A R T I C L E

THE INFLUENCE OF WATER LEVEL ON THE DETECTION OF SIGNS OF NEOTROPICAL OTTERS (*Lontra longicaudis*) ON A FLOOD PLAIN.

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ABSTRACT: The aim of this study was to characterize the habitat used by the Neotropical Otter on a section of the floodplain, and to examine the influence of river level on the detection of scent marking, defined as spraint and/or anal mucus. Over one year, a section of 6 km of the left bank of the Paraná River was searched for scent marking. Those sites were classified by the type of substrate and frequency of use. A linear regression analysis was applied between river level and the number of marking sites found. Most of the positive sites have rocky substrate, followed by sandy. Just over half of the marking sites were only used occasionally, and few sites were associated with high activity. The abundance of rocky substrate when river level is low is probably responsible for the high frequency of otter sign detected. We suggest that studies on *Lontra longicaudis* marking in a floodplain should be carried out during periods of lower river level to facilitate the finding of otter sign. We emphasize that estimates of density and habitat preference cannot be based solely on marking sites, because both this behaviour and its detection are subject to variations due to many factors, including the oscillation of the river level.
Keywords: Scent Marks; Substrate; *Lontra longicaudis*; Paraná River; Atlantic Forest.
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INTRODUCTION

The Neotropical otter, *Lontra longicaudis* (Olfers, 1818), is a semiaquatic mustelid, distributed from Mexico to Uruguay, including most of Brazil (Almeida and Pereira, 2017; Rheingantz et al., 2017). Habitat includes rivers, brooks, lakes, riverbanks, flooded areas, artificial ponds, coastal areas and estuaries; this species can be diurnal or nocturnal, depending on where they live, and can live in pairs or be solitary (Indrusiak and Eizirik, 2003; Rheingantz et al., 2016; Rheingantz et al., 2017). Otters are known for marking their territory with scratches, faeces and anal mucus (Pardini and Trajano, 1999). However, territoriality in these species is different from other carnivores, as otters mark high trophic resource areas in their territories rather than territorial boundaries (Roberts et al., 2016). Marking sites are usually conspicuous places, such as natural rock formations, outside burrows carved in ravines, fallen logs and spaces between tree roots along the banks of watercourses (Quadros and Monteiro-Filho, 2002), or structures built by man, such as concrete slabs (Louzada-Silva et al., 2003).Several ecological and biological studies with otters

use scent marks to understand the use of these marking sites, including research on the type of substrate and the method of use (Quadros and Monteiro Filho, 2002; Kasper et al., 2004; Uchôa et al., 2004; Kasper et al., 2008). In addition, they associate the otter's marking behavior with seasonality, mainly in relation to the seasons (MacDonald and Mason, 1987; Soldateli and Blacher, 1996; Ruiz-Olmo and Gósalbez, 1997; Uchôa, 2004; Olson et al., 2008; Crimmins et al., 2009).

River floodplain systems present temporal variations in biotic and abiotic factors (Vazzoler et al., 1997). In these systems, the hydrological regime is the main factor for maintaining biodiversity and ecological processes (Neiff, 1990). This hydrological regime is naturally regulated by flood pulses (Junk et al., 1989), which are responsible for temporarily connecting the flooded areas with the main river. The increasing number of hydropower dams worldwide is now considered one of the greatest threats to the biota of continental aquatic environments (Rahel, 2007). In addition, the operation of dams directly influence the flood pulse of rivers, because the dams are controlled according to the need for energy production, and thus river levels on dammed rivers are no longer determined by natural climatic conditions (Agostinho et al., 2013; Winemiller et al., 2016). The floodplain of the Upper Paraná River is located between two dammed reservoirs (Agostinho et al., 2013), and a reduction of the flood pulse frequency and intensity after the construction of the Porto Primavera dam has been observed (Rocha, 2010). This variation in the flood pulse directly interferes with otter habitat, since they use the water margins as shelter and for defaecation and marking of territory (Waldemarin and Colares, 2000; Quadros and Monteiro-Filho, 2002).

