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Occurrence of the Guiana dolphin *Sotalia guianensis* (Delphinidae) in Camamu Bay, Bahia, Brazil

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Abstract. Much data is still lacking to conduct a rigorous assessment of the status of the Guiana dolphin, *Sotalia guianensis*, a coastal-estuarine dolphin of eastern Central America and north-eastern South America, considered vulnerable to extinction in Brazil, relevant information is still lacking to evaluate its global population trends. This article presents the first description of the occurrence of the Guiana dolphin in Camamu Bay in Brazil. From November 2016 to October 2017, we conducted 68 on-board monitoring in two zigzags transects, totalling 272 h of sampling effort. Seven groups composed of up to 5 individuals were sighted between November 2016 and June 2017, and five of these groups were encountered in the main channel of the bay. Sightings were independent of the monitoring period and of the phase of the semidiurnal tide but occurred within three days from a spring tide. Guiana dolphins are less frequent in Camamu Bay than in other geographically neighbouring estuaries, even the smaller ones. We hypothesize that the shallowness of the bay and boat traffic may explain this result.

Key words: marine mammal, estuarine environment, group size, environmental factors, geographical distribution.

The Guiana dolphin (*Sotalia guianensis*, Van Beneden, 1864) is a small dolphin found along the Atlantic coast from southern Brazil (Simões-Lopes 1988) to Nicaragua (Edwards & Schnell 2001). This coastal-estuarine species is frequently observed foraging in bays and estuaries (Flores et al. 2010, 2018). Their occurrence, presence and spatio-temporal distribution can be strongly influenced by topographical changes of the seabed and the tidal cycle (Araújo et al. 2003, Santos et al. 2010, de Boer et al. 2014), proximity of the coast (Wedekin et al. 2010) and water depth (Ferro de Godoy et al. 2015) and diverse human activities (e.g. fishing: Ferro de Godoy et al. 2020; leisure boating: Rako et al. 2013).

Guiana dolphins are more vulnerable to anthropic impacts than oceanic species because of their site fidelity (de Oliveira Santos et al. 2001, Rossi-Santos et al. 2007) in shallow areas (<20 m) where diverse human activities can impact them (de Moura et al. 2014).

Currently, *S. guianensis* is listed as near threatened at global scale (Secchi et al. 2018) and vulnerable to extinction in Brazil (Cassano et al. 2017, ICMBIO 2018). Because of its coastal habits, the Guiana dolphin is exposed to prolonged human disturbance, such as habitat degradation, boat traffic, chemical contamination and by-catch. Therefore, there is a need to better understand how populations are distributed and to improve the description of population parameters to ensure successful management and conservation of the species (Reeves et al. 2003, Secchi et al 2018).

The occurrence of the Guiana dolphin around the Bay of Camamu (state of Bahia, Brazil) is known by reports from residents and visitors and by stranding records (Velozo & Schiavetti 2008); however, no regular monitoring of this population was ever conducted.

Thus, this study aimed to describe, for the first time, the occurrence of the Guiana dolphin in the Bay of Camamu and evaluate temporal (monthly, daily) and environmental variables (tide, water depth) as possible contributors of their distribution inside the bay.

Camamu Bay is located on the central coast of the state of Bahia (13° 55'S, 39° 00'W), and has a tropical wet climate (Af), with an average annual rainfall of 2750 mm and water temperature ranging from 23.5 to 27.2°C (Peel et al. 2007, de Amorim et al. 2015).

The Camamu Bay has a surface area of 384 km² and an estuarine system subdivided into three hydrological micro-regions: the northern portion receives discharges from the Serinhaém River; the central portion from the Igrapiúna, Sorojó and Pinaré Rivers and the southern portion from the Maraú River. The bay joins the Atlantic Ocean through a 6.4 km wide entrance channel, with an average depth of 15 m, which extends southwards towards the Maraú River (Oliveira et al. 1998, de Amorim et al. 2015) (Fig. 1).

