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Kleptoparasitism in seabirds during interactions with artisanal fisheries on the coast of Paraná, south Brazil

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RESUMO: Cleptoparasitismo em aves marinhas durante interações com a pesca artesanal na costa do Paraná, sul do Brasil. Estudou-se o cleptoparasitismo intra- e interespecífico em aves marinhas e costeiras durante o lançamento de descartes oriundos da frota pesqueira artesanal, em ambiente de praia e mar aberto na costa do Paraná, sul do Brasil. Ao longo deste estudo foram efetuadas 144 contagens em praia (quatro contagens por área, em cada mês), enquanto em mar aberto foram monitoramos 139 eventos de descartes, originados de 22 lances de pesca de arrasto e 113 eventos de descartes a partir de 25 lances de pesca de caceio durante 18 viagens pesqueiras. Foram registrados 512 eventos de cleptoparasitismo na linha de praia (21,87% interespecífico e 78,12% intraespecífico), sendo *Larus dominicanus* a espécie mais abundante e frequente (55,85% e 63,67% respectivamente) envolvida, ocorrendo ataques principalmente entre adultos (65,55%). Em mar aberto, observou 57 eventos de cleptoparasitismo durante 252 eventos de descartes, envolvendo três espécies, a saber: *Sula leucogaster, Fregata magnificens* e *Larus dominicanus*. Notou-se a prevalência (72%) de interações intraespecíficas entre *Sula leucogaster*. *Fregata magnificens* foi responsável pelo maior número de interações interespecíficas, principalmente contra *Sula leucogaster* (75%). As maiores médias foram observadas no período de outono/inverno na linha de praia e durante o verão em mar aberto. O cleptoparasitismo apresentou maior índice de ocorrência durante o período de defeso, quando a pesca de arrasto está proibida, mas a diferença não foi estatisticamente significativa.

PALAVRAS-CHAVE: Cleptoparasitismo; aves marinhas; descartes pesqueiros.

ABSTRACT: Kleptoparasitism in seabirds during interactions with artisanal fisheries on the coast of Paraná, south Brazil. We studied intra- and interspecific kleptoparasitism in seabirds during fisheries discarding on the shoreline, and in areas of the open sea available to the artisanal fisheries on the coast of Paraná in south Brazil. A total of 144 counts were made on the shoreline (four counts per area per month), on the open sea, we monitored 139 discard events during 22 trawling hauls, and 25 driftnet throws of nets with 113 discard events during 18 fishing trips. We observed 512 events of kleptoparasitism on the shoreline (21.87% interspecific and 78.12% intraspecific), the Kelp Gull and *Larus dominicanus* being the most abundant and frequent involved species (55.85% and 63.67%, respectively) with attacks occurring mainly between adults (65.55%). On the open sea, we observed 57 events of kleptoparasitism during 252 discards events involving three species (Brown Booby *Sula leucogaster,* Magnificent Frigatebird *Fregata magnificens* and Kelp Gull *Larus dominicanus*), with a prevalence of intraspecific interactions (72%) between Brown Boobies. Magnificent Frigatebird was responsible for most interspecific interactions, mainly against Brown Boobies (75%). Most kleptoparasitism events were observed during the autumn/winter period on the shoreline and during the summer on the open sea. Kleptoparasitism levels were, on average, higher during periods with moratorium.

KEY-WORDS: Kleptoparasitism; seabirds; fisheries discards.

Consumption of fisheries discards by scavenging seabirds is a well-known phenomenon that has been described for many parts of the world (Arcos *et al.* 2001, Furness 2003) and during these events it is possible to carry out behavioral studies. An example is a widespread phenomenon among birds known as kleptoparasitism (food theft) (Steele and Hockey 1995, Hamilton 2002, Shealer *et al.* 2005) that is particularly common in surface-feeding seabirds (Duffy 1980, Furness 1987, Quintana and Yorio 1999, Dies and Dies 2005). This behavior can be intra- or interspecific (Yates and Broom 2007) and kleptoparasites may steal prey already held by the target

bird, capture eggs or nestlings through aggressive chasing (Oro and Martínez-Vilalta 1994, Finney *et al.* 2001, Dies and Dies 2005, Moralez-Silva and Monteiro-Filho 2008).

