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ARTISANAL FISHING DISCARDS AS BIRDS' FOOD RESOURCE IN THE SOUTHERN BRAZIL

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ABSTRACT

Fishing discards have been reported as a source of food for birds, especially in industrial fishing, however little is known if the same occurs with artisanal fishing. In this paper, we test the hypothesis that the discards of artisanal fishing are used by birds as food, including limnic and land species. Between August 2013 and July 2014, 30 observations were made at four observation points, located in southern of Brazil, where the frequency of occurrence, similarity in the use of the resource and the comparison between discards areas were analyzed. A total of 33 bird species and 34 discarded taxa were recorded, with differences between the sampled areas. Four groups of birds were identified: (1) waterbirds that consume food in both environments (seven species); (2) waterbirds that consume food in the aquatic environment (seven species); (3) waterbirds consuming food in the land environment (10 species) and (4) land species (nine species). The aquatic environment had a higher number of discards than the land one. Discards are used by a large number of bird species and their use is determined by the discards area, morphological characteristic and foraging technique of birds. Thus, the study hypothesis was accepted.

Key words: bycatch; food ecology; foraging techniques; niche partitioning.

DESCARTES DA PESCA ARTESANAL COMO RECURSO ALIMENTAR PARA AVES NO SUL DO BRASIL

RESUMO

Descartes pesqueiros têm sido relatados como fonte de alimento para aves, principalmente na pesca industrial, no entanto pouco se sabe se o mesmo ocorre com a pesca artesanal. Nesse trabalho testamos a hipóteses de que os descartes da pesca artesanal são utilizados pelas aves como alimento, incluindo espécies límnicas e terrestres. Entre agosto de 2013 e julho de 2014 foram realizadas 30 observações em quatro pontos de observação localizados no sul do Brasil, onde se analisou a frequência de ocorrência, similaridade na utilização do recurso e a comparação entre locais de descarte. Foram registradas 33 espécies de aves e 34 táxons descartados, com diferenças entre as áreas amostradas. Identificaram-se quatro grupos de aves: (1) aquáticas que consomem o alimento em ambos os ambientes (sete espécies); (2) aquáticas que consomem o alimento no ambiente aquático (sete espécies); (3) aquáticas que consomem o alimento no ambiente terrestre (10 espécies) e (4) terrestres (nove espécies). O ambiente aquático apresentou maior número de descartes em relação ao terrestre. Os descartes são aproveitados por um amplo número de espécies de aves e sua utilização é determinada pelo local de descarte, característica morfológica e técnica de forrageio das aves. Assim, a hipótese de estudo foi aceita.

Palavras-chave: *bycatch*; ecologia alimentar; particionamento de nicho; técnicas de forrageio.

INTRODUCTION

There is a growing increase in the number of papers discussing the influence of fishing (incidental catch or discarding – bycatch) in seabirds, however these publications are mostly related to industrial fishing in oceanic areas (Tasker et al., 2000). Information on the impact of the artisanal fleet and the possible interactions with limnic and land species are scarce (Eckhardt et al., 2012).

In Brazil, there are few studies that refer to the interaction of birds with artisanal fishing (Chiaradia, 1991; Branco, 2001; Krul, 2004; Barbieri and Pinna, 2007; Traversi and Vooren, 2010; Miotto et al., 2017), which only address incidental catches through

gill nets (Vaske-Júnior, 1991). Specific discussions on the use of artisanal fishing discards as a source of food and how this resource is used are nonexistent (Carniel and Krul, 2011; Silva-Costa and Bugoni, 2013).

In southern Brazil, the largest contribution of artisanal fishing activity extends between the estuary of Patos Lagoon (EPL) and the adjacent coastal area of Cassino Beach (ACA), concentrating in this area the vast majority of artisanal fishermen from the state of Rio Grande do Sul (Santos et al., 2016). Discards are a common characteristic among all fishing gears in the region; they can be used as an alternative food source by many animals, especially by icthyophagus and necrophagous birds (Branco, 2001; Furness, 2003; Santos et al., 2016). In this region is home of about 40 species of sea birds, limnic and land, of piscivorous and/or necrophagic feeding habit, who are potential predators of fishing discards (Belton, 1994; Vooren and Chiaradia, 1990).

