Ararajuba 6(2):110-116
dezembro de 1998

Richness, abundance and seasonality of bird species in a lagoon of an urban area (Lagoa Rodrigo de Freitas) of Rio de Janeiro, Brazil

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Recebido em 24 de dezembro de 1997; aceito em 25 julho de 1998.

RESUMO. **Riqueza, abundância e sazonalidade de aves em uma lagoa em área urbana (Lagoa Rodrigo de Freitas) no Rio de Janeiro, RJ, Brasil.** Estimamos a riqueza e a abundância de aves da Lagoa Rodrigo de Freitas, RJ, no período de maio de 1996 a abril de 1997. Dentre as 31 espécies registradas, nove foram categorizadas como aquáticas e 22 como terrestres. Nove espécies foram residentes (presentes em 10 ou mais meses do ano) e as demais foram consideradas visitantes. A riqueza mensal de espécies foi relativamente constante ao longo do ano para as espécies aquáticas (variando de 5 a 8 espécies), porém variou mais para as espécies terrestres (7 a 13 espécies). A abundância média das aves aquáticas (148 ± 71,5) foi aproximadamente duas vezes maior que a abundância média das aves terrestres (66 ± 28,3). A abundância foi significativamente maior na estação seca do que na chuvosa para as aves aquáticas (teste de Kruskal-Wallis, H = 8,31, p = 0,004, N = 6), ao contrário das aves terrestres, cuja abundância foi significativamente maior na estação chuvosa do que na estação seca (H = 4,33, p = 0,04, N = 6). Não houve correlação significativa entre a abundância de aves e a pluviosidade do período de estudo para as aves aquáticas e para as terrestres. Entretanto, houve correlação negativa significativa entre a abundância e a pluviosidade das normais climatológicas para as aves aquáticas (r = - 0,80, p = 0,002, N = 12), o contrário ocorrendo para as aves terrestres, cuja correlação foi positiva, porém não significativa (r = 0,48, p = 0,11, N = 12). As aves aquáticas (*Phalacrocorax brasilianus, Fregatta magnificens, Ardea cocoi, A. alba, Egretta thula, Butorides striatus, Nycticorax nycticorax, Larus dominicanus* e *Ceryle torquata*) utilizaram a lagoa apenas como local para busca de alimento, enquanto as aves terrestres, além de sítio de forrageio, utilizaram-na como sítio de nidificação, o que foi indicado por ninhos de *Vanellus chilensis, Fluvicola nengeta* e *Coereba flaveola*, encontrados na vegetação às margens da lagoa. Os resultados sugerem que as aves que utilizam a lagoa não estão ajustando seus ciclos anuais pelas chuvas no período de 12 meses, mas a abundância das populações da comunidade de aves local se ajusta a um padrão de precipitação a longo termo.
PALAVRAS-CHAVE: aves urbanas, aves lacustres, comunidade, lagoa, sazonalidade, Rio de Janeiro.

ABSTRACT. We estimated the richness and abundance of the bird community in a lagoon of an urban area, Lagoa Rodrigo de Freitas, Rio de Janeiro, Brazil, from May 1996 to April 1997. We recorded 31 species, including 9 aquatic species and 22 land birds. Nine species were residents (registered in at least 10 of the 12 sampled months) and the others were considered visitors. The richness of aquatic species (varying from 5 to 8 species), per month, was similar throughout the year whereas land birds varied from 7 to 13 species. The average abundance of aquatic species (148 ±71.5) was approximately twice that of the terrestrial ones (66 ± 28.3). Abundance was significantly higher in the dry season than in the wet season for the aquatic species (Kruskal-Wallis test, H = 8.31, p = 0.004, N = 6), but the abundance of land species was significantly higher in the wet season compared to the dry season (H = 4.33, p = 0.04, N = 6). There was no significant correlation between abundance of aquatic birds and rainfall during the study period. However, there was a significant negative correlation between abundance of aquatic birds and rainfall using the climatological means (r = - 0.80, p = 0.002, N = 12). The opposite was found for land species, which showed a positive but non-significant correlation between abundance and rainfall using the climatological means (r = 0.48, p = 0.11, N = 6). Aquatic birds (*Phalacrocorax brasilianus, Fregatta magnificens, Ardea cocoi, A. alba, Egretta thula, Butorides striatus, Nycticorax nycticorax, Larus dominicanus* and *Ceryle torquata*) used the lagoon only as a source of food, while land species used it also for breeding, as indicated by nests of *Vanellus chilensis, Fluvicola nengeta* and *Coereba flaveola* found on the lagoon borders. The results suggest that the birds using the lagoon are not timing their annual cycles according to the 12-month period rainfall, but rather, that trends in population abundance of the local bird community are adjusted by means of a long-term precipitation pattern.
KEY WORDS: urban birds, community, lagoon, seasonality, Rio de Janeiro.

