

Bird sanctuary does not sustain expansion of its populations due to limited nest site availability

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Abstract. Birds that nest in palms cavities require adequate sites for their reproduction and population growth. In one of these sites, the *Lagoa das Araras* Bird Sanctuary, Blue-and-yellow Macaws *Ara ararauna*, Blue-fronted Parrots *Amazona aestiva* (both Psittaciformes: Psittacidae), and Buff-necked Ibis *Theristicus caudatus* (Pelecaniformes: Threskiornithidae) look for cavities to nest and roost overnight. The present study assessed the availability of nest sites in relation to the abundance of birds nesting in dead buriti (*Mauritia*) palms in this sanctuary threatened by the flooding of artificial reservoirs. We performed a census of the populations of these three palm cavity nesting species using the fixed-point method in summer (wet), autumn, and winter (dry season) in an artificial reservoir in Mato Grosso, Brazil, comparing the months with a Kruskal-Wallis ANOVA. The observations, lasting 2 h each, occurred in two sessions for two days per season (dawn and dusk). We estimated nest site availability by counting and mapping the nesting sites using panoramic photographs of the area, whose results were compared with a Chi square test. The population of the Blue-and-yellow Macaw increased towards the dry season while the Blue-fronted Parrot decreased, and the Buff-necked Ibis remained constant throughout the seasons. The number of nesting sites was not sufficient to sustain the growth of the populations of the three bird species occurring in this sanctuary (42 nests for 130.17 ± 51.17 birds; mean \pm standard deviation). Therefore, the *Lagoa das Araras* Bird Sanctuary, a popular bird watching tourist attraction, cannot be considered a place for population growth due to the competition for limited nesting sites.

