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Site and refuge use by giant river otters (*Pteronura brasiliensis*) in the Western Brazilian Amazonia

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Giant river otters are endangered and knowledge about this species is incomplete, especially in the Brazilian Amazonia, which holds large populations of the species. In order to improve our knowledge for species conservation, we present data on site and refuge use by giant river otters in the Amanã Reserve, Brazilian Amazonia. During 40 sampling trips (October 2004 to September 2008) we recorded information and the physical characteristics of 193 campsites, 182 dens and 62 resting sites. Animals were site-selective, preferentially building their dens, campsites and resting sites at < 2 m from the water, on slopes < 45°, and avoiding using water bodies < 1 m deep. The information presented here stresses the importance of river margins for giant river otters, indicating that these areas are key habitats for their conservation.

Keywords: Amazonas; giant otter; flooded forest; Lutrinae; Mustelidae

Introduction

The giant river otter *Pteronura brasiliensis* Gmelin, 1788 (Carnivora: Mustelidae) is one of the largest freshwater carnivores in South America, and the largest in the sub-family Lutrinae (Duplaix 1980; Carter and Rosas 1997). Adults can reach nearly 1.8 m in total length, and 30 kg in weight, with males slightly larger than females (Duplaix 1980). Endemic to South America, the giant river otter is restricted to aquatic ecosystems in tropical forests and wetlands up to 300 m asl (Carter and Rosas 1997; Schenck 1999). They form cohesive family groups, usually with 3–12 individuals, composed of one reproductive couple and several young from different generations (Duplaix 1980; Schweizer 1992; Carter and Rosas 1997; Staib 2005). Group members usually move, forage, rest, survey and protect their use areas jointly (Duplaix 1980; Schweizer 1992; Carter and Rosas 1997). They feed mainly on fish, usually captured in shallow waters (Duplaix 1980; Laidler 1984; Schweizer 1992; Rosas et al. 1999), but can complement their diet with crustaceans, amphibians, reptiles, birds and other mammals (Laidler 1984; Carter and Rosas 1997).

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Giant river otters are territorial and, apparently, different groups avoid agonistic encounters by scent-marking their use areas (Duplaix 1980; Schweizer 1992; Carter and Rosas 1997; Mourão and Ribas 2004; Ribas 2004). Dens, used for shelter, rest, reproduction and care of the young, are found near the water margins, along the area used by a specific group (Duplaix 1980; Laidler 1984; Carter and Rosas 1997; Eisenberg and Redford 1999; Emmons 1999; Borges and Tomás 2004; Groenendijk et al. 2005). Besides dens, animals also maintain campsites, used for marking their territories, resting, sleeping, drying out, and for social contact among individuals (Duplaix 1980; Groenendijk et al. 2005).

The giant river otter prefers clear or black water rivers, creeks, lakes and ponds (Duplaix 1980; Carter and Rosas 1997), but food and refuge availability, including vegetation cover, shape, structure, accessibility and slope of margins and river banks, as well as water depth, also influence its habitat selection (Duplaix 1980; Carter and Rosas 1997). Overall, home-ranges appear to be 12–32 km of main creeks and tributaries, with records of 20 km² in lakes (Duplaix 1980; Laidler 1984; Schenck 1999; Staib 2005). The areas used by giant river otters are vulnerable to water level oscillations and pulses, directly influencing the resources the animals use. During low water season, individuals use main rivers, which retain larger water surfaces and have higher food availability. Conversely, during high water periods, animals may have to move to higher places, due to the flooding of dens or campsites (Duplaix 1980; Parera 1996). Since their diet is mainly piscivorous, giant river otters may change areas, following seasonal fish migrations (Duplaix 1980).

Giant river otters are endangered according to the International Union for Conservation of Nature (IUCN) Red List (Duplaix et al. 2008), and there is a high risk of extinction among the members of subfamily Lutrinae. Since 1973, the species has been included in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2011). In Brazil, the species had a widespread distribution in the past, but is now officially listed as vulnerable by the Ministry of Environment, and is believed to be locally extinct in the states of Minas Gerais, Rio de Janeiro, Santa Catarina and Rio Grande do Sul (Machado et al. 2008). Stable (and probably increasing) populations are likely to occur only in Amazonia and Pantanal (ICMBio 2010).

