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Prey consumed by wading birds in mangrove swamps of the Caribbean coast of Colombia

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ABSTRACT

The diet composition of wading birds was studied in mangrove swamps of the north western Caribbean coast of Colombia during the non-breeding season for Little Blue Heron (*Egretta caerulea*), Tricolored Heron (*Egretta tricolor*) and Snowy Egret (*Egretta thula*), and during the breeding season for Agami Heron (*Agamia agami*), Cocoi Heron (*Ardea cocoi*), Boat-billed Heron (*Cochlearius cochlearius*) and Bare-throated Tiger-Heron (*Tigrisoma mexicanum*). One-hundred and thirty-two birds were captured, and 32 regurgitations and nine stomach samples were collected. Except for Little Blue Heron, these species ate mostly small fish. Representatives of Poecilidae, *Gambusia* sp. and *Poecilia* sp., were the most important prey taken by Snowy Egret and Tricolored Heron, with significant differences in the weight, and standard length of *Gambusia* sp. consumed by both birds, as well as in the weight of *Poecilia* sp. The other five wading bird species were poorly represented on our samples, but never the less contribute to first records of their diet. The known diet of all species is briefly reviewed.

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Introduction

Owing to their interactions with other organisms, wading birds and other waterbirds can provide indirect benefits for humans and have a positive effect on biodiversity in general, e.g., by regulating fish populations or by cycling nutrients (Green and Elmberg 2014). Likewise, wading birds are among the most visible of wetland species and, occurr in all continents (except Antarctica). They have been the subject of much intensive research (Hafner 1997; Ducommun et al. 2010; Boyle et al. 2012). According to Kushlan (1992), wading birds have proven to be useful in addressing several biological questions of trophic ecology because of the ease of obtaining regurgitated food samples; for example, it is possible to determine how the food abundance and availability influence the niche relations of wading birds (Kushlan et al. 1985). However, the diets of species in the Neotropics are poorly known, particularly in mangrove forests (e.g., Ramo and Busto 1993).

The diets of Tricolored Heron (*Egretta tricolor*), Little Blue Heron (*Egretta caerulea*) and Snowy Egret (*Egretta thula*) have been widely studied in North America (e.g., Kushlan

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1973; Willard 1977; Itzkowitz 1984; Kent 1986). However, there remains a knowledge gap for these widely distributed species, in their South American range, as well as for species that occur exclusively in the Neotropical region such as Cocoi Heron (*Ardea cocoi*), Agami Heron (*Agamia agami*), Bare-throated Tiger-Heron (*Tigrisoma mexicanum*) and Boat-billed Heron (*Cochlearius cochlearius*). Olivares (1973) was the first to focus on describing the natural history of wading birds in Colombia, including their feeding behaviour. Subsequently, few studies on these birds have been conducted (e.g., Lehmann 1959; Borrero and Cruz-Millán 1982; Alfaro and Russi 1986; Rodríguez-Barrios and Troncoso 2006; Olivero-Verbel et al. 2013). Information on the diet of wading birds in coastal sites is scant, and only González and Patiño (1989) have documented prey consumed by nestlings of these species of birds at coastal and inland sites in Colombia.

On the Caribbean coast of Colombia, mangrove swamps are decreasing mainly due to the change in land use (Gómez-Cubillos et al. 2014). On this coast, the Sinú River deltaic estuary hosts the best-conserved mangrove forest of northern Colombia (Cortés-Castillo and Rangel 2011), which serves as habitat for 334 bird species, including 29 wading birds (Estela and López-Victoria 2005). Considering wading birds play important roles in this ecosystem, they can provide useful information on interactions occurring within food webs, and therefore nutrient cycling. Such understanding becomes ever more relevant since these species are close to human settlements and thus subject to anthropic pressure (Crozier and Gawlik 2003). Moreover, ensuring the knowledge of their dietary requirements will help in determining if there could be a conflict with humans or human activities in the estuary (Ruiz-Guerra and Echeverry-Galvis in prep.).

