FRUIT CONSUMPTION, DISTANCE OF SEED DISPERSAL AND GERMINATION OF SOLANACEOUS PLANTS INGESTED BY COMMON OPOSSUM (*DIDELPHIS AURITA*) IN SOUTHERN BRAZIL

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RÉSUMÉ

Les distances minimales de dispersion de quelques Solanacées ont été étudiées et des tests de germination de leurs graines provenant de fèces de *Didelphis aurita* effectués dans le sud du Brésil. Les animaux ont été capturés chaque semaine afin d'obtenir les fèces dans une zone urbaine entre février 1995 et janvier 1996. Les distances minimales de dispersion ont été mesurées par la distance minimale entre le point de collecte de chaque groupe de graines (provenant d'une fiente) et la plante en fruit de la même espèce la plus proche. Les graines de chaque fiente ont été comptées et une partie d'entre elles a été soumise à des tests de germination. La quantité moyenne de graines par fiente variait de 9 à 33. Ces animaux sont des consommateurs opportunistes de Solanacées dont ils ne détruisent pas les graines. Les distances minimales moyennes de dispersion variaient de 40 à 82 m. Les graines de plantes distribuées dans des clairières et en faibles densités avaient tendance à avoir de plus grandes distances de dispersion. Ces résultats ont montré que ce marsupial est un important agent de dispersion de Solanacées dans le sud du Brésil.

SUMMARY

The role of the Common Opossum, *Didelphis aurita,* as an effective seed disperser for Solanaceous plants was studied in a forest fragment of southern Brazil for two years. Opossums were captured once per week to collect feces and to find seeds of these plants. Seeds were then tested for germination rates. The trapping locations allowed estimations of minimum dispersal distances to source plants for the species of seeds found in their feces. Opossums feces contained mainly seeds of six species of Solanaceous plants. The average number of seeds in scats varied among species and ranged from 9 to 33. These Solanaceous fruits were consumed opportunistically by opossums, without seed destruction. The average minimum distances of seed dispersal varied among species and ranged from 40 m to 82 m. There was a trend for seeds from plants distributed in gaps and at low population densities to be transported at longer distances by opossums. Opossums, therefore, meet some requirements of effective seed dispersers, at least for Solanaceous plants.

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INTRODUCTION

Seed dispersion by animals provides many examples of coevolution and seed dispersal syndromes (Smithe, 1970; Charles-Dominique *et al.*, 1981; van der Pijl, 1982; Charles-Dominique, 1986; Howe & Westley, 1986; Howe, 1993). Some species of plants are clearly adapted for dispersal by specific types of animals. For example, bats dispersing *Piper* fruits (Fleming, 1985), some birds dispersing mistletoes (Davidar, 1987) and lizards on a Cactaceous species (Figueira *et al.*, 1994). The minimum requirements for seed dispersal by animals are that first, an animal eats the fruits of the plant, second, the animal does not injury the seed, and third, the animal, in the process of frugivory, carries the seed some distance from the parent plant (Schupp, 1993). On the other hand, many kinds of plants that produce edible fruit are not clearly adapted to make use of specific animals, but rather seem to use animal dispersal in a more general way, leading to diffuse coevolution (Janzen, 1980). The lack of a tight coevolutionary connection between plants and their seed dispersers does not diminish the importance of some dispersers.

In the neotropics, marsupials are common and, as omnivorous or frugivorous, may also occasionally function as seed dispersers (Charles-Dominique *et al.*, 1981; Atramentowicz, 1988; Monteiro-Filho & Dias, 1990; Medellin, 1994). Marsupials as seed dispersers may present the kind of diffuse coevolution between plants and their dispersers that may be very common. The common opossum of South America, *Didelphis aurita* Wied, 1826, is very common in many areas in its range, and has a very generalistic diet. Its diet often includes fruit and so the opossum may often serve as a disperser (Santori *et al.*, 1995; Cáceres, 1996; Freitas *et al.*, 1997). In this work we examined the role of the common opossum as a seed disperser of Solanaceous plants. Some of these plants are thought to have the typical syndrome of bat-dispersed fruit - cryptical color, displayed at the ends of branches to facilitate bat encounters. If opossums are also important seed dispersers, then this previously assumed bat-fruit syndrome may not be as important as once thought for these species. Specifically, we addressed the following questions: 1) does the opossum eat quantities of Solanaceous plants? 2) after eating these fruits, does opossum carry the seeds some distances from the parent plants? 3) do seeds germinate after passing through the gut of the opossum?

