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Avian frugivores feeding on *Mauritia flexuosa* (Arecaceae) fruits in Central Brazil

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RESUMO: Consumo de frutos do buriti *Mauritia flexuosa* (Arecaceae) por aves frugívoras no Brasil Central. O buriti, *M. flexuosa,* tem uma ampla distribuição na América do Sul e é muito comum no Brasil. Existem poucas informações sobre as interações entre frugívoros e a palmeira. Os estudos tinham como objetivo determinar os consumidores do fruto do buriti e analizar a importância de cada um deles. Coletamos dados de disponibilidade de frutos revisando 100 buritis e anotando a presença de frutos maduros, em todo o período de trabalho. A utilização de frutos de buriti por aves frugívoras foi estudada através da observação direta dos cachos em três buritis. As observações incluíram freqüência de visitas, tamanho do bando, número de frutos consumidos e comportamento de forrageamento. Também colocamos três coletores de frutos embaixo de tres cachos de buriti para determinar taxas de queda dos frutos. Oito espécies de aves comeram os frutos do buriti e os psitacideos foram os principais consumidores, especialmente *Orthopsittaca manilata.* Os frutos de *M. flexuosa* são um importante recurso alimentar para frugívoros na estação seca, quando frutos são escassos no cerrado.

PALAVRAS-CHAVE: Cerrado, psitacideos, dispersão, espécie chave, comportamento alimentar.

ABSTRACT: Avian frugivores feeding on *Mauritia flexuosa* (Arecaceae) fruits in Central Brazil. The buriti palm tree *M. flexuosa* has a widespread distribution in South America and is very common in central Brazil. Information about the interactions between frugivores and the buriti palm tree are scarce. The objective of the study was to investigate the consumption of buriti fruits by avian frugivores in the Cerrado of Central Brazil and to analyze its importance to the plant. In order to describe fruit availability, we sampled 100 buritis determining monthly, the presence or absence of ripe fruit. We gathered data on buriti fruit utilization by avian frugivores by direct observation of bunches on three buriti individuals. Observations included visit frequency, flock size, number of eaten fruits, and foraging behavior. We also placed three buriti fruit collectors to evaluate fruit drop rates. Eight species of birds ate the buriti fruit and psitacids were the main consumers, especially *Orthopsittaca manilata.* Fruits of *M. flexuosa* are an important food resource for frugivores in the dry season when other fruits are scarce in the Cerrado.

KEY-WORDS: Cerrado, psitacids, seed dispersal, flock size, visit frequency, visit times, feeding behavior.

The buriti palm, *Mauritia flexuosa* Arecaceae, is a common palm tree in many countries of South America, including Brazil, where it is a conspicuous part of the landscape (Uhl and Dransfield 1987). *M. flexuosa* can occur in monospecific stands following the "veredas": which are swampy areas covered with grasslands, sometimes connecting natural fragments of gallery forest in the cerrado of Central Brazil (Eiten 1990). In the cerrado, the buriti fruit has a mean weight of 59.7 ± 7.6 g and can produce more than 1000 fruits per infrutescence, with an estimated fruit yield of 3.6 tons/ha (M. P. V., *unpubl. data*). Barbosa *et al.* (2010) found a similar result of 3.29 tons/ha for buritis in the Amazonian savanna. Fruits are economically important (Correia 1984) and nutritious, with the pulp contributing with 37% of total weight, constituted mainly by 53% fat, 43% carbohydrates and 4% protein (Lopes *et al.* 1980).

Although the importance of the buriti palm tree for humans has been shown (Kahn 1991), few studies have investigated the interaction between animal frugivores and the buriti palm fruits (Bodmer 1990, Fragoso *et al.* 2003). The term frugivore refers to an animal that feeds primarily on fruits and it is considered a very common diet type (Danell and Bergstrom 2002) that can benefit plants by dispersing seeds. Seed dispersal is important for plants because it allows their progeny to move away from their parents diminishing predation risks and competition (Janzen 1970). There are few specialized frugivores (Jordano *et al.* 2007) because fruit availability varies by season and year, inhibiting frugivore animals to rely on just one plant species (Herrera 2002). However, it has been widely accepted that some species of plants, mainly figs and palms, can function as keystone resources for frugivores in tropical forests because they bear large fruit crops during periods of fruit scarcity and are consumed by large assemblages of frugivores (Terborgh 1986). A large number of neotropical bird species regularly eat