Considering global change scenarios, information on prey consumed by wading birds could be useful in understanding how changes, such as an increase in sea level and variable precipitation could potentially introduce variation in reproductive performance by limiting wading bird access to feeding areas (Kushlan 1986; Frederick and Collopy 1989; Bildstein et al. 1990), with shifts in the timing and availability of wading bird prey (Butler et al. 1998). In this paper, we document the diet composition of wading bird species in mangrove swamps of the northwestern Caribbean coast of Colombia: Tricolored Heron, Little Blue Heron, Snowy Egret, Agami Heron, Cocoi Heron, Bare-throated Tiger-Heron and Boat-billed Heron. We describe the species' diets, determine if there was a size or weight selection for prey and evaluate how much overlap there was in terms of content and importance among species. We also present a brief review of the known diet of these species.

Material and methods

Fieldwork was conducted at the Important Bird Area (IBA) Zona deltaico-estuarina del Río Sinú, located on the north-western Caribbean coast of Colombia, including the Sinú River deltaic estuary (SRDE) (Figure 1). The SRDE has a mangrove forest of about 86 km^2 comprised of four species of mangrove: Red (*Rhizophora mangle*), Black (*Avicenia germinans*), White (*Laguncularia racemosa*) and Tea (*Pelliciera rhizophorae*).

Data were collected at four mangrove swamps where wading birds congregate, such as a nocturnal roost site, a breeding colony of one or several species and isolated nests of individual species. Ciénaga Galo (9° 22′ 8.87″ N, 75° 49′ 40.01′ W) is a swamp with a mangrove island of 2610 m^2 that is used all year round as a nocturnal roost site by

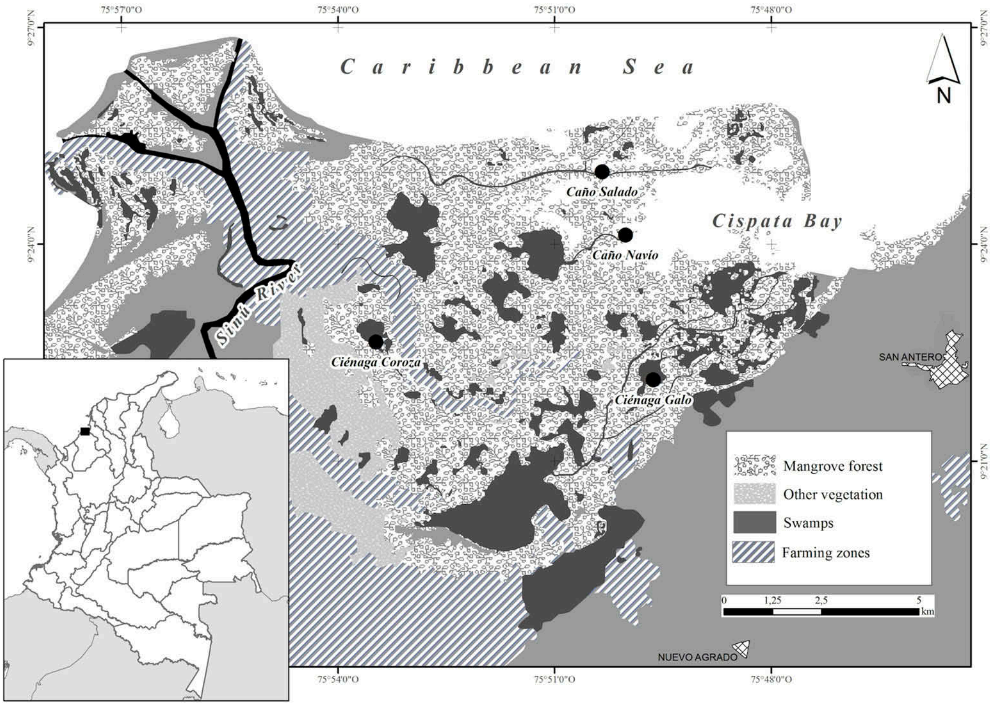

Figure 1. Map of the study area, the Sinú River deltaic estuary, black dots show sites where individual wading birds were captured.