From this, the objective of this work is to identify the composition of artisanal fishing discards and the birds' fauna that interact with this process, testing the hypothesis that species of limnic and land birds also use this source for their feeding.

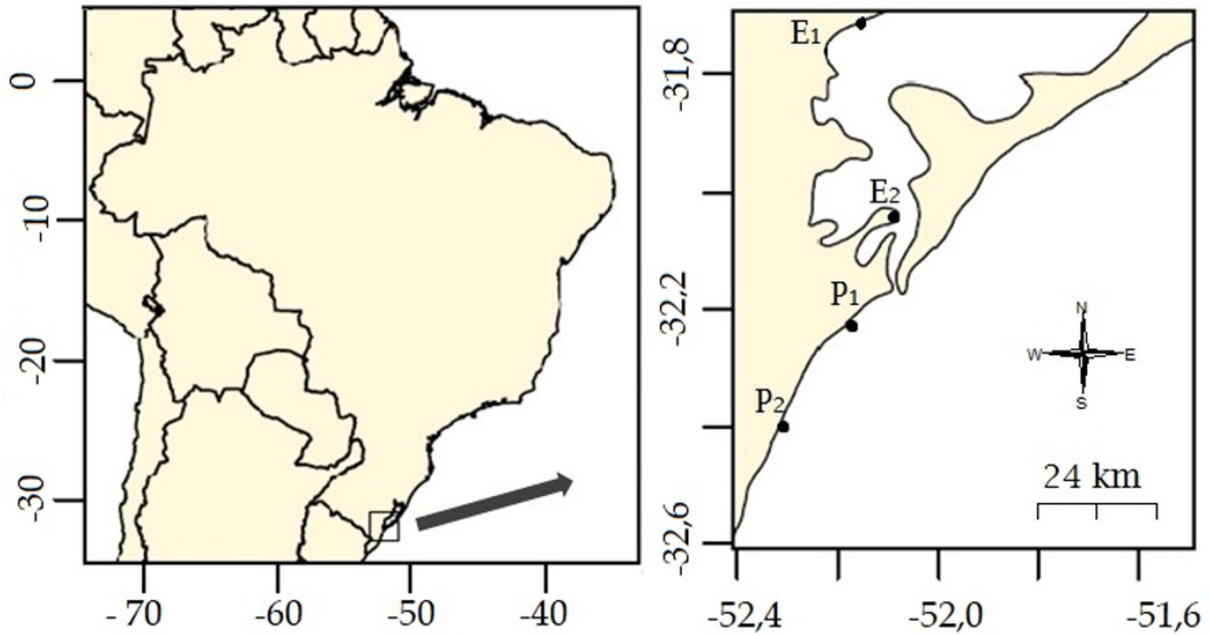

Figure 1. Study area and sampling points (E1 and E2: Patos Lagoon estuary and P1 and P2: adjacent coastal area).

MATERIAL AND METHODS

The study area includes the estuarine and marine artisanal fisheries in the cities of Pelotas and Rio Grande, State of Rio Grande do Sul, along the estuary of Patos Lagoon (EPL) and the adjacent coastal area (ACA) to latitude 32.4 ° S (Figure 1).

The observations were made by the same observer, between August 2013 and July 2014, in four points with different characteristics, two (E1 and E2) in the EPL and two (P1 and P2) in the ACA (Table 1), during the morning period (between 08:00 and 11:00).

Data were recorded from the release of the first discard until consumption of the last piece. At that moment all the birds that consumed some of the discard and the discarded taxa were identified at the species level, according to Piacentini et al. (2015) and Fischer et al. (2011), respectively.

The frequency of occurrence (FO%) for each species of bird and discard at each point was calculated by the ratio of the number of observations of each species and the total number of observations. We used cluster analysis based on the Bray-Curtis index to verify the similarity between the forms of discard capture. We used Student's t test to verify differences in the number of releases of discards between the aquatic and land environment.

Table 1. Description of observation points (P) and observation number (ON) at each point. Lat- Latitude, Long-Longitude, SE-Sampling effort in hours.

