

# Ephemeral river islands serve as roosting and foraging habitat for boreal and austral migratory songbirds

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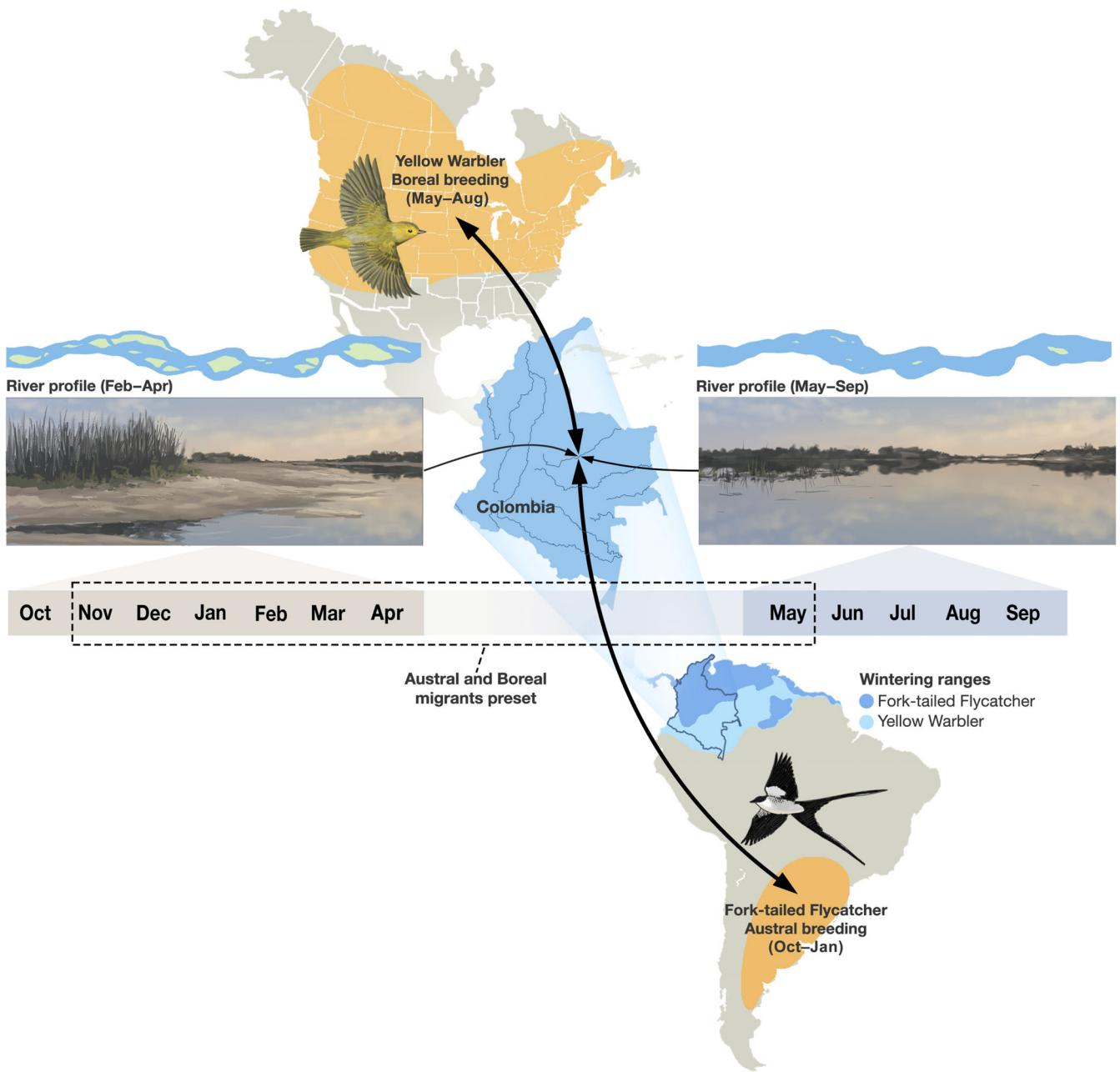
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Migratory birds use different habitats throughout the year as they move between their breeding and nonbreeding grounds. Those that breed in temperate areas can spend more than half of the year elsewhere during migration, at stopovers where they rest and refuel, and at distant nonbreeding localities (Newton, 2007). Therefore, studying the nonbreeding ecology of migratory species is key to understanding their needs throughout the annual cycle. However, knowledge of habitat use and quality in nonbreeding areas is unknown in many cases, particularly for long-distance migrants. Here, we document the role of ephemeral riverine islands in the Meta River in eastern Colombia as habitats where multiple Nearctic-Neotropical migratory songbirds (i.e., those that breed in the northern hemisphere) and Austral-Neotropical migrants (i.e., those that breed in the southern hemisphere) co-occur during

migration and the stationary nonbreeding period (Figure 1), using islands both for foraging and roosting.

