smooth-coated otter is distributed throughout the country, but the other two were known to be restricted to the Himalayas, north of the Ganges and southern India. They were considered to be absent from Central India (Pocock, 1939; Hussain and Choudhury, 1997; Prater, 1971; Foster-Turley and Santiapillai, 1990; Hussain, 1993, 2012), but the Eurasian otter was historically present (Low, 1907). It was recently reported in Satpuda Tiger Reserve (Joshi et al., 2016) and Balaghat Forest Circle (Jena et al., 2016) in Madhya Pradesh. Also, the Asian small-clawed otter was reported in Odisha, Eastern India (Mohapatra et al., 2014). Otters are primarily threatened by habitat loss through resource exploitation such as sand mining, overfishing, as well as infrastructure development including river damming, bank concretization, and diversion (Roos et al., 2015).

Otters are adapted for a semiaquatic life (Pocock, 1939; Prater, 1971) and are a shy and elusive species. They are usually found along rivers, streams, hill creeks, and wetlands with adequate bank-side vegetation, and require cavities among tree roots, pile of rocks, wood and debris, and holes in riverbank for shelter and breeding (Menon, 2009; Hussain, 2012). In Scotland, Kruuk et al. (1993) observed that otters preferred streams with higher fish biomass and that the fish biomass decreased exponentially with the stream width.

The Eurasian otter is a large otter with a coarse, dusky brown coat that looks shaggy when dry and bedraggled when wet, but never as smooth as the smooth-coated otter (Menon, 2009). It often bears spots on its lips and nose, and the rhinarium is naked and black, with a W-shaped upper margin. The tail is conical and long, over half the head and body length. The five toes have strong claws and webbing extending to the end of the digit (*ibid*). The Eurasian otter has been well-studied in Europe (Chanin, 1985; Mason and Macdonald, 1986), but its ecology in Asia lacks detailed studies (Foster-Turley and Santiapillai, 1990). Here we study the drivers that influence the occurrence of Eurasian otter in a riverine ecosystem amidst a mixed-deciduous and sal (*Shorea robusta*) dominated forest of Central India, in the state of Madhya Pradesh. We predict that (i) wider river banks are likely associated with lower otter habitat use as they are easily accessible to predators and also provide less complex habitats for denning; (ii) higher standard deviation of river width is likely associated with high otter use as it provides greater habitat complexity; (iii) and the presence of human activities such as fishing and sand mining negatively affect the otter habitat use.

MATERIALS AND METHODS

Study area

Our study area includes four forest ranges of North and South Balaghat Forest Divisions – North Lamta, South Lamta, Logour, and Balaghat (Figure 1). The area is approximately 963 km^2 and is characterized by mixed dry deciduous and sal-dominated forests. Several perennial streams, including Uskal, a major tributary of the Wainganga, flows through it. The Wainganga River flows to North to South, with the Uskal stream joining the Wainganga in South Lamta Range. Two reservoirs, one built on the Wainganga River in Dhuti, and another in Gangulpara, supplies water for small-scale non-monsoonal farming. The landscape mainly comprises hills, tablelands and plains, and serves as a connecting corridor between Kanha and Pench tiger reserves. The highest point is at 818 m asl in Balaghat Range and decreases gradually at 298 m asl towards west. According to the 2018 All India Tiger Estimation (Jhala et.al., 2020) 21 tigers were identified in North and South Forest Divisions.

There are 35 villages within four ranges surveyed, with a density of 13.4 persons per km^2. Since this is a territorial forest area primarily managed for timber extraction and forestry operations, livestock grazing is permitted in areas where active forestry management is not being undertaken, and collection of dry wood as fuel and NTFP is permitted.

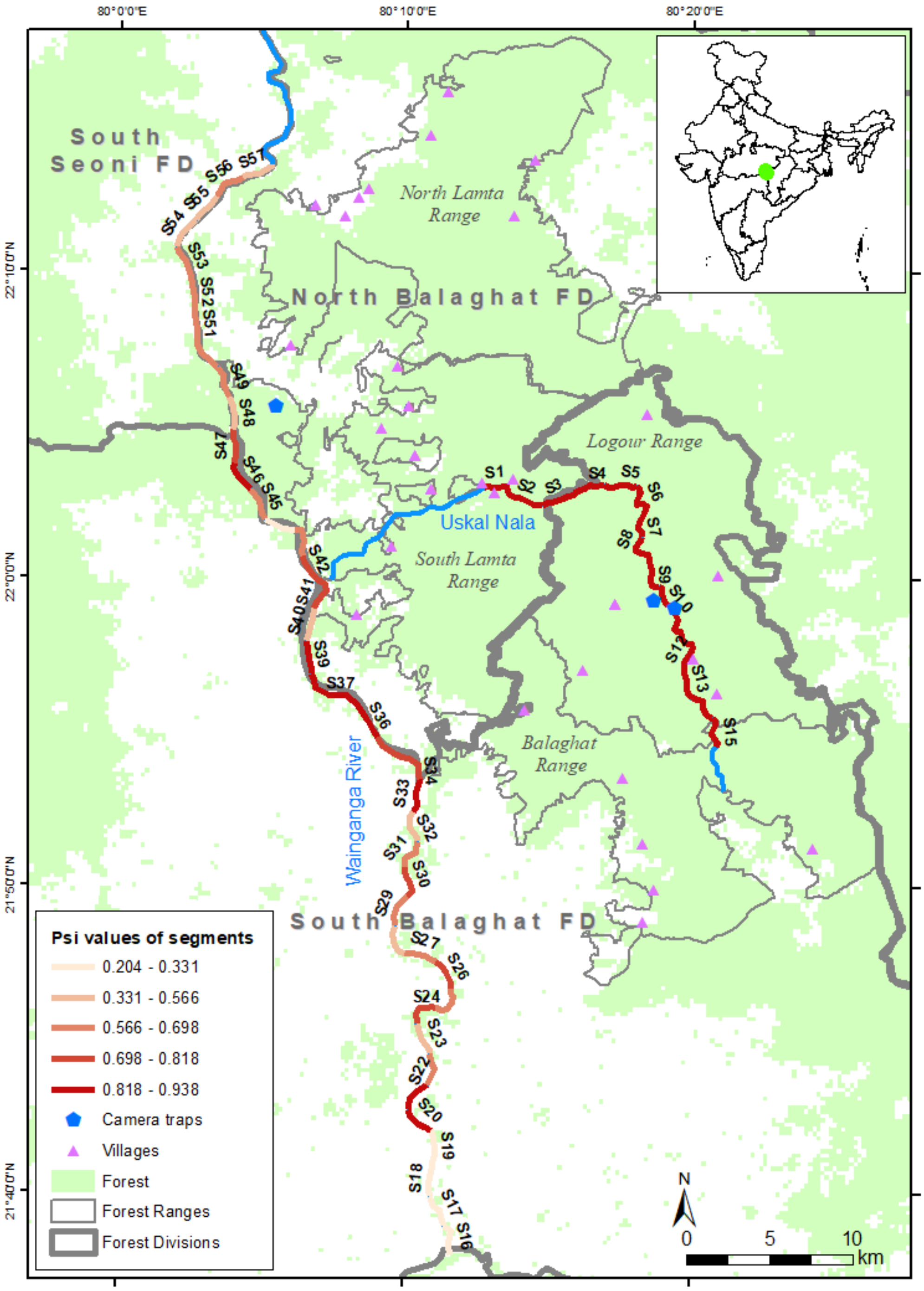

Figure 1. Map of the surveyed waterways in North and South Balaghat Forest Divisions of Madhya Pradesh, India. The probability of habitat use (*Ψ*) of Eurasian otter is also shown here as derived from our top model (Ψ(BnkWid) θ(.) θ'(.) p(BnkSub)).

Methodology

We conducted sign surveys along 45 km of the Uskal stream and 75 km of the Wainganga river during March-April 2018 (Figure 1). We identified the species and the survey areas based on the camera traps deployed during the study for large carnivores in Balaghat, and information from the locals and the Madhya Pradesh Forest Department. We defined our sampling units by 57 two-kilometre-long sections along these two drainages based on previous studies by Erlinge (1968) and Kruuk (1995). Replication was spatial, rather than temporal, with detection (1) – non detection (0) data being collected along 400 m segments within each of the 57 sampling units (Perinchery et al., 2011; Charbonnel et al., 2014). Surveys were conducted between 0800 hrs and 1200 hrs. Both sides of the banks were thoroughly searched on foot to record signs of spraints, pugmarks, and holts (otter dens) by the same group of observers for all the surveys. In addition to data on otter sign detection, information was collected on six individual covariates - river width, bank width, presence/indication of fishing and sand mining, bank substrate, and bank vegetation - to assess their impact on the otter habitat use (Table 1). We checked for multicollinearity and found no correlation between our covariates.

Table 1. Covariates collected along the sampled units and their expected influence on *p* and *Ψ*.

Covariate	Description	Mean and range of covariate values	Expected influence on *p* and *Ψ*
Bank substrate	Estimated as proportion of segments with sandy or muddy substratum	0.42 (0-1)	*p* (+)*
Bank cover	Estimated as proportion of segments that had vegetation cover (bushes) within a sampling unit	0.07 (0-1)	*p* (-)
Bank width	Average bank width in meters	85.60 m (15-200 m)	*p* (-) and *Ψ* (-)
River/ stream width	Standard deviation of river/stream width in meters	7.49 m (0.76-38.4 m)	*Ψ* (+)
Fishing	Estimated as proportion of segments that had signs of fishing within a sampling unit	0.06 (0-1)	*Ψ* (-)
Sand mining	Estimated as proportion of segments that had signs of sand mining within a sampling unit	0.01 (0-1)	*Ψ* (-)

** spraints will be detectable on all substratum*

Given that data collected along linear features like streams are likely to be spatially autocorrelated (species use of one segment is not independent of use of previous segments), we analyzed our data using a model that accounts for spatial clustering of the response variable, following Hines et al. (2010) model in program MARK (ver. 9.0, White and Burnham, 1999). This model has four parameters: *Ψ* (psi) - the probability that the segment is occupied by the species, p - the probability of detecting the species, and θ and θ' - the probabilities of habitat use of a segment given the non-use and use of the previous segment. In our analysis, we used a two-step approach to model parameters of interest. We first began by modelling the effect of bank substrate, bank width and bank cover on detection probability p, while retaining a global covariate structure for *Ψ* (Bank width+River/ stream width+Fishing+Sand mining) (Table 2). Then using the best supported model structure for p, we assessed the influence of covariates on habitat use Ψ (Table 3). Model support was evaluated using AIC (Burnham and Anderson, 2002).

Table 2. Model selection results for alternative parameterizations of detection probability as a function of covariates. A global structure was held for Ψ.

Model	AICc	AICwt	Model Likelihood	k	-2log(L)
Ψ(BnkWid+RivWid+Fishing+SndMng) θ(.) θ'(.) p(BnkSub)	275.57	0.46	1.00	9	253.74
Ψ(BnkWid+RivWid+Fishing+SndMngj) θ(.) θ'(.) p(BnkSub+BnkWid)	276.87	0.24	0.52	10	252.09
Ψ(BnkWid+RivWid+Fishing+SndMng) θ(.) θ'(.) p(BnkSub+BnkCov)	277.15	0.21	0.46	10	252.37
Ψ(BnkWid+RivWid+Fishing+SndMng) θ(.) θ'(.) p(BnkSub+BnkWid+BnkCov)	278.88	0.09	0.19	11	251.02
Ψ(BnkWid+RivWid+Fishing+SndMng) θ(.) θ'(.) p(BnkWid)	293.56	0.00006	0.0001	9	271.73
Ψ(BnkWid+RivWid+Fishing+SndMng) θ(.) θ'(.) p(BnkWid+BnkCov)	294.84	0.00003	0.0001	10	270.06
Ψ(BnkWid+RivWid+Fishing+SndMng) θ(.) θ'(.) p(BnkCov)	302.61	0.00	0.00	9	280.78
Ψ(BnkWid+RivWid+Fishing+SndMng) θ(.) θ'(.) p(.)	302.70	0.00	0.00	8	283.70

k = number of parameters; BnkWid = average bank width; RivWid = standard deviation of river/ stream width; SndMng = sand mining; BnkCov = bank cover; BnkSub = bank substrate

RESULTS

We surveyed a total of 120 km of riverbank edges along Uskal and Wainganga. We detected otter signs in 35 of the 57 sampling units and 108 of the 285 (400 m) segments. The naïve estimate of otter occurrence was 0.61.

Our analysis to determine the effect of bank substrate, bank width, and bank cover on detection probability revealed that only bank substrate had a significant positive impact on detection probability of otters (Table 2, Figure 2a). The detection was much better in the sandy and muddy substratum.

Given that model weights were distributed across several models for Ψ; we report model averaged estimates for all parameters. The model averaged estimate for Ψ was 0.77 ± 0.11 (CI 0.49 - 0.92)). We found evidence for strong spatial autocorrelation in segment-level otter presence. Otter occurrence probability on segments was low 0.25 ± 0.30 (CI 0.02 - 0.88) when the previous segment was not used θ, and several orders of magnitude higher when the previous segment was also used (θ' = 0.98 ± 0.03 (CI 0.74 - 0.99)) and p was 0.57 ± 0.06 (CI 0.45 - 0.68)).

Among the various models for estimating habitat use, the best model included bank width (Table 3). Estimates of β indicated that the probability of use by otters strongly decreased as the bank width increased (Figure 2b). The estimated Ψ values of the sampled segments are reported in Table 4. Other than bank width, covariates in the model did not have significant influence on otter habitat use.

Table 3. Model selection results for *Ψ* as a function of covariates, and associated coefficient estimates.

