Caderno de Pesquisa

Https://online.unisc.br/seer/index.php/cadpesquisa
ISSN on-line: 1677-5600
Doi: 10.17058/cp.v32i3.17275
Universidade de Santa cruz do Sul - Unisc

Recebido em 01 de Novembro de 2020 Aceito em 01 de Dezembro de 2020 Autor para contato: mastozoobr@gmail.com

Frugivorous diet and food availability of *Cerdocyon thous* and *Lycalopex gymnocercus* in the Serra do Sudeste Region, RS, Brazil

Dieta frugívora e disponibilidade alimentar de *Cerdocyon thous* e *Lycalopex gymnocercus* na região da Serra do Sudeste, RS, Brasil

Paulo Francisco Kuester
Patrik Gustavo Wiesel
Eduardo A. Lobo
Universidade de Santa Cruz do Sul - UNISC - Santa Cruz do Sul - Rio Grande do Sul - Brasil

Abstract

Foxes are common species in the Pampa Biome of the State of Rio Grande do Sul, Brazil, however, research on their diet and their role in seed dispersal are still very scarce. In this context, this research aimed to evaluate the seasonal diet of frugivores of crab-eating fox (*Cerdocyon thous* Linnaeus, 1706) and pampas-fox (*Lycalopex gymnocercus* G. Fischer, 1814) in the Pampa Biome. The study area with approximately 1,751 hectares is located in the Phytogeographic Region called Serra de Sudeste, Encruzilhada do Sul County, RS. Fox feces were collected over a year on standardized trails, and fecal samples were counted without distinguishing between the two species, considering the great visual similarity and eating habits. 53 fecal samples were analyzed between June 2015 and July 2016, and 12 plant species belonging to 10 botanical families were identified. The most common species found were Jerivá (*Syagrus romanzoffiana*), Podocarpus (*Podocarpus lambertii*), Pixirica (*Miconia hiemalis*), Guabiroba-do-campo (*Campomanesia aurea*), Bananinha-do-mato (*Bromelia antiacantha*), Cocão (*Erythroxyllum deciduum*) and Uva-do-japão (*Hovenia dulcis*). Both species of foxes have a frugivorous diet adapted to the availability of fruits in each season (fruiting), rather than preference for certain species of plants, clearly demonstrating the opportunistic habit of these two species, and highlighting their importance as dispersers of plant species and consequent maintenance of ecosystems.

Keywords

Pampa Biome, RS, Crab-eating fox, Pampas-fox, frugivorous diet.

Resumo

Os graxains são espécies comuns no Bioma Pampa do Estado do Rio Grande do Sul, Brasil. Porém, as pesquisas sobre sua dieta e seu papel na dispersão de sementes ainda são muito escassas. Nesse contexto, esta pesquisa teve como objetivo avaliar a dieta sazonal frugívora do graxaim-do-mato (*Cerdocyon thous* Linnaeus, 1706) e graxaim-do-campo (*Lycalopex gymnocercus* G. Fischer, 1814) no Bioma Pampa. A área de estudo com aproximadamente 1.751 hectares está localizada na Região Fitogeográfica denominada Serra de Sudeste, Município de Encruzilhada do Sul, RS. Fezes das duas espécies de graxaim foram coletadas ao longo de um ano em trilhas padronizadas, e amostras fecais foram contadas sem distinção entre as duas espécies, considerando a grande semelhança visual e hábitos alimentares. 53 amostras fecais foram analisadas entre junho de 2015 e julho de 2016, e 12 espécies de plantas pertencentes a 10 famílias botânicas foram identificadas. As espécies mais comuns encontradas foram Jerivá (*Syagrus romanzoffiana*), Podocarpus (*Podocarpus lambertii*) Pixirica (*Miconia hiemalis*), Guabiroba-do-campo (*Campomanesia aurea*), Bananinha-do-mato (*Bromelia antiacantha*), Cocão (*Erythroxyllum deciduum*) e Uva-do-japão (*Hovenia dulcis*). Ambas as espécies de graxains possuem dieta frugívora adaptada à disponibilidade de frutos em cada estação (frutificação), ao invés da preferência por certas espécies de plantas, demonstrando claramente o hábito oportunista dessas duas espécies, e destacando sua importância como dispersores de espécies vegetais e consequente manutenção dos ecossistemas.