In this context, the objectives of this work were: (i) to determine the type of substrate where scent marking is commonly found and (ii) investigate the influence of river level on the detection of marking sites. These results are important to underpin data from future studies in flooded areas that are subjected to different anthropic pressures, like the construction of more hydropower dams.

MATERIALS AND METHODS

Study Area

The Paraná river is the main river of the floodplain, being the tenth in the world in river outflow (5x108 m^3 $year^{-1}$) (Agostinho et al., 2013). The study area is on the floodplain of the Upper Paraná River, located in the Environmental Protection Area of the 'Islands and Floodplains of the Paraná River'; it is between the confluences of the Paranapanema and the Ivinhema Rivers with the main watercourse. The location has many types of aquatic environment, such as rivers, ponds and streams, and is characterized by the occurrence of seasonally flooded environments (Thomaz, 1997).

Sampling was carried out on the left bank of the Paraná River. Two sections of 3 km each were selected, both located next to urban areas (22º45'21"S/53º14'19"W and 22º46'7"S/53º15'59"W; 22º43'3"S/53º10'39"W and 22º42'13"S/53º9'0"W) and with a distance of 8 km between them (Figure 1). The two stretches were considered a single study area, amounting to 6 km of sample distance. In this region, the bank consists mainly of rocky cliffs, and the riparian forest is composed of typical species of the Atlantic Forest.

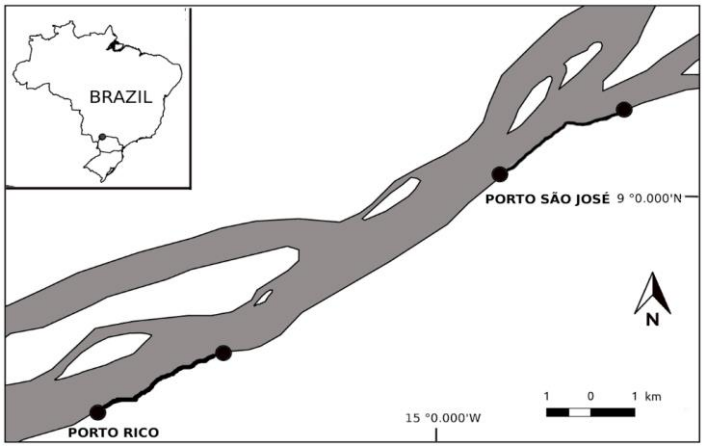


Figure 1: Study area on Paraná River, Brazil.

Sampling

The monthly surveys were carried out between January and December 2016, apart from May. The bank in each section was traversed on foot and by boat in search of marking sites, which we defined as a place with at least one faecal sample and/or anal mucus (Quadros and Monteiro-Filho, 2002). The observations were restricted 1 - 3 m from the water's edge, since several studies most otter movement is within this margin (Kasper et al., 2008; Pardini and Trajano, 1999). The marking sites were classified according to the type of substrate, which can be rocky, sandy, trunk or mixed (presence of branches, trunks, sand and stones), georeferenced using the GPS Network and monitored every subsequent month.

Data Analysis

In order to understand the behaviour of *L. longicaudis* in these sections, a descriptive analysis was carried out based on the frequency of each type of substrate and the frequency of use of the marking sites. They were classified as occasional (1 to 3 months of use seen), frequent (4 to 7 months of use) and intense (8 to 11 months of use) (Colleti et al., 2013). To identify the relationship between the detection of the site and the variation in river level, a linear regression was performed, with the number of marking sites detected as a response variable and the mean of the river level of sampling days as a predictor variable in each sample. A log transformation was applied to meet the assumption of homoscedasticity of this analysis. The same analysis was performed using the mean rainfall on sampling days to compare the data, and to exclude the possibility that rain might remove the spraints. All analyses were performed in STATISTICA 7.0.