Brockmann and Barnard (1979) suggested that kleptoparasitism may be profitable when several ethological and ecological factors, that occured isolated or together: (1) pirates need to be opportunistic with aerobatic flying capabilities; (2) large host concentrations in open habitats must occur and (3) hosts must predictably transport large quantities of food to a fixed location. The majority of kleptoparasitic behavior is facultative, in that the individual or species exhibiting the behavior has alternative

methods of obtaining food (Broom *et al.* 2010), as widely recorded for frigatebirds, that especially attack boobies, tropicbirds, and terns (Furness 1987, Osorno *et al.* 1992, Le Corre and Jouventin 1997). Previous studies have demonstrated that kleptoparasitism success can be influenced by the type and size of prey and by the species and age of the host (Carroll and Cramer 1985, Bertellotti and Yorio 2000, Giaccardi and Yorio 2004, Dies and Dies 2005). In general, young individuals frequently exhibit different feeding strategies and are less efficient in handling prey or in avoiding kleptoparasitism when compared to adults. (Bertellotti and Yorio 1999, Bertellotti and Yorio 2001, Broom *et al.* 2008).

Here we examine intra- and interspecific kleptoparasitism in seabirds during discarding events from the artisanal fisheries on the coast of the state of Paraná in south Brazil, during a two years period. The aims of the present study were to: (1) evaluate kleptoparasitic behavior; (2) verify intra- and interspecific kleptoparasitism in seabirds during fisheries discards on the shoreline and on the open sea, and (3) correlate kleptoparasitism levels with the production of fisheries discards by the artisanal fleet.

MATERIAL AND METHODS

Study site

The study area extended for approximately 107 km along the coast of Paraná (Figure 1), south Brazil, bordered to the north by the Canal of the Varadouro (25°12'S) and to the south by the estuary of the River
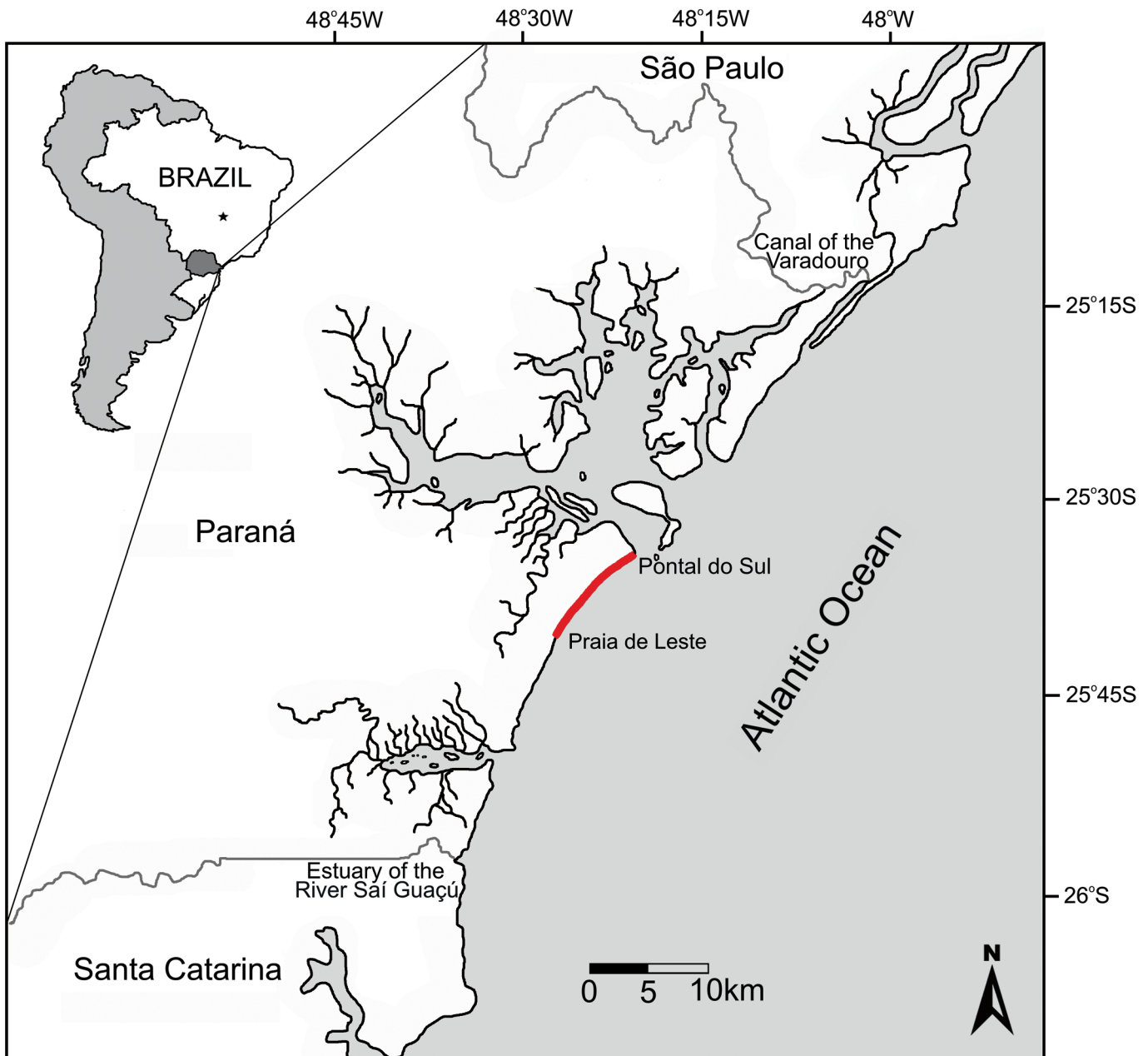

