ECOLOGICAL ASPECTS OF THE DISPERSAL OF A MELASTOMATACEAE BY MARMOSETS AND HOWLER MONKEYS (PRIMATES : PLATYRRHINI) IN A SEMIDECIDUOUS FOREST OF SOUTHEASTERN BRAZIL

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Forest fragments generally show lower biodiversity than preserved areas, but some primate species seem to be apt to live in such small remnants (Lovejoy *et al.,* 1986 ; Schwarzkopf & Rylands, 1989). Diet and feeding behavior of neotropical primates have been studied (Guillotin *et al.,* 1994 ; Julliot, 1994), but their role in tropical ecosystems is not completely understood (Heymann, 1993). In the Old World, monkeys consume fruits brightly colored, with succulent pulp and are potential dispersers of the seeds (Hladik & Hladik, 1967 ; Gautier-Hion *et al.,* 1985). Neotropical primate species are also capable to disseminate several plant species in the rainforest since seeds pass undamaged through their digestive tracts (Hladik & Hladik, 1969 ; Chapman, 1989 ; Julliot, 1994).

The faunae surviving in semideciduous forest fragments of southeastern Brazil, as well as the ecological relationships between primates and plant species in these areas, are poorly known (see Morellato & Leitão-Filho, 1995). Figueiredo (1993, 1994) found Howlers as inadequate dispersers of *Ficus* spp. seeds, and some studies proposed that small seeded plants are dispersed mainly by small monkeys, like Marmosets, while large seeded plants by Howler monkeys (Galetti & Pedroni, 1994 ; Galetti *et al.,* 1994).

This study verifies the dispersal quality of Howlers and Marmosets on the small seeds of a Melastomataceae.

STUDY AREA

Fieldwork was conducted in a forest fragment of 30 ha at the Estação Experimental de Jundiai (Instituto Agronômico de Campinas), southeastern Brazil (23° 06' S, 46° 55' W, 715 m alt.). The area is characterized by a cold and dry winter (May to August) and a warm and rainy summer (November to February). Figure 1 shows the mean temperature and the monthly precipitation during the study period in the area.

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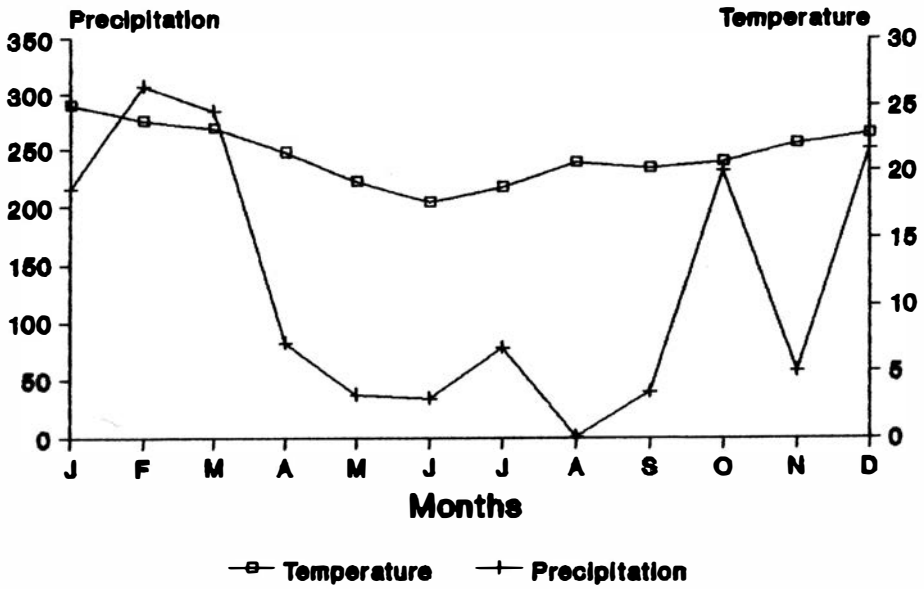

Figure 1. — Average temperature and precipitation in a semideciduous forest of SE Brazil.

