

DIET AND FEEDING BEHAVIOR OF THE REDDISH-BELLIED PARAKEET (*PYRRHURA FRONTALIS*) IN AN ARAUCARIA FOREST IN SOUTHEASTERN BRAZIL

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Resumo. – Dieta e comportamento alimentar da Tiriba-da-testa-vermelha (*Pyrrhura frontalis*) numa floresta de Araucária no sudeste do Brasil. – A dieta e o comportamento alimentar da Tiriba-da-testa-vermelha (*Pyrrhura frontalis*) foram estudados no Parque Estadual de Campos do Jordão, Estado de São Paulo, Brasil. Os periquitos utilizaram 21 espécies de plantas em sua dieta. O maior número de episódios alimentares registrado foi para a gramínea (*Rhynchelitrum roseum*) (21.88%), e o pinho-bravo (*Podocarpus lambertii*) (19.7%). Os itens mais explorados foram as sementes (51.47%), seguidas por folhas (25%). O grande consumo de folhas na dieta não havia ainda sido registrado para nenhuma outra espécie de psitacídeo Neotropical. O tamanho médio de bandos não apresentou variação significativa ao longo do ano, mas o tamanho máximo de bandos foi menor nos meses mais secos e na estação reprodutiva. O tempo que as aves permaneciam em um sítio alimentar foi correlacionado com o tamanho dos bandos quando os periquitos se alimentavam em gramíneas (áreas abertas), mas não quando se alimentavam em árvores. Os menores bandos nunca permaneciam muito tempo em áreas abertas, devido a esses sítios de alimentação não fornecerem tanta proteção quanto as árvores. Neste estudo um sistema de sentinela foi observado quando os bandos utilizavam recursos em áreas abertas.

Abstract. – The diet and feeding behavior of the Reddish-bellied Parakeet (*Pyrrhura frontalis*) was studied in the Campos do Jordão State Park, São Paulo, Brazil. The parakeets used 21 different species of plants in their diet. The largest number of feeding bouts recorded was on the grass *Rhynchelitrum roseum* (Gramineae) (21.88%), and the tree *Podocarpus lambertii* (Podocarpaceae) (19.7%). The seeds were the most explored food item (51.47%), followed by leaves (25%). The high intake of leaves in the diet was not previously recorded for any species of Neotropical psitacids. Mean flock sizes did not vary significantly throughout the year, but maximum flock size was smaller in dry months and in the breeding season. The time the birds spent in a feeding site and flock size were correlated when the parakeets were feeding on grass (open areas), but not when feeding on trees. Because open areas do not provide as much protection as trees, the small flocks would never remain for a long time in the feeding site. A sentinel system was observed when the flocks fed on open areas. *Accepted 18 September 2000.*

Key words: *Pyrrhura frontalis*, feeding, diet, Brazil, Araucaria forest.

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INTRODUCTION

The Reddish-bellied Parakeet (*Pyrrhura frontalis*) is one of the commonest parakeets in

