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Feeding ecology of Cocoi Heron (*Ardea cocoi*) in the flood valley of the Paraná River

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ABSTRACT

The feeding ecology of *Ardea cocoi* were analysed based on 29 herons 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, standardisation, circadian rhythm of feeding activity and habitat preference. The trophic spectrum was made up of 17 taxonomic entities, mainly fishes (IRI = 16,000), followed by mammals and amphibians (IRI = 8,000). The highest percentage of prey size was found in the interval 151→200 mm. The amplitude of the trophic niche ranged between 1.98 and 4.21, and the feeding efficiency between 89.9 and 99.9%. In relation to dietary selectivity, the correlation between abundance of prey in stomachs and abundance of prey in the study area yielded no significant results ($r_s = 0.078$, $P > 0.001$). The rhythm of feeding activity responded to the bell-shaped model. Aquatic vegetation was the unit of vegetation and environment selected more frequently.

Keywords: *Cocoi Heron,* Ardea cocoi, *Ardeidae, stomach content, heron diet, Paraná River, Santa Fe, Argentina*

1. INTRODUCTION

Wetlands exhibit a high concentration of wildlife. Their productivity is usually higher than that of terrestrial systems, which allows remarkable concentrations of fauna not found in other environments (Canevari *et al.*, 1999). Birds, in general, constitute a characteristic component of worldwide aquatic systems. Herons, in particular, are one of the most important components of the bird community associated with different environments of the middle Paraná River (Beltzer, 1981, 2003; Beltzer *et al.*, 2005). They constitute a single guild which conveys them similar morphologies and ecological demands (Jaksic, 1981; Beltzer, 2003). Food is a critical resource for all animals, and it seems reasonable to assume that community structure is established from how food is distributed among species coexisting in a particular place (Wiens, 1989). However, there are mechanisms that allow species to coexist by the differential use of resources and/or space, avoiding competition as a consequence (Pianka, 1978). Many studies on the trophic ecology of herons, their association with habitats, food resources and feeding spectrum have been reported (Kushlan, 1976a, 1976b, 1978, 1981; Amat and Soriguer, 1981; Amat, 1984; McNeil *et al.*, 1993; Lekuona and Campos, 1995; Ntiamoa-Baidú *et al.*, 1998; Ducommun *et al.*, 2008).

The genus *Ardea* includes the largest species of modern herons. *Ardea cocoi* (Cocoi Heron), *A. cinerea* (Grey Heron) and *A. herodias* (Great Blue Heron) are similar species and appear to be closely related (Hancock and Kushlan, 2005), but they are spatially split into different biogeography regions. The first one is located in South America. It occurs from Colombia and Venezuela throughout most of South America to Chile and Argentina, excluding the Andes. It is considered sedentary and is widespread and common throughout its range. The Great Blue Heron and Grey Heron are the Neartic and Eurasian forms respectively.

Although there is an extensive knowledge available about the feeding ecology for Grey Heron (see Lekuona and Campos, 1997; Kreuziger and Achenbach, 1998; Lekuona, 2001; McCanch, 2003; Hancock and Kushlan, 2005; Jakubas and Mioduszewska, 2005; Marquiss and Leitch, 2008; Pistorius, 2008) and Great Blue Heron (*inter alia* Glahn *et al.*, 1995, 1999; Butler, 1997; Hancock and Kushlan, 2005), only a little is known about the feeding activity of the Cocoi Heron. The only avail-

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Figure 1 Cocoi Heron (© Ardea cocoi @ Jardim Botânico de São Paulo).

Figure 2 Grey Heron (© Björn Kreis alias Fernando21).

Figure 3 Great Blue Heron (© Terry Foote).

able contributions being those of Hancock and Kushlan (2005) which presents a general description of the species, and descriptions of foraging (Morales *et al.*, 1981; Yanosky *et al.*, 2000; de la Peña, 2001; Barrionuevo and Marcial, 2006). This study presents new results about the feeding ecology of this species in the valley of the Paraná river, Argentina allowing comparison with other studies.

2. METHODS

Fieldwork was conducted on the 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).

