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## Diet of Black-crowned Night-herons (*Nycticorax nycticorax*) in a Wetland of the Parana River's Alluvial Valley

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### Abstract

We analysed the feeding ecology of *Nycticorax nycticorax* based on forty individuals captured on the Carabajal Island (Santa Fe, 31°39'S, 60°42'W), determining the minimum sample, index of relative importance (IRI), size of prey, feeding efficiency, dietary selectivity, amplitude of the trophic niche, circadian rhythm of feeding activity, and habitat preference. The trophic spectrum was made up of 16 taxonomic entities, mainly fishes (IRI= 9.100), followed by insects (IRI= 1.650), and crustaceans (IRI= 600). The highest percentage of prey size was found in the range of 61-80 mm. The amplitude of the trophic niche ranged between 2.55 and 5.22, and the feeding efficiency between 92.3% and 99%. In relation to dietary selectivity, the correlation between abundance of prey in stomachs and abundance of prey in the study area yielded significant results ( $r = 0.41$ ,  $P > 0.001$ ). The rhythm of feeding activity showed high activity very early in the morning, decreasing towards noon, and increasing again at dusk. Grasslands and Aquatic vegetation were units of vegetation and environment selected more frequently.

**Keywords:** *Nycticorax nycticorax*, feeding ecology, wetlands, Paraná River.

### Siyah Taçlı Gece Balıkçılığının (*Nycticorax nycticorax*) Parana Nehri'nin Aluvyal Vadisindeki Sulak Alanda Beslenmesinin Araştırılması

#### Özet

*Nycticorax nycticorax*'ın beslenme ekolojisi Carabajal Adası'ndan (Santa Fe, 31°32' S, 60°42' W) yakalanan 40 bireye dayalı olarak incelenmiştir. Minimum örnek, bağıl önem indeksi (IRI), yem boyutu, beslenme randımanı, diyet seçiciliği, trofik niş amplitüdü, beslenme aktivitesinin sirkadyen ritmi ve habitat tercihi tespit edilmiştir. Trofik spektrum 16 taksonomik entiteden oluşmaktadır. Önce balıklar (IRI=9.100), sonra böcekler (IRI=1.650) ve kabuklular (IRI=600) gelmektedir. Yem boyutu en fazla 61-80 mm aralığındadır. Trofik niş amplitüdü 2.55-5.22 aralığında, beslenme randımanı %92,3-%99 aralığındadır. Diyet seçiciliğiyle ilgili olarak yemin midedeki ve araştırma alanındaki bulunma bolluğu arasındaki korelasyon önemli bulunmuştur ( $r=0,41$ ,  $P>0,001$ ). Beslenme aktivitesinin ritmi sabahın erken saatlerinde yüksek olup, öğleye doğru azalmakta ve akşam vakti tekrar yükselmektedir. Vegetasyon ve çevre olarak en fazla çayırlar ve sulcul vejetasyon tercih edilmiştir.

**Anahtar Kelimeler:** Besleme ekolojisi, *Nycticorax nycticorax*, Parana Nehri, Sulak alan.

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### INTRODUCTION

Wetlands are high biodiversity areas constantly modified by human activities like urbanization, cattle ranching, and agriculture are the reasons why they are highly susceptible (Cooperrider and Noss 1994). Large wetlands are usually protected, but middle sized and small ones are still unmanaged and both are of high importance for large quantities of resident and migratory waterbirds (Perez-Arteaga et al. 2005). Avifauna is an important component of aquatic systems all over the world and they may be considered as indicators of the water bodies' quality,

productivity, structure, and function. Birds are outstanding consumers within this type of ecosystems (Martinez 1993), playing a key role in the transfer of energy from aquatic to terrestrial systems. Herons, as other birds, can obtain their food from different environmental units within the aquatic system by means of the spatial differential use of the environment or ecospace (Pianka 1982, Dobzhansky et al. 1983, Martinez 1993).

Community structure is usually established from how food is distributed among species coexisting in a particular place, thus turning food

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into a critical resource (Wiens 1989). As the wetlands' productivity is usually higher than that of terrestrial systems, there is enough evidence to support those birds with similar morphologies and ecological demands differentiate their niches to coexist (Pianka 1973, Yanosky et al. 2000). In other words, small shifts in the temporal or spatial scale of the trophic niche may allow some species to survive in a certain place.

