ZOOLOGIA 35: e14664
ISSN 1984-4689 (online)
zoologia.pensoft.net

RESEARCH ARTICLE

# Foraging behavior of Brazilian cormorant, *Nannopterum brasilianus* (Suliformes: Phalacrocoracidae)

**Carla Gheler-Costa[1], Fábio Henrique Comin[2], Letícia C. Gilli[1], Luciano M. Verdade[3]**

[1]*Laboratório Ecologia e Conservação, Pró-Reitoria de Pesquisa e Pós-graduação, Universidade do Sagrado Coração. Rua Irmã Arminda 10-50, Jardim Brasil, 17011-160 Bauru, SP, Brazil.*
[2]*Departamento de Ciências Sociais e Aplicadas, Universidade do Sagrado Coração. Rua Irmã Arminda 10-50, Jardim Brasil, 17011-160 Bauru, SP, Brazil.*
[3]*Centro de Energia Nuclear na Agricultura, Universidade de São Paulo. Caixa Postal 96, 13416-000 Piracicaba, SP, Brazil.*
*Corresponding author: Carla Gheler-Costa* (cgheler@gmail.com)

*http://zoobank.org/342FF666-882D-4ECB-A3B7-0740E876EE4E*

ABSTRACT. Although the concept of optimal foraging has been extensively discussed, foraging efficiency is difficult to assess in vertebrates. In this study, we determined the foraging efficiency of the Brazilian cormorant, *Nannopterum brasilianus* Gmelin, 1789, by the direct, *ad libitum* observation of a group of four to thirteen individuals in an artificial pond at the University of São Paulo, Piracicaba, state of São Paulo, southeastern Brazil. Although this study was carried out in a highly anthropic environment, we can still conclude that the Brazilian cormorant is a relatively efficient browser and short-term diver. In anthropic environments, foraging success depends on the amount of time these birds spend diving, and stealing food is less common. Stealing occurs at relatively low rates but tends to be an efficient way to get food.

KEY WORDS. Food biology, food stealing, foraging success, social behavior, wading birds.

## INTRODUCTION

Even though most will agree that measuring animal behavior in the context of experimental research helps to decrease the subjectivity of observations (Martin and Bateson 1993), descriptive studies – formerly called "naturalistic observations" (Lehner 1979, 1996) – can also help to give a preliminary understanding of a species' natural history, and often generates hypotheses that will lead to experimental research (Bakeman and Gottman 1986). In addition, even preliminary descriptions of behaviors can be quantified.

Although optimal foraging has been extensively discussed (Krebs 1978, Stephens and Krebs 1986, Crawley and Krebs 1992, Alcock 1993, Krebs and Davies 1993), foraging success rate has rarely been determined in vertebrates (Schaller 1972). The reason for this is that it is necessary to describe foraging qualitatively and quantitatively. Predators are rarely conspicuous, and predation usually involves disguise and concealment (Caro and FitzGibbon 1992, Guilford 1992). In addition, successful predation is not as frequent as one might suppose.

Cormorants are usually one of the most abundant wading birds in southeastern Brazil, and yet one of the least studied. They usually take two to three years to reach sexual maturity, breed in groups, and present sexual dimorphism (Morrison et al. 1978). Cormorants spend a considerable amount of time foraging either alone or in groups (Lekuona and Campos 1997) and are short-term divers. Certain wading birds are believed to damage aquaculture; however, their diet is barely known, except that it includes frogs, crabs, mollusks, aquatic insects, reptiles, and even small mammals, besides fish (Sick 1997). At the present study, we determined foraging efficiency of the Brazilian cormorant, *Nannopterum brasilianus* Gmelin, 1789, (Piacentini et al. 2015) and briefly discuss possible implications of food stealing by individuals of the same group.

## MATERIAL AND METHODS

The study site was a roughly round artificial pond of approximately 0.84 ha (1 m deep) located at the University of São Paulo, Campus "Luiz de Queiroz", in Piracicaba, central-east region of the state of São Paulo, Brazil (22°43'S, 47°38'W). "Luiz de Queiroz" has 914,5 ha including fragments of native vegetation and agricultural fields, besides laboratories and office buildings.