Twenty nine Cocoi herons were studied between 1999 and 2002. Eighty percent were killed with a 16-gauge shotgun and the rest were caught with mist nets and subsequently released. 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. 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 provoking the 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 analysis of the diet were the same used for the study of diet of *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 criterion (1973) that is to calculate the diversity

(*H*) for each individual using the formula of Brillouin (1965). The accumulated trophic diversity (*Hk*) was obtained by adding randomly the estimates singles and the curve result of its graphic representation is an aggregation quantitative–qualitative in which the asymptote (point t, p.t.) allows us to determine the minimum sample size. Dietary selectivity was evaluated applying the Spearman Rank Correlation, *rs* (Sokal and Rohlf, 1979; Schefler, 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 Fullnes, 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 than 0.3 indicate high preference for one specific "UVEs" and lower values indicate a smaller preference.

3. RESULTS

All the stomachs analysed ($n = 29$) contained food. We recorded 17 taxa, all of them were animal remains. Their quantification and frequency of occurrence were described and detailed in Table 1. 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).

The application of the index of relative importance (IRI) yielded the following values: fishes = 16,000, were the most important component in quantity, volume and frequency of occurrence; mammals and amphibians = 8,000 and insects = 500. Among fishes, more abundant preys were the species of economic interest such as *Hoplias malabaricus, Leporinus obtusidens* and *Prochilodus lineatus.* Mammals were represented by just one individual, *Holochilus brasiliensis* (Rodentia), and amphibians by the frogs *Leptodactyllus ocellatus* and *Hyla pulchella.*

Diversity values for the stomachs contained a similar number of species and protortion. The accumulated trophic diversity was 1.78 and values were allowed to reach the asymptote.

The size of the prey consumed varied from 44 to 280 mm (Figure 4). The range 151→200 mm was the most common, which include both adults and juveniles fish of *Hoplias malabaricus, Leporinus obtusidens, Prochilodus lineatus* and mammals as *Holochilus brasiliensis.* The intermediate size range were some insects and fish (*e.g. Astyanax* sp.). The smaller prey items were predominantly insects.

Table 1 Trophic spectrum of Cocoi Heron

Organism	*N*	OF
Animals		
Mammalia		
Rodentia		
Holochilus brasiliensis	1	1
Amphibia		
Leptodactyllidae		
Leptodactillus ocellatus	3	2
Hylidae		
Hyla pulchella	5	3
Pisces		
Characidae		
Astyanax bimaculatus	6	9
Salminus maxillosus	7	4
Serrasalmidae		
Serrasalmus spilopleura	2	1
Erythrinidae		
Hoplias malabaricus	26	25
Anostomidae		
Leporinus obtusidens	23	17
Curimatidae		
Prochilodus lineatus	32	30
Pimelodidae		
Pimelodus albicans	13	12
Callichthyidae		
Hoplosternum littorale	11	9
Loricariidae		
Loricaria anus	1	1
Synbranchidae		
Synbranchus marmoratus	1	1
Not identified	19	20
Insecta		
Hemiptera		
Belostomidae		
Belostoma sp.	9	5
Orthoptera		
Paulinidae		
Paulinia acuminata	3	2
Crustaceoa		
Decapoda		
Trichodactyllidae		
Trichodactyllus borelianus	6	4

N, Number of individuals from each food category; OF, Frequency of occurrence of a particular food category.

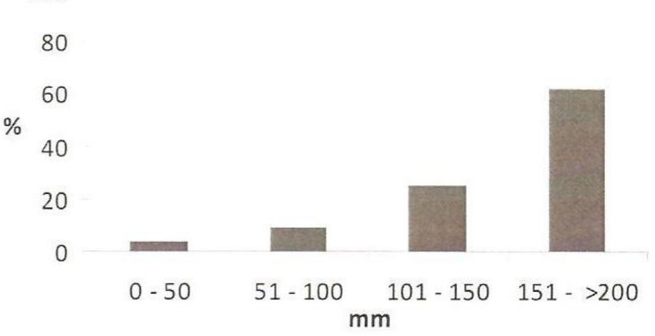

Figure 4 Size of the prey ingested by Cocoi Heron: percentage of the number of prey ingested by size class.

Table 2 Niche amplitude and feeding efficiency 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	3.87	4.21	2.89	1.98
Feeding efficiency	99.9%	98.87%	89.9%	91.02%

Values corresponding to niche amplitude and feeding efficiency, throughout the season, are listed in Table 2. Both variables obtained their highest values in spring and summer. For the niche amplitude, the smallest value was in winter, for the feeding efficiency it was in autumn. Dietary selectivity results, obtained by the calculation of Spearman Rank Correlation, was not significant ($r_s = 0.078$, $P > 0.001$). Cocoi herons showed feeding activity following a bell-shaped model (Figure 5) with a characteristic peak at noon and a reduction at dusk.

