Universidade Estadual Paulista – "Júlio de Mesquita Filho"

Departamento de Ciências Biológicas e Ambientais

Instituto de Biociências

Campus do Litoral Paulista

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Orientador: Prof. Dr. Marcos R. Bornschein

Passerine birds specialized in Giant Bulrush for nesting in subtropical salt marshes

São Vicente, 2023

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Passerine birds specialized in Giant Bulrush for nesting

in subtropical salt marshes

Tamiris Pereira-Lima

Dedico este trabalho à toda minha família. Em especial todas as mulheres que estão presents na minha vida e fizeram de mim quem sou hoje.

Também dedico à todos aqueles apaixonados pelas aves, natureza e toda a liberdade que vem com elas.

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“A única coisa de que precisamos para nos tornarmos bons filósofos é a capacidade de nos admirarmos com as coisas. (...)

Um filósofo nunca se conseguiu habituar completamente ao mundo. (...)

Podes dizer que um filósofo permanece durante toda a sua vida tão capaz de se surpreender como uma criança pequena. (...)

E agora tens que te decidir, Sofia: és uma criança que ainda não se habituou ao mundo? Ou és uma filósofa que pode jurar que isso nunca lhe acontecerá? (...)

Não quero que tu pertenças à categoria dos apáticos e dos indiferentes. Quero que vivas a tua vida de modo consciente.”

❖ *Jostein Gaarden, - O mundo de Sofia*

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RESEARCH ARTICLE

Passerine birds specialized in Giant Bulrush for nesting in subtropical salt marshes

Running title: Specialized birds nesting in salt marshes

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Passerine birds specialized in Giant Bulrush for nesting in subtropical salt marshes

Abstract

Birds' reproduction and nesting are intrinsically related to the environmental features of their habitat. Environments with reduced floristic diversity can make birds specialists in a particular plant species for nesting. We hypothesized that in subtropical salt marshes, an environment with low plant richness, the passerines Wren-Like Rushbird (*Phleocryptes melanops*) and Many-Colored Rush Tyrant (*Tachuris rubrigastra*) are specialists and dependent on the Cyperaceae Giant Bulrush (*Schoenoplectus californicus*) for nesting. Specifically, we aimed to analyze the nesting support and the nesting material of these birds in a subtropical salt marsh, located in Guaratuba Bay, southern Brazil, to investigate a possible specialization in the use of Giant Bulrush. Thereunto, for both bird species, in periods between 2011 and 2021, we made nests measurements, described their nesting supports and nesting material, as well as we characterized the local environment using phytosociological analyzes. We analyzed if there is a specialization in the use of vegetation, comparing the coverage data of plant species with their respective use in nests. We found that Giant Bulrush was the most used plant both as support and as nesting material, despite not being the most abundant plant in the environment. In general, about 60% of Wren-Like Rushbird (n = 160) and 80% of Many-Colored Rush Tyrant (n = 102) nests found were fixed in Giant Bulrush, and we noticed that the nests decreased in height over the years ($p < 0.01$ for both species). We also noticed that, although the Giant Bulrush occurred in low proportions in the local environment (10-20% of vegetation cover), it was found in high proportions in nests (~70% of the nesting material). These results indicate a specialist selection of the Giant Bulrush by the birds for nesting. Considering that the salt marshes is currently threatened by climatic changes, the reproductive success of both species can also be compromised by the lack of a nesting environment and/or nesting resource, or even being more susceptible to flooding (i. e.). Therefore, we suggest that the bird's perpetuation in these ecosystems may be at risk in the future decades, warning to the need for conservation strategies.

Keywords: nesting material; nesting support; Many-Colored Rush Tyrant; specialist bird; Wren-Like Rushbird.

Resumo

A reprodução e a nidificação das aves estão intrinsecamente relacionadas com as características ambientais do seu habitat. Ambientes com diversidade florística reduzida podem tornar aves especialistas em uma espécie vegetal particular para a sua nidificação. Hipotetizamos que, em brejos salinos subtropicais, ambientes com baixa diversidade vegetal, os passeriformes bate-bico (*Phleocryptes melanops*) e papa-piri (*Tachuris rubrigastra*) são especialistas e dependentes da Cyperaceae piri (*Schoenoplectus californicus*) como apoio para seus ninhos e como fonte de material nidular. Especificamente, objetivamos analisar os apoios dos ninhos e o material nidular das aves em um brejo salino subtropical, na Baía de Guaratuba, sudeste do Brasil, averiguando se há especialização ou não no uso do piri. Para tal, fizemos busca de ninhos de ambas as aves, em períodos entre 2011 e 2021, descrevemos suas medidas, os apoios de fixação e a composição do seu material nidular, bem como caracterizamos o ambiente local por meio de análises fitossociológicas. Analisamos se há uso especialista ou aleatório da vegetação contrapondo os dados de cobertura das espécies vegetais no ambiente com a sua respectiva utilização nos ninhos. Constatamos que o piri foi a planta mais utilizada tanto como apoio para fixação dos ninhos como para material nidular em ambas as espécies, apesar de não ser a planta mais abundante do ambiente. No geral, cerca de 60% dos ninhos de bate-bico (n = 160) e 80% dos ninhos do papa-piri (n = 102) estavam fixos em piri e que os ninhos diminuíram em altura ao longo dos anos ($p < 0.01$) para ambas as espécies). Notamos, entretanto, que embora o piri tenha ocorrido em baixas em proporções no ambiente (~10-20% da cobertura vegetal), foi encontrado em altas proporções no ninho (~70% do material nidular). Esses resultados indicam uma seleção especialista do piri pelas aves para a nidificação. Considerando que os brejos salinos são atualmente ameaçados pelas mudanças climáticas, o sucesso reprodutivo de ambas as

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espécies também poderá ser comprometido pela falta de ambiente para nidificação e/ou recurso nidular, ou até mesmo por tornar os ninhos mais suscetíveis a inundações. Portanto, nós sugerimos que a perpetuação das aves nestes ecossistemas pode estar em risco nas próximas décadas, alertando para a necessidade de estratégias de conservação.

Palavras-chave: apoio de fixação de ninhos; ave especialista; bate-bico; material nidular; papa-piri.