RESULTS

During the period of the study, 105 marking sites were found on various substrates. The most frequently used sites were rocky substratum (86.7%), some with cavities and others by bare rock. Sites with sandy substrate (6.7%) were generally covered by roots of tree species and occasionally other types of traces were found, such as footprints and scratches (Figure 2A). The majority (53.3%) of the sites were used only occasionally; 37.1% appeared to be frequently used. Both of these covered all types of substrates except tree trunks, which were only occasionally used. Only 9.5% of the marking sites were classified as heavily used; all of these consisted of rocky substratum. Of these, two were formed by a large rocky cavity surrounded by roots (Figure 2B).

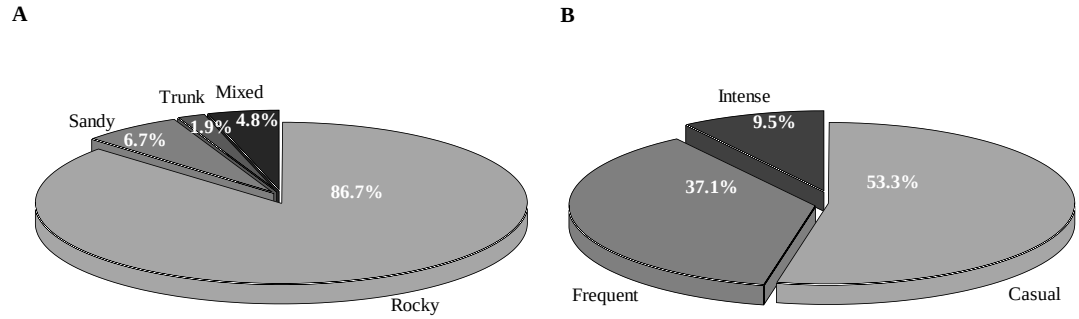


Figure 2: Frequency of substrate type (A) and use of marking sites (B) by *Lontra longicaudis* in a section of the left margin of the Paraná River during 2016.

The linear regression analysis between river level and the number of marking sites detected revealed a statistically significant relationship (R^2=0.73 and P<0.05): these variables were negatively correlated, i.e. as the river level increases, fewer marking sites are observed (Figure 3). In January, the month with the maximum peak of medium depth (595.8 cm), no marking sites were observed at all. Similarly, in March only two were observed, when the average level of the river was 422.1 cm. On the other hand, in July, a drought month with low average depth (200.3), 56 sites were observed, with levels being lower only in August (66 sites in 207 cm of depth), September (58 sites in 220 cm) and November, a month which, according to the literature is the beginning of flood, but that still showed only 241 cm of depth, and with 62 marking sites observed. February presented a low average depth of river (281 cm), even though it was supposed to be a flood season month, but only four marking sites were found (Figure 4). The analysis with the rainfall showed no correlation with the detection of marking sites (R^2=0.01 and P =0.76).

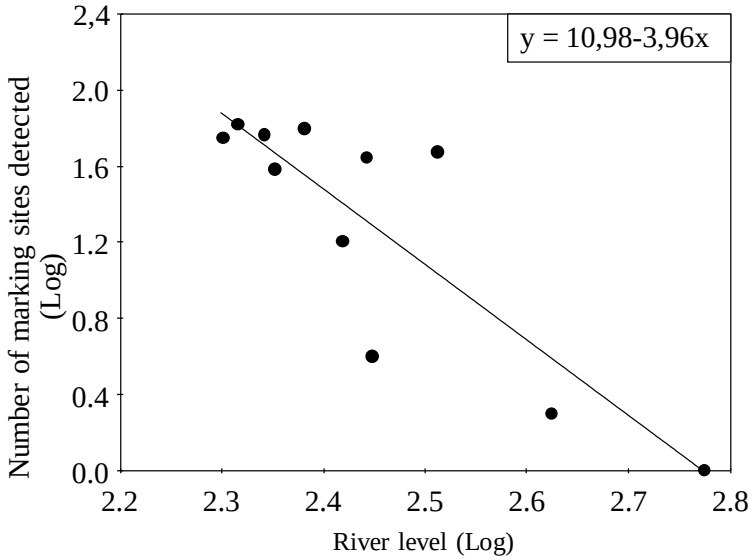


Figure 3: Correlation (line) among the river water level on the *Lontra longicaudis* marking sites observed during 2016. Both variables were log-transformed.