Snowy Egret, Tricolored Heron, Little Blue Heron, Cattle Egret (*Bubulcus ibis*), Great Egret (Ardea alba), Striated Heron (*Butorides striata*), White Ibis (*Eudocimus albus*), Neotropical Cormorant (*Phalacrocorax brasilianus*) and Great-tailed Grackle (*Quiscalus mexicanus*). Ciénaga Coroza (9° 22′ 39.60″ N, 75° 53′ 29.65″W), is mostly a swamp with a mangrove island of 4,130 m^2 where Agami Heron, Boat-billed Heron, Cattle Egret, Great Egret, Tricolored Heron, Snowy Egret, Black-crowned Night-Heron (*Nycticorax nycticorax*), Yellow-crowned Night-Heron (*Nyctanassa violacea*), White Ibis and Neotropical Cormorant breed between July and November. Caño Navío (9° 24′ 12.53″ N, 75° 51′ 16.50″ W) is a tidal creek of 1,923 m in length where Cocoi Heron breeds from June to October. In addition, Caño Salado (9° 25′ 0.13″ N, 75° 50′ 23.52″ W), also a tidal creek of 6,441 m in length, is used as a breeding area by Bare-throated Tiger-Heron and Common Black-Hawk (*Buteogallus anthracinus*) from May to December.

The SRDE has a pluviometric unimodal regime with a dry period from December to April, a transitional period in May-July, and a rainy period (August-November); the average yearly temperature is 27°C (Barreto et al. 1999). Crops and animal husbandry are the most important economic activities, but artisanal fishing and mangrove harvesting are also important for human communities living nearby (CAR de Los Valles del Sinú y del San Jorge and INVEMAR 2010).

We collected regurgitates and/or stomach contents from Snowy Egret, Tricolored Heron, and Little Blue Heron, from roosting sites, while samples were gathered from nests of Agami Heron and regurgitations of Boat-billed Heron in September and October, Cocoi Heron in October, and Bare-throated Tiger-Heron from May to October. Of the 29 species of wading birds occurring at the SRDE, the species studied were: a nocturnal predator, Boat-billed Heron, two poorly known solitary predators, Agami Heron, and Bare-throated Tiger-Heron, and four sociable wading birds: Tricolored Heron, Little Blue Heron, Cocoi Heron, and Snowy Egret. The latter four species are the most abundant herons at the mangrove swamps (Estela and López-Victoria 2005). Care was taken to not sample the same individual more than once by marking the boat routes each night.

We captured 63 adult Snowy Egrets, 57 adult Tricolored Herons, and two juvenile Little Blue Herons, at the roost located in Ciénaga Galo. Our trapping period was of four nights with captures every other day per month for May, June, September, October and December 2015, focusing on adult individuals that were not breeding at the time of sampling. Birds were caught between 18:00 and 21:00 while they slept using flashlights. After sunset when the birds arrived at their roost, a team of three persons used a small boat to approach the roost site paddling quietly; then two persons disembarked to grab individuals from branches and roots of the mangrove trees and placed them in cloth bags for transportation. The person who stayed on the boat was in charge of receiving every cloth bags and making sure that each bird trapped do not hurt itself or do not scape. The birds were taken to INVEMAR (Instituto de Investigaciones Marinas y Costeras) facilities located about 3 km from Ciénaga Galo. Once individuals regurgitated, the contents were collected, and the birds were released close to their capture site on the same night of their capture. Regurgitations deposited in the transport cloth bag were preserved in 70% ethanol for later analysis. We also collected nine stomach contents of birds that were injured and were sacrificed through thoracic compression. For each of these samples, whether regurgitation or stomach content, we counted the number of identifiable prey items, and measured them (see below).

We visited Ciénaga Coroza every second day during six days from September to October 2015, during the beginning of the breeding season of Agami Heron and Boat-billed Heron. We captured four nestlings of Agami Heron and four nestlings of Boat-billed Heron by hand, but only one Boat-billed Heron regurgitated its prey. Therefore, we looked for prey regurgitated in the nests, but most of them were too digested. In October 2015, we found a colony of Cocoi Heron in Caño Navío where nests were located too high (10 m) in mangrove trees to examine. However, we collected prey found on roots and floating on the water after an attack of Capuchin monkey (*Cebus capucinus*) on the nests. From May to October 2015, we looked for nests of Bare-throated Tiger-Heron with nestlings at Caño Salado, where we captured two nestlings from two nests by hand.

Recognisable food items from all samples were identified and classified to genus or species, depending on the level of decomposition. All prey were counted and weighed with an Ohaus Scout ® SP202 analytical scale (accuracy of 0.01 g). We measured fish from the tip of the snout to the posterior end of the last vertebra (standard length). Even though most of the identifiable prey items were partially digested, we used only samples in which these measurements could be performed taking into account the integrity of the food item.

