

Heterospecific sociality of birds on beaches from southeastern Brazil

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ABSTRACT. Studies on the sociality of heterospecific assemblages of birds have promoted a greater understanding of the types of interactions and survivorship between coexisting species. This study verified the group compositions in bird assemblages and analyzed the sociality of migratory and resident species on sandy beaches of southeastern Brazil. A transect was established on the median portion of beaches and all the groups of bird species (monospecific, heterospecific) and solitary individuals were registered four days per month from November 2006 to April 2007. The sociality of each species was calculated by its frequency in heterospecific groups, its proportional number of contacts with other species in heterospecific groups, and the number of species that it associated with. Semipalmated Sandpiper *Calidris pusilla* (Linnaeus, 1766) and Semipalmated Plover *Charadrius semipalmatus* Bonaparte, 1825 (both migratory) had the highest degree of sociality and did not show a preference to associate with either residents or migratory species. Sanderling *Calidris alba* (Pallas, 1764) (migratory) occupied the third position in the sociality rank and associated with migratory species frequently. Southern Caracara *Caracara plancus* (Miller, 1777) and Black Vulture *Coragyps atratus* (Beschstein, 1793) (both resident) were uniquely found among heterospecific groups with necrophagous and resident species. Kelp Gull *Larus dominicanus* Lichtenstein, 1823 (resident) associated more frequently with resident species. The sociality in assemblages of birds may promote advantages such as an increased collective awareness in dangerous situations and indication of sites with abundant food sources.

KEY WORDS. Association; competition; heterospecific groups; Nearctic migrants; shorebirds.

Sociality in animals is related with the response of individuals to various features of the environment, including other individuals of the same or different species (BROWN & ORIANI 1970). For birds, open habitats like beaches enhance the facility to detect predators at far distances and have a continuous food supply from the ocean. These features may favor the presence of large groups with variable composition of birds (RECHER & RECHER 1969, TERBORGH 1990).

Assemblages of birds may diminish the risk of predation due to a collective cautious action of some individuals that favor the group (CRESSWELL 1994, ELGAR 1989, MORI *et al.* 2001), and reduce the probability that an individual may be captured by a predator (PIERSMA 1996). Furthermore, certain species of birds attract other individuals in group feeding situations acting as indicators of high quality places to forage (SMITH 1995). In this way, more sociable species may be less vulnerable to predation and experience increased food input encounters due to the tendency to assemble in heterospecific groups. Contrary to these benefits, some authors argue that species may compete aggressively for space in groups where food is abundant, but all these circumstances are also dependent upon the sociality of species, compositions and flocks sizes, different feeding methods of species, and changes in feeding spaces and distribution of food within tidal cycles (RECHER & RECHER 1969, BURGER *et al.* 1977, 2007).

According to BURGER *et al.* (1977), migratory shorebirds may spend most of the year with heterospecific groups and certain species tend to associate in groups consistently. Hence, supplementary natural history information may be of paramount importance to understand species association and interactions of coexisting birds, including temporary ones involving migratory species that come from Nearctic regions every year in non-breeding period and spend several months with resident birds in tropical coast areas (SICK 1997). This study aims: (1) to reveal the group compositions of migratory and resident birds (monospecific, heterospecific and solitarily) and (2) to analyze the sociality of these species along a coastal region of southeastern Brazil.

MATERIAL AND METHODS

The study was conducted on a 9 km section of continual sandy beaches composed of fine granulation sediments in the municipalities of Itanhaém and Peruíbe, along the south coast of state of São Paulo (24°13'-24°16'S, 46°51'-46° 55'W). Climate of the region is subtropical and humid. Mean annual rainfall is 2278 mm with the rainy season occurring from October to April, and the dry season from May to September. Mean annual temperature is 21.4°C, with maximum temperatures averaging 25.8°C and minimum temperatures averaging 19.0°C (TARIFA 2004). The northern portion of the study area is an urban landscape with

residential areas, whereas the southern portion is bordered by the native *restinga* vegetation with shrubs, cacti and terrestrial bromeliads, without intense human occupancy and activities due the absence of residential areas. The relief of the beaches was smooth with low declivity (of 4° to 6°) and moist on most part of the tide line (87 ± 9 m). Only a small portion out from the reach of the tide line (nearly 10 m) was soft and drier.

