Frugivory and habitat use by thrushes (Turdus spp.) in a suburban area in south Brazil

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Marco Aurélio Pizo
Universidade Estadual Paulista, Rio Claro, São Paulo, Brasil

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Frugivory and habitat use by thrushes (*Turdus* spp.) in a suburban area in south Brazil

Gabriel Gasperin · Marco Aurélio Pizo

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Abstract Thrushes (*Turdus* spp., Turdidae) are among the most common frugivorous birds in urban areas around the world, where they disperse the seeds of a variety of plant species. We studied the abundance, habitat use, foraging behavior and diet of four thrush species (*Turdus rufiventris*, *T. amaurochalinus*, *T. leucomelas*, and *T. albicollis*) in a suburban area in south Brazil. Abundance, habitat use and foraging behavior were based on birds surveyed along a 3,240 m transect crossing open (formed by lawns, streets, and buildings) and forested areas. Diet was based on fecal samples collected from mist-netted birds. *Turdus rufiventris* was the most abundant species, followed by *T. amaurochalinus*, *T. leucomelas*, and *T. albicollis*. All species used forest fragments more frequently than expected by chance. A total of 91.8% (n=147) of the fecal samples contained fruit remains, while 42.2% contained only animal matter. Most of the foraging records were on the ground, where birds got mainly invertebrates. Fruits and invertebrates were eaten more frequently in open than in forested areas. A total of 25 seed morfospecies were found in the droppings, including five exotic plant species. Thrushes overlapped widely in the fruit composition of their diets. The high abundance and degree of frugivory, coupled with the frequent use of forest patches, indicate that thrushes are among the great bird contributors to the seed dispersal occurring in urban forest patches, potentially influencing the vegetation dynamics of such habitats so important for the maintenance of the biodiversity in urban areas.

Keywords Diet · Exotic plants · Frugivory · Habitat use · Seed dispersal · Urban ecology

Introduction

Urban environments are home to an unsuspected biodiversity that is increasingly attracting the attention of conservationists (McKinney 2002). In urban environments, forest patches

G. Gasperin · M. Aurélio Pizo (✉)
Centro de Ciências da Saúde, Universidade do Vale do Rio dos Sinos (UNISINOS), 93022-000
São Leopoldo, RS, Brazil
e-mail: mapizo@unisinos.br

are of special conservation interest because they harbor species not found in the surrounding urban matrix. For the general public, the forested patches of urban parks usually represent the only opportunity to experience the forest realm. If the political support of conservation initiatives depends in part on the positive, direct experiences city dwellers have with the natural world around them (Dunn et al. 2006), we have plenty of reason to protect, restore and study the ecology of urban forest patches. In tropical cities, however, little is currently known about the ecology of such patches, including the dispersal of seeds that form the template upon which the recruitment of plant populations occurs. By virtue of their ubiquity in urban areas, frugivorous birds are the most likely organisms to disperse seeds in urban landscapes (Reichard et al. 2001; Wunderle 1997).

Thrushes of the genus *Turdus* (Turdidae) are among the most common frugivorous birds in altered habitats around the world, including urban areas (Reichard et al. 2001; del Hoyo et al. 2005; Pizo 2007).They are omnivores birds that frequently feed on fruits (del Hoyo et al. 2005; Snow and Snow 1988), but also eat a variety of invertebrates, which are often taken on the ground (del Hoyo et al. 2005). Thrush diets can range from almost exclusively frugivorous to primarily invertebrates (Guitián et al. 2000; Wheelwright 1986). Concerning seed dispersal, thrushes eat fruits of a variety of plants that they swallow whole and rarely reduce the germination success or germination rate of the seeds they ingest (Foster 1987, Traveset 1998). They can also range widely and contribute to the extensive dissemination of seeds (Jordano et al. 2007).

Here we present data on aspects of the ecology of four thrush species (Rufous-bellied Thrush, *Turdus rufiventris*; Creamy-bellied Thrush, *T. amaurochalinus*; Pale-breasted Thrush, *T. leucomelas*; and White-necked Thrush, *T. albicollis*) inhabiting a suburban area in south Brazil that we consider important for the comprehension of their effectiveness (sensu Schupp 1993) as seed dispersers in such environment. We studied their abundance (in relation to each other and to other frugivorous birds), diet, habitat use, and foraging ecology. We were especially interested in answering the following questions: (1) which fruits were eaten and in what amounts?, (2) how the fruit diet overlap among species?, and (3) where thrushes foraged for fruits (open vs. forested habitat) and where they were most likely to deposit seeds?. All the studied thrush species except *T. albicollis* are common in rural and urban settings of Brazil (Fontana 2004; Matarazzo-Neuberger 1995). *Turdus albicollis* is more restricted to forested areas, where it often figures among the most common understory frugivorous birds (Hasui et al. 2007). All of them show extensive frugivory (del Hoyo et al. 2005).