Diet was analysed by calculating for each prey taxon: the percentage frequency of occurrence (%FO), percentage weight (%W) and percentage number of organisms (%N) (Hyslop 1980). An index of relative importance (IRI) (Pinkas et al. 1971) was also used to determine the most important food items. The index of relative importance (IRI) was calculated for all the prey items using the formula:

$$\mathrm{IRI} = (\%\mathrm{N} + \%\mathrm{W}) \times \%\mathrm{FO}$$

We used ANOVA to assess differences among standard length and weight of items consumed by different bird species to compare prey selectivity. We performed normality tests prior to the ANOVA, as well as Tukey tests for post hoc comparisons, all using INFO STAT software. When data transformations failed to achieve normality, measurements were analysed using Kruskal-Wallis or Mann-Whitney-Wilcoxon tests, respondingly. Significance was determined at an alpha level of 0.05.

We also evaluated diet overlap among species with big samples following Schoener (1970):

$$= 1 - \left(\tfrac{1}{2}\right) \sum_{i=1}^{s} \left| P_{ij} - P_{ik} \right|$$

In which s is the number of species type, P_{ij} and P_{ik} are relative abundance of prey i in species i and k. Values ≥ 0.6 indicate significant overlap and possible competition, if resources were limited (Martin 1984).

Results

One-hundred thirty-two individuals were captured, and we obtained nine stomach contents and 32 regurgitations. The most frequently captured species were Snowy Egrets and Tricolored Herons (Table 1).

Four groups of preys were identified in the regurgitations and stomach contents: spiders (Aracnida), insects (Insecta), crustaceans (Malacostraca) and fishes (Actinopterygii). The preys for the seven species of wading birds combined were 85% fish, 14% crustaceans, 0.4% insects and 0.4% spiders. Items taken by Snowy Egret consisted of 213 fishes, 61 isopods (Isopoda) and two dragonflies (Aeshnidae); items taken by Tricolored Heron were composed of 338 fishes, 13 isopods (Isopoda), three mangrove Tree crabs (*Aratus pisonii*) and one dragonfly (Aeshnidae). The two stomach contents of nestlings of Bare-throated Tiger-Heron had two eleotrids (*Dormitator* sp.)

Table 1. Number and species of wading birds captured. Asterisks show species that were captured during the breeding season. 'a' indicates samples collected on nests, ground, roots or branches.

Species	Captured individuals	Individuals that regurgitated	Stomach contents
Agami Heron*[a]	4	0	0
Boat-billed Heron*	4	1	0
Little Blue Heron	2	1	0
Tricolored Heron	57	17	4
Snowy Egret	63	13	4
Bare-throated Tiger-Heron*	2	0	1
Cocoi Heron*[a]	0	0	0
Total	132	32	9

and one shrimp (*Litopenaeus* sp.); as a new report for prey items for this species. We identified eight eleotrids (*Dormitator* sp.) from the Agami Heron nests; nine eleotrids (*Dormitator* sp.) and one anchoveta (*Centengraulis* sp.) were found on tree branches and roots under nests of Cocoi Heron, and a chick of Boat-billed Heron regurgitated 20 recognisable guppies (*Poecilia* sp.). The only bird where no fish was found was the Little Blue Heron whose samples included two spiders (Trachaleidae) and around 20 isopods (Isopoda).

Representatives of Poecilidae, mosquito fish (*Gambusia* sp.) and guppies (*Poecilia* sp.), and one eleotrid (*Dormitator* sp.) were shared by four water bird species: Snowy Egret, Tricolored Heron, Agami Heron, and Cocoi Heron. Whereas a rivuline (*Kryptolebias* sp.), was only taken by Snowy Egret and Tricolored Heron. The anchovies (*Anchoa* sp.) and anchovetas (*Centengraulis* sp.), of Engraulidae, were each taken by only one species, Snowy Egret and Cocoi Heron, respectively.

Even though the total sample of fishes in the diet was 584 individuals, standard length was only recorded for 200 fishes and ranged 10.59 mm to 81.11 mm, with a mean of 29.74 mm. When comparing the standard length to total length, by pair fish taxa, there was a significant difference among taxa ($n = 394$; $F = 29.08$, $df = 1$ $P = 0.001$). We found a significant different among the weight and standard length of fish eaten by adults and nestlings ($P = 0.001$).

