

ORIGINAL ARTICLE

Relationship of Neotropical otter vestiges with environmental and anthropogenic factors

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ABSTRACT

The Neotropical otter, *Lontra longicaudis* (Mustelidae) is a semi-aquatic mustelid that exploits a variety of freshwater habitats. To understand the relative influence of human activities and environmental factors affecting its distribution and habitat use, we conducted systematic, seasonal surveys of otter signs along the middle Guamá River, in Pará state in the eastern Brazilian Amazon. We applied generalized additive models to compare distribution of otters along the river with data collected on environmental factors (landcover type derived from satellite imagery, and *in situ* measurements of physicochemical water characteristics) and anthropogenic factors (fishing gear in the river and human habitation along the river). Most otter signs (indicators of otter habitat use) occurred along the shoreline of the main river channel during the dry season; we observed fewer signs during peak flow, probably because the shoreline and floodplain are flooded, which hid signs and made access to the floodplain difficult. The best-fit model included variables for proportion of forest, presence of fishing gear and boats, bank steepness, and presence of rock formations and sand banks. Otter occurrence was negatively related to forested area and positively related to the presence of fishing gear and boats. Otters are likely attracted to fish trapped in fishing gear because they can easily predate on the trapped fish.

KEYWORDS: anthropogenic impact; habitat use; *Lontra longicaudis*, Amazon

Relação entre os vestígios de lontra neotropical e fatores ambientais e antropogênicos

RESUMO

A lontra neotropical, *Lontra longicaudis* é um mustelídeo semiaquático que usa seu habitat de diferentes formas. Para entender a influência relativa de fatores antrópicos e ambientais sobre a distribuição de lontras neotropicais, nós conduzimos monitoramentos sistemáticos de vestígios de lontras na região do médio Rio Guamá, Pará, Amazônia Oriental. Modelos aditivos generalizados foram usados para analisar a associação entre a ocorrência de lontras ao longo do rio e variáveis ambientais (cobertura da terra derivada de imagens de satélite e características físicoquímicas da água medidas *in situ*) e fatores antrópicos (presença de apetrechos de pesca e comunidades humanas ao longo do rio). A maioria dos vestígios de lontras foi encontrada ao longo das margens do rio durante a estação seca. Obtivemos um número muito menor de registros durante a cheia do rio, provavelmente devida à inundação da linha costeira e da planície de inundação, o que obliterou os sinais e dificultou o acesso à área alagada. O modelo de melhor ajuste incluiu como variáveis explicativas a área florestada, a presença de apetrechos de pesca e barcos, a inclinação das margens e a presença de formações rochosas. A ocorrência de registros de lontra foi relacionada negativamente com a proporção de áreas florestadas, e positivamente com a presença de apetrechos de pesca e barcos. As lontras provavelmente são atraídas por peixes presos em artefatos de pesca, pois podem facilmente preda os peixes presos.

PALAVRAS-CHAVE: impacto antrópico, uso de habitat, *Lontra longicaudis*, Amazônia**CITE AS:** Andrade, A.M.; Arcoverde, D.L.; Albernaz, A.L. 2019. Relationship of Neotropical otter vestiges with environmental and anthropogenic factors. *Acta Amazonica* 49: 183-192.

INTRODUCTION

River otters are semi-aquatic, territorial predators that exploit a variety of riparian habitats. For example, river otters use holts (dens), tree hollows, and sandbanks along waterbodies as sheltering and resting places, particularly along vegetated shorelines that provide protection from predators and extreme weather events (Crowley *et al.* 2012, Gomes Jr 2009). Habitat use of riparian zones is influenced by seasonal fluctuations, hydrologic regimes and availability of prey (Rodríguez and Lewis 1997).

Signs (indicators of habitat use), such as feces and footprints of Eurasian otters (*Lutra lutra*) primarily occur along river margins of mostly intact riparian forests, which may be due to the fact that otter signs are better preserved in intact environments than in altered habitats (Jenkins and Burrows 1980). In altered environments, where riverbanks are more exposed (cleared of native vegetation), Eurasian otters tend to mark their territories more frequently with feces (Kruuk and Hewson 1978).

The Neotropical otter, *Lontra longicaudis* (Olfers 1818) (Mustelidae) (hereafter referred to as otter), is a semi-aquatic species that ranges from Mexico to Argentina, and has recently expanded into northeastern Brazil (Rheingantz *et al.* 2014, Rosas-Ribeiro 2017). Two key factors influencing how otters use their habitat are availability of resources and the degree to which riparian habitats have been altered by humans (Arellano Nicolás *et al.* 2012).