Cocoi Heron used most UVEs, with the exception of "pastures" that was not used by this species. It had a preference for aquatic vegetation firstly and for open waters secondly ($Pi > 0.3$ in both). The lowest preference was for "beach". The obtained values for the *Pi* were showed in Table 3.

4. DISCUSSION

These results provided new information about the feeding ecology of Cocoi Heron in the flood valley of the Paraná River. Fish represented the main food of the Cocoi Heron. Mammals and amphibians constituted secondary food categories, and insects were an accessory category. Those results obtained basically agree with the information contributed by Olivares (1973), Borrero and Cruz-Millan (1982), Yanosky *et al.* (2000), de la Peña (2001), Hancock and Kushlan (2005), and Barrionuevo and Marcial (2006). According Hancock and Kushlan (2005) this species also eats carrion but this was not observed in this study. Dobos (1991) and Butler (1997) found that the Great Blue Heron feeds mainly on fish, also amphibians and crustaceans and occasionally on reptiles, small mammals and birds. According to Jakubas and Mioduszewska (2005) the most important component of Grey Heron's diet is fish, item that forms at least 90% of the diet. These authors also found that other components could be insects, amphibians, and small mammals but they had lower biomass than fish. McCanch (2003), Kreuziger and Achenbach (1998) and Lekuona and Campos (1996) also documented the presence of crustaceans, reptiles, worms and smalls birds in the diet of the Grey heron. In conclusion, these three large herons are mainly, but not exclusively, fish-eating species.

The results obtained relative to the size of prey consumed for Cocoi Heron basically agree with the information contributed by Morales *et al.* (1981). According to this study all animals caught by Cocoi Heron were relatively large between 150 mm and 400 mm. Although implying a considerable management time for the consumer, large size preys imply a richer intake of calories (Brabata and Carmona, 1999) as required by species as large as this. On the other hand, Lehman (1960) and Borrero and Cruz-Millan (1982) report consumption of fish of 200 mm (*Leporinus* sp.) and fish up to 300 mm long respectively by this same species. As noted above, the Grey Heron and Great Blue Heron feed on a variety of prey too, some rather large (like fish) but also come to feed on small prey (like insects). Brabata and Carmona (1999) consider the existence of a direct relationship between the size of the bird and its prey. In contrast,

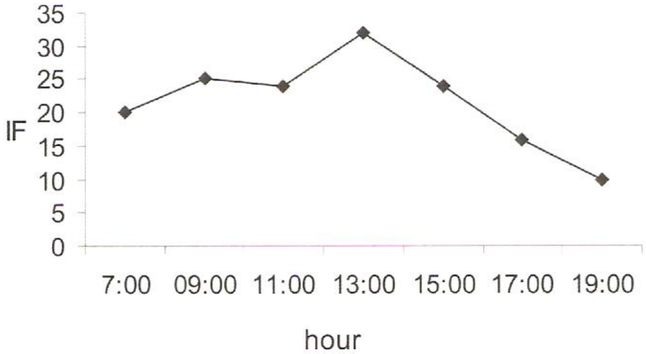

Figure 5 Rate of feeding activity for Cocoi Heron: calculated by the average satiety index (IF) for each time interval of capture.

Table 3 Habitat preference for Cocoi Heron: from the index of habitat preference (*Pi*) for each unit of vegetation and environment (UVEs)

UVEs	*Pi*
Open waters	0.31
Aquatic vegetation	0.40
Gallery forests	0.06
Grasslands	0.13
Pastures	–
Forest	0.09
Beach	0.01

Sodhi (1992) suggested that the length of prey items consumed for herons may be dependent upon length of available prey rather than a bird's morphology. However, to support Sodhi's theory, would require a study on the availability of prey in the study area.

The values obtained in relation to the amplitude of the Cocoi Heron's trophic niche would indicate differences in feeding along the year. In his study, Cramp (1998) found too that the diet of Cocoi Heron varies considerably with season. These results may show certain seasonal changes in the availability of resources in the area characterised by the marked variations in the hydrometric level along the annual cycle (Beltzer and Neiff, 1992).