Lagoons are considered important for many bird species as a source of food and places for breeding, particularly for waders, and also serve as resting places during migratory movements. In Brazil we have several important locations for migratory birds, including lagoons. In the Southeastern Region, however, wetlands have been seriously affected by urban development, recreation and tourism (Antas *et al.* 1986). Studies of bird communities in lagoons deal mainly with species composition and censuses, and few studies have focused on interactions between populations and seasonal fluctuations (Riveros *et al.* 1981). Many food resources are seasonal and many species, including birds, have seasonal fluctuations linked to the abundance of these resources. In tropical birds, the breeding cycle is usually associated with food availability, such as insects, which usually depends on precipitation (Moreau 1950, Wolda 1980, Tanaka and Tanaka 1982, Sick 1997).

Recently, urban locations, such as public gardens and parks, have been used by researchers to study bird communities (Emlen 1974, Gavareski 1976, Argel-de-Oliveira 1995, Matarazzo-Neuberger 1995, Monteiro and Brandão 1995) because urbanization and subsequent habitat fragmentation is increasing at high rates. Therefore, parks, gardens and lagoons are potentially different habitats that offer opportunities to study bird communities and to understand the changes due to the urbanization process

(Gavareski 1976). In this study we estimated richness and abundance of bird species over a year and compared these parameters between dry and wet seasons in a lagoon of an urban area of Rio de Janeiro, which is close to Parque Nacional da Tijuca, an area of Atlantic Forest.

STUDY AREA

The study was carried out at Lagoa Rodrigo de Freitas, located in Rio de Janeiro (22°57'02'' and 22°58'09'' S; 43°11'09'' and 43°13'03'' W;), between the mountains Cantagalo, Cabritos and Saudade in the east, Corcovado and Sumaré in the north, and Ipanema and Leblon in the south (figure 1). This lagoon, which belongs to a chain of 11 large fresh to brackish coastal lagoons behind the sea beach, from Lagoa de Jacarepaguá in the west to Lagoa de Araruama in the east, is separated from the sea by a sand strand, and sea water enters the lagoon by a channel locally called Jardim de Alá. It has an approximate surface of 233 ha and a water volume of 6,990,000 m^3 with maximum depth of 4.3 m (Brito and Lemos 1982). The lagoon has an irregular shape with a perimeter of approximately 7.2 km. The average rainfall of Rio de Janeiro city for 30 years (1961-1990) was of 1,172.9 mm, whereas the average temperature of this period was 23.7°C (max. = 27.2°C and min = 21.0°C) (Ministério da Agricultura e Reforma Agrária 1992).

There is little water circulation in the lagoon, which creates anaerobic conditions (Brito and Lemos 1982). Besides that, with the urbanization process, the lagoon border has been filled in with soil several times. Therefore, its area has decreased and also suffered organic pollution, although the main problem seems to be pollution due to the material carried in by rain from the shanty-towns and drainage from nearby quarters (Brito and Lemos 1982).

