The use of dead stand trees by birds: a prospective study in a Brazilian hydroelectric dam

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Abstract: Hydropower constructions cause severe disturbances to biodiversity. Arboreal plants die after flooding; however, they expose their emerged branches (also called paliteiros) as a new habitat for animals and plants. Nothing is known about how paliteiros influence the presence of aquatic birds. This study verified which species of birds use the paliteiros, what are their behaviors and probably consequences to ecological processes. In November 2018, we sampled 5 km of paliteiros recording perched birds and their behaviors in the Três Marias dam, a 1040 km² flooded area in southeastern Brazil. In total, 5.4% of paliteiros were used by 14 bird species. The Neotropic Cormorant Nannopterum brasilianus (Gmelin, 1789) was the most frequent species. Birds mainly preened feathers; they also rested (with no apparent activity), defecated, hunted, fed, vocalized and drank water. Attention must be focused to some behaviors such as resting and defecation, which may influence long-term ecological processes (e.g., incorporating additional organic matter and changing aquatic community) in the dam.

Keywords: Behavior; Birds; Hydropower building; Human impact.

O uso de paliteiros por aves: um estudo prospectivo em uma usina hidrelétrica no Brasil

Resumo: Construções de hidrelétricas causam severos distúrbios à biodiversidade. Após a inundação de grandes áreas as plantas arbóreas morrem, apesar disso, elas deixam expostos seus galhos emersos (também chamados de paliteiros) criando um novo hábitat para animais e plantas. Nada se sabe sobre como os paliteiros influenciam a presença de aves aquáticas. Este estudo verificou quais espécies de aves utilizam os paliteiros, quais comportamentos elas exibem e suas prováveis consequências para processos ecológicos. Em novembro de 2018 foram amostrados 5 km de paliteiros, as aves empoleiradas nestas estruturas e seus comportamentos na represa de Três Marias, uma área inundada de 1040 km² no sudeste do Brasil. Ao total, 5.4% das árvores mortas foram utilizadas por 14 espécies de aves. O biguá Nannopterus brasilianus (Gmelin, 1789) foi a espécie mais frequente nos paliteiros. As aves frequentemente limparam as penas, descansaram (sem nenhuma atividade aparente), defecaram, caçaram, se alimentaram, vocalizaram e beberam água. Mais atenção deve ser focada em alguns comportamentos das aves tais como o descanso seguido de defecação que podem influenciar processos ecológicos a longo prazo (p. ex., a incorporação de matéria orgânica e mudança de comunidade aquática) na represa.

Palavras-chave: Aves; comportamento; construção de hidrelétricas; impacto humano.
Introduction

Human impacts tied to the exponential increase of urbanization are considered major forces to the loss of biodiversity (McDonald et al. 2013). The construction of dams to generate electricity is a widespread example of impact that converts natural areas to artificial areas. It emerged by manipulation of natural water courses and creation of reservoirs which can cause serious disturbances to biodiversity (Stanford & Ward 1992, Forsberg et al. 2017). Many terrestrial animals and plants are excluded from local community after flooding of large areas due to habitat loss ( Báldi et al. 1998, Mallik & Richardson 2009). Despite it, damming also results in the appearing of new habitats such as remaining dead and standing trees called “paliteiros”. In many cases, some species of birds may profit in dams by the changes promoted by humans and individuals within population may adjust to disturbances of their environment (Reitan & Thingstad 1999). Therefore, aquatic birds can use paliteiros as a perching substrate, however, nothing is known about their frequency of use and behaviors that they exhibit.

A similar and parallel example of remaining perching structure to birds are the scattered trees in human-modified terrestrial landscapes that are useful to species as resting and feeding places during movements between areas serving as stepping stones (Manning et al. 2006). Frugivorous birds can rest or feed in scattered trees or artificial perches and they can defecate and regurgitate seeds contributing to natural regeneration of degraded areas. Also, perches are used by birds to hunt other organisms like ants and rodents thus contributing to a balanced food chain (Herrera & García 2009, Guidetti et al. 2016, Vogel et al. 2018).

The Brazilian territory is privileged in watersheds and it is the second country that generates more hydropower in the world (behind China), with hydropower totaling 68.1% of the country’s electricity and more than 290 large dams (Oliveira 2018). Although the negative perspective on low biodiversity found after construction of hydroelectric dams (Batista et al. 2012), no knowledge exists of what concerns the influence of dead standing trees as perching structures for birds in flooded areas and its ecological importance. Here, we verified which species of birds use the paliteiros in the Três Marias dam located in southeastern Brazil. We also recorded what behaviors birds exhibit and if the quantity of dead branches in paliteiros may influence their momentary presence in the flooded area. With this study, we expect to raise initial information about the use of paliteiros by birds and their ecological consequences in dams.

