TEMPORAL AND SPATIAL PATTERNS OF NESTING WITHIN A BREEDING COLONY IN SOUTHEASTERN BRAZIL

PADRÕES TEMPORAIS E ESPACIAIS DE OCUPAÇÃO DE NINHOS DE UMA COLÔNIA REPRODUTIVA NO SUDESTE DO BRASIL

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ABSTRACT

Breeding colony of Anhinga (Anhinga anhinga), Great White Herons (Ardea alba), Snowy Egrets (Egretta thula), Cattle egret (Bulbucus ibis) and Black-crowned Night Herons (Nycticorax nycticorax) was monitored for, during 1988 till 1989, for: 1) number of breeding pairs, 2) beginning of the breeding period, and 3) height of nest. Similarities and dissimilarities in these three parameters were analyzed to explain temporal and spatial patterns of nesting within the colony. A temporal segregation occurred between the two greatest populations of Black-crowned Night Herons and Cattle Egret. The reproductive temporal sequence observed was Black-crowned Night Herons, Great White Herons and Snowy Egrets, Anhinga and Cattle Egret. Such sequence may be due to the fact that more piscivorous species breed during low water period. The analysis of nests locations showed a vertical stratification of the populations. These results support the notion that species that overlap temporally, segregate vertically in their nest location. Reproductive success of the studied populations were similar to results found in temperate regions. It is suggested that the temporal and vertical structure of the breeding colony is associated with the local structure of the vegetation.
KEY-WORDS: breeding colony, waterbirds, spacial and temporal pattern, success reproductive.

INTRODUCTION

Many species aggregate for feeding, roosting or nesting; behavior which are especially prevalent among waterbirds (Weins, 1992). Factors commonly identified to explain aggregations are the spatial availability of food and defense against predators (Emlen & Demong, 1975; Birkhead & Furness, 1985; Brown, Stutchabruy & Walsh, 1990). Other studies suggest that ectoparasitism and abiotic factors (e.g., tidal level, precipitation, and others) affect habitat quality and may become a dominant force influencing aggregation behavior in birds (Hill & Lein, 1989; Bollinger & Gavin, 1989; Weins, 1992; Boulinier & Lemel, 1996). The interaction between these factors could affect reproductive success, and it could explain its inter-annual variation in the same place (Pulliam, 1988). Gregarious behavior and colonial breeding may be strategies to overcome difficulties in localizing resources with patchy distribution as colonies serve as information centers for its members (Custer & Osborn,1978; Barta & Szép, 1995).

Whether or not limitations related to food acquisition or susceptibility to predation can be overcome by gregarious behavior depends on a number of factors. Nevertheless, there are both advantages and disadvantages of gregariousness for bird species. An important factor influencing whether animals should aggregate is the colony size. Large colonies usually face special problems related to the number of individuals (Brown, Stutchbury & Walsh, 1990). A large population of nesting birds and competition for nest sites may lead to high nesting density. Because nests located on the periphery of a colony are more exposed to predation, birds nesting in relatively smaller colonies are more likely to experience a greater predation risk (Brown, Stutchbury & Walsh, 1990). A large colony may benefit in terms of food acquisition due to the increase in the number of breeding pairs that can provide information on food availability. Large colonies are believed to have a tendency to grow indefinitely. However, excessive growth of a colony causes a decrease in the populations' breeding rate due to intensive competition (Brown, Stutchbury & Walsh, 1990), mainly for nest sites (Parrish, 1995). The ideal size of a colonies will vary among species and habitat.

The response of wild populations to their resources is not always predictable because of the outcome of a number of interacting factors, which may go since a single until multiple factors (Parrish, 1995). Food scarcity often leads to foraging in distant areas, which may result in formation of small colonies (Arengo & Baldassarre, 1995) or the division of populations' breeding period. Strong seasonal peaks in food resources may limit breeding to a single season of the year and cause synchronized breeding of the population. In these cases, large colonies are formed and intense competition for food occurs (Emlen & Demong, 1975). Competition might be lessened by a strategy of fine-scale temporal and spatial segregation in the use of habitat among species with similar feeding habits (Murray, 1971; Hill & Lein, 1989).