Habitat use of riparian zones by otters appears to be related to channel characteristics, such as depth, transparency, and/or velocity of water, or the proximity to particular habitats, such as forests, rock formations and sandbanks (Pardini 1998). Otters are known to prefer to search for prey in lentic environments, such as reservoirs (Pardini 1998, Quadros 2012), but Emmons and Feer (1997) claim that otters prefer to feed in clear, fast flowing streams. Otters appear to inhabit clearer rather than murky rivers (Quadros and Monteiro-Filho 2001), perhaps because prey can be detected and captured more efficiently in clearer waters (Quadros 2012).

In addition to the many natural environmental factors affecting riparian habitat use by otters, human alterations also impact otter distribution in three main ways: (a) via aquatic habitat degradation (Brandt 2004), such as water pollution created by road construction, deforestation, and habitat fragmentation, (b) by the presence of watercrafts, which otters avoid, presumably due to engine noise, and (c) via direct conflicts between otters and humans, when they prey on the same riparian resources, specially fish (Gomes 2009). Conflict with humans is particularly problematic when otters regularly prey on poultry (Marchini and Macdonald 2012) and when they damage fishing gear (Barbieri *et al.* 2012, Castro *et al.* 2014, Rosas-Ribeiro 2017), both of which have led to retaliation by humans.

In structurally complex riparian habitats and landscapes, it is sometimes difficult to detect otter signs along riverbanks, especially when streamside vegetation is abundant and dense, as

is the case along many Amazonian rivers. In fact, otters often hide in dense riparian vegetation (Gomes 2009), making it difficult to visually locate otters, and even their signs, which, in turn, makes it difficult to evaluate factors related to habitat preference of otters.

The Guamá River, which flows past the city of Ourém, in the eastern Brazilian Amazon, has been impacted by numerous human alterations over the past several years, including gravel mining in the riverbed and construction of housing along riverbanks. Both activities detrimentally impacted otters by increasing sediment load in flowing water and destroying fringing vegetation that otters use for hiding and resting. In addition, subsistence fishing has contributed to a decline in local fish populations, forcing otters to raid fishing nets of fishermen (personal observations of the authors and communication with local residents).

Therefore, to better understand how otters are affected by environmental factors and how they are impacted by human alterations to the riverine ecosystem of the Guamá River, namely fishing intensity and urban development, we assessed the distribution of otters and variables related to otter habitat and human stressors along the river.

MATERIAL AND METHODS

Study Area

This study was conducted in the middle reaches of the Guamá River, approximately 40 km in linear distance (80 km in river distance) from Ourém (State of Pará), northern Brazil (1°36'34.73"S, 47°18'57.57"W; 1°33'39.49"S, 47°5'49.74"W). We sampled riverbanks (vegetated and non vegetated), sand beaches, rock ledges, outlets from lakes and tributary streams, and riparian vegetation. The riparian zone of the sampled river section supports three main types of vegetation: secondary forest, also known as "capoeira forest," Alluvial Dense Tropical Rainforest, and Lowland Dense Tropical Rainforest (Martins and Cavararo 2012).

The climate of the region is tropical humid, marked by precipitation in all months of the year and without a defined dry season (type "Af" in the Köppen-Geiger classification) (Carvalho Junior 2008). Maximum temperatures range from 34 to 40 °C, and minimum temperature is 20 °C (Carvalho Junior 2008). In Ourém, the average annual precipitation was 2400 mm between 1997 and 2006, and relative humidity ranged from 75% to 95% (Carvalho Junior 2008). The average annual variation in the river level was 3.7 m between 1993 and 2015, with mean elevation ranging from a minimum of 1.3 m and a maximum of 5 m asl (ANA 2016). In 2015 and 2016, water level was lowest in November and highest in April or May (Figure 1). The rainy season occurs from January to May, with much less rain falling from June to November (Figure 2). The Guamá River encompasses several local fishing communities that engage in subsistence fishing.

