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Birds at a feeder in an urban garden in Venezuela: abundances, interactions and fruit preferences

Pájaros en un comedero de un jardín urbano en Venezuela: abundancias, interacciones y preferencias de frutas

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ABSTRACT

From December 2019 to May 2020 the birds visiting a feeder with fruits were recorded. Six trials were performed, varying the location of the feeder (at open sky or under a tree canopy) or the two pieces of fruits offered (selected among banana, plantain, papaya or mango), which were placed in contact in the center of the feeder or separated toward its corners. The video recordings were watched to identify and quantify the number of species and individuals visiting the feeder and their fruit preferences. The hierarchies and the degree of exclusivity (monopoly) in the use of the feeder (%Exc) were analyzed to determine their relationships with the weight of the birds. The effects of the placing of the fruit pieces and of the feeder itself on the frequency of visits were also analyzed. Sixteen species went down to the feeder for a total of 2493 visits. The Blue-gray Tanager, the Pale-breasted Thrush, and the Tropical Mockingbird jointly represented 66% of the total time spent at the feeder, whereas eight species together represented less than 10% of that time. The frequency of visits (v/h) and the time spent at the feeder per recording hour (min/h) varied widely among trails. There was a positive correlation of the hierarchies and the %Exc with the weight of the birds (n=12; $r_s = 0.745$, $P = 0.005$, y $r_s = 0.731$, $P = 0.007$, respectively). The v/h increased when the pieces of fruits were located separated in the feeder but were not affected by the position of the feeder. When two types of fruits were offered simultaneously to the birds, always three or more species showed preference for one of them. The frequency of visits and the time spent at the feeder by each species varied widely depending on the fruit offered and hierarchical interrelations among the birds.

Keywords: feeder, feeding preferences, interspecific interactions, Neotropics, urban birds.

RESUMEN

Desde diciembre 2019 a mayo 2020 se grabaron en video las aves visitantes a un comedero provisto con dos trozos de fruta (seleccionadas entre banana, plátano, papaya o mango). Se realizaron seis pruebas en las que se varió la ubicación del comedero (a sol abierto o debajo de la copa de un árbol) y la disposición de dos trozos de fruta o (juntos o separados). Las grabaciones se revisaron para identificar y cuantificar las especies e individuos visitantes, la frecuencia y duración de las visitas y las preferencias por fruta ofrecida. Se analizó la correlación entre las jerarquías de las especies y la exclusividad (monopolio) en el uso del comedero (%Exc) con el peso de las especies, así como la relación entre la tasa de visitas por hora (v/h) y la ubicación de las frutas y del comedero. Dieciséis especies bajaron al comedero con un total de 2.493 visitas. El Azulejo, la Paraulata Montañera y la Paraulata Llanera en conjunto representaron 66% del tiempo de ocupación del comedero (minutos por hora de grabación, m/h) mientras que ocho especies en conjunto representaron menos del 10% de dicho tiempo.

Las v/h y el tiempo de permanencia (min/h) de cada especie variaron ampliamente en las distintas pruebas. La posición jerárquica de las especies y el %Exc correlacionaron positivamente con el peso de las aves (n=12; r_s = 0.745, P =0.005, y r_s = 0.731, P =0.007, respectivamente). Las v/h incrementaron cuando los trozos de frutas se encontraban separados en el comedero pero no se vieron afectadas por la ubicación del comedero. Cuando se ofreció a las aves simultáneamente trozos de dos frutas distintas, siempre tres o más especies comieron preferentemente de una de ellas. La frecuencia de visitas y tiempo de uso del comedero por cada especie fue muy variable, dependiendo principalmente de las frutas ofrecidas y de las interacciones jerárquicas entre las aves.

Palabras clave: Aves urbanas, comederos, interacciones interespecíficas, Neotrópico, preferencias alimentarias.

