



First occurrence in mangroves of South America of the exotic species *Sonneratia apetala* Buch.-Ham. from the Indo-Malayan region

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Abstract: This is the 1st record of the *Sonneratia apetala* Buch.-Ham., in the mangroves of South America – Cubatão-Baixada Santista, State of São Paulo, Brazil. The record was made in an area located 2 km apart from the port of Santos. Its arrival was probably made through the ballast water. *S. apetala* as well an exotic it is also an aggressive mangrove species. All 85 individuals identified were georeferenced. In May 2023 they were flowering and in August they already had ripe fruits/propagules. The presence of exotic species in mangroves is worrying, they can cause profound ecological and economic impacts and negatively influence the restoration of native ecosystems. The presence of *S. apetala* in the mangroves of Cubatão region could bring about a radical change in the biological structure of the mangrove ecosystem, in addition to being a new point of dispersal to others areas.

Keywords: Ballast water; biological invasions; invasive species; mangrove; *Sonneratia apetala*; South America.

Primeiro registro nos manguezais da América do Sul da espécie exótica *Sonneratia apetala* Buch.-Ham da região Indo-Malaia

Resumo: Este é o primeiro registro da ocorrência de *Sonneratia apetala* Buch.-Ham., na América do Sul, Cubatão-Baixada Santista, Estado de São Paulo, Brasil. O registro ocorreu em área situada a 2 km do porto de Santos. Sua presença, se fez, provavelmente, por meio da água de lastro dos navios. A *S. apetala* é uma espécie exótica agressiva nos manguezais dessa região. Todos os 85 exemplares identificados foram georeferenciados. Em maio de 2023 estavam floridas e em agosto já tinha frutos/propágulos maduros. A presença de espécies exóticas nos manguezais é preocupante, pois são capazes de gerar impactos ecológicos e econômicos e influenciar, negativamente, na restauração desse ecossistema no estuário de Cubatão. A presença da *S.apetala*, no manguezal da região de Cubatão pode povocar uma mudança radical na estrutura biológica do ecossistema manguezal, além de ser um novo ponto de dispersão para outras áreas.

Palavras-chave: Água de lastro; invasão biológica; espécies invasoras; manguezal; *Sonneratia apetala*; América do Sul.

Introduction

The presence of exotic species in natural ecosystems can have profound ecological and economic impacts. Sometimes alien species are accidentally introduced, others due to negligence or lack of norms.

The Port of Santos (23°57'S latitude and 046°19'W longitude), located in the state of São Paulo, Brazil, is one of the busiest and most important ports in Latin America.

Due to its strategic location and extensive infrastructure, the Port of Santos attracts a diverse range of commercial vessels, connecting Brazil to global markets and facilitating trade with countries around

the world. Located approximately 2 kilometers northeast of the port, an extensive mangrove area (6,000 ha or 60 km²) forms part of the larger coastal ecosystem known as the Santos Estuary (approximately 23°54'S latitude and 046°23'W longitude).

The mangroves of Baixada Santista-Brazil, where the Cubatão mangroves are located, has in total more than 12 thousand hectares. Our restoration project area is in the Municipality of Cubatão has 2,725 hectares. The study area, has the referenced central point (23°54'10.62"W and 046°23'48.28"W), is approximately 1,550 hectares, whose mangroves, until the mid-1990s, were practically degraded. Today the recovery stage is quite advanced because of the

numerous actions to control the pollution and various impacts were also controlled, in parallel to the fact that, since 1993 we are developing a restoration mangrove project in the Baixada Santista Estuary region.

The Baixada Santista Estuary main environmental and climate characteristics can be described as a coastal plain formed by Holocene origin sandy islands, exposed twice a day to tides with maximum amplitude of 1.8 m, salinity values ranging from oceanic to fresh water related to the combined effects of the tides and the freshwater inputs, regulated by high precipitation rates in the summer months (December, January and February) and mean annual values of 1,922 mm.

The relative closeness of the mangrove area to the Port of Santos highlights the potential for ecological interactions between the two areas, particularly in terms of water quality and the introduction of exotic species through ballast water discharge.

This proximity underscores the importance of monitoring and managing the ecological integrity of the mangroves of Cubatão, especially considering the potential risks posed by exotic species and other well-known disturbances associated with the port's area operations.

S. apetala presence in the mangroves of Cubatão Baixada Santista Estuary is cause of great concern, as it seems to adapt very quickly and some specimens already have reached more than 12 meters in height. Most of the specimens identified so far are located on the mangrove fringe, although 5 (five) specimens have already been identified more than 70 meters into the mangrove basin stand.

Sonneratia apetala Buch.-Ham., a pioneer species in ecological succession, is native of the mangroves of the Indo-Malayan region (Tomlinson, 1986). The trees are known to occur on soil under a range of salinity conditions (Rahman et al., 2020).

It is very likely that the exotic specie's presence in Cubatão mangroves, was due to the release of ballast water from international ships and the proximity to port facilities.