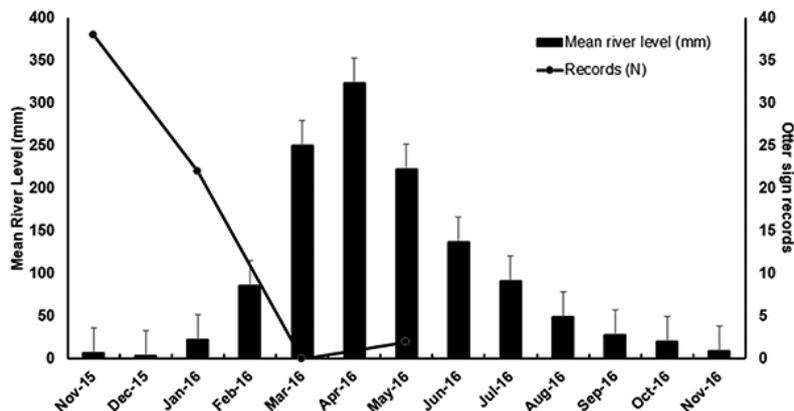


Figure 1. Monthly variation in river water level in the middle Guamá River, in the state of Pará (eastern Brazilian Amazon) and the number of Neotropical otter, *Lontra longicaudis* records registered during four surveys. River-level data are from ANA (2016). Bars are the mean and whiskers the standard deviation.

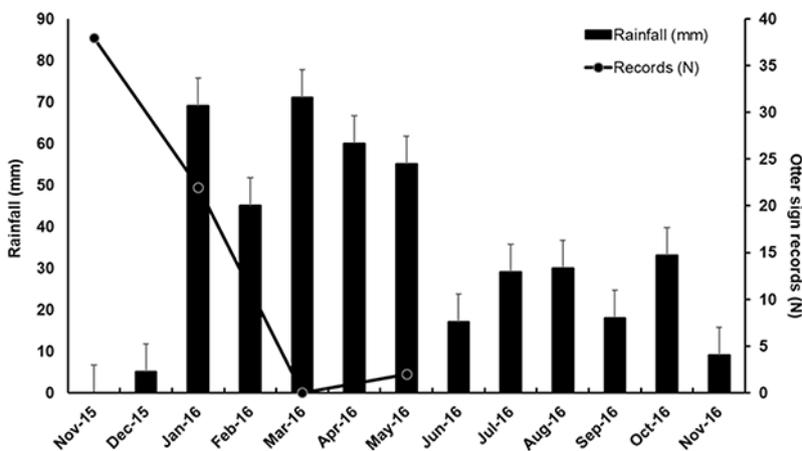


Figure 2. Monthly variation in rainfall and in the number of Neotropical otter, *Lontra longicaudis* records registered during four surveys along the middle Guamá River in the state of Pará (eastern Brazilian Amazon). Rainfall data are from ANA (2016). Bars are the mean and whiskers the standard deviation.

Survey of *Lontra longicaudis*

We conducted otter surveys within seven-day windows during four sampling periods in 2015 and 2016. We established sampling periods based on known seasonal climatic conditions and river stages: November (base flow), January (rising limb), March (peak flow), and May (receding limb). Due to logistical constraints and inaccessibility of parts of the river section during low water levels, we were not able to survey the whole section in all periods, which prevented the standardized comparison of otter records among sampling periods. Therefore we pooled data among periods for a grid-based analysis of the relation of otter records with habitat variables, as described below.

Surveys were conducted from a 5-m-long aluminum boat at a speed ranging from 2.8 to 10.8 km h⁻¹ (Groenendijk *et al.* 2005). As we navigated the boat along the shoreline, we recorded sightings of otters and signs of otter presence on the shoreline. To minimize detection errors, at least two expert observers were involved with spotting otters and their signs during each survey (*sensu* Jeffress *et al.* 2011). Surveys started at 6:00 AM and ended when we had completed our pre-established itinerary, when an exceedingly low river level precluded navigation into more upstream reaches, or when poor weather conditions created unsafe conditions. We surveyed each monitored reach of the river three times during each 1-week-long survey period.

We georeferenced all locations of sightings (direct records) and signs (indirect records) using a Garmin GPS (Etrex 30x). We recorded all signs by type (*sensu* Waldemarin 2004): (1) den site (indicted by a cavity in the riverbank or tree that appeared to have been used for resting and care of offspring), (2) resting site (indicted by a small depression with claw marks and footprints around them), (3) sprinting site (indicated by feces deposited on several occasions), (4) fecal site (indicated by a single stool deposit), (5) scratching site (sites with large concentrations of otter scratches on the river bank), (6) footprints. When we observed fresh feces (i.e., feces deposited recently, no deterioration), we classified the site as being recent or “in use.” In contrast, when the observed feces were old (e.g., dry or mixed with dry leaves and branches), we classified the site as being “in disuse.” All feces were collected to prevent resampling.

