Frugivory by birds on *Miconia albicans* (MELASTOMATACEAE), in a fragment of cerrado in São Carlos, southeastern Brazil

Allenspach, N. and Dias, MM.*

Departamento de Ecologia e Biologia Evolutiva – DEBE, Universidade Federal de São Carlos – UFSCar,
Rod. Washington Luiz, Km 235, CP 676, CEP 13565-905, São Carlos, SP, Brazil
*e-mail: naty_allenspach@yahoo.com.br

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Abstract

The avian guild that consumes *Miconia albicans* (Melastomataceae) fruits and its phenophases were studied in a fragment of cerrado vegetation located in southeastern Brazil. The fruiting period ocurred between October and January, coinciding with the wet season. Nineteen bird species, mainly of generalistic diets, were registered consuming fruits in 96 observational hours. Species of the families Emberizidae, Thraupidae and Tyrannidae showed the largest number of visits, while those of the families Mimidae and Columbidae, with higher body mass, were responsible for a considerable number of consumed fruits. A correlation was found between body mass and average fruit consumption per visit. Tree height was a relevant factor for bird attraction. Results suggest that *M. albicans* may be useful in the recovery of degraded areas.

Keywords: frugivory, ornitochory, phenology, *Miconia*, cerrado.

Frugivoria por aves em *Miconia albicans* (MELASTOMATACEAE), em um fragmento de cerrado em São Carlos, sudeste do Brasil

Resumo

Foi estudada a guilda de aves que consomem frutos de *Miconia albicans* (Melastomataceae), bem como a fenologia dessa planta, em fragmento de cerrado no sudeste do Brasil. O período de frutificação ocorreu entre outubro e janeiro, coincidindo com a estação chuvosa. Dezenove espécies de aves, a maioria com dieta generalista, foram registradas consumindo frutos em 96 horas de observações. Espécies das famílias Emberizidae, Thraupidae e Tyrannidae apresentaram o maior número de visitas, enquanto aquelas das famílias Mimidae e Columbidae, de maior massa corporal, sobressaíram-se pelo número de frutos consumidos. Foi encontrada correlação entre massa corporal e consumo médio de frutos por visita. A altura das árvores foi um fator relevante na atração de aves. Os resultados sugerem que *M. albicans* pode ser útil na recuperação de áreas degradadas.

Palavras-chave: frugivoria, ornitocoria, fenologia, *Miconia*, cerrado.

1. Introduction

Cerrado is the major tropical savana area in South America (Ratter et al., 1997). This vegetation has been greatly reduced by anthropic action, with only several fragments of cerrado remaining in São Paulo state, usually of less than 100 ha each (São Paulo, 1997). Studies have demonstrated that aproximately 50% of cerrado woody species show zoochoric dispersal syndrome (Vieira et al., 2002; Neri et al., 2005). Birds and mammals are believed to be the most important seed dispersers (Howe and Westley, 1997).

Fruit-eating birds may be classified as specialised and opportunistic (Howe and Estabrook, 1977). Following this theory, plants whose dispersal agents are specialised birds would produce large fruits of high nutritional quality (elevated protein content), in a small number, but with large seeds. On the other hand, plants that are dispersed mainly by opportunistic birds would produce small fruits with low nutritional quality (high carbohydrates and water levels), in a large number but with small seeds. Specialised and generalised dispersal systems constitute a paradigm (Howe, 1993) that still motivates research on frugivory and seed dispersal (Jordano et al., 2011).

According to Snow (1981), plants adapted for dispersal by opportunistic frugivorous birds are generally shrubs or small trees, typical from secondary vegetation, colonising edge habitats or recently cleared ground. The family Melastomataceae is an important example of these plants. Species of the genus *Miconia* represent approximately one quarter of the modern Melastomataceae, occuring from the south of Mexico to the north of Argentina and Uruguay (Goldenberg, 2004).

Miconia albicans (Triana) is a treelet that reaches even 3 m in height, occurring in cerrado secondary vegetation, rocky outcrops and coastal formations (Goldenberg, 2004). Its fruits are small and numerous rosy berries that become jade-green during ripening, with high levels of water and carbohydrates (respectively 76.63 and 13.38%) but low protein content (2.17%) (Maruyama et al., 2007). Neri et al. (2005) observed high density of *M. albicans* occuring in regenerating cerrado areas.