Ephemeral islands in the Meta River are mostly submerged during the peak of the rainy season (end of May through September) and emerge with subsiding water levels as the rainy season ends, persisting throughout the dry season and until the next rainy season takes hold (October through the beginning of May) (Figure 1). The emergence of these islands is followed by the rapid colonization and growth of grasses and a fast-growing pioneer shrub (*Tessaria integrifolia*, Asteraceae), which can reach up to 3 m in height and which form dense thickets (Remsen & Parker, 1983). It was in this vegetation that we discovered thousands of roosting migratory songbirds. Through a subsequent exploration of records in a community science database (eBird; Sullivan et al., 2009),

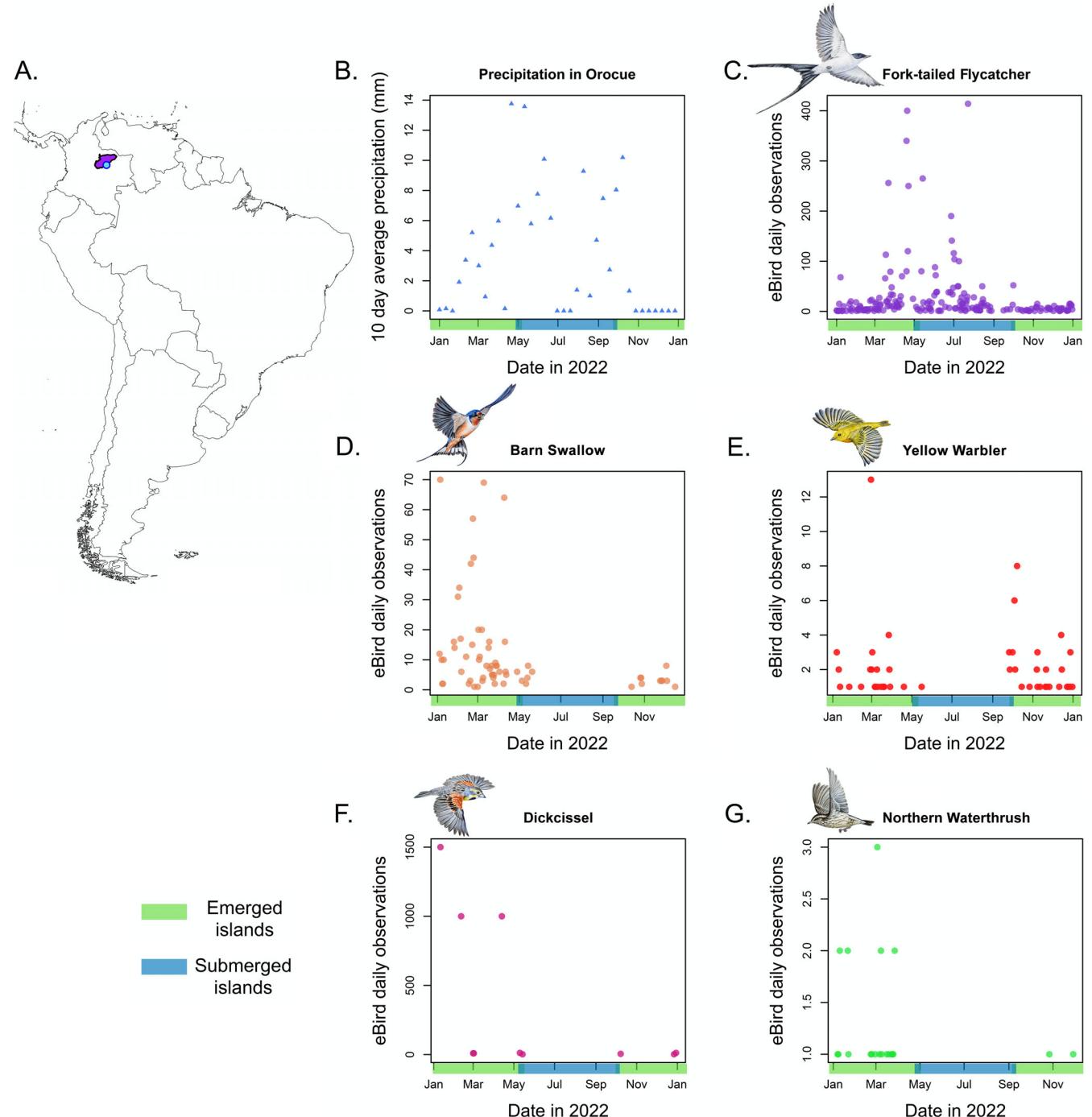


**FIGURE 1** Phenology of Meta River ephemeral islands and two migratory species: Fork-tailed Flycatchers (austral migrants) and Yellow Warblers (boreal migrants). The austral subspecies of Fork-tailed flycatchers (*Tyrannus savana savana*) breeds in southern South America and winters in northern South America, and boreal Yellow Warblers (*Steophaea petechia aestiva*) breed in North America and winter in northern South America and Central America. In April, islands emerge and boreal migrants begin northward migration, while austral migrants arrive from fall migration. Illustration by John Megahan, Museum of Zoology, University of Michigan, used with permission.

we learned that the phenology of island emergence and subsequent vegetation growth coincides with the presence and peak abundance of migratory songbirds in the Casanare department of Colombia (Figure 2).

As a group, North American migratory songbirds are in steep decline (Rosenberg et al., 2019). As part of a larger project that our team is developing to explore

the potential threats to migratory songbirds while on stopover or occupying stationary nonbreeding areas in eastern Colombia, we aimed to describe habitats used for foraging and roosting, with an initial focus on migratory swallows (Hirundinidae). We centered our observations on the riverside town of Orocue, Casanare, during April of 2022 and March–April 2023. We



