Fronteiras: Journal of Social, Technological, and Environmental Science
http://periodicos.unievangelica.edu.br/fronteiras/
ISSN 2238-8869

Article

Temporal and Spatial Distribution of Populations of Scarlet Ibises (*Eudocimus ruber Linnaeus*, 1758) and Roseate Spoonbills (*Platalea ajaja Linnaeus*, 1758) in the Guaraqueçaba Estuary – Paraná

Matheus Felipe da Costa Pereira[1], Carolina Ribeiro Gomes[2], Guilherme Oliveira Teixeira de Carvalho[3], Geraldo Majela Moraes Salvio[4]

[1] Bachelor's degree in Biological Sciences. IFSUDESTEMG. ORCID: 0009-0000-7429-0184. E-mail: mathew1823m@gmail.com
[2] PhD in Forest Engineering. Professor at the Federal Institute of São Paulo. ORCID: 0000-0002-5187-8011. Email: carolrggomes@gmail.com
[3] Master's student in Geography. Federal University of São João Del Rei. ORCID: 0000-0001-9529-9823. Email: guilhermeotc.engambiental@gmail.com
[4] PhD in Forest Engineering. Professor at IFSUDESTEMG. ORCID: 0000-0002-3953-1349. Email: Geraldo.majela@ifsudestemg.edu.br

ABSTRACT
This study aimed to analyze the temporal and spatial distribution of populations of scarlet ibis *(Eudocimus ruber)* and spoonbills *(Platalea ajaja)* in the Guaraqueçaba estuary, on the northern coast of Paraná, Brazil. The proposal was to provide ecological data on these species and understand how the presence of a balanced environment influences their permanence in the region. In addition, we sought to highlight the importance of local Conservation Units (UCs) in the conservation of these coastal birds. The municipality is located in one of the largest remnants of Atlantic Forest and is home to an estuarine complex with a mosaic of CUs, such as Superagui National Park and Guaraqueçaba Ecological Station, which support diverse ecosystems and endangered species. Data collection was conducted during five expeditions between August 2018 and June 2019, along four transects surveyed by boat. Both species were recorded in all sampling months, with seasonal variations in abundance. In total, 1,202 Scarlet Ibises and 91 Roseate Spoonbills were recorded. Scarlet Ibises (*Guarás*) were most abundant in August 2018 (563 individuals) and April 2019 (405 individuals), while Roseate Spoonbills peaked in October 2018 (54 individuals). Spatially, Scarlet Ibises were mainly concentrated in the Tibicanga and Guapicum regions, near the Conservation Units. Roseate Spoonbills (*Colhereiros*), in turn, showed a broader distribution, from Tromomô to the Varadouro Channel. Both species exhibited an aggregated distribution pattern, but without coexisting in the same locations, suggesting interspecific competition or distinct ecological strategies. The frequency of occurrence of Scarlet Ibises was higher in less rainy months (August and April – 100%), while Roseate Spoonbills were more frequent in October, a month with high precipitation. The results reinforce the ecological importance of the estuary and the urgent need for integrated conservation measures and environmental education actions to protect local biodiversity from human impacts.
Keywords: protected areas; conservation; Atlantic Forest; Scarlet Ibises; Roseate Spoonbills.

Introduction

Protected Areas (PAs) are demarcated territorial spaces that serve to conserve or preserve the natural and cultural resources associated with them (Dudley, 2008). According to the National System of Conservation Units (SNUC), the planning, creation, and management of these PAs—legally recognized in Brazil as Conservation Units (CUs)—ensure the maintenance of significant and ecologically viable portions of different populations, habitats, and ecosystems present both in the national territory and in jurisdictional waters (Brazil, 2000).

In Brazil, according to the Brazilian Conservation Units Panel, there are 2,659 CUs, corresponding to a total of 2,565,366.34 km² of Protected Areas, distributed across the six Brazilian biomes: Amazon, Caatinga, Cerrado, Atlantic Forest, Pampa, and Pantanal. Of this total, 1,589 Conservation Units are located in the Atlantic Forest biome, resulting in 11.33% of this ecosystem being protected (CNUC, 2023).

Submission: April 18, 2025 Accepted: July 7, 2025 Publication: 09/04/2025

v.14, n.3, 2025 • p. 1-12. • DOI http://dx.doi.org/10.21664/2238-8869.2025v14i3.7974

© 2021 by the authors. This journal offers immediate open access to its content, following the principle that making scientific knowledge freely available to the public provides greater global democratization of knowledge. This manuscript is distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (https://creativecommons.org/licenses/by-nc/4.0/legalcode), which allows the reproduction and sharing of the licensed material, in whole or in part, for non-commercial purposes only; and the production, reproduction, and sharing of adapted material for non-commercial purposes only.

The Atlantic Forest is considered a global conservation *hotspot*, meaning it is recognized as one of the most important areas to be prioritized for biodiversity conservation due to its great biological richness and high rate of endemism (Tabarelli *et al.*, 2010). However, due to centuries of exploitation of natural resources since the arrival of the Portuguese, little remains of its landscapes, which are now highly degraded. Approximately 28% of the native vegetation cover remains, and this remaining cover is predominantly composed of isolated fragments, which compromises connectivity between habitats and directly affects biodiversity (Joly *et al.*, 2014; Rezende *et al.*, 2018).

Guaraqueçaba, a municipality located on the northern coast of Paraná, lies within one of the last remnants of the Atlantic Forest (Dense Ombrophilous Forest) (Fundação SOS Mata Atlântica & INPE, 2022). The municipal territory lies within a large Environmental Protection Area (APA), whose function is to ensure the reproduction and balance of plant and animal species, in addition to protecting the surroundings of other Conservation Units. This arrangement forms a mosaic of Conservation Units, covering both Integral Protection Units and Sustainable Use Units, thereby promoting the protection of ecosystems and the sustainable use of natural resources (Corrêa, 1996).