The vegetation consists of secondary growth semideciduous forest. This type of vegetation is typical of southeastern Brazil, and descriptions can be found in Morellato (1992) and Morellato & Leitão-Filho (1995). The fauna and flora of the study area are little known, but semideciduous forests generally show high flora diversity (Morellato, 1992). Three monkey species were found living in the forest : *Alouatta fusca fusca* (Ihering, 1914) (the Northern brown howler monkey), *Callithrix penicillata* (É. Geoffroy, 1812) (the Black-tufted-ear marmoset) and *Callicebus personatus nigrifrons* (Spix, 1823) (the Black-fronted titi monkey) (primate names follow Rylands *et al.,* 1995). Only the first two monkey species were found ingesting seeds of *Miconia cinnamomifolia* (DC.) Naud. (Melastomataceae), a common tree in gaps and borders of the area. This plant species reaches heights up to 22 m, with trunks up to 50 cm dbh, and produced thousands of purple fruits between April and July 1995. The fruits have a diameter of 3.9 ± 0.4 mm, and 33.1 ± 8.7 seeds within ($N = 10$).

METHODS

Primates were observed feeding on ten *M. cinnamomifolia* individuals. Faeces of monkeys species containing melastome seeds were searched along established trails in forest edge and towards the interior of the forest ($n = 10$; a total of 2 500 m). The faeces of Howlers and Marmosets were easy to be

distinguished from each other because the former monkey species consumes a great quantity of leaves in addition to fruits. These surveys, and the germination experiments, were done in the last week of July 1995.

One thousand seeds of *Miconia cinnamomifolia* were chosen randomly from faecal droplets of each monkey species (total 2 000 ingested seeds). As a control, it was chosen 1 000 seeds from randomly collected mature fruits underneath the fruiting trees (1 000 non-ingested seeds). Germination sets of 100 seeds in 10 replicates were made for each of the three treatments. Half of the replicates of each treatment were sown on filter paper in covered Petri plates, kept moistened with distilled water and placed in an uncontrolled light and temperature regime inside the laboratory. The other half of the replicates was sown on Petri plates filled with soil, because differences in germination rates observed in laboratory may not be confirmed when seeds experience a more real situation (Figueiredo & Perin, 1995). The soil samples were collected near the site of natural occurrence of *M. cinnamomifolia.* These plates were covered to maintain moisture and exclude seed predators and placed in a forest gap.

The number of germinated seeds in each replicate was verified after two months, and the differences observed were tested using analysis of variance (one-way ANOVA).

RESULTS

Howler monkeys were observed feeding on *M. cinnamomifolia* in two occasions. Their feeding bouts lasted ca. 20 minutes. They eat whole mature and immature fruits. Eighteen Howlers' faeces were found in gaps and forest edges. Their contents revealed hundreds of *M. cinnamomifolia* seeds, as well as pieces of mature and immature *Miconia* fruits, and some seeds of *Syagrus oleraceae* (Arecaceae), *Myrcianthes pungens* (Myrtaceae), and *Copaifera langsdorffii* (Caesalpiniaceae).

Marmosets were observed on *M. cinnamomifolia* on nine occasions. They fed only on mature fruits, mashing and swallowing the whole fruit. Twenty-five faecal droplets, with *M. cinnamomifolia* and *Ficus* sp. seeds, were also found in forest edges and gaps.

The number of *Miconia* seeds germinated in each treatment are shown in Table I (for laboratory trials) and in Table II (for field ones). Laboratory experiments indicated that the germination rates of Marmoset-ingested seeds were similar to control ones ($F = 2.96$, $p = 0.13$). Howler-ingested seeds, however, showed a smaller germination rate when compared both with control ($F = 184.07$, $p < 0.01$) and Marmoset lots ($F = 149.33$, $p < 0.01$). In the field experiments, germination rates were lower than those observed in the laboratory. The results, however, were similar: Howler-ingested seeds germinated less than control ($F = 95.34$, $p < 0.01$) and than Marmoset-ingested seeds ($F = 138.03$, $p < 0.01$), and Marmoset-ingested and control seeds did not differ significantly ($F = 1.35$, $p = 0.29$).