Methods

Study area

Our study was carried out on the campus of the Universidade do Vale do Rio dos Sinos (UNISINOS; 29° 47′ S, 51° 9′ W) located in a suburban area (sensu Marzluff et al. 2001) 3.3 km from the center of São Leopoldo, a city with 200,000 inhabitants in south Brazil. Approximately 18.5% of the campus (91 ha) are composed of forest patches, 4% are covered by water bodies (lakes and streams), the rest consists of lawns with scattered native and exotic plants, and buildings interspersed with streets. Meteorological data collected at São Leopoldo from 1988 to 2003 indicate that precipitation is well distributed throughout the year, totaling around 1,500 mm. The mean monthly temperature is 19.8°C (range= 13.8–25°C).

Semideciduous Atlantic forest (sensu Morellato and Haddad 2000) originally covered the study area, but is now limited to four fragments ranging in size from 0.5 to 3.5 ha that include many exotic plants. A survey of the plants with a diameter at breast height (dbh)≥ 1 cm sampled in 40 3×3 m plots inside the forest fragments revealed a mean (± SD) density of 0.9±0.3 plants/m^2, low dbh (8.6±4.5 cm), and relatively short vegetation (5.2±1.9 m). The five most abundant plant species were the ornithocorous *Guarea macrophyla* (Meliaceae), *Schinus terebenthifolius* (Anacardiaceae), *Myrsine umbellata* and *M. coriacea* (Myrsinaceae), and *Casearia sylvestris* (Salicaceae) (M. A. Pizo and C. M. M. Lhul, unpubl. data).

Abundance and habitat use

Two methods were used to estimate thrush abundance. Four mist nets (12 m long, 2.5 m height, 36-mm mesh) were opened weekly or biweekly from 08:00 to 18:00 at each of the four forest fragments from August 2006 to July 2007 for a total of 967.7 net hours. Positions of the nets were fixed along the study and they were separated from each other from 1 to 50 m. Captured birds were banded with numbered metal rings. From March 2006 to April 2007 a 3,240 m transect was walked slowly during 2.5–3 h periods distributed throughout the day from 06:00 to 18:00 h totaling 84.2 km. The transect crossed 2,210 m of open areas and 1,030 m of the interior and edge of forest fragments. Only thrushes seen irrespective of the distance to the transect were recorded together with their habitats of occurrence (open or forest). The movement of recorded birds was tracked as far as possible to avoid double counting the same bird. Open areas included lawns, streets, and buildings, whereas forest habitat consisted exclusively of edge and interior forest fragments. To determine if thrushes selected open or forested habitats, we used contingency tables contrasting the observed frequencies of transect records of each thrush species in opened and forested habitats with the expected frequencies given by the availability of such habitats along the transect. The availability of opened and forested habitats was estimated by recording the habitat crossed by the transect at each 20 m interval. Contingency tables were tested with chi-square or Fisher Exact tests.

Foraging

For every thrush observed foraging along the transect, we recorded the food item (fruits or invertebrates) and if it was on the ground or in trees. To ensure independence, we considered only the initial observation for each individual bird (Hejl et al. 1990).

To test for seasonal differences in substrates used for foraging (ground × trees), the period from April–September was classified as winter, and October–March as summer. Although rainfall exhibited little seasonal variation, mean monthly temperature was lower in winter (average 16.4°C) than summer (23.2°C). In addition, summer is the main breeding season for thrushes and the period of highest fruit availability in our study area (M. A. Pizo, pers. obs). We further cross-classified all foraging records by thrush species and season (winter × summer) categories. With the resulting two-way frequency table, we performed a log-linear analysis to examine whether species and season (design variables) affect the frequency of substrate use (response variable).

To test for daily differences in substrate use by *T. rufiventris* (the only species for which we had enough data), we classified the foraging records into morning (07:00–09:59), mid-day (10:00–15:59) and afternoon (16:00–19:00) periods for comparison with a chi-square test.

Diet

Birds captured in mist nests were banded and kept in individual clean cloth bags for 10–15 min until they defecated. Fecal samples were then collected and preserved in individual vials containing 70% ethanol for later examination under a stereomicroscope. Fecal samples were categorized as containing animal matter only, animal matter plus fruits (including whole fruits, fruit skins, and seeds), and fruits only. We counted the number of seeds and identified them to species by comparison with a reference collection assembled with fruits collected in the study area.