Model	AICc	AICwt	k	-2log(L)	Estimated β (SE)			
					BnkWid	***RivWid***	***Fishing***	***SndMng***
Ψ(BnkWid) θ(.) θ'(.) p(BnkSub)	267.93	0.42	6	254.25	-0.02 (0.008)			
Ψ(RivWid+BnkWid) θ(.) θ'(.) p(BnkSub)	270.19	0.14	7	253.90	-0.02 (0.008)	-0.03 (0.05)		
Ψ(Fishing+BnkWid) θ(.) θ'(.) p(BnkSub)	270.46	0.12	7	254.17	-0.02 (0.008)		-0.65 (2.28)	
Ψ(SndMng+BnkWid) θ(.) θ'(.) p(BnkSub)	270.47	0.12	7	254.18	-0.02 (0.008)			-0.48 (1.80)
Ψ(RivWid+SndMng+BnkWid) θ(.) θ'(.) p(BnkSub)	272.77	0.04	8	253.77	-0.01 (0.009)		-0.03 (0.05)	-0.71 (1.81)
Ψ(RivWid+Fishing+BnkWid) θ(.) θ'(.) p(BnkSub)	272.89	0.04	8	253.89	-0.02 (0.008)	-0.03 (0.05)	-0.27 (2.33)	
Ψ(Fishing+SndMng+BnkWid) θ(.) θ'(.) p(BnkSub)	273.08	0.03	8	254.08	-0.02 (0.008)		-0.73 (2.28)	-0.55 (1.81)
Ψ(.) θ(.) θ'(.) p(BnkSub)	273.30	0.03	5	262.13				
Ψ(RivWid) θ(.) θ'(.) p(BnkSub)	273.90	0.02	6	260.22		-0.08 (0.05)		
Ψ(SndMng) θ(.) θ'(.) p(BnkSub)	274.46	0.02	6	260.78				-2.98 (4.28)
Ψ(RivWid+SndMng) θ(.) θ'(.) p(BnkSub)	275.13	0.01	7	258.85		-0.07 (0.05)		-2.36 (1.68)
Ψ(RivWid+Fishing+SndMng+BnkWid) θ(.) θ'(.) p(BnkSub)	275.57	0.01	9	253.74	-0.01 (0.009)	-0.03 (0.05)	-0.34 (2.32)	-0.73 (1.82)
Ψ(RivWid+Fishing) θ(.) θ'(.) p(BnkSub)	276.26	0.01	7	259.97		-0.07 (0.06)	-1.51 (2.95)	
Ψ(RivWid+Fishing+SndMng) θ(.) θ'(.) p(BnkSub)	277.50	0.00	8	258.50		-0.07 (0.05)	-1.54 (2.54)	-2.48 (1.77)

k = number of parameters; BnkWid = average bank width; RivWid = standard deviation of river/ stream width; SndMng = sand mining; BnkCov = bank cover; BnkSub = bank substrate

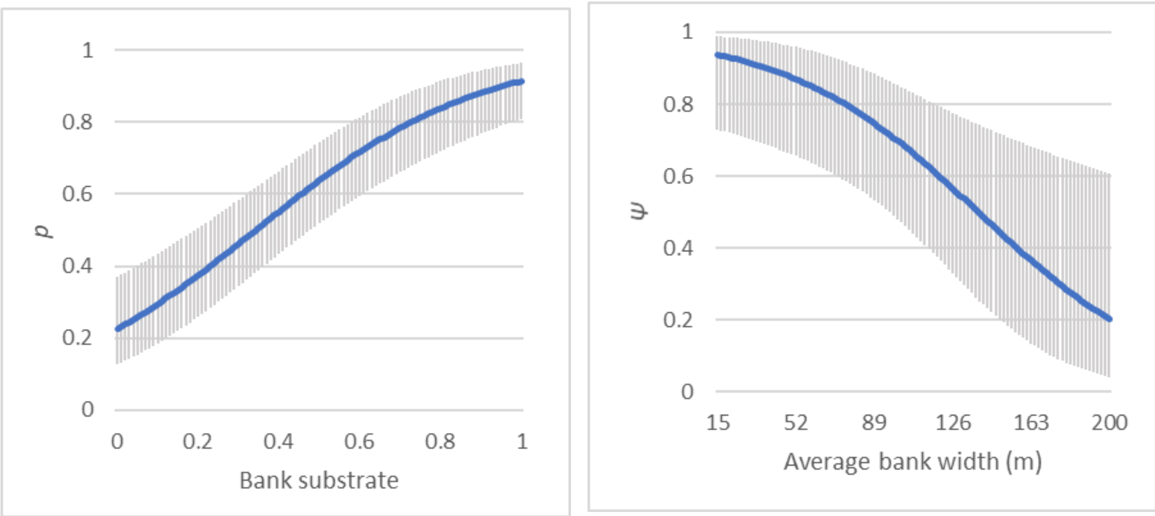

Figure 2. (a) Relationship between bank substrate and detection probability, and (b) relationship between habitat use along the bank width. Dashed lines represent 95% confidence intervals.

Table 4. Estimates of *Ψ* for each sampling unit as derived from the top model (Ψ(BnkWid) θ(.) θ'(.) p(BnkSub)).

Sampling Unit	*Ψ*	SE	LCI	UCI
S1	0.931	0.054	0.721	0.986
S2	0.938	0.051	0.729	0.988
S3	0.933	0.053	0.724	0.987
S4	0.920	0.058	0.709	0.982
S5	0.920	0.058	0.709	0.982
S6	0.927	0.056	0.716	0.984
S7	0.917	0.059	0.705	0.981
S8	0.917	0.059	0.705	0.981
S9	0.912	0.061	0.699	0.979
S10	0.897	0.066	0.683	0.972
S11	0.927	0.056	0.716	0.984
S12	0.912	0.061	0.699	0.979
S13	0.897	0.066	0.683	0.972
S14	0.888	0.068	0.674	0.968
S15	0.895	0.066	0.681	0.971
S16	0.903	0.064	0.689	0.975
S17	0.901	0.065	0.687	0.974
S18	0.907	0.063	0.693	0.977
S19	0.932	0.054	0.723	0.986
S20	0.914	0.061	0.701	0.980
S21	0.875	0.071	0.661	0.961
S22	0.698	0.099	0.480	0.853
S23	0.566	0.122	0.329	0.776
S24	0.814	0.082	0.602	0.927
S25	0.660	0.105	0.437	0.829
S26	0.717	0.096	0.501	0.865

S27	0.650	0.107	0.426	0.823
S28	0.501	0.135	0.257	0.743
S29	0.609	0.114	0.378	0.799
S30	0.734	0.093	0.520	0.876
S31	0.609	0.114	0.378	0.799
S32	0.545	0.127	0.305	0.765
S33	0.854	0.076	0.640	0.950
S34	0.751	0.091	0.537	0.887
S35	0.783	0.087	0.570	0.907
S36	0.284	0.158	0.080	0.646
S37	0.204	0.149	0.041	0.606
S38	0.331	0.158	0.109	0.667
S39	0.284	0.158	0.080	0.646
S40	0.451	0.144	0.208	0.720
S41	0.730	0.094	0.515	0.873
S42	0.738	0.093	0.524	0.879
S43	0.619	0.112	0.390	0.805
S44	0.303	0.159	0.090	0.655
S45	0.698	0.099	0.480	0.853
S46	0.865	0.074	0.651	0.956
S47	0.818	0.082	0.605	0.929
S48	0.451	0.144	0.208	0.720
S49	0.609	0.114	0.378	0.799
S50	0.588	0.118	0.354	0.788
S51	0.670	0.103	0.448	0.835
S52	0.650	0.107	0.426	0.823
S53	0.670	0.103	0.448	0.835
S54	0.523	0.131	0.281	0.754
S55	0.545	0.127	0.305	0.765
S56	0.650	0.107	0.426	0.823
S57	0.512	0.133	0.269	0.749

DISCUSSION

Eurasian otters prefer upstream habitat along rivers, hill creeks and streams with adequate bank-side vegetation as shelter and to breed (Menon, 2009; Hussain, 2012). Most of their behavioural observations are restricted to the Himalaya and the foothills. We show that Eurasian otters in Central India also prefer similar habitats to feed, rest, and breed. The first district gazetteer of Balaghat (Low, 1907) considered this species to be “found in all parts of the District in rivers and nalhas”. It is likely that this species has faced a significant decline in populations in Central India, particularly in Balaghat district in the 20th century. Their habitat specificity, elusive nature, and low population has limited their presence to a few drainages within forests, and they are infrequently detected. This species was reported in Central India in 2016 at Satpuda Tiger Reserve (Joshi et al., 2016) and Balaghat (Jena et al., 2016) during camera trapping surveys for large carnivores.

Our surveys aimed at understanding the occurrence of Eurasian otters along two important drainages within Balaghat. While a variety of habitat features and human disturbance covariates were expected to influence otter habitat use, most covariates we used were associated with considerable uncertainty. However, the strong inverse relationship between bank width and otter habitat use is informative. Eurasian otters being shy and elusive animals prefer areas which have narrow bank width, minimizing distance between them and river pools where they forage and meet other life history needs, but importantly where they may also find cover from terrestrial predators. Moreover, areas associated with narrower banks were usually rockier and more rugged, offering more complex habitats that offered cover, while areas with wider banks were sandy and exposed. Our study corroborates the findings of other study on Eurasian otters in India (Hussain, 2012).

Given that Balaghat Forest Divisions are a Reserve Forest, it is subjected to several management practices such as selective felling. It also accommodates fuel, fodder and forest produce needs of various local communities. Fishing for household consumption, livestock grazing, and small-scale sand extraction for household use are all permitted in certain areas. We did not find any discernible relationships between local fishing and local sand mining on otter habitat use, possibly because these activities are dispersed, occur at low intensities and were measured imperfectly by using simple indices. Local fishing is non-commercial, restricted to narrow river-ways, ideally in and around rocky areas, which are also the preferred habitats of the Eurasian otters, so more work is needed to understand potential impacts on otter populations, den sites, and also assess the attitudes of fisherfolk towards otters. On the other hand, sand mining is restricted to sandy riverbanks especially where the bank-width is quite broad, and likely has little effect on otter habitat use. Further studies need to be undertaken to better understand the impact of human activities on the distribution, demography and behaviour of otters.

Because Eurasian otter rely on fish as a primary source of food (Hussain, 2012), fishing in the dry season by humans may have impacts that are not evident in other seasons. In some locations of the study area such as the Uskal stream, we were informed of people using ichthyotoxic plants to harvest fish. This type of fishing kills all the fishes in the puddles which are then harvested, suggesting competition for a food source during the dry season. Interactions with local fishing groups revealed that they have observed the otters in areas where they fish, and on occasion the otters have destroyed the fishing nets laid overnight. However, we were informed that the damage is easily repaired and that there is no retaliation by local communities, suggesting that otter presence is tolerated in the region.

We recommend forest rivers be given priority for conservation, the tree cover along rivers exempt from coupe felling, and the critical otter habitats be identified and regularly monitored. We also recommend additional studies on otter behaviour, abundance, and population estimation to develop conservation interventions. Further studies also need to be undertaken to determine the subspecies through genetic sampling from otter spraints. Although humans and otters are sharing the same food source and habitat, understanding the interplay of this interaction in cultural, natural, and historic context is crucial to integrate communities as stewards of otter conservation.

Acknowledgments - The authors would like to thank the Madhya Pradesh Forest Department and the Balaghat Forest Circle for their support and permission to conduct this study. Priya Poonia and Upendra Dubey for helping with the fieldwork. Thanks are also due to Dr. Dipankar Ghose, Dr. Sejal Worah, and Soumen Dey for their support through WWF-India.

REFERENCES

Chanin, P. (1985). The natural history of otters. *Croom Helm*, London: 1- 179.

Charbonnel, A., D'Amico, F., Besnard, A., Blanc, F., Buisson, L., Némoz, M. and Laffaille, P. (2014). Spatial replicates as an alternative to temporal replicates for occupancy modelling when surveys are based on linear features of the landscape. *J. of Applied Ecology*, **51**(5): 1425-1433. https://doi.org/10.1111/1365-2664.12301

Burnham, K.P., Anderson, D.R. (2002). *Model selection and multimodel inference: A practical information-theoretic approach* (2nd ed.). Springer, New York.

Erlinge, S. (1968). Territoriality of the Otter Lutra lutra L. *Oikos*, **19**: 81 - 98

Foster-Turley, P., Santiapillai, C. (1990). Action plan for Asian otters. In P. **Foster-Turley, Macdonald, M.S., Mason, C.F.** (Eds.), *Otters: An Action Plan for their Conservation* (pp. 52-63). IUCN, Gland, Switzerland.

Harihar, A., Pandav, B. (2012). Influence of connectivity, wild prey and disturbance on occupancy of tigers in the human-dominated western Terai Arc Landscape. *PLoS ONE* **7**(7), e40105. https://doi.org/10.1371/journal.pone.0040105

Hines, J. E., Nichols, J. D., Royle, J. A., Mackenzie, D. I., Gopalaswamy, A., Kumar, S., Karanth, K. (2010). Tigers on trails: occupancy modeling for cluster sampling. *Ecological Applications*, **20**(5): 1456-1466.

Hussain, S.A. (1993). *Aspects of ecology of smooth-coated otter (Lutra perspicillata) in National Chambal Sanctuary*. [Doctoral dissertation, Aligarh Muslim University]. Shodhganga

Hussain, S.A., Choudhury, B.C. (1997). Status and distribution of smooth-coated otter *Lutra perspicillata* in National Chambal Sanctuary. *Biological Conservation*, **80**(2): 199-206.

Hussain, S.A. (2012). *Mammals of South Asia* (**A.J.T. Johnsingh, Manjrekar, N.** (Eds.). Universities Press, India.

Jena, J., Bhargava, D., Borah, J., Dey, S. (2016). Notes on the Occurrence of the Eurasian Otter (Lutra lutra L.) in the Forest of Balaghat, Madhya Pradesh, India. *IUCN Otter Spec. Group Bull*, **33**(2): 59-63.

Jhala, Y.V., Qureshi, Q., Nayak, A.K.(eds). (2020). *Status of tigers, copredators and prey in India, 2018*. National Tiger Conservation Authority, Government of India, New Delhi, and Wildlife Institute of India, Dehradun.

Joshi, A.S., Tumsare, V.M., Nagar, A.K., Mishra, A.K., Pariwakam, M. P. (2016). Photographic Records of Eurasian Otter *Lutra lutra* from the Central Indian Landscape. *IUCN Otter Spec. Group Bull.* **33**(1): 73-78.

Kruuk, H. (1995). *Wild otters - Predation and Populations*. Oxford University Press

Kruuk, H. (2006). *Otters: Ecology, Behavior and Conservation.* Oxford University Press.

Kruuk, H., Carss, D. N., Conroy, J. W. H. & Durbin, L. S. (1993). Otter (*Lutra lutra* L.) numbers and fish productivity in rivers in north-east Scotland. *Zoological Society of London Symposia*, **65**: 171-191

Low, C.E. (1907). *Central Provinces District Gazetteers: Balaghat District*. Volume A, Descriptive, 36 pp.

Mason, C.F., Macdonald, S.M. (1986). *Otters ecology and conservation*. Cambridge: Cambridge University press.

Menon, V. (2009). *Indian mammals a field guide*. Princeton University Press.

Mohapatra, P., Palei, H.S., Hussain, S.A. (2014). Occurrence of Asian small-clawed otter *Aonyx cinereus* (Illiger, 1815) in Eastern India. *Current Science,* **107***:* 367-370.

Perinchery, A., Jathanna, D., Kumar, A. (2011). Factors determining occupancy and habitat use by Asian small-clawed otters in the Western Ghats, India. *Journal of Mammalogy,* **92**(4): 796-802.

Pocock, R.I. (1939). Notes on some British Indian otters with description of two new species. *J. Bombay Nat. Hist. Soc.,* **41**: 514-518.

Prater, S.H. (1971). *The book of Indian animals (3rd ed.)*. Bombay Natural History Society, Bombay.

Roos, A., Loy, A., de Silva, P., Hajkova, P., Zemanová, B. (2015). *Lutra lutra*. *The IUCN Red List of Threatened Species*. 2015. https://doi.org/10.2305/IUCN.UK.2015-2.RLTS.T12419A21935287.en

Royle, J.A., Dorazio, R.M. (2008). *Hierarchical modeling and inference in ecology*. Academic Press, New York, New York, USA.