This lagoon is used for leisure purposes and is surrounded by buildings and streets with intense traffic; it is also close to a National Park, Parque Nacional da Tijuca. The lagoon is undergoing treatment through the efforts of the local government to remove organic material from the surface (which increases oxygenation) and to recover the edges, using mangrove vegetation.

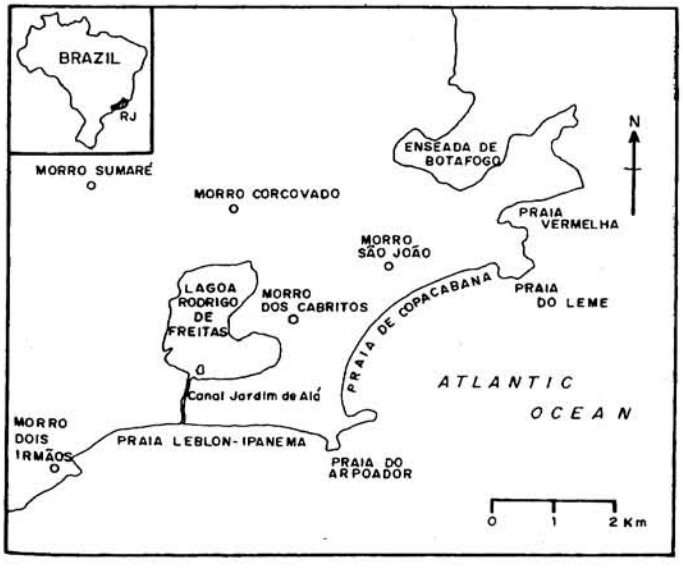

Figure 1. Map of the study area, Lagoa Rodrigo de Freitas, Rio de Janeiro, Brazil.

METHODS

A lacunar system comprises not only the aquatic portion but also the partially flooded vegetation inside it and along the margins (Esteves 1988). To better characterize the bird community of Lagoa Rodrigo de Freitas, we considered here, as part of such a community, not only the aquatic birds but also those species associated with the partially flooded vegetation, as well as with the ground and vegetation along the margins.

We observed the birds monthly between May 1996 and April 1997. We divided the lagoon into six imaginary sections, each one with an approximate extent of 1,200 m along the border and the corresponding water portion. We used these sections of the border as a transect which was made monthly by an observer at a regular walking pace. We observed the bird species present in these areas and censused them using binoculars (8 x 40). Bird density was estimated using the total area of the lagoon for the aquatic birds. We included in the censuses birds seen within a distance of 10 m from the water edge.

During each month we made two transects: one in the morning (06:00 - 10:00 h) and another in the afternoon (14:00 - 18:00 h). Fortnightly we walked along the lagoon perimeter (7.2 km), beginning the transect from a different section each month. We made the observations in days with similar weather conditions (sunny to cloudy days), avoiding rainy days. All the statistical tests followed Zar (1984).

RESULTS

Species composition, richness and abundance. A total of 31 species was recorded during the study period, belonging to 21 families (see tables 1 and 2). The families with the largest number of species in the lagoon were: Ardeidae (five species), Tyrannidae (five species) and Emberezidae (four species). The families with lower numbers of species were Columbidae (two species), Muscicapidae (two species), while the remaining families were represented by one species.

The species richness of aquatic birds, per month, was similar over the year (varying from 5 to 8 species), but the richness of land birds varied from 7 to 13, being highest in the rainy season (November). On average, the richness of land birds (9.6 ± 1.7) was higher than that of aquatic birds (6.3 ± 1.1), but the latter category had greater abundance. The land species abundance varied from 29.5 to 135 individuals on average (table 2), whereas aquatic birds were more abundant, varying from 71 to 272 (table 1).

The most abundant species in the community (including aquatic and land birds) in all sightings (N = 214) were *Phalacrocorax brasiliannus* (44.8%), *Ardea alba* (14.5%),

Table 1. Species composition, abundance (mean per month), richness and density of aquatic birds per month; from May 1996 to April 1997 in Lagoa Rodrigo de Freitas, Rio de Janeiro. R = residents, V = visitors.