Ecological aspects involved in bird-plant relationships have been used in environmental risk assessments and to create biodiversity conservation arrangements, so as to estimate future impoverishment and reduction of original vegetation (Howe and Miriti, 2000; Silva and Tabarelli, 2000). The present study aimed to characterize the avian guild that consumes fruits of *Miconia albicans* and the phenology of the plant, in an attempt to better understand the ecological role of this plant in the fragment studied.

2. Material and Methods

The study was carried out in a non urbanised area in the campus of the Universidade Federal de São Carlos, São Paulo state, southeastern Brazil (21° 58' S and 47° 52' W). This is a 124.68 ha area (Paese, 1997) where cerrado vegetation is very compromised by irregular fires and by *Brachiaria* sp. and *Melinis* sp. (Poaceae) invasion. The regional climate is Cwa.i – Awi (Köppen's system); with wet summers and dry winters (Tolentino, 2007).

According to Dias, Branco and Francisco (in press), a total of 274 bird species have already been sighted in the campus area, and 33% are believed to consume fruits, at least sporadically (Francisco and Galetti, 2001). In research performed with woody species in the area, *M. albicans* appears as the fourth most abundant species (Oliveira and Batalha, 2005).

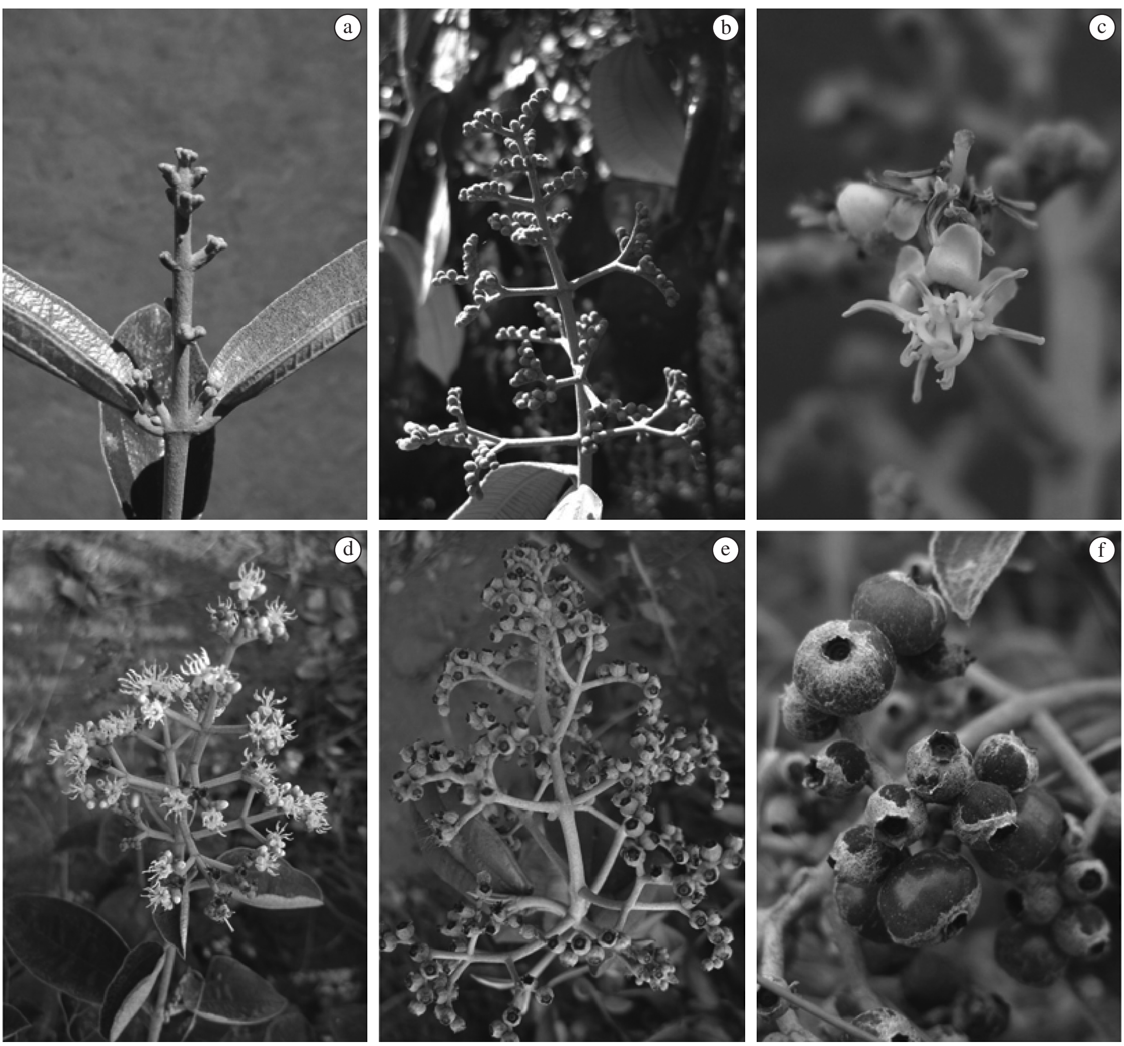

Figure 1. *Miconia albicans* phenophases. a,b) flower buds, c) flower, d) inflorescence, e) immature fruits, f) immature and ripe fruits.

Miconia albicans phenophases (Figure 1) were accompanied every two weeks, between March 2008 and February 2009, following 30 random selected individuals in a pre-existing 800 m trail. Since each treelet has a huge number of flower buds, flowers and/or fruits, it was necessary to estimate the total from an average of direct counting on three inflorescences per individual. Field data was analysed using the Fournier