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ECOSYSTEMS

Seasonality and assemblages of non-passeriform waterbirds in várzea lakes on the lower Amazonas River, Santarém, Pará, Brazil

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Abstract: Amazonian várzeas are annually flooded for at least five months, which influences the occurence of waterbirds. This study investigates the species richness and composition, and individual abundance of waterbird assemblages in 10 *várzea* lakes on the lower Amazon River across a seasonal cycle. A total of 7,970 birds belonging to 52 species were recorded. Of these, 25 species were present in all four phases of the cycle, 5 in three phases, 10 in two and 12 during just one phase. Families with the highest species richness were *Ardeidae* and *Scolopacidae*. In the dry season, we recorded the highest species richness and the highest total abundance values. Thirteen species showed variation in abundance across the seasonal cycle, most being more abundant in the dry season Variation in species richness, abundance, and composition suggests that research on waterbird assemblages in Amazonian várzeas should consider all phases of the seasonal cycle. Furthermore, the occurrence of several migratory species demonstrates the importance of this region for the conservation of this group. Multi-year monitoring would contribute to a better understanding of the dynamics of Amazonian várzea waterbird assemblages.

Key words: Amazon, avifauna, ecology, floodplain.

INTRODUCTION

Within the Amazon Basin river-associated wetlands cover some 300,000 km2, including such white-water rivers as Solimões, Madeira and Amazonas (Pires & Prance 1985, Sioli 1985). Present across practically the entire basin, várzea wetlands have high representativeness making them very important for the maintenance of waterbird assemblages throughout the Amazon biome (Pires-O'Brien & O'Brien 1995, Fraxe et al. 2007). Across an annual cycle, the natural flood pulse of these floodplains occurs in four distinct phases: 1) rising (elevation of water level), 2) peak-flood (sustained high water level), 3) ebb (descent of water level) and 4) dry (waters at lowest level) (Junk 1997, Fraxe et al. 2007). Combined, this makes the várzea floodplain ecosystem extremely changeable across the annual cycle (Junk 1989). This indicates that flood-pulse dynamics may potentially increase the environmental complexity of the floodplains and so drive changes in ecological parameters such as species richness and composition, as well as the individual abundance within bird assemblage populations associated with such wetlands (Remsem-Jr & Parker 1983, Moreno et al. 2004, Cintra et al. 2007, Ferreira et al. 2019).

For waterbirds, the immense number of lakes within the Amazonian floodplains form a key component of this environment. These are generally located in the lower lying areas of the ecosystem, and may, or may not, be connected by channels to other lakes or rivers. They may be able to merge with other water bodies at peak inundation, with connection being limited only by vegetation during that phase (Sioli 1985, Esteves 1998, Henderson et al. 1998). Since, even in the driest period, most lakes do not completely dry out, such sites may have strategic importance for the preservation/conservation of many waterbird species, as they possess (and potentially concentrate) food resources, especially aquatic organisms such as fish and invertebrates. In addition, such lakes are often key sites for the conservation of migratory birds, serving as feeding and resting points on their migration routes (Alves & Pereira 1998).

Not surprisingly, most studies of waterbirds have been conducted in the northern hemisphere (e.g. Bancroft et al. 2002, Steinmetz et al. 2003, Paracuellos & Tellería 2004, Accordi 2010). In Brazil, research on the ecology of birds associated with wetlands has occured mostly in the southern and southeastern regions (e.g. Ishikawa-Ferreira et al. 1999, Guadagnin et al. 2005, Rodrigues & Michelin 2005, Accordi & Hartz 2006, Pimenta et al. 2007, Gimenes & Anjos 2011, Alves et al. 2012). In the Amazon, despite the importance of wetlands in the biome, a relatively small number of ecological studies of the regions waterbird have been conducted (Remsem-Jr & Parker 1983, Willard 1985, Pacheco 1993, Borges & Carvalhães 2000). While some recent studies of waterbirds have occurred, these have mostly been in the state of Amazonas (Cintra et al. 2007, Cintra 2015). Of these, only two deal with variations in species richness and abundance of individuals across the seasonal flooding cycle in floodplains (e.g. Cintra 2012, Ferreira et al. 2019).

The current study is the first quantitatively investigate the structure of waterbird assemblages in várzea floodplain lakes of the lower Amazonas River. We investigated how the waterbird assemblage is influenced by the flood pulse, and asked the following questions: 1) Does species richness vary between seasonal cycle phases? 2) How does species abundance vary across a seasonal cycle, and 3) How does waterbird assemblage species composition vary between phases of the seasonal cycle? These are basic, but still unanswered, questions. With this study, we aim to describe the avifauna at each phase of the seasonal cycle, and how driving ecological parameters are altered by flood pulse dynamics.