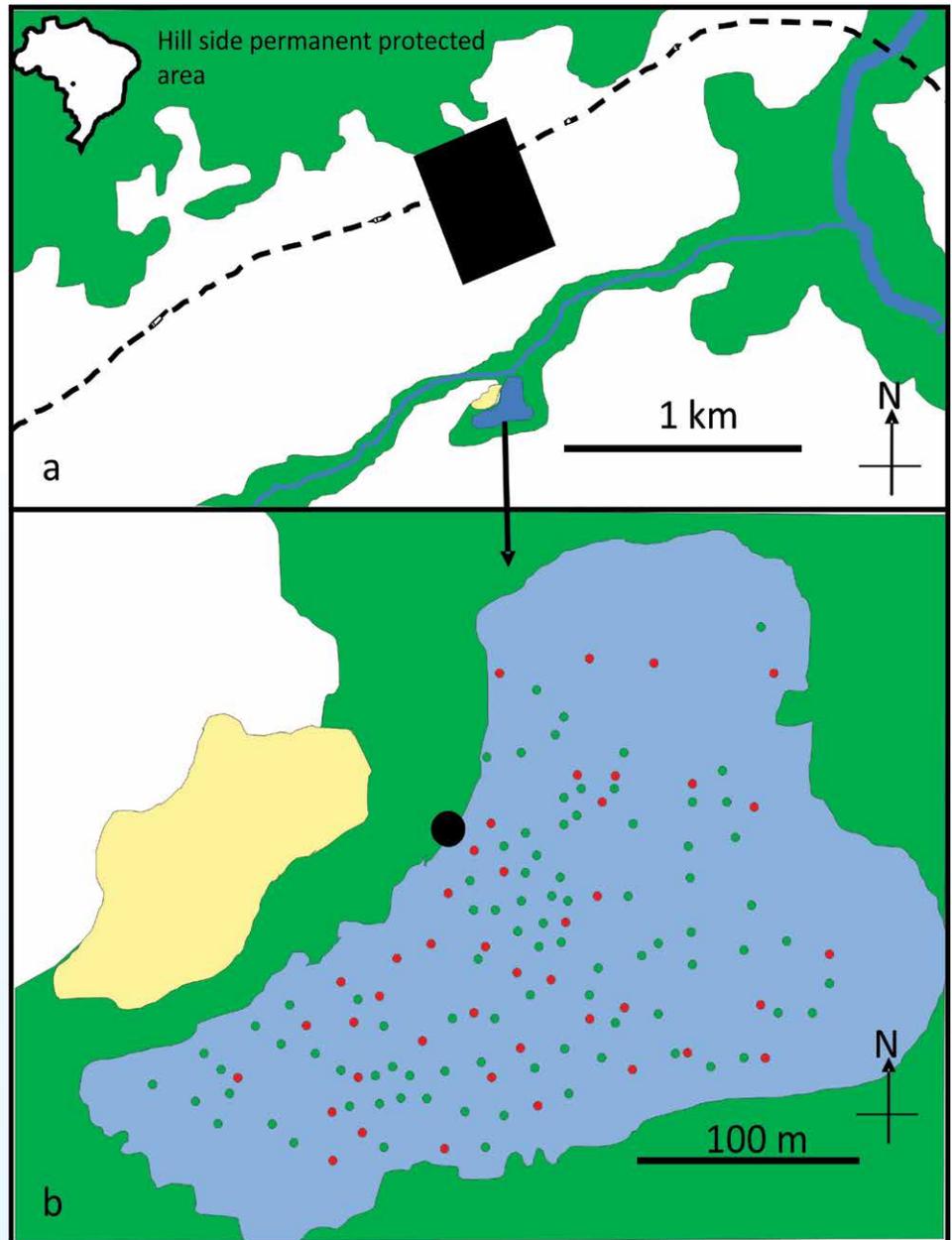


Figure 1. Study area map. a) Larger scale map of the Bom Jardim District (black rectangle) in relation to the *Lagoa das Araras* Bird Sanctuary reservoir and adjacent rivers (blue). The black dashed line represents the road from Cuiabá to the tourism area. b) Detailed map with the distribution of 86 live adult buriti palms (*Mauritia flexuosa*) (green circles) and 42 dead palms with nests (red circles); the black circle marks the observation point. Notice the connectivity between the *Lagoa das Araras* Bird Sanctuary and adjacent riparian vegetation and hill side permanent protected area (green). Note also the availability of foraging sites beside the reservoir for the Buff-necked Ibis (*Theristicus caudatus*) (white areas) and for Blue-and-Yellow Macaws (*Ara ararauna*) and Blue-fronted Parrots (*Amazona aestiva*) (yellow area).

The bird-watching industry attracts millions of dollars to different tropical areas around the world, many of them with poor inhabitants who could potentially benefit from this tourism. This growing industry thus represents a hope for social improvement, as long as the tourism activity is sustainable both economically and environmentally and includes local residents as stakeholders. Nevertheless, conflicts between nature tourism and other economic activities occur frequently (Coelho & Coelho 2012), resulting in the loss of touristic appeal. One of the many areas in such condition is Nobres, 145 km from Cuiabá, in Brazil (Figure 1). Its numerous tourist attractions represent a growing business (Guimarães & Zavala 2009) in a region dominated by farming. On one hand, birds search for cavities in the palm swamps and riparian vegetation along streams, attracting birdwatchers. On the other, rangers build reservoirs for the cattle (Ferrete *et al.* 2004), flooding many nesting sites and preventing the maintenance of these important plants for the bird populations.

The *Lagoa das Araras* Bird Sanctuary in Nobres is both a tourist attraction and an artificial reservoir in a cattle farm and a place where this tension between tourism and land use is acute. In such environments Buriti palms (*Mauritia flexuosa*; Areaceae) grow, characterizing the palm swamps in a singular savanna landscape (Pio 2010). These same palms are dying in the flooded reservoirs. Blue-and-yellow Macaws *Ara ararauna* and Blue-fronted Parrots *Amazona aestiva* (both Psittaciformes: Psittacidae) spend most of their lives in the palm swamps where they excavate cavities in dead buriti palms to reproduce and roost. Other species, like the Buff-necked Ibis *Theristicus caudatus* (Pelecaniformes: Threskiornithidae) also nest in this landscape, taking advantage of and potentially competing for nest sites. Therefore, Buff-necked Ibis indirectly depend on psittacines for producing the cavities they need (Pio 2010). No other cavity-nesting bird was recorded in the area.

Blue-and-yellow Macaws occur from Central America to Brazil. They predominate in Bolivia and Paraguay, living in palm swamps and in forest borders (Sick 1997). Most feeding groups in southern Central America were recorded in areas with abundant palms, using this vegetation for nesting (Tubelis 2009). Blue and yellow Macaws are among the most heavily traded and most expensive birds in illegal wildlife trade (Herrera & Hennessey 2010), making it even more important to provide means for their reproduction here and elsewhere (Regueira & Bernard 2012).