Environmental variables

The environmental variables measured were based on previous studies (Crowley *et al.* 2012; Macías-Sánchez 2003) and on conversations with local people. We measured both site-specific variables related to channel condition (turbidity, velocity, and depth) and remotely measured landscape-scale variables (land cover types). We acquired remotely obtained data from satellite images classified by the TerraClass/ National Institute of Space Research (INPE) database 2014 project (Almeida *et al.* 2016).

In order to characterize habitat types used by otters, we measured both remote environmental variables and on-site conditions of the river channel at each location identified as of recent otter use. For channel condition, we measured (a) water depth, 1 m from the shoreline (depth recorded with a measure tape attached to a weight), (b) turbidity (measured with a Secchi disc), and (c) water velocity (m sec^{-1}), (d) riverbank slope (trigonometric relation between height and distance of slope top from the water), and (e) slope of downed tree trunks, when present (trigonometric relation of height and distance of trunk from the water). We also used rainfall and fluvimetry data [from the National Water Agency (ANA) database for the survey periods.

For remote variables, we reclassified TerraClass landcover classes into fewer ($n = 8$) land cover types by grouping certain TerraClass cover types into eight cover types (five new) with 6.25 ha resolution: (1) pasture (derived from the TerraClass “clean pasture,” “dirty pasture,” and “regenerative pasture”), (2) plantation (derived from the “agriculture” and “plantation” classes of TerraClass), (3) anthropic (derived from the combination of the “urban mosaic” and “occupied” classes of TerraClass), and (4) rock formation or sandbank (which correspond to “other” and “non-forestry” classes of TerraClass). We retained three original TerraClass categories: (5) mining (6) hydrography, (7) forest, and (8) secondary vegetation.

Because the TerraClass hydrography data layer was not sufficiently detailed for our purposes, we constructed a new river shapefile of hydrographic boundaries with 100 m resolution, derived from the satellite imagery available from Google Earth (2017). We then added the new hydrographic shapefile to our reclassified cover-type image using ArcMap (Version 10.4).

Variables for anthropic impacts

We inventoried the number and types of fishing gear used on the river (nets and fish corrals), boats, and the number of dwellings (communities or isolated houses) along the riverbank. We obtained a list of the riverside communities along the river, which contained locations (latitude and longitude), from a resident of each community in the surveyed river section. All the anthropic data listed above was ground-truthed with GPS during our surveys.

Data analysis

All variables were analyzed relative to the four hydrographic phases of the river: base flow, rising limb, receding limb, and peak flow. Because otter signs were collected only once during each survey period, it was not possible to statistically test the relationship between hydrologic fluctuations and habitat use (as inferred from signs). However, because the number of signs we recorded during the four hydrological periods varied widely, we could qualitatively describe these differences and speculate on how Neotropical otters use riparian habitat.

We determined the frequency of occurrence of direct and indirect otter records for each hydrologic period. For spatial analyses, we defined sampling units as 1-km² grid cells overlaid on the river reaches where we conducted our surveys. We then related the frequency of signs along the shoreline with our measured environmental and anthropogenic variables within each surveyed cell. We defined a sampling unit (1 km² cell) based on estimates of linear otter density (one otter per km) estimated by Trinca *et al.* (2013) and our prior field observations. We used the ArcGIS Vers. 10.4 Zonal Statistic Table tool to compile data on the percent cover of each landcover type in each grid cell and associated environmental and anthropic data collected in the field. Thus, within each sampling unit (grid cell), we compiled local and landscape-scale variables along with direct and indirect otter records during each of the four hydrological periods.

We used Pearson correlation to determine if any variables correlated with other variables. We did not use any variables that were well-correlated ($r > 0.7$) in the GLM models. We applied a Generalized Linear Model (GLM) to identify variables that would be most likely to explain use of space by otters in the mid-reaches of the Guamá River. For the GLM models, we related the number of otter records per sampling unit (as a response variable) with each explanatory variable per sampling unit: forest area (m²), secondary forest area (m²), rock formation/sandbank (m²), degree of riverbank slope or

slope of downed tree trunk (on the shoreline or leaning into the water), water depth (m), water velocity (m s⁻¹), turbidity (Secchi disk depth), number of riverside communities or isolated houses, number of fishing gear (nets and corrals combined), and number of vessels (both fishing vessels or used for transportation). The best GLM model was selected based on statistical significance provided by the variables and using the best model according to AICc (Akaike Information Criterion, corrected for small sample size). According to the AIC method, a delta value > 2.0 identifies the model that is clearly superior to the others (Kenneth *et al.* 2002).