P	Lat /Long	Description	ON (SE)
E1	31°41' S/52°9' O	Located in the north of the estuary, near the ciliary forest, swamps and fishing communities (Pelotas)	8 (24)
E2	32°1' S/ 52°5' O	Situated in the center of the estuary, near the urban area, islands, coves and fishing communities (Rio Grande)	8 (24)
P1	32°11' S/52°9' O	Located in the north of Cassino beach, with high anthropogenic presence, near dunes and small streams (Rio Grande)	8 (24)
P2	32°24' S/ 52°20' O	Located 22 km south of P1, with low anthropogenic presence, near dunes and small streams (Rio Grande)	6 (18)

RESULTS

We recorded 33 bird species in a total of 30 observations (Table 1). The families Ardeidae and Laridae were the ones with the highest number of registered species, nine and six, respectively. At species level, *Egretta thula*, *Chroicocephalus maculipennis* and *Larus dominicanus* were present in all observations (100% FO), with a frequency above 50% higher than the second most frequent class.

The bird fauna in EPL was similar to the pattern found in the general analysis; however, with the absence typically marine birds such as *Stercorarius chilensis* and *Macronectes giganteus*, found in ACA. We observed common species in urban and anthropized environments, such as *Coragyps atratus* and *Passer domesticus*. The wealth of birds between the EPL points (E1 and E2) and the ACA (P1 and P2) was very similar; however, in the EPL, the members of the Cathartidae family were recorded in only one point, whereas in the ACA, *Podicephorus major* was recorded only in P1 and *Ciconia maguari* and *Larus atlanticus* were recorded only in P2.

In EPL, the bird fauna was similar to the pattern found in the general analysis, however with the absence of birds typical of marine environment such as *Stercorarius chilensis* and *Macronectes giganteus*, found in ACA. However, there were the presence of common species in urban and anthropized environments, such as *Coragyps atratus* and *Passer domesticus*. The wealth of birds between the EPL points (E1 and E2) and the ACA (P1 and P2) was very similar, however in the EPL the members of the Cathartidae family were recorded in only one point, whereas in the ACA *Podicephorus major* was recorded only in P1 and *Ciconia maguari* and *Larus atlanticus* were recorded only in P2.

Thirty-four discarded taxa were recorded, two crustaceans (*Farfantepenaeus paulensis* e *Callinectes sapidus*), eight elasmobranchs (*Squatina guggenheim, Sphyrna lewini, S. zygaena, Pseudobatos horkelli, Sympterygia acuta, S. bonapartii, Myliobatis goodei, M. ridens*), 23 teleosts (*Hoplias malabaricus, Brevoortia pectinata, Lycengraulis grossidens, Genidens genidens, G. barbus, Porichthys porosissimus, Jenynsia multidentata, Atherinella brasiliensis, Odontesthes sp., Pomatomus saltatrix, Selene vomer, Trachinotus marginatus, Macrodon atricauda, Micropogonias furnieri, Paralonchurus brasiliensis, Pogonias cromis, Stellifer brasiliensis, Mugil sp., Trichiurus lepturus, Peprilus paru, Paralichthys orbignyanus, Catathyridium garmani, Stephanolepis hispidus*) and one cetacean (*Tursiops truncatus*).

The most frequently discarded taxa were *M. furnieri* and *B. pectinata* with 76.7% and 66.7%, respectively. In the EPL the discards were formed mainly by small specimens, containing the two species of crustaceans, limnic fish such as *H. malabaricus*, estuarine such as *G. genidens* and *A. brasiliensis*; and marine species such as hammer sharks *S. lewini* and *S. zygaena*. In contrast, in the ACA region, the discarded specimens were larger, as adult specimens of the stingrays *M. goodei* and *M. ridens* and a newborn of *T. truncatus*. Even the species that were present in the estuary, such as *M. furnieri*, presented this pattern.

The cluster analysis (Figure 2) identified four groups: (1) waterbirds consuming food both on land and in water, seven species; (2) waterbirds consuming food in water, seven species; (3) waterbirds consuming food on land, 10 species and (4) land birds, nine species.