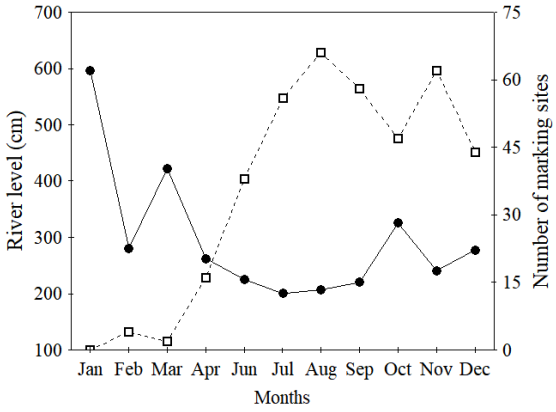


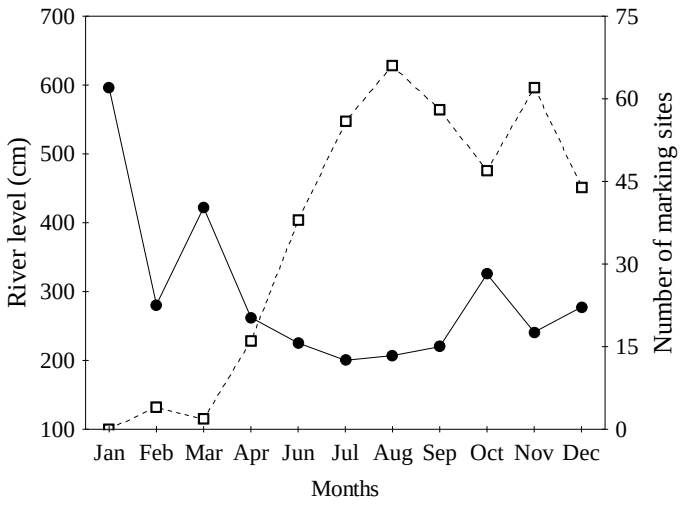
Figure 4: Values of the water level of the Paraná River (circles) and marking sites (squares) observed during 2016.

DISCUSSION

The most used sites found were on rocky substrates, agreeing with the findings in other studies, in which the majority of spraints were found on rocks, followed by sandy cavities (Pardini and Trajano, 1999; Kasper et al., 2004; Uchôa, 2004). These markings were also observed on fallen logs, as also recorded by Kasper et al. (2004; 2008). On the other hand, Santos and Reis (2012), found spraint mainly on bare soil and grass along streams. This indicates that the choice of marking position on the conformation of the banks, and thus the substrate available – in this study, the banks were mainly rocky, indicating that otters did not show any bias against rocky substrates, but does not establish a preference for it. In fact, it appears that the Neotropical otter shows high plasticity in the choice of scent marking sites, tending to be generalist in relation to the habitat structure (Coletti et al., 2013).

Most marking sites were only used occasionally; this pattern was found in several other studies (Pardini and Trajano, 1999; Quadros and Monteiro Filho, 2002; Kasper et al., 2004; Colleti et al., 2013). The higher concentration of spraints at certain points is possibly associated with sites most used by the animal, a behaviour also observed for *Lutra lutra* (Green et al., 1984) and *Lontra canadensis* (Melquist and Hornocker, 1983). However, observational studies of faeces alone cannot confirm preference of use for that location by the species, since many factors can hinder observation of evidence, such as the presence of litter and changes in river level (Quadros and Monteiro-Filho, 2002).

When the river level was low, more marking sites were found, which could be explained by the greater availability of suitable sites on exposed rocky substrate, which also easier to find otter sign on (faeces, scratches, footprints, anal mucus, etc) than other substrates.. In addition, since high water levels wash away the markings, an increase in "re-marking" could be expected following this (Quadros and Monteiro-Filho, 2002; Roberts et al., 2016). Roberts et al. (2016) found greater relative occurrence of spraints with mucus in similar post-flood conditions. Almeida et al.