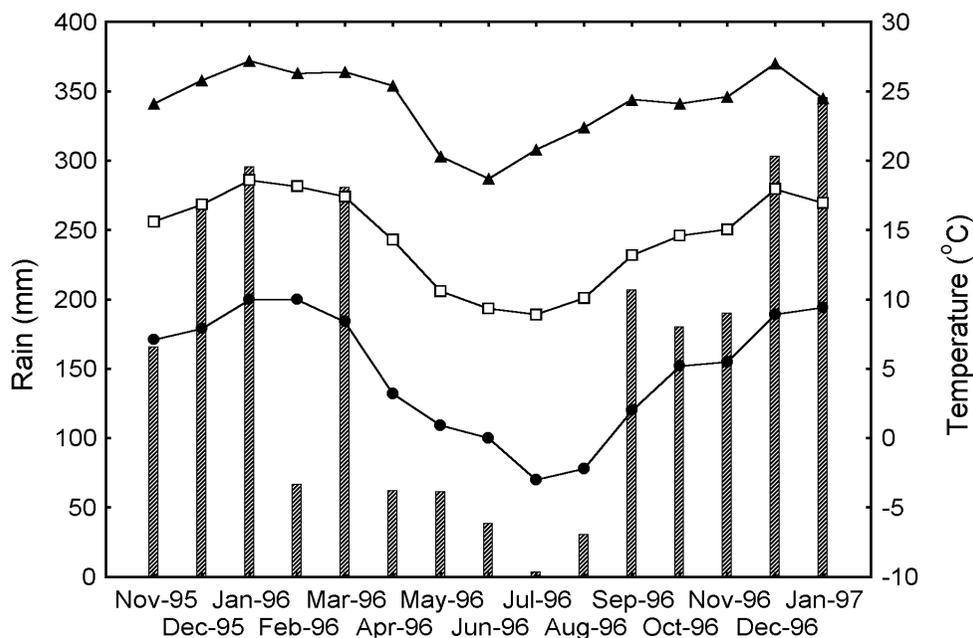


FIG. 1. Seasonal variation in rainfall (bars) for Campos do Jordão during the study period. Triangles, squares, and dots indicate maximum, mean, and minimum temperatures, respectively.

southeastern Brazil (Sick 1997), with a length of 26 cm and ranging from Bahia to the north of Argentina (Forshaw 1977). These psitacids are commonly found in *Araucaria* forests, but also inhabit other types of forest (Forshaw, 1977).

Although *Pyrrhura frontalis* is a common species and have a wide geographical distribution, studies about its feeding habits are anecdotal and have not extensively explored the issue. This species is known to feed basically on fruits, seeds, and flowers of several plant species (Voss & Sander 1980, Marcondes-Machado & Argel de Oliveira 1985, Belton 1994, Pizo *et al.* 1995, Galetti 1997), and occasionally on insect galls (Martuscelli 1994). The *Araucaria* nuts are one of the major items in the diet of this species in Southern Brazil (del Hoyo *et al.*, 1997). Like other psitacid species, they are considered to be seed predators (Janzen 1981), because they usually prey on seeds

and do not contribute to the dispersal of plants.

In this study, we studied the feeding ecology of the Reddish-bellied Parakeet, mainly focusing on diet and feeding behavior, in a forest dominated by *Araucaria angustifolia* (Araucariaceae) and *Podocarpus lambertii* (Podocarpaceae) trees in the state of São Paulo, Brazil.

STUDY SITE AND METHODS

This study was undertaken in the Parque Estadual de Campos do Jordão (PECJ), state of São Paulo (22° 45'S, 45° 30'W), Brazil. The total area of the park is approximately 8300 ha, with an altitudinal gradient going from 1030 to 2007 m. The climate of the region is characterized as subtropical, mesothermic and humid, with no long periods of drought. During the months studied, the mean maxi-

