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DIET AND FLOCK SIZE OF SYMPATRIC PARROTS IN THE ATLANTIC FOREST OF BRAZIL

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Resumo. Parâmetros populacionais de psitacídeos neotropicais, tais como tamanhos de bando e abundância, podem ser influenciados pela disponibilidade de frutos como fonte de alimento. Os psitacídeos podem responder aos períodos de escassez de recursos alterando o tamanho dos bandos, mudando a dieta, ou mesmo movendo-se para outras áreas. Nós estudamos durante 3 anos a dieta, o tamanho de bando e a abundância de dois psitacídeos (*Pyrrhura frontalis* e *Brotogeris tirica*) em uma área de Mata Atlântica no sudeste do Brasil. Também fornecemos algumas informações sobre outras quatro espécies menos abundantes na área (*Forpus xanthopterygius*, *Pionus maximiliani*, *Pionopsitta pileata* e *Triclaria malachitacea*). Os psitacídeos consumiram 40 espécies de plantas pertencentes a 21 famílias. As famílias mais bem representadas na dieta foram Cecropiaceae, Myrtaceae e Moraceae. Em geral, frutos carnosos foram mais consumidos que frutos secos, e *P. frontalis* consumiu mais flores que *B. tirica*. Considerando as estações úmida (verão) e seca (inverno), *B. tirica* e *P. frontalis* foram as únicas espécies a apresentarem diferença inter-estacional no tamanho de bando. Enquanto os bandos de *B. tirica* foram menores na estação seca que na úmida, *P. frontalis* apresentou o padrão inverso. Houve um marcado declínio na abundância dos psitacídeos durante a estação seca, indicando um possível deslocamento para outras áreas. Nós discutimos a possível influência da dieta e disponibilidade de recursos sobre o tamanho dos bandos, bem como sobre as flutuações populacionais observadas.

Abstract. Population parameters of Neotropical parrots, such as flock size distribution and abundance, are likely to be influenced by the availability of fruits as food resources. Parrots may respond to periods of fruit scarcity by altering flock size, changing diet, or even dispersing to a new area. Here we report results of a three-year study on diet, flock size, and seasonal abundance of two parakeet species (*Pyrrhura frontalis* and *Brotogeris tirica*) in the Atlantic forest of southeastern Brazil. We also provide information for four other parrot species (*Forpus xanthopterygius*, *Pionus maximiliani*, *Pionopsitta pileata*, and *Triclaria malachitacea*). We observed parrots eating 40 plant species, primarily fruits of Cecropiaceae, Myrtaceae, and Moraceae. Fleshy fruits predominated over dry ones, and *P. frontalis* ate a greater proportion of flowers than did *B. tirica*. Considering wet (summer) and dry seasons (winter), *B. tirica* and *P. frontalis* were the only species to show significative inter-seasonal difference in mean flock size. *Brotogeris tirica* flocks were smaller in the dry season than in the wet season, whereas *P. frontalis* showed the opposite tendency. A well-marked decline in parrot abundance occurred during the dry season, suggesting that parrots shifted habitats. We discuss the possible influence of diet and food availability on flock size, and suggest the influence of such factors on the seasonal population fluctuations observed. *Accepted 17 July 1995.*

Key words: Atlantic forest, *Brazil*, Brotogeris tirica, *diet*, *parrots*, *Psittacidae*, Pyrrhura frontalis.

INTRODUCTION

Neotropical parrots are ecologically a very important group of birds because of their role as seed predators and the consequent impact they can have on the structure of tropical forests (Janzen 1969, Galetti & Rodrigues 1992). Furthermore, parrots constitute a large fraction of the bird biomass in many Neotropical forests (Terborgh *et al.* 1990). Despite this biological importance and the declining numbers of many species due to habitat destruction and the pet trade (see Beissinger & Snyder 1992), there is a lack of knowledge regarding the ecology of most neotropical parrots.

A pressing issue for any conservation policy is knowledge of population parameters such as variation in flock size distribution and abundance of the species of concern. In the case of "obligate frugivorous" birds such as parrots, population parameters may be tightly linked to fruit availability, as has been demonstrated for other fruit-eating birds (Snow 1962, Crome 1975, Leighton & Leighton 1983, Levey 1988, Loiselle & Blake 1991, Rivera-Milán 1992). The availability of fruits likely varies in space and time (Frankie *et al.* 1974, Hilty 1980, Morellato & Leitão-Filho 1992) and, together with other factors, may influence flock size by dictating the num-

ber of birds that can efficiently forage together (Chapman *et al.* 1989).