Introduction

Bird reproduction is a crucial step for the perpetuity of species, which is intrinsically related to individuals' life histories and the ecosystems they inhabit (Partridge & Harvey 1988, Sæther et al. 2013). The reproduction requires energy investment (Verner & Engelsen 1970, Berg et al. 2006, Moreno 2012, Mainwaring et al. 2014) including the investment in nest building because each nest has different particularity according to the environmental pressures (Hansell 2000, Rodenhouse & Holmes 1992, Friesen et al. 2000, Schultner et al. 2013). Bird nests have a variable range of forms and structures (Hansell 2000) and most maintain adequate internal temperature for eggs and nestlings, serve as a shelter from the weather, camouflage against predators (Collias 1986). Ensuring adequate nest composition and a safe nesting support for fixation in the environment are crucial elements to fulfill the nest functions. Nevertheless, these elements depend on the availability of nesting material and supporting structures for nest fixation in the environment, which is usually related to the local vegetation (Álvarez et al. 2013, Cantarero et al. 2015, Briggs & Deeming 2016, Calvelo et al. 2006, Reinert et al. 2012, Hunter et al. 2016).

For nest construction, birds can use many sources of nesting material, such as the simultaneous obtainment of plant fibers from different species (e.g., Stjernberg 1974, Vaurie 1980, Calvelo et al. 2006, Reinert et al. 2012, Surgey et al. 2012, Biddle et al. 2018, Costa et al. 2019). Birds can also show specialist use of resources, such as epiphytic plants (Cestari 2009), aromatic plants (Mennerat et al. 2009, Ruiz-Castellano et al. 2018), mosses (Álvarez et al. 2013, Briggs & Deeming 2016) and tree bark (Cantarero et al. 2015). In addition, the nests positioning in the environment is also important to avoid predation and gaining energy (Houston, McNamara, & Hutchinson 1993), some birds are specialists in certain structures for supporting and fixing nests, as is the case of Araucaria tit-spinetail (*Leptasthenura setaria*) which only nests in Parana pine (*Araucaria angustifolia*) (Sick 1985). In contrast, some birds are generalists, using various plants and structures from the environment (Collias 1986, Cestari 2009, Zyskowski & Greeney 2010, Álvarez et al. 2013, Chiaradia et al. 2017, Costa et al. 2019), as is the case of Cipo Canastero (*Asthenes luizae*), which uses up to 30 different plants to support its nests (Costa et al. 2019). When we think of an environment that is floodable, as wetlands or salt marshes, choosing a good nesting support in terms of quality and height, could avoid the threat of flooding (i.e. placing nests higher) and ensure the safety of nest (Hunter et al. 2016). Thus, the environment should present a variety of material and support options to consolidate birds' nests and obtain reproductive success (Álvarez et al. 2013, Cantarero et al. 2015, Briggs & Deeming 2016). Conversely, in environments where the vegetation has a reduced diversity, birds may be specialists in a particular plant species for nesting (Lent 1992, Álvarez et al. 2013).

Salt marshes are floodable environments (Leitão-Filho, 1982; Gedan et al., 2011) and have low plant diversity. This environment is daily influenced by marine water (Doody, 2001; Watson & Byrne, 2009; Gedan et al., 2011) and therefore is occupied by halophytic plants, tolerant to flooding and salinity (Little & Little, 2000; Doody, 2001), which leads to this low diversity. Recently, it has been recognized that tidal marshes on part of the Atlantic coast and dominated by Giant Bulrush (*Schoenoplectus californicus*) and Southern Swamp Lily (*Crinum americanum*) are a particular type of salt marshes, called subtropical salt marshes (Bornschein et al., 2017). These environments occur on a part of the coast of southeastern and southern Brazil, associated with mangroves (Bornschein et al., 2017). Saltmarshes are environments that are vulnerable by the climate changes (Schaeffer-Novelli et al. 2016, Servino et al. 2018, Cavanaugh et al. 2019, Cooley et al. 2022). Studies shows that in a future scenario, with an increase of sea level, salt marshes could be vulnerable to submergence and that plants of these environments with low tolerance to flood or increase of salinity or temperature, could be removed (Cooley et al. 2022). The combination of greater flooding, added to the greater frequency of extreme events, could jeopardize the trade-off that balances and guarantees the reproductive success of individuals of the species that inhabit.

Among the species of birds that breed in the subtropical salt marshes, there are the Wren-Like Rushbird (*Phleocryptes melanops*) and the Many-Colored Rush Tyrant (*Tachuris rubrigastra*) (Favretto 2016). These birds occur in marshes, especially in temperate and subtropical regions of south-central South America, including Peru, western Bolivia, Chile, Argentina, southern Paraguay, Uruguay, and southern Brazil (Fjeldså & Krabbe 1990, Ridgely & Tudor 1994, 2009, Schulenberg et al. 2007). In Brazil, they occur in small populations along the Atlantic coast, from the north of Rio Grande do Sul to Rio de Janeiro, in the case of the Wren-Like Rushbird and to São Paulo in the case of the Many-Colored Rush Tyrant (Sick 1985, Belton 1994, Ridgely & Tudor, 2009, Ridgely et al. 2015). Both species are classified as "endangered" on the List of Bird Species belonging to the Wild Fauna Threatened of Extinction in the State of Paraná (Paraná 2018) and in São Paulo for Wren-Like Rushbird (São Paulo 2018) and as "vulnerable" for Many-Colored Rush Tyrant in Santa Catarina (Santana Catarina 2011).

The Wren-Like Rushbird's nest is known from several descriptions of its form, measurements and nesting support (Krone 1910, Hudson 1920, MacDonagh 1933, Narosky et al. 1983, Belton 1984, Sick 1985, Ridgley & Tudor 1994, De la Peña 1996, 2013, Remsen 2003, Lara 2011, Chiaradia et al. 2017, García 2017), as well as the Many-Colored Rush Tyrant (Sick 1985, Belton 1994, Skutch 1996, Hansell 2000, Lüthi 2011, Leiva-Tafur et al. 2017), but not so much for the nesting material. The composition of the nests is a key element to fulfill the necessary functions and is related to the nesting material available in the environment (Álvarez et al. 2013, Cantarero et al. 2015, Briggs & Deeming 2016). Despite its importance, little is known about the composition of nesting material in birds nest structure (Lombardi et al. 2010, Deeming & Mainwaring 2015, Hall et al. 2015). So detailed descriptions exist for only a few species (i. e., Marini et al. 2010, Biddle et al. 2017, Mishra et al. 2017), and for Wren-Like Rushbird and Many-Colored Rush Tyrant, there are disagreements about the composition and supports of their nests.