The Black-crowned Night-herons (*Nycticorax nycticorax*) compose a monospecific genus of generalist predator herons (Beltzer 1981-2003, Beltzer et al. 2005) that feed at night (Voisin 1970, Fasola 1984, Peterson and Chalif 1989). As this species share the environment with other fish predators like the Striated Heron (*Butorides striatus*), the Snowy Egret (*Egretta thula*), and the Great Egret (*Ardea albus*), feeding at night may allow their coexistence (Kronfeld-Schor and Dayan 2003). The *Nycticorax*'s species is spread throughout much of the world from Canada to Argentina (*N. nycticorax* hoactli) and all over Europe, Asia, and Africa (*Nycticorax nycticorax*). This species is native in Argentina and its distribution range comprises the whole country except the high Andes' area (Narosky and Yzuriea 1993).

Black-crowned Night-herons present a varied diet where nestlings are fed mainly on fishes and insects (Perez et al. 1991, Kazantzidis and Goutner 2005). The same occurs with adults but other items like mollusks, crustaceans, small mammals, amphibians, reptiles, invertebrates, vegetation, as well as birds eggs and chicks have been reported (Marshall 1942, Palmer 1962, Collins 1970, Wolford and Boag 1971, Szlivka 1985, Yen 1991, Fasola 1984, Durmus and Adizel 2011).

Although there is an acceptable knowledge base available about the feeding ecology for the Black-crowned Night-heron (Fasola 1984), only little is known about its diet. Besides, most of these researches were conducted in North America, Europe, and northern Africa but available information for South America is scarce. In the study area, diets from other heron's species (i.e. *Butorides striatus*: Beltzer 1983, Beltzer and Muñoz 2001; *Tigrisoma lineatum*: Beltzer 1990; *Ardea albus* and *Egretta thula*: Beltzer 1981; *Bubulcus ibis*: Duccomunn et al. 2008; *Ardea cocoi*: Duccomunn et al. 2010) were reported, but little information is available for the Black-crowned Night-heron

(Beltzer 2007). Furthermore, to our knowledge, no published information is available for other South American countries.

This study presents new results about the feeding ecology of *N. nycticorax* in the valley of the Paraná River, Argentina, thus allowing a comparison with other studies. Besides we will compare diet overlap with other sympatric species of similar size feeding in the same areas and environments.

#### MATERIAL AND METHODS

The fieldwork was conducted on Carabajal island (Santa Fe, 31°39'S, 60°42'W, Ducommun et al. 2008). This study used the same units of vegetation and environment categories ("UVEs") described by Ducommun et al. (2008).

Fourty Black-crowned Night-herons were studied between 1999 and 2002. From those samples, thirty two (8 birds/year) were killed with a 16-gauge shotgun and the rest were caught with mist nets and subsequently released. Captures for scientific purposes were authorized by the Dirección de Ecología y Protección de la Fauna de la Provincia de Santa Fe, Argentina (Permit #: 0428). The stomachs of the dead birds' were injected with 10% formalin (to stop the digestive processes) while in the field and opened in the laboratory. The stomach contents from the live birds were obtained by stomach washing following the criterion of Moddy (1970) and Rosenberg and Cooper (1990), using a probe with warm water with the aim of invoking regurgitation. All contents were fixed in 10% formalin for subsequent qualitative and quantitative analysis. The hour of capture and the weight of the birds and their stomachs were recorded. Field observations were also conducted to determine the habitats used and the hours of activity. Once in the laboratory, we followed the same procedures detailed in Ducommun et al. (2008).

The statistics used for the analysis of the diet were the same used for the study of the diet of the *Bubulcus ibis* (Cattle Egret) by Ducommun et al. (2008). The contribution of each prey item to the diet of the species was established by applying the index of relative importance, IRI (Pinkas et al. 1971). Trophic diversity was determined following Hurtubia's (1973) criterion that is used to calculate the diversity ( $H$ ) for each individual using the formula of Brillouin (1965). The accumulated trophic diversity ( $H_k$ ) was obtained by adding