The conservation of any taxon requires information on its population size and distribution, and on the biological and ecological requirements necessary for its maintenance (e.g. Myers et al. 2000; Olson et al. 2001; Krupnick and Kress 2003; Tear et al. 2005; IUCN 2011). Establishing relationships of species occurrence with environmental variables is important for defining and developing species conservation plans. Unfortunately, the basic knowledge on the giant river otter is far from complete, and this situation is more pronounced in Brazilian Amazonia, which holds some of the larger populations of the species along its distribution (ICMBio 2010). In fact, improving knowledge on giant river otters in Amazonia was identified as a strategic step for the species conservation in Brazil (IBAMA 2001; Vargas & Marmontel 2007; ICMBio 2010). Refuges form one of the fundamental aspects of the ecology of a species and in order to fill part of the knowledge gaps on the biological and ecological requirements of the species, here we present data on site and refuge use by giant river otters in the Amanã Sustainable Development Reserve, in the Western Brazilian Amazonia.

Materials and methods

Study area

The Amanã Sustainable Development Reserve (Amanã SDR, IUCN Category VI) is located in the central part of Amazonas State, covering part of the municipalities of Maraã, Coari, Codajás and Barcelos (Figure 1). Created in 1998, Amanã SDR is one of the largest protected areas in South America, covering nearly 2,313,000 hectares (ha) ($1^{\circ}35'43''$ S to $3^{\circ}16'13''$ S; $62^{\circ}44'10''$ W to $65^{\circ}23'36''$ W), between Negro and Japurá rivers. Together, Amanã SDR, the adjacent Jaú National Park and Mamirauá Sustainable Development Reserve form a single block of nearly 5.7 million ha of continuous protected areas. Amanã SDR is a composite of seasonally flooding white water *várzeas* (6%), black waters *igapós* (9%), non-flooded terra-firme forests (84%) and *campinaranas* (white sand savannas, 1%) (Amazonas 1998; Ayres et al. 2005). The area has large extensions of pristine habitats, with low human densities (an estimated total population of 4000 *ribeirinho* people) and high wildlife richness: approximately 330 species of bird, 520 species of tree, over 300 species of fish, and 69 species of terrestrial mammals (Magurran & Queiroz 2010 and references therein). Less than 3% of the total area is used by the residents for the extraction of natural resources, with other parts designated for scientific and conservation purposes (Ayres et al. 2005).

Within Amanã SDR, the focal area of this study was defined as creeks surrounding Amanã lake: 120 km along the Urumutum, 20 km along Juacaca, 15 km along Juazinho, and 30 km along Baré, all at the headwaters of the lake; plus 15 km along Juá Grande, 8 km along Ubim, 5 km along Açú and 3 km along Cacau, the latter two downstream Amanã lake from our field base. With the exception of the white water of the Juacaca, all others have black water. The margins of all those creeks are composed either of terra firme forests, *várzea* forests, or a combination of both.