Which factors structure bird assemblages in a lake ecosystem depends, in part, on how species interact and utilize available resources such as food and space (Alves et al. 2012). Across a seasonal cycle in lowland Amazonian lakes it is expected that the food resources within the water body will be more concentrated when, in the dry phase, water levels are lower, and that this will, in turn, lead to a higher concentration of both species and individual birds on lakes at this stage of the annual cycle. Accordingly, our hypothesis is that in the várzea floodplain lakes of the lower Amazonas River the richness and abundance of waterbirds will be greater during the periods of lowest water level. For species composition, we hypothesize that it should change only due to the arrival of wetland-associated migrant species. Testing the validity of these proposals furthers understanding of the importance this ecosystem may have for the effective conservation of the Amazonian avifauna.

MATERIALS AND METHODS

Study area

The study was carried out in a floodplain area of the municipality of Santarém, western Pará state, Amazonian Brazil (Fig. 1). The study area is located on the lower Amazon River region, near the small village Santa Maria do Tapará, located 18 km (straight-line) from Santarém

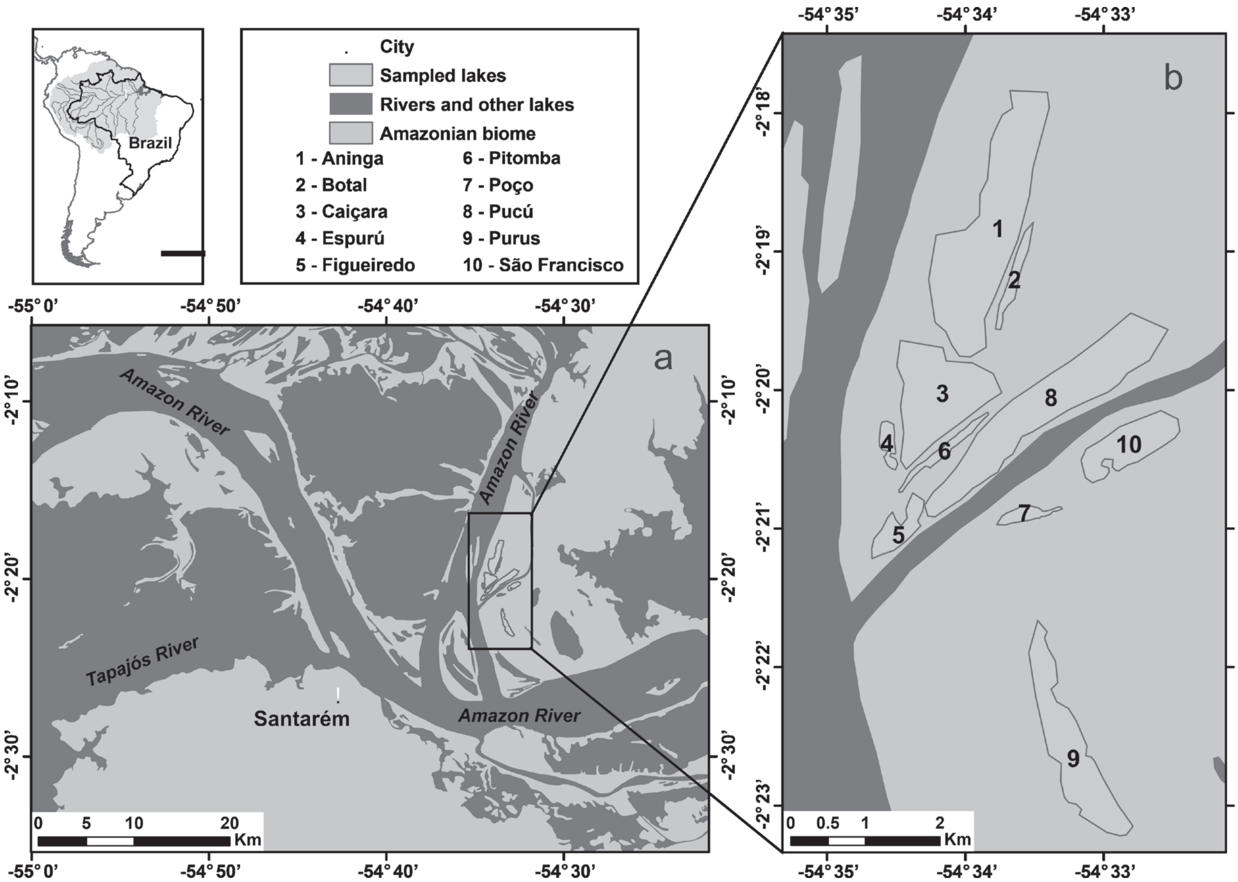

Figure 1. **(a) Location of the study area and of Santarém city, Pará, Brazil, at the confluence of the Tapajós and Amazonas rivers; (b) Detailed image of study area to show the 10 *várzea* lakes selected for the current study.**