White, G.C., and Burnham, K.P. (1999) Program MARK: Survival estimation from populations of marked animals. *Bird Study*, **46**: S120-S139. https://doi.org/10.1080/00063659909477239

RÉSUMÉ

UTILISATION DE L'HABITAT PAR LA LOUTRE EURASIENNE (*Lutra lutra,* LINNAEUS, 1758) DANS UNE AIRE NON PROTÉGÉE DU MADHYA PRADESH, EN INDE

La loutre eurasienne est l'une des trois loutres que l'on trouve en Inde. Elle a récemment été photographiée en Inde centrale dans le district de Balaghat. Nous avons étudié l'utilisation de l'habitat des loutres eurasiennes (*Lutra lutra*) à l'aide de relevés d'indices de présence en échantillonnant 57 sections de cours d'eau le long de la rivière Wainganga et du ruisseau Uskal, dans une réserve forestière (non protégée) de la Division Foret de Balaghat, au cours des mois de mars à avril 2018. Nous avons utilisé une approche basée sur l'occupation pour déterminer l'influence des covariables de l'habitat sur la présence de la loutre. Le substrat de la berge a eu un impact positif significatif sur la probabilité de détection des loutres. La probabilité d'utilisation de l'habitat par les loutres diminuait fortement lorsque la largeur de la berge augmentait. Les études futures devraient viser à mieux comprendre l'impact des activités humaines sur la répartition, la démographie et le comportement des loutres.

RESUMEN

USO DEL HÁBITAT POR LA NUTRIA EURASIÁTICA (*Lutra lutra* LINNAEUS 1758) EN UN ÁREA NO PROTEGIDA DE MADHYA PRADESH, INDIA

La nutria Eurasiática es una de las tres nutrias que se encuentran en la India. En India Central fue recientemente foto-capturada en el distrito de Balaghat. Estudiamos el uso de hábitat de las Nutrias Eurasiáticas (*Lutra lutra*) muestreando 57 segmentos a lo largo del Río Wainganga y el arroyo Uskal, en un bosque de reserva (no-protegido) de la División Forestal de Balaghat, en Marzo-Abril de 2018, utilizando relevamiento de signos. Usamos un enfoque basado en la ocupación, para determinar la influencia de las covariables de hábitat en la ocupación por nutrias. El sustrato de las barrancas tuvo un impacto positivo significativo en la probabilidad de detección de las nutrias. La probabilidad de uso de hábitats por las nutrias disminuyó fuertemente a medida que se incrementaba el ancho de las barrancas. Los estudios futuros deberían enfocarse en entender mejor el impacto de las actividades humanas en la distribución, demografía y comportamiento de las nutrias.

सारांश: मध्य प्रदेश, भारत के एक गैर-संरक्षित क्षेत्र में यूरेशियन ऊदबिलाव (Lutra lutra Linnaeus 1758) द्वारा पर्यावास का उपयोग

यूरेशियन ऊदबिलाव भारत में पायी जाने वाली तीन ऊदबिलाव की प्रजाति में से एक हैं । हाल ही में मध्य भारत के बालाघाट जिले में एक कैमरा ट्रैप अध्ययन में इसे दर्ज किया गया है । हमने वर्ष २०१८ के मार्च- अप्रैल महीने में बालाघाट वन मंडल के संरक्षित (गैर -आरक्षित) क्षेत्र में बैनगंगा एवं उकसल नदी के किनारे ५७ खण्डों में साक्ष्य सर्वेक्षण के माध्यम से यूरेशियन ऊदबिलाव के आवास का अध्ययन किया । हमने ऊदबिलाव के आवास में उसकी स्थिति पर उसके आवास के सहकारकों के प्रभाव का पता लगाने के लिए एक अधिभोग आधारित दृष्टिकोण का उपयोग किया है। नदी के किनारों की भूमि का ऊदबिलाव के खोज की सम्भावना में एक महत्वपूर्ण सकारात्मक प्रभाव हुआ । जैसे जैसे नदी के किनारों की चौड़ाई बढ़ती जाती है वैसे वैसे ऊदबिलाव के आवास की सम्भावना घटती जाती है । भविष्य के अध्ययन को मानवीय गतिविधियों का ऊदबिलाव के वितरण, जनसांख्यिकी और व्यवहार पर प्रभाव को समझने के लिए केंद्रित होना चाहिए।

ARTICLE

FEEDING STRATEGIES FOR CAPTIVE ASIAN SMALL-CLAWED OTTERS (*Aonyx cinereus*, Illiger, 1815): WHAT WORKS TO REDUCE REPETITIVE FEEDING ANTICIPATORY ACTIVITY IN THE COLD SEASON?

Jacob HARROP[1] and Mirela CUCULESCU-SANTANA[1*]

[1] *Department of Applied Sciences, Faculty of Health and Life Sciences, Northumbria University, Newcastle upon Tyne, NE1 8ST, UK. e-mail: mirela.cuculescu@northumbria.ac.uk*


(Received 20th August 2020, accepted 1st April 2021)

Abstract: This case-study analysed the behaviour and enclosure use of a pair of Asian small-clawed otters to investigate the impact of changes in feeding strategy on repetitive behaviours associated with feeding anticipation, in the context of the influence of seasonal changes in temperature on these tropical mammals.

The otters displayed less swimming and resting, less sleeping and more begging, vocalisations and overall vigilance in winter compared to summer, suggesting more hunger due to increased energetic demands for thermoregulation.

The introduction of an additional mid-morning feed in winter without increasing the total amount of food per day was only partly effective on the targeted behaviours. The overall vigilance displays and vocalisations increased significantly, resting and sleeping decreased, but begging did not change compared to previous winter and summer values. Begging before the feed at 14:00 hours was less frequent, suggesting less hunger at this time, but increased to higher values later in the afternoon.

An increase in the total amount of food per day from 20% to 30% of otter body weight in January 2019, with return to 3 feeds/day, was more effective at reducing the targeted behaviours. There were decreases in overall vigilance displays and in the frequencies of begging and short calls and increases in play behaviours, social affiliative interactions and resting and sleeping, suggesting a reduction in levels of hunger and related stress.

This study emphasized the importance of considering how local climate affects enclosure conditions when assessing the nutritional, enrichment and climatisation needs of Asian small-clawed otters.

Citation: Harrop, J and Cuculescu-Santana, M. (2021). Feeding Strategies for Captive Asian Small-Clawed Otters (*Aonyx cinereus*, Illiger, 1815): What Works to reduce Repetitive Feeding Anticipatory Activity in the Cold Season? *IUCN Otter Spec. Group Bull.* **38** (4): 228 - 248

Key Words: abnormal repetitive behaviours, activity patterns, seasonal differences, thermoregulation

INTRODUCTION

Captive Asian small-clawed otters (ASCO) represent important potential genetic reserves and resources for research into otter biology (Bateman et al., 2009). *Aonyx cinereus* (Illiger, 1815) has had 'vulnerable' status on the IUCN Red List since 2008 due to rapid population decline and loss of genetic variation, caused by habitat destruction, water pollution, decline in suitable prey and direct exploitation by humans (Wright et al., 2015). It has been recently moved from CITES Appendix II to Appendix I (CITES, 2019), due to an increase in illegal trade, linked to increased popularity as pets on social media (Kitade and Naruse, 2018; Harrington et al., 2019). The species still has an extensive distribution range in the tropics, from southern and south-eastern India and mainland Asia, through to Indonesia, Taiwan and Philippines, in diverse habitats, including coastal and freshwater wetlands, and rivers and lakes in forested areas (Wright et al., 2015). These wetland habitats are predicted to shrink by 17-41% by 2050 due to loss of suitable climatic areas (Cianfrani et al., 2018), emphasizing the need for both *in situ* and *ex situ* conservation efforts for the survival of the species.

ASCO have high display value in zoos and aquaria due to their playful and inquisitive nature and relatively high levels of activity during the day (Foster-Turley and Markowitz, 1982). The same features, based on innate foraging behaviours (Larivière, 2003; Kruuk, 2006) and high cognitive abilities (Perdue et al, 2011; Perdue et al., 2013; Ladds et al, 2017; Schmelz et al., 2017; Manns et al., 2018), make them prone to becoming bored in captivity and displaying high frequencies of abnormal repetitive behaviours (ARBs) such as pattern locomotion, repetitive up-down movements (begging), door banging, hair plucking, aggression and/or excessive vocalization, which are common in otters at many establishments (Morabito and Bashaw, 2012) and may lead to poor health, poor reproductive success and low welfare (Mason, 2010).

Various types of environmental enrichment are used in many zoos and aquaria to provide more stimulating captive conditions and improve otter welfare (AZA, 2009; Bishop et al., 2013), but there are very few quantitative studies evaluating enrichment effectiveness. Most of these focus on the effect of feeding enrichment on stimulating foraging and reducing ARBs in ASCO (Foster-Turley and Markowitz, 1982; Hawke et al., 2000; Ross, 2002; Gothard, 2007), as in the wild they spend up to 40-60% of their time foraging (Heap et al., 2008). The frequency of ARBs usually peaks as feeding anticipatory activity (FAA) (Hawke et al., 2000; Ross, 2002) and there is evidence to suggest this is mainly due to hunger rather than boredom (Gothard, 2007), especially in the cold season (Cuculescu-Santana et al., 2017). The lower end of the thermoneutral zone for ASCO is estimated at around 16°C (Borgwardt and Culik, 1999) and ambient temperatures below this value present additional thermoregulatory challenges for ASCO as tropical mammals (Kruuk, 2006). The husbandry guidelines for ASCO recommend temperatures of 22.2-24.4 °C for air and 18.3-29.4 °C for water (Heap et al., 2008) but in many zoos in the temperate regions they appear to cope well in both indoor and outdoor enclosures with limited climatisation (Reed-Smith and Polechla, 2002; Dornbusch and Greven, 2009; AZA, 2009).

Seasonal variations in temperature influenced the activity budgets of captive ASCO in both indoor and outdoor enclosures, with more time spent swimming and less feeding anticipatory activity (FAA), foraging and resting in summer compared to winter (Cuculescu-Santana et al., 2017; 2021), showing that the otters adjusted their behaviour to reduce heat loss and compensate for the increased energetic demand for thermoregulation in winter, but also displayed increased ARBs. ASCO have a significantly higher metabolic rate in cold water compared to other otter species, possibly due to poorer insulative capacity of the fur and skin (Borgwardt and Culik, 1999), which makes them lose heat over the whole body, similar to another tropical species, the giant otter *Pteronura brasiliensis*, and in contrast to the better cold-adapted Eurasian otter *Lutra lutra* (Kuhn, 2009; Kuhn and Meyer, 2009). While providing more food in the cold season may seem like an easy solution, the nutrition guidelines for ASCO recommend caution (Henry et al., 2012), because an increase in the amount of food given, combined with the often seen reduced levels of activity due to the colder temperatures, may lead to otters becoming overweight and developing other health problems (AZA, 2009).

This case-study describes the combined influence of seasonal changes in temperature and of a series of changes in feeding strategies aimed at reducing the ARBs associated with FAA on the behaviour of ASCO at the Tynemouth Aquarium, England (55°N latitude; temperate climate). The otters were expected to be more active in the summer with more time spent swimming and playing and less FAA and to display a day-time activity pattern strongly influenced by feeding times, with peaks in locomotion, begging and vocalisations before feeds (FAA), as shown in an earlier study at the same establishment (Cuculescu-Santana et al., 2017). Splitting the same amount of daily food (20% of body weight) between four feeds instead of three in autumn 2018 was expected to reduce FAA by avoiding longer periods with no feeding (Gothard, 2007; Cuculescu-Santana et al., 2021). In January 2019, the additional feed was stopped and the daily amount was increased to 30% of body weight, expecting this to be more effective at reducing FAA (Gothard, 2007). The study was carried out in collaboration with staff at Tynemouth Aquarium as part of their on-going enrichment plans, up to the time when the otters were moved to another establishment with an outdoor area in April 2019.

MATERIALS AND METHODS

Otters, Enclosure and Enrichment

During the study period (November 2015 – March 2019) the Tynemouth Aquarium (TAQ) housed a pair of Asian small-clawed otters: a male born there in November 2005 (Gizmo), and a female born at Chester Zoo in October 2011 (Indra), who arrived at the TAQ in summer 2014 to replace Gizmo's male sibling. Both otters were around 3 kg in weight and were housed in an indoor enclosure of approximately 100m^2 surface area, 3:2 land to water ratio, with various structural enrichments (Figure 1). The otters were fed on a diet of fish, day-old chicks and red meat, along with smaller random scatter feeds (monkey nuts, chopped carrot and apples, crustacean claws, molluscs, mealworms). The feeding schedule, amount of food relative to otter body weight and the feeding enrichment strategies implemented during the study period are summarised in Table 1. Examples of containers used for food presentation are shown in Figure 2.

The enclosure area was not climate-controlled, apart from a heat lamp above the otters' preferred sleeping area and the ambient temperature varied in correlation with the outdoor fluctuations. The pool water temperatures varied between 13.8-19.8 °C in summer and 4.4-16.6 °C in winter months (Figure 3 insert). Natural light entered only through a small window. Artificial light was provided 8:00am-6:00pm (10 hours light:14 hours dark; metal halide bulbs with UVB qualities).

Data Collection

Data were collected on four random days in November-December 2015 (winter 2015), July-September 2016 (summer 2016) and November-December 2018 (winter 2018) and on three random days in January-March 2019 (winter 2019), by two observers (0.977 inter-observer correlation coefficient; Rees, 2015), using the same methods as an earlier study (Cuculescu-Santana et al., 2017). Six 20-minutes observation periods per day were completed in winter 2015, around the second feed and between the second and the third feed (the Aquarium closed to the public before the third feed). Twelve 20-minutes observation periods per day were completed in summer 2016, winter 2018 and winter 2019, to include the morning and midday period, as well as five of the six time intervals from 2015 (in winter 2018-19 the Aquarium closed to the public at 4:00pm, preventing full overlap of data collection times between seasons). The average pool water temperatures for the days of data collection are shown in Figure 3, alongside the average monthly temperatures for the whole study period.