Palavras-chave

Bioma Pampa, RS, graxaim-do-mato, graxaim-do-campo, dieta frugívora.

1. Introduction

Mammals constitute an important group of seed dispersers among vertebrates (BLAKE and LOISELLE, 2018), with emphasis on canids for having omnivorous eating habits (REIS *et al.*, 2011). For example, *Cerdocyon thous* and *Lycalopex gymnocercus* species play an important role in the dispersal and germination of native fruits, either as primary consumers (JORDANO *et al.*, 2007) or secondary consumers (NOGALES *et al.*, 2012), contributing directly to the conservation and regeneration of native plant formations. According to Gatti *et al.* (2006), the diet of *C. thous* can be constituted of 97% of vegetable matter, where the largest fraction of this percentage being composed by fruits. Seed dispersal is a key process within the life cycle of most plants, especially in tropical environments (RICO-GUZMAN, 2012), and can have important consequences for population demographics and genetic structure (SRBEK-ARAUJO *et al.*, 2017). In tropical forests, the majority of tree species have fruits with fleshy pulp, adapted for their consumption by vertebrates and consequent dispersion of their seeds (GALETTI *et al.*, 2011).

According to Dirzo *et al.*, (2014), fragmentation, illegal hunting and illegal trade are the main threats in Neotropical forests, influencing the defaunation process; that is, the rapid and drastic reduction of animal species, with negative effects on demography, biological diversity and ecosystem maintenance. Thus, large and medium-sized mammals, more specialized in habitat, diet, occupying the highest trophic levels and sensitive to fragmentation, are replaced by generalist species, more adapted to anthropic disturbances (ROSSANEIS, 2014). The extinction of seed dispersing animals, due to the forest fragmentation process, can negatively affect the zoocoric plants (MORAN *et al.*, 2009). This problem is increasing in Neotropical forests, where approximately 90% of species depend on frugivorous vertebrates to disperse their seeds (HERRERA, 2002).

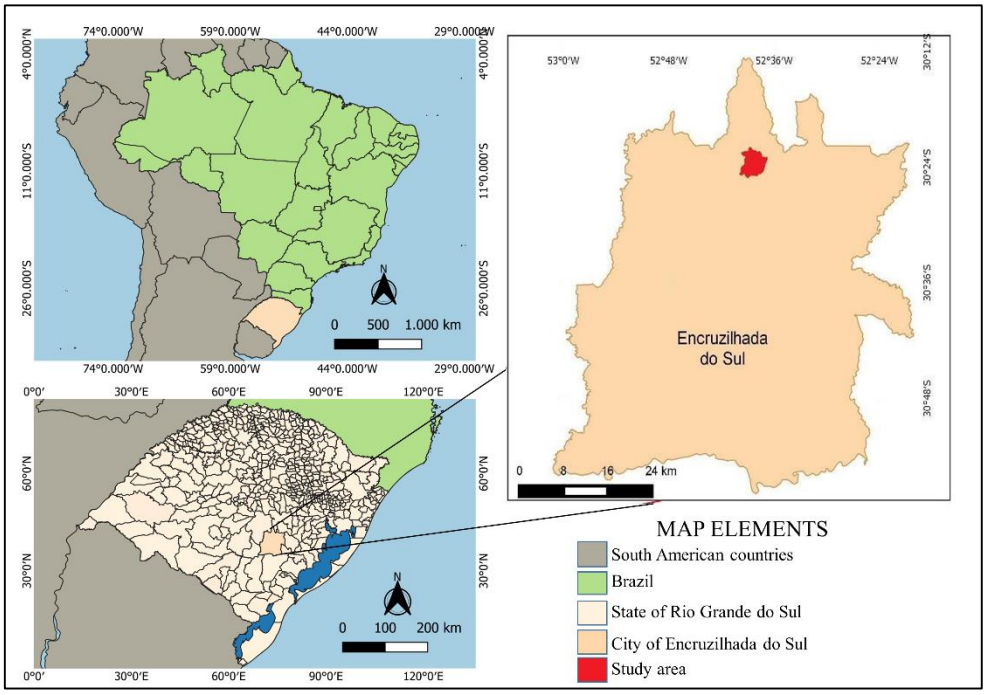
In this context, this research aimed to evaluate the seasonal diet of crab-eating fox (*Cerdocyon thous*) and pampas-fox (*Lycalopex gymnocercus*) frugivores in the region of Serra do Sudeste, Pampa Biome of the State of Rio Grande do Sul, Brazil, a neotropical forest characterized as a temperate subtropical moist area.