Previous studies argued that both species are specialists in "*juncales*", "*totorales*", "*rushbeds*" or "*beds of rush*" environments (Sclater & Hudson 1988, García & Torres 2017, Quiñonez & Hernandez 2017) and that it is from the vegetation of these environments that they build (Krone 1910, Pereyra 1923, Sclater & Hudson 1988, Amaro & Goyoneche 2017) and support their nests (Krone 1910, Hudson 1920, MacDonagh 1933, Marateo 1977, Narosky et al. 1983, Remsen 2003, Lara et al. 2011, De la Peña 2013, Chiaradia et al. 2017, Quiñonez & Hernandez 2017). Some articles suggest the use of "*junco*" and "*totora*" for both species (Krone 1910, Pereyra 1923, Wilson 1926, Hellmayr 1932, MacDonagh 1933, Marateo 1977, Lüthi 2011, Amaro & Goyoneche 2017, Chiaradia 2017, Quiñonez & Hernandez 2017). Although these information's are very important to understand the nest features of these birds, plant popular names could include many different plant species, causing some confusion regarding which plant species are really used by the birds. For example, the word "*junco*" refers to members belonging to the Cyperaceae and Juncaceae families, covering genera such as *Typha sp.*, *Juncus sp.*, *Scirpus sp.*, *Schoenoplectus sp.*, *Cladium sp*. In addition, "*rush of beds*" and "*totorales*", can refer to both species such as *Typha domingensis* and *Schoenoplectus californicus* (e.g. Quiñonez & Hernandez 2017). Thus, new studies regarding the species level of the plants used by these birds are needed to recognize a possible specialist use and even a dependency on a particular plant species for nesting.

Among the few plants that exist in the subtropical salt marshes, the Giant Bulrush (*Schoenoplectus californicus*) reaches 3 m in height and has resistant leaves arranged in an upright position (Heiser 1978, De Lange et al., 1998). Some authors highlight its resistance, emphasizing its potential for building materials such as boats (Hidalgo-Cordero & García-Navarro 2018) and consequently nests. Allied that the subtropical salt marshes are periodically flooded, the height of Giant Bulrush can favor to the nests not be flooded. Considering these premises, we hypothesize that the Giant Bulrush (*Schoenoplectus californicus*) is the key plant species for the nesting of the Wren-Like Rushbird (*Phleocryptes melanops*) and Many-Colored Rush Tyrant (*Tachuris rubrigastra*) in subtropical salt marshes, being the main support plant to the nests and, additionally, the main source of nesting material (specialized selection). Thus, here we aimed to analyze the fixation supports and nesting material of Wren-Like Rushbird and Many-Colored Rush Tyrant nests in a restricted vegetated environment, verifying if there is specialized selection in Giant Bulrush or random use including other plant species. Considering the climate changes issues (i. e. flooding), we also want to investigate how the nests height are changing about the years, trying to link possible changes with abiotics factors.

Methods

Study area

The present study was carried out inside Guaratuba Bay, on the southern coast of the state of Paraná, southern Brazil (Fig. 1). The field sampling covered the entire breeding area of the Wren-Like Rushbird (*Phleocryptes melanops*) and Many-Colored Rush Tyrant (*Tachuris rubrigastra*) in the region. The species' nesting environments are tidal marshes (Reinert et al. 2007), known as subtropical salt marshes (Bornschein et al. 2017) within an estuarine environment fed mainly by the São João and Cubatão rivers. In the region, the tide is semi-diurnal with inequalities, with two high tides and two low tides with different amplitudes every lunar day (Marone et al., 2006). These environments are characterized by the presence of Giant Bulrush (*Schoenoplectus californicus*), Southern Swamp Lily (*Crinum americanum*), and Southern Cattail (*Typha domingensis*) (Fig. 2). Other common plants are Florida Burrhead (*Echinodorus grandiflorus*), Brazil Beauty-Leaf (*Calophyllum brasiliense*) and patches of Sawgrass (*Cladium jamaicense*), further upstream in the river. Mangrove Fern (*Acrostichum danaeifolium*), bushes of Sea Hibiscus (*Talipariti pernambucensis*), White Mangrove (*Laguncularia racemosa*), and Red Mangrove (*Rhizophora mangle*) trees occur further downstream in the river (Reinert et al. 2007).

Nests and fixing supports

Fieldwork occurred from October 2011 to March 2015 and from December 2019 to February 2021. During this period, the nesting area of the Wren-Like Rushbird and Many-Colored Rush Tyrant in Guaratuba Bay was monitored monthly. We searched for individuals of both species, which we followed when located to check if they reported the presence of a nest, and we also made an active search for nests. The observations were aided by binoculars and the nests were georeferenced (Garmin Etrex 10). For the completed nests we made measurements in the field (i.e. nests height) and in the laboratory (Fig. 3). In the field, we described their support plants, identifying the plant species in which the nest was fixed and counting the number of supports used for the fixation.

Phytosociological characterization

For vegetation descriptions, we performed phytosociological characterizations according to Braun-Blanquet (1979), in 1 m² square. We sampled two squares of 1 m² per nest, one with the nest in the center and the other in the surroundings (random, between 2–9 m away from the nest). From each phytosociology square, we recorded the species and, for each species, the respective values of maximum height, sociability, and coverage. The maximum height represents the greatest length of the individual of each plant species in the square. Sociability corresponds to how much the living aerial part of the individuals of each species were grouped or not, and is classified as follows: 1 = isolated individuals; 2 = individuals forming small groups; 3 = individuals forming large groups; 4 = individuals forming large masses; 5 = continuous population. Coverage represents how much the projection of the living aerial parts of each species covered the soil surface (%), adapted from Braun-Blanquet (1979). In these samplings, each aerial portion was considered individualized from the ground as a distinct individual (Braun-Blanquet 1979). Subsequently, we calculated the following descriptor parameters: absolute frequency (AF) and relative frequency (RF) of the species (Rodrigues 1988, Felfili & Resende 2003), in addition to absolute coverage (AC), relative coverage (RC), and relative importance (RI) species (Boldrini & Miotto 1987; Table 1).

Specialist selection or random use of nesting material

We collected 16 completed nests of each species throughout the study period for later identification of nesting material. Concomitantly, we sampled core material in the field, which was used as a basis for the identification of plant species present in the nesting material. We collected leaves (apical, median, and basal portions), bracts, roots, and stems of each species from the study area, which we fixed in FAA_{70} (Johansen 1940, Kraus & Arduim 1997).

The sampled nests were dismantled, keeping them submerged in water for five days. The nesting material dismantled was dried in an oven at an average temperature of 30 ºC for six days for Wren-Like Rushbird, and an average of three days for Many-Colored Rush Tyrant. Under a stereo microscope, we separated the material into morphotypes, which were compared with the core material for identification. For each evaluated nest we weighed the constituent material and relativized the proportion of the total dry mass of the nest. The difference between the dry mass of the nest and the mass of nesting material refers to the mud, lost in the process of dismantling in water. We categorized as "others" the nesting materials whose mass was on average less than or equal to 5% of the total mass of the nest.