Table 2. Species of birds recorded at observation points, E1, E2, P1, P2, in Pelotas and Rio Grande, State of Rio Grande do Sul, Brazil (Taxonomic order Piacentini *et al.* 2015).

Family	Species	E1	E2	P1	P2	FO%
Podicipedidae	*Rollandia rolland*	X				6.7
	Podicephorus major			X		26.7
Procellariidae	*Macronectes giganteus*			X	X	10.0
	Puffinus puffinus			X	X	10.0
Ciconiidae	*Ciconia maguari*	X	X		X	13.3
	Mycteria americana	X	X			10.0
Phalacrocracidae	*Nannopterum brasilianus*	X	X	X	X	46.7
Ardeidae	*Tigrisoma lineatum*	X	X			3.3
	Nycticorax nycticorax	X	X	X	X	16.7
	Ardea cocoi	X	X	X	X	46.7
	A. alba	X	X	X	X	60.0
	Egretta thula	X	X	X	X	100.0
	E. caerulea	X	X			16.7
Cathartidae	*Cathartes burrovianus*	X				6.7
	C. aura	X				6.7
	Coragyps atratus	X				3.3
Stercorariidae	*Stercorarius chilensis*			X	X	10.0
	S. pomarinus			X	X	6.3
Laridae	*Chroicocephalus maculipennis*	X	X	X	X	16.7

	C. cirrocephalus	X	X	X	X	100.0
	Larus atlanticus				X	6.7
	L. dominicanus	X	X	X	X	100.0
Sternidae	*Sternula superciliaris*	X	X			6.7
	Phaetusa simplex	X	X			6.7
	Sterna trudeaui	X	X			6.7
Columbidae	*Columba livia*		X			26.7
Alcedinidae	*Megaceryle torquata*	X	X			6.7
	Chloroceryle amazona	X	X			10.0
Falconidae	*Caracara plancus*			X	X	50.0
	Milvago chimachima			X	X	46.7
	M. chimango			X	X	13.3
Tyrannidae	*Pitangus sulphuratus*	X	X			26.7
Passeridae	*Passer domesticus*	X	X			26.7
Total	33	23	20	16	17	-