city (Fig. 1a). Regional climate is hot and humid, with an average annual temperature of 28°C and average annual precipitation of 1,920 mm (Valente et al. 2011, Prefeitura Municipal de Santarém 2013). Rains are most intense between December and May and least intense between June and November (INMET 2013).

We selected 10 floodplain lakes for the study (Fig. 1b). Várzea forests were the principle vegetation surrounding the study sites, along with natural open grass dominated areas and islands of woody vegetation, dominated by species such as *Cecropia*. Lake margin vegetation is fully-or partially-flooded in all but the dry phase, while the lake waters support a rich assemblage of aquatic macrophytes. Sampled lake size varied between 0.04 and 2.89 Km^2 (Table I), and, while all were connected to the Amazon River when water was highest, almost all were isolated during the driest period of the year.

We collected data between July 2013 and May 2014, so covering a complete seasonal cycle. Data obtained from the Brazilian Navy for this period show that the average water level for the Amazon River was 5.5 m between August and September (ebb phase), when some lakes connected to the river; 3.4 m between October and December (dry), when no lakes connected to the river; 6.3 m between January and March (rising), when almost all lakes connected to the river, and 7.9 m between April and June (floodpeak), when all lakes connected with the Amazon River.

Table I. Geographic coordinates and approximate area (km²) of 10 study lakes during each seasonal cycle phase in the lower Amazonas River.

Lake	Geographical coordinates	Area/Phase			
		Ebb	Dry	Rising-water	Flood-peak
Aninga	2°19'S; 54°34'W	2,26	2,05	2,49	2,89
Botal	2°19'S; 54°33'W	0,15	0,1	0,19	0,24
Caiçara	2°20'S; 54°34'W	0,65	0,3	0,9	1,31
Espurú	2°20'S; 54°W	0,09	0,05	0,15	0,2
Figueiredo	2°21'S; 54°34'W	0,16	0,08	0,26	0,32
Pitomba	2°20'S; 54°34'W	0,06	0,04	0,1	0,14
Poço	2°20'S; 54°33'W	0,07	0,04	0,11	0,17
Pucú	2°20'S; 54°33'W	1,66	0,8	1,96	2,4
Purus	2°22'S; 54°33'W	1,18	1,13	1,23	1,29
São Francisco	2°20'S; 54°32'W	0,22	0,16	0,36	0,61

Field procedures

For data collection, each lake was sampled using the fixed transect method (Bibby et al. 1992), with experimental design adaptated to local logistics. Transect orientation was determined individually for each lake, but covered the perimeter of the study lake to about 20 meters in from the margin. Studies were conducted from wooden canoes (4 people capacity), propelled by a small petrol engine (locally known as a *rabeta*), at an average speed some 10 km/h. We consider that the use of this vessel did not significantly interfere with sampling, as its passage across lakes, resulted in little obvious change to the behavior of the birds, probably because this type of transport is widely used by the local riverside population (Fraxe et al. 2007). In addition, motorized vessels have already been used in several waterbird-focused studies (Gimenes & Anjos 2006, Cintra et al. 2007, Cintra 2012, 2015), since they are especially well-suited to the habitat (Bibby et al. 1992). We used this vessel during the rising, peak-flood and ebb phases. However, in the dry phase access by boat to some lakes was not possible and, consequently, for this phase a transect was traversed on foot along the banks of each lake at an average speed of 1 km/h. Due to this difference in methodologies, a 50-minute sampling effort was standardized for each lake.

During sampling, we recorded each observed individual of each species of non- Passeriform waterbirds. Thus, we obtained, in addition to data on species richness and composition, an estimate of the abundance of each species. Species were identified via visual, with the aid of 10 x 42 binoculars, and/or auditory contact. Individuals seen only in flight were not counted, except for four species (*Gelochelidon nilotica, Phaetusa simplex, Sternula superciliaris* and *Rynchops niger*), which remain in flight most of the time.