Due to the poor condition of animal remains, we did not attempt to identify them. We may have underestimated the contribution of animals in the diet of thrushes because the remains of soft-bodied invertebrates (e.g., earthworms) were difficult to discern in the droppings. In addition, large seeds tend to be regurgitated rather than defecated by birds (Levey 1987) so are poorly represented in droppings. Although biased towards small-seeded plants and hard-bodied invertebrates, fecal analysis provides reliable estimates of the relative importance of various foods for small birds, especially in the broad categories used here (Ralph et al. 1985, Rosenberg and Cooper 1990).

Rarefaction curves were constructed for interspecific comparisons of the seed species richness found in fecal samples. Comparisons were based on confidence intervals derived from 1,000 iterations implemented in EcoSim 7.0 (Gotelli and Entsminger 2001).

Using EcoSim, we also evaluated whether thrush species overlapped significantly in fruit diet. For this, we constructed a bird-species × plant-species matrix with cells filled by the frequencies of occurrences of fruit species in droppings. We compared the interspecific niche overlap against a random model that retains the niche breadth of each thrush species, but randomizes which plant species is included in the diet (Gotelli and Entsminger 2001; Winemiller and Pianka 1990). By using this algorithm we assume that all thrush species are able to feed on every fruit species in the matrix, which we consider a reasonable assumption given the similarities in morphology, behavior, and habitat use (see below) among the thrush species studied. We used Pianka's (1973) pairwise index to calculate niche overlap:

$$O_{12} = O_{21} = \frac{\sum_{i=1}^{n} p_{2i} p_{1i}}{\sqrt{\sum_{i=1}^{n} \left(p_{2i}^2\right)\left(p_{1i}^2\right)}}$$

Where O_{12}, which equals O_{21}, is the overlap of species 1 with species 2, $p_{2\mathrm{i}}$ and $p_{1\mathrm{i}}$ is the proportion of plant species i in the diet of species 2 and species 1, respectively.

Due to sample size restrictions, analyses were restricted to the three most common thrush species (*T. amaurochalinus*, *T. leucomelas*, and *T. rufiventris*) unless otherwise indicated. Plant classification adopted here follows APGII (2003).

Results

Abundance and habitat use

Thrushes as a group were the most frequent birds captured in mist nets (61% of all the birds, and 79.3% of all frugivorous birds captured). Mist nets and transect provided consistent results regarding thrush relative abundances (i.e. the position of each thrush

Table 1 Abundance and diet of thrushes inhabiting a suburban area in south Brazil

Species	Abundance [a]		Diet (% of fecal samples)			
	Mist nets	Transect	N	Animal only	Animal and fruit	Fruit only
Turdus albicollis	5	1	5	20.0	80.0	0.0
T. amaurochalinus	38	48	39	5.1	38.5	56.4
T. leucomelas	13	24	10	0.0	10.0	90.0
T. rufiventris	84	222	93	9.7	32.2	58.1

Abundance was estimated both with mist nets (12×2.5 m) placed in small forest fragments for a total of 967.7 net hours, and along a 3,240 m transect crossing the study area. Recaptures of banded birds were not considered for the abundances derived from mist nets

[a] Figures for abundance refer to number of captures with mist nets and number of records along the transect

species in the ranked order of abundances): *Turdus rufiventris* was the most abundant, followed by *T. amaurochalinus*, *T. leucomelas*, and *T. albicollis* (Table 1). Six birds (four *T. rufiventris*, and two *T. amaurochalinus*) were recaptured in a forest fragment different from where they were marked, indicating the movement of thrushes among forest fragments.

With the exception of *T. albicollis* and, to a lesser extent, *T. leucomelas*, thrushes were often found in open areas. However, all species used forest fragments more frequently than expected by chance (Fig. 1).

Foraging

Most of the foraging records of thrushes were on the ground (66.8%, n=208), which was strongly associated with invertebrate eating (87.0% of 139 records; χ^2=42.3, df=1, p<

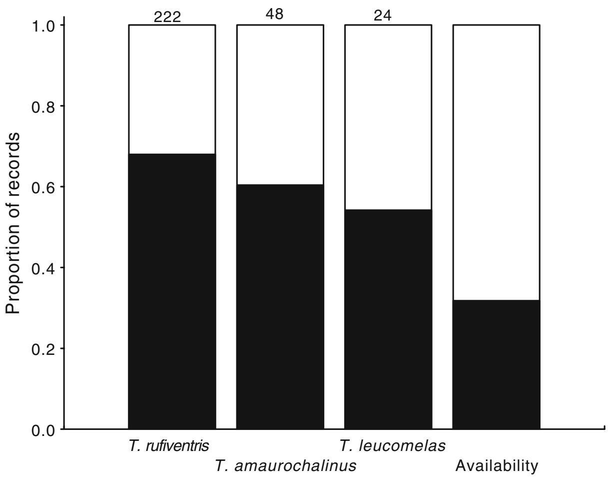

Fig. 1 Thrushes (*Turdus* spp.) used forested habitats more often than its availability in an urbanized area in south Brazil. Habitat use was assessed surveying a transect crossing 2,210 m of open areas (lawns, streets, buildings) and 1,030 m of forest fragments. Chi-square tests contrasting the use of open (*white bars*) vs forested (*black bars*) habitats against their availabilities along the transect were significant for all species (*T. rufiventris*: χ_1^2=69.5, P<0.001; *T. amaurochalinus*: χ_1^2=14.9, P=0.002; *T. leucomelas*: χ_1^2=5.0, P=0.04). Number of records indicated above bars