Blue-fronted Parrots live in humid or dry forests, palm groves and riparian vegetation. These parrots inhabit different arboreal and arbustive Cerrado physiognomies and palm swamps (Sick 1997). There they produce and occupy buriti cavities for nesting (Pio 2010). Illegal trade is common in this species as well (Regueira & Bernard 2012), with more than a thousand of them being sold in Bolivia annually (Herrera & Hennessey 2010).

The Buff-necked Ibis is a large bird that inhabits mostly open fields. It feeds on insects, spiders and small vertebrates, and its habits are diurnal or crepuscular. They occur in different parts of Northern Brazil, in Colombia, and the Andes (Sick 1997). Buff-necked Ibis may be occupying new environments due to deforestation for monocultures or livestock (Serpa *et al.* 2010).

Seasonal fluctuations in bird populations are common (Manuel *et al.* 2011). The populations of birds generally vary due to, among other factors, the availability of food and nesting cavities. In psittacines the seasonality is frequently linked to food availability, and population numbers shift more often during the dry season (Luccas & Antunes 2009).

The animals inhabiting the *Lagoa das Araras* Bird Sanctuary are a significant part of the tourist attraction of this area (*sensu* Drumm & Moore 2003), which adds not only to their moral, emotional, and cultural, value, but also to their direct market value (Sabino *et al.* 2012). The ecological dynamics of the artificial reservoir of *Lagoa das Araras* directly affect bird populations by impacting the availability of adequate nesting sites for key species, potentially altering their behavior, feeding habits, migration, and reproduction. The loss of buriti palms as the result of stream damming harms bird populations for species such as those studied here (Rodrigues & Melo 2007). Furthermore, ecological roles such as seed dispersal and niche construction may be lost along with the local extinction of such species, impacting regional habitat composition and ecosystem integrity as well as the economic viability of the bird-watching business in the area.

Within this context of complex social, cultural, and ecological dynamics, our research aims to link the availability of dead buriti palm nest sites to the abundance, potential growth, and sustainability of populations of birds using dead buriti palms for nesting and roosting throughout the year. This paper sheds light on the potential for a popular bird-watching site to maintain populations of ecological and culturally important bird species.

Material and methods

The *Lagoa das Araras* Bird Sanctuary is located at 14°33'46.55"S and 55°52'16.38"W. To quantify the abundance of the three species nesting in the *Lagoa das Araras* Bird Sanctuary we used the fix point method (Develey 2003). The observer counted all the individuals of the three studied species (Blue-and-yellow Macaw, Blue-fronted Parrot and Buff-necked Ibis). Observations were conducted from January to July, 2012 with two daily sessions (dawn and dusk) lasting 2 h each. We performed four surveys in two days (dusk and dawn) in the rainy (January), intermediate (May) and dry season (July).

Observations were made from a point in which the observer could cover the nesting area completely, allowing for the counting of all individuals arriving and leaving the site. This point was sufficiently distant to avoid observer effects on the birds, which were also habituated to the presence of observers. Approximately 20 tourists visit the site every day. When necessary, we used Bushnell 20 x 50 binoculars. The numbers of each species were counted by the observer and recorded by another researcher to allow for continual observation without the observer having interrupted the counting to take notes.

Buriti palm cavities were counted with the aid of panoramic photographs. We took eight panoramic photographs from different angles of the reservoir covering all of the palms. These photographs were stitched together