Surveys began at 07:00 and ended about 11:00. This period was selected since it is when the majority of diurnal bird species, including waterbirds, are most active, so facilitating detection during sampling (Andrade 1993). On each data collection day, three lakes were sampled, by the same team. Between July 2013 and May 2014 each lake was sampled twice at each stage of the four phases of the seasonal cycle, generating a total of eight samplings per lake.

Data analysis

We used a Jackknife 1 richness estimator to test whether field-based species richness was representative of the study area. We used species rarefaction curves as a function of the sampling effort to estimate at which stage of the seasonal cycle the greatest species richness occured. For this analysis we used the ESTIMATES 9.1.0 program, with rarefaction curves generated in the R computational environment (R Development Core Team 2018).

We used a Friedman Test to check for possible differences in the total number of individuals in the assemblage and in the number of recorded individuals for each species during the seasonal cycle. This test was applied when the expected frequency was equal to or greater than five, and analyzes were run on the program BIOSTAT version 2007. In our study, each lake was sampled twice in each phase of the annual cycle, although we did not use average abundance values. For statistical analysis of abundance, we followed Tavares & Siciliano (2014) and used the field-sample value with the highest number of species for each phase. For example, if during the first sampling of the flooding phase, 200 individuals of a given species were recorded, and in the second sampling of the same phase, 2 individuals were recorded, the abundance value used in the analyzes for this species in the flooding phase was 200 individuals. We consider this approach especially appropriate in such a seasonal habitat, where the abundance of a given species can fluctuate enormously from one sampling to another, even at the same stage of the annual cycle.

We use a Non-metric Multidimensional Scaling (NMDS) to study changes in the bird assemblage composition between seasonal cycle phases. The Between-phase comparisons were made via Analysis of Variance (ANOVA), followed by a Tukey test when there was a significant difference. For both, NMDS and ANOVA, we used the species abundance data standardized via the total catches from the sampling site (with the *decostand* function of the *vegan* package: Oksanen et al. 2015), and a Bray-Curtis dissimilarity index. These analyzes were run in the *vegan* package (Oksanen et al. 2015) of the R computing environment (R Development Core Team 2018).

RESULTS

In total, across all four phases of the annual cycle, we recored a total of 7,970 individuals from 52 species belonging to 21 families (See Appendix). For the entire annual cycle, the species rarefaction curve as a function of sampling effort (Fig. 2), did not reach asymptote, but tended to stabilize. The Jackknife 1 richness estimator indicated species richness in the study area could reach 58 species, and we therefore consider the species richness obtained in the study to be representative. The same can be said when each phase of the cycle is considered separately. For the dry phase, estimated richness was 57 species; in the rising water phase 37 species; in the flood-peak 34 species, and 39 species during the ebb. These values are relatively close to the species richness values obtained in the field; 47, 33, 31, and 36 species for the dry, rising water, flood-peak and ebb phases, respectively.

A visual analysis of the rarefaction curves for each phase of the cycle as a function of sampling effort also show greater dry phase species richness. In this phase, even after ten samplings had been carried out, the curve showed the smallest tendency of all four phases to reach an asymptote. For other phases, on the

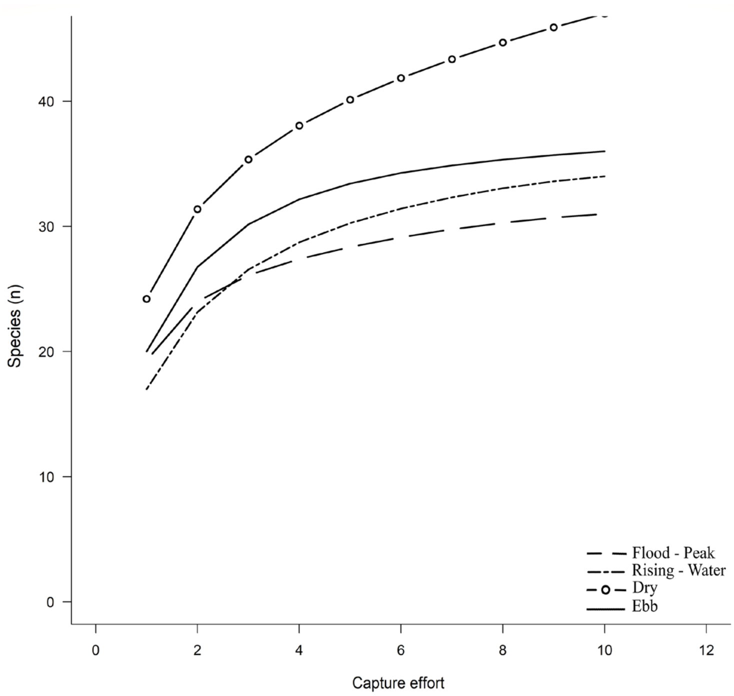

Figure 2. **Species rarefaction curves as a function of the sampling effort covering the entire annual cycle. The line with circles represents the dry phase, the continuous line the ebb phase, the line with short dashes the flood peak, and with longer dashes the rising-water phase.**