**FIGURE 2** Migratory songbird phenology in Casanare Department, Colombia, aligns with the peak of the April rainy season when islands remain emerged. (A) South America map with Orocue (blue dot) and Casanare Department (purple polygon). (B) Precipitation data for 2022 sourced from Ideam Colombia (<http://www.ideam.gov.co/>). (C–G) eBird daily observations of: (C) Fork-tailed Flycatchers, (D) Barn Swallows, (E) Yellow Warblers, (F) Dickcissels, and (G) Northern Waterthrushes. Green lines on the x-axis indicate emerged islands; blue shows submerged. Illustrations by Andreza da Silva, used with permission.

observed and followed large flocks of swallows (e.g., Barn Swallows, *Hirundo rustica*) over grasslands and near the river throughout the day and found that large groups were congregating over the Meta River at dusk to forage on flying insects before heading to unknown roost sites. To find the exact location of roosts, we

observed the flight paths of birds and projected their likely destinations. This led to the observation that multiple birds appeared to land at dusk on riverine islands that were densely vegetated with *T. integrifolia*.

Subsequently, we inspected one of the islands which had a surface area of ~30 hectares and found that the

leaves of *T. integrifolia* had a substantial amount of bird feces covering them, indicating a likely roosting location. We then waited for dusk by the edge of the vegetation and documented the arrival of thousands of migratory songbirds of different species, descending from the sky into the vegetation on the island. We identified birds to species based on a combination of field marks and expert inference and estimated the number of individuals of each species that landed in the area where we were standing. We also documented the departure of birds from this same roosting site at dawn (Appendix S1: Figures S1 and S2 and Videos S1 and S2). The sheer number and diversity of migratory birds roosting together was unexpected.