A transect crossing the middle of the beaches was established and all the groups of bird species (monospecific and heterospecific) and solitary individuals were registered in the morning (8:30-10:30 h) for four days a month from November 2006 to April 2007, totaling 48 hours of observations. Each solitary individual, monospecific or heterospecific group registered was treated as a single contact. The individuals found grouped within an estimated distance less than 5 m to each other on the ground were considered to be a group. This maximum distance of individuals was adopted due to the typical unidirectional movements and cohesion of flocking species when they were perturbed by people or dogs in previous field observations (CESTARI 2008). Groups of flying birds were differentiated when individuals moved in the same direction within a maximum estimated distance of 10 m to each other.

The general term "group" (instead "flock") was employed for all assemblages of birds because some species (i.e. vultures, gulls and falcons) frequently exhibited non-unidirectional movement and lacked cohesion of individuals (HEPPNER 1974).

To discriminate the sociality (S) of species that participated of heterospecific groups, three variables were considered: its frequency in heterospecific groups (Fr), its proportional number of contacts with another species in heterospecific groups (P) and the number of species that it associated with (s). Their relationship is shown in the following formula: $S = Fr.P.s$.

The species frequency (Fr) was obtained by dividing its number of contacts in heterospecific groups (n) and its total sum of contacts in heterospecific groups, monospecific groups and solitary individuals (N). The Fr's were multiplied by 100 to obtain percentage values – $Fr = (n/N).100$.

The species proportional number of contacts with other species in heterospecific groups (P) was obtained by dividing its number of contacts with another species in heterospecific groups (p_1), and the total number of contacts of all species in heterospecific groups (p_t). The P's were multiplied by 100 to obtain the percentage values – $P = (p_1/p_t).100$.

The sociality (S) favors the qualitative aspect of interspecific interactions being directly proportional with the species frequency in heterospecific groups (Fr), the proportional number of contacts in heterospecific groups (P), and the number of associated species (s). A plentiful species in terms of abundance may not be necessarily more social if does not fit these variables. For example, following the sociality formula ($S = Fr.P.s$), species A with 2,000 individuals registered in 10 heterospecific groups, thirty monospecific groups and two solitaires [$Fr = (10/42). 100$], with $p_1 = 20$ in a $p_t = 80$ [$P = (20/80). 100$] and associated with three

species ($s = 3$) is nearly twenty-two times less social ($S = 1.785$) than species B with 200 individuals registered in 30 heterospecific groups, two monospecific groups and one solitary [$Fr = (30/33). 100$], with $p_1 = 50$ in a $p_t = 80$ [$P = (50/80). 100$] and associated with seven species ($s = 7$), totaling $S = 39.769$.

Chi-square test (χ^2) with Yates correction was applied to verify if p_1 with migratory and resident species for each species were significant. The significance $\alpha \pm = 5\%$ was established for all the analyses and only species with 10 or more contacts were analyzed in this study. Occurrence status (resident or migratory) of the bird species follows the list of Brazilian Ornithological Committee (CBRO 2008).

RESULTS

Fourteen resident species Magnificent Frigatebird *Fregata magnificens* Mathews, 1914, Fregatidae, Great Egret *Ardea alba* Linnaeus, 1758, Ardeidae, Snowy Egret *Egretta thula* (Molina, 1782), Ardeidae, Turkey Vulture *Cathartes aura* (Linnaeus, 1758), Cathartidae, Black Vulture *Coragyps atratus* (Beschstein, 1793), Cathartidae, Southern Caracara *Caracara plancus* (Miller, 1777), Falconidae, Southern Lapwing *Vanellus chilensis* (Molina, 1782), Charadriidae, Collared Plover *Charadrius collaris* Vieillot, 1818, Chadriidae, American Oystercatcher *Haematopus palliatus* Temminck, 1820, Haematopodidae, Wattled Jacana *Jacana jacana* (Linnaeus, 1766), Jacanidae, Kelp Gull *Larus dominicanus* Lichtenstein, 1823, Laridae, Royal Tern *Thalasseus maximus* (Buddaert, 1783), Sternidae, Black Skimmer *Rhynchops niger* Linnaeus, 1758, Rhyncopidae, Rock Dove *Columba livia* Gmelin, 1789, Columbidae and six non-breeding Nearctic migratory species American Golden Plover *Pluvialis dominica* (Statius Muller, 1776), Charadriidae, Semipalmated Plover *Charadrius semipalmatus* Bonaparte, 1825, Charadriidae, Ruddy Turnstone *Arenaria interpres* (Linnaeus, 1758), Scolopacidae, Red Knot *Calidris canutus* (Linnaeus, 1758), Scolopacidae, Sanderling *Calidris alba* (Pallas, 1764), Scolopacidae, Semipalmated Sandpiper *Calidris pusilla* (Linnaeus, 1766), Scolopacidae were registered. A total of 3,868 individuals of these two statuses formed 806 contacts of monospecific groups and heterospecific groups, but 250 individuals were solitary. *A. alba* (one contact), *C. aura*, *C. collaris* and *R. niger* (two contacts each species), *C. canutus* and *J. jacana* (three contacts each species), *A. interpres* and *F. magnificens* (eight contacts each species) were excluded from the analyses due to a low number of contacts. The rest of the species with more than 10 contacts were registered participating in monospecific groups, heterospecific groups and solitarily (Tab. I).