Guppies comprised 70.7% of the 594 fishes found in all the samples, followed by mosquito fishes (14.6%), eleotrids (6.6%), and rivulines (5.6%) while anchovies and unidentified fishes ranked at 1% or lower. For Snowy Egret, whose samples were abundant, guppies, eleotrids, and isopods were the most important food source according to the IRI, whereas guppies and gambusias were key resources for Tricolored Heron (Table 2). The average weight for 570 samples was 0.65 g ranging from 0.01 g to 17.13 g.

We compared standard length and weight of guppies for Snowy Egret and Tricolored Heron (Table 3). There was a significant difference for weight of guppies eaten by Snowy Egret and Tricolored Heron ($F = 24.68$, $df = 1$, $P = 0.001$), but not for standard length ($F = 0.18$, $df = 1$ $P = 0.67$). There was also a significant difference in the weight of mosquito fishes eaten by both bird species (Kruskal Wallis; $H = 5.13$, $P = 0.023$); as well as standard lengths of this prey item ($F = 4.72$, $df = 1$ $P = 0.041$). However, this may be due to the small number of samples of mosquito fishes available from Snowy Egrets ($N = 4$, Table 3). Regarding eleotrids taken by both wading bird species, no difference was

Table 2. Prey composition of regurgitations from Snowy Egrets and Tricolored Herons, captured using percentage values of the number (N), weight (W), frequency of occurrence (FO) and index of relative importance (IRI).

		Snowy Egret (N = 17)				Tricolored Heron (N = 21)			
Item		%FO	%N	%W	%IRI	%FO	%N	%W	%IRI
Poecilidae	Guppies	64.71	57.97	55.99	76.22	85.71	67.61	77.90	86.08
	Gambusias	23.53	1.81	0.11	0.69	52.38	23.10	5.65	10.39
Engraulidae	Anchovies	11.76	2.90	7.59	1.32	-	-	-	-
Eleotridae	Eleotrids	35.29	5.43	33.39	15.74	19.05	1.41	13.07	1.90
Rivulidae	Rivulines	11.76	8.70	1.91	1.33	28.57	2.54	2.59	1.01
	Unidentified fishes	5.88	0.36	0.67	0.06	4.76	0.56	0.33	0.03
Aeshnidae	Dragonflies	11.76	0.72	0.01	0.09	4.76	0.28	0.01	0.01
Isopoda	Isopods	17.65	22.10	0.03	4.54	19.05	3.66	0.46	0.54
Grapsidae	Mangrove tree Crabs	-	-	-	-	4.76	0.85	0.01	0.03

Table 3. Mean weight (g) and length (mm) of fish genera found in regurgitates and stomach contents of birds. 'a' indicates a significant difference ($P < 0.05$) between ardeid species.

Sp	Measurements	Anchoveta	*n*	Anchovies	*n*	Eleotrids	*n*	Gambusias	*n*	Rivulines	*n*	Guppies	*n*
Snowy Egret	Weight $\bar{x}$ (Min-Max)			1.41 (0.09–1.77)	8	3.60 (0.56–16.98)	15	0.36[a] (0.07–0.86)	4	0.12 (0.05–0.21)	24	0.51[a] (0.05–1.76)	156
	Standard Length $\bar{x}$ (Min-Max)			42.35 (24.90–59.80)	2	49.15 (28.86–81.11)	6	25.66[a] (19.68–34.41)	3		0	29.84 (15.53–43.51)	83
	Total Length $\bar{x}$ (Min-Max)			69.40	1	62.19 (35.37–101.22)	5	30.89[a] (24.4–41.37)	3		0	35.72 (20.29–54.12)	80
Tricolored Heron	Weight $\bar{x}$ (Min-Max)				0	3.21 (1.07–5.57)	5	0.09 (0.01–0.49)	79	0.35 (0.15–0.70)	9	0.40 (0.01–2.14)	240
	Standard Length $\bar{x}$ (Min-Max)				0	39.98 (32.92–51.30)	3	17.83 (10.59–28.72)	21	32.00 (31.60–32.40)	2	28.23 (15.90–47.35)	66
	Total Length $\bar{x}$ (Min-Max)				0	52.07 (39.64–72.20)	3	21.38 (13.00–33.97)	22	40.50 (39.40–41.60)	2	33.49 (18.30–53.59)	64
	Weight $\bar{x}$ (Min-Max)											1.10 (0.10–2.39)	20
Boat-billed Heron	Standard Length $\bar{x}$ (Min-Max)											37.08 (22.56–47.34)	11
	Total Length $\bar{x}$ (Min-Max)											45.34 (28.76–55.1)	11
	Weight $\bar{x}$ (Min-Max)	8.21	1			8,79 (6.79–12.53)	3						
Cocoi Heron	Standard Length $\bar{x}$ (Min-Max)					64.16	1						
	Total Length $\bar{x}$ (Min-Max)					76.70	1						
	Weight $\bar{x}$ (Min-Max)					5.46 (5.35–5.57)	2						
Bare-throated Heron	Standard Length $\bar{x}$ (Min-Max)					60.49(60.39–60.58)	2						
	Total Length $\bar{x}$ (Min-Max)					65.88	1						
Agami Heron	Weight $\bar{x}$ (Min-Max)					17.13	1						