Considering that the influence of a given variable is not always linear, we used a Generalized Additive Model (GAM), which allowed us to define non-linear relationships between the explanatory and response variables. By doing so, it was possible to smooth out the residuals of the variables, thus improving model results. We chose the best model between GLM and GAM using AICc and the variation explained by each model. We used the package MGCV (Mixed GAM Computing Vehicle) of Program R for analyses. We obtained an estimate of the corrected AIC for small samples and the relative “AIC weight” of each model (AICwgt) using the MuMin algorithm in the Program R.

RESULTS

We recorded 62 otter sightings and signs during the four survey periods, most of which were signs (indirect records). No records were obtained during peak flow (March). During the other hydrologic periods, 3% of the records were obtained during the receding limb (May), 61% during base flow (November), and 35% during the rising limb (January) (Table 1), indicating an inverse relationship between water level and frequency of occurrence for otter signs (Figure 3). We found no relationship between otter signs and amount of rainfall during the month of survey. Otter signs mainly occurred on the riverbanks (62%) and on downed tree trunks (30%), whereas sightings were mostly of otters swimming in the main channel of the river (8% of all records). We observed otters and some otter signs close to fishing nets and boats (Figure 4).

Channel characteristics (water depth, water velocity, and turbidity) were auto-correlated ($p = 0.91$) for all hydrologic periods. Thus, we did not use these variables together in any of the tested models, but instead chose the variable that we assumed would best explain the models (Table 2).

The GAM models performed better than the GLM models; therefore, we only used results for the GAM models. Sixteen GAM models were generated by combining the explanatory variables with the response variables (Table 3). The model that best explained the occurrence of otter records (delta AICc > 2.0) included the variables degree of riverbank slope or slope of downed tree trunk, percent of forest cover (in a cell grid), percent of rock formation/sandbank, combined number of fishing gear, and number of vessels (Table 4).

Table 1. Frequency of Neotropical otter (*Lontra longicaudis*) sightings (direct records) and signs (indirect records) in each hydrographic period (November = base flow; January = rising limb; March = peak flow; May = receding limb) along the middle Guamá River in the state of Pará (eastern Brazilian Amazon). % occur = relative frequency of occurrence.

Type of record	November	January	March	May	% occur
Indirect records					
Footprint	1	0	0	0	1.6
Resting sites	2	0	0	0	3.2
Feces	3	4	0	2	14.5
Possible Dens	7	3	0	0	16.1
Dens	6	5	0	0	17.7
Defecation sites	17	5	0	0	35.5
Direct records					
Visualization	2	5	0	0	11.3
TOTAL	38	22	0	2	100.0

Table 2. Correlation matrix of physicochemical water parameters at location points of otter records in the middle Guamá River in the state of Pará (eastern Brazilian Amazon).

Variables	Velocity	Turbidity	Depth
Velocity	1.0	-	-
Turbidity	0.946	1.0	-
Depth	0.912	0.915	1.0

Table 3. List of General Additive Models (GAM) used to explain the relationship between Neotropical otter, *Lontra longicaudis* records and environmental and anthropic variables. AICc (Akaike Information Criterion corrected for small sample size) and proportion of explained variance are shown for each model. INC = degree of slope; VS = secondary vegetation area, FLO = forest area, RF= rock formation/sand bank area; EBM = number of boats; MOR = number of house(s); ANT = anthropic (nets and corrals combined) = VEL = water velocity; PRO = water depth; FIS = fishing gear.

GAM Model	AICc	Delta	Weight	Variance explained (%)
s(INC) + FLO + RF+ s(FIS)+ EMB	126.5	0	0.798	91
s(FLO) + s(FIS) + EMB + RF	130.1	3.61	0.131	77
s(INC) + s(FLO) + RF+ s(FIS) + EMB	133.4	6.99	0.024	77
s(INC) + s(FLO) + RF+ s(FIS)	133.7	7.24	0.021	96
s(INC) + s(FLO) + s(FIS) + s(RF) + ANT	134.8	8.36	0.012	100
s(INC) + s(FIS) + (VS)	140.3	13.82	0.001	51
INC + s(VS) + s(FIS) + s(PRO)	145.4	18.97	0	81
s(VS) + s(FIS) + EMB	146.0	19.52	0	78
s(INC) + FLO + s(FIS) + s(PRO) + RF	148.3	21.82	0	82
INC + s(VS) + s(FIS) + PRO + EMB	150.7	24.25	0	81
s(INC) + s(FLO) + s(RF) + FIS	153.6	27.14	0	73
s(FIS) + EMB + MOR	163.9	37.48	0	32
s(FLO) + s(FIS) + s(RF)	165.0	38.53	0	100
s(FLO) + s(FIS) + s(RF) + ANT	165.9	39.43	0	100
s(FIS)	175.4	48.92	0	20