intensity percentage (Fournier, 1974), in a classificatory scale from 0 (phenophase absent) to 4 (maximum phenophase intensity). The activity index (percentage of individuals that show the phenophase) per month was also estimated, since both methodologies supply complementary data (Bencke and Morellato, 2002).

The survey of birds consuming *M. albicans* fruits was carried out using the focal tree methodology (Pizo, 1997) between November and December 2008, when a fruiting peak was registered. Eight treelets were observed from a minimum distance of 8-10 m, with 7 × 35 binoculars, trying in this way to avoid behavioural changes by the visitants. The following aspects were registered: visiting species, time and duration of the visit, number of consumed fruits, foraging behaviour, occurence of agonistic encounters and occurrence of defecation and regurgitation. Each treelet was observed for 12 hours, alternating non-consecutive days, totalling 96 observational hours. However, the observations were equally distributed over the day, from 6:00 AM to 6:00 PM, so each time interval was equally sampled in every plant.

Miconia albicans has a very dense crown, which made visualization difficult. So, in order to calculate averages and frequencies for bird visits, only those with recorded duration and fruit consumption were considered. For some species, the total number of visits used to calculate average consumption of fruits per visit is not the same utilised in the calculation of average visit duration.

For correlational analyses, the Spearman correlation coefficient was applied. Body masses and predominant diets were obtained from the literature (Motta-Junior, 1990; Marini et al., 1997; Sick, 1997; Piratelli and Pereira, 2002; Antunes, 2005). Meteorological data is available at Embrapa (2009).

3. Results

Flowering occured between August and October (Figure 2), when an activity peak was observed. September