Our observations indicated that thousands of Austral-Neotropical and Nearctic-Neotropical migratory songbirds co-occur on these ephemeral islands for at least several weeks in April, which coincides with the boreal spring migration and the austral fall migration (e.g., Figure 1). We observed thousands of Barn Swallows and Fork-tailed Flycatchers (*Tyrannus savana*) at the roost, as well as hundreds of Bank Swallows (*Riparia riparia*). We also documented thousands of Dickcissels (*Spiza americana*) on the same ephemeral islands, but they were foraging over areas of tall grass. Finally, we also observed tens of Yellow Warblers (*Setophaga petechia*) and Northern Waterthrushes (*Parkesia noveboracensis*) foraging for insects in the *T. integrifolia* throughout the day, and roosting with the other migratory species that arrived at dusk. Although we observed Cliff Swallows (*Petrochelidon pyrrhonota*) foraging over the savannas near Orocue, we did not record this species at the island roost. Notably, two of the observed species have been designated as Species At Risk in Canada including Barn Swallow (population trend  $-73\%$  over 50 years) and Bank Swallow ( $-93\%$ ) (Smith et al., 2023). These same species, as well as Dickcissels ( $-14\%$ ), have been designated as Species of Greatest Conservation Need in the United States (Rosenberg et al., 2016).

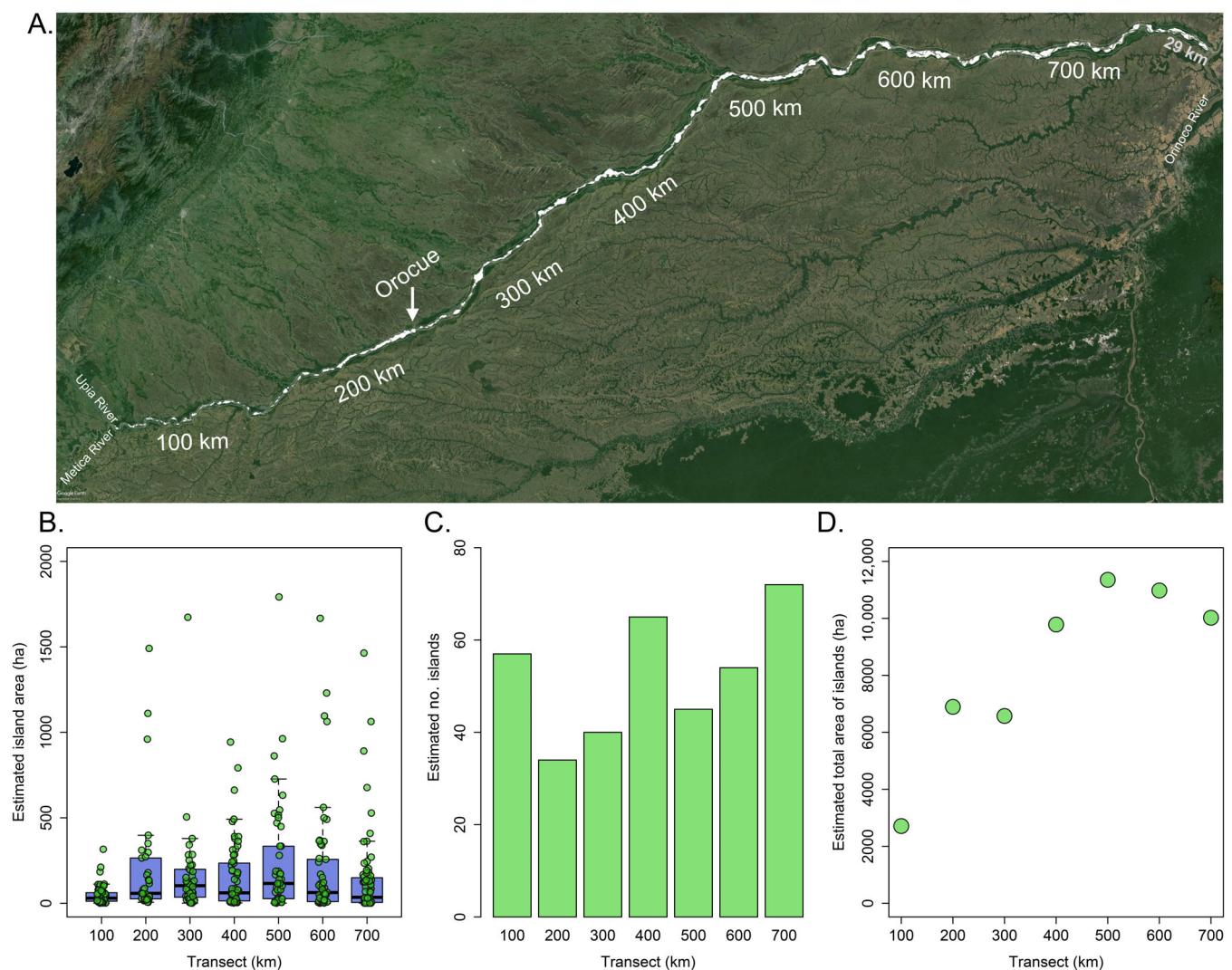
To explore how migrant presence and abundance varies in relation to the flood cycles of the Meta River, we analyzed bird observations submitted by bird-watchers to the eBird database for the year 2022 in the Casanare Department (Sullivan et al., 2009). We found that both boreal and austral migratory songbird abundance peaked in the Casanare Department in March and April (Figure 2A). The increase in precipitation also likely boosts insect availability (Poulin et al., 1992). For instance, in Villavicencio—a city in the vicinity of our study area that has similar precipitation phenology—different species of mosquitoes begin increasing in abundance at the end of the dry season, reaching their peak of abundance in May (Bates, 1945).