These areas are home to endemic species, such as the black-faced lion tamarin *(Leontopithecus caissara* Lorini & Persson, 1990*)*, whose distribution is restricted to Superagui National Park, and the Brazilian blue macaw *(Amazona braziliensis* Linnaeus, 1758*)*, an endangered species that uses the areas of Pinheiro and Pinheirinho Islands, which are part of Superagui National Park (Brazil, 1997), for rest and reproduction (Leuzinger *et al.*, 2014).

With the protection of these areas, the biodiversity of the site, where many of the species are threatened with extinction, has been preserved (Brazil, 1989; MMA, 2022). Among the species that inhabit the region and are threatened by anthropic pressure are the scarlet ibis and the spoonbill.

The scarlet ibis *(Eudocimus ruber* Linnaeus, 1758*)* is a bird of the Threskiornithidae family, which inhabits flooded areas such as estuaries and mangroves, where it searches for food and nests. It feeds on small invertebrates, such as crustaceans and insects, with a greater specificity for crabs, such as the fiddler crab (Uca *spp.*), which, in addition to providing the nutrients necessary for its survival, provides the carotenoid canthaxanthin, responsible for the intense red plumage characteristic of this bird (Sick, 1997; Olmos, Silva & Barbieri, 2022). Prado, 2001; Roselli & Barbieri, 2022).

Their foraging is determined by the tides, which expose the soil, where they leave the mudflats in search of food during low tide. Always seen in flocks, they are gregarious, especially in mangroves (Sick, 1997), and may share their nesting grounds with other bird species, such as spoonbills and herons (Zanin *et al.*, 2008; Fink & Cremer, 2015; Paludo *et al.*, 2018).

Guaras occur in several regions of the Americas, including Brazil, the Caribbean, Ecuador, Colombia, Venezuela, Guyana, Suriname, and Trinidad and Tobago (Stotz *et al.,* 1996; Sick, 1997; Pacheco *et al.,* 2021). In Brazil, this species was previously widely distributed along the coastline, accompanying the formation of mangroves and adjacent environments, from the state of Amapá to Santa Catarina (Sick, 1997; Gonçalves *et al.,* 2010). However, over the last few centuries, there has been a sharp decline in population, attributed to the fragmentation of mangroves, hunting, egg collection, and the species' own ecology, especially with regard to its dispersal movements (Rodrigues, 1995; Gonçalves *et al.,* 2010; Straube, 2011; Chupil & Monteiro, 2018). As a result of these changes in distribution, only three areas are currently recognized as having considerable populations of Guarás in Brazil: two well-established areas in the states of Pará and Maranhão (Hass, 1996; Gonçalves *et al., 2010) and* one in the process of reoccupation in the south-southeast, with records in the regions of Cubatão (SP) and on the coast of Paraná (Marcondes-Machado & Monteiro-Filho, 1990; Gonçalves *et al.,* 2010; Souza, 2014).

According to the IUCN Red List of Threatened Species (2023), the Guará is a species that, in its areas of occurrence, is classified as of least concern, but reports that its population continues to decline due to the suspected destruction of its habitat (IUCN, 2023).

Spoonbills *(Platalea ajaja* Linnaeus, 1758*)* are birds that also belong to the Threskiornithidae family and are named after the shape of their beak, which resembles a spoon. They use it as a sieve to obtain their food by moving it through the water.

With a generalist foraging characteristic, they feed on small fish, insects, mollusks, and crustaceans in flooded areas, depending directly on water levels and flooding patterns to search for food, build nests, and

ensure the survival of their young (Kushlan, 1993; Sick, 1997; Alho, 2012). Their pink coloration is also due to the presence of carotenoids: canthaxanthin and astaxanthin, obtained through their diet (Sick, 1997).

Gregarious in nature, they inhabit muddy beaches, either inland or on the coast, with a wide geographical distribution, occurring from the southern United States to Argentina. In Brazil, they can be found in almost all biomes, from the central region to the entire southern region of the country (Sick, 1997).

Platalea ajaja is on the red list, a species whose overall population is considered of least concern and stable, although some populations have unknown trends due to a lack of studies (IUCN, 2023).

According to Martins & Wanderley (2009), human occupation in mangrove areas has resulted in the loss of part of the biodiversity of these areas. These ecosystems are fundamental for several species, serving as areas for feeding, reproduction, rest, and maintenance of life (Pinheiro *et al.,* 2008). As a result of degradation, some species have become endangered, such as the scarlet ibis (*Eudocimus ruber),* which disappeared from the region for decades and only returned about 40 years later (Salvio, 2015). Given this scenario, ecological studies have been conducted focusing on the abundance and distribution of species, considering factors such as climate and tidal patterns, which reinforces the importance of conservation through Protected Areas (Noguchi, 2011; Grose, 2016; Vigário, 2020).

This study focused on the species *Eudocimus ruber* and *Platalea ajaja*, relating them to the variables of abundance and distribution, due to the benefit that birds provide to the environment and to all other species, animals, or plants (Pizzo & Galetti, 2010), and due to the fact that these birds are recognized as bioindicators of habitat quality, which allows us to understand how conservation areas are fundamental for species conservation (Aleixo & Galetti, 2010), and due to the fact that these birds are recognized as bioindicators of habitat quality, which allows us to understand how conservation units are fundamental for species conservation (Aleixo & Vielliard, 1995).

Abundance and distribution are the two most important variables for characterizing populations and assessing extinction risk (Gaston *et al.,* 2000; Ball *et al.,* 2024). Santini *et al. (*2022) further corroborate that associating abundance estimates with risk assessments is essential, even for species with a large distribution area, as they may still be in population decline.

The overall objective of the study was to analyze the temporal and spatial distribution of *Eudocimus ruber* and *Platalea ajaja* in the Guaraqueçaba estuary, on the northern coast of Paraná, seeking to understand how the presence of a balanced environment influences the permanence of these species in the region. Based on the data obtained, we also sought to highlight the importance of local Conservation Units in maintaining these environments and conserving the associated biodiversity.