other hand, rarefaction curves showed a strong tendency to stabilize (Fig. 2).

Of the 52 species, only 25 were recorded in all four phases, while 5 were recorded in three phases, 10 in two and 12 species were recorded only in one phase of the seasonal cycle. Ardeidae and Scolopacidae were the families with the highest species richness, with 11 and 8 species, respectively. In contrast, 12 families were represented by a single species (see Appendix). Ten of the species recorded during the study are considered northern migrants, with *Calidris fuscicollis* and *Tringa melanoleuca* being new records for the study region.

Friedman' test indicate that overall assemblage abundance varied significantly between phases of the annual cycle (Fr = 9.48; gl = 3; p = 0.02), with the dry phase showing the greatest number of individuals (3,293) compared to the other three (1,616 during rising water, 1,496 for flood-peak, 1,565 during the ebb). Thirteen species showed significant between-phase variation in abundance (Table II). Of these, most (9) were more abundant in the dry phase, 1 was most abundant during the flood-peak, 2 in the ebb and 1 when waters were rising (Appendix).

The NMDS showed that the composition of bird assemblage had changed in relation to the seasonal cycle phases (Stress: 0.19; F: 56.67; p = 0.01). The Tukey test revealed that significative differences in species composition ocurred between the phases ebb and dry (p = 0.03), the dry and flood-peak, (p = 0.02) and between the dry and risingwater (p = 0.001) (Fig. 3).

DISCUSSION

As predicted, our study showed that the waterbird assemblage in várzea floodplain lakes on the lower Rio Amazonas is strongly influenced by the annual flood pulse. This is supported principally by the changes in species richness and in abundance of individuals of several species across the seasonal cycle. This general pattern has also been found in other studies of wetland birds in the Amazon as well as in other regions of Brazil. For example, Soares & Rodrigues (2009) showed that the composition

Table II. **Number of records on each phase of the annual hydrological cycle of the 13 species recorded in this study wich showed variation in abundance along phases of the four annual flooding cicle in várzea lakes of the lower amazon river. The last column shows the p values of Friedman Test.**

Taxa	Ebb	Dry	Rising-water	Flood-peak	*p*
Anatidae					
Dendrocygna autumnalis (Linnaeus, 1758)	240	149	0	0	0,0002
Ardeidae					
Butorides striata (Linnaeus, 1758)	67	91	6	17	0,0002
Ardea alba Linnaeus, 1758	80	817	259	137	0,01
Egretta thula (Molina, 1782)	64	363	179	32	0,003
Egretta caerulea (Linnaeus, 1758)	4	41	1	14	0,007
Accipitridae					
Rostrhamus sociabilis (Vieillot, 1817)	68	4	2	44	0,0001
Aramidae					
Aramus guarauna (Linnaeus, 1766)	22	16	22	49	0,04
Charadriidae					
Vanellus chilensis (Molina, 1782)	12	52	0	0	0,02
Charadrius collaris Vieillot, 1818	17	50	0	0	0,047
Scolopacidae					
Tringa solitaria Wilson, 1813	10	44	2	0	0,01
Jacanidae					
Jacana jacana (Linnaeus, 1766)	75	296	299	255	0,003
Sternula superciliaris (Vieillot, 1819)	33	50	0	1	0,04
Phaetusa simplex (Gmelin, 1789)	179	378	75	38	0,02

and abundance of the waterbird assemblage of Santo Amaro Lake, Lençóis Maranhenses National Park, varied between the dry and rainy seasons, while over the course of three years of study, Figueira et al. (2006) also found variations in avifaunal abundance, including waterbirds, in Poconé, in the northern Brazilian Pantanal.