The goal of this study is to describe the temporal and spatial patterns of nesting by five species of waterbirds at a colony in São Paulo State of Brazil: Anhinga (Anhinga anhinga), Great White Herons (Ardea alba), Snowy Egrets (Egretta thula), Cattle Egret (Bulbucus ibis) and Black-crowned Night Herons (Nycticorax nycticorax). Specifically, I document and compare the number of breeding pairs in each population during the time of stay in the colony, the temporal period of breeding, and height of nests. I also discuss the implications of these results regarding the factors that may explain the patterns of temporal segregation between reproductive populations and differences among species for nest sites.

METHODS

Study Area: The breeding colony is located in a 5 ha area of secondary riparian forest on the floodplain of the Piracicaba and Piracicaba-Mirim rivers, near the Piracicaba city (23o10'S and 48o40'W), São Paulo State - Brazil (Fig. 1). In the last few decades, the Piracicaba and Piracicaba Mirim rivers have been disturbed by the discharge of agricultural and urban-industrial pollutants. This influx has increased the eutrophication of these rivers, especially during low water levels. In addition, the riparian forest in the region has been cut, which has contributed to the decline in richness and abundance of the local species of fishes. Therefore, food resources for colonial waterbirds have apparently declined in areas adjacent to the breeding colony.

Vegetation within the study area is multi-layered (Catharino, 1989). In less disturbed areas, canopy height ranged from 15 to 18m, with emergent trees reaching up to 30m. The dense understory, consists of shrubs, herbs, and saplings of canopy trees. Woody liana is common, especially in canopy gaps caused by tree fall. Common tree families includs Fabaceae, Ulmaceae, Euphorbiaceae and Meliaceae. The most frequently encountered species are Trema micrantha, Actinostemum communis, Trichilia clausseni and Poecilante parviflora. Latter species are generally associated with vegetation regrowth in disturbed areas. The major density of breeding waterbirds in the colony is located within a canopy gap.

Research was conducted between August 1988 and February 1989, amounting to 370 hours of observation of the breeding colony. Systematic censuses were conducted to monitor the number of breeding pairs and nests at the site. These censuses took place from three different locations: 1) an observatory located about 300 m from the colony; 2) a blind located within the colony at 15m height; and 3) two 10 m long transects within the colony. The number of nests above at the first two observation site, while the number of nests below the vegetation were at the latter site. The methods used to estimate the number of nests depend on how a species responds to the presence of humans (Tremblay & Ellison, 1979). Populations of species accustomed to humans were accurately estimated by walking through the colony and counting marked individuals (e.g., Casmerodius albus, Bulbucus ibis and Anhinga anhinga). Those disturbed by the presence of humans (e.g., Nycticorax nycticorax and Egretta thula) were estimated by watching the nest and counting individuals from a distance. Methods were combined in order to best score nests within the colony.

Average number of nests observed over all days to was used estimate the population size of breeding birds. The number of active nests were multiplied by two to determine the total number of birds (Custer & Osborn, 1978). Only nests with eggs or nestlings were considered active (Frederick & Collopy, 1989). The height of nests was measured from the nest to the ground and for all species in the colony. Subsets of nests were selected based on ease of access to obtain detailed measurements of eggs and nestlings. Eggs and nestlings were weighed and described during developmental phases. The number of eggs laid, hatched, and number of young fledged were recorded. Censuses were performed twice a week over of the breeding season observed in the colony.

RESULTS

Temporal Pattern of Breeding: The colony occupied 2 ha within the secondary forest region and the nests were generally concentrated within two areas. Based on nests classes a total of 1,018 dindividuals were estimated for the five species present in the colony: Anhinga anhinga, Casmerodius albus, Egretta thula, Bulbucus ibis and Nycticorax nycticorax.

The number of breeding individuals varied widely from 370 Bulbucus ibis to 40 Anhinga anhinga (Table 1). Breeding occurred between August and January. The colony breeding season lasted five and a half months, with the average stay of each species during three and a half months. Although there was considerable overlap in breeding phenology, the most common species Nycticorax nycticorax and Bulbucus ibis, bred largely at different times (Figure 2). The other three species overlapped with both Nycticorax nycticorax and Bulbucus ibis. There appears to be a temporal separation between the two largest breeding populations.

The first two months of the breeding period in this study area correspond to the driest months of the year, when rivers are at their lowest levels. December and January, on the other hand, are characterized as the rainy season (Figure 3).