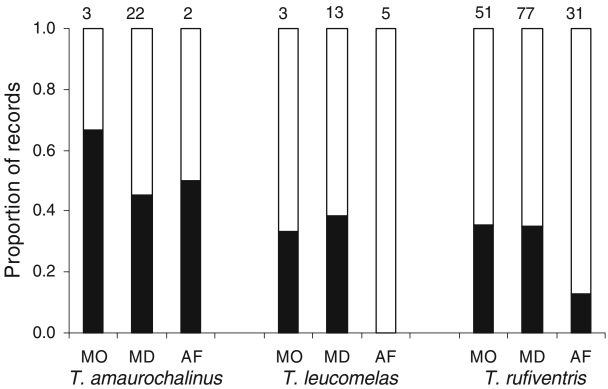

Fig. 2 Frequency of ground (*white bars*) and tree (*black bars*) foraging records of thrush species (*Turdus* spp.) in morning (MO; 07:00–09:59 h), mid-day (MD; 10:00–15:59 h) and afternoon periods (AF; 16:00–19:00 h). Number of records indicated above bars

0.001). Although thrushes occasionally ate fallen fruits, fruits were obtained predominantly in trees (89.7% of 69 records; χ^2=74.8, df=1, p<0.001). Species did not differ in their frequencies of substrate use (χ^2=1.0, df=2, p=0.61). Likewise, no among-species seasonal difference in the use of foraging substrates was detected (χ^2=2.2, df=2, p=0.33) showing that thrushes consistently favor ground over tree foraging throughout the year. The substrates used by *T. rufiventris* for foraging varied during the day, with more ground foraging in the afternoon (χ^2=5.8, df=2, p=0.05), a trend mirrored by *T. leucomelas* (Fig. 2).

All three thrush species tended to eat fruits (χ^2=3.7, df=2, p=0.15) and invertebrates (χ^2=4.1, df=2, p=0.13) more frequently in open than in forested areas (Fig. 3). However, this may only reflect our supposed greater ability to detect foraging in open areas.

Diet

Overall, 57.8% (n=147) of the fecal samples contained only fruit skins or seeds, whereas 8.2% contained only animal remains. Both fruit and animal matter were detected in 34.0%

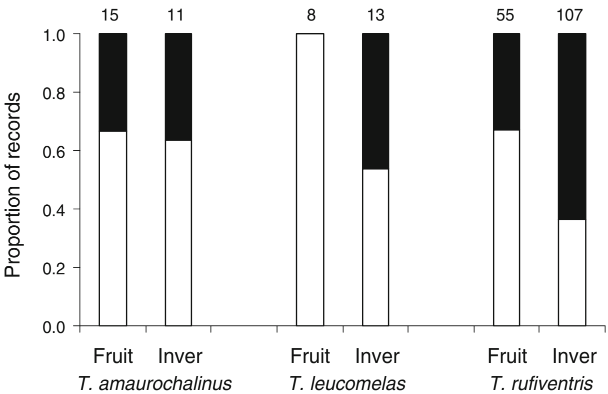

Fig. 3 Frequency of fruit and invertebrate (Inver) eating in open (*white bars*) and forested (*black bars*) areas by thrush species (*Turdus* spp.) in a suburban landscape in south Brazil. Number of records indicated above bars

of the droppings (Table 1). The degree of frugivory as revealed by the percentage of samples containing fruit remains or seeds ranged from 80% for *T. albicollis* to 100% for *T. leucomelas*, although these two extremes were based on relatively few samples (Table 1). Droppings contained from 1 to 6,000 seeds (median: 5.5 seeds) representing from one to four different species, but most droppings (67%, n=92) contained the seeds of a single species. No interspecific difference in the number of seed species per dropping was detected between *T.amaurochalinus* and *T. rufiventris,* the two species for which we had enough data for testing (one single dropping of *T. rufiventris* containing four seed species was pooled with three-seed species droppings for analysis; χ^2=5.6, df=2, p=0.06).