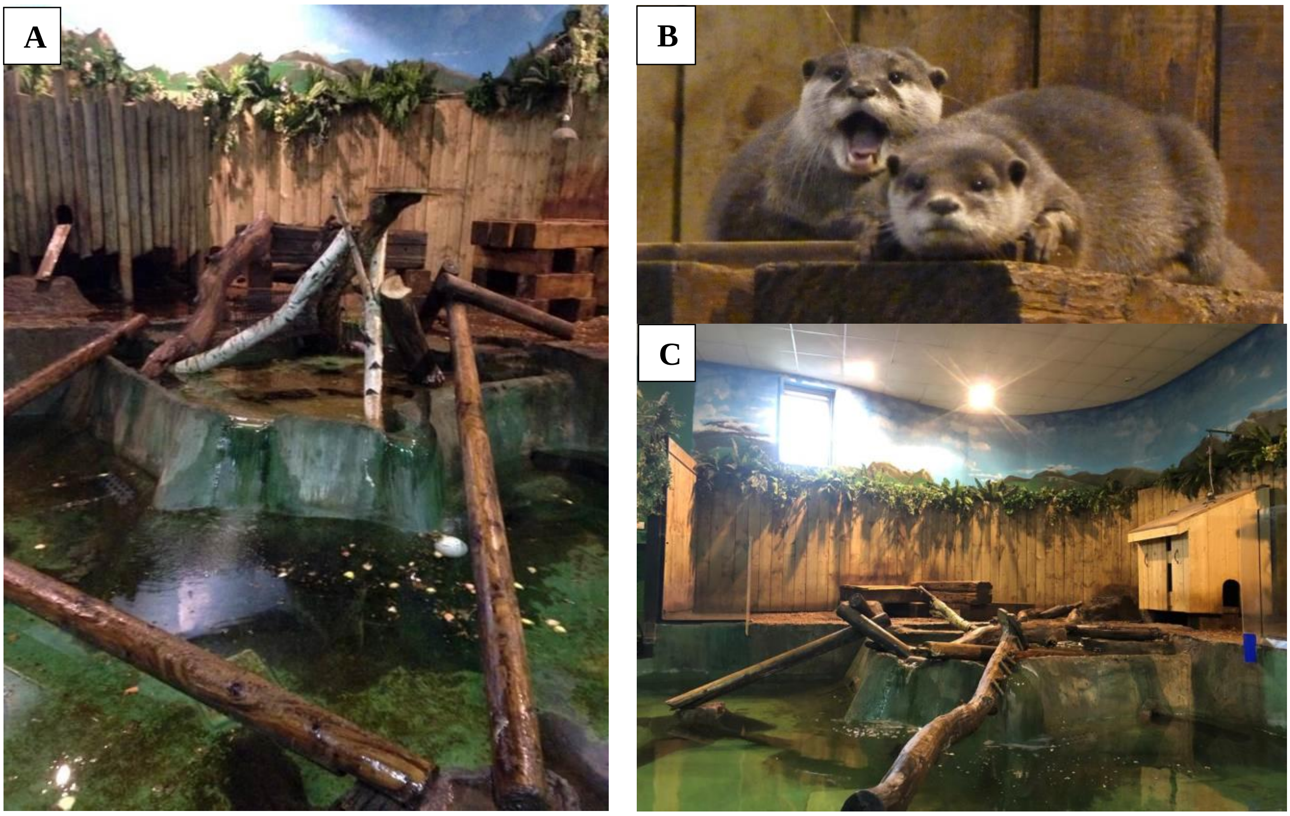

Figure 1. The otters and their enclosure at the Tynemouth Aquarium, UK (*Photos A-C Copyright Mirela Cuculescu-Santana)*. **A:** Structural enrichments, including a den on the left, a river at the back, shallow pool in the middle and large pool at the front (0.8 m depth; 18,000 l volume; filtered recirculated water), a box with bark chippings, climbing structures, log bridges, wooden blocks with a heat lamp above them (right), which was the otters' preferred sleeping place; **B:** Indra (left) and Gizmo (right); **C:** The height of the climbing structures was reduced, the logs were slightly rearranged and the heat lamp was moved to the new den (right), built in 2017. Surface area ~100m^2, 3:2 land to water ratio, concrete ground.

Focal instantaneous time sampling every 15 seconds was used for the state behaviours of the male only (Table 2) and scan every 60 seconds for the location in the enclosure of both otters (Table 3) (Martin and Bateson, 2007). Only the male was used as the focal animal for consistency of monitoring the time spent in the water in different seasons, as he tended to swim more than the female (Janusz, 2017), and for comparison with earlier observations from summer and winter 2013 (Cuculescu-Santana et al., 2017). The event behaviours (Table 2) were recorded for both otters using the continuous scan method with one-zero rule for each 1-minute interval of observation time (Rees, 2015). The approximate visitor numbers were recorded for each 1-minute interval using a ranked score from 1 to 5 (1=a few; 2=several; 3=many; 4=full room; 5=crowded room).

Figure 2. Containers used for food presentation to the otters at the Tynemouth Aquarium during the seasons when behavioural and enclosure use data were collected (*Photos Copyright A-B Jacob Harrop*). **A**: Clear plastic box (yellow lid) with holes, attached to kong ball; **B**: Opaque container with holes.

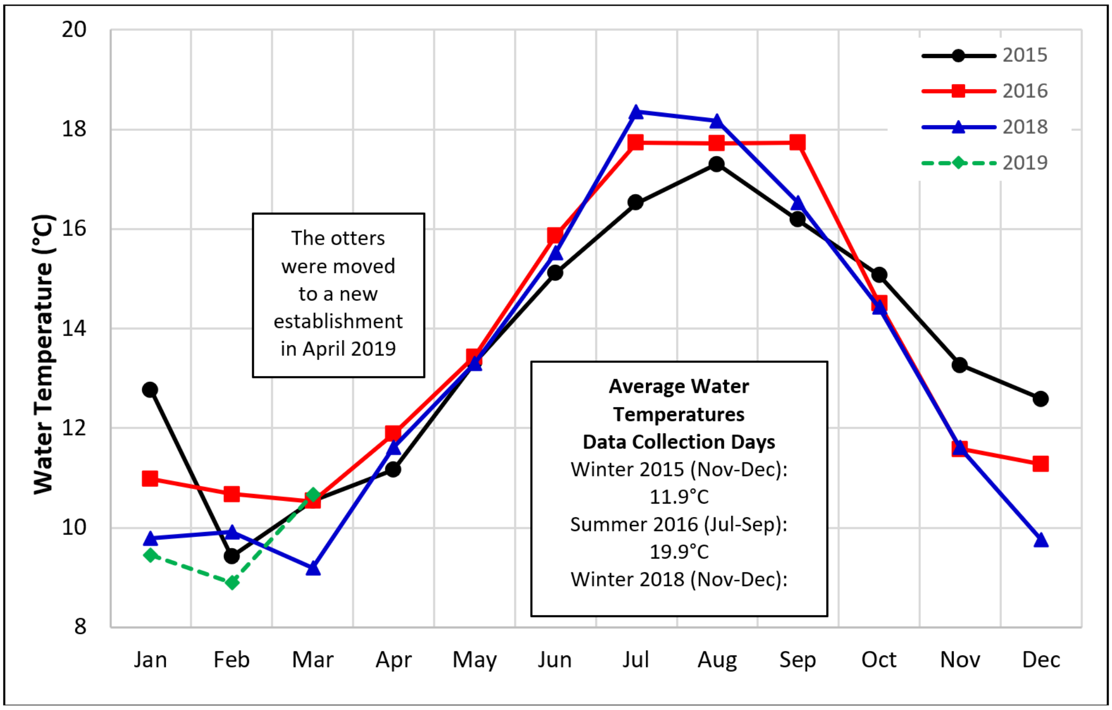

Figure 3. Average monthly surface water temperatures for the large otter pool at the Tynemouth Aquarium for 2015-2016 and 2018-19 and the corresponding average water temperatures for the days of data collection during each season (insert).

Data Processing and Data Analysis

State behaviour data were converted into times spent engaged in each behaviour, during each observation period, and used to produce average behavioural budgets and day-time patterns of activity for each season (presented as % of observation time). The event behaviour data were processed as frequency of 1-minute intervals during which they occurred per observation period (presented as % of total number of 1-minute intervals per season or per time of day/season). The frequency and length of swimming bouts were estimated by counting the total number of 1-minute intervals during which swimming was recorded 4, 3, 2, 1 or 0 times for each season. Location data were processed as frequency of occurrence at each location per observation period (presented as % of total number of locations recorded per season or per time of day/season). Visitor data were processed as average scores per observation period, time of day and season. Kruskal-Wallis tests for the influence of season and time of day on otter behaviour and enclosure use were carried out in SPSS V26 at level of significance $P<0.05$, using the actual time and frequency values. The tests for the influence of season were carried out using only the data sets for the times of day when data were collected in all four seasons included in this study. The two-way chi square test (Microsoft Excel) was used to test for the influence of season on the frequency of occurrence of 1-minute intervals with swimming recorded 4, 3, 2, 1 or 0 times.

Table 1. Feeding schedules and the main feeding enrichment strategies used at the Tynemouth Aquarium between November 2015 and March 2019, around and during the times when the data presented in this study were collected.

Time of Implementation	Feeding Strategy
November 2015 – September 2018[1] **3 feeds** **20% of body weight (~600g/day)**	**9:00 am** and **4:30 pm**: food scattered around the enclosure, on dry areas or in the water, or hidden inside holes in the wooden structures; **2:00 pm**: food usually placed inside a puzzle-box (plastic container with small holes on the sides, filled either with criss-crossing elastic cords, pine cones, or soft spiky coloured balls) lowered into the water, from the outside of the enclosure; public talk delivered by a keeper located outside the enclosure
October 2018 – early January 2019 **4 feeds** **20% of body weight (~600g/day)**	**9:00 am** and **4:30 pm**: food scattered around the enclosure, as above; **11:30 am:** extra feed, food scattered around the enclosure, as above; keeper inside the enclosure on days when the feed was combined with training; **2:00 pm**: food scattered all around the enclosure, or placed inside a puzzle-box (as above) placed either on dry areas or into the water; public talk delivered by a keeper located outside the enclosure
January – March 2019 **3 feeds** **30% of body weight (~900g/day)**	**9:00 am** and **4:30 pm**: food scattered around the enclosure, as above; **2:00 pm**: food scattered all around the enclosure, or placed inside a puzzle-box (as above) placed either on dry areas or into the water; public talk delivered by a keeper located outside the enclosure;

[1]Various other forms of food presentation were used between November 2015 and September 2018, within the same schedule, for shorter periods of time (eg. meat and vegetable kebabs, vine balls, closed containers with lids that the otters had to open, mealworms scattered inside boxes with straw or soil, kong balls, ice pops in the summer, etc.).

Ethical Considerations

The project received ethical approval from the Ethics Commission of Northumbria University and was carried out with consent from and in collaboration with the Displays Manager and the Keepers at the TAQ. The data were collected from outside the enclosure without any direct interaction between observers and otters.

Table 2. Otter ethogram. State behaviours and event behaviours (Cuculescu-Santana et al., 2017).

State Behaviours	Description of Behaviour
Swimming	Locomotion in deep or shallow water, with the head out or under water, including diving and foraging in water
Land Locomotion	Walking, climbing or running on the ground or on other dry structures in the enclosure (with the head up)
Foraging	Locomotion on land with the head down and the nose close to the ground, interpreted as searching for food
Scent Marking	Rubbing a body part against the ground, a structure or a wall (while stationary at that location)
Aggression	Fighting or aggressive displays towards another otter
Maintenance	Eating (biting and chewing food), drinking and self-grooming (using paws or mouth to clean, dry or smooth fur; scratching)
Playing	Non-aggressive playful interaction with another otter or another object, e.g. pebble, plastic toy, enrichment object
Vigilance	Being alert and looking around while stationary, on four limbs, lying down with head up, or standing (vigilance standing or 'begging' displays)
Social Affiliative	Rubbing body against the body of another otter; rolling around with another otter in or out of water; sexual behaviour; social grooming (using paws or mouth to clean, dry or smooth the fur of another otter)
Resting & Sleeping	Lying down with head down and eyes open or closed; occasionally looking around when a noise occurs.
Out of Sight	Inside the den, or behind a structure, so that the observer cannot see what the otter is doing.
Event Behaviours	**Description of Behaviour**
Begging	Standing on rear paws or doing repetitive up-down movements, with forepaws held in front
Short Calls	Short loud 'squeaky' sounds
Long Squeals	Longer and higher pitched sounds

Table 3. Areas of the otter enclosure and their description.

Location	Description
Ground Area	Pebble-like concrete surface around the enclosure;
Climbing Structures	Tree branches over the small shallow pool, with a platform at the top; thicker oblique tree trunks linking the ground area to the log bridges over the larger deep pool and to a thick horizontal bridge over the river; wall around the small pool; rocks;
Log Bridges	Three horizontal thin logs, supported by tree stumps immersed in the large pool, forming a 'path' over the large pool (rearranged slightly in autumn 2018);
Den	A small house providing shelter for the otters out of sight of the visitors, with straw bedding inside; rebuilt in autumn 2017 and heat lamp moved to radiate inside the den;
Sleeping Places	Flat wooden blocks stacked under a heat lamp (until autumn 2017); a wire mesh cage placed near the wooden blocks;
River	Area with shallow flowing water, flowing into the small pool;
Small Pool	Shallow round pool, with two waterfalls to the large pool;
Large Pool	Deeper curved shoreline pool, with a clear side for underwater viewing, with immersed tree stumps with hollowed out areas, providing underwater passages.

RESULTS

Seasonal Differences under Standard Feeding Strategy – Winter 2015 and Summer 2016

Under standard feeding strategy conditions (3 feeds a day; 20% wt/body wt), the male otter at the Tynemouth Aquarium (TAQ) spent significantly more time swimming in summer 2016 compared to winter 2015 (32.5% > 18.6%), less time foraging on land (3.2% < 12.6%), significantly less time displaying vigilance (7.9% < 13.9%) and more time resting and sleeping (12.9% > 8.8%) (Figure 4). The values for aggression were low in both seasons (0-0.3%). In summer 2016, the relative frequency of continuous swimming bouts was significantly higher than expected if no seasonal influence was assumed, while that of 1-minute intervals with no swimming was significantly lower, with the opposite applying to winter 2015 (Table 4).

There were no differences between the summer 2016 and winter 2015 frequencies of repetitive event behaviours, with relatively high values for begging (32.5-36%) and short calls (41.5%), and low values for long squeals (7.3-7.8%) in both seasons (Figure 5).

The seasonal differences in enclosure use (Figure 6) reflected the differences described for state behaviours. The large pool and the small pool were used significantly more frequently in summer 2016 than in winter 2015 (33.5% > 20% and 5.3% > 3.3%, respectively). The sleeping places were also used more frequently in summer 2016 (30.3% > 24.1%). In contrast, the climbing structures (6.4% > 0.5%) and the ground areas (14.1% > 4.8%) were used significantly more frequently in winter 2015 than in summer 2016.

The Influence of the Changes in Feeding Strategies

The introduction of an additional mid-morning feed in winter 2018 (4 feeds/day; 20% wt/body wt), aimed at reducing repetitive behaviours, appeared to have the opposite effect. The time spent displaying vigilance increased significantly to 28.4%, more than double the value for winter 2015, with decreases in foraging on land (5.9% < 12.6%), resting and sleeping (5.4% < 8.8%), playing (2.1% < 4.5%), affiliative social interaction (1.1% < 5.8%) and maintenance (14.4% < 18.5%) (Figure 4). Slightly more time was spent swimming in winter 2018 (21.9%) and the frequency of continuous swimming bouts up to 30-45 seconds (swimming recorded 3-4 times in the same 1-minute interval) was also higher than in winter 2015 (Table 4). For event behaviours, only the relative frequencies of short calls and long squeals increased significantly, to 79% and 14.5%, respectively, almost double the corresponding values for winter 2015. The value for begging was very close to those for the previous seasons (Figure 5).