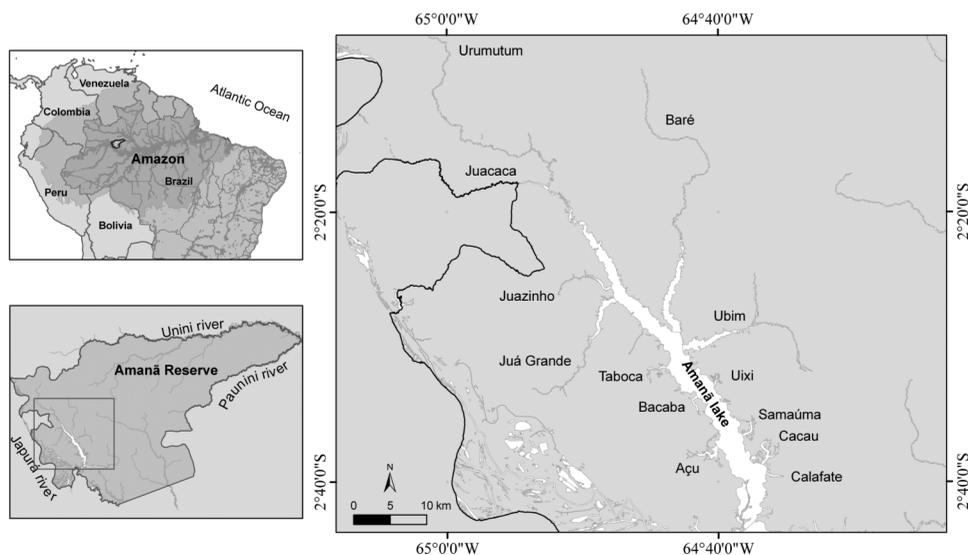


Figure 1. Overview of the study area and sampling locations for giant river otters (*Pteronura brasiliensis*) around Amanã lake and adjoining creeks, at the Amanã Sustainable Development Reserve, Amazonas State, Brazil. Samplings extended from October 2004 to September 2008.

On average, the area experiences a 10 metre seasonal variation in water level, with profound effects on all the aquatic ecosystems (Junk et al. 1989). The water level usually starts to rise in November, reaching a peak around May and mid-July, receding from late July to September, with a low water peak from September to November (Ramalho et al. 2009). Annual average temperature is 29°C (Ayres 1993).

Sampling procedures

A total of 40 sampling trips were performed between October 2004 and September 2008 in search of signs of the presence and use of margins and banks by giant river otters. Extreme low water levels, restrictions imposed by residents to access the areas they use and logistic limitations restrained trips in the months of December 2004, April 2005, January, April, July and August 2006, April 2007 and March 2008. Each trip consisted of nearly 10-day excursions, with a minimum sampling effort of 11 hours of search per day. Since giant river otters are exclusively diurnal (Carter & Rosas 1997), searches were performed during the day, by motor or paddle boat, reaching the most distant navigable point. Boat speed never exceeded 10 km h⁻¹. Daily distance searched was calculated with a Garmin 76S Map GPS.

Giant river otters were considered present in an area based on direct observation and indirect evidence (Groenendijk et al. 2005). Records were photographed and/or filmed, and had their precise locations taken with the GPS. Only campsites, dens and resting sites were taken as records, as those signs are indicative of giant otter residency in a water course and remain recognizable even when not continuously used. Campsites were defined as sites by the margin of water bodies associated with a latrine or, in some cases, an isolated latrine only; tunnel-shaped holes built on the banks were recorded as dens; resting sites were cleared areas or small holes, cylindrical or semi-circular in shape, not associated with latrines (Groenendijk et al. 2005) (Figure 2).

In every new trip, previously recorded sites were visited to verify the continuous use of those areas. Dens, campsites and resting sites were measured and characterized following the methodologies used by Schenck (1999), Lasso (2003), and Souza (2004): (a) measurement (in cm) of maximum width and height of main den entrances, presence/absence of vegetation at the entrance and location (i.e. if constructed directly on the soil or under root systems); (b) measurement (in cm) of maximum length and width of both campsites and resting sites, always considering the length parallel to the water margin, and the width perpendicular to it; (c) slope (in degrees), expressed by the ratio between the distance and height from the evidence to the water; (d) water transparency (in cm); and (e) water depth (in cm).

Distances and heights in relation to the water level were measured using two 3-m perpendicular rulers, or a larger measuring tape when necessary, and the degree of slope was then calculated using the formula $\alpha = \arctg \times (h/d)$, where α = the degree of slope from the water level, \arctg = arctangent, h = height from the base of the evidence to the water level, and d = distance from the base of the evidence to the water level. A graduated cable, connected to one ballast and a Secchi disk, was used to measure water depth and transparency, always taken at the middle point of the water body. All variables were classified into categories or classes, and analysed based on descriptive statistics, using the software BioEstat 5.0 (Ayres et al. 2007).