Materials and Methods

Guaraqueçaba, in addition to having several Conservation Units, is located on the shores of one of the largest and most important estuarine complexes in the world, located on the northern coast of the state of Paraná (Lat.: 25.297199°; Long: -48.326334°) and has a great wealth and diversity of beings, habitats, and favorable living conditions for these organisms (IPARDES, 1989).

The study used the species *Eudocimus ruber* (Guará) and *Platalea ajaja* (Spoonbills), as birds are one of the most diverse and well-studied zoological groups in all environments and are considered bioindicators of habitat quality (Aleixo & Vielliard, 1995).

Data collection was carried out through five field expeditions, distributed in August and October 2018, and January, April, and June 2019, totaling 20 sample surveys in Guaraqueçaba Bay, extending to Laranjeiras Bay. To sight the species, the active search method was adopted, focusing on the species, conducted by two researchers responsible for systemic observation during the route of *the* previously defined *transects* (Fig. 1) and traveled by boat. The campaigns did not strictly follow the division by seasons, with the aim of covering different periods and thus obtaining a different sample of the temporal and spatial variation in the abundance of *Eudocimus ruber and Platalea ajaja* in the region.

Figure 1. Map of *the transects* covered during the sampling campaigns (*Transect* 01 - Tromomô Region; *Transect* 02 - Varadouro Channel; *Transect* 03 - Tibicanga and Guapicum Regions; *Transect* 04 - Ilha das Peças and Superagui National Park). Source: Carvalho, G.O.T (2025).

Regarding the recording of species and their verification, photographs and videos were considered as documentary evidence of the species, which allowed for the reliable determination of the taxon, based on the Brazilian Committee of Ornithological Records (Sick, 1997).

Material evidence was obtained through active onboard searches, focusing on daytime and evening hours during the expeditions. Nikon 10x50mm binoculars and a Silstar NV 70 spotting scope with a 70mm lens, 60x magnification, 1:10 aperture, and 1.25-inch eyepiece diameter, mounted on a tripod, were used.

Professional (Nikon D-90) and semi-professional (Nikon D-5100) digital cameras were also used, as well as Full HDx36 digital camcorders and Garmin GPS for georeferencing sampling points and subsequent map creation using ArcGis *software*. The records were made at a distance, within a radius of 50m to 100m, without any type of interference to avoid disturbing the individuals, as they are cautious birds (Rodrigues, 1995; Sick, 1997).

Historical rainfall data were obtained from the Paraná Rural Development Institute (IAPAR, 2022). Variations in tidal range were obtained from the Tide Table (Tide Table, 2018).

The frequency of species was obtained from the number of records for each species divided by the total number of field trips, according to Silva *et al.*, 2012, using the following calculation:

FO% = Nsi x 100 / Nts

Where: FO = frequency of occurrence; Nsi = number of field trips in which species i was recorded (observation/focus); Nts = total number of field trips.

Each species was classified into categories according to its frequency of occurrence in the study area for each period in which the species was recorded. The categories were: abundant (75-100%), frequent (50-74%), common (25-49%), rare (6-24%), and occasional (<5%) (Silva *et al.*, 2012).

With the sampled data, we sought to answer the following guiding questions: Were the guarás and spoonbills observed during all months in which the sampling campaigns took place? Where in the bay were the two species recorded? What were the distribution patterns? What were the causes and influences for this distribution? What were the possible antagonisms? How did the population dynamics occur?

Results and Discussion

Through data collection, it was possible to confirm the existence of scarlet ibis *(Eudocimus ruber)* and spoonbills *(Platalea ajaja)* during all months of the expedition in the region, with fluctuations in the abundance of the species in each sampling month.

At the end of the five expeditions, a total of 1,202 Guará macaws and 91 spoonbills were sighted, with the months of greatest abundance for Guará macaws being August 2018 (563 individuals) and April 2019 (405 individuals), while the highest abundances of spoonbills were in August 2018 (12 individuals) and October 2018 (54 individuals) (Fig. 2).

The record of greater abundance of Guarás for the month of August contradicts the pattern observed in other coastal regions of Brazil, such as Cananéia and Ilha Comprida (SP), where the largest populations occur during spring and summer (Oliveira, 2009; Barbieri, 2009), as well as in Santa Catarina (Rodrigues, 1995; Silva and Silva, 2007). This atypical behavior may be related to specific ecological factors, especially food supply. In addition, because it is winter, the month of August had low tides, favoring the exposure of mudflats, expanding access to food, and optimizing foraging for this species (Cabra, 2015; Martins, 2015). Thus, the abundance recorded in August, even though it contradicts expected patterns, may reflect an adaptive strategy in response to food availability, reinforcing the importance of considering local ecological particularities when analyzing the distribution patterns of the species.