Methods

1. Study area

The study was conducted at Pirapitinga Ecological Station (PES), which has an approximate area of 1,090 ha and 20 km perimeter. It is located in the reservoir of Três Marias hydroelectric power in the municipality of Morada Nova de Minas, Minas Gerais State, southeast Brazil. The PES is located at the confluence of the Riachão stream with the São Francisco river (18°20' S - 18°23' S and 45°17' W - 45°20' W) (Azevedo et al. 1987) (Figure 1). It is surrounded by a high amount of paliteiros resulted from dead savanna or Cerrado trees caused by the flooding of 1962. The paliteiros emerged 6-7 years ago due to the reduction of the water level of the dam. There are 36 species of aquatic birds in the PES area (Plano de Manejo Estação Ecológica de Pirapitinga 2013).

2. Data collection

Data collection was conducted by a team of five people in the morning from 07:30 h to 12:00 h on 26 November 2018. Approximately
5 km of paliteiros were sampled at the edge of the main channel from Três Marias dam, near the PES housing. We sampled the abundance of dead trees in paliteiros, the bird species richness and the frequency of use of paliteiros by birds as well as their behavior when perched in an emerged branch (or tip). Different portions of paliteiros were sampled simultaneously to avoid double counting of the same individual bird. We treated one paliteiro as a total of 100 tips of emerged branches (i.e., above water surface) which corresponds to 33 ± 8.30 dead trees (see results). Some of the branches were bifurcated and contained more than one tip. Other future studies may differently deal a paliteiro unit than us considering that there is no previous definition of how many trees or tips form a paliteiro unit. Perched birds were identified, counted and observed with the aid of binoculars. The focal animal technique was applied for 30 seconds per bird and bird behavior was identified and quantified. We classified bird behavior into nine categories: (1) resting, when perched birds apparently exhibited no active behavior; (2) preening, when birds cleaned feathers with beak or feet; (3) hunting, when birds flew or dove to chase a prey; (4) feeding; (5) drinking; (6) defecating; (7) communicating, when birds vocalized; (8) nesting, when birds had a nest or were building a nest; and (9) drying feathers with opened wings. The nomenclature of the species follows the Brazilian Ornithological Records Committee (Piacentini et al. 2015).

3. Data analyses

Jackknife 1 estimator was used to estimate the number of bird species in paliteiros. We also used a logistic regression to know if the number of dead trees (i.e., sampling units) in paliteiros influenced the presence/absence of birds. An emerged individual branch (i.e., with one tip) or an emerged and bifurcated branch (i.e., with two or more tips) is the closest way of what we found to represent a dead tree. This procedure was taken because we did not have access to the submerged and complete structure of branches and stems to accurately isolate individual trees in the dam.

The species accumulation curve with rarefaction method analysis was used to know the representativeness of bird species considering the number of paliteiros and number of birds sampled, respectively. The same procedure was adapted to know the representativeness of bird behavior types. In this case, we considered types of behavior instead specific species. Analyses were performed in R Statistical software v 3.5.1 (R Core Team 2019). “Vegan” was the complementary R package used in the analyses.

Results

We sampled 28 paliteiros in PES. Each paliteiro has 33 ± 8.30 dead trees (maximum and minimum number of trees were 65 and 20, respectively). Seventy-three birds of 14 species used 5.4% (N = 48) of the total number of dead trees (N = 888) in paliteiros. The Neotropic Cormorant Nanopterum brasilianus (Gmelin, 1789) was the most frequent species (Figure 2). The number of dead trees did not influence the presence of birds in paliteiros (df = 26; z = -0.54; p = 0.59). Jackknife 1 estimated 20.75 ± 2.55 (SE) species of birds to the sampled area. Rarefaction method analysis estimated the need of four paliteiros (or 400 tips or nearly 12 dead trees) or 10 individuals of birds to record an additional species of bird.

Preening was the most frequent behavior used by birds followed by resting (Figure 3, Table 1). No nesting or wing-drying behaviors were recorded. Rarefaction method analysis estimated the need of eight paliteiros (or 800 tips or nearly 24 dead trees) or 16 individuals of birds to record a new type of behavior.

Discussion

The present study was the first to evaluate the use of paliteiros by birds. Twelve out of 14 species were aquatic birds and they represented 33.3% of a total of 36 species of aquatic birds in the entire region (Plano de Manejo Estação Ecológica de Pirapitinga 2013). The Jackknife estimator pointed that no more than 21 species or 58% of total species may use paliteiros in the region. Also, birds showed a variety of behaviors when perched in paliteiros. Although the short-time nature of our results, we sampled a significant number of dead trees and this prospective study incorporated a sampling protocol that can be used in future researches regarding the use of paliteiros by birds. Furthermore, we argue that more attention also must be focused to some behaviors...
(e.g., defecation, and hunting) that may influence ecological processes in dams.