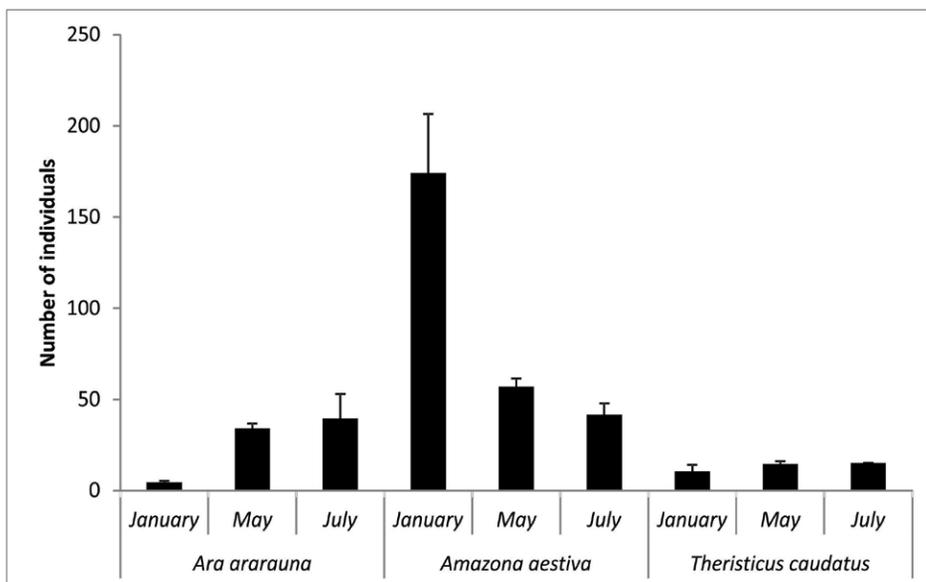


Figure 2. Abundance (mean \pm standard deviation) of Blue-and-Yellow Macaws (*Ara ararauna*), Blue-fronted Parrots (*Amazona aestiva*), and Buff-necked Ibis (*Theristicus caudatus*) variation during the study period (Kruskal-Wallis ANOVA; $H = 7.550$; $p = 0.023$; *post-hoc* January x July $p = 0.037$ for *Ara ararauna*; $H = 9.846$; $p = 0.007$; *post-hoc* January x July $p = 0.005$ for *Amazona aestiva*; and $H = 0.910$; $p = 0.634$ for the *Theristicus caudatus*).

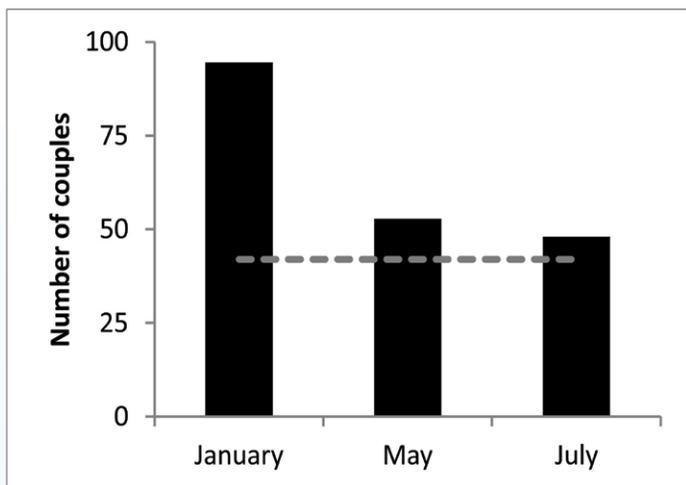


Figure 3. Comparison between the maximum number of bird couples nesting in the Lagoa das Araras Bird Sanctuary throughout the months (columns) and the number of cavities available for nesting (grey dashed line) ($\chi^2 = 9.25 \times 10^{-16}$; $p = 1$).

in a digital studio using the program Canon Utilities Photostitch Version 3.1.21.45 Canon ©. We counted the number of nesting sites available using these eight panoramic photographs.

For data analysis we applied a Spearman's test of correlation to evaluate fluctuations and trends in the numbers of individuals, accompanied by a Kruskal-Wallis Analysis of Variance considering months as treatments. These non-parametric tests were used due to the non-normal distribution of our data (Shapiro-Wilks; $W < 0.82$; $p < 0.018$). Results were refined by the *post-hoc* test of multiple median comparisons (Siegel & Castellan Jr. 2006). We inferred the possibility of population sustainability and growth by comparing the availability of dead palms in the area with the number of bird pairs using a Chi-square test that considered the expected number of nesting pairs to be equal to the number of cavities available. Significance level was pre-set at $\alpha = 0.5$. All values are presented as mean \pm standard deviation.