Sp: species

found in the items consumed (weight F = 0.13, df = 1, P = 0.7; standard length F = 0.36, df = 1, P = 0.6). The diet overlap observed by Schoener's index was of 68% between Tricolored Heron and Snowy Egret.

Discussion

We were able to explore the diet of seven species of wading birds at the SRDE, with *Poecilia* sp. as the most common prey, followed by *Gambusia* sp.; even in small samples for some egret species. The weight of *Gambusia* sp. and *Poecilia* sp., as well as the standard length for *Gambusia* sp., differed between Snowy Egret and Tricolored Heron. Samples were too difficult to obtain for Agami Heron and Bare-throated leaving them still the most poorly known wading birds in the area and in general in the Neotropic for their diet (Kushlan 1992). Our samples were obtained from non-breeding adults, especially Snowy Egret and Tricolored Heron, and thus differ from previous studies, which focus on regurgitated items during the breeding season (Kushlan 1992). Hafner (1997) suggests it is essential to understand the ecological requirements of wading birds outside the breeding period since they provide the key to many questions concerning the dynamics of population control or natural selection, but also to encompass such population studies in light natural ensembles. Unfortunately, inter-species comparisons were not possible for all heron species studied, which calls for a continuing effort to increase our studies on these species.

Review of diet studies

Little Blue Heron

Rodgers and Smith (2012) consider this heron an opportunist; taking a variety of small fish, small amphibians, and invertebrates, mainly crustaceans including isopods (*Ligia* sp.). Miranda and Collazo (1997) found that seven Little Blue Herons ate exclusively crabs (*Uca* spp.) in mangrove swamps in Brazil; but Gianuca et al. (2012), using nestling regurgitates, reported shrimp was the most important item of Little Blue Heron diet but they also ate mullet (*Mugil* sp.), and members of the family Characidae (*Astyanax* sp., *Cheirodon* sp. *Hyphessobrycon* sp.), and crabs in an estuary in Brazil. Olmos et al. (2001) also considered the Little Blue Heron a specialist carcinophage during the breeding season in mangrove swamps of Puerto Rico. In Venezuela, Marín et al. (2003) found only shrimps (*Penaeus* sp.) in stomachs collected, and Kushlan et al. (1985) reported fishes and insects were consumed in the Llanos. In Panama, Wetmore (1981) reported this heron takes mole crabs (Decapoda). Throughout its range in North America, Little Blue Herons capture small fish such as anchovies (*Anchoa* spp.), Mosquitofish (*Gambusia affinis*), Sailfin molly (*Poecilia latipinna*), and invertebrates like crayfish (Cambarinae), grass shrimps (*Palaemonetes* spp.), crabs (*Sesarma, Aratus, Callinectes, Menippe*), insects (Coleoptera, Hemiptera, Odonata, Orthoptera, Diptera, Neuroptera) and amphibians (*Rana* spp. and *Hyla* spp.) (Kent 1986; Smith 1997; Rodgers and Smith 2012). This led some authors (e.g., Jenni 1969; Rodgers 1983; Master et al. 1993) to conclude that Little Blue Heron is a generalist.

At the SRDE, Little Blue Herons are a common and abundant bird inhabiting mangrove swamps and other habitats, such as rice fields and freshwater wetlands, so it would be likely that this heron could have a variety of prey. However, more information must be collected, including comparisons between rainy and dry periods, and from their breeding colony location, which is yet to be found at the study site, to understand the comprehensive requirements of this species in the area.