	MONTHS													
Family/Species	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**Freq. %**	**Category**
Phalacrocoracidae														
Phalacrocorax brasilianus	180	129.5	151	94.5	134	115	71.5	54.5	56	67	59.5	44.5	100	R
Fregatidae														
Fregata magnificens	0.5	0.5	1	3	1	4	0.5	3.5	5	5	0.5	1	100	R
Ardeidae														
Ardea cocoi	1.5	1.5	0	0	0.5	1	1.5	1	1	0	1	1.5	75	V
Ardea alba	21	25	94	60	45	23	7	17	18.5	18	28.5	19	100	R
Egretta thula	6.5	25.5	22	44.5	25	24	2	0	0	0	2.5	5	75	V
Butorides striatus	2.5	0.5	0	0	0	0	0.5	0	0.5	0	0.5	0	42	V
Nycticorax nycticorax	0.5	0	0	0	0	0	0.5	2	1	1	0	0	42	V
Laridae														
Larus dominicanus	0	0	3	11	10.5	6	1	0	0	0	0	0	42	V
Alcedinidae														
Ceryle torquata	2.5	2	1	1.5	0	1	0	0	0	1	0.5	0	58	V
TOTAL	**215**	**184.5**	**272**	**214.5**	**216**	**174**	**84.5**	**78**	**82**	**92**	**93**	**71**		
Richness	**8**	**7**	**6**	**6**	**6**	**7**	**8**	**5**	**6**	**5**	**7**	**5**		
Average density (ind./ha)	**0.92**	**0.79**	**1.17**	**0.92**	**0.93**	**0.75**	**0.86**	**0.33**	**0.35**	**0.39**	**0.40**	**0.30**		

Table 2. Species composition, abundance (mean per month), and richness of land birds per month; using the shore of the lagoon from May 1996 to April 1997 in Lagoa Rodrigo de Freitas, Rio de Janeiro. R = residents, V = visitors.

	MONTHS													
Family/Species	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**Freq. %**	**Category**
Charadriidae														
Vanellus chilensis	2.5	1	3	1.5	3.5	5.5	4	4	6	1	3.5	2.5	100	R
Columbidae														
Columba livia	0	0	1	0.5	0	0	0.5	0	1	0	0	1	42	V
Columbina talpacoti	3	0	6	4.5	10	2	2.5	9.5	17	16	5	4	92	R
Psitacidae														
Brotogeris versicolorus	0	0	0	0	0	0	0	0	0	0	0	0.5	8	V
Cuculidae														
Crotophaga ani	0	3	1	0	0	0	0	0	0.5	0	0	0.5	33	V
Trochilidae														
Eupetomena macroura	1	2.5	5	0.5	0	0	0	1	1.5	2	0	0	58	V
Apodidae														
Streptoprogne zonaris	0	0	0	0	3	0	0	0	0	0	0	0	8	V
Tyrannidae														
Elaenia flavogaster	0	0	0	0	0	0	0.5	0	0	0	0	0	8	V
Fluvicola nengeta	5	7.5	7	5.5	10.5	6.5	7	3.5	3	14	9.5	14	100	R
Machetornis rixosus	2	2	0	0	1	2.5	4.5	7.5	4.5	0	6.5	5.5	75	V
Pitangus sulphuratus	5.5	7.5	12	10.5	5	13.5	7	6.5	5	3	8.5	9.5	100	R
Tyrannus melancholicus	0	2.5	2	1	0.5	0	2	0	0	4	0.5	0	58	V
Hirundinidae														
Notiochelidon cyanoleuca	6	0.5	16	2	8.5	14.5	13	15	9.5	46	4	8	100	R
Troglodytidae														
Troglodytes aedon	0	0	0	0	1	0	2.5	1.5	0	1	0.5	0.5	50	V

Table 2. Cont.