Here we report on seasonal variability in flock size, diet, and abundance of two common, sympatric parakeet species (*Brotogeris tirica* and *Pyrrhura frontalis*) in an area of Atlantic forest in southeastern Brazil. Additional information on four other less common species of parrots also is provided.

METHODS

Study site. The study was carried out at Parque Estadual Intervales, Ribeirão Grande, São Paulo State (24°16'S, 48°25'W), a 49000 ha reserve in the Serra de Paranapiacaba mountains of southeastern Brazil. The reserve ranges in elevation from 60 m a.s.l. near the coast to 1100 m in the interior. Our study was carried out at an elevation of 700 m where the vegetation is composed of primary forest with trees reaching up 30 m, and patches of second growth vegetation near human settlements. Climate is generally wet, with rain or fog ocurring in most days which led Willis & Schuchmann (1993) to classify the vegetation as a cloud forest. Annual precipitation is around 1600 mm, with a dry season from April to August (winter), when the temperature often drops below 5°C and frosts may occur, and a wet season from September to March. Seasonal variation in temperature is pronounced, ranging from a minimum mean temperature of 13.4°C in winter to 21.6°C in summer.

Six parrot species (Pisittacidae) occur at Parque Estadual Intervales: Reddish-bellied Parakeet (*Pyrrhura frontalis*), Plain Parakeet (*Brotogeris tirica*), Blue-winged Parrotlet (*Forpus xanthopterygius*), Scaly-headed Parrot (*Pionus maximiliani*), Red-capped Parrot (*Pionopsitta pileata*), and Blue-bellied Parrot (*Triclaria malachitacea*) (scientific names follow De Schauensee 1970). The former four species are among the most common parrots within their ranges, the latter two are endemic to the Atlantic forest and are considered threatened (Ridgely 1981, Collar *et al.* 1992).

Data were collected from December 1989 to December 1991, and from August 1992 to January 1994 during monthly visits (4—10 days each) to the reserve. Observations were conducted while walking along several trails and unpaved roads that cross the study area performing aproximately 20 km. We observed parrots between 06:00 and 18:00 h, avoiding days with heavy rains and wind which reduce census reliability (Karr 1981). Overall, about 533 and 366 hours were spent walking in wet and dry seasons, respectively.

Diet. We recorded a feeding-bout whenever we encountered parrots feeding. Thus, a single bout could represent one or more parrots feeding on a plant species, irrespective of the length of time they fed. If the parrot (or a flock) moved to another food source, a new bout was recorded. This method emphasizes the diversity of items ingested by parrots, but does not provide information on the amount of each plant species consumed. However, we used this method because parrots usually flew away upon detecting the presence of the observer. Thus, our estimate of a parrot's diet is based on frequency of feeding-bouts (see Snyder *et al.* 1987, Galetti 1993).

Whenever possible, plants eaten were collected for further identification at the herbarium of the Universidade Estadual de Campinas (UEC).

Flock sizes and abundance estimate. From August 1990 to December 1991 we estimated the monthly abundance of parrot species in terms of number of individuals detected per field time (289 h in the wet season and 198 h in the dry season). Such estimate was obtained by multiplying the average encounter rate of each parrot species by their monthly mean flock size (see Terborgh *et al.* 1990). The average encounter rate was based on number of flocks seen or only heard during walks. Mean flock sizes were obtained by counting only flocks effectively seen perched or flying overhead. We adopted this method to estimate abundance because of the wandering habits of parrot flocks, and also because of the absence of a complete trail system in the study area which makes density estimates unreliable. Because our goal was to detect general patterns of annual population fluctuations, we assume that this procedure is sufficient.

At Parque Estadual Intervales, parrots were easily identified by their regularly emitted metallic call-notes which are audible at great distances. Thus, the abundance estimate suffers little influence of factors such as hearing ability (Bart 1985) and song attenuation (Waide & Narins

1988), that commonly affect accuracy in singing bird surveys.

Statistical Analysis. We used Chi² test to compare the diet of flowers and fruits between parrot species. Kruskal-Wallis test was used to evaluate monthly variability in flock sizes, and Mann-Whitney test with normal approximation statistic (Snedecor & Cochran 1980) was used to compare flock sizes between species and seasons. Flocks counted in different dry or wet seasons were pooled in inter-seasonal comparisons. All tests followed Zar (1984).

RESULTS

Brotogeris tirica and *P. frontalis* were the most abundant parrots at the study site and results presented here primarily relate to these species. Additional species are discussed whenever our data permit.