In Brazil the CONABIO Resolution nr 7, May 29, 2018, concerned with the identification of new introduced species, emphasizes that introduction of exotic species can cause changes in biomes and this fact has been a concern that requires profound consideration of adopting recommended measures that when identifying the presence of an exotic species, preventive and corrective management measures are urged to be taken.

Material and Methods

First species were located in the monitoring area (Figure 1), then boat incursions were made in the Perequê river, Cubatão river and the area near to the harbor of Santos to check the extension of presence of *Sonneratia apetala* in the mangroves. GPS positioning were registered by Garmin Etrex 10 and photograph records were done.

After the first identification of a specimens of *S. apetala*, it was decided to use a drone, aiming to facilitate the presence of other specimens so, the mangrove area was scanned by using the TOPODRONE 200 Ultra embedded in FJI M300 RTK drone, the profiler includes a Velodyne Ultra Puck sensor, a high-precision IMU (Honeywell), and a receiver HNSS L1/L2 Survey (U-BÇOX) (Figure 2).

Drone images were analyzed, some specimens were localized, and their presence was confirmed locally.

Results and Discussion

Sonneratia apetala are easily recognized in the field by the peculiar shape of the canopy (Figure 3), size and number of pneumatophores (Figures 4 and 5), leaf format and color (Figure 6) and the distinctive fruits (Figures 7 and 8) and flowers (Figure 9).

The presence of *S. apetala* was noted in May 2023. To date, more than 80 specimens have been found in the Cubatão-Baixada Santista mangrove (São Paulo-Brazil) (Figure 10). All specimens were georeferenced with the aim of being able to track them individually for later studies but also to investigate their possible dispersal route, from the Santos harbor to more distant locations.

Some observed specimens are up to 12 meters tall; pneumatophores are four times higher than those of native species.

A large quantity of fruits was observed, in one tree more than 1,000 propagules were counted and within each fruit up to 60 seeds (Figure 11). Ripe fruits and seeds float, which facilitates their dispersion by the tide. It was also observed that the fallen fruits are already part of the animals' diet (as some specimens were partially eaten).

Its distribution is in a still relatively restricted area but is clear that it is related to the route of ships, hence the assumption that the fruits/propagules (and/or seeds) have been transported through ship ballast

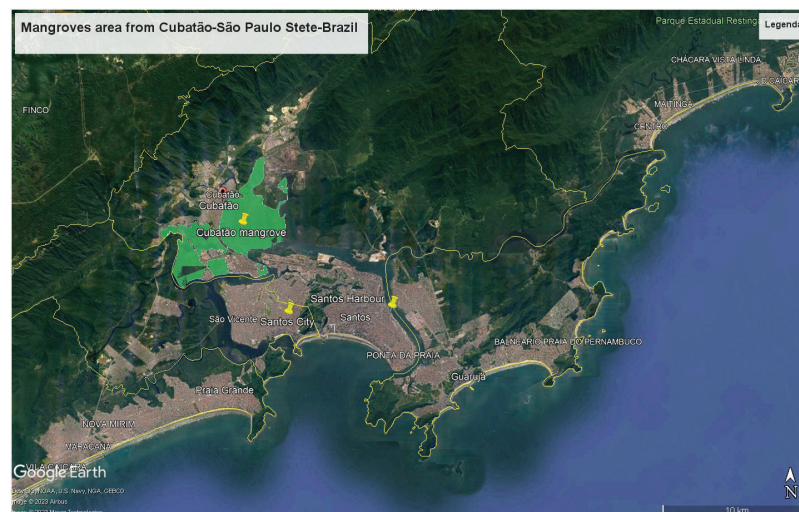


Figure 1. Mangroves of the Cubatão-Baixada Santista estuary where the Port of Santos is located.



Figure 2. TOPODRONE 200 Ultra embedded in FJI M300 RTK drone, the profiler includes a Velodyne Ultra Puck sensor, a high-precision IMU (Honeywell), and a receiver HNSS L1/L2 Survey (U-BÇOX).



Figure 4. Roots of *Sonneratia apetala* (extend up to 20 meters) (Photo E. Hatamura).



Figure 3. One of the specimens of *Sonneratia apetala* (Photo E. Hatamura).

water. A probable route was traced, and the location of the identified specimens corroborate this option.

All these factors support with its ability to rapid dispersal and adaptation (Ren *et al.* 2009). Although this species is widely found in China's restoration projects (Chen *et al.* 2009; Fazlioglu *et al.* 2020).

In addition to this first record of *S. apetala* in South America, it is urgent that we consider the ecological issue of the presence



Figure 5. Characteristics of pneumatophores of *Sonneratia apetala* (up to 80 cm high) (Photo E. Hatamura).



Figure 6. Leaf of *Sonneratia apetala* (Photo E. Hatamura).



Figure 7. Trees of *Sonneratia apetala* with fruit (Photo E. Hatamura).



Figure 10. Location of georeferenced *Sonneratia apetala*.