We identified 25 seed morphospecies in the droppings, a figure that may be underestimated because fruit skins were not identified. Most species appeared infrequently in the feces, which were greatly dominated by *Schinus terebinthifolius* (Anacardiaceae), *Myrsine coriaceae* (Myrsinaceae), *Psychotria carthagenensis* (Rubiaceae), and *Cecropia pachystachia* (Urticaceae), present in 91.3% of the seed-containing droppings (n=92; Table 2). Seeds varied in diameter from < 1 to 9 mm. The tiny seeds of *Leandra* sp. (Melastomataceae) were the most abundant, with up to 6,000 present in a single dropping. Seeds of five exotic plant species were detected in 16.3% of the droppings (Table 2).

The superposition among the confidence intervals of the rarefied curves suggested no interspecific difference in the fruit species richness eaten by thrushes (Fig. 4). The curve for *T. leucomelas* indicated a tendency for a richer diet (mean and variances of the estimated fruit species richness “rarefied” down to the smallest sample size: *T. leucomelas* mean= 11.00, σ=0.00; *T. amaurochalinus* mean=8.24, σ=1.87; *T. rufiventris* mean=8.28, σ= 1.86), although the small number of droppings obtained for *T. leucomelas* (10) call for caution in the interpretation of these results.

The overlap in fruit diet were higher than expected by chance (0.76, p<0.001), suggesting that thrushes eat roughly the same fruit species in similar proportions. Highest overlap (0.87) occurred between *T. rufiventris* and *T. amaurochalinus*, while the latter species and *T. leucomelas* overlapped the least (0.60). Although thrushes had similar seed profiles, subtle differences were noted. Taking the top four plant species eaten for instance, *C. pachystachia* seeds were found more frequently in the droppings of *T. rufiventris* (11.8%, n=93) than in *T. amaurochalinus’* droppings (5.1%, n=39), whereas the reverse is true for *S. terebinthifolius* (14.0% and 25.6%, respectively), *M. coriacea* (14.0% and 25.6%), and *P. carthagenensis* (7.5% and 15.4%).

Discussion

Thrushes are among the most common birds in our study area and are also common in other urban areas in Brazil and elsewhere (Argel-de-Oliveira 1995, del Hoyo et al. 2005). As a group, they are likely more common in urban areas than in more natural environments. For instance, *T. rufiventris* had an abundance of 80.6 individuals/1,000 net hours in the study area, differing greatly from 1.1 individuals/1,000 net hours found by Hasui et al. (2007) in a well-preserved Atlantic forest site. Even *T. albicollis*, a species more sensitive to habitat disturbance and more dependent on forested habitat (Stotz et al. 1996), presented similar abundances between our (5.2 individuals/1,000 net hours) and Hasui’s work (5.3 individuals/1,000 net hours). The key to the high abundance of thrushes in urban environments probably lie with the highly productive lawn and ornamental plant ecosystem that provides a rich source of food, especially invertebrates (Falk 1976). Although underestimated in our fecal analysis, invertebrates formed an

Table 2 Plant species eaten by four thrush species in a suburban area in south Brazil

	Frequency (%)	Median number of seeds (range)	Thrush species [a]
Anacardiaceae			
Schinus terebinthifolius	28.3	9.5 (1–52)	Ta, Tb, Tl, Tr
Lauraceae			
Cinnamomum zeylanicum *	2.2	1	Tl, Tr
Cinnamomum sp.2 *	1.1	1	Ta
Cinnamomum sp. 3 *	1.1	7	Tl
Moraceae			
Morus nigra *	9.8	6 (1–30)	Ta, Tl, Tr
Ficus sp.	3.3	82.5 (6–115)	Tb, Tr
Melastomataceae			
Leandra sp.	6.5	38 (3–6,000)	Tl, Tr
Miconia sp. 1	4.3	18 (2–30)	Ta, Tl
Miconia sp. 2	3.3	26 (14–80)	Ta, Tr
Myrsinaceae			
Myrsine coriaceae	26.1	2 (1–59)	Ta, Tl, Tr
Myrsine umbelata	1.1	6	Tr
Myrtaceae			
Syzygium cumini *	2.2	1	Tr
Rubiaceae			
Psychotria carthagenensis	17.4	3 (1–25)	Ta, Tb, Tl, Tr
Salicaceae			
Casearia sylvestris	3.3	1 (1–2)	Ta, Tl, Tr
Sapindaceae			
Allophylus edulis	1.1	1	Tr
Paullinia sp.	1.1	1	Ta
Solanaceae			
Solanum americanum	1.1	1	Ta
Urticaceae			
Cecropia pachystachia	19.7	50 (1–1,250)	Ta, Tb, Tl, Tr
Unidentified 1	1.1	1	Tl
Unidentified 2	1.1	4	Ta
Unidentified 3	1.1	1	Ta
Unidentified 4	1.1	18	Ta
Unidentified 5	1.1	7	Tr
Unidentified 6	1.1	46	Tr
Unidentified 7	1.1	5	Tr