(2012) observed a greater probability of finding latrines when the river depth was lower. There are many possible factors for this result, such as prey availability and reproduction (Roberts et al., 2016). This way, the oscillation of spraint number with the alternation of the periods is not necessarily related to the density of otters, so it is therefore not possible to estimate population indirectly using only otter sign (Jenkins and Burrows, 1980; Pardini and Trajano, 1999; Ruiz-Olmo et al., 2001).

As the river level rises and floods the adjacent areas, most of marking sites and are washed away (Ruiz-Olmo and Gosálbez, 1997). During flooding, in some places, the river bank will have steep rocky walls or, in others, a flatter area covered by vegetation, thus reducing the number of places available for spraint deposition. As a result of physical conditions, access to certain sites for researchers is hampered by the slope of the terrain or the density of vegetation. In addition to inaccessibility, the areas next to the water margin are typically litter-strewn, which makes it much harder to see tracks or spraint (Quadros and Monteiro-Filho, 2002). The lack of traces in February, a month with low river level but only four observed sites, can be attributed to the high fluctuation of the river level in this specific year. Historically, it would be expected that the river level would be high in this month, but due to climatic factors, it had dropped in February and risen again in March. Thus, our results showed that the regulation of river level influences the available habitat of otters on Paraná River, and the operation of hydroelectric situated upstream could be a limiting factor on the living area available to the otter population.

CONCLUSION

If a study area is situated on a floodplain, it will undergo seasonal variations due to the flood pulse, which would normally be heavily influenced by rainfall. When, however, there are upstream dams, operated to regulate flow for energy generation, (Agostinho et al., 2009), this has a much greater effect on flow, with river level potentially oscillating even over a single day.

According to our results, the detection of scent marks (spraint, anal mucus and other otter sign) is affected by river level, which negatively affects the accuracy of visualization of the marking behaviour of the species. The absence of relation between the detection of scent marks and rainfall supports the accuracy of this discovery, indicating that river level acts as the major regulatory agent of the detection of scent marking. This indicates that river level fluctuations, must be taken into account when designing studies or drawing conclusions based on detection of otter spraint.

We also conclude that the greater availability of rocky substrate, and the greater ease of observation of otter spraint etc on it, means that more otter sign was observed on this type of substrate, rather than it being a preference of the animal. We suggest that low river level is the best period to look for signs of otters, because the available substrate is easier to access for survey, and otter sign is easier to see.

The great influence of upstream hydroelectric dams on river level, and available habitat for otters, and the fact that flow is regulated entirely to meet the demands of energy production, means that they should be considered a potential threat to the otter population.

For this reason, long-term studies are necessary to monitor the otter population, and are essential for the development of mitigation and conservation measures. We emphasize that marking studies alone do not indicate habitat preference or population density, because spraint and so on are so easily removed by environmental factors such as river level. Moreover, we suggest that future research should be carried out to

investigate seasonality of otter marking behavior and the impact of daily fluctuations of river level as a result of dam flow regulation on otter behavior.

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RÉSUMÉ

LA DÉTECTION DU MARQUAGE DE LA LOUTRE À LONGUE QUEUE (*Lontra longicaudis*) INFLUENCÉE PAR LE NIVEAU D'EAU EN PLAINE INONDABLE