Data analysis

We performed generalized linear models (GLMs) using the maximum likelihood method for all data analysis (Bolker 2008). The selection of the most adequate distribution family (Binomial, Gaussian, or Beta) for each model was made based on the nature of the response variable evaluated (binary, continuous, or proportion). The models were checked for overdispersion when necessary (i.e., Binomial models) and diagnostic graphs for residual analysis were also explored to confirm the assumptions of homoscedasticity and normality when necessary (i.e., Gaussian models). All analyzes were performed one for Wren-Like Rushbird and another for Many-Colored Rush Tyrant. We used R software, using the MASS, bbmle, betareg, ggplot2 and lmtest packages.

Nests and fixing supports

Aiming to test what plant species are most used as support for nesting support, we performed a linear model for each bird species adjusted to the binomial family. The response variable was represented by a binary vector (0 or 1), considering, for each sampled nest, the use of the plant species as support (success = 1) or the non-use of the plant species as support (failure = 0). We compared only the two most used plant species for each bird in models. Among the Wren-Like Rushbird's nests, we randomly selected 160 different nests to evaluate the success or failure in the use of each plant species. In the case of the Many-Colored Rush Tyrant, we randomly selected 102 nests to evaluate the success or failure in the use of each plant species in the analysis. Thus, the predictor of each model was composed of 1 fixed factor with two levels: the two species of plants most used by each bird. We tested if the success rate of use differs between the two plant species (i.e., if there is any preference between them for each bird species), submitting the models to the Likelihood Ratio Test (LRT) with the Chi-square statistic, considering $p < 0.05$ as a criterion of significance in the comparison.

To see how nest height of both species changed over the years, we performed linear models superimposing height (response variable) against abiotic factors (predictor variables). The predictors variables chosen were the Giant Bulrush height, Tide height, Precipitation, Temperature, and Maximum Wind Gust. We made the monthly averages and for each year we chose the maximum values of each abiotic factor, to verify the variation of the maximum averages along 8 years. All assumptions of normality and homoscedasticity were tested to guarantee the reliability of the models. We also submitted the models to LRT – Chi-square and considered $p < 0.05$ to identify predictor effects.

Phytosociological characterization

Aiming to test if the plant species in the environment had different coverage (i.e., if there are any dominant species), we performed two linear models adjusted to the Gaussian family (normal distribution) with 1 fixed factor (plant species), for each bird. A model was performed for each bird species, comparing the plant coverage found in the phytosociological squares carried out around their nests. We compared only the three main plant species, those that presented average coverage above 5% in the squares. The average coverage considered the mean of the squares with the nest in the center and around it (random), to obtain a greater representation of the environment around the nests. Therefore, the response variable used was "average coverage" and the predictor (plant species) presented three levels: the three most representative species. We randomly selected the coverage values of 90 different squares for the Wren-Like Rushbird and 60 for the Many-Colored Rush Tyrant. We used one-third of the squares to evaluate the coverage of each plant species separately, aiming to guarantee the independence between the samples compared. We tested whether the coverage differs among the three plant species using LRT with the Chi-square statistic and Tukey's post-hoc test (considering $p < 0.05$) for pairwise comparisons.

Specialist selection or random use of nesting material

Aiming to analyze whether the birds used the nesting material with a specialist selection or random use, we tested if the amount of a particular plant species used as nesting material is proportional to its coverage in the environment, signalizing a cause-effect relationship. Thus, for each bird species, we designed linear models for the main plant species used as nesting material (i.e., those that appeared in proportions above 5%). The models were performed to determine whether there is an eventual use of plant species as nesting material following their coverage in the environment (random use) or, on the contrary, in disproportion with their coverage in the environment (specialist use).

For each plant species, one model was fitted to the Gaussian family contrasting the mass of each plant species in the nest (response variable) with its respective coverage in the environmental squares (predictor variable). Second, one model adjusted to the Gaussian family contrasted the total nest mass (response variable) with the cover of each one of the different plant species considered in the environment (predictor variable). The third model contrasted the proportion of each plant species in the nest (mass of the species in the nest / total mass of the nest) with its respective coverage in the environment. In this case, the model was fitted to a beta family, suitable for proportion data (Bolker 2008). For all models, a total of 16 nests for each bird species were used. We calculated the significant effects of the predictor variable from the LRT with Chi-square statistics ($p < 0.05$).

Finally, we designed probability density curves, for both bird species, to assess whether the probability of finding a certain plant species in the environment is similar to finding it in the nests. Such curves were constructed only for those plant species that demonstrated some cause-effect relationship between nest and environment in the previous analysis (i.e., Giant Bulrush). We created the models with the probability density function of the beta family, using the maximum likelihood method and the negative log-likelihood function to estimate the models' parameters (Bolker 2008). Then, we graphically superimpose the curves for the proportion of plant species in the environment with the curves for the proportion of plant species in the nest. The plot indicated whether the probability of finding the plant species in the nest is similar to finding it in the environment with the same proportions. To corroborate the null hypothesis, that the species randomly selects the Giant Bulrush, we expected overlapping curves, indicating that the probability of finding the Giant Bulrush in the nest is the same as in the environment.

Results

Nests and fixing supports

We found 408 Wren-Like Rushbird's nests, 210 were completed and 199 of these had their fixation supports measured. All completed nests were globular with a side entrance (door) and weighed an average of 55 g. They were fixed between 60 and 340 cm in height ($\bar{x}$ = 107 cm ± 20 cm), and they de from the base of the nest above to the sediment and measured 13.5 cm in height on average (Table 2). The nest depth (front to bottom) was, on average, greater than the width (left to right), giving the nest an elliptical form. Wall thickness was as thin as 0.1 cm or as thick as 1.6 cm and nest mass ranged from 36.0 – 84.0 g ($\bar{x}$ = 55.4 g ± 12.3 g; Table 2). Also, we found that the nests decreased in height in relation to the ground over the years (LRT: Chi-square = 8.72; $p < 0.01$; Figure 4), they reduced from 185 cm in 2011 to 108 cm in 2021. The variation of nests height were positively related to maximum wind gust (LRT: Chi-square = 5.11; $p = 0.02$).

For Wren-Like Rushbird, 87% of nests were fixed in only one plant species and 13% fixed in two or more plant species. Altogether, the nests were fixed in six different species of plants, and the two most used species were Giant Bulrush and Southern Cattail (Fig. 5). We noted that the success rate of using the Giant Bulrush as support is 63%, higher than that of Southern Cattail, equivalent to 37% (LRT: Chi-square = 4.92; p = 0.02). Furthermore, the Giant Bulrush presented $\bar{x}$ = 5 support points per nest and a maximum of 14 points per nest, while the Cattail supported nests with $\bar{x}$ = 7 support points and a maximum of 22 points per nest.