2. Methodology

Study Area

The study area is located in the Physiographic Region called Serra de Sudeste, municipality of Encruzilhada do Sul, located in the Pampa Biome of the State of Rio Grande do Sul, Brazil, with altitudes ranging between 100 and 432 meters. The total data collection area corresponds to approximately 1,751 hectares (Fig. 1).

Figure 1. Location of the study area in the municipality of Encruzilhada do Sul, RS, Brazil.

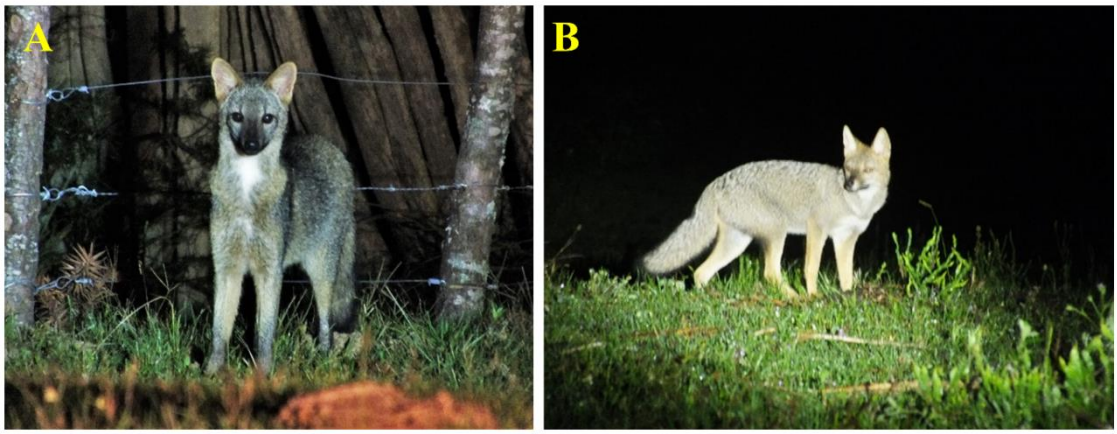


The climate type that predominates in the southern region of the State of Rio Grande do Sul is subtropical, with hot summer, however, in the Serra do Sudeste, with higher altitudes, the climate is temperate, with mild summer and well distributed rains, without a dry season, with the average temperature of the hottest month not reaching 22ºC, and precipitation from 1,100 to 2,000 mm (CARVALHO, 2005). The vegetation cover of the study area is included in the phytogeographic classification called Steppe (IBGE, 2012), with two subtypes: Park and Woody-grassland (Fig. 2).

Feces of two foxes were included in the survey, the crab-eating fox (*Cerdocyon thous*) and the pampas-fox (*Lycalopex gymnocercus*) (Fig. 3). Samples were collected between June 2015 and July 2016 on standardized trails, and fecal samples were counted without distinguishing between the two species, considering the great visual similarity and eating habits. Feces were identified considering the diameter, traces, footprints and presence of hair.

Figure 2. Study area landscape overview. A - Park steppe. B - Woody-grassland steppe.

Figure 3. Photographs of the two species of foxes, *Cerdocyon thous* (A), *Lycalopex Gymnocercus* (B).



The methodology consisted of an active search along standardized trails, following Reis e*t al.* (2014). For this purpose, a ride was carried out on a track of approximately 10.5 km during the day. All feces found were photographed and the vegetal content analyzed and identified in the field or laboratory, using specialized bibliography (BACKES and IRGANG, 2002; LORENZI *et al.*, 2002).

Data analysis

For data analyses, descriptive statistics was used (Mean, standard deviation and coefficient of variation). Statistical differences between variables were established using the non-parametric Kruskal-Wallis test, considering the low sample size (CALLEGARI-JACQUES, 2006). The quantitative similarity of the plant species found in the fecal samples, between the different seasons, was determined by means of a cluster analysis using the Paired group Method, following the recommendations of Hammer *et al.* (2001). The PAST Program ver. 2.17c was used (HAMMER *et al.*, 2001).