FIGURE 1: Map of the coast of the state of Paraná in south Brazil showing the study areas.

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Saí-Guaçu (25°58'S). This area is characterized by the great extension of the continental shelf, which is mostly covered by sandy substrate. The marine system of the shallow shelf of the coast is under influence of plataform water (*sensu* Emilsson 1959) and continental waters, and in some occasions by intrusions of South Atlantic Central Waters (SACW) (Brandini 1990). Fishing for shrimp and fish in Pontal do Paraná, south Paraná, has been defined as artisanal. The fishery is also wide in scope, provides many jobs, requires a modest per capita capitalization, and supply fish mainly for direct human consumption (Caddy and Griffiths 1995, Andriguetto-Filho 1999).

Bird counts and observations of feeding behaviour on the shoreline

We conducted observations on seabird feeding behavior in January-December 2005 at three different locations: (1) Pontal do Sul, (2) Barrancos and (3) Shangrilá. These areas were chosen because are very representative of the artisanal fishing in this state. Observations extended to approximately 150 meters in each direction from the observer and counting was weekly performed in each sample area. Counts of seabirds started when discarding of species of non-commercial size and by-catch occurred along the shoreline; *i.e.,* when the cleaning and selling of fishes ceased. In addition, counts during the moratorium period for trawling were made during March, April and May.

Observation period varied according to fishermen and their fishing activities. Counts during trawling periods were made from 9:30 am to 2:00 pm, while counts during driftnets activities were made from 10:00 am to 5:00 pm. A total of 144 counts were carried our (four counts in each area in each month) using binoculars (15 x 60).

We counted the numbers of Kelp Gulls *Larus dominicanus* of each recognizable age-group, based on plumage coloration patterns: (1) juveniles (1st year), (2) immatures (2nd year), (3) immatures (3rd year) and (4) adults (*e.g.,* Krul 1999).

Bird counts and observations of feeding behavior on the open sea

We accompanied 18 fishing trips on the open sea in 2006 and counted the number of species and individuals of each species involved in kleptoparasitism in a fishery area that extended from Pontal do Sul to Praia de Leste (Figure 1). Data on the birds scavenging on discards were recorded by making observations using binoculars (15 x 60) from fishing boats during normal trawling and driftnet fishing trips.