For the Many-Colored Rush Tyrant, we found 111 completed nests, 103 of which had their support measured. All nests were cup-shaped with a top opening and weighed an average of 4 g. The nests were attached between 41 and 160 cm ($\bar{x}$ = 88 cm ± 26 cm) in relation to the sediment and measured, on average, 10 cm in height considering the "support tail" and about 6 cm without it. Nest diameters had very similar values, giving an almost circular, somewhat an elliptical form to the incubator chamber (Table 2). Just like, Wren-Like Rushbird, the nests of Many-Colored Rush Tyrant have decreased in height over the years (LRT: Chi-square = 12.65; p < 0.01), they reduced from 170 cm in 2011 to 99 cm in 2021, and the variation of nests height were positively explained by the precipitation (LRT: Chi-square = 5.29; p = 0.02; Fig. 4) and maximum wind gust (LRT: Chi-square = 9.15; p < 0.01). In general, the nests were fixed in only one plant species and the two most used species were Giant Bulrush and Sawgrass (Fig. 5). Giant Bulrush had a higher success rate of use (87%) when compared to the Sawgrass (13%) (LRT: Chi-square = 93.67; p < 0.01).

Phytosociological characterization

Of the 210 Wren-Like Rushbird completed nests found, in 104 of them, it was possible to make the phytosociological characterization, both in the squares with the nest in the center and the surrounding squares, totaling 208 squares. The phytophysiognomy of the region was mainly characterized by the presence of herbaceous vegetation, with rare trees (Table 3). From the greatest relative importance to the lowest, we find Southern Swamp Lily, Giant Bulrush, Southern Cattail, Florida Burrhead, and the White mangrove and Red mangrove trees. The last three species did not account for 5% of the total relative importance (Table 3). In the phytosociological squares carried out when nests of the Many-Colored Rush Tyrant were found (n = 162 in total), the plants were predominantly herbaceous. Thus, as for the Wren-Like Rushbird, the most relevant species in the environment were Southern Swamp Lily and Giant Bulrush, followed by *Fuirena sp.*, Sawgrass, Florida Burrhead, and Southern Cattail (Table 3). Southern Swamp Lily and Giant Bulrush were the most important species, with the first presenting mode of sociability as “continuous population” (value 5) and the second presenting mode of sociability as “forming small groups” in both cases (value 2; Table 3).

We noted that the covers of the three main plant species found in the phytosociological squares in the nesting environment of the Wren-Like Rushbird were different (LRT: Chi-square = 105.95; $p < 0.01$). Southern Swamp Lily presented higher relative coverage than Giant Bulrush (Tukey: $p < 0.01$) and the coverage of both were higher than that of Southern Cattail (Tukey: $p < 0.01$ and $p = 0.01$, respectively). In the phytosociological squares carried out around the Many-Colored Rush Tyrant nests, the plants also differed from each other in terms of coverage (LRT: Chi-square=65.54; $p < 0.01$). We noticed that Southern Swamp Lily presented greater relative coverage compared to all species in the environment (Tukey: $p < 0.01$). Giant Bulrush and

Sawgrass showed no significant difference comparing their distribution (Tukey: p = 0.09).

Specialist selection or random use of nesting material

We found that Giant Bulrush had the greatest contribution to the nest architecture for both bird species, comprising, on average, 68% of the total nesting material for Wren-Like Rushbird and 88% for Many-Colored Rush Tyrant nesting material. Southern Swamp Lily had the second largest contribution, comprising, on average, 28% of the total nesting material for Wren-Like Rushbird and 2% for Many-Colored Rush Tyrant. Other materials made up ~2.5% of the total nesting material for both bird species, including unidentified plants, Southern Cattail inflorescence, shells of the mollusk *Heleobia australis*, fur, feathers, rubber, plastic, and paper in the Wren-Like Rushbird nests. In the Many-Colored Rush Tyrant nests, we found unidentified plants, stones, inflorescence of Giant Bulrush and Southern Cattail, dark fibers, fly pupae (suborder Brachycera), Amphipoda of the Talitridae family, isopods of the Sphaeromatidae family and beetles of the Scolytidae family.

In the Wren-Like Rushbird nests, we found a positive relationship between the increase in Giant Bulrush in the environment and the increase in the mass of Giant Bulrush in the nest, as well as with the increase in the total mass of the nest (Fig. 6). However, the proportion of Giant Bulrush as nesting material remains approximately around 70% in the nest, regardless of the coverage of Giant Bulrush in the environment (Fig. 6). In contrast, the mass of Southern Swamp Lily in the nest, the total mass of the nest and the proportion of Southern Swamp Lily in the nest are not related to the variation of the cover of Southern Swamp Lily in the environment (Fig. 6). In addition, we observed that the proportion of Giant Bulrush as nesting material in the Wren-Like Rushbirds' nest has an antagonistic relationship to the proportion of Giant Bulrush in the environment (Fig. 7). That is, Giant Bulrush is regularly and abundantly present as nesting material, while it is less probable to be found in the environment (Fig. 7). The most probable proportion values of Giant Bulrush in the environment are between 10–20%, while the proportion value most probable to find Giant Bulrush as nesting material is around 70% (Fig. 7).

With regards to the Many-Colored Rush Tyrant nests, we found the Giant Bulrush in proportions greater than 75% of the nesting material regardless of the availability of this plant in the environment. For Many-Colored Rush Tyrant, there wasn't relationship between the mass of its nest and proportions of materials according to the coverage of Giant Bulrush and Southern Swamp Lily plants in the environment (Fig. 6). Similar to Wren-Like Rushbird nests, the presence of Giant Bulrush in the nest was much more representative than its coverage in the environment. The most probable proportion values of Giant Bulrush in the environment are between 10–20%, while the proportion value most probable to find Giant Bulrush as nesting material is around 75–100% (Fig. 7).

Discussion

We found that the Wren-Like Rushbird and Many-Colored Rush Tyrant preferentially use Giant Bulrush as support and source of material for their nests. These results indicate that, in line with our original hypothesis, the birds make specialist use of Giant Bulrush in the subtropical salt marshes. This conclusion is because, even with low abundances of Giant Bulrush in the environment, birds preferentially use it as support and keep it in high proportions (around 70% for the Wren-Like Rushbird and above 75% for the Many-Colored Rush Tyrant) in the composition of their nest architectures. Also, in

Wren-Like Rushbirds' nests, when the availability of Giant Bulrush in the environment is low, the bird decreases the total mass of its nests (and consequently the size and/or robustness of the nest) to maintain an ideal proportion of Giant Bulrush as nesting material. In opposition, Many-Colored Rush Tyrant showed no relationship with the distribution of Giant Bulrush in the environment, and its nests were easily composed entirely of this plant. This fact indicates that, regardless of its availability in the environment, Giant Bulrush was selected for nest construction. In this way, our results suggest a specialist use and dependence on Giant Bulrush by both birds.