The artificial pond where this study took place was constructed with cement in the late 1940s. The following species are known from this poind: *Cyprinus carpio* Linnaeus, 1758, *Oreochromis niloticus* (Linnaeus, 1758), and *Pimelodus* sp., all of which have been introduced by humans. The pond has no macrophytes and is surrounded by grass and a few trees. Domestic geese, *Anser anser* var. *domesticus* (Linnaeus, 1758); wild ducks, *Cairina moschata* Linnaeus, 1758); ireres, *Dendrocygna viduata* (Linnaeus, 1766); great white egrets, *Ardea alba* Linnaeus, 1758; and the snowy egrets, *Egretta thula* (Molina, 1782) are also present. People use the area around the pond as a city park.

The cormorant group was observed during a total period of 10h:12 min, early in the morning (7–10 am) and late in the afternoon (4–6 pm), for five days, in November 2000. Group size was determined on every observation period. Foraging behavior was observed with a 10 × 25 binocular by *ad libitum* sampling, and every occurrence of the behaviors we focused on was recorded (Altmann 1974, Martin and Bateson 1993, Lehner 1996). The following behaviors were considered: diving, fishing, and food stealing.

Diving lasting periods (in seconds) were recorded with a digital chronometer. Fish captured by cormorants could be recorded as the bird emerged to swallow the prey (Sick 1997). We considered a behavior as stealing or as an stealing attempt when an individual moved toward another and took, or tried to take, fish from it. Fishing success was calculated as the number of times a cormorant emerged with a fish, divided by the total number of dives. Stealing success was calculated by the number of times any cormorant was successful in taking another birds' fish divided by the total number of successful fishing attempts.

We used descriptive statistics on diving period, foraging success and stealing success. In addition, we used one-way Analysis of Variance (ANOVA) to test the possible relationships between diving lasting period and foraging success, stealing attempts and stealing success.

## RESULTS

The average diving period lasted 10.41 ± 4.82 sec (n = 410), ranging from 3.28 to 23.77 sec. The success rate of fishing was 28.05% (n = 115). Diving lasting period significantly differed between successful and unsuccessful dives ($F = 17.19$, $p \leq 0.001$, n = 410) (Fig. 1). The steal attempt rate was 4.63% (n = 19/410). The stealing success rate was 2.44% (n = 10/410), whereas attempt rate was 16.52% (n = 19/115). The successful steal rate was 52.63% (n = 10/19). There was a significant relationship between dive lasting period and fishing success ($F = 17.19$, $p \leq 0.001$, n = 410), where shorter dives (8.862 ± 4.239 sec) are more successful than longer (11.018 ± 4.907 sec) dives. There was no significant relationship between dive lasting period and stealing ($F = 2.44$, $p = 0.136$, n = 19) (Fig. 2).

## DISCUSSION

The foraging success of the Brazilian cormorant in the present study can be considered low when compared with the foraging success of the great white egret (Wiggins 1991). The great white egret employs a different foraging strategy, usually waiting for the prey in shallow waters. Such strategy can be individually more effective, but it is possible that it does not work when population densities are high or in large social groups (Crawley and Krebs 1992), as it is the case with the cormorant, even outside of the reproductive period. However, the anhinga, *Anhinga anhinga* (Linnaeus, 1766), has a foraging strategy similar to the Brazilian cormorant (Sick 1997, Carvalho 2010).

Although the foraging behavior of cormorants generally involves diving, these birds do not seem to be adapted to long periods of submersion (average at the present study = 10.41 ± 4.82 sec). As a matter of fact, shorter dives were significantly more associated with fishing success than longer dives in our data. This pattern suggests that the prey is possibly detected when the cormorant is still swimming, not diving. Dive would be the final attack over an already detected prey. Otherwise, if dives were exploratory, we would expect that longer dives would result in more prey catching success. However, foraging success by waterfowl can be influenced by environmental factors such as water depth, substrate and prey size. As a matter of fact, Brazilian cormorants can dive as deep as 20 m, what would imply on a distinct foraging strategy (Duffy et al. 1986, Wilson and Wilson 1988, Monteiro-Filho 1992, Carbone and Houston 1994, Sapoznikow and Quintana 2003). Therefore, our data pertains mostly to shallow waters.