3. Results and discussion

53 fecal samples were analyzed between June 2015 and July 2016, and 12 plant species belonging to 10 botanical families were identified (Table 1). Among them, 11 species were identified at a specific level, and a group of grasses was identified only at the family level, since the species in this group were considered accessory in the diet of foxes, only assisting in the digestion processes (SILVEIRA-NETO et al., 1976).

Table 1. Taxonomic identification and popular names of plant species found in the feces of *C. thous* and *L. gymnocercus*.

Family	Genus/Species	Popular name
Araceae	*Butia odorata* (Barb.Rodr.) Noblick	Butiá
	Syagrus romanzoffiana (Cham.) Glassman.	Jerivá
Bromeliaceae	*Bromelia antiacantha* Bertol.	Bananinha-do-mato
Ebenaceae	*Diospyros inconstans* Jacq.	Maria-preta
Erythroxylaceae	*Erythroxylum deciduum* A.St.-Hil.	Cocão
Myrtaceae	*Campomanesia aurea* O.Berg	Guabiroba-do-campo
	Eugenia involucrata DC.	Cerejeira
Melastomataceae	*Miconia hyemalis* A.St.-Hil. & Naudin	Pixirica
Poaceae		Gramíneas
Podocarpaceae	*Podocarpus lambertii* Klotzsch ex Endl.	Pinheiro-bravo
Rhamnaceae	*Hovenia dulcis* Thunb.	Uva-do-japão
Sapindaceae	*Alophyllus edulis* (A.St.-Hil., Cambess. & A. Juss.) Radlk.	Chal-chal

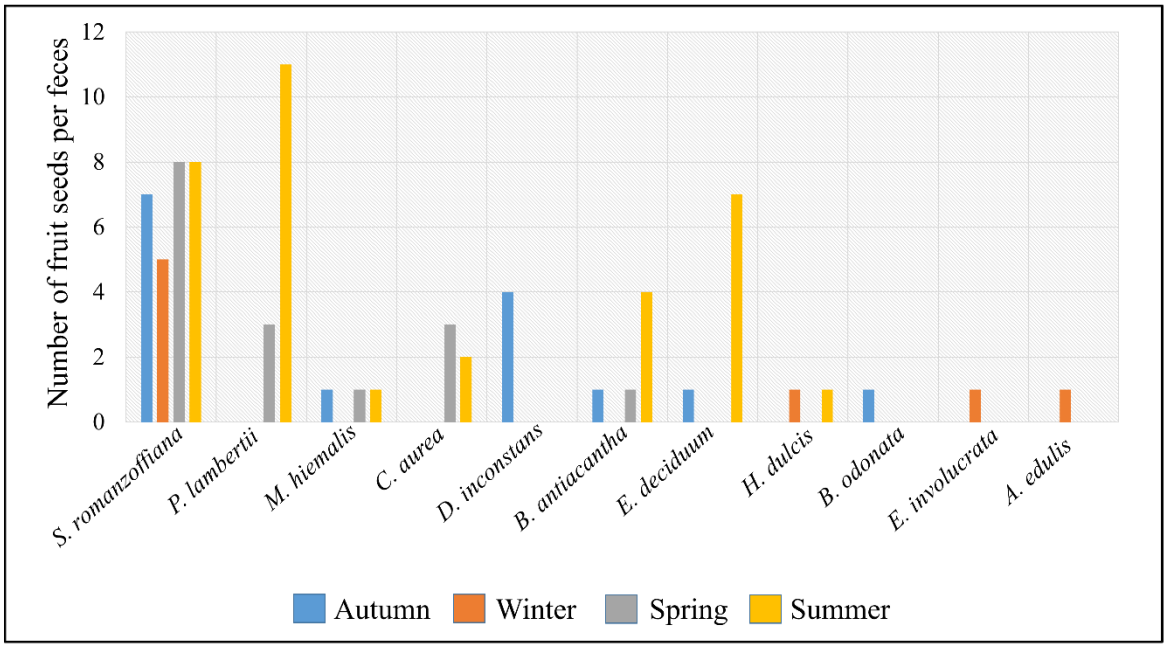
Among the 11 plant species found, *S. romanzoffiana* was the only one that occurred in all seasons of the year (Tab. 2), while seven species were represented in at least two seasons (Fig. 4), being jerivá (*S. romanzoffiana*), pinheiro-bravo (*P. lambertii*), pixirica (*M. hiemalis*), guabiroba-do- campo (*C. aurea*), bananinha-do-mato (*B. antiacantha*), Cocão (*E. deciduum*) and uva-do-japão (*H. dulcis*). We emphasize that the registration of plant species in fecal samples was intrinsically related to the availability of these plants in each season (fruiting). Examples of the two most common fruit-tree species in fox feces are shown in figure 5.