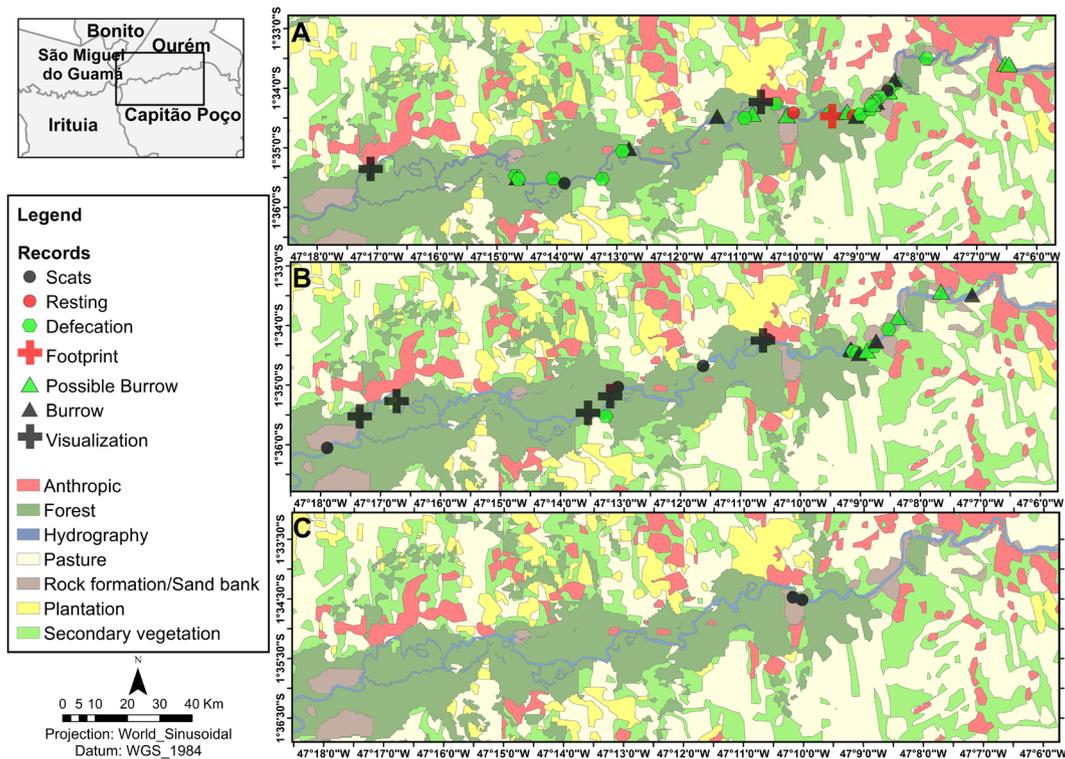


Figure 3. Distribution of Neotropical otter, *Lontra longicaudis* records along the surveyed section of the middle Guamá River (Pará, Brazil) during three hydrological periods. A – base flow (November); B – rising limb (January); C – receding limb (May). This figure is in color in the electronic version.

