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Original Investigation

Anthropogenic and seasonal determinants of giant otter sightings along waterways in the northern Brazilian Amazon

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ABSTRACT

Historic anthropogenic impacts affecting the distribution and ecology of Giant otters are well documented, however little is known regarding the factors affecting the current distribution of this species. Our objective was to determine the relative importance of temporal (seasonal river levels), and anthropogenic (presence of houses, boats and fishing nets) factors on the distribution of Giant otters around a sustainable-use protected area in the eastern Brazilian Amazon. We conducted a total of 6836.1 km of boat surveys to record locations of both direct and indirect Giant otter sightings along 198.9 km of waterways. To understand the importance of the factors at different spatial scales we conducted analysis using data summarized at two spatial scales: 50 km river “zones” and 5.1 km river sections. Our results showed that anthropogenic disturbances were the most important determinants of the presence of both direct and indirect signs, with Giant otters rarely detected within 40 km of the nearest town. Giant otters were present in the waterways throughout the annual water cycle (high, decreasing, low and increasing river levels), with direct observations positively related with the number of fishing nets present in the waterways. Our results suggest considerable spatial and temporal overlap between Giant otters and the activities of local fishermen which must be considered for the effective management of conservation conflicts in this rapidly developing region.

Introduction

Human population growth and the associated anthropogenic effects have led to the disturbance of increasing numbers of animal habitats. Human activities may significantly interfere with wild fauna, altering the natural behaviour (Silva and Best, 1996; Duplaix, 2002), reproductive success (De la Torre et al., 2000; Arrojo and Razin, 2006), and physiology of many organisms (Romero and Wikelski, 2002).

The encroachment of human populations into increasingly remote areas has reduced the distance between humans and wild animals. This process may result in conflicts (Redpath et al., 2013) that additively and synergistically contribute to the effect of the anthropogenic disturbances. Most conservation-related conflicts are the result of economic impacts caused by wild fauna to human activities, such as fishing, aquaculture (Gómez and Jorgenson, 1999; Recharte et al., 2008; Kloskowski, 2011; Barbieri et al., 2012; Rosas-Ribeiro et al., 2012), or livestock farming (Michalski et al., 2006). In riverside communities, piscivorous species such as fresh-water dolphins (Silva and Best, 1996; Loch et al., 2009), alligators (Peres and Carkeeka, 1993) and otters (Barbieri et al., 2012; Michalski et al., 2012; Rosas-Ribeiro et al., 2012) are often blamed for the reduced productivity of fishing activities and may therefore suffer direct retaliation from the local human population (Gómez and Jorgenson, 1999; Recharte et al., 2008; Loch et al., 2009).

The giant otter (*Pteronura brasiliensis*, Zimmerman, 1780) is a large, group living member of the Mustelidae family that was once distributed across South America (Duplaix, 1980; Carter and Rosas, 1997; Rosas et al., 2009). Although dependent on waterways and forest cover (Carter and Rosas, 1997) giant otters are otherwise highly adaptable and are found across biomes that have very different climates and environmental conditions i.e. ranging from wetlands (e.g. Brazilian Pantanal) to drier savannah areas

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(e.g. "Cerrado" in the centre of Brazil). The distribution of giant otter groups varies spatially and temporally depending on a variety of factors. Giant otter spatial distribution has been related to prey abundance and local habitat conditions (Carter and Rosas, 1997; Davenport, 2010; Rosas-Ribeiro et al., 2012) that are thought to determine core group territory (Carter and Rosas, 1997). The distribution also varies temporally with factors such as reproductive activity (Groenendijk and Hajek, 2006) and food supply particularly in seasonally flooded areas (Leuchtenberger et al., 2013).

The size and piscivorous diet of giant otters means that they are often involved in confrontations with humans (Gómez and Jorgenson, 1999; Recharte et al., 2008; Michalski et al., 2012; Rosas-Ribeiro et al., 2012). Due to the complexity of their social system (Carter and Rosas, 1997; Ribas and Mourao, 2004; Davenport, 2010) and extensive spatial requirements (Carter and Rosas, 1997) giant otters are sensitive to a variety of anthropogenic perturbations including: deforestation surrounding waterways (Duplaix, 2002; Michalski et al., 2006; Rosas et al., 2007), tourism/traffic of watercraft (Staib and Schenck, 1994; Duplaix, 2002), the number of fishing nets (Utreras et al., 2005; Rosas et al., 2007), river pollution, and the exploitation of fishing resources (Carter and Rosas, 1997; Duplaix, 2002). These sensitivities, coupled with historic decimation of populations, have led to an "endangered" status for the species since 2000, according to IUCN Red List Criteria (Duplaix et al., 2008).