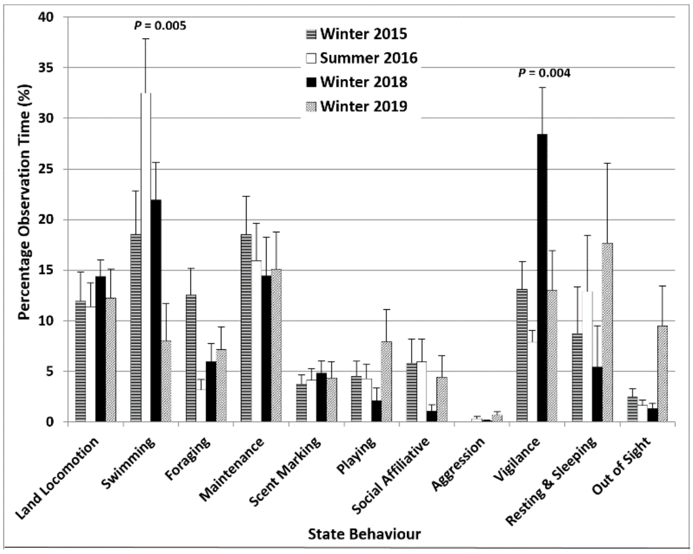

Figure 4. State Behaviours: Seasonal differences in time budgets (means ± standard error of means; N = 20 for Winter 2015, Summer 2016 and Winter 2018; N = 15 for Winter 2019; outcomes of the Kruskal Wallis test for the behaviours that were significantly influenced by season, at $P \leq 0.05$ level of significance; 3 d.f.; swimming H = 12.986; vigilance H = 13.353)

Table 4. Seasonal differences in the relative frequency of 1-Minute Intervals during which swimming was recorded 0, 1-2, and 3-4 times using focal instantaneous time sampling every 15 seconds (Two-way Chi-square test; 6 d.f.; $P<0.001$, $\chi^2=167.5$).

Season (Total Time)	Relative Frequency of 1-Minute Intervals during which Swimming was recorded 0, 1-2 and 3-4 times		
	0 Times	1-2 Times	3-4 Times
Winter 2015 (400 Min)	60%	34%	7%
Summer 2016 (400 Min)	42%	33%	25%
Winter 2018 (400 Min)	55%	33%	12%
Winter 2019 (300 Min)	84%	13%	3%

The increase in the daily amount of food to 30% wt/body wt in January 2019 and the removal of the fourth feed were associated with a significant decrease in the percentage of time spent engaged in vigilance and swimming, to 13% and 8%, respectively, to around half the values for winter 2018. Compared to winter 2018, there were relatively large increases in the time spent resting and sleeping (17.7% > 5.4%) and out of sight (9.5% > 1.3%), as well as in time spent playing (7.9% > 2.1%) and in affiliative social interaction (4.4% > 1.1%) (Figure 4). The relative frequency of 1-minute intervals with no swimming was 84%, higher than in all previous seasons (Table 4).

The changes in the relative frequencies of event behaviours were also mostly in the desired direction. The values for short calls (39%) and begging (21.3%) decreased compared to winter 2018 (79% short calls, 35.3% begging; Figure 5), while the frequency of long squeals increased (27.3% > 14.5%).

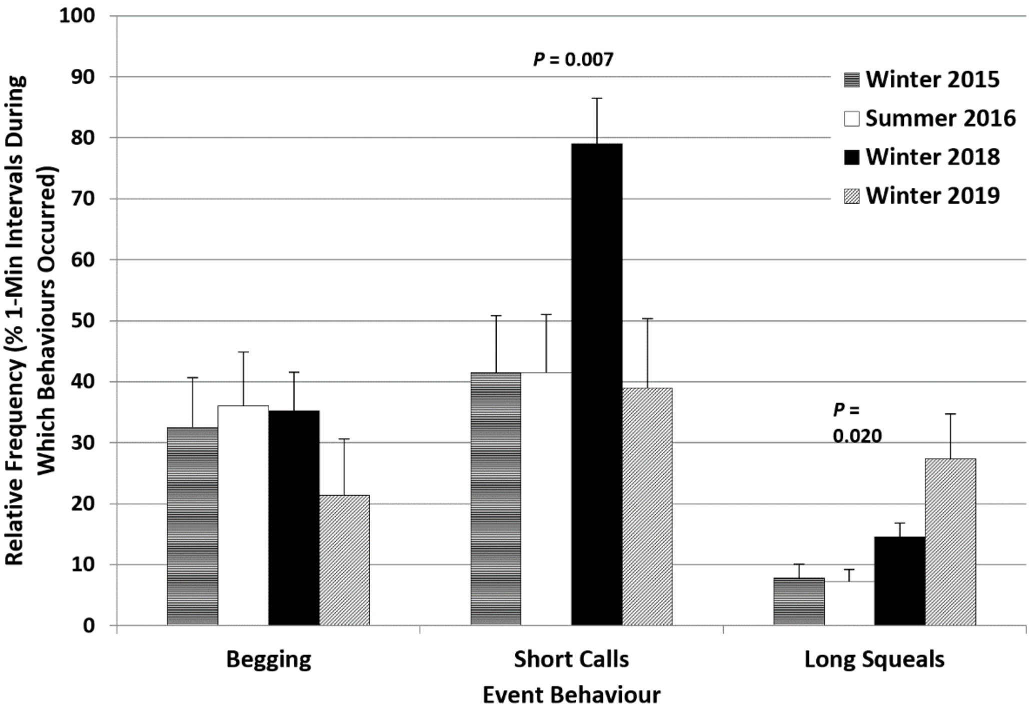

Figure 5. Event Behaviours: Seasonal differences in relative frequencies (means ± standard error of means; N = 20 for Winter 2015, Summer 2016 and Winter 2018; N = 15 for Winter 2019; outcomes of the Kruskal Wallis test for the behaviours that were significantly influenced by season, at $P \leq 0.05$ level of significance; 3 d.f.; long squeals H=9.856; short calls H=12.096)

The differences in enclosure use relative to winter 2015 were consistent with the differences in behaviour. The log bridges where vigilance was usually displayed and the ground areas were used significantly more frequently in winter 2018 (40.1% > 25.9% and 23.4% > 14.1%, respectively), with less frequent use of the sleeping places (12.4% < 24.1%) and the den (1.1% < 4%) and no use of the climbing structures (Figure 6). In winter 2019 there were significant increases in the frequency of use of the den (30.8% > 4%), where the heat lamp had been relocated to, and of the climbing structures (18.7% > 6.4%). Areas used significantly less frequently compared to winter 2015 were the log bridges (6.7% < 25.9%) and the large (10.2% < 20%) and small pools (1% < 3.3%). The former sleeping places were also used less frequently (14.2% < 24.1%) (Figure 6).

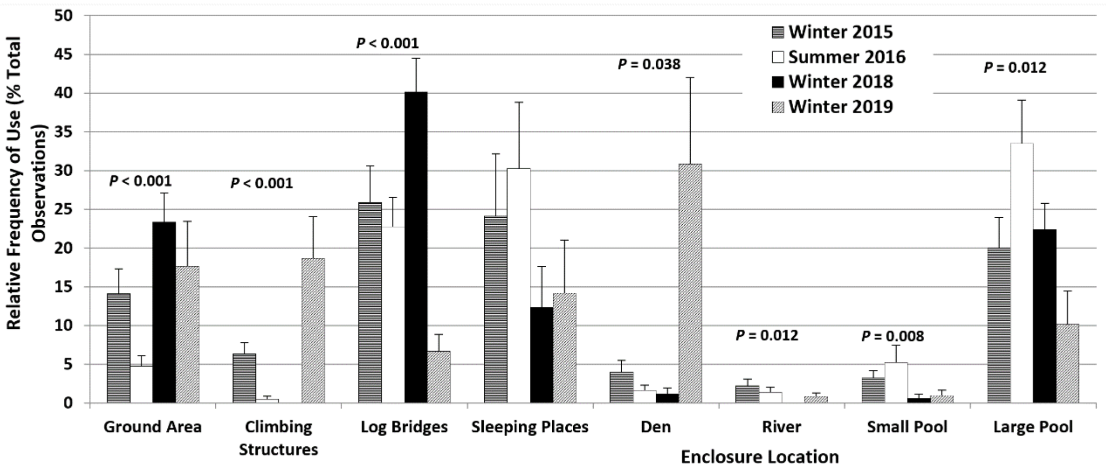

Figure 6. Enclosure Use: Seasonal differences in the time spent at each location in the enclosure (means ± standard error of means; N=20 for Winter 2015, Summer 2016 and Winter 2018; N=15 for Winter 2019; outcomes of the Kruskal Wallis test for the locations whose use significantly influenced by season, at $P \leq 0.05$ level of significance; 3 d.f.; climbing structures H=35.721; den H=8.441; ground area H=18.488; large pool H=10.984; log bridges H=21.915; river H=11.027; small pool H=11.831)

Day-Time Activity Patterns and Variation in Visitor Numbers in Different Seasons

Figures 7-11 present the influence of time of day on otter behaviour, using all the data collected in the four seasons included in this study. The values used to produce Figures 7-11 and the outcomes of the statistical analysis for the influence of time of day on state and event behaviours are available as **Supplementary Materials**.

In winter 2015 (Figure 7; standard feeding strategy) there were peaks in land locomotion, swimming and vigilance during the 13:40-14:00 interval before the second feed of the day, with another peak in vigilance during the 15:30-15:50 interval. During feeding (14:00-14:20), there were peaks in foraging and maintenance (mostly eating and drinking) and in scent marking. The values for foraging and maintenance (mostly self-grooming) remained relatively high over the next time interval (14:20-14:40), when higher values were also found for social affiliative behaviours (body rubbing and allogrooming) and for resting and sleeping. Meanwhile values for land locomotion, swimming and vigilance were low. Resting and sleeping still represented around 20% of the time budget during the 15:10-15:30 interval, when there was a peak in playing, usually represented by solitary play with a pebble or shell. A scatter feed usually occurred during the 15:50-16:10 interval which was associated with a greater diversity of behaviours recorded during this interval.

The summer pattern of behaviour under standard feeding strategy (Figure 8, summer 2016) was fairly similar to that seen in winter 2015. During the 13:40-14:00 interval there were higher values for swimming and lower values for vigilance, and during the 14:20-14:40 interval there was less foraging and maintenance and more resting and sleeping. In summer 2016 there was more swimming during the 15:10-15:30 and 15:30-15:50 intervals, compared to winter 2015. During the earlier time intervals, between 10:30 and 12:10 (no winter 2015 data), the majority of the time budget consisted of resting and sleeping and less active behaviours, such as solitary object play, maintenance and social interaction. Land locomotion and swimming gradually increased after 11:30, up to the peaks described above for the 13:40-14:00 interval.

The main difference between winter 2018 (Figure 9; 4 feeds, still only 20% wt/body wt) and winter 2015 was that the values for vigilance were much higher for all time intervals, apart from the 14:00-14:20 interval. The increase in vigilance (up to 5 times) resulted in less social interaction and foraging and more swimming during 14:20-14:40 and much less resting and sleeping during 15:10-15:30. The values for land locomotion and swimming (mostly repetitive, along the same route) were also higher during the 15:30-15:50 interval. For the seven time intervals between 10:30-13:40 (no winter 2015 data) the values for vigilance were higher than for summer 2016 and more time was spent out of sight in the den. The 11:30 feed (scatter feed) was associated with more time spent engaged in maintenance, foraging and scent marking during the 11:30-11:50 and 11:50-12:10 intervals, compared to summer 2016.

After the increase in the amount of daily feed to 30% wt/body wt and the return to 3 feeds/day in January 2019 (Figure 10; winter 2019) the proportion of time spent displaying vigilance during the 14:20-14:40 interval and later in the afternoon decreased, with increases in the proportion of time spent engaged in social affiliative behaviours, resting and sleeping, playing and being out of sight in the den, compared to winter 2018 and winter 2015. The time budget for the 13:40-14:00 interval in winter 2019 was also different from that seen in the other seasons, with a large proportion of time spent resting and sleeping instead of displaying mostly repetitive running and swimming along the same route. The time budgets for the intervals before 13:40 also consisted of more resting and sleeping compared to both winter 2018 and summer 2016.

In all four seasons, the daily peaks in vigilance and in repetitive locomotory behaviours (Figures 7-10) were associated with peaks in the relative frequencies of short calls, begging and long squeals (Figure 11 A-D). The values for short calls were higher for most time intervals in winter 2018, compared to summer 2016 and winter 2015. However, the values for begging around the 14:00 feed were lower in winter 2018 compared to all other seasons, but increased to higher values during the 15:10-15:30 and 15:30-15:50 intervals. In winter 2019 the relative frequencies of short calls for all three time intervals between 13:00 and 14:00 were lower than in winter 2018 and summer 2016, while the values for begging around the 14:00 feed were higher compared to winter 2018. The relative frequencies of long squeals were higher in winter 2019 than in other seasons during most of the time intervals.

The average visitor score was consistently lower in winter than summer, with peaks in both seasons around 14:00-14:20 when the main feed and public talk took place and around 11:30 (Figure 12). In summer 2016, there was another peak in visitor score around 15:30-15:50 associated with longer opening hours.