That phenological increase in mosquito abundance coincides with the arrival and increase in abundance of these aerial insectivorous migratory songbirds in the area (Figure 2B–G).

Ephemeral river islands vary from year to year depending on the intensity of the rainy season. Moreover, islands likely vary in number and size along different parts of the river. Factors such as water currents, types of sediments, and the presence of tributaries may influence the formation and persistence of these islands. Aiming to understand how islands are distributed along the Meta River, we first used satellite images, derived from Google Earth (Images © 2013–2014 Maxar Technologies, CNES/Airbus, Airbus and Landsat/Copernicus), to estimate the reach of the river, starting from the mouth of the Metica River to the mouth of the Meta River where it meets with the Orinoco River (Figure 3A). Then, we divided the river into transects of 100 km in length and we estimated the sizes of islands using the polygon function in Google Earth (Figure 3A). We found that there were hundreds of islands spread along the Meta River at the time when the satellite images were taken, ranging in size from about 5 to 18,000 ha with mean size of about 160 ha (Figure 3A). We also found that the number of islands and their total size slightly increased downstream toward the east (Figure 3C,D).

Ephemeral river islands are constantly undergoing successional dynamics, providing a unique and arguably stable niche for transient communities of migratory songbirds to exploit during the nonbreeding period. We hypothesize that pioneer riparian vegetation associated with ephemeral substrate, such as *T. integrifolia*, provides an important habitat for insectivorous migratory songbirds in South America. In fact, Alder Flycatchers (*Empidonax alnorum*) have also been observed defending territories in *T. integrifolia* in the wintering grounds in Argentina (Areta et al., 2016). The diversity in island size in the Meta River provides a favorable system to study the relationship between island ephemeral, river geomorphology, and migratory songbird habitat preference. Island size likely influences island persistence, the abundance of pioneer vegetation in the area, and potentially avian use.

Moreover, the ephemeral dynamics of island emergence coinciding with the arrival of migratory songbirds and an increase in insect abundance also sets the stage for the formation of transient ecological communities that appear every year. Attributes related to whether these islands are connected to the mainland, their size, and age (if they survived the previous rainy seasons), potentially influence the presence of predators such as large mammals and snakes, and the probability of migratory songbirds establishing a roosting site there. For example, on the rivers of Manú National Park in Peru,



**FIGURE 3** Islands of different sizes are distributed along the reach of the Meta River. (A) Google Earth Pro Image Landsat/Copernicus of the Meta River. The white polygons indicate islands that were measured to estimate area. To understand how the number and size of islands change along the river, we divided the length into segments of 100 km. (B) Distribution of island sizes along the Meta River. There are small and large islands in all transects except the first, which has only smaller islands. Green dots represent individual islands. (C) The number of islands increases slightly downstream toward the east. (D) Total area of islands (the sum of area in a transect) also increases slightly downstream toward the east.

year-round resident bird species that nest on islands disconnected from the mainland experience lower nest predation rates than those that nest on the mainland (Ocampo & Londoño, 2015). Colonial birds in the family Icteridae in equatorial latitudes also prefer river islands for breeding as they are protected from predatory mammals and snakes (Robinson, 1985). We believe that roosting migratory songbirds likely minimize predation risk by using riverine islands, a hypothesis that remains to be explicitly tested.