Previous studies showed that the plants most found as support for fixing the nest of the Wren-Like Rushbird were Giant Bulrush and Southern Cattail (Krone 1910, Belton 1984, Sick 1985, Ridgley & Tudor 1994, De la Peña 1996, 2013, 2021, Remsen 2003, Lara 2011, Lüthi 2011, Amaro & Goyoneche 2017, Chiaradia et al. 2017, García 2017, Quiñonez & Hernandez 2017). For Many-Colored Rush Tyrant, the most used species was also the Giant Bulrush (Pereyra 1923, Wilson 1926, Hellmayr 1932, Sick 1985, Sclater & Hudson 1988, Lüthi 2011, De la Peña 2013, Amaro & Goyoneche 2017) but they were also fixed in Sawgrass and Southern Cattail (Abajos & Areta 2009, Amaro & Goyoneche 2017). In this study, Giant Bulrush showed greater importance for nest fixing than Southern Cattail and Sawgrass, a fact that could be explained by its vigor (de Lange, 1998). Giant Bulrush, Southern Cattail, and Sawgrass are the tallest species in the subtropical salt marshes environment, easily reaching 3 meters in height. This fact may explain the preference of Wren-Like Rushbid for the first two species mentioned and, of Many-Colored Rush Tyrant, for the three species, although Giant Bulrush was preferred on a larger scale than the other two. In the same way, the use of the Giant Bulrush as material can serve to give firmness to the structure of the nest (Sick 1984, Sclater & Hudson 1988) and weather protection, because it is fibrous and resistant compared to other plants (Hidalgo-Cordero & García-Navarro 2018) which may explain the preference of birds for this plant, such as nesting support and material.

Tall plants allow for avoiding tidal floods because the birds can fix their nests in higher places in the vegetation (Reinert 2006, Noske et al. 2013, Hunter et al. 2016) as well, maintains above-water-level foraging for the birds (Favretto et al. 2022). However, even with tall plants in the environment, our results suggests that the height of the nests decreased over the years, and that they varied mainly by precipitation and wind gusts, that is, with more rain and wind, higher the nests were placed. This can be explained by the fact that the combination of maximum wind gusts and rain can increase the local water level (Resio & Westerink 2008, Cooley et al. 2022), subjecting nests to flooding. Even, the wind could be helpful to predict coming of a strong precipitation (Lin et al. 2001, Meehl et al. 2007), making it necessary to position the nests higher in the vegetation to avoid flooding. In this case using Giant Bulrush as nesting support, can benefits the reproduction, considering its vigor (stronger) and height (taller). Our results show how nests vary in height. But it is important to further investigate the reason why the nests decreased in height, perhaps it is related to extreme events such as cyclones, or because of a decrease in the vigor of Giant Bulrush, more abiotic factors need to be investigated.

We noted that when there is greater coverage of the Giant Bulrush in the environment, in the case of the Wren-Like Rushbid, the nest mass increases. A greater mass in a nest implies greater robustness, avoiding predation, providing more resistance and protection to the nest (Sclater & Hudson 1988, Slagsvold 1989, Hansell 2000), and indicates quality from male to female (Collias & Collias 1984, Soler et al. 1998). This could be a positive point to ensure the reproductive success of the bird, but mostly when the nest is fixed in Giant Bulrush. We noticed that when using the Southern Cattail to fix the nests, a larger number of supports was needed. Thus, a robust nest when fixed on supports that are not so efficient to endure the weight can require a greater energetic effort to complete the fixation of its nest (Crossner 1977, Heenan 2013, Alvaréz et al. 2013) deviating from the main objective, reproductive success. Our field observations indicate that Southern Cattail when used as support for the Wren-Like Rushbirds' nests is fragile and, after rains, when the nests become denser, the supports often give way, and the nest topples over. In this case, a greater mass in the nest supported by a fragile plant would not benefit the species and, on the contrary, could reduce reproductive success rates.

The dependence of Wren-Like Rushbird and Many-Colored Rush Tyrant birds on Giant Bulrush is noteworthy considering the current context of climate change, which threatens the occurrence and abundance of Giant Bulrush in estuarine environments (Ivanauskas et al. 1997, Michener et al. 1997, Hartig et al. 2002, Reinert et al. 2006, Thorne et al. 2012, da Rosa et al. 2018, Servino et al. 2018). The salt marshes are undergoing fragmentation (Ivanauskas et al. 1997, Vinent et al. 2021) and the subtropical salt marshes are undergoing the effect of tropicalization, with the replacement of the original flora by mangroves (Scheffel et al. 2018, Cavanaugh et al. 2019, Cooley et al. 2022). Additionally, the Giant Bulrush is overturned by the action of extreme events, like storms and strong winds, which are increasingly frequent (Thorne et al. 2012, Reinert et al. 2007, Servino et al. 2018, Cooley et al. 2022), and decrease in density with increasing floods (Simas et al. al. 2001, Hughes 2004, da Rosa et al. 2018). These already identified impacts, added to the increase in sea level, the frequency of tidal floods and rainfall (Michener et al. 1997, Hartig et al. 2002, Gedan 2011, Thorne et al. 2012, Vousdoukas et al. 2020, Parkinson & Wdowinski 2022) consolidate the possible scenario of retraction in the distribution and density of Giant Bulrush in the environment.

Based on our results, a possible retraction of the available areas for breeding to the Wren-Like Rushbird and Many-Colored Rush Tyrant in the local study would reduce the source of nesting material as well as the availability of good supports for fixing the nests. Nests could be impossible to be constructed locally or they could be built with reduced mass (Moreno et al. 2005, Alvaréz et al. 2013, Deeming & Mainwaring 2015), decreasing nest quality, mainly for Wren-Like Rushbird that have a direct relationship between their mass and the cover of this plant in the environment. In the second place, this reduction could lead to the search for more fragile plants (i.e., Southern Cattail) to support the nests of the Wren-Like Rushbird, which could give way with the weight of the nest after rains. This reduction could also lead to the fixation of the Many-Colored Rush Tyrant nests in lower plants (i.e., Florida Burrhead), which could make nests more susceptible to flooding. Associated with the decrease in adequate nesting resources and added to the scenario of increased extreme events, there may be a decrease in investment in nest quality and incubation for both species (Coulson 1968, Crossner 1977, Mainwaring & Hartley 2009, Heenan 2013), as well as energy deviating to less cost-effective resources, negatively affecting the reproductive success of the species (Slagsvold 1989).