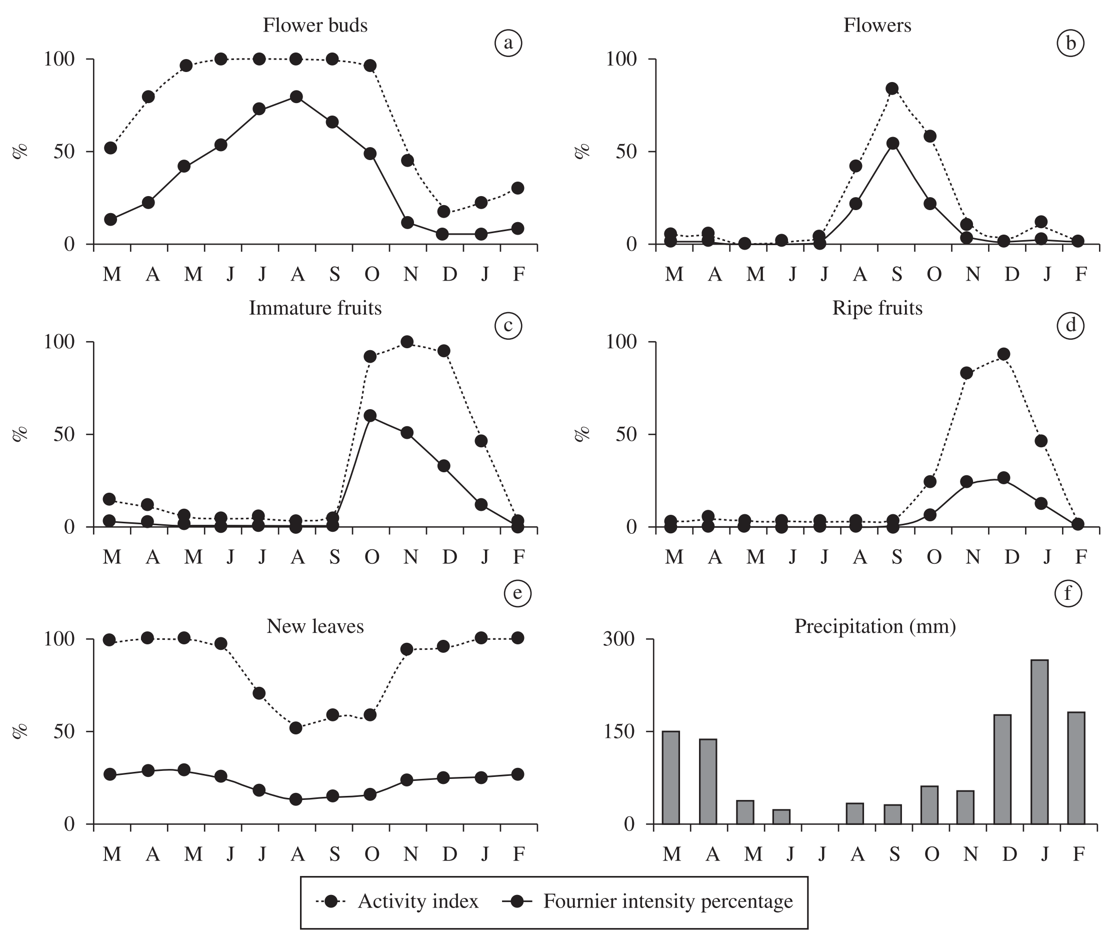

Figure 2. Activity index and Fournier intensity percentage of the phenophases observed in 30 adult trees of *Miconia albicans*, between March 2008 and February 2009. Months are represented by their capital letters. a) Flower buds, b) Flowers, c) Immature fruits, d) Ripe fruits, e) New leaves, f) Precipitation (mm).

Table 1. Bird species recorded consuming *Miconia albicans* fruits during 96 observational hours. a) Number of observations with complete data of visit duration. b) Number of observations with complete data of fruit consumption. c) Total consumed fruits per species. d) Main diet, according Motta-Junior (1990); Piratelli and Pereira (2002): FRU = frugivore; INS = insectivore; ONI = omnivore; SE = seed eaters.

Species	Visits	N (a)	Average visit duration (seconds)	N (b)	Consumed fruits (c)	Average fruit consumed	Diet (d)
Columbidae							
Patagioenas picazuro (Temminck)	24	11	410.64 ± 222.48	7	232	33.14 ± 24.28	FRU
Psittacidae							
Aratinga aurea (Gmelin)	2	0	-	1	24	24.00 ± 0.00	FRU
Tyrannidae							
Elaenia sp.	3	3	31.00 ± 13.45	3	9	3.00 ± 2.65	ONI
Myiarchus sp.	1	1	18.00 ± 0.00	1	3	3.00 ± 0.00	
Myiodynastes maculatus (Statius Muller)	8	8	81.25 ± 62.75	8	46	5.75 ± 5.37	ONI
Pitangus sulphuratus (Linnaeus)	9	9	136.22 ± 201.36	7	27	3.86 ± 4.06	ONI
Tyrannus albogularis Burmeister	1	1	74.00 ± 0.00	1	8	8.00 ± 0.00	INS
Tyrannus melancholicus Vieillot	1	1	151.00 ± 0.00	1	13	13.00 ± 0.00	INS
Tyrannus savana Vieillot	16	15	59.53 ± 35.55	13	79	6.08 ± 3.84	INS
Corvidae							
Cyanocorax cristatellus (Temminck)	3	0	-	0	-	-	ONI
Turdidae							
Turdus leucomelas (Vieillot)	9	6	107.67 ± 139.08	7	79	11.29 ± 6.42	ONI
Mimidae							
Mimus saturninus (Lichtenstein)	19	14	127.21 ± 95.28	13	281	21.62 ± 24.09	INS
Thraupidae							
Saltatricula atricollis Vieillot	1	1	49.00 ± 0.00	1	7	7.00 ± 0.00	SE
Schistochlamys ruficapillus (Vieillot)	2	2	67.50 ± 61.52	2	3	1.50 ± 2.12	ONI
Tangara cayana (Linnaeus)	6	6	74.33 ± 98.21	3	35	11.67 ± 11.55	ONI
Tangara sayaca (Linnaeus)	33	17	102.94 ± 71.38	12	161	13.42 ± 9.18	ONI
Emberizidae							
Sporophila caerulescens (Vieillot)	34	21	108.52 ± 130.98	20	100	5.00 ± 4.41	SE
Volatinia jacarina (Linnaeus)	19	11	143.36 ± 73.97	8	37	4.63 ± 3.02	SE
Zonotrichia capensis (Statius Muller)	21	20	98.85 ± 57.83	12	60	5.00 ± 3.64	SE
Total	212	147	-	120	1204	-	-