We monitored 139 discard events during 22 trawling hauls, and 25 driftnet throws of nets with 113 discard events. Each haul and throw corresponds to a release and retreat of the net into the water. In the same way, each discard event was represented by discards being thrown on the sea surface. For this reason one haul or net throw can be related to more than one discard event. These counts were however dependent on the activities of the fishermen. For example, during a moratorium period of three months, fishermen switched to deploying driftnets rather than trawls.

Statistical analyses

Underlying assumptions of the statistical tests were verified in all cases. Analysis of Variance (ANOVA) was used when data were normally distributed and homogeneous. When ANOVA was not appropriate, the non-parametric Kruskal-Wallis Test was used. Values reported are means ± SE. Differences were considered significant when $P < 0.05$. Post-hoc comparisons were then performed with the LSD test.

RESULTS

On the shoreline

We recorded 512 events of kleptoparasitism on the shoreline during 144 counts, 112 of which were interspecific and 400 (78.12%) intraspecific. Intraspecific events involved Kelp Gulls of all ages and were observed during discard originating from both trawl net and driftnet (shrimp and fish). Kelp Gulls comprised 55.8% of birds observed performing kleptoparasitism and were present in 63.7% of the events (Table 1). Black Vultures *Coragyps atratus* and Snowy Egretts *Egretta thula* were also commonly seen, although their interactions were predominantly intraspecific (78.1% of the cases).

No differences were noted in the occurrence of kleptoparasitism among the three study areas (H = 3.94; $P > 0.05$). Barrancos had the highest mean number of kleptoparasitism events (6.3 ± 1.3), followed by Pontal do Sul (5.7 ± 1.2) and Shangrilá (3.9 ± 0.4).

Rates of kleptoparasitism varied throughout the year (F = 2.58; $P < 0.05$). Post-hoc analyses showed differences between June (7.4 ± 1.9) and March (3.6 ± 1.2), May (4.3 ± 0.7), August (4 ± 0.7) and September (3.6 ± 0.6) ($P < 0.05$; Figure 2).

There were no differences in the average number of kleptoparasitism events among seasons (H = 1.4, $P > 0.05$). The highest average was observed during the autumn and winter (4.5 ± 0.6 and 5.4 ± 0.8, respectively) and the lowest one in the summer (2.3 ± 0.3;

TABLE 1: Relative abundance (%) and relative Frequency (%) of kleptoparasitism in seabirds that interacted with discards on the shoreline, state of Paraná in south Brazil (n = 144 counts).

Species	Relative Abundance	Relative Frequency
Ardea alba	1.4	4.5
Cathartes aura	1.2	0.9
Coragyps atratus	14.4	11.7
Egretta thula	9.4	13.5
Fregata magnificens	7.6	12.6
Larus dominicanus	65.5	55.8
Phalacrocorax brasilianus	0.2	0.9

Figure 3). There was no difference (H = 0.21, P > 0.05) in the number of records between the moratorium period (4.5 ± 0.6) and the open fishing period (4.7 ± 0.6), however in May, when the moratorium period is finishing, the highest number of kleptoparasitism on the shore line was recorded (Figure 4).

Kleptoparasitism events between adult Kelp Gulls were the most common (65.6% of all observations), when
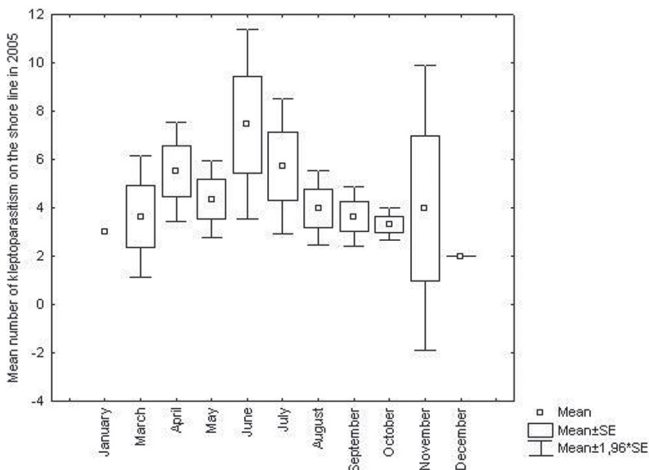