	MONTHS													
Family/Species	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**Freq. %**	**Category**
Muscicapidae														
Turdus rufiventris	0	0.5	0	0	0	1.5	0	1	0	0	0	0	25	V
T. amaurochalinus	0	0	0	0	0	0	0	0	0	0	1	0	8	V
Emberezidae														
Coereba flaveola	0	1	0	0	1	0	0.5	0.5	0	0	0	0	33	V
Thraupis sayaca	0	0	0	0	0.5	0	1	0	0	0	0	0	17	V
Thraupis palmarum	1	0	0	0	0	0	0	0	0	0	0	0.5	17	V
Sicalis flaveola	0	0	0	0	0	0	0	0	0	1	0	0	8	V
Passeridae														
Passer domesticus	12.5	1.5	5	7	24.5	23.5	23.5	32.5	32	46	12.5	16	100	R
Estrildidae														
Estrilda astrild	1	0	0	0	0	0	2.5	4.5	2	1	3	0	50	V
TOTAL	**39.5**	**29.5**	**58**	**33**	**69**	**69.5**	**71**	**87**	**82**	**135**	**54.5**	**62.5**		
Richness	**10**	**11**	**10**	**9**	**11**	**8**	**13**	**11**	**8**	**7**	**9**	**8**		

Passer domesticus (9.2%), *Egretta thula* (6.1%) and *Notiochelidon cyanoleuca* (5.5%) (figure 2). The rarest species in the community were *Columba livia, Streptoprogne zonaris, Coereba flaveola, Turdus rufiventris, T. amaurochalinus, Thraupis sayaca, T. palmarum, Sicalis flaveola, Elaenia flavogaster* and *Brotogeris tirica* (0.1%) (figure 2).

The aquatic birds mean density estimated for the study period varied from 0.30 to 1.17 individuals/ha (table 1). Between July and September the density was higher than in other months due to the presence of *Larus dominicanus*, which were observed fishing in flocks in the lagoon until October, and to the increased abundance of *A. alba*, particularly in July.

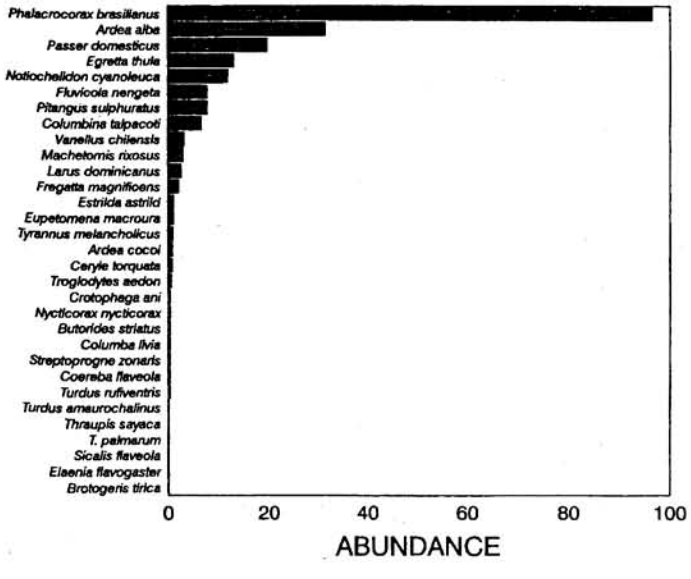

Figure 2. Average abundance distribution (N = 214) over a year for the bird community of Lagoa Rodrigo de Freitas, Rio de Janeiro, Brazil.