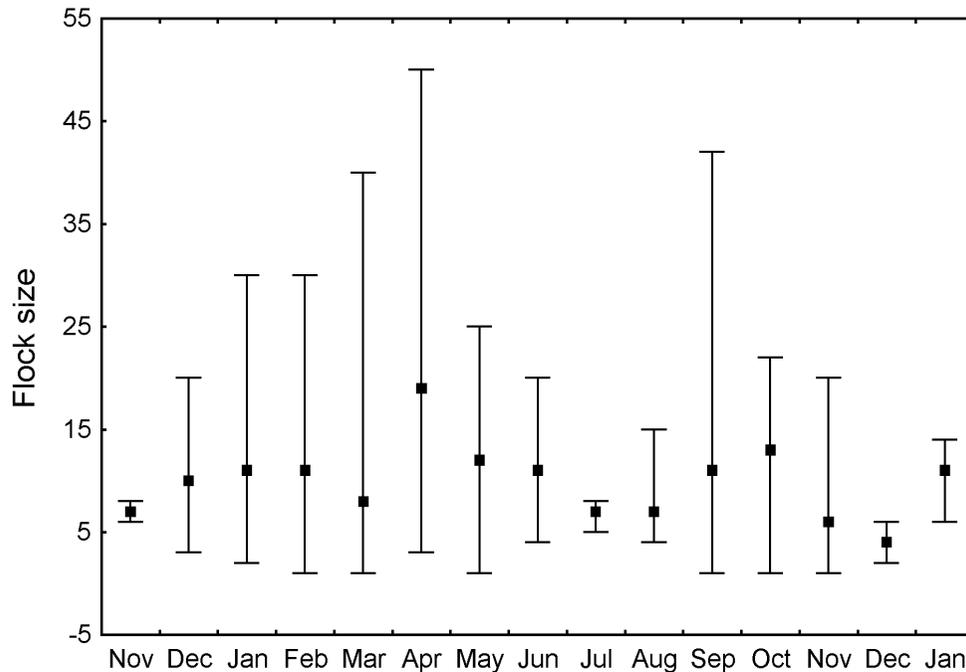


FIG. 2. Seasonal variation in flock size of Reddish-bellied Parakeets (mean, maximum and minimum) in Parque Estadual de Campos do Jordão.

mum and minimum temperatures were 24.1°C and 4.9°C (Fig. 1). Mean rainfall during 1996 was 166.4 mm. The PECJ vegetation is composed of three basic formations: *Araucaria-Podocarpus* forest, broad-leaved forest on the Atlantic slopes, and open fields at higher altitudes (Seibert *et al.* 1975).

Observations were recorded *ad libitum* (Altmann 1974), i.e., we registered all possible events occurring during the study period. Field work was conducted from November 1995 to January 1997, during monthly visits from five to seven days. The birds were directly observed during walks through trails in the forests and open areas between 06:30 to 13:30 h, and 16:30 to 18:00 h. The diet was estimated by recording feeding bouts, i. e., every time one or more individuals were feeding on a certain plant. If the birds moved to another resource and started feeding, this

was considered as a new feeding bout (Altmann 1974, Galetti 1993). The number of birds and time spent during each feeding bout were also recorded for the purpose of estimating the exploitation (number of birds × time spent on the resource) of the plants. The different methods to estimate resource utilization (feeding bouts) and exploitation were compared by a paired t-test (Sokal & Rohlf 1995).

The behavioral patterns for obtaining food items were classified as suggested by Moermond & Denslow (1985): 1) picking, when the birds grabbed fruits close to their perch; 2) reaching, when the birds had to lean outwards or downwards the perching pole; 3) hanging, when the entire body of the bird hung from the perch upside down. The methods for food ingestion were classified as: 1) pick and bite, when the bird picked the

TABLE 1. Relative importance of different plant species in the diet of Reddish-bellied Parakeets: Origin, number (percentage) of feeding bouts, food items, months observed and flock size ranges, based on data collected from November 1995 to January 1997.