The Amazon basin harbours the largest remaining populations of giant otters (Carter and Rosas, 1997). Brazil governs approximately 60% of Amazon forests, and the Brazilian government has invested heavily in establishing protected areas across Amazonia (Peres, 2011). Although the number and size of Amazonian protected areas have increased in recent decades (Soares-Filho et al., 2010; Nepstad et al., 2011), the area accounted for by sustainable-use protected areas exceeds the area represented by more completely protected units (51.5% of the total area) (Peres, 2011). Sustainable-use protected areas allow for some forms of human use, which may lead to conflicts between humans and endangered species, such as the giant otter (Michalski et al., 2012; Rosas-Ribeiro et al., 2012). Therefore, studies that assess the influence of human interference contribute essential information for the effective management and conservation of endangered species.

To assess the effects of human activity and seasonal river levels on giant otter populations in sustainable-use protected areas, we sought to answer the following questions: (1) What are the effects of anthropogenic interference (e.g., riverside homes, fishing nets, and boats) on the occurrence and spatial and temporal distribution of giant otter sightings? (2) What is the effect of seasonality (i.e., river water level) on the occurrence and spatial and temporal distribution of giant otter sightings in a sustainable-use protected area?

Material and methods

Study area

We collected data between March 2011 and June 2013 in the area surrounding the National Forest of Amapá (0°55′N, 51°35′W) on the Araguari and Falsino rivers (Fig. 1). The National Forest (Floresta Nacional—FLONA) is a sustainable-use Protected Area located in the centre of the Amapá state in the extreme north of the eastern Brazilian Amazon; the forest has an area of approximately 412,000 hectares (ICMBio, 2012). The Araguari and Falsino rivers are part of the Araguari river watershed (ANA, 2013). Both rivers can be classified as clear-water rivers because of the small quantity of suspended particles (Junk et al., 2012) and have similar physical and chemical characteristics (Supplemental material 1).

Between 2010 and 2012, the rainy season in the region encompassed the months of February, March, and April and was characterized by an average monthly precipitation of 275.7 ± SD 99.1 mm (range 44.8–422.0 mm); during the dry season (September to November), the monthly average precipitation was 59.6 ± SD 36.4 mm (range 12.0–145.8 mm) (ANA, 2013).

Giant otter sampling

Giant otter sightings were obtained from a total of 198.9 km of rivers (river length measured via GPS) surrounding the National Forest of Amapá. Between March 2011 and June 2013, monthly diurnal (8am to 5pm) river based surveys took place in each zone. The surveys were conducted using a 9-m-long motorized aluminium boat with a 25 HP engine at an average speed of 10.8 ± SD 2.8 km/h (range 2.0–20.0 km/h) (Groenendijk et al., 2005). Due to logistical difficulties it was not possible to survey during some months, but the longest interval between surveys was 62 days. The sampling area was divided into three zones: (1) Porto Grande town—FLONA headquarters, Araguari river (51.0 km); (2) FLONA headquarters—Mutum river, Araguari river (76.5 km); and (3) FLONA headquarters—Grande Waterfall, Falsino river (71.4 km) (Fig. 1).

We designated visual encounters of giant otters as "direct" sightings; "indirect" sightings consisted of observations of otter activity, such as territory markings (e.g., latrines, camp sites, and dens) and tracks (e.g., footprints and scratches) (Duplaix, 1980; Groenendijk et al., 2005). All "direct" and "indirect" sightings of giant otters were georeferenced using a GPS.

Seasonal and anthropogenic variables

To quantify whether and how seasonal and anthropogenic variables influenced the spatial and temporal distribution of giant otter sightings, we selected one seasonal variable (river water level) and three anthropogenic variables (location of homes, boats, and fishing nets) as previous studies have reported that these variables influence movements, and distribution of giant otter populations (Gómez and Jorgenson, 1999; Duplaix, 2002; Rosas-Ribeiro et al., 2012).

Records of anthropogenic activities were georeferenced along the rivers during the giant otter sampling; more specifically, we recorded the positions of watercraft (e.g., motorized and non-motorized boats), fishing nets, and homes of local people.

We obtained data on river water levels (daily river level values) from the virtual database of the National Water Agency (Agência Nacional das Águas—ANA)-http://hidroweb.ana.gov.br. The active data collection station (Capivara station–30080000, 3°49′N, 54°29′W) closest to the study site is located within the Protected Area and has data available through September 2012.

Data analysis

To examine the spatial and temporal distributions of the direct and indirect giant otter sightings, we organized the analyses along a hierarchy of scales. First, on a coarse scale, we compared the seasonal detection frequency in the three sampling zones using the Wilcoxon signed rank test (Table 1). We also counted the number of homes (n = 39), boats (n = 263), trawl nets (n = 39), and fishing nets (n = 144) in each zone to characterize the human activities in the region. On a more granular scale, we divided the rivers into equal-length sections within each zone. We obtained the length of the sections using an objective *bandwidth* selection method (Hengl, 2009) and Berman and Diggle's (1989) algorithm (Supplemental material 2). From the *bandwidth* selection calculation, we obtained an optimal bandwidth (i.e. separation distance) of any value greater