was the only month when flower intensity went over 50%. However, it is important to emphasize the fact that the number of flowers registered is lower than the real number, since they keep open for a few days only, and so could not all be registered on the biweekly surveys. The procedure also explains the mismatching between the low number of flowers in relation to the large number of immature fruits recorded afterwards.

A peak in the activity index and in the Fournier intensity percentage of ripe fruits was observed between October and January. This interval was considered the fruiting period of *M. albicans* and coincided with the wet season. Morphometric data of the fruits (n = 50) were: diameter 6.3 (±0.587) mm and average weight of 0.14 (±0.034) g. A mean of 19.52 (±6.34) seeds per fruit was found, with average weight of 7.047 mg each (n = 1000). Seeds correspond to approximately 5.06% of the fruit weight.

Only birds were observed consuming *M. albicans* fruits. A total of 212 visits with fruit consumption were registered, performed by 19 bird species, from eight families (Table 1). Any new species was observed consuming *M. albicans* fruits after 72 hours of observation. An average frequency of 2.21 ± 3.48 visits/hour was found, with a peak of 5.4 ± 6.0 visits/hour registered between 6:00 AM and 7:00 AM. During the day, the frequency of visits decreased, until its minimum value (0.3 ± 0.5) between 5:00 PM and 6:00 PM.

Species of the family Emberizidae were the most representative in number of visits (34.9%), followed by Thraupidae (19.81%) and Tyrannidae (18.4%) families. In relation to fruit consumption, species of the families Mimidae, Columbidae and Thraupidae were the most responsible, with 23.34, 19.27 and 17.11% respectively of consumption. Many birds with juvenile plumage were observed consuming *M. albicans* fruits, notably *Sporophila caerulescens*, *Volatinia jacarina* and *Mimus saturninus*.

Although species of family Emberizidae – which has a typical grain diet (Sick, 1997) – had a prominent number of visits, they were seen in the majority of the visits taking the seeds out of the fruits and rejecting pulp and skin. *Sporophila caerulescens*, *Volatinia jacarina* and *Zonotrichia capensis* have already been registered in the same area as granivores (Motta-Junior, 1990) and since mainly seeds are found fragmented in Emberizidae's stomach (Lopes et al., 2005) they are believed not to be great seed dispersers. *Aratinga aurea* (Figure 3), *Tangara cayana* and *Saltatricula atricollis* were observed mandibulating fruits, but degluting them totally. This behaviour may destroy seeds or not (Moermond, 1983) and only germination tests can verify if these species might act as *M. albicans* seed dispersers.

Regurgitation, defecation and agonistic encounters were insignificant for all species observed. The average fruit consumption per visit varied from 1.5 fruit/visit (*Schistochlamys ruficapillus*) to 33.14 (*Patagioenas picazuro*). A correlation was found between body mass and average fruit consumption per visit (Spearman correlation coeficient: rs = 0.549; p = 0.023) but no significant correlation between average fruit consumption per visit and average visit duration.