FIGURE 2: Mean number of events of kleptoparasitism on the shoreline in the year 2005 (coast of Paraná, south Brazil).
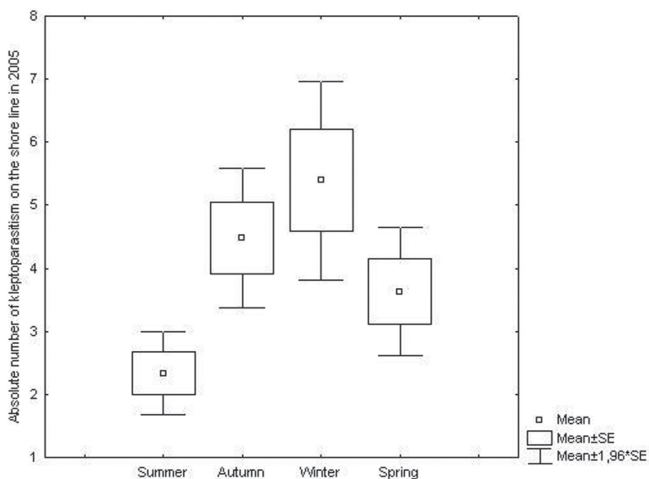

FIGURE 3: Mean number of events of kleptoparasitism on the shoreline across seasons in the year 2005 (coast of Paraná, south Brazil).

compared to all other age-class interactions (< 7.5%). During discards, adult Kelp Gull comprised 86.4% of all the birds observed, while juveniles and immature represented 4.7 and 8.8%, respectively. A weak correlation (Spearman's rank correlation, r = 0.02) were identified between discards production and kleptoparasitism on the shore line in 2005.

On the open sea

We recorded 57 kleptoparasitism interactions during 252 discards events on the open sea, involving three species: Brown Booby *Sula leucogaster,* Magnificent Frigatebird *Fregata magnificens* and Kelp Gull *Larus dominicanus* (Table 2, Figure 5). Brown Boobies were numerically dominant during interactions with fisheries discards and during kleptoparasitism events. In spite of this, the highest levels of interaction during fisheries discards were
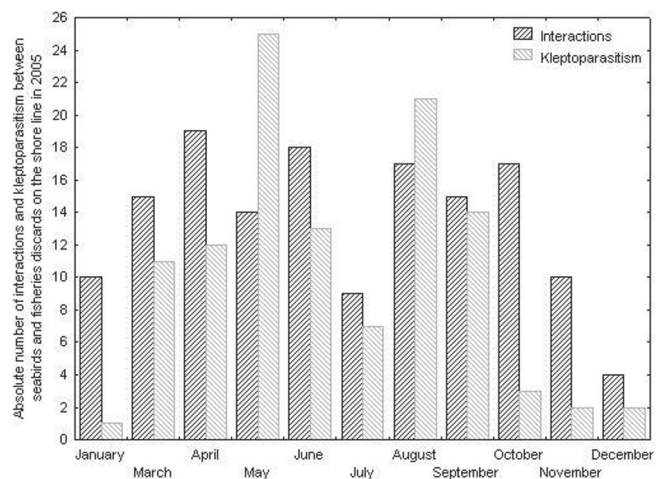