randomly the estimates, singles, and the curve result of its graphic representation which is an aggregation quantitative-qualitative in which the asymptote (point t, p.t.) allows the determination of the minimum sample size. Trophic diversity intervals (low, medium and high) were determined by dividing the difference between the lowest and highest values into three equal intervals. Dietary selectivity was evaluated applying the Spearman Rank Correlation,  $r_s$  (Sokal and Rohlf 1979, Scheffler 1981). Feeding efficiency,  $Pe$ , was estimated following Acosta Cruz et al. (1988) and the trophic amplitude of the niche was calculated by means of the index of Levins (1968). They were calculated for each year's season. With the purpose of establishing the hourly rhythm of the feeding activity, the average satiety index was calculated, IF (Mean Index of Fullness, Maule and Horton 1984). Finally, the association of this species with different environments typical of the flood valley of the Paraná River was analysed by means of the index of habitat preference,  $Pi$  (Duncan 1983). Following the criteria proposed by Bignal et al. (1988) values higher of 0.3 indicate high preference for one specific "UVEs" and values lower indicate a smaller preference.

### RESULTS

All the stomachs analysed (n= 40) contained food. We registered 16 taxa, all of them animal remains, where fishes were the most abundant. Their quantification and frequency of occurrence are described and detailed in Table 1.

The application of the index of relative importance (IRI) yielded the following values: fishes= 9100, most important component in quantity, volume, and frequency of occurrence, insects= 1650, crustaceans= 600, and amphibians= 300. Among the fishes, the more abundant preys were species of economic interest such as the juveniles of *Leporinus obtusidens*, *Pimelodus albicans*, *Hoplias malabaricus*, and *Hypostomus* sp. However, *Synbranchus marmoratus* was the most important and abundant item among the fishes. Insects were represented by Belostomatidae and Acrididae and crustaceans by Trychodactylidae and Palaemonidae.

Diversity values for the stomach ranged from 0 to 1.86. Those stomachs comprised in the low diversity interval were more frequent. The accumulated trophic diversity was 3.5 and the values were allowed to reach the asymptote.

The size of the most consumed prey varied from 61 to 80 mm (Fig. 1) represented, mostly, by *S. marmoratus* and *L. obtusidens*. The intermediate size range (21-40 mm and 41-60 mm) represented 25% of the total prey that included small fishes and crustaceans. The smaller prey items (0-20 mm) were predominantly insects.

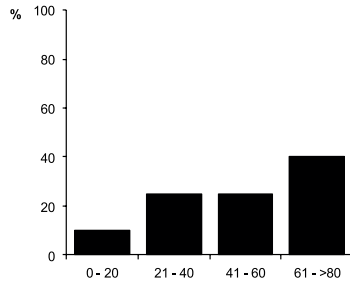
Values corresponding to niche amplitude and feeding efficiency, throughout the season, appear in Table 2. Both variables obtained their highest values in the spring followed by summer and winter that showed similar high values. Dietary selectivity results, obtained by the calculation of Spearman Rank Correlation, was significant ( $r_s = 0.41$ ,  $P > 0.001$ ). Black-crowned Night-herons showed a high feeding activity early in the morning, descending towards noon, to increase again around 7pm (Fig. 2).

This species used most "UVEs", with the exception of "pastures" and "forests". It had a preference for "grasslands" firstly ( $Pi = 0.62$ ) and for "aquatic vegetation" secondly ( $Pi = 0.38$ ). The lowest preference was for "open waters" ( $Pi = 0.11$ ). The obtained values for the  $Pi$  are shown in Table 3.

### DISCUSSION

Our results provide novel information about the feeding ecology of Black-crowned Night-herons in the flood valley of the Paraná River. Fish represented the main food item, which agrees with data provided for adults (González-Martín and González-Solís 1990, Fasola 1993, Durmuş and Adizel 2011) and nestlings (Perez et al. 1991, Hall and Kress 2008). However, diet seems to vary greatly among seasons, sites, and ambients (Collins 1970, Fasola 1984). While we found that amphibians and crustaceans constituted secondary food categories, other authors reported they were the most consumed items (Crustaceans: Valverde 1955, Amphibians: Fasola et al. 1981, Lazslo 1986). In our study insects constituted an accessory category, something also found by Fasola et al. (1981), Laszlo (1986), and Perez et al. (1991). Once again, the preys' contribution to diet varies between studies as insects were also found to be either the main food item (Vasvari 1939, Hafner 1977, Kazantzidis and Goutner 2005) or a secondary food category (Valverde 1955).