DISCUSSION

Primate ingestion did not inhibit germination of *Miconia cinnamomifolia* seeds. The reduction of germination rates observed for Howler-ingested seeds is

TABLE I

Number of vertebrate-ingested and non-ingested Miconia cinnamomifolia *seeds germinated in laboratory trials.*

Treatment	Replicates					$\bar{x} \pm SD$
	1	2	3	4	5	
Control	69	73	74	68	71	71.0 ± 2.6
Howler-ingested	39	43	36	47	42	41.4 ± 4.2
Marmoset-ingested	69	73	80	79	74	75.0 ± 4.5

TABLE II

Number of vertebrate-ingested and non-ingested Miconia cinnamomifolia *seeds germinated in field germination trials.*

Treatment	Replicates					$\bar{x} \pm SD$
	1	2	3	4	5	
Control	46	49	47	36	41	43.8 ± 5.3
Howler-ingested	10	06	18	15	15	12.8 ± 4.8
Marmoset-ingested	39	44	38	41	42	40.8 ± 2.4

probably due to the behaviour of feeding on immature fruits showed by this monkey. Howlers, therefore, can be considered a non-specialized disperser of *M. cinnamomifolia.* Almost half of the Howler-ingested seeds germinated, hence Howlers can contribute to increase the recruitment of the plant species in gaps and forest edges. Marmosets, contrariwise, are better seed dispersers. Marmoset activity, mainly in successional, disturbed and edge habitats (Stevenson & Rylands, 1988), may increase seedling recruitment of *M. cinnamomifolia* in the forest fragment.

Fragmentation of native forests and hunting can provoke extinction or extreme population declines of several primate species (Lovejoy *et al.,* 1986), and this can lead to long-term effects on the recruitment of several plant species (Howe, 1984). Some studies showed the importance of monkeys on seed dispersal and germination of several plant species (Izawa, 1975 ; Garber, 1986 ; Galetti *et al.,* 1994 ; Zang & Wang, 1995). In this study, both primate species may contribute to regeneration of forest edges and gaps by dispersing the seeds of a pioneer tree. The maintenance and regeneration of forest remnants are very important in southeastern Brazil, because the Northern howler monkey and the Black-fronted titi monkey are on the verge of extinction (Mittermeier, 1986 ; Fonseca *et al.,* 1994), and the Black-tufted-ear marmoset is threatened by deforestation of its small geographic range (Emmons, 1990).

The present study strengthened the hypothesis that smaller monkey species are better dispersers of small seeds than larger monkey species like Howlers.

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SUMMARY

Feeding behavior and digestion effect on fruits and seeds of a pioneer tree (*Miconia cinnamomifolia*) by primates (*Alouatta fusca fusca* and *Callithrix penicillata*) were investigated in a forest fragment of southeastern Brazil. Howler monkeys consumed mature as well as immature fruits, and the germination rates of ingested seeds were reduced when compared with non-ingested ones. Marmosets defecated unharmed seeds and were considered better seed dispersers than Howlers. These results strengthened the hypothesis that plant species with small seeds are dispersed mainly by small monkey species.

RÉSUMÉ

Nous avons étudié le comportement alimentaire et l'effet de la digestion sur les graines d'un arbre néotropical (*Miconia cinnamomifolia*) par les primates (*Alouatta fusca fusca* et *Callithrix penicillata*) dans une forêt du sud-est du Brésil. *Alouatta fusca* consomme en partie des fruits immatures et les taux de germination des graines ingérées sont réduits. *Callithrix penicillata* est un meilleur disperseur des graines de *M. cinnamomifolia.* Ces résultats confortent l'hypothèse selon laquelle les petites graines sont disséminées par des petits animaux.

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