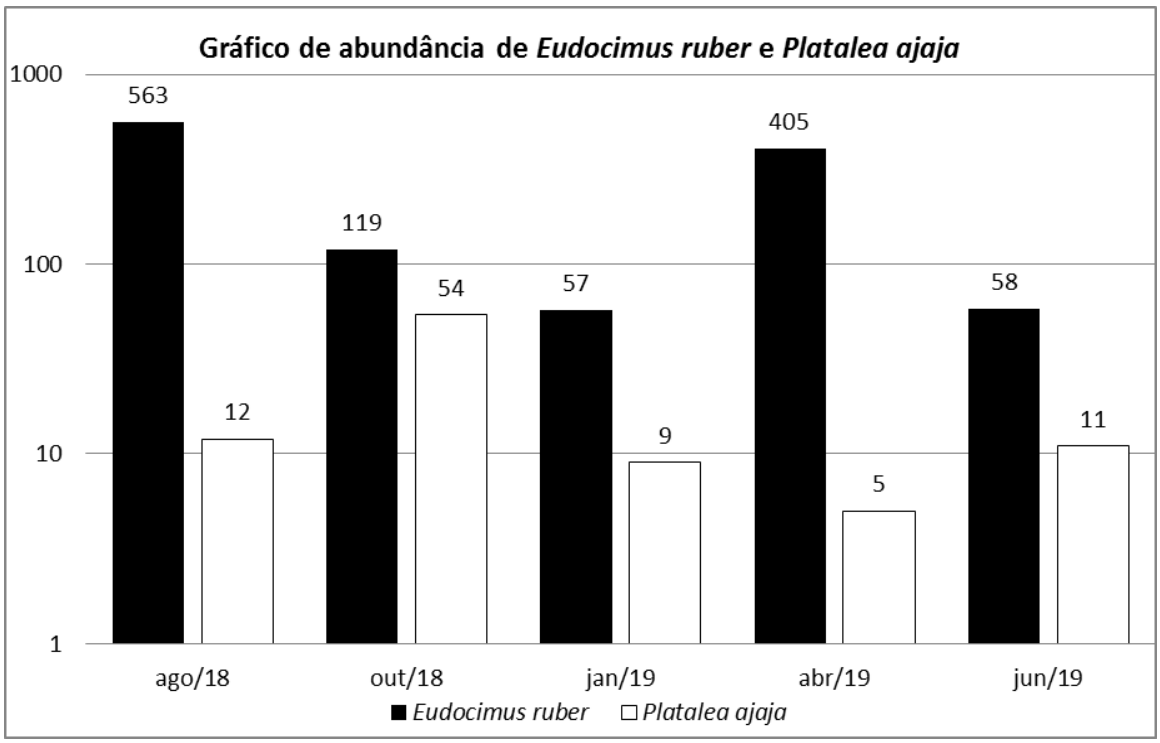

Figure 2. Abundance of species during sampling campaigns. Source: Author's own work (2025).

Spatial distribution could be observed through the creation of maps, which when superimposed (Fig. 3), it was verified that the species studied are distributed across distinct areas, and that the Guarás mostly gathered their flocks in the regions of Tibicanga and Guapicum, located on the edges of Ilha das Peças, part of which are within or close to the Conservation Unit, such as the Superagui National Park (PN), the Guaraqueçaba Ecological Station (ESEC) - ESEC, and near the municipality of Guaraqueçaba, and represented in Fig. 1 by transects 02, 03, and 04.

The spoonbills had a wider distribution (Fig. 3), with sightings recorded in greater numbers in the regions of Tromomô, within the Guaraqueçaba ESEC, near the municipal area, on Ilha das Peças, which is part of the Superagui National Park, extending to the Varadouro Canal, on the border between the states of Paraná and São Paulo, represented in Fig. 1 by the four transects.

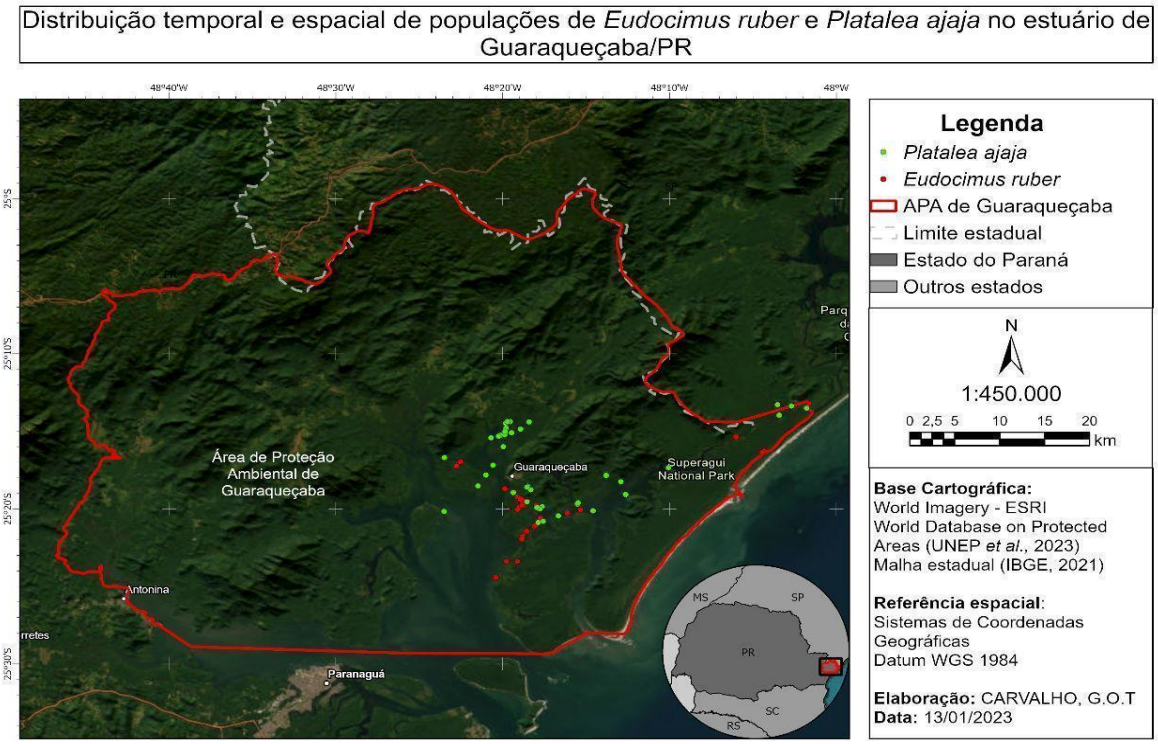

Figure 3. General map of the spatial distribution of *Eudocimus ruber* and *Platalea ajaja* populations in the Guaraqueçaba estuary – PR during the expeditions. Source: Carvalho, G.O.T (2025).