Diet. We observed parrots feeding on a total of 40 plant species, from 21 families, during a total of 188 feeding-bouts (Table 1). The families most often used by parrots were Cecropiaceae (represented by only one species, *Cecropia glazioui*; 39 bouts), Myrtaceae (22 bouts), and Moraceae (21 bouts). These four families together comprised 43.6% of the feeding-bouts. Fleshy fruits (i.e., dispersed by animals) predominated over dry ones (i.e., dispersed by wind or gravity; 76.6% and 23.4% of the fruits eaten, respectively), but fruits were frequently eaten in an immature, green condition. *Pyrrhura frontalis* for example, ate the endosperm of immature fruits of the palm *Euterpe edulis* during the wet season, and only the pulp when fruits became ripe in the dry season. Fruits were consumed during 80.3% of all feeding-bouts, and 18.0% of the bouts were on flowers.

Brotogeris tirica and *P. frontalis* were responsible for 85.1% of the observed feeding-bouts. Overall, *P. frontalis* used more flowers than *B. tirica* (25.2% and 12.1% of their respective feeding-bouts; $Chi^2 = 4.53$, $df = 1$, $P = 0.03$). Such difference was recorded during the wet season ($Chi^2 = 5.65$, $df = 1$, $P = 0.01$), but was not detected for the dry season (Two-tailed Fisher Exact Test, $P = 0.45$), when very few feeding-bouts were recorded.

Variability in flock sizes. Brotogeris tirica and *P. frontalis* accounted for 76.8% of the 1220 flocks counted (Table 2). Overall, they had larger flocks

TABLE 1. Plant species observed eaten by parrots at Parque Estadual Intervales, southeastern Brazil. Plant families are arranged in alphabetical order. Plant taxonomy follows Cronquist (1981).

Plant species	Fruit type[a]	Parrot species[b]	Item eaten[c]	Month	Feeding bouts
		Pf	Se	Apr-May	
	f	Pf	Se	Dec, Feb	3
		Bt	Se	Jan	5
Arecaceae					
Euterpe edulis	f	Pf	Pu	Apr, Jul-Dec	
Asteraceae					
Ambrosia polystacha		Pf	Fl	Dec-Jan	13
		Fx	Fl	Dec	1
Mikania sp.	d	Fx	Se	Sep	1
Piptocarpha sp.		Pf	Fl	Jul	
Vernonia sp.		Pf	Fl	Nov	
Bombacaceae					
Pseudobombax sp.		Bt	Ne	Aug	
Bromeliaceae					
Aechmea ornata		Tm	Fl	Nov	
Vriesea sp.	d	Bt	Se	Dec-Jan	
Burseraceae					
Protium widgrenii	f	Pf	Ar	Nov	
Cactaceae					
Rhipsalis sp.		Bt	Pu/Se	Aug	

Plant species	Fruit type[a]	Parrot species[b]	Item eaten[c]	Month	Feeding bouts
		Pf	Pu/Se	Jan-Mar	9
		Bt	Pu/Se	Feb-May	25
		Fx	Pu/Se	Feb, Jun-Aug	5
Euphorbiaceae					
Alchornea triplinervia	d	Pf	Se	Oct-Nov	
Croton sp.	d	Pf	Se	Jan	4
Hieronyma alchorneoides	f	Pf	Se	Mar, Apr	2
		Bt	Se	Mar	1
Tetrorchidium rubrivenium	f	Pf	Ar/Se	Jan-Mar	4
Loranthaceae					
Psittacanthus sp.		Bt	Se	May	
		Bt	Fl	Dec	
		Pm	Fl	Feb	
Marcgraviaceae					
Norantea brasiliensis		Pf	Fl	Nov	1
		Bt	Fl	Jan	?
Marcgravia polyantha	f	Fx	Fr	Nov	
Melastomataceae					
Miconia cabusu		Pf	Se	Jan	1
Tibouchina mutabilis	d	Pf	Se	Jan-Feb	3
		Pf	Fl	Nov-Dec	6
		Pf	Le	Jan	1
		Bt	Fl	Dec-Jan	3
		Bt	Se	Feb	
Mimosaceae					
Inga sp.	f	Pm	Se	Apr	1
Piptadenia gonoacantha	d	Pf	Se	Jul	2
Moraceae					
Coussapoa microcarpa	f	Pf	Se	Nov	2
Ficus enormis	f	Pf	Se	Sep, Nov	5
Ficus glabra	f	Bt	Se	Nov	7
Ficus sp.	f	Pf	Se	Jul, Nov	2
Myrtaceae					
Campomanesia sp.		Tm	Se	Dec	8
Eucalyptus sp.[d]		Pf	Fl	Sep	1
		Bt	Fl	Dec	1
Myrcia rostrata		Pf	Se	Dec-Jan	9
Psidium catleyanum		Pf	Se	Mar	1
		Tm	Se	May	1
Psidium guajava[d]		Tm	Se	May	1
Pinaceae					
Pinnus sp.[d]		Pf	Ps	Apr	1
Poaceae					
Merostachis sp.	d	Pf	Se	Jul, Sep	2
		Bt	Se	Sep	1
Rubiaceae					
Posoqueria latifolia		Bt	Pu	Dec	2
Solanaceae					
Solanum mauricianum	f	Pf	Se	Nov	3
		Pp	Se	Oct	2
Ulmaceae					
Trema micrantha	f	Pf	Se	Feb	1
		Bt	Se	Feb	2
		Fx	Se	Jan-Feb	4