Le but de cette étude était de caractériser l'habitat utilisé par la loutre à longue queue sur une section donnée de la plaine inondable et d'examiner l'influence du niveau de la rivière sur la détection du marquage olfactif, défini comme épreinte et/ou sécrétion anale. Durant un an, des marquages olfactifs ont été recherchés sur une section de 6 km en rive gauche de la rivière Paraná. Nous avons classé ces sites en fonction du type de substrat et de la fréquence d'utilisation. Une analyse de régression linéaire a été appliquée entre le niveau de la rivière et le nombre de sites de marquage trouvés. La plupart des sites positifs ont un substrat rocheux, ensuite sableux. Un peu plus de la moitié des sites de marquage n'étaient utilisés qu'occasionnellement et peu de sites étaient associés à une activité élevée. L'abondance du substrat rocheux, lorsque le niveau de la rivière est bas, est probablement responsable de la fréquence élevée d'indices de présence de loutre. Nous suggérons que des études sur le marquage de *Lontra longicaudis* dans une plaine inondable soient effectuées pendant les périodes d'étiage de la rivière afin de faciliter la détection d'indices de présence de la loutre. Nous tenons à souligner que les estimations de densité et de préférence d'habitat ne peuvent pas être basées uniquement sur les sites de marquage, car ce comportement et sa détection sont sujet à des variations dues à de nombreux facteurs, en ce compris la variation du niveau de la rivière.

RESUMEN

DETECCIÓN DEL MARCADO POR NUTRIAS NEOTROPICALES (*Lontra longicaudis*), INFLUENCIADA POR EL NIVEL DE LAS AGUAS FLUVIALES EN UNA PLANICIE DE INUNDACIÓN

El objetivo de este estudio fue caracterizar el hábitat utilizado por la Nutria Neotropical en una sección de la planicie de inundación y examinar la influencia del nivel del río en la detección de sus sitios de marcado, los que están formados esencialmente por marcas de olor y/o mucosidad anal. A lo largo de un año, inspeccionamos una sección de 6 km sobre la margen izquierda del Río Paraná, buscando signos de marcado. Esos sitios fueron clasificados en cuanto al tipo de sustrato y la frecuencia de uso. Aplicamos un análisis de regresión lineal, entre el nivel del río y el número de sitios de marcado encontrados. La mayoría de los sitios positivos tienen sustrato rocoso, seguido por arenoso. Un poco más de la mitad de los sitios de marcado fueron usados sólo ocasionalmente, y pocos estuvieron asociados con alta actividad. La abundancia de sustrato rocoso cuando el río está bajo, es probablemente la responsable de la alta frecuencia de signos de nutria detectada. Sugerimos que los estudios de marcado de *Lontra longicaudis* en planicies de inundación deberían llevarse a cabo en períodos de bajo nivel de los ríos, para facilitar el hallazgo de signos. Enfatizamos que las estimaciones de densidad y de preferencia de hábitat no pueden basarse solamente en los sitios de marcado, porque tanto este comportamiento como su detección están sujetos a variaciones debidas a muchos factores, incluyendo la oscilación en el nivel de los ríos.

RESUMO

INFLUÊNCIA DO NÍVEL DO RIO NA DETECÇÃO DE MARCAÇÕES DE LONTRA NEOTROPICAL (*Lontra longicaudis*) EM UMA PLANÍCIE DE INUNDAÇÃO

O objetivo desse estudo foi caracterizar o habitat utilizado pela Lontra Neotropical em um trecho de planície de inundação e avaliar a influência do nível do rio na detecção de locais de marcação, que são essencialmente demarcados por sinais odoríferos. Ao longo de um ano, um trecho de 6km na margem esquerda do rio Paraná foi vistoriado à procura de pegadas, fezes e muco anal. Esses locais foram caracterizados pelo tipo de substrato e frequência de uso. Além disso, foi aplicada uma análise de regressão linear entre o nível do rio e o número de marcações encontradas. A maioria dos locais encontrados apresentou substrato rochoso, seguido por areia. Pouco mais da metade dos locais de marcação foram ocasionais e poucos foram associados à elevada atividade animal. A elevada presença de substrato rochoso nesse local quando o rio está baixo provavelmente é responsável pela elevada frequência de sinais de marcação encontrada. Sugere-se que estudos com marcação de *Lontra longicaudis* em planície de inundação devem ser realizados em períodos com baixo nível do rio para facilitar o encontro de sinais de marcação. Enfatizamos que estimativas de densidade e de preferência de habitat não podem ser baseados em locais de marcação, porque este comportamento é sujeito a variações devido a vários fatores, como a oscilação do nível do rio.