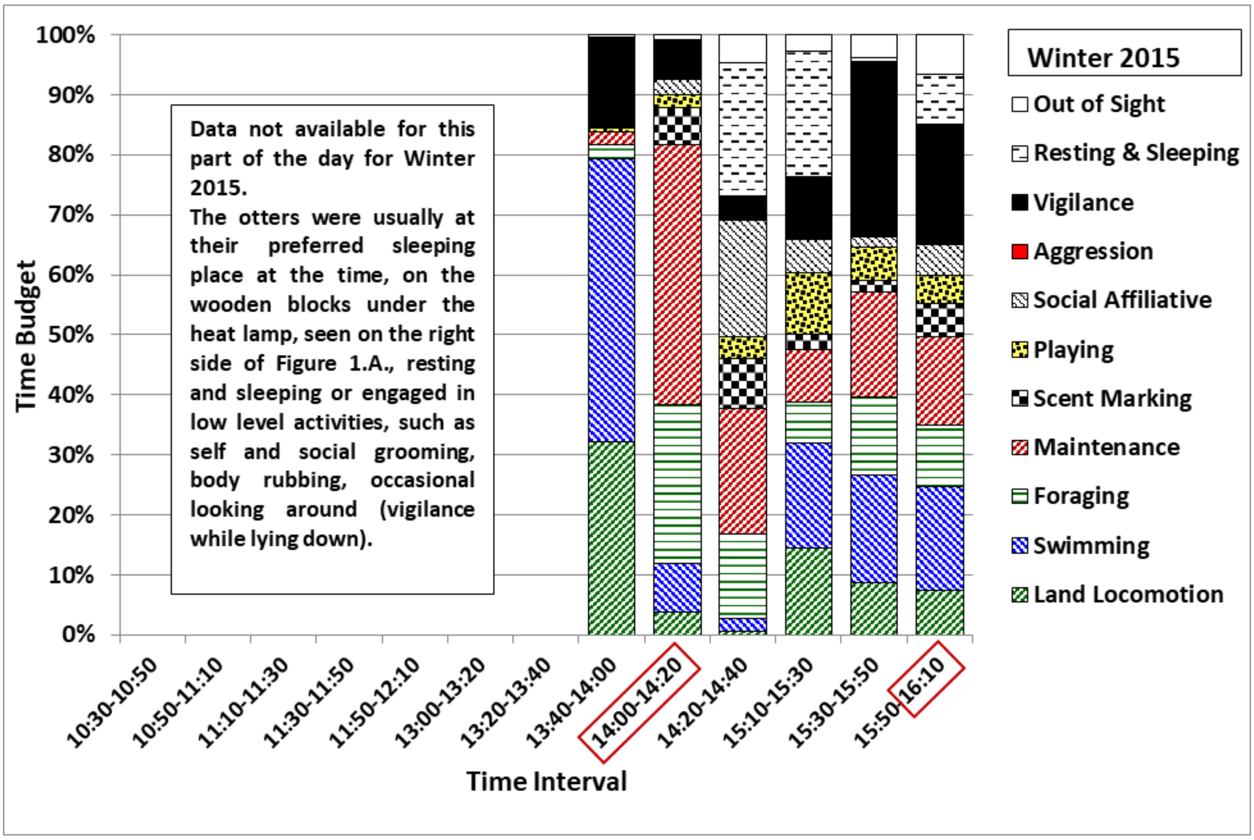

Figure 7. Winter 2015: The influence of time of day (ToD) on the otters' behavioural time budget (*N*=4 days). Feeding times: second feed at 14:00; third feed between 16:00-16:30 (marked by red boxes).

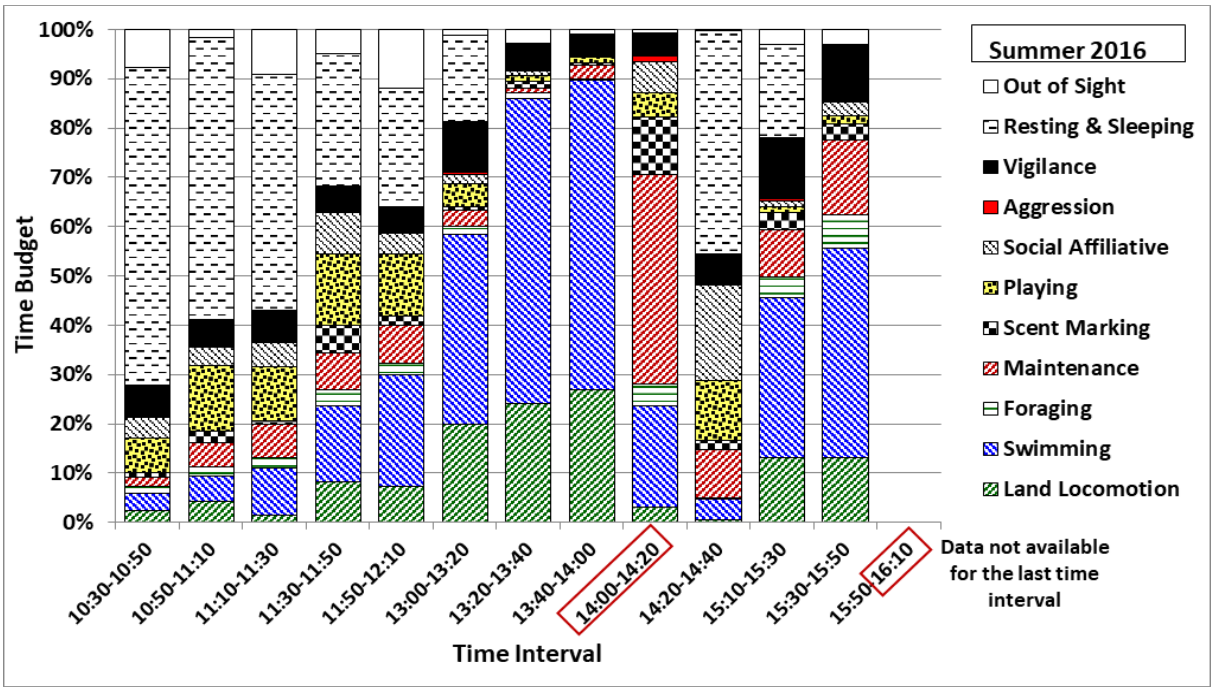

Figure 8. Summer 2016: The influence of time of day (ToD) on the otters' behavioural time budget (*N*=4 days). Feeding times: second feed at 14:00; third feed between 16:00-16:30 (marked by red boxes).

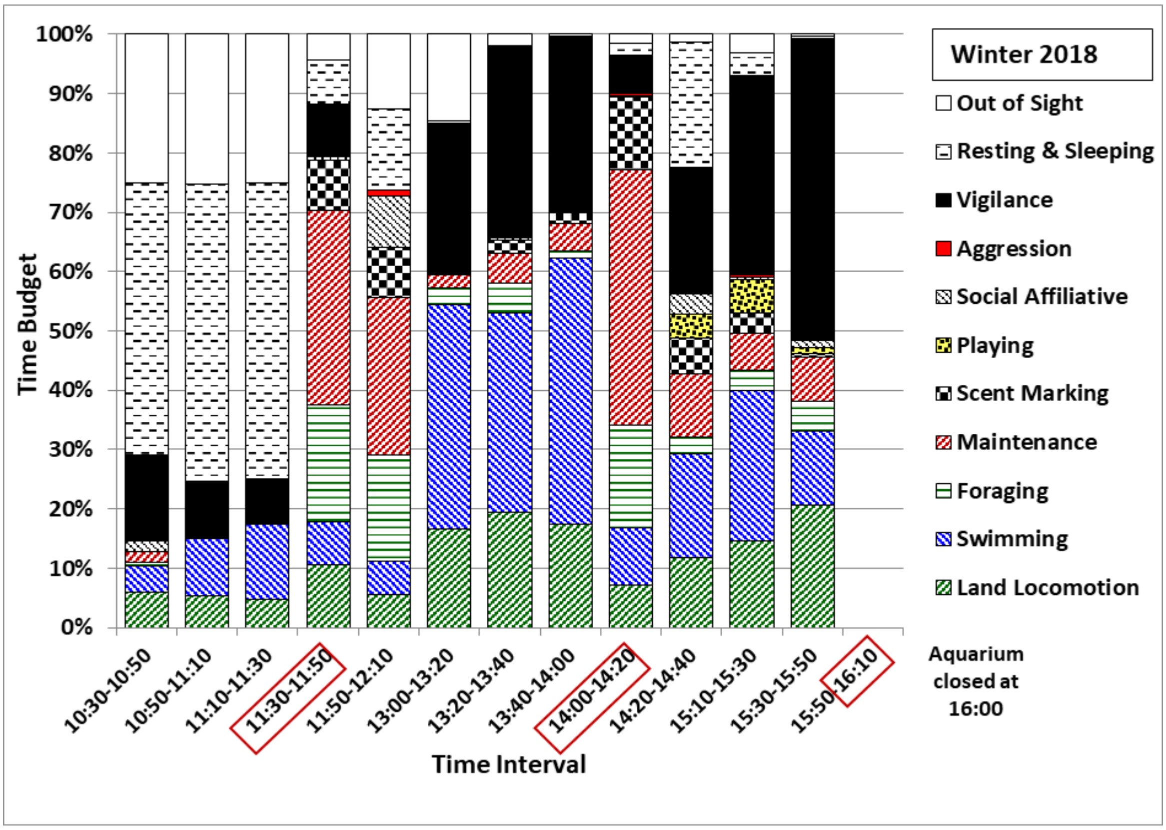

Figure 9. Winter 2018: The influence of time of day (ToD) on the otters' behavioural time budget (N = 4 days). Feeding times: second feed at 11:30; third feed at 14:00; fourth feed between 16:00-16:30 (marked by red boxes).

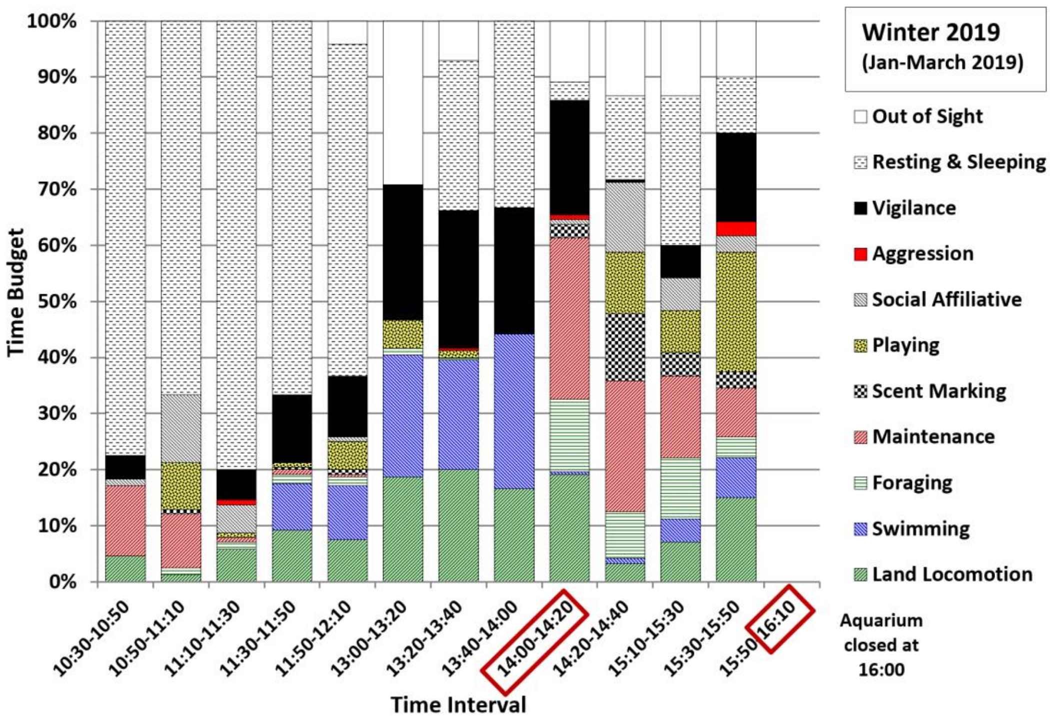

Figure 10. Winter 2019: The influence of time of day (ToD) on the otters' behavioural time budget (N=3 days). Feeding times: second feed at 14:00; third feed between 16:00-16:30 (marked by red boxes).

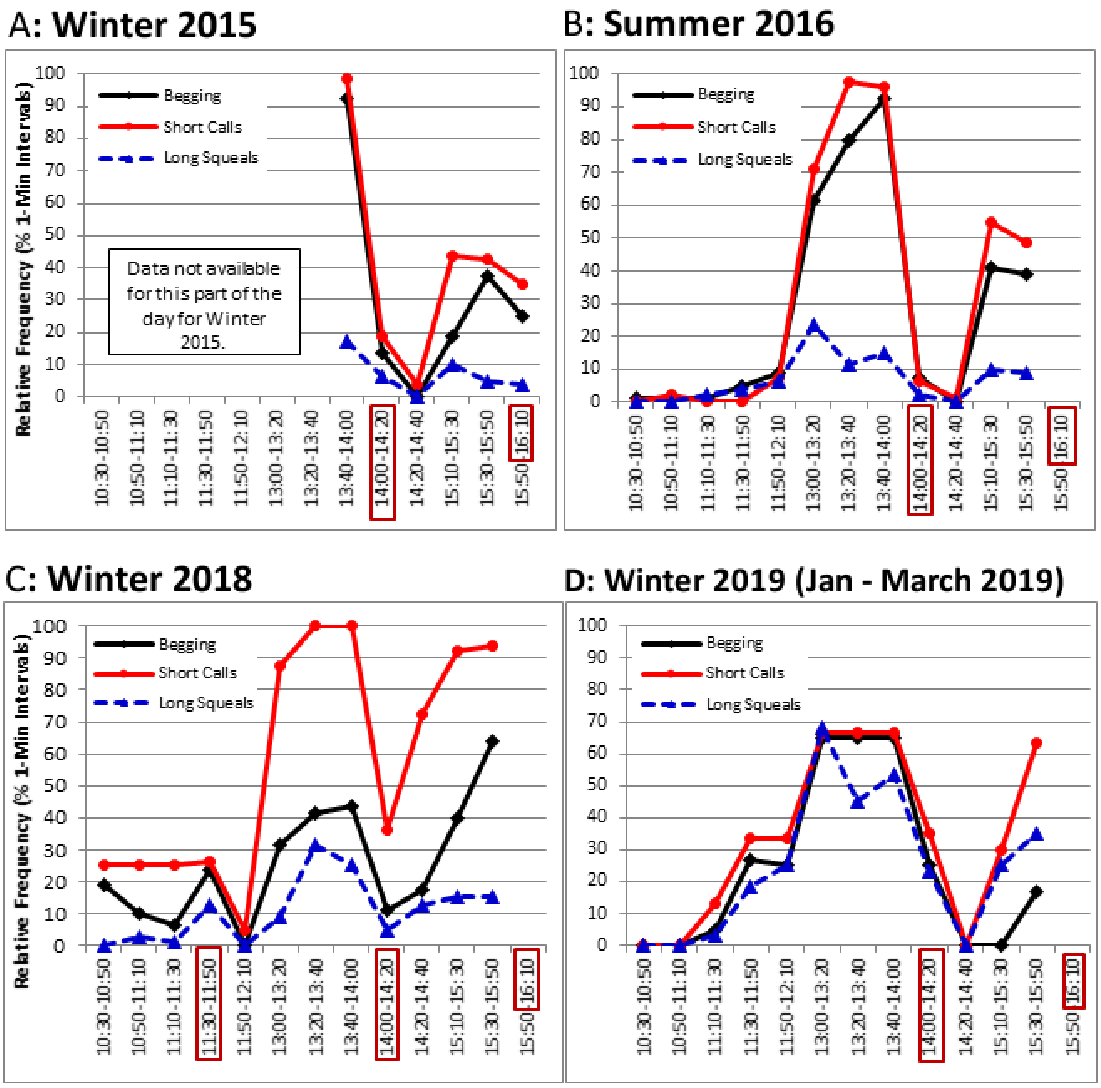

Figure 11. Event Behaviours: The influence of time of day on the relative frequencies (%) of event behaviours in: (**A**) Winter 2015 (*N*=4 days); (**B**) Summer 2016 (*N*=4 days); (**C**) Winter 2018 (*N*=4 days); and (**D**) Winter 2019 (*N*=3). Feeding times in each season are marked by red boxes.