The results obtained relative to the size of prey consumed for Black-crowned Night-herons basically agreed with the information available for other areas, where this species fed mainly on fishes

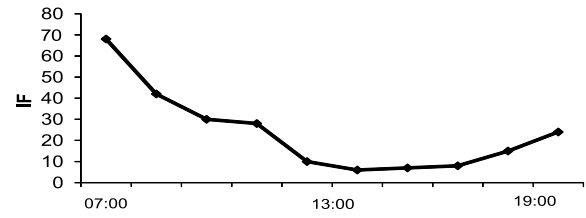


**Fig. 1.** Size of the prey ingested by Black-crowned Night-herons: Percentage of the number of prey ingested by size class.

**Table 1.** Trophic spectrum of Black-crowned Night-herons: N= Number of individuals from each food category and OF= Frequency of occurrence of a particular food category.

	N	OF
Amphibia		
Hylidae		
<i>Hypsiboas pulchellus</i>	12	9
Pisces		
Characidae		
<i>Astyanax bimaculatus</i>	3	2
<i>Astyanax</i> sp.	4	2
Anostomidae		
<i>Leporinus obtusidens</i>	4	3
Erythrinidae		
<i>Hoplias malabaricus</i>	3	2
Curimtidae		
<i>Pseudocurimata</i> sp.	2	2
Rampichthyidae		
<i>Eigenmannia virescens</i>	1	1
Pimelodidae		
<i>Pimelodella maculatus</i>	1	1
<i>Pimelodus albicans</i>	8	5
Callichthyidae		
<i>Hoplosternum littorale</i>	7	6
Synbranchidae		
<i>Synbranchus marmoratus</i>	21	19
Loricariidae		
<i>Hypostomus</i> sp.	3	3
Insecta		
Hemiptera		
<i>Belostoma micantulum</i>	8	5
Orthoptera		
Acrididae n.i.	2	1
Crustacea		
Trychodacthiliidae		
<i>Trychodactyllus borelianus</i>	10	6
Palaemonidae		
<i>Palaemonetes argentinus</i>	9	5

like *Cyprinus carpio* (González-Martín and González-Solís 1990) and *Barbus comiza* (Perez et al. 1991); both species with adult sizes of about 100 mm (Balik et al. 2006, Olivera 2007). However, *N. nycticorax* was able to capture fishes (*Schizodon borellii*) up to 235 mm (Beltzer et al. 1987). It is clear



**Fig. 2.** Rate of feeding activity for Black-crowned Night-herons: Calculated by the average satiety index (IF) for each time interval of capture.

**Table 2.** Niche Amplitude and Feeding Efficiency of Black-crowned Night-herons throughout the season.

	Spring	Summer	Autumn	Winter
Dates	21/9 – 20/12	21/12-20/3	21/3-20/6	21/6-20/9
Niche Amplitude	5.22	3.84	2.55	3.47
Feeding Efficiency	99	97.32	92.3	97.82

**Table 3.** Habitat preference for Black-crowned Night-herons: Calculated by means of the index of habitat preference (Pi) for each units of vegetation and environment (“UVEs”)

“UVE’s”	Pi
open waters	0.11
aquatic vegetation	0.38
gallery forests	0.21
grasslands	0.62
pastures	---
forest	---
beach	0.14

that this species prefer prey sizes that maximize the balance between their beak size and the energy consumed since, Black-crowned Night-herons, fed their nestlings with bigger prey as long as their body (and beak) size increased (Perez et al. 1991). However, this species is known for taking advantage of temporary abundances of food (Davis 1993), so it may mainly consume smaller prey such as insects (Kazantzidis and Goutner 2005), crustaceans (Hall and Kress 2008), or small fishes (Durmuş and Adizel 2011), if those are highly abundant (easier to capture) in the feeding area.

The values obtained in relation to the amplitude of the Black-crowned Night-heron’s trophic niche would indicate differences in feeding along the year, something also noted in other areas for this species (Collins 1970, Fasola 1993). It is important to note that the value of the reached p.t. indicates that the number of stomachs studied fits the statistical requirements of a minimum sample (Magurran 1989). At our study site, such differences in the availability of resources may be caused by marked variations in the hydrometric level along the annual cycle (Beltzer and Neiff 1992), since this variation was also noted not only for Black-crowned Night-

herons but for other species like Cattle Egrets (Ducommun et al. 2008) and Cocoi Herons (Ducommun et al. 2010).