The lagoon as a source of food and resting site. The species that were recorded using the lagoon itself, rather than the margins, as a source of food such as fish, were: *P. brasilianus, A. alba, E. thula, Ardea cocoi, Ceryle torquata, Pitangus sulphuratus, Butorides striatus, Nycticorax nicticorax* and *L. dominicanus*. Some species used the lagoon edges as a source of arthropods (*e.g. Fluvicola nengeta, Vanellus chilensis, Machetornis rixosus, P. sulphuratus, C. livia, Columbina talpacoti, P. domesticus*). Others, such as *N. cyanoleuca,* foraged for arthropods in the air space close to the water surface. Other species fed on the vegetation at the edge near the water or the shrubs and trees around the lagoon, such as *Eupetomena macroura, T. palmarum, T. sayaca, Tyrannus melancholicus, Turdus rufiventris, C. flaveola* and *Estrilda astrild.*

Of the 31 registered species in the lagoon only nine were considered residents (registered in at least ten of the twelve sampled months): *P. brasilianus, Fregatta magnificens, A. alba, V. chilensis, C. talpacoti, F. nengeta, P. sulphuratus, N. cyanoleuca* and *P. domesticus*. *Phalacrocorax brasilianus* and *A. alba* occupied the water body, feeding in the lagoon, while the borders of the lagoon were used by *V. chilensis, F. nengeta* and *P. domesticus* (table 1). *Notiochelidon cyanoleuca* was seen catching insects on the water surface and also in the air along the borders of the lagoon. *Pitangus sulphuratus* was seen preying on insects on the vegetation border, in the air and also fishing near the border. *Fregatta magnificens* was seen flying over the lagoon.

The remaining species were considered visitors to the lagoon (not registered in at least 10 of the 12 sampled months), using it as site to search for food and to rest (table 1). Some of these (*e.g. B. tirica,* which was seen visiting a bromeliad on a tree on the lagoon border) probably came

from the adjacent forest, Floresta da Tijuca. The same bromeliad was also visited by *E. macroura.*

The species whose frequency of occurrence (% of the months the species was seen) was higher than 60%, such as *A. cocoi, E. thula, E. macroura, C. torquata, M. rixosus* and *T. melancholicus,* were usually seen on the margin of the lagoon. *Egretta thula* was the fifth most abundant species at the lagoon, and it was usually recorded feeding in monospecific and heterospecific flocks.

We recorded *P. brasilianus* using trees (casuarinas) at the edge of the lagoon for roosting. It is possible that *B. striatus* and *N. nycticorax* also slept near the lagoon. They were seen once at night and very early in the morning before sunrise. The egrets, however, do not seem to use the lagoon for roosting, leaving at the end of the day and arriving early in the morning (they were usually seen coming and leaving the lagoon from the south). Some species were registered flying over the lagoon (but not taking food directly from the water or the edges), such as *F. magnificens.* We recorded nests of *F. nengeta, C. flaveola, V. chilensis* and, more recently, a nest of *E. astrild* (M. A. S. Alves, pers. obs.), all on the edge vegetation and also registered chicks of *V. chilensis* on the ground vegetation near the margins.

Seasonality. Based on the thirty years monthly rainfall pattern for Rio de Janeiro city, we considered the dry season the period from May to October and the wet season from November to April (figure 3). During the study period, September was atypically wet, whereas February and March had low precipitation levels (figure 4).

The aquatic species abundance was significantly higher in the dry season compared to the wet season (figure 4)(Kruskal-Wallis test, $H = 8.31$, $df = 1$, $p = 0.004$, $N = 6$). The richness in the wet season (6-8 species) was similar to that of the dry season (5-8 species). No significant correlation was found between abundance and precipitation in the study period ($r = -0.36$, $p = 0.250$, $N = 12$). However, there was a negative significant correlation between the aquatic birds abundance and the climatological means (1961-1990) ($r = -0.80$, $p = 0.002$, $N = 12$).

Contrary to the aquatic birds, the land birds abundance was significantly higher during the wet season compared to the dry season (figure 4) ($H = 4.33$, $df = 1$, $p = 0.037$). The richness in the wet season (7-13 species) was higher than in the dry season (8-11 species). No significant correlation was found between abundance and precipitation in the study period ($r = 0.19$, $p = 0.534$, $N = 12$). However, there was a positive, but not significant, correlation between the aquatic birds abundance and the climatological means ($r = 0.48$, $df = 1$, $p = 0.114$).