Considering the heterospecific groups, *C. semipalmatus* had the highest number of contacts with 13 species ($P = 31.6\%$, $p_1 = 101$). *C. pusilla* ($P = 17.5\%$, $p_1 = 56$) and *C. alba* ($P = 10.9\%$, $p_1 = 35$) had the second and third highest number of contacts with other species (Tab. II). Including the total frequency of contacts (Fr) in heterospecific groups and the total number of associated species (s) in the analyses, *C. pusilla*, *C. semipalmatus* and *C. alba* had the highest degree of sociality, respectively (Fig. 1).

Table I. Bird species and its distribution in monospecific groups, heterospecific groups and solitary registered on the south coast from São Paulo State, Brazil. (C) Number of contacts, (I) number of individuals, (AI) average individuals, (SD) standard deviation.

Species	Monospecific groups			Heterospecific groups			Total groups			Solitaries		Total Contacts
	C	I	AI (± SD)	C	I	AI (± SD)	C	I	AI (± SD)	C		
Fregatidae												
<i>Fregata magnificens</i> (Mathews, 1914)*	5	12	2,4 ± 0,49	0	0	0	5	12	2,4 ± 0,49	3	8	
Ardeidae												
<i>Ardea alba</i> (Linnaeus, 1758)*	0	0	0	1	1	–	1	1	–	0	1	
<i>Egretta thula</i> (Molina, 1782)	27	111	4,11 ± 4	5	8	1,75 ± 0,96	32	119	3,80 ± 3,83	48	80	
Cathartidae												
<i>Cathartes aura</i> (Linnaeus, 1758)*	1	2	2	0	0	–	1	2	2	1	2	
<i>Coragyps atratus</i> (Beschstein, 1793)	22	152	6,9 ± 8,93	3	38	12 ± 17,35	25	190	7,52 ± 9,88	4	29	
Falconidae												
<i>Caracara plancus</i> (Miller, 1777)	7	23	3 ± 2	2	14	7 ± 8,48	9	37	4 ± 4,07	8	17	
Charadriidae												
<i>Vanellus chilensis</i> (Molina, 1782)	30	71	2,35 ± 1,02	4	17	3,4 ± 2,3	34	87	2,5 ± 1,28	25	59	
<i>Charadrius collaris</i> (Viellot, 1818)*	0	0	0	2	2	1	2	2	1	0	2	
<i>Pluvialis dominica</i> (Statius Muller, 1776)	2	5	2,67 ± 0,58	12	41	3,15 ± 1,52	14	46	3,06 ± 1,39	3	17	
<i>Charadrius semipalmatus</i> (Bonaparte, 1825)	250	1325	5,48 ± 5,65	76	721	9,49 ± 12,26	326	2046	6,4 ± 7,85	53	379	
Haematopodidae												
<i>Haematopus palliatus</i> (Temminck, 1820)	23	54	2,42 ± 1,22	6	19	2,71 ± 2,06	29	73	2,5 ± 1,45	5	34	
Scolopacidae												
<i>Arenaria interpres</i> (Linnaeus, 1758)*	1	2	2	7	12	1,33 ± 0,70	8	14	1,4 ± 0,7	0	8	
<i>Calidris canutus</i> (Linnaeus, 1758)*	0	0	0	3	5	1,67 ± 0,58	3	5	1,67 ± 0,58	0	3	
<i>Calidris alba</i> (Pallas, 1764)	1	11	11	24	83	2,33 ± 1,68	25	94	2,68 ± 2,39	0	25	
<i>Calidris pusilla</i> (Linnaeus, 1766)	7	31	4,43 ± 2,93	42	139	3,3 ± 5,28	49	170	3,47 ± 5	2	51	
Jacaniidae												
<i>Jacana jacana</i> (Linnaeus, 1766)*	0	0	0	3	3	1	3	3	1	0	3	
Laridae												
<i>Larus dominicanus</i> (Lichtenstein, 1823)	56	293	5,05 ± 4,72	23	320	11,03 ± 12,55	79	613	7,02 ± 8,58	74	153	
Sternidae												
<i>Thalasseus maximus</i> (Buddaert, 1783)	3	65	21,67 ± 26,65	13	125	9,61 ± 11,28	16	81	11,87 ± 14,84	1	17	
Rhyncoptidae												
<i>Rhyncops niger</i> (Linnaeus, 1758)*	0	0	0	1	2	–	1	2	–	1	2	
Columbidae												
<i>Columba livia</i> (Gmelin, 1789)	61	269	4,41 ± 3,51	1	2	–	62	271	4,37 ± 3,5	22	84	