Results

The Lagoa das Araras Bird Sanctuary was frequented by a group of 39.5 ± 13.4 Blue-and-yellow Macaws, 174 ± 32.5 Blue-fronted Parrots and 13.3 ± 2.5 Buff-necked Ibis. There were 42 cavities (nests) in the buriti palms in the reservoir, one in each dead buriti palm. Another 86 adult palms were alive, although their roots were completely submersed even during the dry season. Twelve juvenile buritis were growing in the margins of the reservoir (Figure 1).

The abundance of Blue-and-yellow Macaws increased gradually during the study period (Spearman; $r = 0.758$; $p = 0.004$). A significant difference was only seen between January and July (Kruskal-Wallis ANOVA; $H = 7.550$; $p = 0.023$; *post-hoc* January x July $p = 0.037$). In Blue-fronted Parrots, a decrease in abundance occurred (Spearman; $r = -0.946$; $p < 0.001$). Again the Kruskal-Wallis test only detected differences between January and July ($H = 9.846$; $p = 0.007$; *post-hoc* January x July $p = 0.005$). Finally, for the Buff-necked Ibis the abundance of birds was constant during the study period (Spearman; $r = 0.268$; $p = 0.399$); none of the months were statistically different from one another (Kruskal-Wallis ANOVA; $H = 0.910$; $p = 0.634$) (Figure 2).

A negative correlation in the abundance of the two Psittacidae species, the Blue-and-yellow Macaw and the Blue-fronted Parrot were also observed throughout the study period (Spearman; $r = -0.742$; $p = 0.006$).

Chi square tests revealed that the availability of nest sites in the Lagoa das Araras Bird Sanctuary was insufficient for populations of all the nesting species there ($\chi^2 = 9.25 \times 10^{-16}$; $p = 1$; Figure 3). We observed that birds facing intra- and interspecific competition for nest sites (among the three studied birds) shifted from the study site to adjacent areas (Figure 1) or otherwise avoided the cavities incapable of supporting reproduction.

Discussion

From January to July we recorded an increase in the abundance of Blue-and-yellow Macaws, a decrease of Blue-fronted Parrots, and no shifts in the abundance of Buff-necked Ibis. In January, the month with the most birds of these three species occurring in Lagoa das Araras, the nests in buriti palms were insufficient to shelter and support all of them. Therefore, the Lagoa das Araras Bird Sanctuary cannot be considered to be a place that supports the expansion of the populations of the bird species nesting there, obliging them to move to surrounding areas and occupy other types of nests (in *T. caudatus*' case). During January in particular, there exists strong inter- and intraspecific competition for nest sites that likely interferes with population growth. With high densities of at least two species requiring adequate sized cavities, individuals compete for limited nest sites (Berkunsky & Reboresda 2009).

Blue-and-yellow Macaw abundance increased gradually towards the dry season. This increase may be related to the approaching reproductive period, between August and December (Bianchi 1998). In the Hyacinth Macaw, *Anodorhynchus hyacinthinus*, the reproductive period occurs between July and March, with higher reproductive rates from August to January (Antas *et al.* 2010). According to Bianchi (1998), Macaws may start exploring buriti palms searching for suitable nesting sites three months before the reproductive period starts. The earlier search for a nesting site may guarantee better nests.

We observed a decrease in the abundance of Blue-fronted Parrots during the study period, possibly related to competition for nest sites, a common interaction in palm swamps (Presti *et al.* 2009). Blue-and-yellow Macaws may displace the parrots by occupying their cavities. In fact, Brightsmith (2005) suggests smaller species reproduce earlier to avoid competition. The negative correlation between Blue-and-yellow Macaws and Blue-fronted Parrots we observed supports this possibility. Another study on Blue-fronted Parrots reported similar results, the numerous individuals of this species present in May left between July and October, rising again in December at the end of the Macaws' reproductive period (Carrara *et al.* 2007). Likewise, competition between an *Ara* and an *Amazona* species have been previously reported (Bonadie & Bacon 2000). Competition is likely since the parrot's reproductive period precedes the macaw's where these species are not together.