It was also possible to observe that both species have an aggregated distribution pattern, that is, they live in groups. However, it was not possible to observe the coexistence of Guarás and Spoonbills in any of the months of collection, contradicting the literature, which states that there is a possibility of nest sharing by these species (Sick, 1997).

This may be due to several reasons, such as interspecific competition (Frederick, 2002), where the presence of large groups of scarlet ibis inhabiting areas of better environmental quality, as they are more specialized niche birds and have a more restricted diet, drives away populations of spoonbills, which have a different beak morphology and foraging technique, allowing them to seek other areas and food (Morse, 1974; Podulka *et al.*, 2004), or due to the extensive area for exploration; or because, according to Matheus & Del Hoyo (1992), spoonbills may be more active at night.

Table 1 provides an overview of the number of scarlet ibis *(Eudocimus ruber)* and spoonbills *(Platalea ajaja)* sighted and their frequency of occurrence in each month of observation:

Table 1. Number of birds sighted and frequency of occurrence of *Eudocimus ruber* and *Platalea ajaja* during data recording expeditions in the Guaraqueçaba Estuary - PR.

Meses de coleta	N° de aves avistadas / Freq. Ocorrência (%)	
	Eudocimus ruber	*Platalea ajaja*
agosto/18	563 / 100	12 / 75
outubro/18	119 / 75	54 / 100
janeiro/19	57 / 25	9 / 25
abril/19	405 / 100	5 / 50
junho/19	58 / 50	11 / 75

Source: Author's own work (2025).

In August 2018, scarlet ibis were seen in all four *transects*, and most often sighted in large groups, as occurred on 08/28/2018, when a flock of 317 individuals was recorded at a single point at a time of day when the tide was very low, exposing a large amount of soil and forming shallow pools of water, allowing the species to forage. In contrast, spoonbills, recorded in only three *transects,* were sighted in flocks of up to three individuals. The result obtained for the guarás population in August is important, since in another study conducted previously, the largest populations recorded were in January (Vigário *et al.*, 2020).

Spoonbills were much less abundant than Guaras during this period, which may be related to the species' displacement to breeding areas, such as the Lagoa dos Patos estuary, Rio Grande, in Rio Grande do Sul, where they begin to occupy the colony in the estuary in September (Gianuca, 2010).

In October 2018, the scarlet ibis population was recorded in three of *the* four *transects*, i.e., abundant, with a decline in abundance compared to the previous month of collection, while the spoonbill population was recorded in all four *transects*, classified as abundant, showing considerable growth in abundance compared to the previous sampling campaign.

Unlike the study by Vigário *et al.* (2020), which did not record the presence of scarlet macaws *(Eudocimus ruber)* in October and November, the present study found populations of the species during this period. This record was possible due to the field campaign carried out between October 30, 2018, and November 3, 2018, which highlights the importance of variation in sampling for a more accurate understanding of species dynamics.

In January 2019, the populations of both species studied declined in abundance and were seen in only one *transect*, classified as common. Here, we observed a decline in the number of individuals in the guarás populations, contrary to records for the largest populations of the species in January, reaching 225 specimens sighted for the month (Vigário *et al.*, 2020).

As for the spoonbills, during the collection period, which was in the summer season, the reduced number of individuals is consistent when compared to studies conducted in other regions, which record the smallest populations for the same season, as it is a period when there is normally more rainfall and, consequently, water levels rise (Antas & Palo Jr., 2004).

In April 2019, the Guarás population began to grow again, being recorded in all four *transects*, and therefore considered abundant, while the Spoonbill population remained low, being sighted in two *transects* and categorized as frequent.

June 2019 marked the end of the field data collection schedule, and during that month, we observed a decline in the number of individuals in the Guarás populations. They were sighted in only two *transects* and classified as frequent. The Colhereiros population showed a slight increase compared to the last collection, and they were recorded in three *transects* and classified as abundant.

Calculating the frequency of occurrence of species provided a detailed view of their temporal distribution over the months of collection, and it was observed that in months with lower precipitation levels, such as August 2018 (91.9 mm) and April 2019 (129.2 mm) the frequency of Guarás was higher (August/18: 100%; April/19: 100%) than in months with high rainfall, such as October 2018 (376.2 mm) and January 2019 (472.2 mm) (Fig. 4).

However, this result contradicts the literature, which states that it is during the months with the highest rainfall that the largest groups of Guarás can be observed, due to their reproductive behavior of forming colonies for nesting during these periods (Paludo *et al.*, 2018).

Knowing the dispersal behaviors for reproduction of this species, there is a possibility that these flocks are migrating to other regions during the periods when they are recorded in smaller numbers, such as Ilha Comprida, São Paulo. This is especially true because it is close to the study area and there are records of breeding colonies of the species (Paludo et al., 2018).

As for spoonbills, little is known about their reproductive ecology, dispersal behaviors, and influences. Through a bibliographic study, it was found that individuals of the species are most frequently sighted in seasons when water levels are lower (Antas & Antas, 2004), which contradicts the results obtained in this study, which recorded the highest frequency of occurrence of the species in October 2018 (100%), when water levels were high. Palo Jr., 2004), which contradicts the results obtained in this study, which recorded the highest

frequency of occurrence of the species in October 2018 (100%), when it marked one of the highest rainfall rates in the collection period (376.2 mm) and the highest abundance, 54 specimens (Fig. 4).

During the study period, despite recording the presence of young Guaras and Spoonbills, no possible breeding colonies were identified in the Guaraqueçaba estuary, but other authors have recorded a breeding colony of guarás very close to the studied areas, on Ilha Comprida, located in the state of São Paulo, which borders the municipal territory of Guaraqueçaba to the north (Paludo *et al.*, 2018).

All species depend on a balanced environment for their existence in a given area, including us humans, as well as the guarás and spoonbills. Among the possible factors that antagonize the presence of these species are the degradation of mangroves for disorderly occupation and the noise generated by boats (Cabral, 2015; Martins, 2015), as well as the unconscious exploitation of crustaceans, mollusks, and fish by human populations living in regions close to mangroves, which are part of the diet of these species. Although this exploitation is essential for the subsistence of these communities, it can cause imbalances in the ecosystem when practiced unconsciously and without proper supervision (Souza *et al.*, 2018).