Spatial Stratification of Nests: Vertical placement of nests differed among the five species ($F=46.79$, $p>0.0001$) and formed three groups distinct (Table 2). Nycticorax nycticorax, Egretta thula and Bulbucus ibis, nests height did not differ, with most nests being placed at heights from 3.0 to 3.3 m. Both Casmerodius albus and Anhinga anhinga placed their nests higher in the foliage, generally from 8.8 to 11.6 meters high (see Table 2). Casmerodius albus placed their nests preferentially in the canopy, on the open platforms formed at the top of the trees covered by the tangled lianas. Anhinga anhinga, occupied the same height as Casmerodius albus, but placed their nests in branches forks located immediately under emergent trees. Nycticorax nycticorax occupied the forks formed by the branches below tree tops with tangled lianas. Snowy and Cattle Egrets nested on lianas mats, at a lower height.

Reproductive Effort and Success: The average number of eggs laid by each species varied from 2.7 to 4.0 (Table 1). The loss of eggs and nestlings averaged 33% for Nycticorax nycticorax, Casmerodius albus and Bulbucus ibis, 31% for Egretta thula, and 12.5% for Egretta thula, *and 12.5% for* Anhinga anhinga.

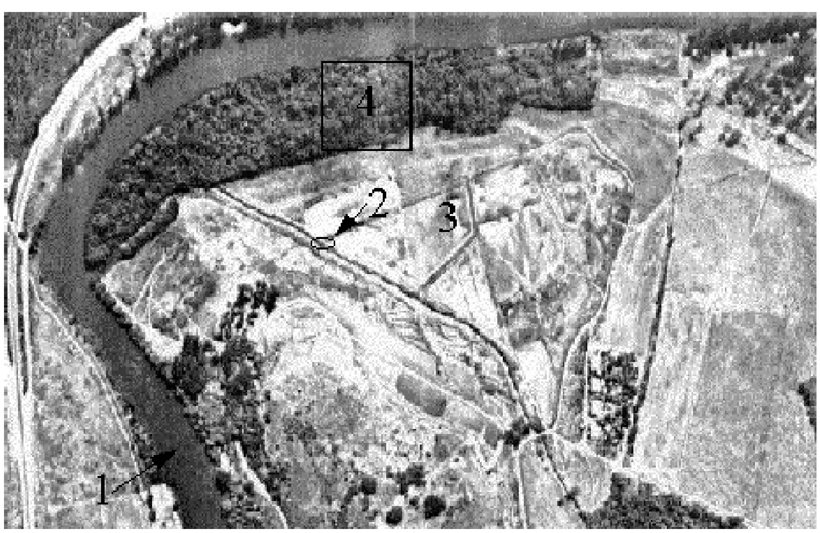

FIGURE 1 - Aerial photo of study area (scale 1:8000) in southeastern brazil (1) piracicaba river; (2) piracicaba-mirim river; (3) agricultural area of rice and (4) breeding colony site