Frequency were based on 92 fecal samples containing seeds. Plant species followed by an asterisk are exotics

[a] Codes for thrush species: Ta = *Turdus amaurochalinus*, Tb = *T. albicollis*, Tl = *T. leucomelas*, Tr = *T. rufiventris*

important part of the diet of thrushes, as indicated by the high and temporally consistent frequency of ground foraging. In agreement with this assertion, low availability of invertebrates was pointed out as a cause of the decline of *Turdus philomelos* in rural areas of UK (Peach et al. 2004).

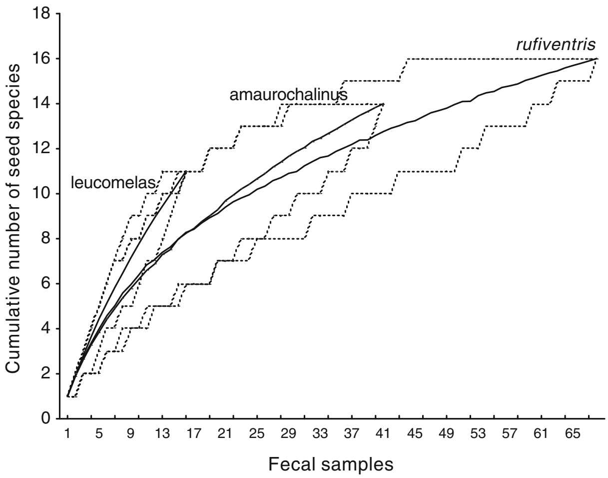

Fig. 4 Cumulative rarefied curves showing the average number of seed species found in the fecal samples of *Turdus rufiventris, T. amaurochalinus and T. leucomelas*. *Dotted lines* refer to 95% confidence intervals. *Curves* were constructed with 1,000 iterations

Although frequently seen in open areas looking for prey on the ground (del Hoyo et al. 2005), even the species apparently more adapted to the urban environment (e.g. *T. rufiventris*) use forest patches frequently. Urban forest patches are used by thrushes to nest and probably provide shelter against predators (Cohen and Lindell 2004, M.A. Pizo pers. obs.). In Porto Alegre, the biggest city (over 1,200,000 inhabitants) near (30 km) the study area, *T. rufiventris* is among the top ten most common species (Fontana 2004), increasing in abundance from the center of the city to the periphery following a gradient of increasing vegetation cover (Ruszczyk et al. 1987). Together, this points to the importance of the vegetation cover to thrush populations in urban environments, paralleling what Cohen and Lindell (2005) found for *Turdus assimilis* in Costa Rican rural areas. Because thrushes were recorded more frequently in forest patches (Fig. 1), these are likely the habitats where thrushes more often deposit seeds, thus contributing to the vegetation dynamics of forest patches.

The degree of frugivory was high for all thrush species in our study, corroborating the tendency of thrushes to eat fruits frequently in both natural and urbanized areas (del Hoyo et al. 2005; Guitián et al. 2000; Snow and Snow 1988; Wheelwright 1986). The high frequency of *T. albicollis* droppings containing only animal matter stands out in comparison with the other species, but it should be interpreted with caution due to small sample size. *Turdus albicollis* is known to eat fruits extensively in other regions (del Hoyo et al. 2005, Hasui et al. 2007). Although highly frugivorous, the contribution of fruits to the diet of thrushes may vary spatially. In a drier fragmented landscape covered by remnants of semideciduous Atlantic forest imbedded in a rural matrix in SE Brazil, the year-round degree of frugivory for *T. rufiventris* (51.6%, n=30 fecal samples), and *T. leucomelas* (62%, n=30) was lower than we found in this study (90.3% and 100%, respectively) (M. S. Facchio and M. A. Pizo unpubl. data). That thrushes have a flexible diet is not new, but what remains to be learned is if this geographic variation reflects differences in local fruit availability, actual inter-population differences in feeding habits or a rural–urban gradient in diet composition.