Figure 8. Fruits of *Sonneratia apetala* (Photo E. Hatamura).

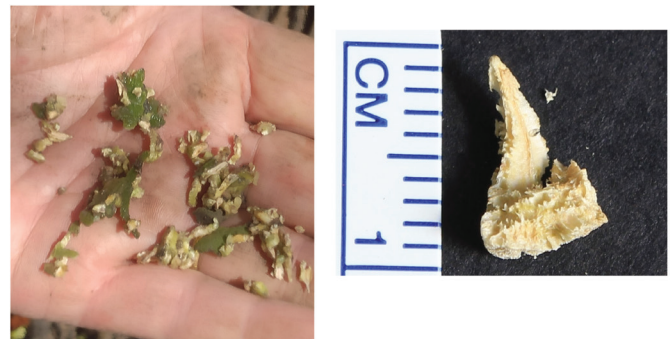


Figure 11. Seeds of *Sonneratia apetala* (Photo E. Hatamura).



Figure 9. Flower of *Sonneratia apetala* (Photo G.G.J. Eysink).

of this species, aiming to assess the need for its total eradication, before the situation becomes irreversible mainly due to the size of the trees; the large amount of fruits and seeds, without forgetting to mention the species aggressiveness of its roots and structure of the pneumatophores.

All these factors highlight the aggressiveness of the species whether in the occupation of the area, competition with native species and its great potential and success for dispersal. It is worth noting here that the mangroves in the Cubatão region and the Baixada Santista Estuary,

previously degraded, are now at an advanced stage of recovery, but there are still places to be restored.

The presence of *S. apetala* in South American soil (actually in Brazilian territory) can lead to a radical change in the ecosystem configuration and the biological diversity of local native species.

The presence of this exotic species (especially due to its aggressive characteristics and ability to occupy the still unoccupied niches), could negatively influence the reestablishment of all mangroves with species native to the region and could even cause significant socio-environmental impacts.

Sonneratia apetala presence is a casualty and brings into question enormous impacts that exotic species can cause prejudices where the mangroves have a very strong and important relationship with the presence of artisanal fishermen and also due to the multiple ecosystem's role (including the not silting up the harbors).

It should be considered the issue that mangroves are a nursery for important commercial fishes and other species (birds, crabs, and fish), and there are fish species of great economic value that move more than 2,000 km to come to this estuary to spawn.

An urgent decision to eradicate this invasive species is strongly recommended by the authors, as well as the implementation of an Environmental Management Policy.

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Author Contributions

Geraldo Guilherme José Eysink: substantial contribution to the concept and design of the study; data collection; analysis and interpretation; manuscript preparation and critical revision; adding intellectual content.

Edmar Hatamura: data collection; analysis and interpretation; manuscript preparation and critical revision.

Yara Schaffer-Novelli: substantial contribution to the concept and design of the study; analysis and interpretation; manuscript preparation and critical revision; adding intellectual content.

Conflicts of Interest

The authors declares that they have no conflict of interest related to the publication of this manuscript.

Ethics

This study did not involve human beings and/or clinical trials that should be approved by one Institutional Committee.

Data availability

Supporting data are available at: <https://data.scielo.org/dataset.xhtml?persistentId=doi:10.48331/scielodata.A5MQL>.

References

- CHEN, L., WANG, W., ZHANG, Y. & LIN, G. 2009. Recent progresses in mangrove conservation, restoration and research in China. *J. Plant. Ecol. England*, 2(2):45–54. <https://doi.org/10.1093/jpe/rtp009>
- CONABIO. 2018. Comissão Nacional da Biodiversidade. Estratégia nacional para espécies exóticas invasoras. Anexo da Resolução CONABIO nº 7, de 29 maio de 2018.
- FAZLIOGLU, F. & CHEN, L. 2020. Introduced non-native mangroves express better growth performance than co-occurring native mangroves. *Sci. Rep., England*, 10:3854. <https://doi.org/10.1038/s41598-020-60454-z>
- RAHMAN, S., SASS-KLAASSEN, U., ZUIDEMA, P.A, CHOWDHURY, Q. & BEECKMAN, H. 2020. Salinity drives growth dynamics of the mangrove tree *Sonneratia apetala* Buch.-Ham. in the Sundarbans, Bangladesh. *Dendrochronologia, Italy*, 62. <https://doi.org/10.1016/j.dendro.2020.125711>
- REN, H., LU, H., SHEN, W., HUANG, C., GUO, Q., LI, Z. & JIAN, S. 2009. *Sonneratia apetala* Buch.Ham in the mangrove ecosystems of China: An invasive species or restoration species? *Ecol. Eng. Netherlands*, 35:1243–1248. 2009. <https://doi.org/10.1016/j.ecoleng.2009.05.008>
- TOMLINSON P. B. 2016. The botany of mangroves. Cambridge University Press, Cambridge. 1986. p. 413. <https://doi.org/10.1017/CBO9781139946575>

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