The number of Buff-necked Ibis remained constant throughout the study. This lack of seasonality was previously pointed out in Paraguayan chacos (Brooks 1997) and Rio de Janeiro (Serpa *et al.* 2010). Dead buriti palms are not their exclusive nest sites and nest substrate has little importance on reproductive success (Donázar *et al.* 1994). Factors like food and habitat availability may be related to this bird's occurrence in the area. Oliveira (2008), in his study on the use of electric transmission towers by Buff-necked Ibis, states that these birds are opportunistic in relation to overnight nests. They prefer palm swamps to roost instead of transmission towers, as long as cavities are available. This bird normally nests also on cliffs and tall trees in preserved areas of the Cerrado, but, since they were unavailable in the study site, the *Lagoa das Araras* Bird Sanctuary did not support a population growth for *T. caudatus* either, forcing them to leave the area. Some of these animals chose to roost close to foraging areas (Calderón 2010). Thus, since they are not obligatory users of dead palms, this is not a limiting resource for Buff-necked Ibis population expansion. Once more, the rule that generalist species are less susceptible to environmental fluctuations holds true (Colles *et al.* 2009).

Buriti palms are a very important resource for birds (Bonadie & Bacon 2000). The buriti palms present in the *Lagoa das Araras* Bird Sanctuary were used for roosting overnight and as nest sites by the three species studied. These palms are particularly frequent in low humid areas of the Cerrado, forming palm swamps (Storti 1993). Buriti wood is hard and moderately heavy (Lorenzi 2002), making it an adequate shelter for the birds. Nevertheless, under the unfavorable conditions of dammed areas in farms this wood quickly decomposes, and trunks collapse (Lorenzi 2002), turning these cavities into temporary as opposed to long term resources. According to

Bianchi (1998), psittacines can only excavate the cavities in already decomposing stems of dead crownless buritis in palm swamps. Since these nests' main openings are placed on the top of the trunk, each palm houses a single nest. Secondary holes can be dug to the sides of the cavities, but the birds are unable to start a nest from the side of the trunk. These palms are important because they are one of the limiting resources for the growth and maintenance of nesting populations (Guedes 1993).

The fact that cavities are less numerous than the pairs of nesting birds limits the local carrying capacity of these populations. The cavities are used as nests, and competition occurs when there are not enough cavities. The carrying capacity is the number of individuals of a given species that the resources in the environment can sustain (Hui 2006). Many birds need dead palms to nest, but they are unable to produce the cavities (Antas *et al.* 2010). Buff-necked Ibis occupy cavities previously excavated by the psittacines, occasionally altering them according to their needs. In a climax community the environment has achieved the carrying capacity and competition is strong for limiting resources (Hui 2006). Competition is a mechanism that enables one individual's behavior to affect the wellbeing of others (Hamilton 2010). Thus, in a climax community, competition will potentially limit populations like those of Blue-and-yellow Macaws, Blue-fronted Parrots, and Buff-necked Ibis.

These birds' nest sites can only be occupied by a single couple per reproductive season (Berkunsky & Reboreda 2009). Hyacinth Macaws compete for cavities with various birds, bees, and mammals, with only one cavity-using species remaining in the hollow (Antas *et al.* 2010). In Blue-and-yellow Macaws, intraspecific disputes for nests occur between reproductive couples due to the limited availability of adequate nests (Bianchi 1998, Seixas & Mourão, 2002). Similar nest site competition occurs in Buff-necked Ibis (Bouton & Bouton 2001). The three species observed in this study likely compete between and within populations in both intraspecific and interspecific competition for the available cavities to nest.

With regard to conservation, the three species studied are considered to be of least concern, but Blue-and-yellow Macaws and Blue-fronted Parrots are in fast population decline (IUCN 2012), probably due to habitat loss and illegal wildlife trade (Regueira & Bernard 2012). Thus the importance of protecting reproductive sites for these species, such as palm swamps impacted by damming, is heightened. Our results also contribute generally to our understanding of Psittaciformes biology in nature (Guedes 2004).

We conclude that, although the abundance of Blue-and-yellow Macaws and Blue-fronted Parrots in the study area vary with the seasons while the Buff-necked Ibis numbers remain constant, there are never enough cavities to support all of the birds present in this important bird watching site that we studied. Although the study area is called a bird sanctuary, and although part of the economic profit in the study area comes from bird watching tourism, we predict that no expansion in the bird populations that visit the area can occur due to competition for limited nesting and roosting sites, a process that is amplified and reinforced by the accelerated loss of nest sites caused by damming. Damming

thus has potentially negative impacts on both the birds living there and the tourism industry that they attract.

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