Plant species	Origin	Feeding bouts	Items ¹	Months	Flock size range
Gramineae					
<i>Rhynchelistrum roseum</i>	Exotic	30 (21.88%)	se,le	Jan, Feb, Jun-Nov	1-42
Cupressaceae					
<i>Cupressus sempervirens</i>	Exotic	17 (12.39%)	se,le	Jan, Mar, May-Dec	1-30
Leguminosae					
<i>Acacia decurrens</i>	Exotic	3 (2.18%)	se	Dec, Jan	8-20
<i>Mimosa scabrella</i>	Native	4 (2.91%)	se	Jan, Feb	3-15
<i>Mimosa cf. myuros</i>	Native	1 (0.72%)	se	Oct	4
Podocarpaceae					
<i>Podocarpus lambertii</i>	Native	27 (19.70%)	se	Feb-Aug	1-40
Araucariaceae					
<i>Araucaria angustifolia</i>	Native	10 (7.28%)	se,sr	May, Jul-Oct	1-16
Pinaceae					
<i>Pinus elliottii</i>	Exotic	15 (10.93%)	se,sp	Feb-Jun, Aug	4-25
<i>Pinus patula</i>	Exotic	6 (4.37%)	sp	Mar-Jul	5-50
<i>Pinus</i> sp.	Exotic	2 (1.45%)	sp	Nov, Dec	2
Compositae					
<i>Piptocarpha axilaris</i>	Native	2 (1.45%)	le	May	4-12
Symplocaceae					
<i>Symplocos</i> sp.	Native	1 (0.72%)	se	Feb	5
Viscaceae					
<i>Phyticusa</i> sp.	Native	1 (0.72%)	se	Oct	10
Myrtaceae					
<i>Gomidesia sellowiana</i>	Native	3 (2.18%)	se	Oct, Nov	2-6
Polygalaceae					
<i>Polygala</i> sp.	Native	1 (0.72%)	fl	Dec	6
Rosaceae					
<i>Prunus persica</i>	Exotic	4 (2.91%)	pu	Jan, Nov, Dec	1-4
<i>Prunus domestica</i>	Exotic	1 (0.72%)	pu	Jan	12
<i>Pyrus communis</i>	Exotic	3 (2.18%)	pu,fl	Jan, Sep	5-6
<i>Malus silvestris</i>	Exotic	3 (2.18%)	pu,le	Jan	6
Bromeliaceae					
<i>Aechmea nudicaulis</i>	Native	1 (0.72%)	le	Sep	1
Usneaceae					
<i>Usnea barbata</i>	Native	2 (1.45%)	st	Mar	5-9

¹st = stem, sp = sprout, le = leaf, se = seed, fl = flower, pu = pulp, sr = strobilus.

item with the beak, took it with the foot, and bit off pieces of the item, which were ground and swallowed (Simmons 1961); 2) bite, when the birds bit off pieces of the item without picking it from the plant; 3) grind and swal-

low, when the birds picked the item with the beak and grounded and swallowed it whole (Moermond & Denslow 1985). Total time of observation was 329 h.

Parrots are often known to be left-handed

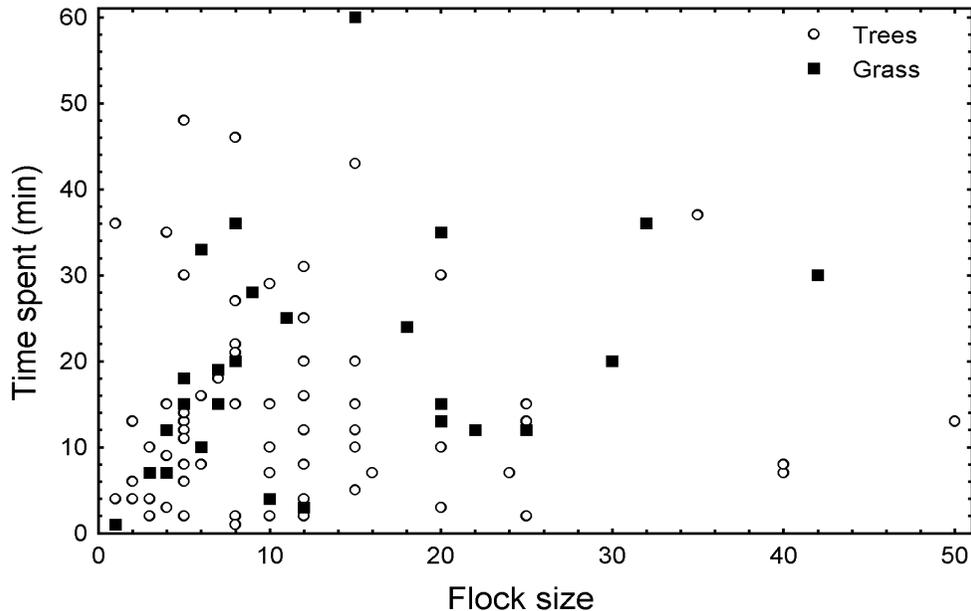


FIG. 3. Variation in the time spent at a feeding site according to flock size by Reddish-bellied Parakeets feeding on open areas (grass) and trees.