FIGURE 4: Absolute number of interactions and kleptoparasitism between seabirds and fisheries discards on the shore line (coast of Paraná, south Brazil) in each month during 2005.
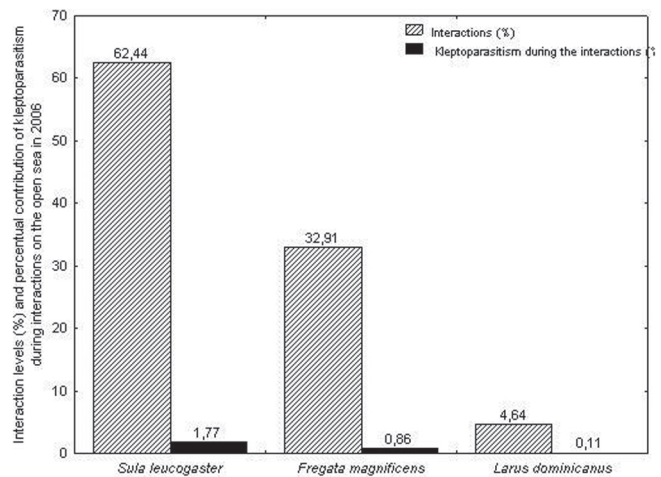

FIGURE 5: Percentage of interactions and kleptoparasitism between seabirds and fisheries discards on the open sea (coast of Paraná in south Brazil) in 2006.

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TABLE 2: Frequency and abundance of seabirds using discards on the open sea, state of Paraná in south Brazil, and their kleptoparasitism levels (%) during this interaction with fisheries discards.

Species	Trawl nets		Driftnets		Kleptoparasitism	
	Frequency	Abundance	Frequency	Abundance	Frequency	Abundance
*Fregata magnificens**	14.3	39.6	10.6	38.8	35.0	31.2
*Larus dominicanus**	3.5	5.3	0.8	3.7	1.7	4.1
Thalasseus sandvicensis	6.4	4.7	0.0	0.0	0.0	0.0
Sterna hirundinacea	0.7	0.2	0.0	0.0	0.0	0.0
Thalasseus maximus	1.4	0.4	0.0	0.0	0.0	0.0
Sterna sp.	1.4	0.4	0.0	0.0	0.0	0.0
Phalacrocorax brasilianus	2.1	0.6	0.0	0.0	0.0	0.0
*Sula leucogaster**	12.9	48.6	8.8	57.4	63.1	64.5

* Species involved in events of kleptoparasitism.

observed in the other two species (Magnificent Frigate-bird and Kelp Gull).

Intraspecific kleptoparasitism were common on the open sea (72% of events), the Brown Booby being the predominant (63%) species during this type of interaction. In contrast, Magnificent Frigatebirds were involved in more interspecific interactions, mainly (75%) targeting Brown Boobies. Kelp Gulls showed an extremely low level of kleptoparasitism and were involved in just two observations of intraspecific interaction among adults (Table 3).

Kleptoparasitism was observed during February, April, July, October and December, with highest levels occurring during the moratorium period (October-December 2006; Figure 6). In February and April we observed a low level of kleptoparasitism (3.5%), with an increase during July (14.01%). However, the highest levels of kleptoparasitism were recorded during October and December, representing the moratorium period in 2006, with percentages of 19.29% and 59.64%, respectively. However, there were no differences in kleptoparasitism levels among months on the open sea (H = 4, P > 0.05).

Also, there were no differences in the level of kleptoparasitism among seasons (H = 0.10, P > 0.05).

The mean number of kleptoparasitism events during trawling and driftnet activities did not differ (F = 0.72, P > 0.05). However, the highest average was observed during driftnet activities (15.6 ± 9.52).
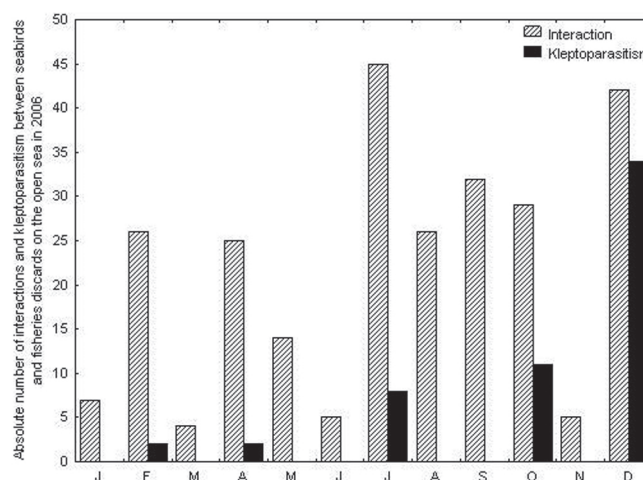

FIGURE 6: Absolute number of interactions and kleptoparasitism between seabirds and fisheries discards on the open sea (Paraná, south Brazil) in each month during 2006.