Feeding efficiency values found for Cocoi Heron accord with those of Ricklefs (1998) who affirms that values between 60 and 90% correspond to predators that consume food of animal origin. Ducommun *et al.* (2008) found for Cattle Egret, whose diet is carnivorous too, that feeding efficiency reach close to 90%. Values of this variable for both species had an opposite temporal pattern (seasonal pattern). The feeding efficiency of Cocoi Heron reaches the lowest value and of the Cattle Egret the highest value in autumn and *vice versa* in spring. These patterns would be explained by different patterns of habitat use and therefore the type of prey.

The value of the Spearman Rank Correlation, indicates that Cocoi Heron was not selective about any food items. This flexibility of its diet is evidenced by stomach contents that show a wide diversity of items. These results coincide with that of Jenni (1973), who stated that herons are, in general, opportunistic birds regarding food, so that their spectra may vary widely. Sodhi (1992) postulated that prey selection in herons may be dependent upon four factors: prey availability in the foraging area, prey vulnerability, physiological stimuli of the predator and competition for food resources among sympatric herons. Jakubas and Mioduszewska (2005) argue that in the case of the Grey Heron, the diet is strongly influenced by the first of these factors.

In relation to the circadian rhythm of food, Yanosky *et al.* (2001) found a similar pattern to that reported here for Cocoi Heron: a diurnal feeding activity with only a peak in activity at noon and a reduction at dusk. Hancock and Kushlan (2005) found the opposite circadian pattern for the Grey Heron: more activity at dawn and at dusk and roost during the middle of the day and at night and they explain that although in literature this species is considered a diurnal feeder, it generally feeds all day. These same authors suggested that Cocoi Heron would have a wide rhythm as it feeds both day and night but we cannot corroborate this idea because the scope of our work covers only daylight hours and we did not capture birds at night.

The obtained values for the *Pi* showed a higher preference of Cocoi Heron for some two "UVEs": aquatic vegetation and open water. Yanosky *et al.* (2001) from a study on habitat use and availability would characterise this species as a habitat specialist too because it showed mainly preference for one type of environment (swamps). It also becomes possible that this heron catches fish in aquatic situations but in the vegetation it captures other preys, such as insects and amphibians, which live associated with vegetation. Pastures was the unique environment which was not associated, because this is the choice for herons that are basically insectivorous, as *Syrigma sibilatrix* (Whistling Heron) and Cattle Egrets (Beltzer, 2007; Ducommun *et al.*, 2008). According to the classification made by Hancock and Kushlan (2005), large herons are fundamentally species that stand preys in water or on emergent or floating plants. So it is possible that Grey Heron and Great Blue Heron prefer the same units of vegetation and environment preferred by Cocoi Heron. Moreover, these three species have the ability to venture into open waters. The length of their hind limbs represents the ability of these herons for using deeper wetlands.

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.

5. REFERENCES

Acosta Cruz, M., Torres, O. and Mugica Valdés, L. (1988) Subnicho trófico de *Dendrocygna bicolor* (Vieillot) (Aves: Anatidae) en dos arroceras de Cuba. *Cienc. Biol.*, **19–20**, 41–50.

Amat, J.A. (1984) Las poblaciones de aves acuáticas en las lagunas andaluzas. Composición y diversidad durante un ciclo anual. *Ardeola*, **31**, 61–79.

Amat, J.A. and Soriguer, R.C. (1981) Alimentación primaveral de la garcita bueyera. *Doñana Acta Vertebrata*, **8**, 207–213.

Brabata, G. and Carmona, R. (1999) Conducta alimentaria de cuatro especies de aves playeras (Charadriiformes: Scolopacidae) en Chametla, B.C.S., México. *Rev. Biol. Trop.*, **47**, 239–243.

Beltzer, A.H. (2003) Aspectos tróficos de la comunidad de aves de los esteros del Iberá. In: Alabarez, B.B. (ed.), *Fauna del Iberá*, pp 257–272. Universidad Nacional del Nordeste, Corrientes, Argentina.

Beltzer, A.H. (2007) *Relaciones tróficas y mecanismos de segregación ecológica entre las especies de garzas del valle de inundación del río Paraná (AVES: ARDEIDAE).* Unpublished PhD Thesis, Universidad Nacional de La Plata, Facultad de Ciencias Naturales y Museo.