There are several islands and islets, algae prairies, coral reefs and large preserved mangroves in Camamu Bay and remnants of Atlantic Forest in its surroundings. The average depth of the estuarine system is only 5 m and the bottom topography is irregular with predominant mud and fine sand (Rocha 2016)

We conducted surveys in the central portion of Camamu Bay due to its accessibility by boat, in contrast to other parts of the Bay which are considered too shallow to navigate. The sampling area (384 km²) was divided into two sections: section A, with 20 transect lines and a total length of 28.5 km and section B, with 24 lines and 27.2 km in length; transects were toured with a zigzag design (Fig. 1) (Buckland, 2001). Surveys were carried out from November 2016 to October 2017, in an 8 m long wooden vessel equipped with an outboard motor, piloted at a constant speed of 10 km/h (Cremer et al. 2011). Each survey consisted of a complete tour in each section (A or B) and lasted about four hours.

In November and December 2016, each section was visited twice a month (from 8 a.m. to 12 noon and from 12 noon to 4 p.m.). From January to October 2017, each section was visited three times a month: from 6 a.m. to 10 a.m. (morning), 10 a.m. to 2 p.m. (midday), and 2 p.m. to 6 p.m. (afternoon), surveys were always completed in periods of six consecutive days. We increased the survey period and monthly sampling effort to six days after noticing a low rate of dolphin observations during the first two months of sampling.

Sighting data were recorded by a single observer (D.A.) positioned at the bow of the vessel, using 7x50 mm binoculars when necessary. Once a group of Guiana dolphins was sighted, the vessel was temporarily diverted off course and directed toward the group. Then, with the boat completely stopped and its engine turned off, without interfering with dolphin's behaviour, we collected the

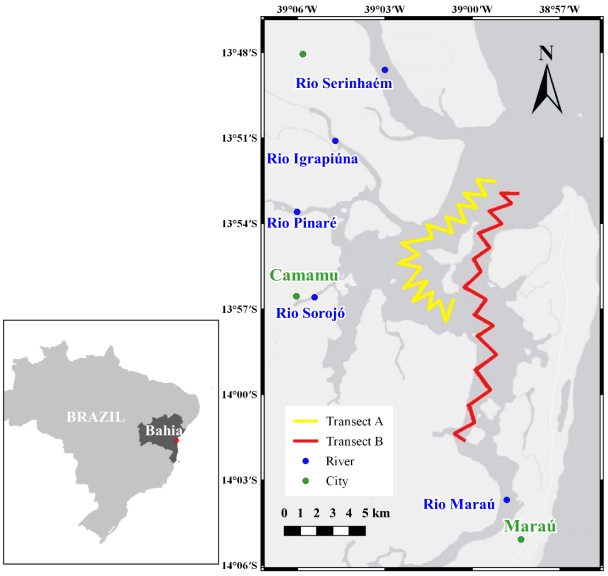

Figure 1. Study area. (a) Camamu Bay relative location within Brazil (b) Hydrographical and geographical features where surveys were conducted. Yellow and red lines indicate survey transects to assess Guiana Dolphin occurrence during this research.

following data: geographical position of the boat with a GPS, time when observed the group of dolphins, estimated number of individuals, and age class composition of the group. Calves were distinguished from adults by their light gray-pink skin (Randi et al. 2008) and their significantly shorter body length than adults (Di Beneditto & Ramos 2004).

Sighting locations of the groups of Guiana dolphins were plotted on a cartographic basis and a bathymetric map with the software ®ESRI ArcGis 10, using the information from the nautical chart nº 1131 of the Directorate of Hydrography and Navigation of the Brazilian Navy. The time interval since the last low tide and the tidal state (ebb or flood) at the time of detection of each group were defined based on the tide table for the Port of Ilhéus of the Brazilian National Oceanographic Database (Marinha do Brasil 2020).

Here we describe the groups of Guiana dolphins recorded during a year of survey and the potential influence of time, tide and human activities on their occurrence in Camamu Bay.

A total of 2005.1 km was travelled in during 68 days of monitoring from November 2016 to October 2017 in Camamu Bay, Brazil. Direct observations of the dolphins were performed in 272 h of sampling effort. Six groups of 2 to 5 Guiana dolphins and one solitary adult were sighted, totalling 17 adults and 2 calves. These seven observations were recorded in five different months between November 2016 and June 2017 (Table 1).