Feeding efficiency values found for *N. nycticorax* were concordant with Ricklefs (1998) who affirmed that values between 60–90% correspond to predators that consume food of animal origin, as mentioned for other ictiofagous herons in the area (Ducommun et al. 2008, Ducommun et al. 2010).

In relation to the circadian rhythm of food, our results reinforce the already described nocturnal feeding habits of the Black-crowned Night-herons (Hanzak 1970, Voisin 1970, Whatmough 1978, Fasola 1984, Peterson and Chalif 1989). Unlike the previously mentioned reports on *N. nycticorax*'s feeding behavior, we added to the available observational information a new index of data that supports this nocturnal behavior. The IF index was high early in the morning, decreased towards noon, and rised at dusk, suggesting that the main feeding activity occurred during night hours as described by Seibert (1951) and Fasola (1984). Despite not having captured individuals during night hours, we still consider that *N. nycticorax* feed at night. We conclude that since the item this species consumed most (*S. marmoratus*) is a fish with nocturnal habits and capable of crawling on pastures (Hoar 1978) because its capacity of breathing atmospheric oxygen (Schmidt-Nielsen 1983).

The obtained values for the Pi showed higher preference of Black-crowned Night-herons for some two “UVEs”: grasslands and aquatic vegetation, something also found by Durmuş and Adizel (2011) who stated that this species prefer muddy and mashy areas.

It becomes possible that this heron catch fish in aquatic situation but in the vegetation capture other prey, such as insects and amphibians, which are associated with vegetation. However, during the high water seasons, fishes can be also caught in grasslands since they get partially covered by water. Besides forests (only used for roosting), pastures was one of the environments to which *N. nycticorax* was not associated, being this “UVEs” the choice for herons that are basically insectivorous, as *Syrigma sibilatrix* (Whistling Heron) and *B. ibis* (Beltzer 2007, Ducommun et al. 2008). According to the classification made by Kushlan and Hancock (2005), middle sized herons like *N. nycticorax* are fundamentally “stand and wait” or “walk slowly”

that capture prey in water or on emergent or floating plants.

Jenni (1973) noted that herons present, in general, an oportunistic behavior and so can vary their trophic specra depending on the seasons, body condition, and resource availability. Sperman's Rank correlation values (rs) showed that the Black-crowned Night-heron has an opportunistic feeding behavior, something that agreed with the varied diet described by several authors (Valverde 1955, Fasola et al. 1981, Durmuş and Adizel 2011). Furthermore, Fasola (1993) found that this species even varied its diet (or at least how a single food item contributed to the diet) between UVEs of the same area reporting, for example, that fishes were the main foot item in wetlands, rivers. and lagoons but amphibians were predominate in the rice fields.

In the study area, Black-crowned Night-herons coexist with other heron's species of simiar sizes and diets like *B. striatus*, *E. thula*, and *A. albus* (Beltzer 2007). Such coexistence may be posible by the niches' differentiation in diets and feeding behavior (Kushlan et al. 1982, Forbes 1987, Broocks 1991, Campos and Fernández Cruz 1991, Custer and Peterson 1991). To our understanding, feeding at night represents for the Black-crowned Night-heron an adaptation to minimize competition with other fish predator herons that use the same areas to forage. Furthermore, this nocturnal behavior allows this species to use *S. marmoratus* as a food resource; something diurnal herons can't do. Our data agrees with that provided by Nuñez et al. (2008), who described a low niche overlap between *N. nycticorax* and 1) *B. striatus* (6%), 2) *E. thula* (12%), and 3) *A. albus* (12%) in a Mexican wetland. Besides, *N. nycticorax* mainly consumed bigger preys than *B. striatus*, *A. albus* (21-30mm for both species – Beltzer 2007), and *E. thula* (11-20mm – Beltzer 2007). This reinforces the idea that prey size is more important than type in segregating similar syntopic species (Reynolds and Meslow 1984, Cooper et al. 1990).

Our manuscript expands the available information for the Black-crowned Night-heron in Argentina, filling a knowllege gap for this species in southern South America.

Studies like this one provide basic information in regard to the conservation of the species and biodiversity management in a system as complex as the Paraná River.

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