Figure 2. Examples of a den (top), a resting site (middle), and a campsite (bottom) used by giant river otters (*Pteronura brasiliensis*) around Amanã lake and adjoining creeks, at the Amanã Sustainable Development Reserve, Amazonas State, Brazil. Resting sites are not associated with latrines.

Results

A total of 193 campsites, 182 dens and 62 resting sites were recorded. With the exception of the Cacau creek, where only footprints and claw marks were observed, all other sampled creeks presented dens, camping sites or resting sites used by giant river otters (Figure 1). Of the dens 84% were built directly over the soil and 16% under root systems; 67% of them had vegetation at their entrances. Entrances had a mean width of 56 cm (interval: 22–218 cm, $n = 182$) and height of 41 cm (18–90 cm) (Figure 3).

Average den height was 175 cm above the water level (interval 17–680 cm), with 36% situated between 0 and 113 cm. The dens' average slope was 29° (7–59°), with 71% of measurements between 22° and 43° . The average water depth near the dens was 324 cm (100–1000 cm range), with 60% of the measurements between 167 and 333 cm. The average water transparency for those sites was 107 cm (50–175 cm range), with 65% of the measurements between 68 and 103 cm.

Average campsite length was 312 cm (107–1350 cm, $n = 193$) and width 270 cm (100–1520 cm). Average campsite height was 188 cm (34–680 cm), with 51% of measurements between 113 and 227 cm. The average slope for campsites was 33° (from 4° to 65°), with 55% of the measurements between 22° and 43° (Figure 3). Average water transparency for those sites was 100 cm (50–205 cm), with 60% of measurements between 68 and 103 cm. Average water depth was 259 cm (100–618 cm), with 58% of the measurements between 167 and 333 cm.

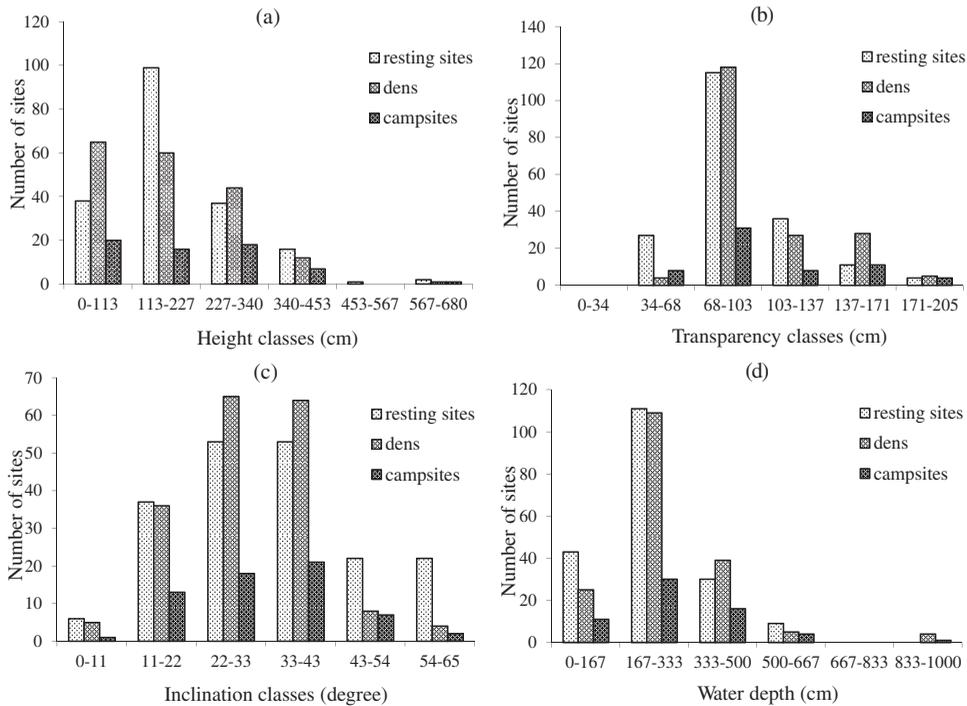


Figure 3. Height (a), water transparency (b), slope (c), and depth (d) for resting sites, dens and campsites used by giant river otters (*Pteronura brasiliensis*) in the Amanã Sustainable Development Reserve, Amazonas State, Brazil. Samplings extended from October 2004 to September 2008.