[a] Fruit type: f - fleshy fruit, d - dry fruit.
[b] Parrot species: Pf - *Pyrrhura frontalis*, Bt - *Brotogeris tirica*, Fx - *Forpus xanthopterygius*, Pm - *Pionus maximiliani*, Pp - *Pionopsitta pileata*, and Tm - *Triclaria malachitacea*.
[c] Items eaten: Fl - flower, Se - seed, Pu - pulp, Le - leaf, Ar - aril, Ne - nectar, Ps - pine seeds. [d] Exotic species.

than the other species (Mann-Whitney U-test = 2.55—7.30, all $P < 0.01$) and showed considerable month-to-month variability in flock sizes (Kruskal-Wallis H = 91.48, $P \ll 0.001$, range 1—40 for *B. tirica*, and H = 93.59, $P \ll 0.001$, range 1—34 for *P. frontalis*). In addition, they were the only species to show significant intraspecific differences in mean flock sizes between wet and dry seasons (Table 2), whereas presenting opposite tendencies. *Brotogeris tirica* had smaller flocks during the dry seasons (U = 2.86, $P = 0.004$), with flock size distribution more skewed toward smaller flocks than in the wet seasons (Fig. 1a). On the contrary, *P. frontalis* had grouped into larger flocks during the dry seasons (U = 2.95, $P = 0.003$, Fig. 1b). Consequently, although mean flock size of *B. tirica* and *P. frontalis* did not differ in the wet seasons (U = 1.31, $P = 0.06$), the latter species occurred in larger flocks than the former in dry seasons (U = 5.35, $P \ll 0.001$).

Pionopsitta pileata flocks rarely exceeded four individuals (table 2), and although only eight *Triclaria malachitacea* flocks were counted, we believe, based on vocalizations from uncounted flocks, that its mean flock size is about two or three individuals throughout the year.

Annual fluctuations in parrot numbers. During the dry season, a decrease in parrot abundance was observed at the study site for the four commonest species (Fig. 2). *Pionopsitta pileata* and *T. malachitacea* occur in low numbers, and we do not have enough data to describe a pattern.

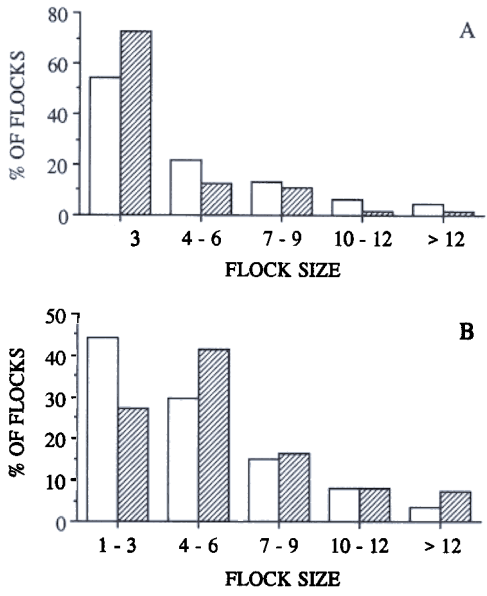

FIG. 1. Flock size distribution of A) *Brotogeris tirica*, and B) *Pyrrhura frontalis* in the wet seasons (white bars) and dry seasons (hatched bars) at Parque Estadual Intervales, southeastern Brazil. Flocks were counted monthly from December 1989 to December 1991, and from August 1992 to January 1994.

Brotogeris tirica and *P. frontalis* numbers increased at the onset of the wet season, peaking in January—February 1991 and then dropping in the dry season (Fig. 2). *Brotogeris tirica* was exceeded in abundance by *P. frontalis* from the middle of the dry season to early wet season.