Miconia albicans treelets used for focal observations varied from 1.5 to 3.0 m, and hold between 600 and 9000 available fruits (ripe and immature). There is a correlation between tree height and number of visits (Spearman correlation coeficient: rs = 0.753; p = 0.031), but no significant correlation was found between the available fruits and number of visits.

During the survey, the predation of a *Tangara sayaca* that was consuming *M. albicans* fruits, by a *Callithrix jaccus* (Linnaeus) (Cebidae) was observed. At 6:45 AM, three adult marmosets came to a *M. albicans* treelet and kept inside

Figure 3. *Aratinga aurea* feeding on *Miconia albicans* fruits.

its crown, that was dense and so hampered visualization. This treelet was being visited by many *T. sayaca* at that moment. A few minutes later, one marmoset left the plant with the already dead bird in its claws, went to a higher neighbouring tree (about 5 m high) and fed on the bird. The other two marmosets followed the first, but they kept a distance from each other. Then, the group came back to the *M. albicans* treelet (bringing the bird carcass together), stayed for a few minutes and left.

4. Discussion

Miconia albicans treelets showed a high syncrony, with remarkable phenophases. Synchronised fruit production may be a strategy to increase the attractiveness of the frugivorous species responsible for seed dispersal (Augspurger, 1981). The fruiting period coincides with the wet season, when many fruits of other ornithocoric dispersion syndrome plants are available in the same area, like: *Davila rugosa* Poiret (Dilleniaceae) (Francisco and Galetti, 2002a), *Ocotea pulchella* (Nees) Mez (Lauraceae) (Francisco and Galetti, 2002b), *Pera glabrata* (Schott) Baill (Euphorbiaceae) (Francisco et al., 2007), *Rapanea lancifolia* (Ruiz and Pavon) Mez (Francisco and Galetti, 2001) and *Zanthoxylum rhoifolium* Lam. (Rutaceae) (Silva et al., 2008).

Fruit richness in the period and the high abundance of *M. albicans* in the studied area (Oliveira and Batalha, 2005) may be an explanation for the low frequency of visits observed for *M. albicans*. In comparison to data from the abovementioned literature, *M. albicans* showed from similar to a 3 times lower frequency of bird visits, while the number of observed species could be considered high (in a range of 11 species for *R. lancifolia* to 20 for *P. glabrata*). However, since there are annual climate variations and different methodologies applied, comparisons must be regarded with caution.

Fruit abundance during *M. albicans* fruiting season could explain either the absent correlation between available fruits per treelet and number of visits, since *M. albicans* fruits are of low nutritional quality. These fruits are eaten mainly by birds with generalist diets which seek better protein sources. Only treelet height showed to be a relevant factor for bird attraction. Since safety is not completely associated with perching height (Blumstein et al., 2004), it is the interaction with many other factors that results in the tree choice by the birds: forraging patterns, plant community composition and structure, predation risk (Howe, 1979; Robinson and Holmes, 1982; Levey and Moermond, 1984; Hasuí et al., 2007).

Large and cryptic birds are less vulnerable to predators, spending more time on fruiting plants (Pratt and Stiles, 1983; Silva et al., 2008). The heaviest bird observed consuming *M. albicans* fruits, *P. picazuro*, showed the largest average visit duration (410,64 ± 222,48 seconds). The marmoset predation of a small bird consuming *M. albicans* fruits is a strong example of the importance of predation risk during bird feed. The lack of a correlation between average fruit consumption per visit and average visit duration may be a consequence of variated time spent in state of allertness during the visit, just as of different foraging patterns used by each species or previous consumption of other food sources.

Miconia albicans seed dispersal potential by birds could only be inferred through the behavioural aspects observed in the survey. Short visits (less than 3 minutes) and low defecation rates means that seeds may be carried out far away from the parent-plant (Pratt and Stiles, 1983). Future studies are necessary to verify the dispersive potential of the birds here listed and also know *M. albicans* germination and seedling characteristics.

Characterised by a generalist dispersal system, *M. albicans* seeds may be dispersed even in disturbed areas where large frugivores are absent. As a pioneer plant, it is known that *M. albicans* is able to naturally establish under *Eucalyptus* sp. plantations (Saporetti et al., 2003). All these attributes suggest *M. albicans* may be useful in the recovery of degraded areas.

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