Regarding the number of seeds per fruit-tree species observed in the feces of *C. thous* and/or *L. gymnocercus*, in each season, the quantitative similarity index (paired group method) revealed greater similarity between autumn, winter and spring (Fig. 6), basically by sharing the lowest average number of seeds per fruit-tree species (2.5 ± 2.5 seed, 2.0 ± 2.0 seed, and 3.2 ± 2.9 seed, respectively), compared to summer, which had the highest average number of seeds per fruit-tree species (4.9 ± 3.9 seed), mainly *S. romanzoffiana*, which had the highest number of seeds, five to eight depending on the season. However, comparing the average number of seeds per fruit-tree species in each season, no significant differences were found ($p > 0.05$) (Fig. 7), due to the great variability of observations around the average of each season, as demonstrated by the high coefficients of variation in autumn, winter, spring and summer, being 100.0%, 100.0%, 90.6% and 79.6%, respectively.

Table 2. Number of fruit-tree species observed in the feces of *C. thous* and/or *L. gymnocercus*, in each season. (n): Total number of species, (S): Species richness, $\bar{x}$ (Average) (± standard deviation): Average number of seeds per fruit-tree species (total number of seeds divided by species richness at each time of year).

Fruit-tree species	Autumn	Winter	Spring	Summer
Syagrus romanzoffiana	7	5	8	8
Podocarpus lambertii	0	0	3	11
Miconia hiemalis	1	0	1	1
Campomanesia aurea	0	0	3	2
Diospyros inconstans	4	0	0	0
Bromelia antiacantha	1	0	1	4
Erythroxylum deciduum	1	0	0	7
Hovenia dulcis	0	1	0	1
Butia odorata	1	0	0	0
Eugenia involucrata	0	1	0	0
Alophyllus edulis	0	1	0	0
n	15	8	16	34
S	6	4	5	7
($\bar{x}$ ± standard deviation)	2.5 ± 2.5	2.0 ± 2.0	3.2 ± 2.9	4.9 ± 3.9
Coefficient of Variation (%)	100.0%	100.0%	90.6%	79.6%

Figure 4. Most consumed native fruit-tree species in each season according to availability.



Among the tree species, *S. romanzoffiana* seeds were the most dispersed due to the high consumption. However, although these foxes disperse the seeds of these plants, their effective role in the dispersal and germination of new individuals of this palm species is questionable, since the vast majority of feces containing seeds were deposited in unfavorable places for germination and establishment of new seedlings, such as forest edges, open areas and roads, exposed to negative environmental factors such as high solar radiation, low humidity

and soil compaction. Bustamante *et al.* (1992) working with *L. gimnocercus* also report that this fox, despite being a good disperser, defecates in open areas unfavorable to germination. Even if these seeds germinated in these areas, the seedlings would be subject to herbivory and dehydration.

In the present study, no type of seed germinating in fox feces was observed, but small clusters of approximately 10 seedlings of *S. romanzoffiana* were found scattered throughout the region, far from any adult tree of this species (Fig. 8), inferring that these seedlings were born at these points due to the dispersal of the animal. Similarly, Alonso-Paz *et al.* (1995), in areas of open plains in Uruguay, found in three different feces seeds of the butia palm tree (*Butia odorata*), germinating in the soil. Grasses (Poaceae), although they do noy have much energy value, were found in most of the sampled feces, probably their consumption is related to the digestion processes of the animal, corroborating with Motta-junior *et al.* (1994).

Figure 5. Two species of fruit-tree most consumed by *C. thous* and /or *L. gimnocercus*. On the right, some feces that show its occurrence in the foxes' diet. (A) *Podocarpus lambertii* and (B) *Syagrus romanzoffiana.*

Figure 6. Cluster analysis (Paired group method) for the number of fruit-tree species seeds observed in the feces of *C. thous* and /or *L. gymnocercus* in each season. Cophenetic Coefficient = 0.96. (Au: Autumn. Wi: Winter, Sp: Spring, Su: Summer).