or right-handed when grabbing food (McNeil *et al.* 1971). A Chi-square test was used to assess whether *Pyrrhura frontalis* has a preference of usage of left or right foot. Flock size variation throughout the year was analyzed by a Kruskal-Wallis test. We used the Spearman rank correlation coefficient (Sokal & Rohlf 1995) to verify if there was any correlation between flock size and time spent in a given plant.

RESULTS

During the study period, we recorded 137 feeding bouts and the parakeets ate 21 plant species of 14 families (Table 1). The diet items consisted of seeds (51.47%), leaves (25%), sprouts (13.24%), fruit pulp (5.88%), flowers (1.47%), stems (1.47%) and strobilus (1.47%). Some plant species were represented by more than one item (Table 1), for example, leaves and seeds were eaten from the

grass *Rhynchelitrum roseum*, but most plant species (15) contributed with a single item. The plant families with the greatest number of species in the diet of *P. frontalis* were Rosaceae and Leguminosae, being represented by four and three species, respectively. In our study, from all plant species consumed, 52.4% are natives and 47.6% are exotic (Table 1). The greatest number of feeding bouts was recorded on *Rhynchelitrum roseum* (Gramineae) (21.88%) and *Podocarpus lambertii* (19.7%). The results from feeding bouts and exploitation were not significantly different ($t = 0.022$; $P = 0.984$), thus indicating that the estimate of resource usage by feeding bouts was satisfactory.

The fruit pulp was eaten only in Rosaceae species (Table 1). The seeds and fruit pulp were mostly consumed during the wet season. Immature fruits from the following plants were eaten: *P. lambertii*, *Pyrus communis*, *Prunus domestica*, *Malus silvestris*, *Gomidesia sello-*

wiana and *Acacia decurrens*. Some plant species, e.g., *R. roseum*, *Pinus elliottii*, *Pinus patula* and *Piptocarpha axilaris*, were available throughout the whole year, but the parakeets explored mainly *R. roseum* and *P. elliottii*, with only one record in May for *P. axilaris*.

The methods for obtaining the food items were not evenly used and depended a lot on the plant being explored: picking = 80.42%; reaching = 12.58%; hanging = 7% (n = 143). The ingestion methods were also unevenly used: pick and bite = 38.94%; bite = 6.10%; grind and swallow = 54.96% (n = 131). The parakeets used their feet to handle items of 11 plant species, but there was no significant difference in use of right or left foot in relation to the kind of food items ($\chi^2_1 = 0.308$; $P = 0.5789$; n = 76 total, 40 left, 36 right).

The parakeets were rarely observed drinking, but in one occasion, 40 birds one after the other drank water from a bromeliad, so all individuals could drink. On another episode, three individuals were observed drinking water from a rain pond in a trail.

The mean number of individuals on the flocks varied significantly throughout the year (Kruskal-Wallis test; $H_{12} = 22.39$, $P = 0.032$), and there was a tendency for the maximum flock size to decrease during the driest months (June–August) and during the breeding season (October–January) (Fig. 2). When foraging in small flocks (eight individuals or less), the parakeets were very silent, and there were usually one or two sentinels (when the flock was feeding on the grass) perched on branches, at least 2 m high, of nearby trees. The sentinels were identified as birds that perched on a nearby tree and were not feeding, while the rest of the flock members were ground feeding. The largest flocks were observed in open areas where the parakeets fed on grass leaves and seeds. The plant species visited by large flocks (i. e., 25 individuals or more) were *Cupressus sempervirens*, *P. lambertii*, *P. elliottii*, *P. patula* and *R. roseum* (Table

1). During the breeding season, the flock size of birds foraging close to nest sites never exceeded eight individuals.