For resting sites, the average length was 408 cm (100–1400 cm, $n = 62$) and width 235 cm (90–800 cm) (Figure 3). The average height was 200 cm from the water level (12–680 cm), with 32% between 0 and 113 cm. Average slope was 31° (from 4° to 59°), with 63% of measurements between 22° and 43° . Near resting sites, the average water transparency was 111 cm (50–200 cm), with 50% of measurements between 68 and 103 cm. Average water depth was 283 cm (100–932 cm), with 50% of measurements between 167 and 333 cm.

Discussion

Site and refuge use

The adoption of conservation and management strategies focused on threatened species requires a good understanding of the physical characteristics of the habitat used by them. Such information can help when mapping preferred areas and setting priorities for habitat conservation. In the Amanã Sustainable Development Reserve, the area used by giant river otters around Amanã lake showed clear patterns regarding site and refuge use: dens, campsites and resting sites are preferentially built at a short distances from the water (1–2 m away); dens tend to be built directly over soil, with some vegetation covering their entrances; access to used sites are at slopes $< 45^\circ$; and animals avoid using water bodies < 1 m deep. Such patterns stress the importance of river margins as critical habitats for giant river otters, and stress the necessity to include those areas in any effort to conserve the species (Duplaix 1980; Schweizer 1992; Borges and Tomás 2004; de Mattos et al. 2004; Souza 2004).

The location of dens and campsites closer to the water and at sites with shallower inclines allows rapid and less energy-demanding access to both resting and feeding areas by the animals. Sizes of campsites used by giant river otters are related to animals' group size and history of use (Duplaix 1980; Schweizer 1992; Carter and Rosas 1997, but see also Staib 2005), but campsites are also usually at short distances from water, in places with a good visibility of the surroundings (Carter and Rosas 1997).

The physical constitution of habitats, the vulnerability to flooding and the amplitude of the water level fluctuations can affect the availability of shelters, and the relationship between otters and their prey. During our sampling, we observed that more inclined margins, especially those along Baré and Urumutum creeks, were being eroded, both by rain and river action, with the consequent loss of soil and vegetation. Giant river otters avoided constructing dens along those unstable areas. Also, in our study otters built their dens mainly over soil, and not under root systems or fallen trees, as specified by Carter and Rosas (1997). The construction of dens by giant river otters directly over soil was also observed along water bodies in Ecuadorian Amazonia (Lasso 2003), a pattern possibly explained by the use of more debris-free margins.

The average height of the dens observed in our study (41 cm) is similar to that observed at the Balbina hydroelectric reservoir, in Central Brazilian Amazonia (de Mattos et al. 2004; Rosas et al. 2007), and in the Pantanal of Mato Grosso (Souza 2004). However, the average width of our observations (56 cm) was twice the size of that observed in Balbina (28 cm) and half the size of that in Pantanal (95 cm). New giant river otter den entrances are usually smaller than those of older dens, as constant use tends to increase their size (Duplaix 1980; Schweizer 1992; Rosas et al. 2007). Therefore, assuming that entrance size would be an indicator of time since construction, it is possible that Amanã's dens were, on average, being used for a longer

period when compared to Balbina's, but less than those in Pantanal. However, longer observations are necessary to support such a hypothesis.

In Amanã, Balbina and Pantanal there was a predominance of dens with small entrances, which may represent a strategy by the species to improve protection of family members. Dens with large entrances become vulnerable to use by individuals of other species, such as caimans (Duplaix 1980; Schweizer 1992; Souza 2004). In fact, in the headwater of Amanã Lake, some dens with large openings were used by dwarf caimans, *Paleosuchus palpebrosus*, which probably caused giant river otters to abandon those refuges. Occupation of dens by the Pantanal caiman (*Caiman crocodilus yacare*) is also favoured by broad entrances (Souza 2004). Protection from predators may also explain the frequent presence of some vegetation hiding the den's entrance, instead of an openly exposed hole (Schweizer 1992; Carter and Rosas 1997; Borges and Tomás 2004; Souza 2004), with the vegetation acting as a visual barrier to potential invasive species. The vegetation, associated with soil slope, acting as a physical barrier, may be an effective and lasting way of protection for giant river otters (e.g. Souza 2004). Water courses around Amanã Lake are commonly used by local inhabitants to access areas where they extract resources; therefore dens protected by marginal vegetation may contribute to reducing potential human interactions.