TABLE 2. Mean sizes of 1220 flocks of 6 parrot species counted during wet and dry seasons at Parque Estadual Intervales, southeastern Brazil. Asterisks indicate inter-seasonal difference in mean flock size (Mann-Whitney U-test: ** $P < 0.01$).

Parrot species[a]	Wet season		Dry season			Total		
	mean[b]	N	mean[b]	sd	N	mean[b]		N
Pf	4.9[a]	388**	5.8[a]	3.7	111	5.1	3.8	499
Bt	4.7[a]	383**	3.2[b]	2.9	55	4.5[a]	4.2	438
Fx	3.9[a,b]	64	4.1[a,b]	2.4	18	4.0[a]	2.8	82
Pm	3.4[b]	97	2.5[b]	1.5	22	3.3	2.6	119
Pp	2.3	57	2.8[b]	2.0	17	2.4	1.6	74
Tm	2.5	4	2.0	0.8	4	2.2	1.0	8

[a] Parrot species: Pf - *Pyrrhura frontalis*, Bt - *Brotogeris tirica*, Fx - *Forpus xanthopterygius*, Pm - *Pionus maximiliani*, Pp - *Pionopsitta pileata*, and Tm - *Triclaria malachitacea*.

[b] In the intra-seasonal comparison, means sharing the same letter are not significantly different (Mann-Whitney U-test). Due to the small sample size, *Triclaria malachitacea* mean was not compared to the others.

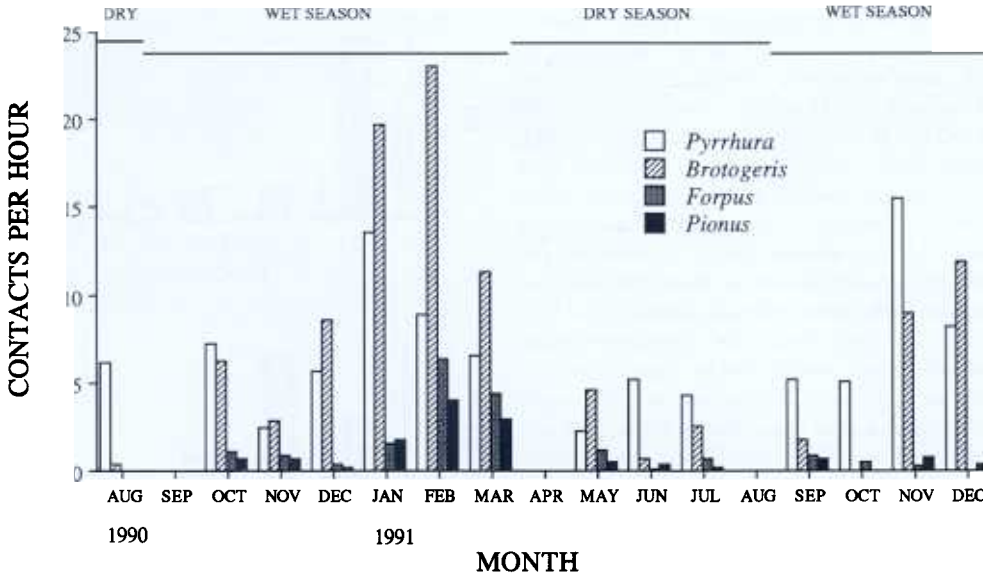

FIG. 2. Monthly abundance of the four commonest parrots at Parque Estadual Intervales, southeastern Brazil. September 1990, and April and August 1991 were not sampled.

The peak in abundance observed in January–February 1991 (Fig. 2) was not a consequence of larger flocks that would possibly occur with the incorporation of newly fledglings into the flocks. The mean flock size recorded during these two months of high abundance did not differ from that recorded during the other months of 1990–91 wet season, neither for *B. tirica* ($U = 0.74$, $P = 0.45$) nor for *P. frontalis* ($U = 0.21$, $P = 0.83$).

Forpus xanthopterygius and *P. maximiliani* increased in abundance late in the wet season of 1990–91, reaching a peak in February (Fig. 2). Patterns of abundance were similar between these two species, and their average encounter rate did not differ ($Chi^2 = 0.48$, $df = 1$, $P = > 0.50$). However, *F. xanthopterygius* may be temporarily absent from the area during the dry season. We did not record any flock of this species from April to July 1990, although they were present during the dry season of 1991.