DISCUSSION

The behaviour and enclosure use of the pair of ASCO at the Tynemouth Aquarium (TAQ) over four seasons between November 2015 and March 2019 were presented as a case-study to analyse the impact of the introduction of an additional feed without increasing the total amount of food per day in winter 2018, relative to winter 2015 and summer 2016, and of an increase in the total amount of food per day from 20% to 30% of otter body weight in winter 2019, with return to 3 feeds/day, in the context of the influence of seasonal changes in temperature on these tropical mammals.

The additional mid-morning feed introduced in winter 2018 did not appear to have the full desired effect. The aim was to reduce the pattern running and swimming before feeds and the frequencies of up-down stands (begging) and short calls. However, the percentage of time spent displaying vigilance, including begging, and the frequencies of short calls and long squeals increased significantly, to around double the values for winter 2015. The values for land locomotion, swimming and begging increased slightly, while those for foraging on land, resting and sleeping, playing, affiliative social interaction and maintenance decreased compared to winter

2015. Comparing the day-time activity patterns revealed that the additional feed at 11:30 reduced begging before the 14:00 feed, as the otters would have been less hungry than in seasons when they had not eaten since around 9:30. However begging during later afternoon intervals was much more frequent and the values for vigilance and short calls were higher throughout the day, up to values of 51% of the time budget for vigilance and a relative frequency of 64% for begging and 94% for short calls during the 15:30-15:50 time interval. This suggested that splitting the same amount of food between four feeds instead of three, with the extra feed given at a time of the day when the otters were usually resting or engaging in less energetic behaviours, was only partly effective at reducing the abnormal repetitive behaviours (ARBs) of the otters at the TAQ.

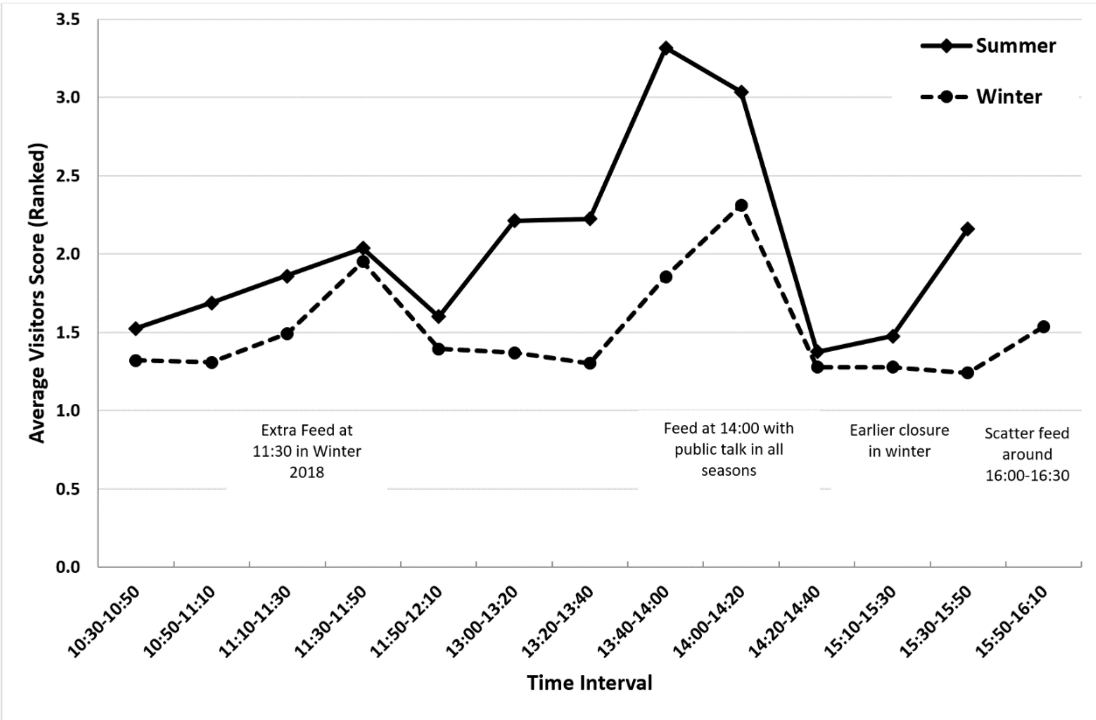

Figure 12: Variations in the approximate number of visitors at the otter enclosure in summer (*N*=4) and winter (*N*=7 for 10:30-13:40; *N*=11 for 13:40-15:50; *N*=4 for 15:50-16:10). The visitor score was recorded on a scale from 1 to 5 (1=a few; 2=several; 3=many; 4=full room; 5=crowded room).

The extra feed intervention was based on otter husbandry guidelines (AZA, 2009) that recommended changing the number of feeds per day (3 or more being preferable), the mode of food presentation, to stimulate naturalistic foraging activities, and/or randomising feeds in order to reduce ARBs, informed by earlier studies on ASCO (Foster-Turley and Markowitz, 1982; Hawke et al., 2000; Ross, 2002; Gothard, 2007). Although the ASCO at the TAQ did not display any potentially harmful repetitive behaviours, such as hair plucking or manipulating enclosure doors (Ross, 2002; Morabito and Bashaw, 2012) and aggression levels were low, repetitive begging and short calls occurred during around 30-40% of the observation time in both seasons monitored prior to this intervention. Frequent short calls have been associated with stress in ASCO (Scheifele et al., 2015) and repetitive begging with hunger, rather than being a sign of boredom or an attempt to attract the attention of visitors (Gothard, 2007), whose numbers were lower in winter than in summer on data collection days at the TAQ. In addition, the seasonal differences between winter 2015 and summer 2016, when the male otter spent more time displaying vigilance and foraging on land in winter and less time resting and sleeping suggested higher levels of restlessness in winter. There was also significantly less swimming in winter and in shorter bouts, with corresponding differences in enclosure use, which was probably due to the difference in water temperature (around 12°C in winter 2015 and 20°C in summer 2016). As tropical mammals, ASCO have a higher metabolic rate in cold water compared to other otter species, possibly due to poorer insulative capacity of the fur and skin (Borgwardt and Culik, 1999). ASCO were reported to swim less but rest more in winter compared to summer in both indoor (Cuculescu-Santana et al., 2017) and outdoor enclosures (Cuculescu-Santana et al., 2021) to adjust to the increased energetic demands of thermoregulation in winter.

The introduction of additional methods of food presentation at the TAQ since summer 2015, in the form of using a variety of puzzle-like containers that made extracting food more challenging, was associated with an increase in the percentage of time spent swimming and a decrease in land locomotion in winter 2015, compared to the winter 2013 values from an earlier study at the same establishment (Cuculescu-Santana et al., 2017). This was probably because the puzzle-like containers were often placed in the water, which led to more time spent swimming to retrieve food during feeds and also looking for food at other times, as ASCO have demonstrated ability to remember food locations (Perdue et al., 2013), but did not lead to the desired changes in foraging on land and in all the ARBs targeted. The winter values for foraging on land and vigilance were very similar, the frequency of short calls was lower but that of begging was 1.5 times higher than in winter 2013. Using grapevine balls as food dispensers (Ross, 2002) and a system of catapults for randomised feeding times and locations in the enclosure (Hawke et al., 2000) proved to be effective in reducing ARBs in ASCO at other establishments, but did not increase foraging (Hawke et al., 2000). The limitations in space and scope for naturalistic foraging activities are a likely contributor to the prevalence of stereotypical behaviours in captive ASCO, who spend up to 40-60% of their time in the wild foraging (Heap et al., 2008) and in other otter species, such as the North American river otters *Lontra canadensis* (Morabito and Bashaw, 2012), who spend around 60% of their active time foraging and hunting in the wild (Davis et al., 1992). This suggested that more inventive or more varied feeding enrichment methods must be implemented to stimulate foraging.

Because the more varied feeding enrichments at the TAQ had only a limited impact on ARBs and the extra feed introduced in winter 2018 had some undesirable effects, an increase in the amount of food provided was considered. Hunger is suspected as a cause of ARBs in otters (Gothard, 2007) but nutrition guidelines for ASCO recommend caution with increasing the amount of food in the cold season to avoid unhealthy weight gain (Henry et al., 2012), as many otters become less active in cold weather (AZA, 2009). However, the otters at the TAQ became more active throughout the day in winter 2018 (November-December 2018) compared to summer 2016 and winter 2015. This was mainly due to the reduction in time spent resting and sleeping after the feed at 14:00, when they continued to forage, swim, run around and display vigilance, instead of retreating to their preferred sleeping place and engaging in affiliative social interactions and self-grooming prior to settling down to sleep (Cuculescu-Santana et al., 2017). They remained relatively restless during the rest of the observation time up to 15:50 when the aquarium was closed to the public. Resting, sleeping and play are key behavioural indicators of welfare and habitat quality in captivity, with the increased prevalence of play behaviours also being linked to nutritional availability in captive mammals (Gothard, 2007; Sarti Oliveira et al., 2010). Moreover, the temperatures in January 2019 were even lower than at the end of 2018, which ultimately led to the decision to return to 3 feeds/day and increase the amount of food to 30% weight/ body weight.

The renewed attempt to reduce the frequency of ARBs at the TAQ appeared to be more successful, as the percentage of time spent displaying vigilance decreased significantly in winter 2019 compared to winter 2018, to values similar to those recorded for winter 2015. The male otter also spent significantly less time swimming, slightly less time engaged in land locomotion and more time playing, resting and sleeping and out of sight in the den compared to all other seasons. The time spent in affiliative social interaction increased relative to winter 2018, to values still lower than those recorded in winter 2015 and summer 2016, although it is very likely that some affiliative social interaction occurred during the time spent out of sight in the den, under the heat lamp. The overall frequency of begging decreased to values lower than in all previous seasons and that of short calls decreased to values similar to those for winter 2015 and summer 2016. These changes in behaviour were consistent with the changes in enclosure use, with significant decreases in the use of the pools and the log bridges, where begging was usually displayed, as these were the closest to the areas where the keepers and the visitors were located or passing by, and significant increases in the use of the den and the climbing structures. The further decrease in the time spent swimming was most likely due to their faster rate of heat dissipation in cold water compared to the cold-adapted Eurasian otter *Lutra lutra* (Kuhn, 2009; Kuhn and Meyer, 2009). Water temperatures in January-March 2019 (winter 2019) were around 9-10°C, which is below the lower end of the thermoneutral zone for ASCO (16°C, Borgwardt and Culik, 1999) and below the recommended range of water temperatures for ASCO (18.3-29.4°C, Heap et al., 2008). The other changes in behaviour appeared to support the link between hunger and ARBs associated with feeding anticipatory activity proposed by Gothard (2007) and Cuculescu-Santana et al. (2017) and the link between play behaviour and a well-fed and healthy state proposed by Sarti Oliveira et al. (2010), with the additional food offsetting the increased energy requirements for thermoregulation and providing more energy for social and leisure behaviours.

It was interesting to note that in winter 2019 the otters still displayed a peak in begging and short calls around the time of the former mid-morning feed in winter 2018, which had not been seen in summer 2016, nor in winter 2015. No quantitative data were available for this interval in winter 2015, but qualitative observations of the second author during frequent visits to the TAQ suggested that the otters were usually sleeping between 10:30 and 12:30. The regularity of feeding times is known to influence the circadian rhythm of carnivores (Mistlberger, 2011), a process which allows for the optimal display of behaviours and physiological processes such as salivation and digestion in relation to the time of day (Bassett and Buchanan-Smith, 2007; Carneiro and Araujo, 2012) and it is very likely that the otters at the TAQ were still adjusting their circadian rhythm from that entrained by the feeding schedule used in winter 2018.

The analysis of the day-time activity patterns of the otters at the TAQ supported the hypothesis that repetitive begging is a more likely indicator of hunger (Gothard, 2007), while short calls are indicators of stress (Scheifele et al., 2015). In winter 2019, the values for begging before the feed at 14:00 were higher than in winter 2018, but during later afternoon they did not increase as much as in winter 2018 and were also lower than in summer 2016 and winter 2015. The frequencies of short calls before the feed at 14:00 and during later afternoon up to 15:30, were lower than in all other seasons, suggesting less stress associated with hunger when the amount of food was increased to 30% of body weight. It was not very clear why the frequency of long squeals was overall significantly higher in winter 2019 than in all other seasons, particularly between 13:00-14:00 and 15:10-15:50, when the keepers were passing by the otter enclosure more frequently. It is possible that this was related to the increased frequency of interaction between otters and keepers in February-March 2019 as part of the training to prepare them for travel, in the period leading up to their move to another establishment.

While this case-study is limited to one establishment and two otters, it provides useful insights into the impact of different changes in feeding strategy on the behavioural budgets, enclosure use and day-time activity patterns of a species for which only a small number of published peer-reviewed studies are available. Other limitations were the lack of more detailed information about any fluctuations in otter weights and the combined influence of seasonality and changes in feeding strategies on the otters' behaviour. We have tried to address the latter by providing data for a winter (2015) and summer (2016) season with similar feeding strategies and by using only the data for the time intervals covered in all four seasons for the main analysis of differences in behaviour and enclosure use.

CONCLUSIONS AND RECOMMENDATIONS

Increasing the amount of food provided per day from 20% to 30% of the otters' body weight proved to be more effective at reducing abnormal repetitive behaviours (ARBs) associated with feeding anticipation and stress than increasing the number of feeds from 3 to 4 per day, with the same total amount of food (20% of body weight).

Seasonal changes in temperature influenced the behaviour of captive Asian small-clawed otters, suggesting changes in thermoregulatory costs and energy budgets and highlighting the importance of considering how local climate affects enclosure conditions when assessing the nutritional, enrichment and climatisation needs of this tropical species of otters.

More research is needed into the behavioural and physiological effects of changes in temperature and feeding strategies on captive otters, to validate these findings.

Acknowledgements - The authors would like to thank Susie Lovick-Earle, Cassandra Naisbitt, Catherine Ward and all other staff at the Tynemouth Aquarium (formerly the Blue Reef Aquarium Tynemouth) for their enthusiasm and support with this project and for looking after the otters. The work was carried out within the standard workloads of staff and students at Northumbria University and staff at the Tynemouth Aquarium.

REFERENCES

AZA (2009). *Otter (Lutrinae) Care Manual*. Silver Spring, MD: Association of Zoos and Aquariums. 154 p.

Bassett, L., Buchanan-Smith, H.M. (2007). Effects of predictability on the welfare of captive animals. *Appl. Anim. Behav. Sci.* **102**(3-4)**:** 223-245.

Bateman, H.L., Bond, J.B., Campbell, M., Barrie, M., Riggs, G., Snyder, B., Swanson, W.F. (2009). Characterization of basal seminal traits and reproductive endocrine profiles in North American river otters and Asian small-clawed otters. *Zoo Biol.* **28:** 107-126.

Bishop, J., Hosey, G., Plowman, A. (2013) *Handbook of Zoo Research. Guidelines for Conducting Research in Zoos*. London. BIAZA. 231 p.

Borgwardt, N., Culik, B.M. (1999). Asian small-clawed otters (*Amblonyx cinerea*): resting and swimming metabolic rates. *J. Comp. Physiol. B* **169:** 100-106.