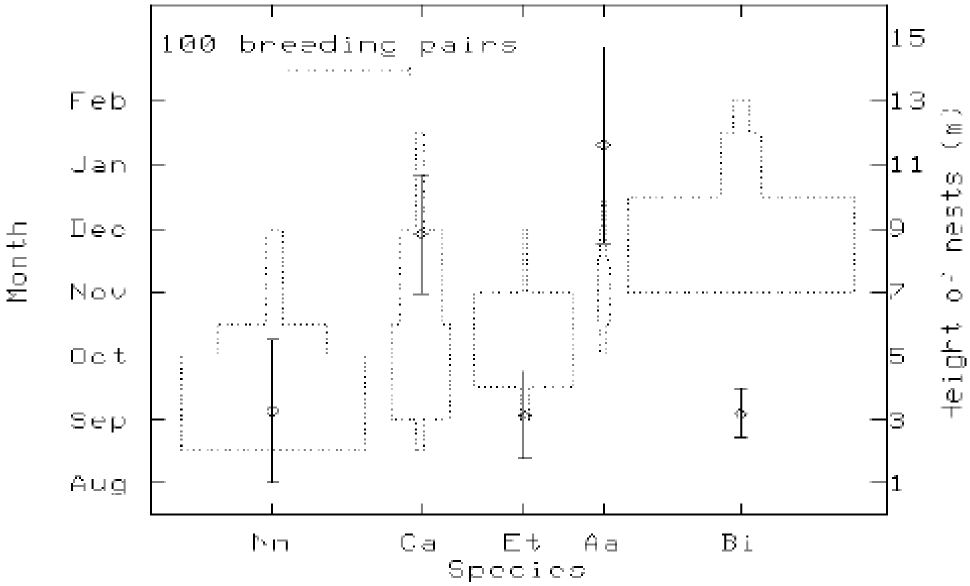

FIGURE 2 - Temporal and spatial segregation of five species nesting in southeastern Brazil. Abbreviations are as follows: Nn= Nycticorax nycticorax, Ca= Casmerodius albus, Et= Egretta thula, Aa= Anhinga anhinga and Bi= Bulbucus ibis. The box width of each shows the population size in time, ◈= average of nest height, and bars vertical represent one standard deviation.

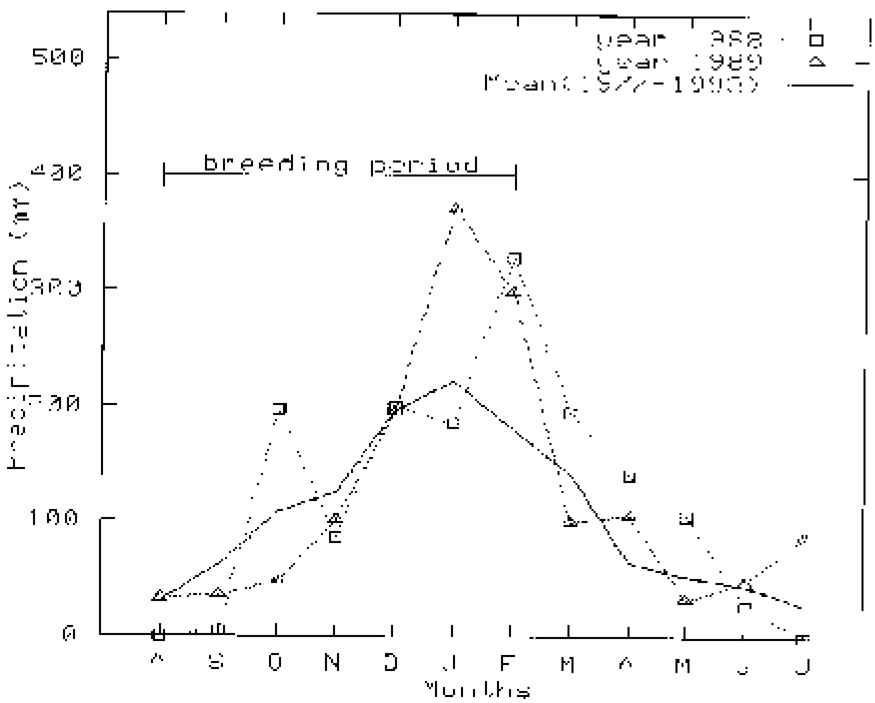

FIGURE 3 - Rainfall recorded during the breeding p eriod at a colony in southeastern Brazil. The solid line represents the average monthty values from 1977 to 1993; D.and ¨ avarage of the rainfall during the study period and ½¾¾½ reproductive period.

Table 1 - Aspects of the breeding biology and development of eggs and nestlings for five species breeding in the colony

Breeding Variables	Anhinga	Great Heron	Swnoy Egret	Black-crowed Night Heron	Catle Egret
Population size pairs	20 pairs	50 pairs	80 pairs	150 pairs	185
Begining of breeding	Begining of october	Middle of august	Beginning of september	Middle of august	end of october
Location of nests	Fork of emergent trees	Plataform of lianas	Above lianas	Below branches of lianas	Above lianas
Mean height of nests (m)	11.6 ± 3.0 (n=5)	8.8 ± 1.8 (n=20)	3.5 ± 1.4 (n=23)	3.3 ± 2.3 (n=16)	3.0 ± 0.6 (n=5)
Laying eggs per pair [a]	4 ± 0.00 (n=2)	3.80 ± 0.45 (n=5)	3.25 ± 0.43 (n=4)	2.75 ± 0.96 (n=4)	2.67 ± 0.58 (n=3)
Weight of the eggs [a] (g)	-	-	20.38 ± 0.65 (n=13)	29.00 ± 7.31 (n=6)	2.63±1.60 (n=4)
Hatched eggs per pair [a]	4.00 ± 0.00 (n=2)	2.80 ± 0.84 (n=5)	2.25 ± 0.43 (n=4)	2.25 ± 0.96 (n=4)	2 ± 0.00 (n=3)
Number of young	3.67 ± 0.58 (n=2)	2.20 ± 0.84 (n=5)	1.75 ± 0.43 (n=4)	1.75 ± 0.50 (n=4)	2.00 ± 0.00 (n=3)