The number of dolphins observed was independent of the monitoring period: 0.3, 0.29 and 0.25 individuals were recorded per survey during a morning, midday and afternoon survey, respectively. Most sightings (n = 5; 71.42%) occurred in Sector A; in the main channel of the bay (Fig. 2).

The depth range where the Guiana dolphins were observed varied from 1 to 20 meters. Four groups were observed during flood tides, between two and four hours after the low tide, and three groups were sighted during the last hour before the low tide (Fig. 3). All sightings occurred between 2 days before and 3 days after a spring tide (Table 1).

Table 1. Time, location, and composition of Guiana dolphin groups observed in Camamu Bay. Interval: interval from sighting to nearest spring tide in days

Group	Date	Time	Interval	Sector	Group size	Composition
1	12/11/2016	09:47	2	B	3	3 adults
2	03/12/2016	10:59	-2	B	4	4 adults
3	08/02/2017	09:48	3	A	2	2 adults
4	12/02/2017	09:48	-1	A	2	2 adults
5	25/03/2017	10:16	2	A	1	1 adult
6	12/06/2017	15:05	0	A	5	3 adults, 2 calves
7	14/06/2017	12:20	-1	A	2	2 adults

Guiana dolphin encounters were less frequent in the study area (Camamu Bay) than in other estuaries in the State of Bahia. It took about 10 days of boat survey to spot a group of Guiana dolphins in Camamu Bay compared to 0.22 days in the Paraguaçu Bay (Batista et al. 2014), 1.02 in Caravelas (Cantor et al. 2012), and 2.82 in Canavieiras (Melo 2018). With regard to group size, the largest group observed in this study had five individuals ($\bar{x} = 2.7$ individuals), while the average group size in Paraguaçu Bay (located 120 km north of Camamu Bay) is nine individuals (Batista et al. 2014) and ranges from 3.4 to 4.7 in the other estuaries of southern Bahia (Ilhéus: Santos et al. 2010, Canavieiras: Recchia and Le Pendu 2012, Caravelas: Cantor et al. 2012).

Most sightings of groups were made in the main navigation channel of Camamu Bay, which has an average depth of 15 meters (de Amorim et al. 2015).

The depth of this channel may facilitate dolphins to move freely in the bay, whereas outside the channel could present some difficulties due to the irregular bathymetry, shallower areas, coral reefs, and sandbanks (de Amorim et al. 2015).

It is known that when observed in bays and estuaries, Guiana dolphins forage preferentially in canals and areas with depths between 10 to 15 m (Baía de Sepetiba: Simão & Poletto, 2002, Baía de Guanabara: Azevedo et al., 2007, Baía do Pontal: Santos et al. 2010, Baía de Paraguaçu: Batista et al. 2014, Gulf of Venezuela: Espinoza-Rodríguez et al. 2019). Similarly, bottlenose dolphins (*Tursiops truncatus*) forage in deeper areas of the Moray Firth estuary; this may be due to a higher concentration of prey, the presence of a preferred prey, and bathymetric feature that facilitate prey capture (Hastie et al. 2004).

However, Guiana dolphins may prefer shallow waters when strong currents or sediments in deeper areas hinder foraging (Wedekin et al. 2010).