DISCUSSION

On the shore line

Our study presented novel information about kleptoparasitism levels on the shoreline, since all previous studies evaluated kleptoparasitism in birds on the open sea (Oro and Martínez-Vilalta 1994, Arcos *et al.* 2001, Martínez-Abraín *et al.* 2003, Morand-Ferron *et al.* 2007, Broom *et al.* 2008), and mainly in relation

TABLE 3: Frequency and abundance (%) of seabirds using discards on the open sea, state of Paraná in south Brazil, during events of kleptoparasitism.

Species	Interactions during kleptoparasitism counts		Kleptoparasitism	
	Frequency	Abundance	Frequency	Abundance
Fregata magnificens	80	25.9	35.0	31.2
Larus dominicanus	20	4.3	1.7	4.1
Thalasseus sandvicensis	40	4.0	0.0	0.0
Sterna hirundindo	20	1.3	0.0	0.0
Thalasseus maximus	20	1.6	0.0	0.0
Sterna sp.	20	0.3	0.0	0.0
Phalacrocorax brasilianus	20	1.0	0.0	0.0
Sula leucogaster	100	61.2	63.1	64.5

to kleptoparasitism by gulls (Bertelloti and Yorio 1999, Arcos *et al.* 2001, Garthe and Scherp 2003, Yorio and Caille 2004).

Rates of aerial kleptoparasitism recorded at Pontal do Paraná on the shoreline, in a total of 512 events during the whole year, may be considered high, when compared to others studies. In the Ebro Delta, Spain, Oro and Martínez-Vilalta (1994), recorded 213 kleptoparasitic attacks by Caspian Gulls *Larus cachinnans* on Audouin's Gull *L. audouinii* during 3 months in the breeding period of gulls. Martínez-Abraín *et al.* (2003) observed 21 aerial kleptoparasitism in three colonies of gulls on the western Mediterranean, from April to June in 1994. Finney *et al.* (2001) recorded 103 attack of European Herring Gulls *L. argentatus* and Lesser Black-backed Gulls *L. fuscus* against Atlantic Puffins *Fratercula arctica,* during their breeding season in Scotland in 1999. Dies and Dies (2005) observed 98 aerial pursuits from gulls against Sandwich Terns *Thalasseus sandvicensis* off Eastern Spain in their breeding period, between April and June. The only similar results were observed by Bertellotti and Yorio (2001), who recorded 450 intraspecific kleptoparasitism involving gulls in Argentina, between November 1996 and May 1997. The high number of kleptoparasitism events observed on the shoreline probably occurs because fishermen tend to discard fish in a single pile a few times per day, which can be perceived easily by seabirds. Consequently, and in a very short period of time (a few seconds) seabirds tend flock near these piles, consuming fisheries discards and competing for this resource.

We did not observe any difference in the occurrence of kleptoparasitism among the three study sites, but did notice an inverse relationship among larger amounts discarded and kleptoparasitism, as seen in Shangrilá (Carniel *et al. in prep.*). This inverse relationship also appears to be seasonal, with higher rates of kleptoparasitism occurring during autumn and winter, when fisheries discards are less available compared to summer and spring. It is important to highlight that fisheries discards represent an important resource for seabirds, attracting high number of birds and increasing the chance of competition (Arcos *et al.* 2001). The high levels of discards produced attract seabirds, determining the increase in the number of species and individuals involved in feeding on discards (Furness 2002, Abelló *et al.* 2003, Schwemmer and Garthe 2005).