There was a significant correlation between flock size and the time the birds spent on given food plants only when feeding on the grass species *R. roseum* ($r_s = 0.409$, $P = 0.038$). No such correlation was observed when considering the most frequently used tree species (*P. lambertii*, $r_s = 0.143$, $P = 0.242$; *A. angustifolia*, $r_s = -0.056$, $P = 0.879$; *Cupressus sempervirens*, $r_s = 0.229$, $P = 0.377$; and *Pinus* sp., $r_s = 0.204$, $P = 0.450$). There was a tendency for larger flocks to remain longer at the feeding site, whenever the parakeets were feeding on grass leaves and seeds (Fig. 3). Whenever the birds were feeding among trees, even small flocks stayed for long times at the site (Fig. 3).

We observed “supplant attacks” when an individual flew towards another and displaced the latter from the feeding site, and “real attacks”, when an individual physically attempted to remove another from the feeding site. The parakeets were observed attacking *Zonotrichia capensis* (real attacks), and *Pitangus sulphuratus* (supplant attacks). On the other hand, the parakeets were attacked by *Turdus rufiventris*, *Cacicus crysopterus* and *Cyanocorax chrysops* (all supplant attacks). In one occasion, a flock of a 10 parakeets was foraging on the ground when two Yellow-headed Caracaras (*Milvago chimachima*) approached the feeding site. The sentinels that were perched on a *Cupressus* tree alarmed the others and the flock flew away.

DISCUSSION

The feeding on seeds of *A. angustifolia*, *P. elliottii* and fruits of *P. lambertii* by parakeets has been observed before by Belton (1994), Sick (1997) and Voss & Sander (1980). Our study has expanded their food items to flowers, leaves and lichen. Previous studies on the

Atlantic forest of Southeastern Brazil reported a quite different plant species composition in the diet of *P. frontalis* (del Hoyo *et al.* 1997, Pizo *et al.* 1995). That is probably caused by the different species composition of the *Araucaria* forest compared to lower altitude Atlantic forests. Although in the *Araucaria* forests of Southern Brazil, the seeds of this plant were a major diet item for *P. frontalis* (Belton 1994, del Hoyo *et al.* 1997), we found that the *Araucaria* seeds were the fourth most consumed item in Campos do Jordão. A more detailed study would be needed to determine whether this preference is correlated with local plant densities.

The large number of feeding bouts observed in *P. lambertii* is probably due to the fact that it is the most abundant tree in the study site, and is available during all the first semester of the year. The presence of leguminous plants in the parakeets' diet was relatively small compared to other plant species and items. On the other hand, if we consider that these resources were more dispersed and less abundant, the leguminous plants were well explored. Roth (1984) and Galetti (1993) consider leguminous fruits to be important items in the diet of psittacids in the Neotropical forests.

Fleming *et al.* (1985) considers psittacids to be important seed dispersers for some plant species with small seeds. On the other hand, Janzen (1981) argues that psittacids are rarely frugivorous and usually predate on seeds. In our study, we may consider the Reddish-bellied Parakeets to be seed predators, because they usually ground the seeds before swallowing them.