[a] mean ± std.deviation (n=number of nests observed)

Table 2 - Comparison of nest hight among five species of water birds breeding Brazil

Species	Mean height for nest [a]	n	Tukey class [b]
Anhinga anhinga	11.6	5	a
Casmerodius albus	8.8	20	b
Nycticorax nycticorax	3.3	16	c
Egretta thula	3.2	23	c
Bulbucus ibis	3.0	5	c
	F-value 46.79 ($p<0.0001$)		

[a] original data was transformed to ln(x)
[b] means with the same letter are not significantly different at p=0.05

DISCUSSION

Temporal segregation between was found the species that breed in the study area. Custer & Osborn, (1978) also found asynchronous nest-building phases in North Carolina. Maxwell & Kale (1977) found that Florida caerulea, started to breed later than the other colony species. For the same specie (Rodgers Jr,1980) found two peaks of breed activities, this peaks occurred repeatedly among the studied years; he suggested this result probably reflect the breeding cycle. Frederick & Collopy (1989) have shown a strong difference for the nesting chronology of four species (Casmerodius albus, Egretta tricolor, Egretta caerulea and Eudocimus albus) in Florida. They discuss the possibility that such results could be artifacts from the sampling period, since water level and rainfall data did correlate with the differences among nest initiations. Presumably this would be associated with other variables, such as temperature, prey activity and reproductive cycle. Food or space nest limitations might be expected to lead to asynchronous breeding behavior, especially for conspecifics that overlap more closely in food and nesting characteristics. However, temporal segregation may also occur due to different peaks in the availability of food items used by nesting species within a colony.

In relation to populations size in the colony, differences in the numbers of pairs were observed. Availability of food or environmental conditions may explain variance in the number of individuals breeding both within and among colonies (Peakall, 1970; Brown, Stutchbury & Walsh, 1990). Anthropogenic changes are expected to affect the breeding colonies in the studied of bird species, as (Frederick & Collopy, 1989; Bildstein, Post & Johnston, 1990), report that food density is closely related to the reproductive success of Ciconiforms.

The results showed a temporal segregation among species of the breeding colony. Casmerodius albus, Egretta thula and Nycticorax nycticorax bred during the time when the river levels were at the lowest. (Custer & Osborn, 1978; Lopez-Ornat & Ramo,1992) also found that Ardeids bred during low water levels. Reduced water levels likely to facilitate food acquisition by these species. Anhinga anhinga and Bulbucus ibis bred at the beginning of the rainy period. According to (Sick, 1985) these two species differ in their feeding behavior (Anhinga anhinga) and diet (Bulbucus ibis). Results found for Cattle Egret agrees with results reported in Rodgers Jr.(1987). They showed a delayed breeding cycle associated with the wetter and warmest months, and bred after Little Blue Heron. Consequently, temporal segregation for these species is not likely to be due to present-day food competition. Instead, limitation of nesting space or differences in the temporal food availability probably accounts for differences in the breeding period. To Rodgers, Jr (1980) the asynchrony is probably due to temporary differences in food availability caused by large territories that decrease colony space availability.

Maxwell & Kale, (1977) and Jenni (1969), found that nests of Egretta thula and Bulbucus ibis showed an average nests height from 2.04 m to 2.59. Results of this work support the notion that species that overlap temporally in breeding, also segregate vertically in nest placement within the colony (Figure 2, Table 2). Nycticorax nycticorax and Egretta thula occupied the same nest height within the colony, but breed at different times in relation to Bulbucus ibis. Cattle Egrets avoid competion for space within the colony. Alternatively, the particular morphology of species and their nests might explain nest placement. One way to test this hypothesis would be to remove one species from the nesting colony and to observe if vertical nest placement expands or shifts to sites formerly by the removed species.