Similar dynamics of ephemeral island phenology have been documented for the Amazon basin, where these systems have promoted the evolution of a unique nonmigratory avifauna specialized in utilizing and dispersing

among these dynamic islands (Johnson et al., 2023; Luna et al., 2022; Remsen & Parker, 1983). Moreover, these “resident” bird species in ephemeral islands in the Amazon basin have been noted to occur in densities an order of magnitude higher than those found in communities on the mainland (Remsen & Parker, 1983). Our observations suggest high densities of migratory songbirds occupying ephemeral river islands in the Meta River in comparison to the mainland.

The Orinoco Plains and the Amazon are adjacent regions, and while they share some avian species, they also differ, largely because the Orinoco has extensive areas of grasslands surrounded by riparian forest, while the Amazon is largely forested. Although these two

regions have similar phenological dynamics of precipitation (e.g., Silva et al., 2021), habitat differences influence the type of resources available and thus the species that inhabit those areas. Indeed, the migratory species that we reported in the Meta River prefer to forage over grasslands or in riparian habitats when on their nonbreeding grounds. In contrast, seasonally flooded islands in the Brazilian Amazon have been found to be important roosting sites for the Purple Martin (*Progne subis*; a species not observed in Orocue) (Fraser et al., 2017; Santos et al., 2021), with one island on the Rio Negro hosting over 250,000 roosting individuals between February and April (Grossman, 2022).

During expeditions to the Meta River's ephemeral islands, we also confirmed migratory and nonmigratory Fork-tailed Flycatchers, identified based on characteristics in Pyle (1997). Some populations, like *Tyrannus savana monachus* in eastern Colombia, are nonmigratory, while *T. s. savana* is an Austral-Neotropical migratory group. eBird data for Casanare show year-round presence peaking during migration and the rainy season (Figure 3B,C). Occasionally, nonmigratory individuals with juvenile characteristics joined migratory flocks, but adults were mostly in savannas away from the river suggesting segregation in roost site use. Barn Swallows also exhibit intra-population co-occurrence in April, with boreal and austral breeding populations likely coexisting in eastern Colombia as boreal migrants return northward and austral migrants depart for equatorial latitudes (Winkler et al., 2017).

Speciation in birds appears to happen most commonly through an initial stage of geographic isolation that leads to evolutionary changes resulting in reproductive isolation, followed by range expansion which occasionally leads to secondary contact and further differentiation (Price, 2008). However, Fork-tailed Flycatchers and Barn Swallows are diverging with populations co-occurring geographically during part of the year providing potential overlap for breeding to occur. This highlights the importance of understanding the mechanisms leading to switches in migratory behavior and those that govern the timing of other life history events such as reproduction and molting.

In summary, we found that thousands of migratory songbirds that breed in the northern and southern hemispheres co-occur in high densities on ephemeral river islands of the Meta River. Additionally, we found that island flood dynamics are synchronized with the boreal (spring) and austral (fall) migrations. How this ecological association evolved, how tight it is, and the spatial-temporal dynamics remain to be tested. Moreover, how migratory songbirds find and select the islands on which they will roost is an intriguing question given that

each year the geomorphology of the river changes. Do they select islands that have fewer ground predators, for example? What are the consequences, both positive and negative, of inter and intraspecies co-occurrence on the individuals and populations using the islands (e.g., competition for resources, disease transmission, speciation)? How dependent are they on the resources that these islands provide at the population and species level? What is the relative importance of these islands compared with other habitats on the landscape given ongoing landscape change? Finally, given the decline of North American migratory aerial insectivorous and other birds (Spiller & Dettmers, 2019), should protecting ephemeral islands of the Meta River be a conservation priority? We suggest that conservation measures covering the thousands of hectares of islands likely require a more holistic view of the Meta River—and other rivers like it—with their dynamic phenology and geomorphology.

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## CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

## DATA AVAILABILITY STATEMENT

Data (Gomez-Bahamon, 2024) are available in figshare at <https://doi.org/10.6084/m9.figshare.25715292.v1>.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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