* Species excluded of the analyses (number of total contacts < 10).

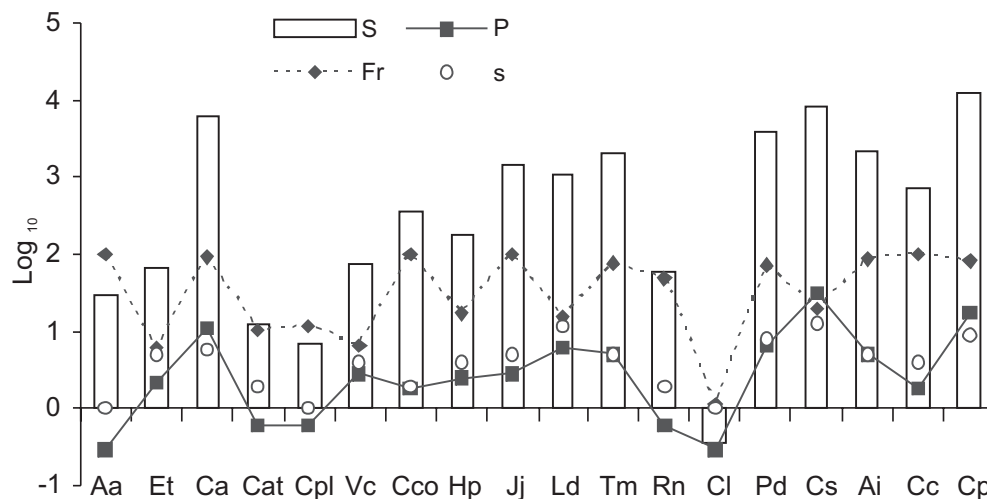


Figure 1. Sociality (S), frequency in heterospecific groups (Fr), proportional number of contacts with another species in heterospecific groups (P) and the number of species that each registered species interacted (s) on the south coast from São Paulo State, Brazil. The Y axis values were converted in logarithm scale (\log_{10}). Letters in the X axis means scientific names that are described on the legend of table II.

Table II. Number of contacts between species that participated of heterospecific groups in southeastern coast, Brazil. (p1) number of contacts with another species in heterospecific groups; (s) total number of interacted species; (Cs) *C. semipalmatus*, (Cp) *C. pusilla*, (Ca) *C. alba*, (Tm) *T. maximus*, (Ai) *A. interpres*, (Pd) *P. dominica*, (Ld) *L. dominicanus*, (Vc) *V. chilensis*, (Jj) *J. jacana*, (Cc) *C. canutus*, (Et) *E. thula*, (Hp) *H. palliatus*, (Cco) *C. collaris*, (Cl) *C. livia*, (Cpl) *C. plancus*, (Cat) *C. atratus*, (Aa) *A. alba*, (Rn) *R. niger*.