We observed the highest averages of kleptoparasitism in June, but in relation to absolute number of kleptoparasitism events on the shore line, the highest values occurred during May, which represents the last month of moratorium period on the coast of Paraná. This is in agreement with Oro and Marínez-Vilalta (1994), who observed higher numbers of attacks during the moratorium period in Spain. Our data corroborate the hypothesis raised by Morand-Ferron *et al.* 2007, who proposed

that food stealing may be a form of flexible foraging that allows predators to survive to periods of low food availability. Similarly, several studies showed that a reduction in fishing effort, for example during moratorium periods, intensifies intraspecific and interspecific competition, thus reducing the success of foraging for species with high vulnerability to kleptoparasitism (Camphuysen *et al.* 1995, Oro 1996, González-Solis *et al.* 1997, Regehr and Montevecchi 1997).

Opportunistic species such as Kelp Gulls can benefit from fisheries discard events and are often involved in a majority of aggressive behaviors against other species (Yorio and Caille 2004). In our study, Kelp Gulls was the dominant species during the discard events on the shoreline throughout the year and the main species involved in attacks against other seabirds. This is in agreement with previous studies with other gull species (*e.g.,* Oro and Martínez-Vilalta 1994, Quintana and Yorio 1999, Bertellotti and Yorio 2001, Arcos *et al.* 2001, Wilson and Marston 2002, Martínez-Abraín *et al.* 2003, Giraldeau and Caraco in Broom *et al.* 2008, Dies and Dies 2005).

Previous studies have demonstrated that kleptoparasitism success can be influenced by the age of the birds as seen during this study (Carroll and Cramer 1985, Bertellotti and Yorio 2000, Bertellotti and Yorio 2001, Dies and Dies 2005, Broom *et al.* 2008). Young individuals have lower levels of success in kleptoparasitism compared to adults, and frequently exhibited different feeding strategies. However, Oro and Martínez-Vilalta (1994) and Steele and Hockey (1995) observed that juvenile Kelp Gulls may also show an efficient kleptoparasitic behavior. Our data also pointed that Kelp Gulls of all ages were involved in intraspecific interactions, despite the highest levels of kleptoparasitism have been observed between adults. Oro and Martínez-Vilalta (1994) and Bertellotti and Yorio (2001) observed the dominance of adults attacking juveniles, with percentages of 78.9% and 43% attacks, respectively.

The rate of kleptoparasitism may decrease as food availability increases (Steele and Hockey 1995). However, in the present study the level of kleptoparasitism showed a weak correlation with the discarded volume, and was more intense during the moratorium period. This suggests that the volume of discards produced in the study area is enough to support the local seabird populations, contributing to the low levels of kleptoparasitism.

On the open sea

Brown Boobies were the most frequent species involved in kleptoparasitic events at sea, while Magnificent Frigatebirds were the most common species involved in interspecific interactions. Frigatebirds most commonly kleptoparasitized boobies, in a high level (75%) when

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compared to data from Osorno *et al.* (1992), who reported a total frequency of chases of only 8.7%.

Furness (1987) suggested that the low impact is the condition for the kleptoparasite/host interaction to be evolutionarily stable. Our results from interactions between frigatebirds and boobies are consistent with this hypothesis, being also similar to results from the Western Indian Ocean obtained, where both host and kleptoparasites coexist in large numbers (Le Corre and Jouventin 1997).

In the open sea, kleptoparasitism was observed more intensely during the moratorium period, suggesting that the reduction in the volume of discards increases the competition between seabirds (Oro and Martínez-Vilalta 1994, Camphuysen *et al.* 1995, Oro 1996, González-Solis *et al.* 1997 and Regehr and Montevecchi 1997). While months with trawling usually have 15- canoes fishing close together, during the moratorium period there was a smaller (1-8) number of canoes in the area.

Several factors can influence success rates during kleptoparasitism. For example, the size of the fish carried by seabirds can increase the probability of kleptoparasitism (Ratcliffe *et al.* 1997, Quintana and Yorio 1999, Dies and Dies 2005). Another important factor is that prey cannot be stolen if their handling time is less than the time needed for a kleptoparasitic attack (Steele and Hockey 1995, Broom *et al.* 2008). This may be the reason for the lower level of kleptoparasitism observed in November. During this month we observed just one driftnet throw of net, with few discards produced, they can be overlooked by seabirds on the open sea.

ACKNOWLEDGEMENTS

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