Carneiro, B.T.S., Araujo, J.F. (2012). Food entrainment: Major and recent findings. *Front. Behav. Neurosci.* **6:** 83. doi: https://doi.org/10.3389/fnbeh.2012.00083

Cianfrani, C., Broennimann, O., Loy, A., Guisan, A. (2018). More than range exposure: Global otter vulnerability to climate change. *Biol. Conserv.* **221:** 103-113.

CITES (2019) *Convention on International Trade in Endangered Species of Wild Fauna and Flora. Appendices I, II and III (26/11/2019).* United Nations Environment Programme, 75p.

Cuculescu-Santana, M., Horn, C., Briggs, R.N., Bowe, C., Geraughty, M.L. (2017). Seasonal changes in the behaviour and enclosure use of captive Asian small clawed otters *Aonyx cinereus*. *IUCN Otter Spec. Group Bull.* **34(1):** 29-50.

Cuculescu-Santana, M., Mason, J., Purchase, K., McKie, R. (2021). Outdoor enclosure use and behaviour of adult and cub Asian small-clawed otters *Aonyx cinereus* in summer and winter. *IUCN Otter Spec. Group Bull.* **38:** 3-27.

Davis, H.G., Aulerich, R.J., Bursian, S.J., Sikarskie, J.G., Stuht, J.N. (1992). Feed consumption and food transit time in Northern river otters (*Lutra canadensis*). *Journal of Zoo and Wildlife Medicine*, **23(2):** 241-244.

Dornbusch, T., Greven, H. (2009). Notes on keeping of Asian small-clawed otters (*Amblonyx cinereus*) in European zoos. *Zool. Garten* **78:** 75-80. [In German with English abstract].

Foster-Turley, P., Markowitz, H. (1982). A captive behavioral enrichment study with Asian small-clawed river otters (*Aonyx cinerea*). *Zoo Biology*, **1:** 29-43.

Gothard, N. (2007). What is the proximate cause of begging behaviour in a group of captive Asian short-clawed otters? *IUCN Otter Spec. Group Bull.* **24:** 14-35.

Harrington, L.A., Macdonald, D.W., D'Cruze, N. (2019). Popularity of pet otters on YouTube: evidence of an emerging trade threat. *Nat. Conserv.* **36:** 17–45.

Hawke, L., Lauer, P., Bartholomeusz, D., Steen, Z. (2000). Effects of increased food dispersal and random feeding time/ place on stereotyped behaviours in otters at Adelaide Zoo. *Int. Zoo News 47:* 71-81.

Heap, C.J., Wright, L., Andrews, L. (2008). *Summary of husbandry guidelines for Asian small clawed otters in captivity.* IUCN/ SSC Otter Specialist Group, Otters in Captivity Task Force. 17 p. http://www.otterspecialistgroup.org/osg-newsite/wp-content/uploads/2017/05/OCT_ASO_Husbandry_Guidelines_Summary.pdf

Henry, B., Maslanka, M., Heuer, K., Reed-Smith, J., Nidasio, G. (2012). *Summary of nutrition guidelines for otters in zoos, aquaria, rehabilitation and wildlife sanctuaries.* IUCN/ SSC Otter Specialist Group, Otters in Zoos, Aquaria, Rehabilitation and Wildlife Sanctuaries Task Force. 26 p.

Janusz, M.A. (2017) The effect of enrichment on the behaviour and enclosure use of Asian small-clawed otters (*Aonyx cinereus*) at the Blue Reef Aquarium Tynemouth. *BSc Project Report.* Northumbria University, Newcastle upon Tyne, UK. 55 p.

Kitade, T., Naruse, Y. (2018). *Otter Alert: A rapid assessment of illegal trade and booming demand in Japan.* TRAFFIC Japan Office, 31 p.

Kruuk, H. (2006). *Otters: ecology, behaviour and conservation*. Oxford University Press. 265 p.

Kuhn, R. (2009). Comparative analysis of structural and functional hair coat characteristics, including heat loss regulation, in the Lutrinae (Carnivora: Mustelidae). *PhD Thesis.* University of Hamburg, Hamburg, Germany. 225 pp.

Kuhn, R.A., Meyer, W. (2009). Infrared thermography of the body surface in the Eurasian otter *Lutra lutra* and the giant otter *Pteronura brasiliensis*. *Aquat. Biol.* **6:** 143-152.

Ladds, Z., Hoppitt, W., Boogert, N.J. (2017). Social learning in otters. *R. Soc. open sci.* **4:** 170489.

Larivière, S. (2003). *Amblonyx cinereus. Mamm. Species* **720:** 1-5.

Manns, M., Ströckens, F., Stavenhagen, P., Ocklenburg, S. (2018). Paw preferences in the Asian small-clawed otter – using an inexpensive, video-based protocol to study laterality of rare species in the zoo. *Laterality.* **23(6):** 722-737.

Martin, P., Bateson, P. (2007) *Measuring behaviour. An introductory guide*. 3rd Edition. Cambridge University Press. 176 p.

Mason, G. (2010). Species differences in responses to captivity: Stress, welfare and the comparative method. *Trends Ecol. Evol.* **25(12):** 713-721.

Mistlberger, R.E. (2011). Neurobiology of food anticipatory circadian rhythms. *Physiol. and Behav.* **104:** 535-545.

Morabito, P., Bashaw, M.J. (2013). A survey of abnormal repetitive behaviours in North American river otters housed in zoos. *J. Appl. Anim. Welf. Sci.* **15:** 208-221.

Perdue, B.M., Snyder, R.J., Zhihe, Z., Marr, M.J., Maple, T.L. (2011). Sex differences in spatial ability: A test of the range size hypothesis in the order Carnivora. *Biol. Lett.* **7:** 380-383.

Perdue, B.M., Snyder, R.J., Maple, T.L. (2013). Cognitive research in Asian small-clawed otters. *Int. J. Comp. Psychol.* **26:** 105-113.

Reed-Smith, J., Polechla, P.J.Jr. (2002). Husbandry and captive breeding of otters (Lutrinae) in North and Latin America: A synopsis of current progress. *Proc. VIIth International Otter Colloquium*, p 276-281. https://www.iucnosgbull.org/Volume19A/Vol19_A_Index.html

Rees, P.A. (2015). *Studying captive animals: A workbook of methods in behaviour, welfare and ecology*. Wiley-Blackwell. 301 p.

Ross, S.R. (2002). The effect of a simple feeding enrichment strategy on the behaviour of two Asian small-clawed otters (*Aonyx cinerea*). *Aquat. Mammals* **28:** 113-120.

Sarti Oliveira, A.F., Olieira Rossi, A., Romualdo Silva, L.F., Correa Lau, M., Barreto, R.E. (2010). Play behaviour in nonhuman animals and the animal welfare issue. *J. Ethol.* **28:** 1-5.

Scheifele, P.M., Johnson, M.T., Fry, M., Hamel, B., Laclede, K. (2015). Vocal classification of vocalizations of a pair of Asian Small-Clawed otters to determine stress. *J. Acoust. Soc. Am.* **138:** EL105-EL109.

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*). *Anim. Cogn.* **20(6):** 1107-1114.

Wright, L., de Silva, P., Chan, B., Reza Lubis, I. (2015). *Aonyx cinereus*. The IUCN Red List of threatened species 2015. Downloaded 30 January 2016. Available from https://dx.doi.org/10.2305/IUCN.UK.2015-2.RLTS.T44166A21939068.en

RÉSUMÉ

STRATÉGIES D'ALIMENTATION DE LA LOUTRE CENDRÉE (A*onyx cinereus*, Illiger, 1815) EN CAPTIVITÉ : QUELLES MESURES EFFICACES POUR RÉDUIRE ANTICIPATIVEMENT L'ACTIVITÉ RÉPÉTITIVE D'ALIMENTATION DURANT LA SAISON FROIDE ?

Cette étude de cas a analysé le comportement et l'utilisation de l'enclos d'un couple de loutres cendrées pour étudier l'impact des changements de stratégie d'alimentation sur les comportements répétitifs associés à l'anticipation de l'alimentation, dans le contexte de l'influence des changements saisonniers de température sur ces mammifères tropicaux.

Les loutres ont un comportement de moindre natation, repos et sommeil mais davantage de mendicité, de vocalisations et de vigilance globale en hiver par rapport à l'été, suggérant un plus grand appétit dû aux besoins énergétiques accrus pour la thermorégulation.

L'introduction d'un complément alimentaire en milieu de matinée en hiver sans augmenter la quantité totale de nourriture par jour n'a été que partiellement efficace sur les comportements ciblés. Les manifestations de vigilance et les vocalisations globales ont augmenté de manière significative, le repos et le sommeil ont diminué, mais la mendicité n'a pas changé par rapport aux valeurs hivernales et estivales précédentes. La mendicité avant le repas de 14h était moins fréquente, suggérant un moindre appétit à ce moment-là, mais a augmenté vers des valeurs plus élevées en fin d'après-midi.

Une augmentation journalière de la quantité totale de nourriture de 20 % à 30 % du poids corporel de la loutre en janvier 2019, avec un retour à 3 repas/jour, a été plus efficace pour réduire les comportements ciblés. Il y a eu une diminution des manifestations de vigilance globale et des fréquences de mendicité et d'appels courts et une augmentation des comportements de jeu, des interactions sociales d'affiliation et du repos et du sommeil, suggérant une réduction des niveaux de faim et de stress associés.

Cette étude a souligné l'importance de voir comment le climat local affecte les conditions de captivité lors de l'évaluation des besoins nutritionnels, d'enrichissement et de climatisation de l'enclos pour les loutres cendrées.

RESUMEN

ESTRATEGIAS DE ALIMENTACIÓN PARA NUTRIAS DE UÑAS PEQUEÑAS ASIÁTICAS (A*onyx cinereus*, Illiger, 1815) EN CAUTIVERIO: ¿QUÉ ES LO QUE FUNCIONA PARA REDUCIR LA ACTIVIDAD ANTICIPATORIA REPETITIVA DE ALIMENTACIÓN DURANTE LA ESTACIÓN FRÍA?

Este estudio de caso analizó el comportamiento y el uso del recinto por una pareja de Nutrias de Uñas Pequeñas Asiáticas, para investigar el impacto de cambios en la estrategia de alimentación sobre los comportamientos repetitivos asociados a la anticipación de la alimentación, en el contexto de la influencia de los cambios estacionales de la temperatura en estos mamíferos tropicales.

Las nutrias desplegaron menos natación y descanso, menos sueño y más actividad de pedir, vocalizaciones y vigilancia general en invierno en comparación con el verano, lo que sugiere que tenían más apetito debido al aumento de la demanda energética para termoregulación.

La introducción de una sesión de alimentación a media mañana durante el invierno, sin aumentar el monto total de comida por día, fue sólo parcialmente efectiva respecto a los comportamientos que se evaluaban. Los despliegues de vigilancia general y las vocalizaciones aumentaron significativamente, el descanso y el sueño disminuyeron, pero la actividad de pedir no cambió, en comparación con valores de inviernos y veranos previos. La actividad de pedir antes de la sesión de alimentación de las 14:00 hs fue menos frecuente, lo que sugiere que tenían menos apetito en ese momento, pero se incrementó a valores más altos más avanzada la tarde.

Algo que fue más efectivo para reducir los comportamientos señalados, fue un incremento -en Enero de 2019- en el monto total de alimento por día, de 20% del peso corporal a 30 %, volviendo a 3 sesiones de alimentación/día. Hubo disminuciones en los despliegues de vigilancia y en las frecuencias de “pedir” y de llamads cortos, y aumentos en los comportamientos de juego, interacciones sociales afiliativas y descanso y sueño, lo que sugiere una reducción en los niveles de hambre y el stress relacionado.

Este estudio enfatiza la importancia de considerar cómo el clima local afecta las condiciones de los recintos, cuando se evalúan las necesidades nutricionales, de enriquecimiento y climatización de las nutrias de uñas pequeñas asiáticas.

ViRTUAL OTTERS

RIVER OTTER JOURNAL - A HISTORICAL ARCHIVE

The River Otter Journal was the news publication of the River Otter Alliance (ROA) from 1991 to 2013. It is a charming and eclectic mixture of science, poetry, anecdote, games and puzzles, which both entertained and informed.

A historical archive of the River Otter Journal has been set up by agreement with the board of the ROA by Victor Camp and Tom Serfass, under the aegis of the IUCN/SSC Otter Specialist Group, and is hosted by the Bulletin of the IUCN/SSC Otter Specialist Group.

The publications are available at https://riverotterjournal.org/index.html

ROA was founded as a non-profit tax-exempt organization in June 1991 by Carol S Peterson, John Mulvihill Esq., and biologists Leslie Malville and Joe Powell "to promote the survival of the North American River Otter (*Lontra canadensis*) through education, research, reintroduction and habitat protection". The goals were to support current research and reintroduction programs, monitor abundance and distribution in the United States and educate the general public through our newsletter, The River Otter Journal which focused on topics primarily related to the North American River Otter, however, included information on all thirteen species of otters. The goal was to be a center of communications among wildlife biologists, environmental organizations, fishermen, and all interested parties on a national and international basis in order to ensure the healthy future of the river otter. The membership included persons throughout the world from a broad range of vocations, research scientists, biologists, wildlife officials, rehabilitators, and "otter enthusiasts" of all ages.

Lesley Wright

O S G N E W S

NEW MEMBERS OF OSG

Since the last issue, we have welcomed 4 new members to the OSG: you can read more about him on the Members-Only pages.

Taisa Adhya, India: While working on the Fishing Cat, my team discovered the presence of Eurasian Otters in Chilika, Asia's largest brackish water lagoon and India's oldest Ramsar site. This is the first record of the Eurasian Otter from the Indian East coast. The Smooth coated Otter is also present in Chilika. Our results establish that Chilika gives refuge to a viable and breeding population of both otters. My main area of interest lies in understanding what processes lead to the co-occurrence of all three wetland mammals in Chilika. Going forward, I will propose a science based conservation and management plan for protection of all three species in this landscape which is located completely outside the purview of protected areas.

Macarena Barros, Chile: My interests are sursurveillance and epidemiological evaluation of Toxoplasma gondii, distemper, parvovirus and leptospira in dogs and domestic cats, American mink and the Southern river otter in southern Chile. I am currently leading a FIPA 2018-28 project "Distribution, abundance and risks for the conservation of Southern river otter in the Allipén and Toltén river, IX Region of Araucanía" where we are mainly working with camera traps and capturing individuals: www.proyectohuillin.org.

Mišel Jelić, Croatia: I have worked on nature and biodiversity protection since 2005, leading a variety of field survey projects, including Natura 2000 implementation project "Investigation of the Distribution of Otters (Lutra lutra L.) in the Continental Part of Croatia". I am currently working on the genetic structure of otter populations along the rivers bordering Croatia, and Slovenia and Hungary. My current and historical distribution data has been found very useful by other researchers. In the future I intend to make as much of my data available as possible.

Manfred Meiner, Mexico: I am a biologist and conservation photographer that has documented the Neotropical River Otter. I believe in the power of images to connect people beyond words. Website: manfredmeiners.coma.