Vegetation structure at a site may influence nest placement within the colony, so a dense vegetation could retrain large birds from build in their nest deep in the canopy. Similar to the results of this study, Maxwell & Kale (1977), observed that Egretta thula and Bulbucus ibis occupied the same height for placing the in nests, and Casmerodius albus had nests located, on average, higher in the canopy when compared to the others. The absence of statistical differences among herons in the Florida colony was likely due to the fact that these observations occurred in a colony located in a mangrove vegetation (Maxwell & Kale, 1977), characterized by a uniform environment with a low height and plant diversity species. The vegetation structure can be an important factor in the placement of nests in the colony area and, associated with food supply and density, may influence reproductive success (Kushlan, 1976; Lopez-Ornat & Ramo, 1992; Cézilly, Boy, Green & Hirons, 1995).

Clutch sizes were similar to those reported by Maxwell & Kale (1977), Jenni (1969), Rodgers Jr. (1980a,b) and Sick (1985) for these same species. On the other hand, the results found in this research may be reflecting the small sample size. According to Maxwell & Kale (1977), eggs laid during the incubation phase were of 28.8% for Egretta thula (n=186); 30.9% for Bulbucus ibis (n= 73) and 33.3% for Casmerodius albus (n= 28). Hence, results from the present study in southeastern Brazil match those from temperate areas. Avian clutch size is likely to be influenced by a species' evolutionary history, whereas mortality of eggs and youngs is probably varies according to local environmental conditions, nest collapse or predation (Rodgers Jr., 1987; Brown, Stutchbury & Walsh, 1990). Indeed Maxwell & Kale (1977) considered competition and nest location as factors responsible for the low breeding success of heron species. For the other species these factors may results in an increase of the survival rate, as is shown in Bulbucus ibis and Nycticorax nycticorax, considering that theses species maintain a clear temporal segregation. Similar results were obtained for to mortality rates, for Snow Egret (Rogders Jr., 1980) and to Cattle Egrets (Rodgers Jr.,1987). On the other hand, food may be an important resource to the reproductive success in Ciconiformes (Kushlan, 1976; Rodgers Jr., 1987; Frederick & Callopy, 1989; Bildstein, Post & Johnston, 1990; Lopez-Ornat & Ramo 1992; Erwin et al., 1996). Thus, the temporal nesting segregation of species during the breeding season within an individual colony may have influenced the increase of breeding success in the two larger populations which nest at the same height.

The results of this study on the reproductive success, spatial stratification of nests, and temporal pattern of breeding suggest that the facility of food acquisition considering the low water level and prey activity and availability of nest site due to the vegetation structure, leads to an optimization of the colony area. Nycticorax nycticorax and Bulbucus ibis have consequently obtained a slightly higher nesting success when compared to those reported by other authors, possibly due to temporal segregation.

RESUMO

Durante os anos de 1988 e 1989 foi monitorada uma colônia reprodutiva formada por: Anhinga (Anhinga anhinga), Garça branca grande (Ardea alba), Garça branca pequena (Egretta thula), Garça boiadeira (Bulbucus ibis) e o Socó (Nycticorax nycticorax). As variáveis observadas foram: 1) números de pares reproduzindo, 2) início do período reprodutivo e 3) altura dos ninhos. Similaridades e diferenças entre os parâmetros avaliados foram analisados para explicar padrões temporal e vertical de distribuição dos ninhos dentro da colônia reprodutiva. Os resultados obtidos mostraram, que para todas as espécies que compõem o ninhal, ocorreu uma diferença temporal quanto aos locais de ninho. No entanto, uma segregação temporal marcante foi entre as duas maiores populações formada por Nycticorax nycticorax e Bulbucus ibis.. Este último resultado pode ser explicado pelas diferenças de comportamento alimentar existente entre as espécies. As análises quanto localização dos ninhos mostraram uma estratificação vertical para a ocupação da área de reprodução. Assim, os resultados suportam a idéia que as espécies que se sobrepõem temporalmente estão separadas verticalmente quanto a altura dos ninhos. O sucesso reprodutivo mostrou que as espécies apresentaram os mesmos resultados encontrados para aqueles observados em regiões temperadas. Isto sugere que a ocupação, tanto temporal quanto vertical, está associada a estrutura da vegetação e não interferindo no sucesso reprodutivo das mesmas.
PALAVRAS-CHAVE: colonia reprodutiva, ciconiformes, padrões temporal e espacial, sucesso reprodutivo.

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