DISCUSSION

Diet. Neotropical parrots primarily feed on fruits (mainly seeds) and flowers (Forshaw 1989, Galetti 1993), but also can feed on insects, algae, and even snails (Roth 1984, Sazima 1989). We have never, however, observed parrots eating anything but vegetable material at Parque Estadual Intervales.

Studies carried out in the Amazonian region (Roth 1984, Munn 1988), and in a semideciduous forest in southeastern Brazil (Galetti 1993), have shown that leguminous fruits are an important food source for parrots. They not only comprised a great proportion of the species eaten, but also accounted for many of the feeding-bouts recorded. At our study site, however, leguminous fruits were of minor importance, probably because they are often anemochoric (i.e., dispersed by the wind) and are predominantely produced during the dry season (see Morellato & Leitão-Filho 1992 for a study conducted in a similar area), when parrots are less abundant and few feeding-bouts were recorded. Similarly, species of Sapotaceae and Lecythidaceae, major food items for Amazonian parrots (Roth 1984), were not recorded in the diet of parrots of Parque Estadual Intervales. In fact, these two families are important components of Amazonian plant communities (Prance *et al.* 1976), but not so in the Atlantic forest of southeastern Brazil, where Myrtaceae are among the most dominant families (Silva

& Leitão-Filho 1982). Similarly, Cecropiaceae (responsible for 20.7% of the feeding-bouts), although represented by only one species (*Cecropia glazioui*), is highly abundant at the study site (pers. observ.). Thus, although additional data regarding plant abundance are needed, we suspect that the overall importance of some families like Myrtaceae and Cecropiaceae in the diet of parrots at Parque Estadual Intervales may be primarily influenced by their dominance in terms of number of species and individuals.

Predominance of fleshy fruits over dry ones recorded in our diet survey might also simply reflect the general higher abundance of fleshy fruits in tropical wet forests (Dirzo & Dominguez 1986, Morellato & Leitão-Filho 1992). In semideciduous forests near our study site, where dry fruits are more abundant than fleshy ones, the arboreal seed predators (monkeys and parrots) used more dry than fleshy fruits, particularly during the dry season (Galetti 1993, Galetti & Pedroni 1994).

Population fluctuations. Seasonal variation in the abundance of tropical frugivorous birds that occurs in response to changes in food supply has been reported for both canopy and understory bird assemblages (Crome 1975, Greenberg 1981, Leighton & Leighton 1983, Loiselle 1988, Levey 1988, Loiselle & Blake 1991, Rivera-Milan 1992). Such fluctuations may be particularly marked in parrots, because they are nomadic and a major fruit crop may have a large impact on their local abundance (Lanning & Shiflett 1983, Loiselle 1988). In fact, according to Terborgh *et al.* (1990), the main problem in censusing parrots is their fluctuating numbers that occur in response to local availability of food resources.

This study indicates that parrot species are less abundant or even absent from Parque Estadual Intervales during dry seasons. In general, average encounter rates during dry seasons were two to five-fold smaller than those registered in the wet seasons. We suspect that the availability of fruits which comprised more than 80% of parrot's diet, and particularly fleshy fruits (76.6% of fruits eaten), may be correlated to such population fluctuation. Parrots may also respond to climatic changes (e.g., temperature and moisture conditions) that occur during the dry season (see Karr & Freemark 1983). However, assessing the role played by each possible factor that might induce habitat shifts among parrots is a difficult task and beyond the scope of this paper.

Although there are no phenological studies focusing on the flora of Parque Estadual Intervales, studies carried out at Serra do Japi (about 150 km from our study site and with similar vegetation) showed that fleshy fruits are particularly plentiful during the wet season, and that flowering occurs chiefly in the dry season or early wet season (Morellato *et al.* 1989, Morellato & Leitão-Filho 1992). There is no reason to suspect that the flora of our study site follows a different pattern, and our general impressions support this contention.

In fact, parrot flock size, one of the components of our abundance estimate, may vary monthly in response to a great variety of poorly-known factors (Chapman *et al.* 1989, Rodrigues-Estrella *et al.* 1992), but food availability is likely to play an important role in such variation by setting limits on the number of birds that can forage together efficiently (Bradbury & Vehrencamp 1976, Chapman *et al.* 1989).

The palm tree *Euterpe edulis* is the only species to abundantly bear fruits during the dry season in the study site. This palm occurs in a density of 42 mature trees/ha, each individual produces two bunches with hundreds of fruits. These fruits represent an important food item for *Pyrrhura frontalis* which was the only parrot species observed consuming them. For instance, 50% of the feeding-bouts recorded for *P. frontalis* during the dry season (N = 18) were on fruits of *E. edulis*. Thus, according to the optimal foraging theory (Chapman *et al.* 1989 and references included), it is possible that *P. frontalis* grouped into larger groups to explore such an abundant food source. On the other hand, *B. tirica* may break into smaller flocks that are able to more efficiently find and exploit rare and clumped fruit crops occurring in the dry seasons (see Chapman *et al.* 1989).