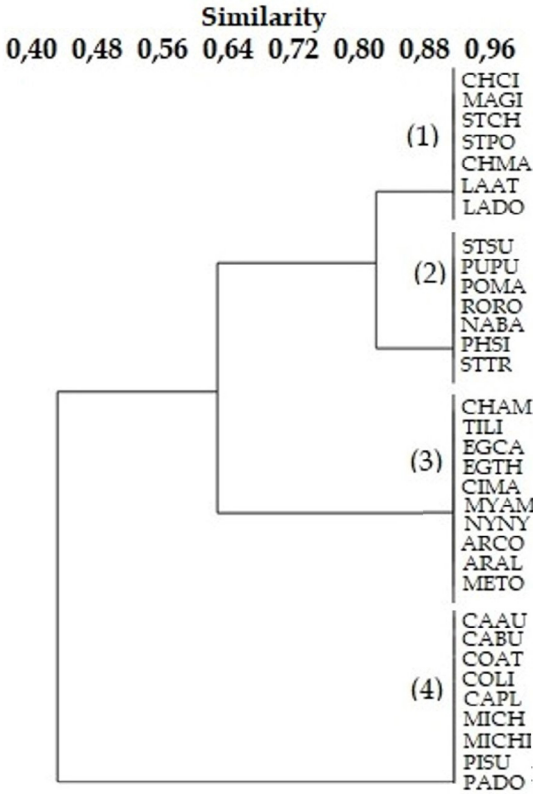

Figure 2. Cluster representing the four food habitat groups of bird species. (1): Waterbirds consuming food both on land and in water – CHCI (*Chroicocephalus cirrocephalus*), MAGI (*Macronectes giganteus*), STCH (*Stercorarius chilensis*), STPO (*Stercorarius pomarinus*), CHMA (*Chroicocephalus maculipennis*), LAAT (*Larus atlanticus*), LADO (*Larus dominicanus*); (2) Waterbirds consuming food in water – STSU (*Sternula superciliaris*), PUPU (*Puffinus puffinus*), POMA (*Podicephorus major*), RORO (*Rollandia rolland*), NABA (*Nannopterum brasilianus*), PHSI (*Phaetusa simplex*), STTR (*Sterna trudeaui*); (3) Waterbirds consuming food in land – CHAM (*Chloroceryle amazona*), TILI (*Tigrisoma lineatum*), EGCA (*Egretta caerulea*), EGTH (*Egretta thula*), CIMA (*Ciconia maguari*), MYAM (*Mycteria americana*), NYNY (*Nycticorax nycticorax*), ARCO (*Ardea cocoi*), ARAL (*Ardea alba*), METO (*Megaceryle torquata*); (4) Land birds – CAAU (*Cathartes aura*), CABU (*Cathartes burrovianus*), COAT (*Coragyps atratus*), COLI (*Columbia livia*), CAPL (*Caracara plancus*), MICH (*Milvago chimachima*), MICHI (*Milvago chimango*), PISU (*Pitangus sulphuratus*), PADO (*Passer domesticus*).

The Student's t test showed significant differences of the number of discards between the aquatic (mean = 5.25) and land environment (mean = 2.91) ($t = 3.06$, d.f. = 6, $p = 0.02$).

DISCUSSION

The present work presents data similar to that found in other regions for *L. dominicanus* and *C. maculipennis* (Branco, 2001). The high values of FO% of seagulls in the consumption of artisanal fishing discards are due to a highly opportunistic and generalist behavior of these species. The main items in their diet are fish from fishing discards, both in limnologic and marine environments (Silva-Costa and Bugoni, 2013)

The contribution of fishery discards to food can reach 73-90% of the items consumed (Oro et al., 1999), however, this resource may be restricting natural foraging tactics and reducing niche partitioning. According to the principle of competitive exclusion, species that occupy similar or identical niches tend to compete, which may result in the local extinction of the less fit competitor (Connell, 1980; Giacomini, 2007).

Moreover, studies affirm that there may be a high index of intraspecific kleptoparasitism with predominance of interactions among adult individuals (Carniel and Krul, 2011), this may alienate juvenile individuals from the feeding areas, reducing discard consumption rates (Martínez et al., 2002; Giaccardi and Yorio, 2004).

There was little difference in species composition between the EPL (E1 and E2) and the ACA (P1 and P2) points, possibly due to the proximity and similarity in the physical structure of the points; however, the pattern was opposite between EPL and ACA, where we recorded 15 species that fed exclusively on discards in the EPL, while eight species were exclusive to the ACA. The presence of large species of opportunistic and necrophagous habit, exclusively in ACA, may be due to the higher deposition of carcasses in the land environment than in the aquatic environment (Carniel and Krul, 2011).

Figure 2 shows the difference in bird composition at each discards area (land or aquatic environment), where a strong grouping of bird species is observed: 1) Opportunistic/generalist species, which consuming discards in both environments; 2) Marine species, which consuming only fish discarded in the aquatic environment; 3) Limnic habit species and piscivorous/opportunistic, which consuming smaller discards in the land environment; and 4) Opportunistic necrophagous species, which feed on the land environment of carcasses and larger parts of the discards.

The different characteristics of fishing gear found in the region influence the place of discard. In the EPL, it is common to observe the discard release in the aquatic environment (lagoon) right after the fishery, mainly in the fishing of gill and bottom trawling. This pattern is modified in days of agitated water, when the discard release occurs in the fishing facilities and the discarding occurs in the land environment (Santos et al., 2016).

In ACA, the main artisanal fishing gear are the gillnet and beach seine, all of which carry out discarding in the region of the beach, thus discarded items can be deposited both in the aquatic environment (ocean) and in the land environment (beach). The variation of the tide can determine the exact location, and consequently the composition of the birds that will interact (Santos and Vieira, 2016).

CONCLUSION

The results obtained here allow to accept the hypothesis of study and emphasize the importance of the discards of the artisanal fishery for the birds. Although some questions are still open for discussion, such as the energy contribution gained, intensity of consumption and possible partitioning of the trophic niche.

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