Intraspecific competition for food can result in an increase in the time spent in foraging and greater risks associated with it (Alcock 1993). The apparent correlation between fishing and stealing behavior at the present study (see Fig. 2) corroborates this hypothesis, although some overlap would be expected. The stealing successful rate seems low (2.44%). However, the relative successful stealing rate is considerably higher (52.63%). This means that, although relatively rare, at least in small groups such as the one observed in the present study, stealing can be an efficient way to get food. In theory, stealing attempts would increase as group size increases. Further test of this hypothesis should be prioritized.

Although foraging success is related to how long the diving lasts, stealing is not. This pattern suggests that stealing is an opportunistic behavior. When individuals forage in groups, cooperatively or not, as soon as a bird gets a prey, another bird

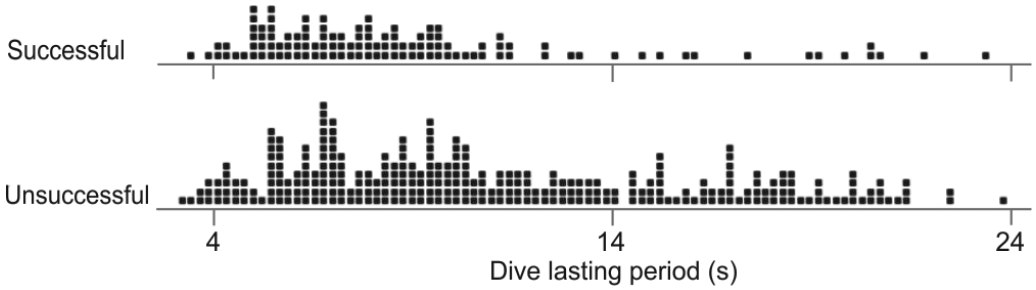


Figure 1. Frequency of successful and unsuccessful dive durations.

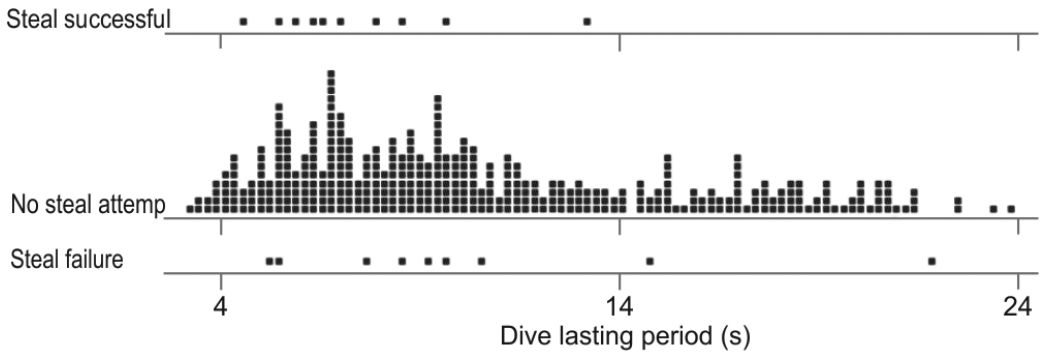


Figure 2. Relationship between dive duration and stealing success.

may try to steal it. Although the distance among individuals during foraging was not recorded in the present study, stealing attempts mostly involved individuals in closer proximity.

In similar conditions to the present study (i.e., anthropic shallow water bodies with relatively small group sizes), the following inferences about the Brazilian cormorant's foraging behavior are made: 1) Brazilian cormorants are relatively efficient browsers and short-term divers; 2) Foraging success is related to dive lasting period, but stealing is not; 3) Stealing occurs at relatively low rates but tends to be an efficient way to get food.

## ACKNOWLEDGEMENTS

Edson Davanzo and José E. Cyrino identified the fish. Gustavo S. Betini helped with field work. LMV holds a Productivity Scholarship from Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq, 312049/2015-3).

## LITERATURE CITED

Alcock J (1993) Animal Behavior. Sinauer, Massachusetts, 522 pp.

Altmann J (1974) Observational study of behavior: sampling methods. Behaviour 49: 227–267. https://doi.org/10.1163/156853974X00534

Bakeman R, Gottman GM (1986) Observing Interaction: An Introduction to Sequential Analysis. Cambridge University, Cambridge, 324 pp.