Reproduction, which is reported to take place from September through February in south and southeastern Brazil (Forshaw 1989), may influence flock size as well (Chapman *et al.* 1989). However, the peak in abundance of *B. tirica* and *P. frontalis* observed in January—February 1991

can not be atributed to an increase in flock size due to the incorporation of youngs into the flocks. The high abundance then registered was in fact a result of more flocks being contacted with a consequent increase in average encounter rates.

Pionopsitta pileata was strikingly normadic at the study site, appearing throughout the year in small flocks that rarely were seen perched. Sick (1985) had previously noted temporary absences of this species from mountains of southeastern Brazil. Triclaria malachitacea is the rarest parrot species at the study site, although it may be locally common when feeding on large fruit crops (e.g., orange trees in orchard) as recorded elsewhere (Collar *et al.* 1992) and are particularly common in lowland forests at Parque Estadual Intervales (pers. observ.). This species primarily uses the subcanopy of the forest and has the status of one of the most secretive parrots in the world (Ridgely 1981). At our study site, *T. malachitacea* used degraded habitat patches near human settlements but was also observed in primary forest Sick (1968) observed post-breeding movement of this species from the highlands down into the coastal flats of Atlantic forest in southeastern Brazil.

In conclusion, our data indicate that the parrot species studied here engage in seasonal movements at Parque Estadual Intervales. Although further studies are needed, food suply may influence such movements. Given the wandering habits of parrot species, and that fruit availability likely vary in a spatial and temporal manner (Levey 1988), conservation programs for Atlantic forest psitacids will require large areas preferentially encompassing, as suggested by Willis & Schuchmann (1993), complete elevational gradients.

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REFERENCES

Bart, J. 1985. Causes of recording errors in singing bird surveys. Wilson Bull. 97: 161—172.

Beissinger, S. R., & N. F. R. Snyder. 1992. New World parrots in crisis. Washington.

Bradbury, J. W., & S. Vehrencamp. 1976. Social organization and foraging in emballuronid bats II. A model for the determination of group size. Behav. Ecol. Sociobiol. 1: 383—404.

Chapman, C. A., Chapman, L. J., & L. Lefebvre. 1989. Variability in parrot flock size: possible functions of communal roosts. Condor 91: 842—847.

Collar, N. J., Gonzaga, L. P., Krabbe, N., Madroño-Nieto, A., Naranjo, L. G., Parker III., T. A., & D. C. Wege. 1992. Threatened birds of the Americas. The ICBP/IUCN Red Data Book. Third edition. Cambridge.

Crome, F. H. J. 1975. The ecology of fruits pigeons in tropical northern Queensland. Aust. Wildl. Res. 2: 155—185.

Cronquist, A. 1981. An integrated system of classification of flowering plants. New York.

De Schauensee, R. M. 1970. A guide to the birds of South America. Wynnewood.

Dirzo, R., & C. A. Dominguez. 1986. Seed shadows, seed predation and the advantages of dispersal. Pp. 237—249 *in* Estrada, A., & T. H. Fleming (eds.). Frugivores and seed dispersal. Dordrecht.

Forshaw, J. M. 1989. Parrots of the World. Third edition. London.

Frankie, G. W., Baker, H. G., & P. A. Opler. 1974. Comparative phenological studies of trees in tropical lowland wet and dry forest sites of Costa Rica. J. Ecol. 62: 881—919.

Galetti, M. 1993. Diet of the Scaly-headed Parrot (*Pionus maximiliani*) in a semideciduous forest in southeastern Brazil. Biotropica 25: 419—425.

Galetti, M., & F. Pedroni. 1994. Seasonal diet of capuchin monkey (*Cebus apella*) in a semideciduous forest in south-east Brazil. J. Trop. Ecol. 10: 27—39.

Galetti, M., & M. Rodrigues. 1992. Comparative seed predation of pods by parrots in Brazil. Biotropica 24: 222—224.

Greenberg, R. 1981. The abundance of forest canopy birds on Barro Colorado Island, Panama. Biotropica 13: 241—251.

Hilty, S. L. 1980. Flowering and fruiting periodicity in a premontane rain forest in Pacific Colombia. Biotropica 12: 292—306.