DISCUSSION

The aquatic birds abundance in the lagoon was higher in the dry season than in the wet season. Probably, this is because most bird species nest during the wet season and breeding sites for the most abundant species are far from the lagoon (Sick 1997). The absence of *E. thula* from December to February may be associated with breeding in other places far from the lagoon. This might also be the case for *P. brasilianus* and *A. alba,* as during this period there was also a reduction in their number. Both species were observed breeding on islands off the coast of Rio de Janeiro, such as Alfavaca Island (Sick 1997).

The higher abundance of aquatic birds recorded in the dry season compared to the wet season may also be associated with the occurrence of bird species using the lagoon during this season and with the recruitment of young after breeding. A species that used the lagoon during the dry season as a foraging site was *L. dominicanus.* This species was recorded during five months (July to November 1996) fishing in the lagoon. Other species did not have an evident temporal pattern of occurrence at the lagoon, perhaps because the majority uses the flooded vegetation, the ground and the vegetation of the margins only occasionally. Among these

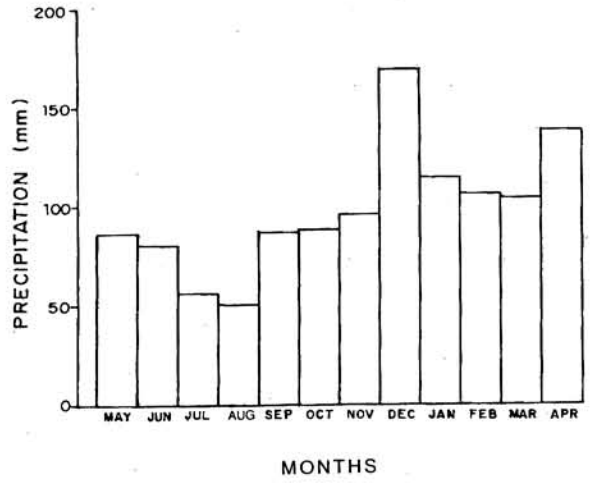

Figure 3. Precipitation pattern for 30 years (1961-1990) (climatological means) in Rio de Janeiro, Brazil.

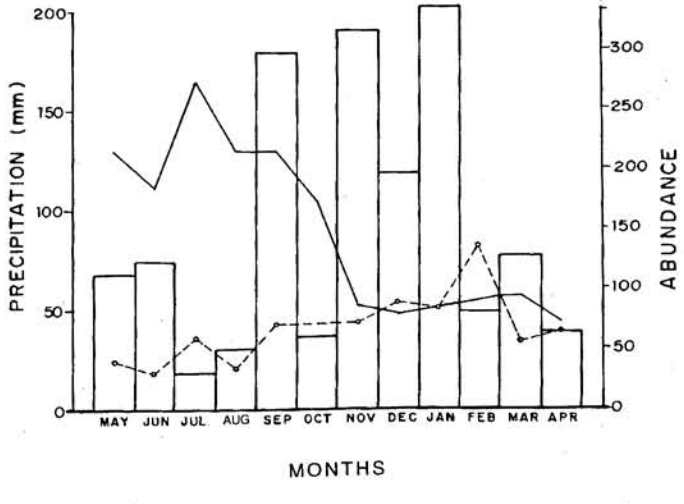

Figure 4. Precipitation (bars) and abundance of aquatic (continuous line) and land (dashed lines) birds during the study period in Lagoa Rodrigo de Freitas, Rio de Janeiro, Brazil. The abundance points refer to average number of individuals per month.

was *E. astrild*, that appeared in February and March, being seen on the vegetation edge in flocks of two or more birds, looking for food in the grass nearby. *Turdus amaurochalinus*, a known migrant species (Sick 1997), was recorded only in March as a transient species on the lagoon's margins. The presence of one *S. flaveola* in April 1997 may be due to a possible release from captivity, since this species usually does not occur in the urban area of Rio de Janeiro city (J.F. Pacheco, pers. comm.).