Cocoi Heron

Our data from the breeding season at SRDE showed that nestling diet includes fish, similar to what was found in other locations of the Caribbean coast of Colombia, such as Ciénaga de Lorica in Córdoba department in October (Borrero and Cruz-Millán 1982). In other areas, like Isla de Salamanca National Park (Colombia), blue land crab (*Cardiosoma guainumi*) and a carcase of a Northern raccoon (*Procyon lotor*) and crab-eating raccoon (*Procyon cancrivorus*) were found in their stomach contents (Borrero and Cruz-Millán 1982). According to Ducommun et al. (2010), Cocoi Herons took mainly fish including the streaked prochilod (*Prochilodus lineatus*) and trahira (*Hoplias malabaricus*), as well as mammals and amphibians in the valley of the Paraná River, Argentina. In colonies of the Brazilian coastal plains, Cocoi Herons are known to eat fish such as white mouth croaker (*Micropogonias furnieri*), trahira (*H. malabaricus*) and pale catfish (*Rhamdia quelen*), crustaceans as blue crab (*Callinectes* sp.), beetles (Coleoptera), reptiles like the yellow-bellied liophis (*Erythrolamprus poecilogyrus*) and rodents (Faria et al. 2016). Marín et al. (2003) reported only Mozambique tilapia (*Oreochromis mossambicus*) as prey of this heron. Unfortunately, we were not able to capture individuals of this heron, since it nested in mangrove trees higher than 10 metres and only heavily digested prey were found on roots. This colony was found accidentally in October 2015, when a few nests with nestlings remained after an attack by Capuchin monkeys (*Cebus capucinus*).

Agami Heron

According to Willard (1985), this heron took prey from 2 to 10 cm, and 52 percent of them were Characidae, particularly dusky narrow hatchetfish (*Triportheus angulatus*) and *Astyanax* sp., at Manu National Park, Perú. This heron also takes Cichlids (*Aequidens*), but not much more is known about its prey (Stier and Kushlan 2015). At the Pacuare Nature Reserve, Costa Rica, food included small (1–2 cm) fish and other items too small to identify, likely including water striders (Gerridae) (Kushlan and Hines 2016).

At the SRDE, we found mainly eleotrids (*Dormitator* sp.), but more information is needed before we can assess how much each food item contributes to the heron's diet. Nestlings did not regurgitate when handled and diet samples were thus found on the ground. A probe with saline solution (Calver and Porter 1986) was also used, but it did not work, and no further manipulation was done.

Boat-billed Heron

In the Llanos region of Colombia, González and Patiño (1989) reported Boat-billed Heron ate mainly atipa (*Hoplosternum littorale*), marbled swamp eel (*Symbranchus marmoratus*) and trahira (*H. malabaricus*). On the Pacific coast of Guatemala, Biderman and Dickerman (1978) examined stomach contents of adult Boat-billed Herons and found fish, such as Pacific fat sleeper (*Dormitator latifrons*), Pacific molly (*Poecilia butleri*) and blue sea catfish (*Ariopsis guatemalensis*); along with white leg shrimp (*Litopenaeus vannamei*) and fresh-water prawn (*Macrobrachium tenellum*).

In Mexico, nestlings were fed white leg shrimp (*L. vannamei*) and prawns, catfish (Ariidae sp.), and a variety of fish like the yellowfin snook (*Centropomus robalito*), spotter sleeper (*Eleotris picta*), smoothbelly goby (*Sicydium gymnogaster*), sheepshead minnow (*Cyprinodon variegatus*), and redfin needlefish (*Strongylura notata*); while adults took shrimp and the Pacific fat sleeper (*D. latifrons*), Palenque priapella (*Priapella compressa*) (Tashian 1952; Dickerman and Juarez 1971; Mock 1975; Ramo and Busto 1993). In Panama, adults consumed shrimps, and freshwater prawns and nestlings were fed marbled swamp eel (*S. marmoratus*) (Wetmore 1981). As an oddity, in Surinam, adults ate ants (Formicidae), and nestling diet included fish like yellowfin snooks (*C. robalito*) and trahiras (*H. malabaricus*) (Haverschmidt 1969). At our study site, we found only guppies; however, given this is a nocturnal hunter, other methods might be needed to better assess its diet.