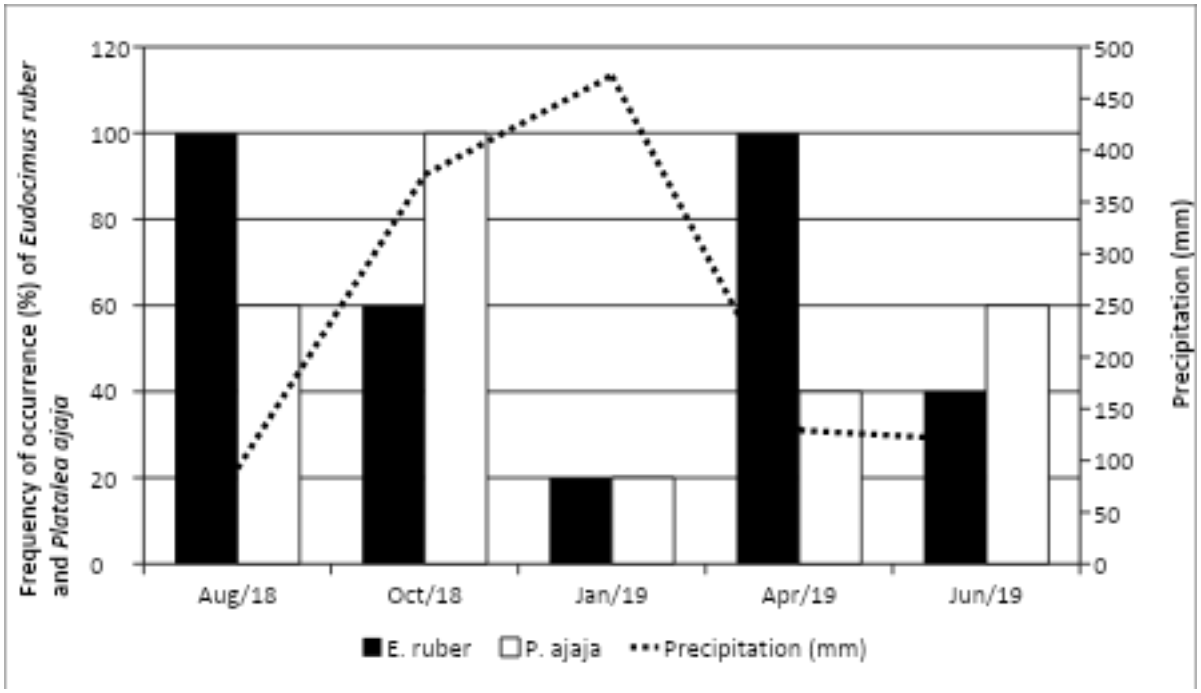

Figure 4. Frequency (%) of occurrence of Eudocimus ruber and Platalea ajaja in the Guaraqueçaba estuary, from August 2018 to June 2019, and precipitation. Source: Author's own work (2025).

Conclusion

This study successfully answered the questions that guided the research. Guarás and Colhereiros were observed in all months of the field campaigns, demonstrating a constant presence in the region. However, there were variations in abundance over time, with Greater Flamingos more numerous in months with lower rainfall and Spoonbills more present in rainier periods, a result that contradicts data described in the literature and reveals particularities of the studied region.

In terms of spatial distribution, the two species were concentrated in different areas of Guaraqueçaba Bay, with Guaras being seen in areas close to Conservation Units, such as Tibicanga and Guapicum, while Spoonbills had a wider distribution, reaching the limits of the estuary. Both species were distributed in groups, but were not recorded occupying the same locations at the same time, suggesting the existence of indirect antagonisms, possibly related to competition for space or different ecological strategies.

Through these data, we were also able to better understand the dynamics of the populations throughout the year, revealing variations influenced by environmental factors such as tides and precipitation. Although no breeding colonies were observed, young birds were recorded, and the proximity of known colonies in the region may indicate that the study area may serve as a feeding and resting area during reproductive cycles.

By gathering this information, this article contributes significantly to knowledge about the two species in southern Brazil. These results generate unprecedented data on the local ecology of these birds and reinforce

the importance of well-preserved environments, such as the Conservation Units created in Guaraqueçaba, for the maintenance of biodiversity. In addition, they pave the way for new research on reproductive behavior, habitat use, and ecological relationships between similar species.

References

ALEIXO A & VIELLIARD ME 1995. Composition and dynamics of the avifauna of Mata de Santa Genebra, Campinas - São Paulo, Brazil. Revista Brasileira de Zoologia, Campinas, 12(3):493-511.

ALHO CJR, SILVA JSV 2012. Effects of severe floods and droughts on wildlife of the Pantanal wetland (Brazil): a review. Animal, Switzerland, 2(4): 590-610.

ANTAS PTZ, PALO JR H 2004. Pantanal: bird guide: species of the SESC Pantanal Private Natural Heritage Reserve. National Department; SESC, Rio de Janeiro, 249 pp.

BALL TS, BALMFORD B, BALMFORD A, RINALDO D, VISCONTI P, GREEN, R 2024. A general relationship between population size and extinction risk. *arXiv preprint arXiv*: 2411.

BARBIERI E 2009. Feeding sites frequented by the Guará *(Eudocimus ruber)* in the Cananéia-Ilha Comprida estuary, São Paulo. Neotropical Ornithology 20(1): 73-79.

BRAZIL. Decree No. 97,688, of April 25, 1989. Creates the Superagui National Park in the State of Paraná and provides other measures. *Official Gazette of the Federative Republic of Brazil*, Brasília, DF, April 26, 1989. Section 1, p. 6417.