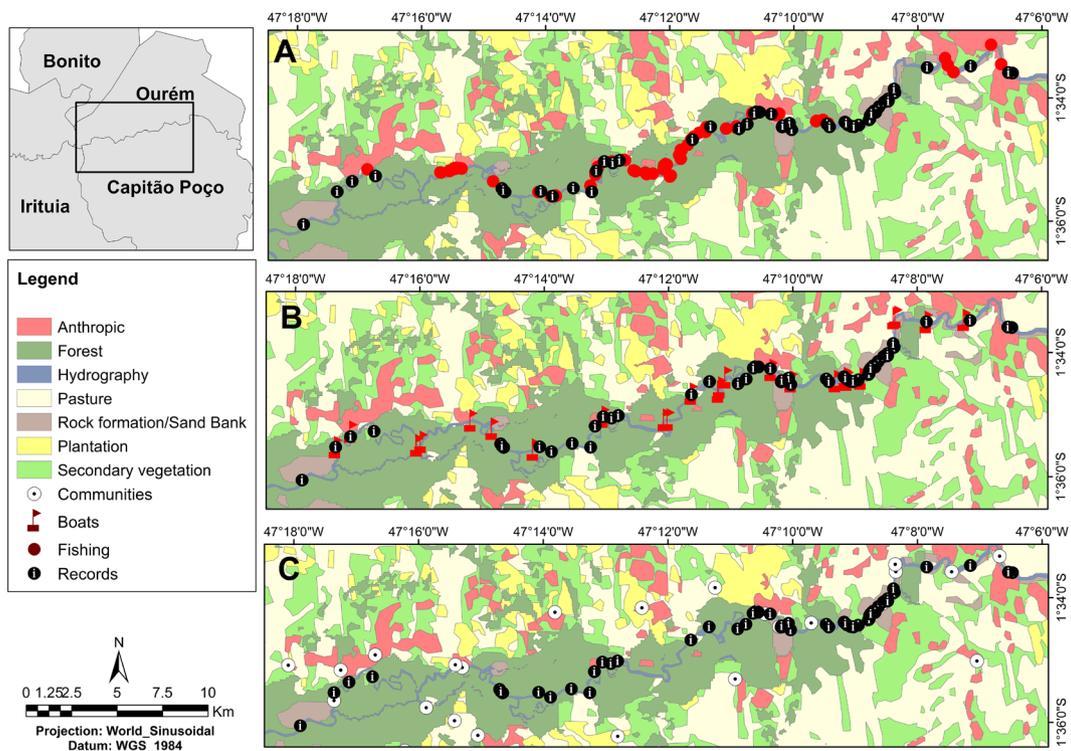


Figure 4. Distribution of Neotropical otter, *Lontra longicaudis* records and human impact variable records along the surveyed section of the middle Guamá River (Pará, Brazil), A – fishing gear (Fishing); B – boats (Boats); C – isolated or communal habitations (Communities). This figure is in color in the electronic version.

Table 4. Parameters of the General Additive Model (GAM) relating Neotropical otter, *Lontra longicaudis* records to anthropic and environmental variables. Model: $s(\%Slope) + Forest\ area + Rock\ formation/sandbank + s(Fishing) + Boats$.

Coefficients	Estimate	SE	z value	Pr(> z)
(Intercept)	-7.78E+04	3.77E+05	-0.207	0.836332
Forest area	-9.12E-03	2.38E-03	-3.833	<0.001
Rock formation/ sandbank	9.59E-03	2.05E-03	4.688	<0.001
Boats	1.31E+03	2.94E+02	4.475	<0.001
Smoothing terms	Edf	Ref.df	Chi.sq	p-value
s(%Slope)	5.110	5.398	17.92	0.005 *
s(Fishing)	8.956	8.997	22.30	0.008 *

* significant at $p < 0.05$

DISCUSSION

The number of otter records was mainly related to variations in the water level of the river. During peak flow, the river covers its floodplain, which forces otters to forage over a larger area as their prey (mainly fish) disperse into tributaries and onto floodplains (Crowley *et al.* 2012). This dispersal complicated our surveying effort, which may explain why we obtained so few records during the flood season (peak and receding limb of the hydrograph). During the flood season, we were not able to navigate across the entire additional flooded habitat potentially being used by otters, as there were many obstructions to navigation. In addition, at peak flow, sandbanks, downed tree trunks and rock formations are mostly submerged, thereby reducing the potential number of records on these microhabitats. In addition, at low stages of the river, risks associated with foraging increase because otters must seek food further afield and on land, which increases their exposure to predation or being hit by vehicles on roads (Ruiz-Olmo *et al.* 2011). The peak flow of the Guamá River coincides with the rainy season, when we observed no otter records. Otter signs on muddy shores, such as footprints, are quickly washed away by rain, limiting observations to only recently deposited signs.

Flooded forest habitats are probably used by otters for shelter, specially when they have offspring, as forest cover provides better camouflage when pups are vulnerable to predation (Colares and Waldemarin 2000), particularly near sites with high intensity of human activity, as indicated by the presence of fishing gear (Chanin 1985). In environments without human presence, otters tend to use less sheltered microhabitats in thickly vegetated or hardly accessible areas and establish their dens and resting sites in the open (Miles 1984).