In conclusion, we suggest that there is a specialist selection of Giant Bulrush as support and source of nesting material in the nests of the Wren-Like Rushbird and Many-Colored Rush Tyrant, signaling the dependence of the birds on this plant. Based on this, scenarios arising from climate change suggest that both the Giant Bulrush as well as the Wren-Like Rushbird, and the Many-Colored Rush Tyrant may be threatened. As a complement to the present study, we suggest that future studies investigate the adaptability of birds in other regions where Giant Bulrush has lower relative importance. We also suggest exploring other interactions of the bird with the environment, such as reproductive success as a function of parameters such as nest mass, and quality of supports, and try to explore others more abiotics factors (i. e. wind direction, relative humidity, measured tide). Favretto et al. (2022) recently suggested that these species choose the nesting site according to the height and density of the plants in the environment. Therefore, further studies investigating other variables are important.

Finally, our findings brought important and detailed information about the reproductive biology of the species, clarifying gaps, and evidencing the specialization of species to Giant Bulrush in the locality. The information contained in this study is an important starting point for new monitoring programs that investigate the impacts of tropicalization on bird environments, intending to measure possible management and conservation actions.

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Tables

Table 1. Description of the phytosociological parameters used to analyze squares carried out in the environment around the Wren-Like Rushbird and Many-Colored Rush Tyrant nests, to characterize the local vegetation of the subtropical salt marshes in Guaratuba Bay, Paraná.

Variables	Description	Calculation	Formula
Absolut Frequency (AFi)	How many times a species appeared among the total squares.	Indicates the division of the number of squares in which it occurred (si) by the total number of squares sampled (S)	AFi=(si/S)x100
Relative Frequency (RFi)	How many times a species appeared among the total squares of all species	In percentage, it indicates the division of the value of its absolute frequency (AFi) by the sum of the absolute frequencies of all species (ΣAF)	RFi=(AFi/ΣAF)x100
Absolut Coverage (ACi)	Represents how much the projection of the living aerial parts of each species covered the soil surface (%)	Indicates the sum of its coverage obtained in the squares where it occurred (ΣCi)	ACi=ΣCi
Relative Coverage (RCi)	Coverage of each species about all species that appeared	Indicates the division of the value of its absolute coverage (ACi) by the sum of the absolute coverage of all species (ΣAC)	RCi=(ACi/ΣCA)x100
Relative Importance (RIi)	Indicates which species was most relevant in the environment	Index resulting from the sum of its relative frequency (RFi) and coverage (RCi)	RIi=RFi+RCi

Table 2. Measurements (cm) and mass (g) of nests of the Wren-Like Rushbird (*Phleocryptes melanops*) and Many-Colored Rush Tyrant (*Tachuris rubrigastra*) nests in Guaratuba Bay, Paraná state, southern Brazil. SD = standard deviation.

Measurement type	Measurement	N	Range	Average ± SD
	Wren-Like Rushbird (*Phleocryptes melanops*)			
External heights	1 - Height from the base of the nest to the sediment	159	0,6–3,04	107,0 ± 20,0
	2- External height of the nest (roof to base)	120	8,5–23,2	13,5 ± 2,8
	3- External height of the door (bottom edge) to the base of the nest	81	3,5–14,0	8,6 ± 1,9
	4- External height from door (top edge) to nest ceiling	40	0,3–3,0	1,2 ± 0,6
Outside diameters	5- External depth (front to back)	119	3,0–13,2	9,2 ± 1,7
	6- Outside width (left to right)	122	4,2–12,5	8,6 ± 1,5
Opening	7- Door height	111	1,0–4,2	2,5 ± 0,6
	8- Door width	109	1,5–4,8	3,4 ± 0,6
	9- Door ramp thickness	114	0,3–2,3	1,0 ± 0,4
Heights internal	10- Internal height of the nest (roof to base)	37	5,1–10,7	8,8 ± 1,3
	11- Internal height of the door (bottom edge) to the base of the nest	15	2,5–9,7	5,9 ± 1,8
Internal diameters	12- Internal depth in the door (front to back)	116	2,1–9,5	5,9 ± 1,2
	13- Inner depth 1 cm below the door (front to back)	37	3,4–8,4	6,5 ± 1,0
	14- Inner width (left to right)	37	3,6–7,2	6,1 ± 0,8
Thicknesses	15- Ceiling thickness	37	0,1–9,5	0,9 ± 1,5
	16- Sidewall thickness	38	0,2–1,0	0,6 ± 0,2
	17- Wall thickness below the door	37	0,1–1,6	0,6 ± 0,3
Mass	Mass	36	36,0–84,0	55,4 ± 12,3
	Many-Colored Rush Tyrant (*Tachuris rubrigastra*)			
External heights	18- Height from the base of the nest to the sediment	60	41,0–160,0	88,0 ± 26,0
	19- Nest height with support tail	42	5,0–14,5	10,3 ± 2,0
	20- Height of the nest without support tail	26	5,40–10,5	7,0 ± 1,2
Diameters	21- Larger inner diameter	40	3,2–4,3	3,74 ± 0,2
	22- Larger outside diameter	40	4,0–5,5	4,8 ± 0,3
	23- Smaller inner diameter	40	2,4–4,8	3,65 ± 0,6
	24- Smallest outside diameter	40	3,9–5,2	4,51±0,34
Heights internal	25- Nest depth	40	2,4–4,8	3,6 ± 0,6
Mass	Mass	16	2,7–6,4	4,0 ± 1,0

Table 3. Phytosociological parameters of subtropical salt marshes in Guaratuba Bay, Paraná state, southern Brazil, from the phytosociological squares of 1 m² in the surroundings of the Wren-Like Rushbird (n = 204) and Many-Colored Rush Tyrant (n = 162) nests.