Beltzer, A.H., Quiroga, M.A. and Schnack. J.A. (2005). Algunas ardeidas del valle de inundación del río Paraná: consideraciones sobre el nicho ecológico y mecanismos de aislamiento. *INSUGEO, Tucumán, Miscelánea*, **14**, 499–526.

Barrionuevo, R. and Marcial, R. (2006) Ecología trófica de la fauna acuática en el Manglar de san Pedro-Sechura. *Universalia*, **11**, 44–56.

Bignal, E.M., Curtis, D.J. and Matthews, J.L. (1988) Islau Land Types. Birds habitats and nature conservation. Part. 1: Land use and birds on Islay. *NCC Chief Scientist Directorate*, 809.

Borrero, J.I. and Cruz-Millán, C.A. (1982) Notas sobre la historia de la garza morena Ardea cocoi (Aves) en Colombia. *Acta Biológica Colombiana*, **1**, 51–75.

Butler, R. (1997) *The Great Blue Heron.* British Columbia, Canada.

Canevari, P., Blanco, D.E., Bucher, E.H., Castro, G. and Davidson, I. (1999). *Los humedales de la Argentina. Clasificación, Situación Actual, Conservación y Legislación.* Publicación No. 46. Wetlands International, Buenos Aires, Argentina.

Cramp, S. (1998) *The Complete Birds of the Western Palearctic* on CD-ROM. Oxford University Press, Software Optimedia.

de la Peña, M.R. (2001) Observaciones de campo en la alimentación de las aves. *FAVE*, **15**, 99–107.

Dobos, R. (1991) Two incidents of Great Blue Herons Feeding on Birds. *Ontario Birds*, **9**, 87–88.

Ducommun, M.P., Quiroga, M.A., Beltzer, A.H. and Schnack J.A. (2008) Diet of Cattle Egrets in the flood valley of the paraná river, north Argentina. *Avian Biol. Res.*, **1**, 145–151.

Duncan, P. (1983). Determination of the use of habitat by horses in Mediterranean wetland. *J. Anim. Ecol.*, **52**, 93–109.

Glahn, J.F., King, J.O. and King D.T. (1995) Impact of Great Blue Heron on channels catfish farms. *J. World Aquaculture Soc.*, **26**, 194–199.

Glahn, J.F., Tomsa, T. and Preusser, K.J. (1999) Impact of Great Blue Heron predation at trout-rearing facilities in the northeaster United States. *North Am. J. Aquaculture*, **61**, 349–354.

Hancock, J. and Kushlan, J. (2005) *The Herons. Bird Families of the World.* Oxford University Press inc., New York.

Hurtubia, J. (1973) Trophic diversity measurement in sympatric species. *Ecology*, **54**, 885–890.

Jacksic, F. (1981). The guild structure of a community of predatory vertebrates in Central Chile. *Oecología*, **49**, 21–28.

Jakubas, D. and Mioduszewska, A. (2005) Diet composition and food consumption of the Grey Heron (*Ardea cinerea*) from breeding colonies in northern Poland. *Eur. J. Wildl. Res.*, **51**, 191–198.

Jenni, D.A. (1973) Regional variation in the food of Nestling Cattle Egrets. *Auk*, **90**, 821–826.

Kreuziger, J. and Achenbach, E.L. (1998). Graureiher (*Ardea cinerea*) verschlingt Küken des Haubentauchers (*Podiceps cristatus*). *Vogelwarte*, **39**, 301–302.

Kushlan, J.A. (1976a) Wading bird predation in seasonally fluctuating pon. *Auk*, **93**, 464–476.

Kushlan, J.A. (1976b) Feeding behavior of North American Herons. *Auk*, **93**, 86–94.

Kushlan, J.A. (1978) Nonrigorous foraging by Robbing Egrets. *Ecology*, **59**, 649–653.

Kushlan, J.A. (1981) Resource use strategies of wading birds. *Wilson Bull.*, **93**, 145–163.

Lekuona, J.M. and Campos, F. (1995). Le succès de reproduction du Héron cendré (*Ardea cinerea*) dans le Bassin d'Arcachon. *Alauda*, **63**, 179–183.

Lekuona, J.M. (2001) Variations in food composition and foraging behaviour of Grey heron *Ardea cinerea* in Aragon river (Northern Spain) during the breeding season. *Anu. Ornit Navarra 1999*, **6**, 19–25.