We found that most species were more abundant in the dry phase. The increase in the richness and/or abundance of waterbirds in the dry phase or in the ebb appears to be a recurrent pattern, reported in the majority of studies (Alves & Pereira 1998, Guadagnin et al. 2005, Accordi & Hartz 2006, Figueira et al. 2006, Silva & Blamires 2007, Soares & Rodrigues 2009, Gimenes & Anjos 2011, Cintra 2012, Tavares & Siciliano 2014, Ferreira et al. 2019).

It is also important to highlight that some species did not follow this general pattern and were more abundant in other phases of the cycle (e.g. *Dendrocygna autumnalis*, *Rostrhamus sociabilis*) than the dry phase. The fact that a species shows between-phase fluctuations in abundance in the study area shows that its population, or part of it, moves to other locations for some part of the seasonal cycle. In the case of the species recorded in the present study, we believe that this is likely to be related to three factors: concentration of resources, availability of specific habitat and migratory movements

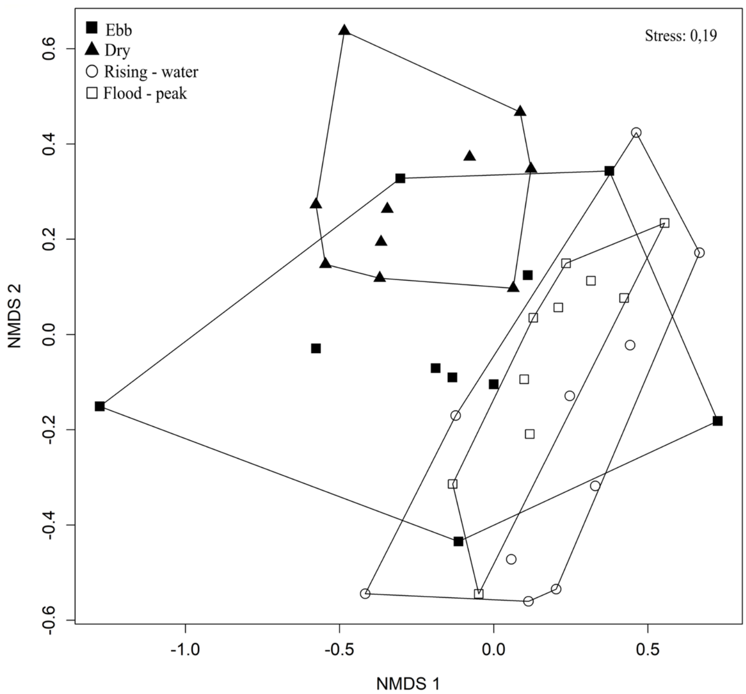

Figure 3. Seasonal changes in aquatic bird assemblage composition across the four annual flooding phases.

(which involve habitat availability and food resources).

In the dry phase, low water levels are likely to result in a concentration of waterbird food resources in várzea lakes, positively affecting the richness and/or abundance of bird species at such sites. This was reported, for example, by Cintra et al. (2007) in the Amazon, and Gimenes & Anjos (2006) in the southtern brazilian. In the current study, the majority of Ardeidae, show this behavior, a situation also reported from other regions of Brazil (Olmos & Silva 2001, Antas & Palo-Júnior 2004, Pimenta et al. 2007, Nunes & Tomas 2008, Martínez-Vilalta et al. 2014).

While *Aramus guarauna* and *Rostrhamus sociabilis* abundances are also influenced by food resource availability, but these species were not most abundant in the dry phase, but, respectively, in those phases when waters were rising and falling. The greater abundance of these two species in these respective phases may be related to the period of greater abundance of gastropods of the genus *Pomacea*, the preferred food of both birds (Magalhães 1990, Del Hoyo et al. 1996). These molluscs show a strong peak of reproductive activity in the flood-peak (Kretzschmar & Heckman 1995), which can lead to an increase in their abundance in the ebb phase, as snails hatched in the peak flood period mature.

Sternidae (with the exception of *G. nilotica*) and Charadriidae were most abundant in the dry phase. In addition to the greater concentration of food resources at this stage of the sazonal cycle, this may be related to time-specific habitat use, since the taxa both breed and rest on the beaches that form on the banks of lakes and rivers (Gochfeld & Burger 1996a, b, Pierce & Boesman 2013, Wiersma et al. 2013). During other stages of the cycle, these habitats are flooded, causing the population, or part of it to move to other regions, a phenomenon also been reported by Nunes & Tomas (2008) for the Pantanal.