In our study, water transparency was very similar among dens, campsites and resting sites. Some studies have indicated water transparency as an important environmental factor affecting fish capture, habitat use and distribution of giant river otters (Duplaix 1980; Carter and Rosas 1997), while others found no relationship between transparency and habitat preference (Schenck 1999). Under water, giant river otters hunt primarily by sight, but the presence of external facial vibrissae appears to assist them when hunting in murky waters (Schweizer 1992). Therefore, otters may in fact prefer more transparent water bodies, but can also present some degree of flexibility, depending on resource availability and environmental restrictions.

Giant river otters are opportunistic predators, catching prey according to their availability, but the habitats' physical structure, water depth, and the level of exposure to threats certainly influence their site use. In a study on the feeding habits of giant river otters in the Balbina hydroelectric reservoir, animals changed their predominant food item according to their availability, but there was a higher frequency of fish families with species having sedentary habits, living generally in lentic environments and river-edge areas (Cabral et al. 2010). Captive adult giant river otters eat on average 10–13% of their body weight per day, or nearly 3–4 kg of food (mainly fish) per day (Carter et al. 1999; Staib 2005). Depending on the habitat conditions, capturing such amounts of fish in natural conditions can be time and energy-consuming. Debris in the shallow channels and water bodies could impede the use of those habitats by giant river otters, hampering their locomotion and preying. Moreover, very shallow waters tend also to contain lower oxygen concentrations and are less suitable for higher fish concentrations. These factors may explain the avoidance of very shallow waters by giant river otters, as observed in our study (but see Staib 2005).

Conservation implications

In Brazil, until the late 1970s, hunting for pelt was the main threat to giant river otters. Currently, with a legal status of protected species and a significant decrease in hunting, the major risks for the conservation of giant river otters are the destruction and conversion of natural habitats (Carter and Rosas 1997; Schenck 1999; Isola

2000, 2004; Duplaix et al. 2008). The increase in human populations and their arrival in once pristine areas affect environmental conditions necessary for the maintenance of the species. Such conditions may involve changes in water quality, food and shelter availability, river margin conditions, as well as increases in conflicts between humans and giant river otters (e.g. Vargas and Marmontel 2007). Other threats also include persecution by fishermen, who frequently accuse giant river otters of competing for fish, the drainage of wetlands for agriculture, the dredging of rivers, streams and creeks for boat transportation and mining, the pollution of water by fertilizers and fuel, and canine diseases such as parvovirus and distemper transferred through domestic stock (see Duplaix et al. 2008 and references therein).

The distribution of the giant river otter is patchy throughout its range and there are records of tracked animals moving up to 160 km along river margins in south-eastern Peru (Staib 2005). The combination of a patchy distribution with a high potential mobility requires the protection of stretches of rivers and their margins to create corridors between suitable living areas for the species. This measure is necessary and, in some areas such as those between Amanã Reserve and the nearby Mamirauá Reserve, urgent. In fact, the action plan prepared by the Brazilian Ministry of Environment points to the protection and recovery of river margins and increasing knowledge about the species' spatial distribution as two of the strategies necessary for the conservation of giant river otters in the country (ICMBio 2010). Amanã SDR is an important protected area in the Brazilian Amazonia, but is still waiting for the full implementation of its management plan. Our data have indicated that giant river otters are site-selective towards specific river margins when building their dens, campsites and resting sites in the area. Therefore, in order to improve the conservation of the species, when preparing Amanã's management plan we recommend special attention be directed to those habitats, propose that some of them be declared restricted access areas.

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