INTRODUCTION

The concentration of human population in towns and cities is a phenomenon that continues to grow worldwide (Grimm *et al.* 2008, Faeth *et al.* 2011, Sanz & Caula 2014, UN 2019). The occupation and adaptation of spaces for the settlement of people bring about drastic change in the characteristics of the affected lands, which makes them, to a greater or lesser extent, uninhabitable for most of the species of living organisms that occupied the unaltered environment or, on the contrary, creates favorable conditions for species adaptable to the new environment (Chace & Walsh 2004, Tablado-Almeda 2006). The further the urbanization process progresses, the fewer possibilities of direct contacts between people and the native fauna and flora of the region occupied (Gaston *et al.* 2007). Parks and different green areas of cities serve to attract or maintain a fraction (generally very small) of animals and plants displaced by the anthropization process (Marzluff 2005; Evans *et al.* 2009). House gardens also fulfill this function (Gaston *et al.* 2005, Fuller *et al.* 2008, Akinnifesi *et al.* 2009, Goddard *et al.* 2009, Seijas & Seijas-Falkenhagen 2020), although with a much lower effectiveness due to their small sizes.

People living in cities have little opportunity to observe "wild" animals other than those capable of occupying the green areas and gardens mentioned in the previous paragraph (Miller 2005, Goddard *et al.* 2009, Tryjanowski *et al.* 2015). One way to increase the possibilities of observing these animals in their homes is by providing them with shelter or nesting structures, as well as water and food that serve as attractants (Hostetler *et al.* 2003, Burton & Doblar 2004). The adaptation of gardens with some of the mentioned attractions is an activity in which millions of people participate, particularly in developed countries in temperate zones (Fuller *et al.* 2008, Warren *et al.* 2010) and, perhaps, also in countries in tropical regions for which, in any case, there are very few published studies. Arranging backyards and gardens to attract wildlife species (particularly birds) is an activity that supports an entire industry worth millions of dollars (Chace & Walsh 2004, Ishigame & Baxter 2007). It has generated a vast scientific literature and has extension and teaching programs in public institutions and universities (Audubon, n/d, Thomas *et al.* 1973, Cecil 2002, Gowen 2004, Adams 2005).

Artificial feeding of birds (and other wild animals) could have significant ecological effects (See review in Dunkley & Cattet 2003) and not all of them beneficial from a conservation point of view. The quantity and quality of food offered in artificial feeders can have negative consequences, such as the transmission of diseases between the species that visit it, facilitate the proliferation of unwanted species, malnutrition of the diners due to the supply of inappropriate food, among other undesirable affects (Tablado-Almeda 2006, Ishigame & Baxter 2007, Orros *et al.* 2015, Galbraith *et al.* 2017), so its potential implementation for conservation should be based on well-conducted investigations (Fuller *et al.* 2008).

In Latin America, studies on urban ecology are scarce (Leveau & Leveau 2004, Bellocq *et al.* 2017), and even less are those dedicated to birds that use artificial feeders (Echeverría & Vasallo 2008). In the case of Venezuela, the installation of bird feeders has been recommended for people's enjoyment and to provide opportunities to learn about birds interspecific hierarchies when competing for food (Phelps 1999, Caula & Manara 2015). The preferences of some bird species for different types of food were succinctly described by Aveledo (1968). These later readings offer general recommendations on how to fix the feeders (location, design, and type of food) but no data are provided to support the options they mention. Levin *et al.* (2000), Sainz-Borgo & Levin (2012) and Sainz-Borgo (2017) conducted more detailed studies on the interactions of birds in feeders established in Caracas, but the emphasis of these investigations was to determine the validity of some ecological or behavioral theories.

In this article we describe the characteristics of the assemblage of birds visiting an artificial feeder with fruit in the garden of a house located on the periphery of Guanare (Portuguesa, Venezuela). The dynamics of this assemblage and the interactions among species are analyzed, as well as the preferences for some fruits and the influence that some simple elements of the feeder design, such as its location or disposition of fruit pieces offered can exert on the frequency of visit or consumption of fruits by the different bird species. Based on the results, some basic management recommendations are presented.

MATERIALS AND METHODS

The study took place in a garden of 500 m^2 located in a house of La Colonia neighborhood, outskirts of Guanare, Portuguesa state, Venezuela. Details on the characteristics of this garden are found in Seijas & Seijas-Falkenhagen (2020). Birds have been fed daily with fruits in this garden since 2003. For this study, the feeder consisted of a square concrete block (40cm × 40cm and 5cm thick) placed at ground level. The pieces of fruit were placed on the surface of this block, and covered with a grid (5×5) of plastic-coated wires. The grid impeded the birds from taking out or turning upside down the food, but also served for the birds as a perching device (Fig. 1).