All eight Scolopacidae species were either recorded exclusively in the dry phase or were more abundant at this time. All recorded species are northern migrants (Stotz et al. 1996), which apparently use várzea as a feeding and resting stop during migration. Their occurrence principally in the dry phase also coincides with the presence of habitat (beaches and muddy environments) appropriate for these species (Stotz et al. 1996). *Gallinago paraguaiae* is not a northern migrant, but Sick (1997) mentions that some populations are migratory within South America, which may be related to the presence of this species in the dry phase in the present study.

Of the three species of Anatidae recorded by the study, two were more abundant in the ebb phase. In general, Anatidae tend to be abundant in open flooded habitats (Sick 1997). Since flooded areas diminish in extent in the dry phase, a decrease in the abundance of these species is not unexpected. *Dendrocygna autumnalis* performs local seasonal migrations within the Pantanal, where the populations may diminish or even disappear during the dry phase (Nunes & Tomas 2008). In the current study, in contrast, this species did not occurred in the rising water and flood-peak phases. This finding highlight how little studied are the movement patterns of this species in Amazonian várzea.

Our study contributes data on the occurrence and abundance of 52 waterbird species (including two new occurrence records) across an annual cycle of inundation in Amazonian várzea lakes in a poorly-studied region. With this study, we establish a data baseline that can support future research on these species in the region. Variation in waterbird abundance and assemblage composition across the sazonal cycle, and the presence of rare species recorded only once or twice during the study period suggest that research investigating Amazonian várzea waterbird assemblages should consider all phases of the seasonal cycle. Such studies will be highly importante for the conservation of this relatively fragile ecosystem, since studies carried out in only one phase of the cycle, even in the phase with greates bird species richness, are unlikley to obtain all relevant biological information concerning the species that use this environment. In addition, the occurrence of several long-distance migratory species in várzea floodplain lakes (e.g. Scolopacidae) demonstrates the importance of these habitats for the conservation of this group of birds. Long-term monitoring of waterbirds across a number of seasonal cycles could test whether the pattern described in the current study is repeated across multiple years, so leading to an improved understanding of the dynamics of waterbird assemblages in Amazonian várzea.

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Appendix. **Habitat classification according to Accordi (2010), occurrence status (resident, R or migratory, M) and abundance in each seasonal cycle phase for each species recorded in 10 *várzea* lakes of the lower Amazonas River during the study. Occurrence status, taxonomy and nomenclature follow CBRO (2015). The final column shows p values for the Freidman test comparing between-phase abundance for each species across the seasonal cycle.**

Family / Species	Classification	Status	Ebb	Dry	Rising-water	Flood-peak	*p*
Anhimidae							
Anhima cornuta (Linnaeus, 1766)	Riparian Bird	R	32	25	45	34	0,27
Anatidae							
Dendrocygna autumnalis (Linnaeus, 1758)	Waterbird	R	240	149	0	0	0,0002
Cairina moschata (Linnaeus, 1758)	Waterbird	R	26	17	23	21	0,53
Amazonetta brasiliensis (Gmelin, 1789)	Waterbird	R	172	87	149	108	0,37
Phalacrocoracidae							
Nannopterum brasilianum (Gmelin, 1789)	Waterbird / Seabird	R	59	118	109	5	0,1
Anhingidae							
Anhinga anhinga (Linnaeus, 1766)	Waterbird	R	22	44	2	3	0,1
Ardeidae							
Tigrisoma lineatum (Boddaert, 1783)	Waterbird	R	32	49	40	40	0,43
Cochlearius cochlearius (Linnaeus, 1766)	Waterbird	R	0	9	2	0	0,84
Ixobrychus exilis (Gmelin, 1789)	Waterbird	R	0	2	0	0	
Nycticorax nycticorax (Linnaeus, 1758)	Waterbird	R	4	23	16	7	0,4
Butorides striata (Linnaeus, 1758)	Waterbird	R	67	91	6	17	0,0002
Bubulcus ibis (Linnaeus, 1758)	Waterbird	R	135	192	114	361	0,1
Ardea cocoi Linnaeus, 1766	Waterbird	R	18	30	26	17	0,24
Ardea alba Linnaeus, 1758	Waterbird	R	80	817	259	137	0,01
Pilherodius pileatus (Boddaert, 1783)	Waterbird	R	0	1	0	0	
Egretta thula (Molina, 1782)	Waterbird	R	64	363	179	32	0,003
Egretta caerulea (Linnaeus, 1758)	Waterbird	R	4	41	1	14	0,007
Threskiornithidae							
Mesembrinibis cayennensis (Gmelin, 1789)	Waterbird	R	5	14	8	12	0,42
Theristicus caudatus (Boddaert, 1783)	Waterbird	R	7	52	15	61	0,24
Pandionidae							
Pandion haliaetus (Linnaeus, 1758)	Waterbird	MS	1	1	2	0	*
Accipitridae							
Busarellus nigricollis (Latham, 1790)	Waterbird / Riparian Bird	R	9	23	14	19	0,16
Rostrhamus sociabilis (Vieillot, 1817)	Waterbird	R	68	4	2	44	0,0001
Urubitinga urubitinga (Gmelin, 1788)	Waterbird / Riparian Bird	R	4	1	1	3	0,88
Eurypygidae							
Eurypyga helias (Pallas, 1781)	Waterbird	R	0	0	2	0	*
Aramidae							
Aramus guarauna (Linnaeus, 1766)	Waterbird	R	22	16	22	49	0,04
Rallidae							
Aramides cajaneus (Statius Muller, 1776)	Waterbird	R	9	2	0	1	0,49
Laterallus exilis (Temminck, 1831)	Waterbird	R	0	1	0	0	*
Porphyrio flavirostris (Gmelin, 1789)	Waterbird	R	0	0	22	8	0,09