fruit (Moermond and Denslow 1985) and it has been shown that the extinction of seed dispersing species could negatively affect plant establishment (Loiselle and Blake 2002). The importance of frugivores as seed dispersal agents is difficult to assess because different seed dispersers tend to disperse seeds to different habitats, at different rates, and distances depending on their behavior, degree of specialization and abundance (Montoya *et al.* 2008). The objectives of this study were to investigate the frugivore birds that feed on the buriti fruit and their role as potential dispersers of *M. flexuosa.* We wanted to determine the period of time in which the fruits of *M. flexuosa* were available and examine the possible frugivore species that were present and actively eating the buriti fruit in the study area. We were interested in collecting information on the abundance of these frugivores, foraging behavior, fruit consumption, frequency of visit, and flock size. We believed that these characteristics would help us to assess the importance of the frugivores to the buriti palm tree and would allow us to determine potential seed dispersal agents.

METHODS

The association between avian frugivores and the buriti was studied during 10 months (1992-1993) in the Águas Emendadas Ecological Reserve (AEER), a 10.500 ha protected area localized in the Cerrado of Central Brazil. AEER protects a six-kilometer long vereda that connects the two major watershed of Latin America, La Plata and the Amazon. The total swampy area was of 78 ha with more than 2000 adult buriti palm trees. To describe fruit availability and with the aid of binoculars, we sampled monthly 100 buritis within a total area of 4 ha determining the number of bunches with ripe fruit and registering psitacid foraging signs (partially eaten fruits still attached to the bunch). Investigations on fruit consumption by frugivore birds included 46 hours of direct observation of bunches (with binoculars) in three buriti palm trees, wearing camouflage clothes and at a distance of approximately 50 m from the palm tree. After obtaining some preliminary information on psitacid activity within the study area, the observation periods were determined to be from 06:00-08:00 in the morning and from 16:30 to 18:30 in the afternoon. We gathered data on feeding behavior, frequency of visits, flock size and visit times, and also registered all possible events of interest occurred during the study period, like agonistic encounters among psitacids. To evaluate rate of fruit drop, which we assume was directly related with fruit availability and consumption, we placed three fruit collectors beneath three buriti bunches in three different palm trees. We checked fruit traps every two days, counted all fruits, and evaluated fruit/seed damage. Statistical analysis includes a Kruskall Wallis test when comparing flock size and fruit consumption in different fruit traps. To determine differences in visit times we utilized a One Way Analysis of Variance, with a post-hoc Tukey test when necessary.

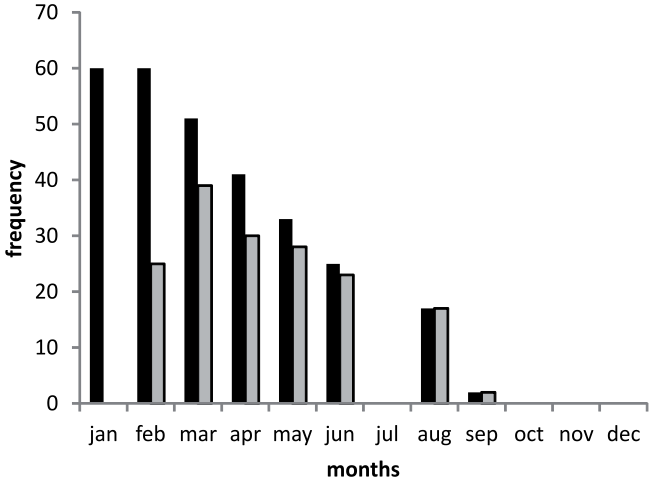

FIGURE 1: Number of buriti bunches with ripe fruit (black bar) and number of bunches visited by macaws (gray bar) at Águas Emendadas Ecological Reserve, Central Brazil.