Lekuona, J.M. and Campos, F. (1996) Seasonal dynarnics of Grey Herons on a large river in Spain. *Col. Waterbirds*, **19**, 214–219.

Lekuona, J.M. and Campos, F. (1997) Composición de la dieta y comportamiento trófico de la Garza Real *Ardea cinerea* y de la Garza Imperial *Ardea purpurea* en el rio Aragón durante la época reproductora. *Anuario Ornitológico de Navarra*, **3**, 21–28.

Lehman, F.C. (1960) Hallazgo de una colonia de *Ardea cocoi* en el Valle de Cauca. *Nov. Colom.*, **1**, 279.

Levins, R. (1968) *Evolution in changing environment.* Princeton, New Jersey.

Magurran, A.E. (1989) *La diversidad ecológica y su medición.* Vedra, Barcelona, Spain.

Marquiss, M. and Leitch A.F. (1990) The diet of Grey Herons *Ardea cinerea* breeding at Loch Leven, Scotland, and the importance of their predation on ducklings. *Ibis*, **132**, 535–549.

Maule, A.G. and Horton H.F. (1984) Feeding ecology of walleye *Sttizostedion vitreun viterun* in the MidColumbia river, with emphasis on the interaction between valleye and juvenile anadromus fishes. *Fish Bull.*, **82**, 411–416.

McCanch, N. (2003) Grey Heron choking on Little Grebe. *Brit. Birds*, **96**, 86.

McNeil, R., Drapeau, P. and Pierotti, R. (1993) Nocturnality in colonial waterbirds: occurrence special adaptations and suspected benefits. *Curr. Ornithol.*, **10**, 187–246.

Moddy, D.T. (1970) A method for food samples from insectivorous birds. *Auk*, **87**, 579.

Morales, G., Pinowski, J., Pacheco, J., Madriz, M. and Gómez, F. (1981). Densidades poblacionales, flujo de energyía y hábitos alimentarios de las aves ictiófagas de los módulos de Apure, Venezuela. *Acta Biol. Venez.*, **11**, 1–45.

Ntiamoa-Baidú, Y., Piersma, T., Wiersma, P., Poot, M., Batley, P. and Gordon, C. (1998) Habitat selection, daily foraging routines and diet of waterbirds in coatal lagoon in Ghana. *Ibis*, **140**, 89–103.

Olivares, A. (1973) *Las Ciconiformes Colombianas. Garzas - Coclearios - Ibis - Cigüeñas - Espátulas - Flamencos.* Tercer Mundo, Bogotá, Colombia.

Pianka, E.R. (1978). *Evolutionary ecology.* Harper's, New York.

Pinkas, L., Oliphant, M.S. and Iverson, Z.L. (1971) Food habits of albacore bluefin tuna and bonito in California waters. *Dept. of Fish and Game, Fish Bull.*, **152**, 1–105.

Pistorius, P.A. (2008) Grey Heron (*Ardea cinerea*) Predation on the Aldabra White-throated Rail (*Dryolimnas cuvieri aldabranus*). *Wilson J. Ornithol.*, **120**, 631–632.

Ricklefs, R.E. (1998) Invitación a la ecologyía. Economía de la naturaleza. Médica Panamericana, Buenos Aires, Argentina.

Rosenber, K.V. and Cooper, R.J. (1990) Approaches to avian diet analysis. *Stud. Avian Biol.*, **13**, 80–90.

Schefler, W.C. (1981) *Bioestadística.* Fondo Educativo Interameriecano, México.

Sodhi, N.S. (1992) Food-nich relationships of five north Indian Herons. *Forktail*, **7**, 125–130.

Sokal, R.R. and Rohlf, F.J. (1979) Biometría. Principios y métos estadísticos en la investigación boilógica. Blume, Madrid, Spain.

Wiens, J.A. (1989). *The Ecology of Bird Communities.* Cambridge University Press, Cambridge.

Yanosky, A.A., Escalante, A., Schuchmann, K. and Kittlein, M. (2000) Ecología de una Comunidad de Aves Vadeadoras en el Nordeste Argentino. In: Cabrera, E., Mercolli, C. and Resquin, R. (eds.), *Manejo de Fauna Silvestre en Amazonia y Latinoamérica*, pp. 219–236. Cites-Py, Fundación Moisés Bertoni, University of Florida, Asunción.