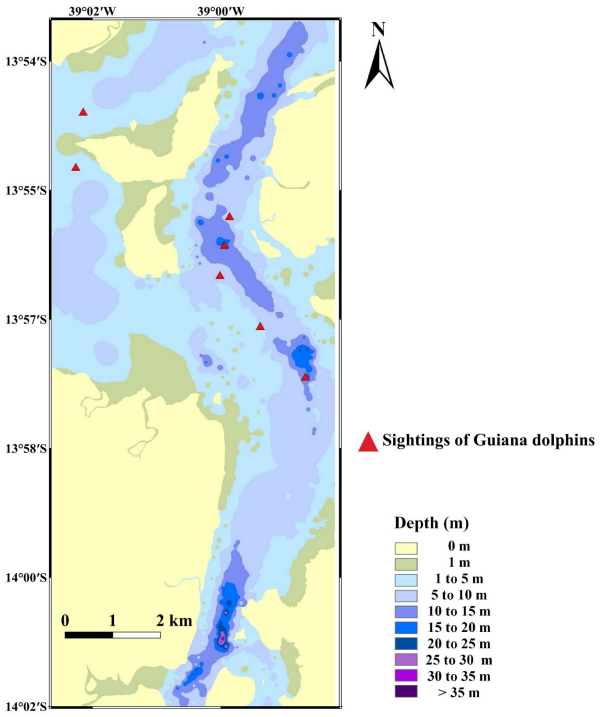

Figure 2. Spatial distribution of the groups of Guiana dolphins sighted in Camamu Bay between November 2016 and October 2017.

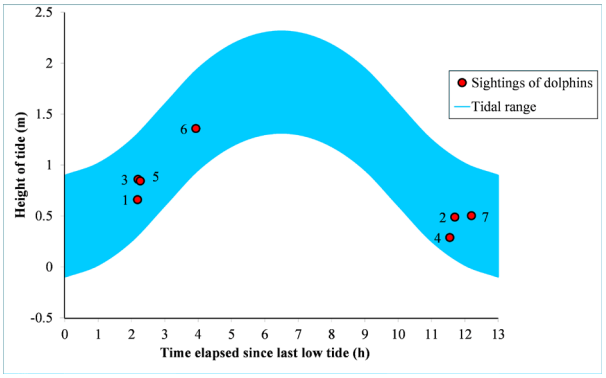

Figure 3. Sightings of Guiana dolphin groups in Camamu Bay according to time interval since the last low tide. The blue area represents the largest tidal range during the study period.

The groups of Guiana dolphins were observed during the flood tide and at the end of the ebb tide. The low number of groups recorded prevents us from statistically demonstrating a significant preference for a given tidal phase. A higher frequency of sightings of dolphins in estuaries at the end of the flood tide was observed in Guiana dolphins (Santos et al. 2010) and Indian bottlenose dolphins, *T. aduncus* (Fury & Harrison 2011), but Paitach et al. (2017) showed that the influence of the tidal cycle on the use of the Babitonga Bay by Guiana dolphins and Franciscana dolphins (*Pontoporia blanvillei*) varies according to habitat characteristics. All groups were observed shortly before or after a spring tide, which may be related to the shallowness of the bay or to a variation in prey abundance and species assemblage with tidal range (Krumme et al. 2004).

Camamu Bay presents large boat traffic activities, mainly with speedboats: there are two private companies that local community members and visitors use to cross from one side to the other. These crossings are scheduled every hour, between 6 a.m. and 5 p.m. every day. According to resident fishers, speedboat traffic increases significantly in the Bay of Camamu during vacation and holidays and has a negative effect on Guiana dolphin presence. For example, Marega-Imamura et al. (2018) explained that outboard vessels cause short term negative behavioural reactions in Guiana dolphins. These behavioural changes vary between populations, and in the long term, the impacts of anthropogenic noise and vessel traffic on coastal dolphins can lead either to physical movements, when groups of dolphins abandon the disturbed area entirely, or to an adaptive modification of the sounds they produce in a noisy environment (Weilgart 2007, Leão et al 2016, Pais et al 2018). Understanding population features and main threats to the Guiana dolphin, such as the increase in tourism, motorboat traffic, low-frequency ambient noise produced by boat traffic, habitat degradation, among others) are necessary for the conservation of Guiana dolphins (Secchi et al. 2018). Changes in boat traffic, human interactions and disturbances may require special legislation and control but could potentially minimize the short-term negative impacts on these animals (Tosi and Ferreira 2009).

This first study indicates that Guiana dolphins are less frequent in Camamu Bay than in other even smaller estuaries along the coast of the State of Bahia (Santos et al. 2010, Cantor et al. 2012, Recchia and Le Pendu 2012) and has attempted to provide information on the possible variables influencing their presence in the bay. Long term spatial and temporal distribution, density, residency (through photo-identification) and other population parameters in this area require more detailed analyses and the inclusion of other sites that were not covered will generate information in order to develop strategies for their conservation and management (Reeves et al. 2003); as well as monitoring boat traffic in the estuary to evaluate their impact on Guiana dolphins.

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