Although *A. cocoi* was frequently seen (75% of the censuses made), its abundance was low. This species apparently started occupying the lagoon only recently (pers. obs.). One or two individuals were usually seen in each survey. Contrary to the egrets present in the lagoon, *A. cocoi* is solitary.

Fregatta magnificens was present throughout the year, but not seen directly fishing in the lagoon, since it is a kleptoparasitic species (Sick 1997), and stole fish from other species feeding in the lagoon. Therefore, this species indirectly takes fish from the lagoon.

The tendency of land birds to be more abundant in the wet season may be because most bird species breed in this season and some of the land birds may have been using the lagoon margins or nearby areas for breeding. The highest abundance of land birds in February may also be associated with the recruitment of young just after the breeding season.

The absence of a significant correlation between bird abundance and amount of rainfall during the study period, but a negative significant correlation with the climatological means, suggest that the trends in population abundance of the local bird community are adjusted to a long-term pattern of precipitation. A similar trend was found for the marsupial *Monodelphis domestica* of the Caatinga of Northeastern Brazil (Cerqueira and Bergallo 1993). In that case, they also found no significant correlation between frequency of pregnant females with the rainfall in the study period, but a significant correlation was found using the normal means of rainfall in the same months. This relationship was associated with photoperiod, since a negative significant correlation between pregnancy and daylight was found, suggesting that the reproduction of this marsupial is in part controlled by seasonal changes in photoperiod.

In tropical birds, however, the breeding cycle is generally not noticeably influenced by photoperiod, but rather associated with food availability, which usually depends on precipitation (Sick 1997). In the tropics, variation in insect abundance is related to changes in rainfall, the insects being more abundant during the rainy season in general (Moreau 1950, Wolda 1980, Tanaka and Tanaka 1982). The increase in insect abundance favors many Passeriformes (Sick 1997). Also, in dry seasonal forests, many plants bear fruit during the rainy season (Van Schaik *et al.* 1993), favoring frugivorous birds. However, in tropical birds there are some examples, such as the stonechat, *Saxicola torquata*, which indicate that annual cycles can be internally generated by an environment-independent mechanism that is not associated with birds' ability to detect subtle cues in the 12-month cycle (Gwinner and Dittami 1990). Our results show that the birds using this lagoon are not timing their annual cycles by rainfall in a short-term basis (12-month), but trends in abundance of the local bird community apparently are adjusted by a long-term pattern of precipitation. Therefore, they may be using, in part, the photoperiod to time their annual cycles.

The finding that birds are using the edge vegetation for nesting and foraging, re-enforces the importance of the program of recovering the edges using vegetation. The recent improvement in habitat conditions of the lagoon (decrease of water pollution and recovery of the original vegetation of the margins) probably will affect favorably the bird community, especially in terms of food and breeding sites, and therefore may increase the local richness and abundance of birds in the future. The fluctuations in abundance of the species occurring in the lagoon can be better understood through studies that assess fish productivity and species' interactions.

ACKNOWLEDGMENTS

This study is part of the results of the 'Ecology, Conservation and Management of Southeastern Brazilian Ecosystems Program' and of the Southeastern Brazilian Vertebrate Ecology Project (Vertebrate Ecology Laboratory), both of the Setor de Ecologia, IBRAG, Universidade do Estado do Rio de Janeiro (UERJ). Carlos F. D. Rocha and Helena G. Bergallo provided the first spark for starting this study and, together with Monique Van Sluys and José Fernando Pacheco, helped with suggestions, which greatly improved the manuscript. I also thank the referees, Robert Bierregaard and William Belton, and Regina Macedo, for their constructive suggestions. During the development of this study M. A. S. A. received a Research Grant (process no. 301524/88-2) from the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq).

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