Neotropical otters in our study area seemed to congregate near fishing gear and fishing vessels during fishing operations, which seems to indicate that they seek the fish trapped in fishing gear, which requires less energy than foraging for free-swimming prey, and supports the definition of Neotropical

otters as opportunistic feeders (Pardini 1998, Rheingantz *et al.* 2017b, a). These results suggest that there is a moderate amount of conflict between humans and otters in our study area, due to a likely reduction in fishing yield caused by otters pilfering fish and damaging fishing gear. Fishermen also reported that they often dress up a scarecrow with clothes with vibrant colors, such as red, to scare off otters from fishing nets. Otters are frequently killed in retaliation for stealing fish (Barbieri *et al.* 2012), yet the impact of such human-induced mortality on Neotropical otter populations is not known (Rheingantz *et al.* 2017a). Conflicts between fishermen and otters are common worldwide [e.g., *Lutra lutra* in the Czech Republic (Poledníková *et al.* 2013) and Poland (Kloskowski, 2011), *Pteronura brasiliensis* in Brazil (Rosas-Ribeiro *et al.* 2012) and Peru (Recharte *et al.* 2008), and *Lontra longicaudis* among artisanal fishermen in southeastern Brazil (Barbieri *et al.* 2012). Neotropical otters also prey on small farm animals, such as ducks and chickens, which roam freely in the riverside communities in our study area (Barbieri *et al.* 2012). In this context, the presence of domestic dogs near riverine communities appears to cause otters to become nocturnal (Rheingantz *et al.* 2016, 2017a).

Hunting giant river otters (*Pteronura brasiliensis*) for fur was a common economic activity in Brazil in the decades from the 1950s to the 1970s (Carter and Rosas 1997). From personal observations and informal conversations with fishermen in our study area, it appears that otter hunting is no longer routinely practiced, except for occasional retaliatory killings of otters that attack farm animals.

The proximity of otters to fishing gear suggests that they routinely explore new niches. Future studies should determine whether the close proximity of otters and fishermen in the middle Guamá is due to otters actively seeking easy meals in the form of trapped fish, or whether fishermen set their traps where otters congregate because of the abundance of fish. Whatever the cause of the close proximity of otters and fishermen, our results suggest that otters know that fish are available near fishing gear and near working fisherman, thus making them more susceptible to conflicts with humans.

To our knowledge, this is the first study to relate riverbank slope and slope of downed tree trunks to the occurrence of otter records. Otters often climb to escape terrestrial predators (when far from water) and when searching for food on land (Silva and Quintela 2010). Although the maximum slope that an otter can climb has not been determined, there is one record of a Neotropical otter climbing a slope of 84.3° (Silva and Quintela 2010). The association between otters and rock formations and sandbanks in our study is due to the fact that otters mark their territories and deposit stools in these places. In addition, these types of microhabitat tend to be exposed even during peak flows, which allowed us to record data from these sites during the receding limb. Although river depth,

velocity and turbidity were not significantly related with otter records in our models, these variables frequently correlate with the distribution of fish (Rodríguez and Lewis 1997), which we presumed to be an important factor affecting the spatial distribution of otters. The seasonal variation in river level probably had a stronger effect on otter distribution than physical characteristics of the river channel.

Lontra longicaudis populations are predicted to decline in 25% over the next 27 years (Almeida *et al.* 2017), which corresponds to about three generations of the species (Pacifi *et al.* 2013). The interaction of otters with fishing gear is known to cause conflicts between otters and humans (Barbieri *et al.* 2012; Castro *et al.* 2014). Thus our results point to that the association between otter records and human fishing activities may threaten otter populations in the middle Guamá River and lead to a decline of the species in the area. The effects of the interaction with fishermen and of other impacts, such as urbanization and habitat fragmentation on otters in the Guamá should be further evaluated through long-term studies that can explicitly estimate detection accuracy from repeated observations. Long-term datasets would make it possible to account for detectability and evaluate with higher confidence the patterns of behavior and habitat use by otters in different seasons. When accounting for factors confounding detection accuracy, average occupation by *L. longicaudis* increased by 6% (Rosas-Ribeiro 2017).

CONCLUSIONS

We described the variation in the number of direct and indirect records of Neotropical otters inhabiting the middle Guamá River, in the eastern Brazilian Amazon. Our models relating otter records with environmental conditions and anthropogenic impact variables indicated that otters were associated with riparian forest, riverside rock formations and sandbanks (both used to mark territories), and fishing gear along the river. The positive relationship between otters and fishing gear is likely associated with the aggregation of fish in fish traps and the ease with which otters can pilfer fish from the traps. Neotropical otters are apt at exploiting new niches, but exploitation of human altered environments along the river has led to conflicts with humans when otters raid fishing nets and prey on barnyard fowl. Incursions of human developments into primary forest will inevitably lead to more human/otter conflicts.

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