Janzen, D. H. 1969. Seed-eaters *versus* seed size, number, toxicity, and dispersal. Evolution 23: 1—27.

Karr, J. 1981. Surveying birds in the tropics. Stud. Avian Biol. 6: 548—553.

Karr, J. R., & K. E. Freemark. 1983. Habitat selection and environmental gradients: dynamics in the "stable" tropics. Ecology 64: 1481—1494.

Lanning, D. V., & J. J. Shiflet. 1983. Nesting ecology of Thick-billed Parrots. Condor 85: 66—73.

Leighton, M., & D. Leighton. 1983. Vertebrate responses to fruiting seasonality within a Bornean rain forest, Pp. 197—209 *in* Sutton, S. L., Whitmore, T. C., & A. C. Chadwick (eds.). Tropical rain forest: ecology and management. Oxford.

Levey, D. J. 1988. Spatial and temporal variation in Costa Rican fruit and fruit-eating bird abundance. Ecol. Monogr. 58: 251—269.

Loiselle, B. A. 1988. Bird abundance and seasonality in a Costa Rican lowland forest canopy. Condor 90: 761—772.

Loiselle, B. A., & J. G. Blake. 1991. Temporal variation in birds and fruits along an elevational gradient in Costa Rica. Ecology 72: 180—193.

Morellato, L. P. C., & H. F. Leitão-Filho. 1992. Padrões de fruitificação na Serra do Japi. Pp. 112—140 *in* Morellato, L. P. C. (ed.). História natural da Serra do Japi. Campinas.

Morellato, L. P. C., Rodrigues, R. R., Leitão-Filho, H. F., & C. A. Joly. 1989. Estudo comparativo da fenologia de espécies arbóreas de floresta de altitude e floresta mesófila semidecídua na Serra do Japi, Jundiaí, São Paulo. Revta. brasil. Bot. 12: 85—98.

Munn, C. A. 1988. Macaw biology in Manu National Park, Peru. Parrot Letter 1: 18—21.

Prance, G. T., Rodrigues, W. A., & M. F. Da Silva. 1976. Inventário florestal de um hectare de terra firme km 30 da estrada Manaus-Itacoatiara. Acta Amazônica 6: 9—35.

Ridgely, R. S. 1981. The current distribution and status of mainland Neotropical parrots. Pp. 233—284 *in* Pasquier, R. F. (ed.). Conservation of New World parrots. Washington.

Rivera-Milán, F. F. 1992. Distribution and relative abundance patterns of columbids in Puerto Rico. Condor 94: 224—238.

Rodrigues-Estrella, R., Mata, E. S., & L. Rivera. 1992. Ecological notes on the Green Parakeet of Isla Socorro, Mexico. Condor 94: 523—525.

Roth, P. 1984. Repartição do habitat entre psitacídeos simpátricos no sul da Amazônia. Acta Amazônica 14: 175—221.

Sazima, I. 1989. Peach-fronted Parakeet feeding on winged termites. Wilson Bull. 101: 656—657.

Sick, H. 1968. Vogelwanderungen im kontinentalen Südamerika. Vogelwarte 24: 217—242.

Sick, H. 1985. Ornitologia brasileira: uma introdução. Brasília.

Silva, A. F. S., & H. F. Leitão-Filho. 1982. Composição florística e estrutura de um trecho de Mata Atlântica de encosta no município de Ubatuba (São Paulo, Brasil). Revta. brasil. Bot. 5: 43—52.

Snedecor, G. W., & W. G. Cochran. 1980. Statistical methods. Ames.

Snow, D. W. 1962. The natural history of the oilbird, *Steatornis caripensis* in Trinidad, W. I. Part 2. Population, breeding, ecology and food. Zoologica (N. Y.) 47: 199—221.

Snyder, N. F. R., Wiley, J. W., & C. B. Kepler. 1987. The parrots of Luquillo: natural history and conservation of the Puerto Rican Parrot. Los Angeles.

Terborgh, J., Robinson, S. K., Parker III, T. A., Munn, C. A., & N. Pierpont. 1990. Structure and organization of an Amazonian forest bird community. Ecol. Monogr. 60: 213—238.

Waide, R. B., & P. M. Narins. 1988. Tropical forest bird counts and the effect of sound attenuation. Auk 105: 296—302.

Willis, E. O., & K.-L. Schuchmann. 1993. Comparison of cloud-forest avifaunas in southeastern Brazil and western Colombia. Orn. Neotrop. 4: 55—63.

Zar, J. H. 1984. Biostatistical analysis. London.