Thrushes are known to provide high quality seed dispersal services to a variety of plant species (Traveset 1998), which our data corroborate. Seeds found in feces were invariably intact and most of the droppings contained a single seed species, thus avoiding the potentially negative effects of interspecific seedling competition for resources (Loiselle 1990).These similarities in seed treatment coupled with the high overlap in fruit diet, and the similar use of habitats is suggestive of ecological redundancy in what concerns seed dispersal services provided by thrushes in this urban environment. Ecological redundancy in seed dispersal is also a possibility in species-rich tropical forests (Loiselle et al. 2007), but it may be more likely in urban areas. Such areas usually present restricted spatial opportunities for plant recruitment (represented by the small forest fragments in our constantly gardened area), smaller plant diversity than in tropical forests, and a variety of frugivorous birds using all the habitats available, conditions that may favor the redundancy of seed dispersers from the plant's point of view. However, the issue of ecological redundancy in seed dispersal involving thrushes deserves further investigation addressing aspects not considered here but important in seed dispersal, as the germination performance of seeds and the likelihood of long-distance seed dispersal provided by each thrush species (Loiselle et al. 2007).

As a by-product of their catholic fruit diet, thrushes frequently disperse the seeds of exotic plant species in urban environments (Lombardi and Motta 1993, Reichard et al. 2001, Scheibler and Melo 2003). At least two of the exotic plants found in the diet of thrushes (*Morus nigra* and *Syzygium cumini*) are invasive species that can be detrimental to the native flora (Instituto Horus 2008). Presently we can not envisage a mean of directing the interest of thrushes to native fruits only in detriment of exotic ones. However, given that thrushes frequently eat the fruits of plants outside the forested areas, the use of native in place of exotic plants as ornamentals in urban areas would help to refrain the ongoing invasion of exotics into urban forest patches.

In conclusion, the high abundance and degree of frugivory coupled with the frequent use of forest patches indicate that thrushes are among the great contributors to the seed dispersal occurring in urban forest patches. Their capacity to occupy open areas permit them visit different forest fragments, thus promoting the seed movement among different forest patches. With this set of characteristics, thrushes likely contribute a great deal to the vegetation dynamics of urban forest patches. Together with other forest bird species, their permanence in the urban environment should be promoted by protecting urban forest patches. This assertion may sound odd to those accustomed to see thrushes away from any forested area in the urban realm, but we have shown that they use urban forested patches frequently, which is suggestive of the importance of such habitats to the daily life of thrushes in cities.

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References

II APG (2003) An update of the angiosperm phylogeny group classification for the orders and families of flowering plants: APG II. Bot J Linn Soc 141:399–436. doi:10.1046/j.1095-8339.2003.t01-1-00158.x

Argel-De-Oliveira MM (1995) Aves e vegetação em um bairro residencial da cidade de São Paulo (São Paulo, Brasil). Rev Bras Zool 12:81–92

Cohen EB, Lindell CA (2004) Survival, habitat use and movements of fledgling white-throated Robins in a Costa Rican agricultural landscape. Auk 121:404–414. doi:10.1642/0004-8038(2004)121[0404:SHUAMO]2.0.CO;2