Wren-Like Rushbird (*Phleocryptes melanops*)						
Parameters	**Southern Swamp Lily**	**Giant Bulrush**	**Southern Cattail**	**Florida Burrhead**	**White Mangrove**	**Red Mangrove**
Height (average)	1,16	2,20	1,87	0,94	1,96	1,38
Sociability (mode)	5,00	2,00	3,50	1,00	1,00	1,00
Absolute frequency	0,93	0,85	0,22	0,09	0,02	0,01
Relative frequency	43,96	39,86	10,42	4,26	1,39	0,46
Absolute coverage	8194,50	2934,00	950,50	183,00	102,00	40,50
Relative coverage	67,05	23,00	8,03	1,48	0,93	0,37
Relative importance	111,04	63,26	18,45	5,74	2,32	0,83
Many-Colored Rush Tyrant (*Tachuris rubrigastra*)						
Parameters	**Southern Swamp Lily**	**Giant Bulrush**	**Southern Cattail**	**Florida Burrhead**	**Sawgrass**	***Fuirena* sp.**
Height (average)	0,89	1,82	1,95	0,85	2,20	1,60
Sociability (mode)	5,00	2,50	2,00	1,00	5,00	1,50
Absolute frequency	0,93	0,94	0,06	0,17	0,25	0,09
Relative frequency	33,71	34,39	9,23	12,36	8,99	22,77
Absolute coverage	5053,50	1720,50	103,00	353,00	1076,50	34,00
Relative coverage	57,30	19,47	1,16	3,99	12,15	0,38
Relative importance	91,02	53,85	10,39	16,35	21,13	23,15

Figures legends

Figure 1. Study area inside Guaratuba Bay, Paraná state, southern Brazil.

Figure 1. Phytophysiognomies where Wren-Like Rushbird (*Phleocryptes melanops*) (F) and Many-Colored Rush Tyrant (*Tachuris rubrigastra*) (H) nest in Guaratuba Bay, Paraná, southern Brazil. (A) Phytophysiognomiy is dominated by Giant Bulrush (*Schoenoplectus californicus*); (B) Phytophysiognomy is dominated by Southern Swamp Lily (*Crinum americanum)* with broad and short leaves and Giant Bulrush with narrow and long leaves, and the presence of Florida Burrhead (*Echinodorus grandiflorus)* with broad leaves; (C) Phytophysiognomy dominated by Southern Cattail (*Typha domingensis*), with orange-brown inflorescence; (D) Phytophysiognomy dominated by Southern Swamp Lily with white inflorescence, the tree on the right is the white mangrove (*Laguncularia racemosa*). In (E) there is the Wren-Like Rushbird's nest, and in (F) a picture of him. In (G) there is the Many-Colored Rush Tyrant's nest and in (H) a picture of him.

Figure 3. Schematic model of the measurements taken from the nests of the Wren-Like Rushbird (*Phleocryptes melanops*) and Many-Colored Rush Tyrant (*Tachuris rubrigastra*). (A and E) View of the Wren-Like Rushbird's and Many-Colored Rush Tyrant's nest fixed in the environment. (B and H) Front view of the nest, uncut. (C and F) Cross section of the nest, in top view. (D and G) Sagittal view of the nest. 1) Height from the base of the nest door to the floor; 2) External height of the nest (roof to base); 3) External height of the door (bottom edge) to the base of the nest; 4) External height of the door (upper edge) to the nest ceiling; 5) External depth (front to back); 6) Outer width (left to right); 7) Door height; 8) Door width; 9) Door ramp thickness; 10) Internal height of the nest (roof to base); 11) Internal height of the door (bottom edge) to the base of the nest; 12) Internal depth in the door line (front to back); 13) Internal depth 1 cm below the door (front to back); 14) Internal width (left to right); 15) Ceiling thickness; 16) Sidewall thickness; 17) Wall thickness below the door; 18) Height from the base to the sediment of the Many-Colored Rush Tyrant nest; 19) Nest height with support tail; 20) Nest height without support tail; 21) Larger inner diameter of the nest; 22) Larger outside diameter of the nest; 23) Smaller inner diameter of the nest; 24) Smaller outside diameter of the nest; 25) Nest depth.

Figure 4. Relationships between nests height and abiotic factors: Giant Bulrush height (A and F), Tide (B and G), Precipitation (C and H), Temperature (D and I) and Maximum Wing Gust (E and J), based on the maximum values of average heights of nests and abiotic factors over the years, for both Wren-Like Rushbird

and Many-Colored Rush Tyrant. Only (E), (H) and (J) showed a significant effect of the abiotic factor ($p < 0.05$).

Figure 5. Species of plants used to support the Wren-Like Rushbird (*Phleocryptes melanops*) (A and B) and Many-Colored Rush Tyrant (*Tachuris rubrigastra*) (C) nests. (A) Fixed nests on only one plant species. (B) Fixed nests in two or three plant species. (C) Many-Colored Rush Tyrant nests supported by one plant species. *Ca = Crinum americanum* (Southern Swamp Lily)*; Cj = Cladium jamaicense* (Sawgrass)*; Eg = Echinodorus grandiflorus* (Florida Burrhead)*; Lr = Laguncularia racemosa* (White Mangrove)*; Rm = Rhizophora mangle* (Red Mangrove)*; Sc = Schoenoplectus californicus* (Giant Bulrush)*; Td = Typha domingensis* (Southern Cattail).

Figure 6. Relationships between the parameters of the nests and the plants coverage (%) in the environment. Graphics from A to F regard the Wren-Like Rushbird (*Phleocryptes melanops*) and from G to L regard the Many-Colored Rush Tyrant (*Tachuris rubrigastra*), all of them related to the cover of Giant Bulrush (*Schoenoplectus californicus*) and Southern Swamp Lily (*Crinum americanum*). (A) and (G): mass of Giant Bulrush in the nests in relation to their coverage in the environment. (D) and (J): mass of Southern Swamp Lily in the nests in relation to their coverage in the environment. (B) and (H): total mass of the nests in relation to the coverage of Giant Bulrush in the environment. (E) and (K): total mass of the nests in relation to the coverage of Southern Swamp Lily in the environment. (C) and (I): proportion of Giant Bulrush in relation to their coverage in the environment. (F) and (L): proportion of Southern Swamp Lily in relation to their coverage in the environment. The lines indicate the linear models performed for each one of the relationships evaluated. Only models (A) and (C) showed a significant effect of the predictor ($p < 0.05$).

Figure 7. Probabilistic models designed to illustrate the probability (in probabilistic density) of finding Giant Bulrush (*Schoenoplectus californicus*) in the environment and the nests of the Wren-Like Rushbird (*Phleocryptes melanops*) and Many-Colored Rush Tyrant (*Tachuris rubrigastra*). The histograms (black bars) represent the frequency of distribution, divided into classes, of the Giant Bulrush cover observed in the field in the phytosociological squares of 1 m^2 ($n = 208$ squares). The curves represent the probabilistic density values predicted by the models, representing the probability of finding a certain proportion of Giant Bulrush in the nest (curve in green) and in the environment (curve in gray).

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