MATERIAL AND METHODS

STUDY AREA

The study took place in an urban area of Curitiba, southern Brazil (25° 25' S, 49° 18' W), at about 940 metres above sea level. The 5 ha-study area comprises a disturbed mixed ombrophilous forest (Fig. 1). The mean annual temperature is 16.5 °C in the region and the annual rainfall ranges around 1 350 mm (Maack, 1981). There are two different seasons in the region: the dry season (April-August) and the wet season (September-March), although this seasonality is not well marked (data from the "Estação Meteorológica da Universidade Federal do Paraná", 8 km distant from the study area).

STUDY ANIMAL

The common opossum is a small mammall abundant in mixed forest fragments of southern Brazil (Cáceres & Monteiro-Filho, 1998). This opossum

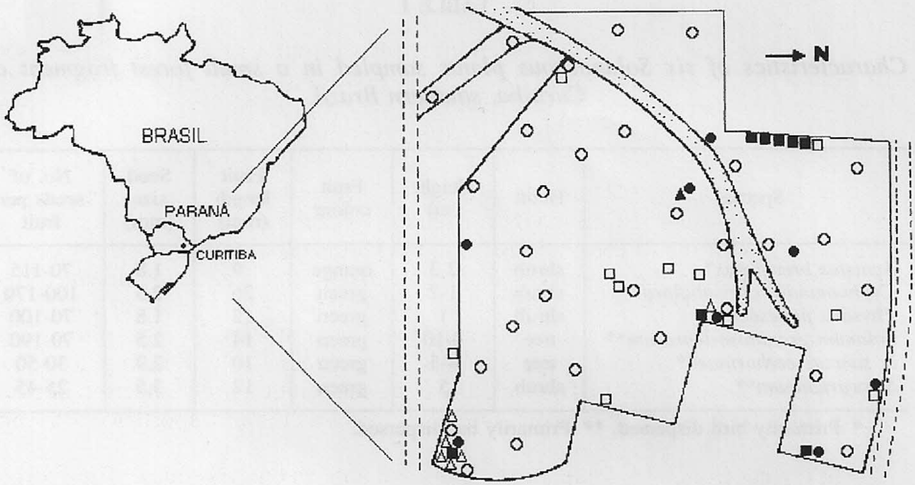

Figure 1. — Localization of the study area (5 ha) in Brazil with a detailed view of traps (open circles) and Solanaceous fruiting plant locations. *Acnistus breviflorus* (closed squares), *Cyphomandra corymbiflora* (open triangles), *Solanum granuloso-leprosum* (closed circles), *S. sanctae-catharinae* (open squares) and *S. swartzianum* (closed triangle). Dotted lines = roads, dotted area = a creek.

was captured using 30 live traps (40 by 20 by 20 cm) placed uniformly and in fixed points of the study area (Fig. 1). Traps were set once per week from February 1995 to January 1996. The bait utilized was a mixture of banana, peanut butter and catfish liver oil. Scats of opossums were collected on the floor of traps after their release.

Plant species

The six Solanaceous species studied are commonly pioneer plants found in disturbed forest fragments near Curitiba. They mainly show bat-dispersed characteristics in their fruits, such as the drab colour, juice, and exposed outside dense crown position (van der Pijl, 1982). Below there are some characteristics present by them in the study area (Tab. I).

Fruit consumption

Solanaceous seeds were obtained from scats of the common opossum which were washed with aid of a bolter (0.5 mm mesh) and analysed. The rates of occurrences of these seeds in feces were tested in relation to the estimated home range size and the rate of recaptures of each opossum through the nonparametric Spearman R correlations. Home range sizes were estimated through the number of different traps in the area where each opossum was captured (this area was obtained by the Minimum Convex Polygon Method; Mohr, 1947). Fruiting Solanaceous plants of the study area were noted every month by counting fallen fruits on the ground below the marked fruiting plants or by direct observation on

TABLE I

Characteristics of six Solanaceous plants sampled in a small forest fragment of Curitiba, southern Brazil.