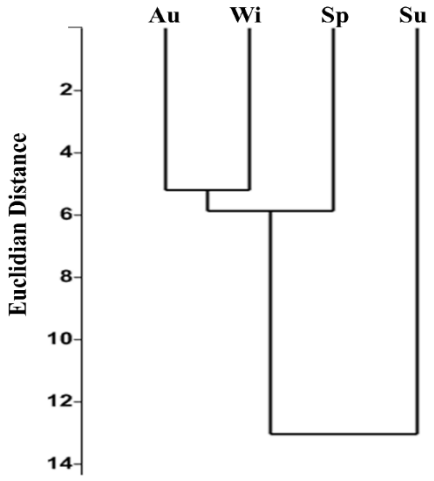


Figure 7. Mean (± standard deviation) of the number of fruit-tree species seeds observed in the feces of *C. thous* and/or *L. gymnocercus* in each season (Au: Autumn. Wi: Winter, Sp: Spring, Su: Summer). (*) No significant difference (p>0.05).

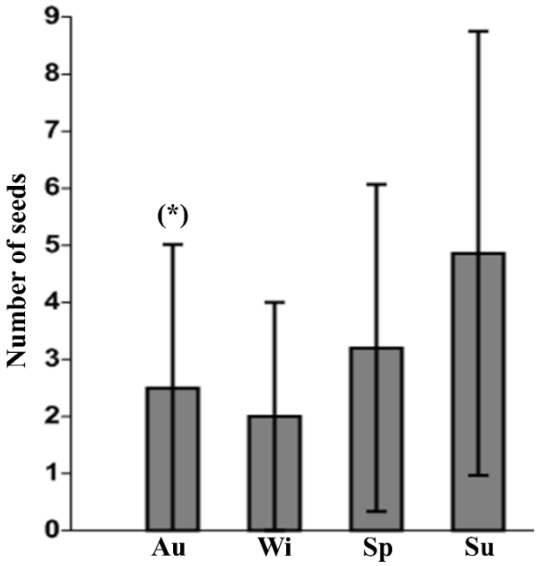
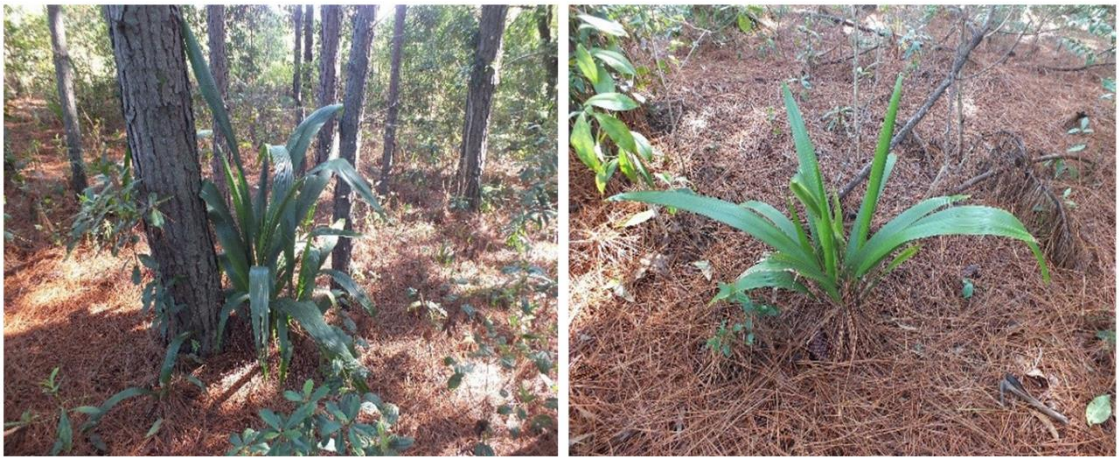


Figure 8. Two examples of zoochory of Jerivá (*S. romanzoffiana*), where seedlings are germinating far from a possible mother plant.



4. Conclusion

The two species of foxes studied, *C. thous* and *L. Gymnocercus*, have a frugivorous diet adapted to the availability of fruits in different seasons. Food preferences for a single type of plant species have not yet been found, which clearly demonstrates the opportunistic habit of these two species. We also highlight the importance of these species in relevant ecological processes such as the dispersion of plant species and, consequently, in the maintenance and recovery of ecosystems.

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