Although *Araucaria* is a common tree around the study site and its seeds were available for almost the same period observed for *Podocarpus*, it was less used as food by the parakeets. This might indicate some difference for the parakeets in the cost for obtaining and/or exploring the items from these two

tree species. Moermond & Denslow (1985) argue that the accessibility of fruits strongly influence fruit choice in birds' diets. Accessibility might be defined as a series of characteristics of the food item that are correlated with characteristics of the birds that eat them. For instance, fruits that are distant from the perch are reached more easily by birds with certain tarsus shapes and modifications in leg musculature. Therefore, each bird will select the food items that can be reached with the lower cost and can provide a maximum profit according to its own characteristics. There is evidence that *Araucaria* seeds are more costly and less profitable for parakeets than the seeds of *Podocarpus*. Because the *Araucaria* seeds have a hard external layer, Reddish-bellied Parakeets usually open small windows in the seed and eat only a small portion of the endosperm. *Podocarpus* seeds, on the other hand, do not have hard external layers and were much easier to eat. This is not a problem for all psittacid species, for the larger parrots Vinaceous Amazon (*Amazona vinacea*) explore very well the *Araucaria* seeds by breaking the hard exterior layer and eating the endosperm completely.

The same argument presented above might explain the high amount of grass leaves and seeds in the diet of the parakeets. Grasses are abundant in several open areas of the study site and thus can be easily found. Monocotyledon seeds are important food items for a number of psittacids, such as *Cacatua galerita* (Forshaw 1977), *Cacatua roseicapilla*, *Psephotus haematonotus* (Westcott & Cockburn 1988), *Pezoporus wallicus wallicus* (Bryant 1994) and *Psephotus dissimilis* (Garnett & Crowley 1995). However, most birds will not eat such a large amount of leaves as observed for *P. frontalis*. The presence of leaves in the diet had not been reported before for Neotropical psittacids, only for the Kakapo (*Strigops habroptilus*) (Forshaw 1977).

Nos & Camerino (1984) reported that

Brotogeris versicolorus, *Myiopsitta monachus* and *Pyrrhura molinae* have a clear preference to grab food items with the left foot. McNeil *et al.* (1971) showed that individuals of *Aratinga pertinax* presented either left or right-handed preference to grab food items, but there was no predominance of left over right-handed individuals in the sample. Although our observations showed no clear preference of foot usage in the species as a whole, it is not possible to determine whether there was an individual preference for left or right foot. It has been argued that the use of both hands increase the diversity of food items and resources in the diet (Cannon, 1983).

The availability of food items plays an important role in flock size variability, because it limits the number of animals that can forage together efficiently. When resources are rare and clustered, the foraging flocks become smaller (Bradbury & Vehrencamp 1976, Stacey 1986, Altmann 1974). Pizo *et al.* (1995) argue that during periods of lesser food resources, psittacids change the flock sizes and may migrate to other areas in Serra do Mar, Atlantic forest. Because of the large availability of resources (food and reproduction sites), the parakeets probably forage only within the PECJ limits, and just change flock sizes.

According to Murton (1971), the main benefit of flocking in birds would be to improve foraging efficiency, instead of predation avoidance. Faaborg (1988) and Westcott & Cockburn (1988) argue that predator detection would be of greater benefit. Further evidence corroborating the second hypothesis may be given by our results. The time spent in the feeding site was significantly correlated with flock size only in open areas. This means that the larger the flock, the longer the time the parakeets spent exploiting the resource (grass seeds and leaves). However, when they were feeding on trees, there was no significant relationship between flock size and time

spent at the feeding site. Because the parakeets were relatively more protected from predation in trees than on the ground, they stayed for long periods at the same feeding site even in small flocks.

Harrocks & Hunte (1986) define sentinel as one alert individual, perched in a prominent place, watching members of its flock foraging nearby. On the other hand, McGowan & Woolfendem (1989) argue that if the members of a flock take turns as sentinels during a feeding episode, they should not be considered as true sentinels. According to this classification, the sentinels observed in feeding flocks of *Pyrrhura frontalis* should not be considered true sentinels.

As discussed above, the overall aspects of diet and feeding behavior of the Reddish-bellied Parakeet in Campos do Jordão are similar to other psittacid species (except, of course, the large amount of leaves consumed). The social system and diversity of food acquisition methods presented by this species, ensure that, although the study area is anthropically disturbed, the available resources are optimally explored.

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