Species	Habit	Height (m)	Fruit colour	Fruit length (mm)	Seed size (mm)	No. of seeds per fruit
*Acnistus breviflorus**	shrub	2-3	orange	9	1.8	70-115
*Cyphomandra corymbiflora***	shrub	1-2	green	26	2.5	100-170
*Physalis pubescens***	shrub	1	green	12	1.8	70-100
*Solanum granuloso-leprosum***	tree	8-10	green	14	2.5	70-190
*S. sanctae-catharinae***	tree	4-5	green	10	2.9	30-50
*S. swartzianum***	shrub	5	green	12	3.5	25-45

* Primarily bird dispersed. ** Primarily bat dispersed.

small plants. The population densities of these plants were recorded by searching for fruiting Solanaceous plants over the entire study area during the time of opossum captures.

DISTANCES OF DISPERSAL

The minimum distance from each parent plant to the nearest opossum scat containing seeds was obtained as follows. We plotted, on a scale map, locations of plants and scats and measured the minimum distance of any scat to the nearest plant of the appropriate species.

GERMINATION EXPERIMENTS

A part of each seed sample recorded in scats was separated for germination experiments. These seeds were placed in closed Petri dishes (10 cm in diameter) containing humid toilet paper. After this, dishes were placed in a natural environment under diffuse light, resembling a gap and at ground level. They were often watered for conservation of the humidity and treated with specific fungicide to avoid fungus growth.

RESULTS

FRUIT CONSUMPTION

Eighteen common opossum individuals were captured, resulting in a total of 78 scats collected containing Solanaceous seeds (18 captures and 60 recaptures) which accounted for 50 % of all collected scats (total of 157). Six species of Solanaceous plants were regularly found in the opossum scats during different periods of the year, but mainly during the wet season (September to March), which was mostly related to the availability of fruits in the area (Fig. 2). The fruit

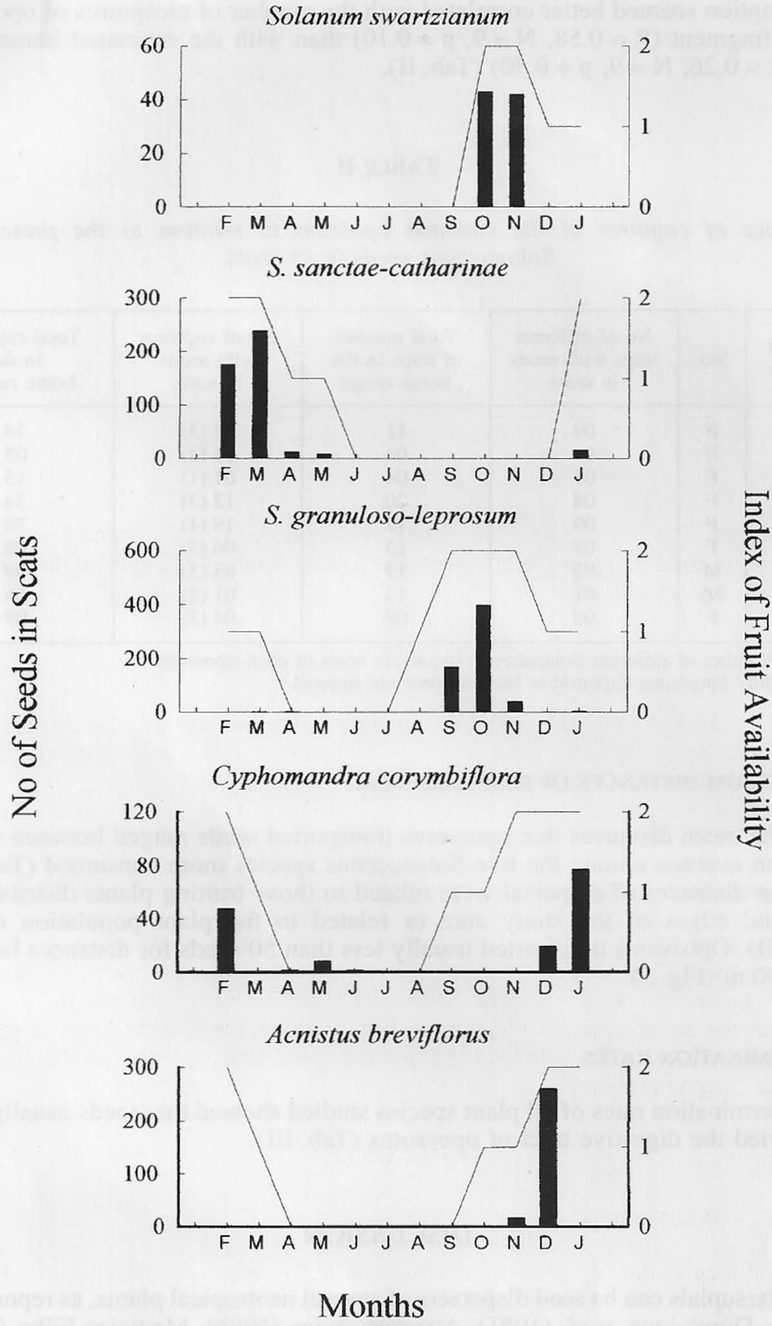

Figure 2. — Opossum consumption of five Solanaceous fruits expressed by the total number of seeds found per month in wet season (September to March) scats (bars). Fruit availability (line): 0 - Absent, 1 - Low, 2 - High.