Carbone C, Houston AI (1994) Patterns in the diving behaviour of the pochard *Aythya ferina*: a test of an optimality model. Animal Behaviour 48: 457–465. https://doi.org/10.1006/anbe.1994.1259

Caro TM, FitzGibbon CD (1992) Large carnivores and their prey: the quick and the dead. In: Crawley MJ (Ed.) Natural enemies: the population biology of predators, parasites and diseases. Blackwel, Oxford, 117–142. https://doi.org/10.1002/9781444314076.ch5

Carvalho FF (2010) Comportamento alimentar das aves piscívoras aquáticas do Parque Natural Chico Mendes. Revista Eletrônica de Biologia 3: 11–19.

Crawley MJ, Krebs JR (1992) Foraging theory. In: Crawley MJ (Ed.) Natural enemies: the population biology of predators, parasites and diseases. Blackwel, Oxford, 90–114.

Duffy DC, Wilson RP, Wilson MP, Velasquez CR (1986) Plunge – diving by Olivaceous Cormorant in Chile. Wilson Bulletin 98: 607–608.

Guilford T (1992) Predator psychology and the evolution of prey coloration. In: Crawley MJ (Ed.) Natural enemies: the population biology of predators, parasites and diseases. Blackwel, Oxford, 377–394. https://doi.org/10.1002/9781444314076.ch16

Krebs JR (1978) Optimal foraging: decision rules for predators. In: Krebs JR, Davies NB (Eds) Behavioural ecology: an evolutionary approach. Sinauer, Massachusetts, 23–63.

Krebs JR, Davies NB (1993) An introduction to behavioural ecology. Blackwell. Oxford, 432 pp.

Lehner PN (1979) Handbook of Ethological Methods. Cambridge University Press, Cambridge, 678 pp.

Lehner PN (1996) Handbook of Ethological Methods (2nd edn). Cambridge University Press, Cambridge, 694 pp.

Lekuoma JM, Campos F (1997) Foraging ecology of cormorants (*Phalacrocorax carbo*) wintering in northern Spain. Folia Zoologica 46: 243–252.

Martin P, Bateson P (1993) Measuring behavior: an introductory guide. Second edition. Cambridge University Press, Cambridge,186 pp. https://doi.org/10.1017/CBO9781139168342

Monteiro-Filho ELA (1992) Pesca associada entre golfinhos e aves marinhas. Revista Brasileira de Zoologia 9: 29–37. https://doi.org/10.1590/S0101-81751992000100005

Morrison ML, Slack RD, Shanley Jr E (1978) Age and foraging ability relationships of olivaceous cormorants. Wilson Bulletin 90: 414–422.

Piacentini V, Aleixo A, Agne CE, Maurício GN, Pacheco JF, Bravo, GA, Brito GRR, Naka LN, Olmos F, Posso S, Silveira LF, Betini, GS, Carrano E, Franz I, Lees AC, Lima LM, Pioli D, Schunck F, Raposo do Amaral F, Bencke GA, Cohn-Haft M, Figueiredo LFA, Straube FC, Cesari E (2015) Annotated checklist of the birds of Brazil by the Brazilian Ornithological Records Committee. Revista Brasileira de Ornitologia 23: 90–298.

Sapoznikow A, Quintana F (2003) Foraging behaviour and feeding locations of Imperial Cormorants and Rock Shags breeding sympatrically in Patagonia, Argentina. Waterbirds 26: 184–191. https://doi.org/10.1675/1524-4695(2003)026[0184:FBAFLO]2.0.CO;2

Schaller GB (1972) The Serengeti Lion: a study of predator-prey relations. The University of Chicago Press, Chicago, 504 pp.

Sick H (1997) Ornitologia Brasileira (2nd edn). Nova Fronteira, Rio de Janeiro, 912 pp.

Stephens DW, Krebs JR (1986) Foraging Theory. Princeton University, New Jersey, 262 pp.

Wiggins DA (1991) Foraging success and aggression in solitary and group-feeding Great Egrets (*Casmerodius albus*). Colonial Waterbirds 14: 176–179. https://doi.org/10.2307/1521508

Wilson RP, Wilson MPT (1988) Foraging behaviour in four sympatric cormorants. Journal of Animal Ecology 57: 943–955. https://doi.org/10.2307/5103

Submitted: 22 June 2017
Accepted: 5 December 2017
Available online: 3 July 2018
Editorial responsibility: Luís Fábio Silveira

Author Contributions: The authors contributed equally to this article.

**Competing Interests:** The authors have declared that no competing interests exist.