The water level of the Três Marias dam has been reduced and exposed the dead arboreal trees 6-7 years ago. Although the number of dead trees did not influence the presence of birds in paliteiros, a gradual process of colonization and use of paliteiros by aquatic bird species should be occurring in the area. During the colonization process, several adaptations (e.g., life history, general tolerance to disturbances, ability to disperse to other habitats) that are specific for species affect the possibilities for each bird to adjust (or not) its behavior in human-altered conditions. For instance, the Neotropic Cormorant (N. brasilianus), a top aquatic predator, was the most frequent species in our study and it may be considered as an example of generalist species with high incidence of colonization in anthropic environments (Orta 1994, Sick 1997). The cormorants showed a bunch of behaviors in the paliteiros and they opportunistically hunts a variety of prey using submerged and efficient dives in small and large natural and artificial lakes, as well as in rivers and marine ecosystems throughout the Brazilian territory (Barquete et al. 2008). The presence of cormorants and other aquatic top predator birds (e.g., heron and kingfishers) may alter significantly their prey abundance (Steinmetz et al. 2003).

Some birds that defecated in paliteiros may have acted as fertilizer agents incorporating additional organic matter into water and/or acting as food provider to detritivorous species (e.g., fish and crustaceans). Therefore, birds may play an important role as nutrient vectors (mainly phosphorus and nitrogen) which interfere in the trophic chain of aquatic ecosystems (Manny et al. 1994). This is a similar mechanistic process that occurs when frugivorous birds defecate seeds from perches in degraded areas: they may feed other organisms (e.g. ants), increase the seed bank, and indirectly modify the local community of plants and animals (Christianini & Oliveira 2009, Herrera & Garcia 2009, Guidetti et al. 2016). Furthermore, some usual bird places such as dormitories and rookeries may be more protected from predators when they border aquatic ecosystems similarly to paliteiros; the high concentration of individuals (including their droppings) may change local macrophytes biomass and their associated organisms (Castelo-Branco 2008). More

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**Table 1.** Bird species and their behaviors when perched on paliteiros in Três Marias dam, southeastern Brazil. (P) preening, (R) resting, (D) defecating, (H) hunting, (F) feeding, (V) vocalizing, and (Dr) drinking. Number in parenthesis indicates the frequency of behavior type.

| Taxa | Portuguese name | English name | Behavior |
|------|-----------------|--------------|----------|
| Anseriformes Linnaeus, 1758 | | | |
| Anatidae Leach, 1820 | | | |
| Dendrocygna autumnalis (Linnaeus, 1758) | marreca-cabocla | Black-bellied Whistling-Duck | R(4), D(1), P(2), V(1) |
| Cairina moschata (Linnaeus, 1758) | pato-do-mato | Muscovy Duck | P(1) |
| Ciconiformes Bonaparte, 1854 | | | |
| Ciconiidae Sundeivall, 1836 | | | |
| Mycteria americana Linnaeus, 1758 | cabeça-seca | Wood Stork | R(1) |
| Suliformes Sharpe, 1891 | | | |
| Phalacrocoracidae Reichenbach, 1849 | | | |
| Nannopterum brasilianus (Gmelin, 1789) | Biguá | Neotropic Cormorant | R (5), D(2), P(8), Dr(1) |
| Pelecaniformes Sharpe, 1891 | | | |
| Ardeidae Leach, 1820 | | | |
| Ardea cocoi Linnaeus, 1766 | garça-moura | Coci Heron | R(2) |
| Ardea alba Linnaeus, 1758 | garça-branca | Great Egret | R(3), H(1), P(1) |
| Accipitriformes Bonaparte, 1831 | | | |
| Pandionidae Bonaparte, 1854 | | | |
| Pandion haliaetus (Linnaeus, 1758) | águia-pescadora | Osprey | P(1) |
| Ciconiiformes Forbes, 1844 | | | |
| Alcedinidae Rafinesque, 1815 | | | |
| Chloroceryle amazona (Latham,1790) | martim-pescador-verde | Amazon Kingfisher | R(1), H(1), F(1) |
| Passeriformes Linnaeus, 1758 | | | |
| Tyranninae Vigors, 1825 | | | |
| Tyrannus savana Daudin, 1802 | Tesourinha | Fork-tailed Flycatcher | P(1) |
| Tyranninae Vigors, 1825 | | | |
| Stelgidopteryx raficollis (Vieillot, 1817) | Andorinha-serradora | Southern Rough-winged | R(1), P(2) |
| Tachycineta albiventer (Boddaert, 1783) | andorinha-do –rio | White-winged Swallow | R(1), P(3) |
| Tachycineta leucorrhoa (Vieillot, 1817) | andorinha-de-sobre-branco | White-rumped Swallow | R(1), P(2) |
| Tachycineta sp. | | | R(4), P(4) |
| Icteridae Vigors, 1825 | | | |
| Gnorimosops chopi (Vieillot, 1819) | pásaro-preto | Chopin Blackbird | P(1) |
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studies are necessary to investigate if paliteiros facilitate or attract higher concentration of other organisms such as plants, fish and invertebrates.

The use of paliteiros by birds is a recent and underexploited theme. Our study is far from a definitive conclusion, however, it is the first step to discover more information about the importance of this man-altered habitat to birds and how the presence of birds may positively or negatively influence ecological processes. We encourage more comparative studies to verify if older flooded areas with paliteiros may have higher bird biodiversity than recent ones and if birds may comprise more specific ecological functions in the local food chain.

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Contribution to data analysis and interpretation: C. Cestari.

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