Cohen EB, Lindell CA (2005) Habitat use of adult white-throated Robins during the breeding season in a mosaic landscape in Costa Rica. J Field Ornithol 76:279–286
Del Hoyo J, Elliot A, Christie DA (2005) Handbook of the birds of the world, vol. 10. Cuckoo-shrikes to thrushes. Lynx Edicions, Barcelona, Spain
Dunn RR, Gavin MC, Sanchez MC, Solomon JL (2006) The pigeon paradox: dependence of global conservation on urban nature. Conserv Biol 20:1814–1816. doi:10.1111/j.1523-1739.2006.00533.x
Falk JH (1976) Energetics of a suburban lawn ecosystem. Ecology 57:141–150. doi:10.2307/1936405
Fontana CS (2004) Estrutura de uma comunidade urbana de aves: um experimento em Porto Alegre, Rio Grande do Sul. Ph.D. thesis, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil
Foster MS (1987) Feeding methods and efficiencies of selected frugivorous birds. Condor 89:566–580. doi:10.2307/1368645
Gotelli NJ, Entsminger GL (2001) EcoSim: Null models software for ecology. Version 7.0. Acquired Intelligence Inc. & Kesey-Bear. Available via http://homepages.together.net/~gentsmin/ecosim.htm. Accessed 10 Dec 2007
Guitián J, Guitián P, Munilla I, Guitián J, Bermejo T, Larrinaga AR, Navarro L, López B (2000) Zorzales, espinos y serbales: un estudio sobre el consumo de frutos silvestres de las aves migratorias en la costa occidental europea. Universidade de Santiago de Compostela, Santiago de Compostela, Spain
Hasui E, Gomes VSM, Silva WR (2007) Effects of vegetation traits on habitat preferences of frugivorous birds in Atlantic rain forest. Biotropica 39:502–509. doi:10.1111/j.1744-7429.2007.00299.x
Hejl SL, Verner J, Bell GW (1990) Sequential versus initial observations in studies of avian foraging. St Avian Biol 13:166–173
Instituto Horus (2008) Lista oficial das espécies invasoras do Brasil. Available via http://www.institutohorus.org.br. Accessed 03 Apr 2008
Jordano P, Garcia C, Godoy JA, García-Castaño JL (2007) Differential contribution of frugivores to complex seed dispersal patterns. Proc Natl Acad Sci USA 104:3278–3282. doi:10.1073/pnas.0606793104
Levey DJ (1987) Seed size and fruit-handling techniques of avian frugivores. Am Nat 129:471–485. doi:10.1086/284652
Loiselle BA (1990) Seed in droppings of tropical fruit-eating birds: importance of considering seed composition. Oecologia 82:494–500. doi:10.1007/BF00319792
Loiselle BA, Blendinger PG, Blake JG, Ryder TB (2007) Ecological redundancy in seed dispersal systems: a comparison between manakins (Aves: Pipridae) in two tropical forests. In: Dennis AJ, Schupp EW, Green RJ, Westcott DW (eds) Seed dispersal: theory and its application in a changing world. CABI, Wallingford, UK, pp 179–195
Lombardi JA, Motta Junior JC (1993) Seeds of the champak, *Michelia champaca* L. (Magnoliaceae), as a food source for Brazilian birds. Cienc Cult 45:408–409
Marzluff JM, Bowman R, Donnelly R (2001) A historical perspective on urban bird research: trends, terms and approaches. In: Marzluff JM, Bowman R, Donnelly R (eds) Avian ecology and conservation in an urbanizing world. Kluwer Academic, Dordrecht, The Netherlands, pp 1–17
Matarazzo-Neuberger WM (1995) Comunidades de aves de cinco parques e praças da Grande São Paulo, Estado de São Paulo. Ararajuba 3:13–19
Mckinney ML (2002) Urbanization, biodiversity, and conservation. Bioscience 52:883–890. doi:10.1641/0006-3568(2002)052[0883:UBAC]2.0.CO;2
Morellato LPC, Haddad CFB (2000) Introduction: the Brazilian Atlantic forest. Biotropica 32:786–792
Peach WJ, Denny M, Cotton PA, Hill IF, Gruar D, Barritt D, Impey A, Mallord J (2004) Habitat selection by Song Thrushes in stable and declining farmland populations. J Appl Ecol 41:275–293. doi:10.1111/j.0021-8901.2004.00892.x
Pianka ER (1973) The structure of lizard communities. Annu Rev Ecol Syst 4:53–74. doi:10.1146/annurev.es.04.110173.000413
Pizo MA (2007) Frugivory by birds in degraded areas of Brazil. In: Dennis AJ, Schupp EW, Green RJ, Westcott DW (eds) Seed dispersal: theory and its application in a changing world. CABI, Wallingford, UK, pp 615–627
Ralph CP, Nagata SE, Ralph PH (1985) Analysis of droppings to describe diets of small birds. J Field Ornithol 56:165–174
Reichard SH, Chalker-Scott L, Buchanan S (2001) Interactions among non-native plants and birds. In: Marzluff JM, Bowman R, Donnelly R (eds) Avian ecology and conservation in an urbanizing world. Kluwer Academic, Dordrecht, The Netherlands, pp 179–223
Rosenberg KV, Cooper RJ (1990) Approaches to avian diet analysis. St Avian Biol 13:80–90
Ruszczyk A, Rodrigues JJS, Roberts TMT, Bendati MMA, Del Pino RS, Marques JCV, Melo MTQ (1987) Distribution patterns of eight bird species in the urbanization gradient of Porto Alegre, Brazil. Cienc Cult 39:14–19

Scheibler DR, Melo TA Jr (2003) Frugivory by birds on two exotic *Ligustrum species* (Oleaceae) in Brazil. Ararajuba 11:89–91
Schupp EW (1993) Quantity, quality, and the effectiveness of seed dispersal by animals. Vegetatio 107 (108):15–29
Snow B, Snow D (1988) Birds and berries. T. & A. D. Poyser, Carlton, UK
Stotz DF, Fitzpatrick JW, Parker TAIII, Moskowitz DK (1996) Neotropical birds: ecology and conservation. University of Chicago Press, Chicago
Traveset A (1998) Effect of seed passage through vertebrate frugivore's guts on germination: a review. Perspect Plant Ecol Evol Syst 1/2:151–190. doi:10.1078/1433-8319-00057
Wheelwright NT (1986) The diet of American Robins: an analysis of U.S. Biological Survey records. Auk 103:710–725
Winemiller KO, Pianka ER (1990) Organization in natural assemblages of desert lizards and tropical fishes. Ecol Monogr 60:27–55. doi:10.2307/1943025
Wunderle JM Jr (1997) The role of animal seed dispersal in accelerating native forest regeneration on degraded tropical lands. For Ecol Manag 99:223–235