	Cs	Cp	Ca	Tm	Ai	Pd	Ld	Vc	Jj	Cc	Et	Hp	Cco	Cl	Cpl	Cat	Aa	Rn
Cs	x	35	22	12	8	7	3	3	2	2	2	2	2	1	0	0	0	0
Cp	35	x	6	0	1	4	1	3	3	1	0	0	2	0	0	0	0	0
Ca	22	6	x	0	3	2	1	0	0	1	0	0	0	0	0	0	0	0
Tm	12	0	0	x	0	1	1	0	0	0	1	2	0	0	0	0	0	1
Ai	8	1	3	0	x	2	2	0	0	0	0	0	0	0	0	0	0	0
Pd	7	4	2	1	2	x	2	0	0	2	0	2	0	0	0	0	0	0
Ld	3	1	1	1	2	2	x	1	1	0	2	4	0	0	0	1	0	1
Vc	3	3	0	0	0	0	1	x	2	0	0	0	0	0	0	0	0	0
Jj	2	3	0	0	0	0	1	2	x	0	1	0	0	0	0	0	0	0
Cc	2	1	1	0	0	2	0	0	0	x	0	0	0	0	0	0	0	0
Et	2	0	0	1	0	0	2	0	1	0	x	0	0	0	0	0	1	0
Hp	2	0	0	2	0	2	4	0	0	0	0	x	0	0	0	0	0	0
Cco	2	2	0	0	0	0	0	0	0	0	0	0	x	0	0	0	0	0
Cl	1	0	0	0	0	0	0	0	0	0	0	0	0	x	0	0	0	0
Cpl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x	2	0	0
Cat	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	x	0	0
Aa	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	x	0
Rn	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	x
p1	101	56	35	17	16	22	20	9	9	6	7	8	4	1	2	3	1	2
s	13	9	6	5	5	8	12	4	5	4	5	4	2	1	1	2	1	2

No species with more than 10 contacts associated with heterospecific groups formed exclusively by migration. Only *C. alba* (migratory) associated frequently with migratory species ($\Sigma\chi^2_{(1)} = 9.19$, $p = 0.024$, $n = 34$), mainly with *C. semipalmatus* ($p_1 = 22$, nearly 63% of total contacts, Tab. II).

Caracara plancus and *C. atratus* constituted heterospecific groups formed uniquely by resident species and, *L. dominicanus* (resident) interacted more with resident species ($\Sigma\chi^2_{(1)} = 8.34$, $p = 0.039$, $n = 11$, Tab. II). *Columba livia*, an exotic and resident species in Brazil, associated only in one group with *C. semipalmatus*, a migratory species (Tab. II).

DISCUSSION

Three migratory species *C. pusilla*, *C. semipalmatus* and *C. alba* displayed similar frequency in heterospecific groups (Fr), number of contacts with another species (P) and number of species interacted (s) that reflected their highest sociality. Additionally, *C. pusilla* and *C. semipalmatus* participated of heterospecific groups with no significant preference of association with either residents or migratory species. *In route*, migratory birds face a myriad of ecological and physiological challenges (SKAGEN 2006) and as a rule, the social plasticity with other species may be important to explore among habitats with a high richness of birds (migratory or not) during their permanence in wintering areas. Despite the general occurrence of ecological division of coastal bird species by the feeding niches available during different times of the year (VOOREN & CHIARADIA 1990), interspecific competition for space and food may exist (PRAVOSUDOV *et al.* 1994, BURGER *et al.* 2007). However, advantages such as the decrease in predation risk (ELGAR 1989), reduction of the probability that an individual be captured by a predator (PIERSMA 1996), and the indication of suitable habitats where the birds are concentrated (SMITH 1995) would compensate for these negative challenges.

Interspecific agonistic behaviors are less frequent than intraspecific encounters due to probable differences in morphological aspects and ecological tactics molded by evolutionary processes in distinct species (RECHER & RECHER 1969). Competitions for food between distant related species are rarely registered (ATKINS 1980, BURGER 2007) and the majority of studies on avian resource sharing have assumed that competition will be most severe between closely related forms (RECHER & RECHER 1969). According to MATTHYSEN (1994), the relative number of individuals per species decreases in a heterospecific group when the number of species per group increases. In this way aggregation of sociable species increasing the richness in heterospecific groups may be important collectively in reducing intraspecific competitions due to the common indifference to compete between species in groups (RECHER & RECHER 1969). Furthermore, the more sociable species may benefit when they are temporarily refueling with other species and cannot flee to suitable areas, even in rare situations of highly competitive places, in low quality staging sites or bad physiological conditions (GILL *et al.* 2001).