Snowy Egret and Tricolored Heron

In mangrove swamps of the SRDE, food habits of adult Tricolored Herons and Snowy Egrets were similar, with the most important prey being guppies. In July 2016, Tricolored Heron nests were first found in Ciénaga Coroza, and guppies were found in one nest with nestlings, but these data were not included in the analysis. In Cartagena (Caribbean coast of Colombia), nestlings of Snowy Egrets and Tricolored Herons regurgitated both poecilids (*Poecilia caucana*) and juveniles of Parassi mullet (*M. incilis*); along with shrimps (González and Patiño 1989). In the Llanos of Casanare, blanquitos (*Curimata* sp.), atipa (*H. littorale*) and insects are part of their diet (González and Patiño 1989). In Venezuela, Marín et al. (2003) found Snowy Egret ate crabs (*Uca* sp.), shrimps (*Penaeus* sp.) and fish such as pupfish (*Cyprinodon dearborni*) and Mozambique tilapia (*O. mossambicus*), whereas Tricolored Herons took pupfish (*C. dearborni*), shrimps (*Penaeus* sp.) and Mozambique tilapia (*O. mossambicus*); likewise, in the Venezuelan Llanos, Snowy Egrets consumed deep-bodied (*Markiana nigripinnis*) and compressed-bodied (*Ctenobrycon spirulus*) characins, Blanquito (*Curimata* sp.), insects and crustaceans (Kushlan et al. 1985).

In Brazil, the items of greatest relative importance for Snowy Egret were shrimp, Poecilidae and Hemiptera (Gerridae), and for Tricolored Heron were Poecilidae, Centropomidae, and Gobidae (Miranda and Collazo 1997). Nestlings of Snowy Egrets in Cuba were fed with fish, crustaceans, insects, and amphibians, but Tricolored Heron nestlings were fed only fishes of 18–30 mm in length (Denis 2006). In Puerto Rico, killifish (*Fundulus* sp.) is part of the diet of Tricolored Heron (Palmer 1962), with small-bodied fish, topminnows and killifishes being the most common food items of the Snowy Egret and Tricolored Heron in the U.S. (Frederick 1997). This coincides with fishes taken by these species at the SRDE, such as Gambusia, Poecilia, and Anchoa (Kushlan 1973; Kent 1986; Parsons and Master 2000; Boyle et al. 2012). Smith (1997) reported nestlings of Snowy Egret were fed on introduced fish species, whereas Tricolored Heron nestlings were fed only native fish ranging from 1.8 to 3.0 cm (Kent 1986). But their diet also including amphibians, shrimp, crayfish, spiders and insects. Ramo and Busto (1993) reported fish were the most central component of the diet of nestlings of Snowy Egret and Tricolored Heron in Mexico, especially sheepshead minnow (*C. variegatus*) and mangrove molly (*Poecilia orri*).

Even though few samples were obtained from some species in our study, we suggest that small size fish are the most important item for wading birds in this delta-estuary, during the non-breeding season, followed by crustaceans. The Schoener Index indicates a diet overlap between the two most abundant species during their non-breeding season. This overlap is based on Snowy Egret and Tricolored Heron sharing Poecilidae regardless of their length; however, prey weight did differ between both ardeids. While our results revealed Tricolored Heron and Snowy Egret concentrate on guppies, it is necessary to determine if this is the case during the breeding season, emphasising that both species breed between July and November at the study area. Both species use the same nocturnal roosting site, Ciénaga Galo likely where both Neotropical migratory populations and breeding population of these birds are together. The evidence of the occurrence of migrant individuals of Snowy Egret is based on one bird banded in Virginia (U.S.), which was found at t the Sinú River deltaic estuary in 1975 (Ruiz-Guerra in prep.) suggesting overwintering and resident Snowy Egret overlap at the SRDE.

A significant knowledge gap for various Neotropical species remains, but this work contributes to filling that gap. We encourage others to engage in research into these wading birds in Neotropical mangrove swamps to contribute to conservation strategies currently underway in this ecosystem, following a full cycle approach. According to Butler and Vennesland (2000), considering that wading birds deal with the cumulative impact of global change and human population growth, we require information on how their habitats may sustain populations. Likewise, since the leading causes of population fluctuations of wading birds are generally not related to shortages of nesting or foraging habitat, but instead are the result of food availability (Butler 1994). Efforts could include, but not be limited to, information on prey availability and density, seasonal fluctuation, interactions between components of this heavily degraded habitats, and specifically, in the case of Neotropical swamps, include the dynamic relationship between the ecological and the human components.

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No potential conflict of interest was reported by the authors.

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