Appendix. Continuation.

Family / Species	Classification	Status	Ebb	Dry	Rising-water	Flood-peak	*p*
Heliornithidae							
Heliornis fulica (Boddaert, 1783)	Waterbird	R	3	1	9	5	0,29
Charadriidae							
Vanellus chilensis (Molina, 1782)	Shore Bird / Waterbird	R	12	52	0	0	0,02
Pluvialis dominica (Statius Muller, 1776)	Shore Bird / Waterbird	MS	19	0	0	0	*
Charadrius collaris Vieillot, 1818	Shore Bird / Waterbird	R	17	50	0	0	0,047
Recurvirostridae							
Himantopus mexicanus (Statius Muller, 1776)	Shore Bird / Waterbird	R	2	6	0	0	0,69
Scolopacidae							
Gallinago paraguaiae (Vieillot, 1816)	Shore Bird	R	0	2	0	0	*
Actitis macularius (Linnaeus, 1766)	Shore Bird	MS	0	5	0	0	*
Tringa solitaria Wilson, 1813	Shore Bird	MS	10	44	2	0	0,01
Tringa melanoleuca (Gmelin, 1789)	Shore Bird	MS	0	2	0	0	*
Tringa flavipes (Gmelin, 1789)	Shore Bird	MS	2	14	0	0	0,3
Calidris minutilla (Vieillot, 1819)	Shore Bird	MS	0	5	0	0	*
Calidris fuscicollis (Vieillot, 1819)	Shore Bird	MS	0	1	0	0	*
Calidris melanotos (Vieillot, 1819)	Shore Bird	MS	0	8	0	0	*
Jacanidae							
Jacana jacana (Linnaeus, 1766)	Waterbird / Shore Bird	R	75	296	299	255	0,003
Sternidae							
Sternula superciliaris (Vieillot, 1819)	Waterbird / Seabird	R	33	50	0	1	0,04
Phaetusa simplex (Gmelin, 1789)	Waterbird / Seabird	R	179	378	75	38	0,02
Gelochelidon nilotica (Gmelin, 1789)	Waterbird / Seabird	MS	0	15	5	29	0,5
Rynchopidae							
Rynchops niger Linnaeus, 1758	Waterbird / Seabird	R	2	20	0	0	0,65
Opisthocomidae							
Opisthocomus hoazin (Statius Muller, 1776)	Riparian Bird	R	69	88	102	96	0,054
Cuculidae							
Crotophaga major Gmelin, 1788	Riparian Bird	R	55	80	56	69	0,56
Alcedinidae							
Megaceryle torquata (Linnaeus, 1766)	Riparian Bird / Waterbird	R	5	7	4	8	0,69
Chloroceryle amazona (Latham, 1790)	Riparian Bird / Waterbird	R	0	0	1	0	*
Chloroceryle aenea (Pallas, 1764)	Riparian Bird / Waterbird	R	0	0	5	3	0,8
Chloroceryle americana (Gmelin, 1788)	Riparian Bird / Waterbird	R	0	1	0	1	*

*** There was no statistical analysis.**

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Danilo Augusto Almeida dos Santos was responsible for preparing the project, field logistics and written production of the research. Giulianne Sampaio Ferreira participated in collaboration in field logistics with data collection, participating in a secondary way in the writing of this work. Edson Varga Lopes supervisor responsible for research and fieldwork, also working on the written production of this article.