BRAZIL. Law No. 9,513, of November 20, 1997. Expands the boundaries of Superagui National Park. *Official Gazette of the Federative Republic of Brazil*, Brasília, DF, Nov. 21, 1997. Section 1, p. 27181.

BRAZIL. Law No. 9,985 of July 18, 2000. Establishes the National System of Nature Conservation Units. *Official Gazette of the Federative Republic of Brazil*, Brasília, DF, July 19, 2000. Section 1, p. 1.

BRAZIL. MINISTRY OF THE ENVIRONMENT 2022. Ordinance No. 148 of June 7, 2022. *Official Gazette of the Union*, Brasília, DF, p. 74, June 7, 2022.

BRAZIL. Ministry of the Environment. National Register of Conservation Units - CNUC. Law No. 9,985/2000. Consolidated Table of Conservation Units, 2023. Brasília: Ministry of the Environment, 2023.

CABRAL BLF 2015. Between tides: artisanal fishing and boating in Guaratuba Bay. Master's thesis in Environment and Development, Federal University of Paraná, Curitiba (PR), 145 p.

CHUPIL H & MONTEIRO-FILHO ELA 2018. History of the scarlet ibis *Eudocimus ruber* in the south and south-east Brazil. Bulletin of the British Ornithologist's Club, 138(4): 281-285.

CORRÊA F 1996. The Atlantic Forest Biosphere Reserve: A guide to understanding its objectives and management system. Vol. II, UNESCO, São Paulo, 27pp.

DUDLEY N, editor 2008. Guidelines for applying Protected Area Management Categories. IUCN, Gland, Switzerland, 85pp.

FINK D & CREMER MJ 2015. The return of the scarlet ibis: first breeding event in southern Brazil after local extinction. Revista Brasileira de Ornitologia, 23(4): 385-391.

FREDERICK PC 2002. Wading birds in the marine environment. In BURGER J & SCHREIBER EA. Biology of marine birds. CRC Press, Boca Raton, p. 618-655.

SOS MATA ATLÂNTICA FOUNDATION & INPE. *Atlas of Atlantic Forest remnants in the period 2020-2021*. Technical report. São Paulo, 2022.

GASTON KJ, BLACKBURN TM, GREENWOOD JJD, GREGORY RD, QUINN RM & LAWTON JH 2000. Abundance-occupancy relationships. Journal of Applied Ecology, 37(1): 39-59.

GONÇALVES EC, FERRARI SF, BURLAMAQUI TC, MIRANDA L, SANTOS MS, SILVA A & SCHNEIDER MPC 2010. Genetic diversity and differentiation of three Brazilian populations of scarlet ibis (*Eudocimus ruber)*. Journal of Ornithology, 151(4): 797-803.

GROSE AV 2016. The scarlet ibis *Eudocimus ruber* (birds: Threskiornithidae) in the Babitonga Bay estuary, northern coast of Santa Catarina: repopulation, distribution, and biology. Doctoral thesis, Federal University of Paraná, Curitiba.

HASS A 1996. Behavioral biology of *Eudocimus ruber* (Aves, Threskiornithidae) in the mangroves of Cajual Island, Maranhão: reproduction and feeding. Master's thesis, State University of Campinas, Campinas, 91 pp.

INSTITUTE OF RURAL DEVELOPMENT OF PARANÁ - IAPAR-EMATER. Historical and current meteorological data. 2022.

IPARDES 1989. Guaraqueçaba APA: socio-economic characterization of fishermen and small rural producers. Curitiba, Brazil, IPARDES, 87pp.

IUCN 2023. *The IUCN Red List of Threatened Species*. Version 2022-2.

JOLY CA, METZGER JP, TABARELLI M 2014. Experiences from the Brazilian Atlantic Forest: ecological findings and conservation initiatives. *New Phytologist***,** 204(3): 459-473.

KUSHLAN JA 1993. Colonial waterbirds as bioindicators of environmental change (review). *Waterbirds Society*, 2(1): 83-97.

LEUZINGER MD, GODOY LR da C, FERNANDES MHC 2014. Ecological Stations and Biological Reserves: research and preservation. UniCEUB, Brasília, 235 pp.

MARCONDES-MACHADO LO & MONTEIRO-FILHO ELA 1990. The scarlet ibis *Eudocimus ruber* in southeastern Brazil. *Bulletin of the British Ornithologist's Club*, 110(1): 123-126.

MARTINS PTA & WANDERLEY LL 2009. Dynamics of occupation of contiguous areas (period 1987-2008) and its relationship with anthropogenic stressors in the mangrove swamp of the Cachoeira River, Ilhéus, Bahia. *Society & Nature,* 21(2): 77-89.

MARTINS MC 2015. Monitoring of interactions between gray dolphins and boats in the Cananéia-SP estuarine lagoon complex**.** Master's Thesis in Biological Sciences, Biological Sciences Sector, Federal University of Paraná, Curitiba (PR), 53 f.

MATHEUS P & DEL HOYO J 1992. Family Threskiornithidae. In J DEL HOYO, ELLIOT A and SARGATAL J, editors. *Handbook of the World Birds: Ostrich to Ducks*. Lynx Ediciones, Barcelona, p. 472-506.

MORSE DH 1974. Niche breadth as a function of social dominance. *American Naturalist*. 108(964): 818-830.

NOGUCHI RG 2011. Distribution and abundance of Guarás, *Eudocimus ruber* Linnaeus, 1758 (Ciconiiformes: Threskiornithidae) in the Iguape/Cananéia estuarine lagoon complex, State of São Paulo. Final Course Project (Bachelor of Biological Sciences), Federal University of Paraná, Curitiba.

OLIVEIRA TCG 2009. Species diversity and behavior of a community of estuarine birds on a shoal in the Lagamar de Cananéia, southern coast of the State of São Paulo, Brazil. Doctoral Thesis, Federal University of Paraná, Curitiba, 129f.