consumption seemed better correlated with the number of recaptures of opossums in the fragment ($R = 0.58$, $N = 9$, $p = 0.10$) than with the estimated home range size ($R = 0.26$, $N = 9$, $p = 0.50$) (Tab. II).

TABLE II

Dynamics of captures of the common opossum in relation to the presence of Solanaceous seeds in its scats.

Animal number	Sex	No of different traps with seeds in scats	Total number of traps in the home range	No of captures with seeds in scats	Total captures in the home range*
1	F	09	11	17 (3)	34
3	F	04	04	05 (2)	05
4	F	01	04	01 (1)	15
6	F	08	20	12 (3)	34
7	F	09	12	19 (4)	39
8	F	05	13	06 (3)	08
11	M	02	19	03 (3)	09
12	M	01	12	01 (2)	06
18	F	02	09	04 (3)	05

() Number of different Solanaceous species in scats of each opossum.
* Only opossums captured at least 5 times are showed.

MINIMUM DISTANCES OF SEED DISPERSAL

The mean distances that opossums transported seeds ranged between 40 and 82 m on average among the five Solanaceous species more consumed (Tab. III). Greatest distances of dispersal were related to those fruiting plants distributed in gaps and edges of the study area or related to the plant population density (Tab. III). Opossums transported usually less than 50 seeds for distances between 10 to 90 m (Fig. 3).

GERMINATION RATES

Germination rates of all plant species studied showed that seeds usually cross uninjuried the digestive tract of opossums (Tab. III).

DISCUSSION

Marsupials can be seed dispersers of several neotropical plants, as reported by Charles-Dominique *et al.* (1981), Atramentowicz (1988), Monteiro-Filho (1987), Monteiro-filho & Dias (1990), Medellin (1994) and Cáceres (1996). Our study shows that the common opossum can be an effective seed disperser of some pioneer Solanaceous plants. As pioneer plants are important for forest regeneration

TABLE III

Average minimum distances of dispersal and number of seeds transported by the common opossum in relation to the population densities of parent plants and germination rates of Solanaceous species found in its feces.

Solanaceous species	Distance of seed dispersal (m) **	No. of seeds transported **	Density (plants per ha)	Percent of germination (%)	No. of seeds tested
Acnistus breviflorus	76 ± 35	46 ± 65	1.0*	65	66
Cyphomandra corymbiflora	73 ± 35	15 ± 23	0.5*	60	65
Physalis pubescens	—	17 ± 14	—	86	38
Solanum granuloso-leprosum	49 ± 39	32 ± 72	2.0	57	113
S. sanctae-catharinae	40 ± 18	14 ± 28	2.8	44	143
S. swartzianum	82 ± 29	9 ± 12	0.3	50	32

* Plant distribution clumped in gaps or edges.
** Means ± Standart Deviation.