RESULTS

Fruits were available along seven months and a fruit-dropping peak was registered in the middle of the dry season that generally goes from May to September. Thirty-five percent of the buritis (n = 100) had ripe fruits in the beginning of the study and all of the 60 bunches were visited by avian frugivores until the end of investigations (Figure 1). We collected a total of 2359 fruits on fruit collectors during the study period (1276 fruits in the first fruit collector, 897 in the second, and 186 in the third). The fruit-dropping rate varied in fruit collectors (Kruskall-Wallis = 58.4, $p < 0.01$), with a maximum of 21.78 fruits/day in the first fruit collector in June and

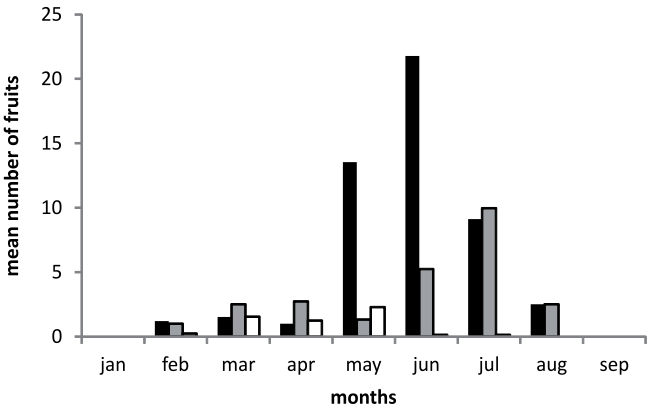

FIGURE 2: Mean number of fruits dropped per day in the three buriti fruit collectors at Águas Emendadas Ecological Reserve, Central Brazil. First, second, and third fruit collectors are represented respectively by black, gray, and white bars.

9.96 fruits/day in the second fruit collector in July. Fruit droppings in the third collector were low at any time, with a maximum of 2.29 fruits/day in May (Figure 2).

Eight species of birds were observed feeding on the buriti fruit (*Caracara plancus, Ara ararauna, Orthopsittaca manilata, Amazona aestiva, Cyanocorax cristatellus, Tangara palmarum, Schistochlamys melanopis,* and *Gnorimopsar chopi*). The three species of psitacids were the main consumers (*A. ararauna, O. manilata,* and *A. aestiva*) and were commonly seen foraging in the study area (Table 1). These species were responsible for 93% of all fruit droppings found on fruit collectors (n = 2359). We were able to determine frugivore identity because of the characteristic marks psitacids make with their beaks on the mesocarp and endocarp of the fruit.

The behavior of psitacids when eating the buriti fruit is similar in certain aspects. They perch on the bunch and with the beak start to peel the fruit, taking off the hard scales of the fruit coat and eating the exposed pulp. They partially eat the pulp leaving the rest of the fruit attached to the bunch. Sometimes they remove the fruit from the bunch and manipulate it with the foot. In this case, *O. manilata* generally ate all the pulp and discarded the clean endocarp near the base of the palm. Psitacids were also observed flying with the fruit on the beak to a leaf of the same palm tree or to the leaf of a neighboring buriti. All species were seen at least one time carrying the buriti fruit in the beak and *O. manilata* was seen six times carrying the fruit and accidentally dropping it between two buriti palm trees. In two occasions, we saw *O. manilata* carrying the fruit and flying away, following the vereda (until out of sight) for at least 500 meters without dropping the fruit.

There were some important differences in foraging behavior between parrots and macaws. *Amazona aestiva* stayed foraging in the same bunch of the same individual and macaws commonly switched from one buriti to another. Parrots generally ate all the pulp in the fruit, sometimes damaging the endocarp that was left with the seed exposed. Many of these seeds were attacked by coleopterans (Scollitidae). During fieldwork, only macaws were seen foraging on the buriti of the first fruit collector. In contrast, both macaws and parrots visited buritis where the other two fruit collectors were placed. In the first fruit collector, we found 0.5% of seed predation by coleopterans (n = 1276), whereas in the second this proportion reached 2.1% (n = 897). There was no seed predation by coleopterans in the third fruit collector. *Amazona aestiva* was seen defending the bunch against *O. manilata, A. ararauna, G. chopi,* and *C. plancus,* and always expelled intruders. Agonistic encounters among macaws were also common and ended when one individual moved to another bunch of another palm tree. As a consequence, at certain times, the study area was characterized by an intense transit of macaws while foraging. Sentinel behavior was observed during foraging activities of macaws, but not in parrots.

TABLE 1: Mean time of psitacid visits (MVT in minutes) to forage on buriti fruits and mean number of buriti fruits dropped (MFD). Águas Emendadas Ecological Reserve, Central Brazil. sd = standard deviation, n = sample size.