Despite its high sociality, *C. alba* showed preference to join with migratory species. SICK (1997) mentioned the frequent association of *C. alba* in heterospecific groups of Nearctic birds on the peak period of migration. Nearctic birds breed in North America during the summer moving to South America in the winter to feed and rest (SICK 1997, LARRAZÁBAL *et al.* 2002). The association of Nearctic migratory birds is related to the same stopover sites used along the route of Brazilian Atlantic coast. According to SICK (1997), Nearctic birds arrive in Brazil mainly along the Atlantic coast and the Amazon basin (north and northeastern regions), and crossing the country at the Patagonian southern extreme point in Argentina. LYRA-NEVES *et al.* (2004), showed the use of Atlantic route by *C. alba* in a observation study carried out at Coroa do Avião (northeast coast of Brazil) to recover codes established in the Pan-American Shorebirds Program. They used three places on the Atlantic route where individuals were ringed: Coroa do Avião (northeastern Brazil), Lagoa do Peixe (southern Brazil) and Maranhão (northern Brazil). Proving it, some authors registered the majority of Nearctic species of this study (*C. semipalmatus*, *C. alba*, *C. pusilla*, *C. canutus*, *A. interpres* and *P. dominica*) along the Brazilian coast in north (RODRIGUES 2000), northeast (TELINO-JUNIOR *et al.* 2003, CABRAL *et al.* 2006), southeastern (OLMOS & SILVA 2001, BARBIERI & MENDONÇA 2005) and south (VOOREN & CHIARADIA 1990, BRANCO *et al.* 2004) regions.

Among the migratory species, *C. alba* had a higher number of proportional contacts with *C. semipalmatus*. These species share intertidal areas, but they avoid competition during foraging differently. *C. alba* foraged more tactilely than visually by frequently probing its bill in the sand. According to PIERSMA (1996), this species has an array of sensory receptors in the bill tips that allow it to detect the vibrations of small polychaetes at distances of 2 cm from the bill tip. *C. semipalmatus* fed by sight and waited for prey on the surface of the ground, sometimes trembling the feet to reveal a prey.

The resident *C. plancus* and *C. atratus* were observed feeding on dead animals (mainly fish) in heterospecific groups (including *L. dominicanus*,) on the beaches of this region. Interactions between scavenger species are common when dead animals are encountered. In this context, considering the overlap of diets that include carcasses, no other function beyond competition for food is attributed for grouping of these resident species. Probably the assemblages of individuals around the food attract more individuals (SMITH 1995) and hierarchy dominance based mainly on body size between these scavenger species may exist to mitigate competition (WALLACE & TEMPLE 1987).

Larus dominicanus (resident) had a significant number of contacts while resting in heterospecific groups with residents (*T. maximus*, *R. niger*, *V. chilensis*, *E. thula*, and *H. palliatus*) along the tide line or feeding upon carcasses (registered once in association with *C. atratus*) on upper beach. Its presence during the year on the southeast Brazilian coast (BARBIERI & MENDONÇA 2008) probably influenced the customary association with other

resident species. VOOREN & CHIARADIA (1990) cited frequent association between *L. dominicanus* and *T. maximus* in groups with more than 50 individuals resting on a beach in south coast of Brazil. It's feasible that *L. dominicanus* associates in heterospecific groups as a defense strategy when resting (BARBIERI & PINNA 2007). Some species members that associated in groups, such as *T. maximus*, *R. niger* and *H. palliatus*, are lesser in body weight and have a higher capacity to escape in dangerous situations than *L. dominicanus* providing an early warning system. Observations in this study revealed that these features may offer reasons why *L. dominicanus* was observed fleeing first in circumstances of humans and domestic dog approximation.

SICK (1997) cited the necrophagous behavior of *L. dominicanus* feeding on animal carcasses and garbage along the beach, as observed in this study. According to BARBIERI & MENDONÇA (2008), this species may be favored due to its opportunistic behavior in feeding upon waste from shrimp fishing and other human actions that increase dead marine organisms on the beaches of southeastern coast region. In this study, *L. dominicanus* associated with *C. atratus* only to feed on a big dead fish, keeping far from the group when the number of vultures exceeded four individuals.

Columba livia (resident) was observed once with *C. semipalmatus* (migratory) in a feeding situation. This species was introduced as domestic bird in Brazil in the 15th century and quickly adapted to anthropogenic places (SICK 1997). Normally this opportunistic dove is encountered in monospecific groups feeding on the remains of human food (bread, peanuts and appetizers) discarded on the beach. Its unique contact of association with *C. semipalmatus* was probably due to a high concentration of food section on the beach. *C. semipalmatus* forages for polychaete worms, small gastropods, crustaceans and insects (WIERSMA 2000) and its diet differs broadly of *C. livia* eliminating any possible competition.

Studies on sociality of coastal species are scarce, and this study provides a background to measure it in further analyses, and to better understand the associations and interactions between coexisting birds. Previously available information indicated less inter-specific agonistic behavior than in intra-specific contacts in birds (RECHER & RECHER 1969). Despite the differences in morphological and ecological aspects, when competition emerges more sociable species may have survivorship advantages over less sociable individuals.

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