OLMOS F, SILVA E SILVA R, PRADO A 2001. Breeding season diet of Scarlet Ibises and Little Blue Herons in a Brazilian mangrove swamp. Waterbirds: The International Journal of Waterbird Biology, 24(1): 50-57.

PACHECO JF, SILVEIRA L.F, ALEIXO A, AGNE CE, BENCKE GA, BRAVO G.A, BRITO GRR, COHN-HAFT M, MAURÍCIO GN, NAKA LN, OLMOS F, POSSO S, LEES AC, FIGUEIREDO LFA, CARRANO E, GUEDES RC, CESARI E, FRANZ I, SCHUNCK F & PIACENTINI VQ 2021. Annotated checklist of the birds of Brazil by the Brazilian Ornithological Records Committee - second edition. *Ornithology Research,* 29(2): 1-123.

PALUDO D, CAMPOS FP, COLLAÇO FL, FRACASSO HAA, MARTUSCELLI P & KLONOWSKI VS 2018. Reproduction of *Eudocimus ruber* in the Iguape - Cananéia - Ilha Comprida estuary complex, São Paulo, Brazil. *Ornithological News,* 202(1): 8-15.

PINHEIRO MAA, COSTA TM, GADIG OBF & BUCHMAN FSC 2008. Coastal ecosystems and their biodiversity in the Baixada Santista region. In Oliveira AJFC, Pinheiro MAA, Fontes RF. *Environmental Overview of the Baixada Santista region.* São Paulo State University - Experimental *Campus* of the São Paulo Coast, São Vicente, pp. 7-26.

PIZZO MA & GALETTI M 2010. Methods and Perspectives of Frugivory and Seed Dispersal by Birds. In Matter SV, Straube FC, Accordi LA, Piacentini VQ, Cândido FJ. *Ornithology and Conservation: Applied Science, Research Techniques, and Surveys*. Roca, São Paulo, pp. 493-506.

PODULKA S, ROHRBAUGH JRW, BONEY R, editors. 2004. *Handbook of Birds Biology*. Cornell Lab of Ornithology, 2nd edition Ithaca, New York, p. 225.

REZENDE CL, SCARANO FR, ASSAD ED, JOLY CA, METZGER JP, STRASSBURG BBN, TABARELLI M, FONSECA GA, MITTERMEIER RA 2018. From hotspot to hopespot: An opportunity for the Brazilian Atlantic Forest. *Perspectives in Ecology and Conservation*, Rio de Janeiro,16(4): 208-214.

RODRIGUES AAF 1995. Occurrence of reproduction of *Eudocimus ruber* on Cajual Island, Maranhão, Brazil (Ciconiiformes: Threskiornithidae). Ararajuba, 3(3): 67-68.

ROSELLI LY, BARBIERI E 2022. Seasonal variation of estuarine birds from Trapandé Bay, Cananéia, Brazil. *Ocean and Coastal Research,* 70.

SALVIO GMM, SANTOS EF, BATISTA JC, TEIXEIRA AL, SILVEIRA JÚNIOR WJ 2015. Temporal and spatial distribution of a population of scarlet ibis *(Eudocimus ruber)* in the Guaraqueçaba estuary, Paraná. In *XII Brazilian Ecology Congress, São Lourenço, 2015.* Proceedings... São Lourenço, CEB.

SANTINI L, ISAAC NJB, HUIJBREGTS MAJ, FICETOLA GF, CARBONE C & THUILLER W 2022. Population density estimates for terrestrial mammal species. Global Ecology and Biogeography, 31(4), 716-726.

SICK H 1997. Brazilian Ornithology. Editora Nova Fronteira. Rio de Janeiro, 912 pp.

SILVA E SILVA R 2007. Red guaras in Brazil: the vibrant colors of preservation. *Avisbrasilis*, São Paulo, 240 pp.

SILVA RRS, MORETE CN, MASO M 2012. Study and composition of the avifauna of the Fafram-Ituverava Campus, SP. *Nucleus*, 9(2): 301-312.

SOUZA CA, DUARTE LFA, JOÃO MCA & PINHEIRO MAA 2018. Biodiversity and conservation of mangroves: biological and economic importance. In Pinheiro MAA & Talamoni ACC (Eds.). *Environmental Education on Mangroves.* UNESP, Institute of Biosciences, São Paulo Coastal Campus, São Vicente, pp. 16-55.

SOUZA RM 2014. The scenic singularities of the Paraná coast: A look at the cultural landscape of Guaraqueçaba (PR). Doctoral thesis in Geography, State University of Maringá, Maringá, 204 pp.

STOTZ DF, FITZPATRICK JW, PARKER TA & MOSKOVITS DK 1996. *Neotropical birds: ecology and conservation*. University of Chicago Press, Chicago, *Environmental Conservation* 23(4): 381-381.

STRAUBE FC 2011. Ruins and vultures: history of ornithology in Paraná. Pre-Nattererian period (1541 to 1819). Vol. III(1), Hori Consultoria Ambiental, Curitiba, p. 195.

TABARELLI M, SGUIAR AV, RIBEIRO MC, METZGER JP, PERES CA 2010. Prospects for biodiversity conservation in the Atlantic Forest: lessons from aging human-modified landscapes. *Biological Conservation*, 143(10): 2328-2340.

TIDE TABLE. Preia-Marés de Baía de Paranaguá. 2018.

VIGÁRIO DC, KRUL R & SPACH HL 2020. Ecology of Eudocimus ruber (Pelecaniformes, Threskiornithidae) on the coast of the state of Paraná, Brazil. *Oecologia Australis*, 24(4): 964-970.

ZANIN GR, TOSIN LF & BARBIERI E 2008. Influence of the tide on the abundance of *Egretta caerulea* (Linnaeus, 1758) in an estuarine cove on Ilha Comprida, São Paulo, Brazil. *Studies in Biology, Environment and Diversity*, 30(70/72): 133-139.