Species	MVT	sd	n	MFD	sd	n
Orthopsittaca manilata	8.6	8.8	92	1.7	1.3	120
Amazona aestiva	5.0	3.6	21	1.0	0	36
Ara ararauna	4.1	2.4	20	1.0	0	30

Orthopsittaca manilata visited the area in large flocks with a mean size of 9.6 ± 11.9 (n = 120) and in one instance, 76 individuals of *O. manilata* arrived together to the study site and divided into groups of 5 to 10 individuals before perching on the buriti bunches to forage. The mean flock size of *A. ararauna* was 4.2 ± 4.1 (n = 18) with a maximum of 30 individuals per flock. *Amazona aestiva* generally visited the area in pairs with a mean flock size of 2.0 ± 0.3 (n = 36) and a maximum of three individuals per flock. Individuals of the three species were also seen foraging alone in the study area. Comparisons between flock sizes showed significant differences among species (Kruskall-Wallis = 53.42, $p < 0.01$).

Orthopsittaca manilata also spent a longer time foraging when compared with *A. ararauna* or *A. aestiva* (ANOVA, $p < 0.01$) (Table 1), although there were no significant differences in the number of fruits dropped among species (Kruskal Wallis = 1.85, $p = 0.1335$). This may be explained because *O. manilata* generally left the fruit partially eaten attached to the bunch.

Other birds such as *G. chopi, T. palmarum,* and *S. melanopis* were seen taking advantage of the fruits left by psitacids on bunches by pecking the exposed pulp. *Gnorimopsar chopi* visited the study area almost every day, in large flocks of about 30 individuals, in contrast with the other two species that visited the vereda sporadically and alone.

Cyanocorax cristatellus and *C. plancus* were seen picking the fruit from the buriti bunch and flying away. On six occasions, *C. cristatellus* picked the buriti fruit and flew to the cerrado, perching in the vegetation (at distances from 200 to 300 meters from the vereda). *Caracara plancus* was seen four times taking the buriti fruit from the bunch, flying away, and descending on a small road, where it ate the fruit. In a one-week census by car on this road (21 km), we found 35 clean endocarps.

DISCUSSION

Psitacids are generally considered seed predators (Janzen 1981, Pizo *et al.* 1995, Kristosch and Marcondes-Machado 2001), but in the case of *M. flexuosa,* all psitacids ate the buriti fruit without damaging the seed and

were capable of transporting the seed, thus functioning as seed dispersal agents. Fruit and seed size may play a very important role in determining the fate of a seed when being utilized by frugivores, as pointed out by Vieira (2003). We consider *O. manilata* as the most important frugivore in relation to *M. flexuosa,* basically because of visit frequency, time spent foraging, and flock size. The distribution of *O. manilata* and *M. flexuosa* overlap broadly, supporting this idea, and Roth (1984) considers the diet of *O. manilata* as being specialized on the buriti fruit in the Amazon region. Bonadie and Bacon (2000) analyzed the diet of *O. manilata* and *Amazona amazonica* and found out that 94% of the diet of *O. manilata* was based on the *M. flexuosa* and *Roystonea oleracea* palm fruit in Trinidad. The interaction of *A. aestiva* and *A. ararauna* with *M. flexuosa* was less intense and in the case of *A. aestiva* could be harmful, given this species' foraging behavior of eating all the endocarp and leaving the seed exposed, which may augment coleopteran attack and thus have a negative indirect effect on the plant.

We consider *G. chopi, T. palmarum,* and *S. melanopis* as opportunistic frugivores, with no negative or positive effect on *Mauritia flexuosa.* In contrast, *C. cristatellus* and *C. plancus* can have a negative effect on the palm tree because they carry the seed to inappropriate sites (dry cerrado), where *M. flexuosa* is unable to germinate and grow. Galleti and Guimaraes (2004) observed *C. plancus* carrying the seeds of *Attalea phalerata* palms, considering this species as a potential seed dispersal agent.

M. flexuosa fruits were abundant and offered during a long period of time, with a fruiting peak in the driest months of the year when other fruits are scarce. We suggest that the buriti fruit represents a key resource for the cerrado frugivores in Central Brazil and that *O. manilata* is a key species for the dispersal process of the buriti seed.

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