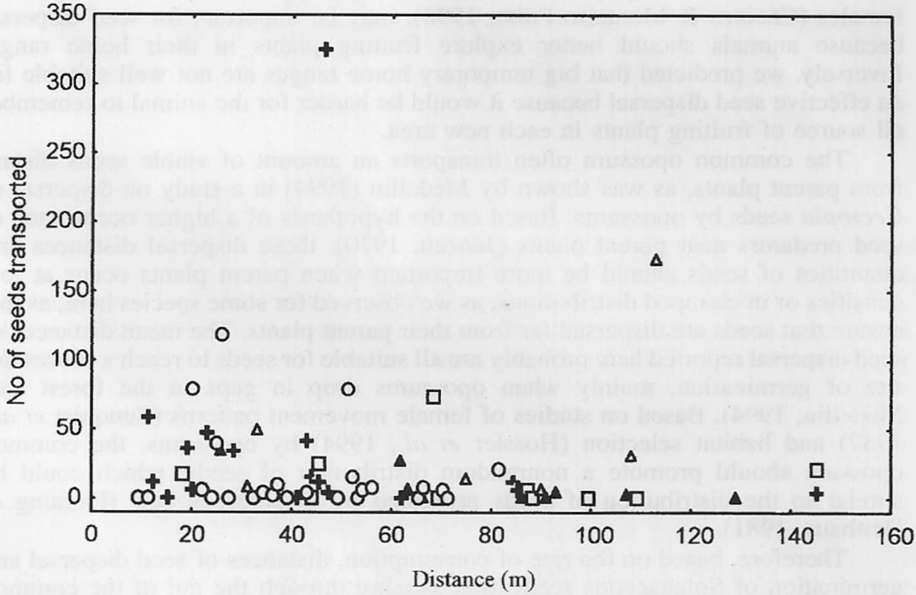

Figure 3. — Minimum dispersal distances of Solanaceous seeds dropped by the common opossum in a forest fragment of southern Brazil. Crosses: *Solanum granuloso-leprosum,* circles: *S. sanctae-catharinae,* closed triangles: *S. swartzianum,* opened triangles: *Acnistus breviflorus,* squares: *Cyphomandra corymbiflora.*

(Gorchov *et al.*, 1993), this primitive mammal should play an important role in the conservation of forests. Considering that this opossum occurs in peri-urban areas (Julien-Laferrière *et al.*, 1997), it may transport seeds from forest fragments to more disturbed sites in cities or rural areas (see Cordero & Nicolas, 1992; Cáceres & Monteiro-Filho, unpubl. data).

As was observed for other neotropical plants (Smithe, 1970; Charles-Dominique *et al.*, 1981; Snow, 1981; Howe, 1993), the Solanaceous plants, despite their bat-dispersed characteristics, here, are thought to show a generalized dispersal system, as they offer superabundant fruits of lower nutritional values to attract a wide host of flying (such as bats and birds) and nonflying frugivorous vertebrates (e.g., marsupials and rodents). This report was confirmed for another *Solanum* species in southern Brazil, including another didelphid marsupial, *D. albiventris,* as its seed disperser (Cáceres & Moura, unpubl. data).

Many birds (Cruz, 1981; Barnea *et al.*, 1990, Charles-Dominique, 1986), bats (Fleming & Heithaus, 1981; Reis & Guillaumet, 1983; Uieda & Vasconcellos-Neto, 1985; Charles-Dominique, 1986; Muller & Reis, 1992) and foxes (Lombardi & Motta-Júnior, 1993; Motta-Júnior *et al.*, 1994) disperse Solanaceous seeds and marsupials such as the common opossum may also do it. Frugivorous marsupials should disperse Solanaceous species elsewhere in the neotropics, based on the species richness of this plant family (Smith & Downs, 1966; Cronquist, 1981; Bohs, 1994).

The opportunistic behavior of the common opossum in feeding on Solanaceous fruits in southern Brazil has already been reported by Atramentowicz (1988) in French Guiana. Its high permanence in a smaller area, as was seen for opossum females (Cáceres & Monteiro-Filho, 1998), may be important for seed dispersal because animals should better explore fruiting plants in their home range. Inversely, we predicted that big temporary home ranges are not well suitable for an effective seed dispersal because it would be harder for the animal to remember all source of fruiting plants in each new area.

The common opossum often transports an amount of viable seeds distant from parent plants, as was shown by Medellin (1994) in a study on dispersal of *Cecropia* seeds by opossums. Based on the hypothesis of a higher occurrence of seed predators near parent plants (Janzen, 1970), these dispersal distances and quantities of seeds should be more important when parent plants occur at low densities or in clumped distributions, as we observed for some species here, as this ensure that seeds are dispersed far from their parent plants. The mean distances of seed dispersal reported here probably are all suitable for seeds to reach a successful site of germination, mainly when opossums drop in gaps in the forest (see Medellin, 1994). Based on studies of female movement patterns (Sunquist *et al.*, 1987) and habitat selection (Hossler *et al.*, 1994) by opossums, the common opossum should promote a nonrandom distribution of seeds, which could be similar to the distribution of seeds promoted by frugivorous bats (Fleming & Heithaus, 1981).

Therefore, based on the rate of consumption, distances of seed dispersal and germination of Solanaceous seeds after passing through the gut of the common opossum, this small mammal may prove to be an effective seed disperser of such plants in southern Brazil. From a conservation view, other studies are necessary to corroborate the role of marsupials on seed dispersal.

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