Two feeders were prepared, one at the open sky, on the floor of the house's parking space and the other under the canopy of a Pomagás tree (*Syzygium* sp). This last feeder was placed on the ground, 0.55 m from the trunk of the tree and 2.40 m from the edge of its canopy. The beginning of the canopy was 1.9 m above the feeder. Only cultivated fruits were offered to the birds (banana, plantain, papaya and mango) not to attract some abundant granivorous birds common in the city (mostly different pigeon species; Seijas *et al.* 2011) and because frugivores seem to be more affected by the effects of urbanization than omnivores and granivores (Sanz & Caula 2014).

The activities of the birds at the feeder were recorded on video with a cell phone placed on a tripod at a height of 30 cm and 1 m away from the feeder. The recordings were grouped into trials (or treatments) (Table 1). Each trial consisted of offering the birds two pieces of 150g of the same fruit or different fruits, which were placed on alternate days either together (in contact) in the center of the feeder, or separate (at least 20 cm apart) towards the left or right corners of it (from the recording perspective). In any case, it was considered that the food was supplied *ad libitum*, since the birds never completely consumed it in the total period of around one hour from the beginning of the first recording session to the end of the last one.

The recording sessions of the first four trials were carried out exclusively on weekends, to minimize human disturbances typical of working days in the mornings. In the last two treatments, the recordings were made on consecutive days since they coincided with the confinement forced by the quarantine due to the coronavirus pandemic.

The position of each piece of fruit (left or right) was alternated every day, to detect and correct possible biases due to the location of the food (Levey 1987, Jackson *et*

Figure 1. View of the feeder and the recording device. A plastic ladder protects the cell phone from the sun and rain and prevents birds from perching on it and knocking it down.

Table 1. Trials carried out to study the interactions between birds and their preferences for fruit types or feeder location. The first four treatments were carried out on Saturdays and Sundays and the recording sessions of the last two were carried out on consecutive days.

Trial N°	Fruits supplied	Feeder location	Recording days	Sampling interval
1	Papaya-plantain	Open sky	12	Dec-14-2019 to Jan-19-2020
2	Only papaya	Open sky	6	Jan-25-2020 to Feb-9-2020
3	Only plantain	Open sky	8	Feb-15-2020 to Mar-8-2020
4	Plantain-banana	Open sky or under tree	12	Mar-14-2020 to Apr-20-2020
5	Mango-banana	Open sky or under tree	9	Apr-25-2020 to May-3-2020
6	Mango	Open sky	10	May 8-17-2020

al. 1998, Bosque & Calchi 2003). In the fourth and fifth trials (Plantain-banana and Mango-banana, respectively) the pieces of fruit were always separated, with the banana always on the right. In these cases, what changed was the location of the feeder, which was alternately one day at open sky and the other under the Pomagás tree.

For the first four trials, four videos of approximately seven minutes each were recorded every sampling day. The first one started 10 minutes before sunrise, the second one at sunrise and the other two sessions at 20 and 40 min after sunrise, respectively. Due to difficulties of visibility and the low number of birds visiting the feeder very early in the morning, in the last two trials, the number of recording sessions was reduced to just three daily, but with an increased duration of about 10 minutes each, with a separation of 15 minutes between them, the first one beginning at sunrise. The videos were then transferred to a computer for their analyses. The effective recording time was taken as the gross recording time minus 30 seconds, considering that the behavior of the birds in the first 15 and last 15 seconds of each session may be conditioned by the presence of the researcher placing and removing the recording device.

Each bird that came to the feeder was registered as a visit. A bird was considered to be using the feeder when perched on it (even if not eating) or when eating (even if not perched on it), which occurred occasionally in the case of larger birds. The following information was taken for each visit: species, arrival time, interaction with other birds in the feeder (share with or expel the preceding occupant), number of times the bird pecked each of the pieces of fruit supplied, time and causes for leaving the feeder (displaced by another bird, in pursuit of another bird, approach of the investigator, or for unknown reasons). For each trail we calculated the visitation rate of every bird species as the total number of visits per effective recording hour (v/h) and the cumulative time at the feeder (total time spend in minutes per effective recording hour; min/h).

For each visiting bird, the time spent eating from a piece of fruit (right or left) was calculated prorating the total time at the feeder according to the number of pecks on each piece. Indirect data on the reproductive activity of a species were taken by noting if the visitor was a juvenile and, in the case of adults, if they carried food in their bills when leaving the feeder. Using Microsoft Excel ©, the residence time and time shared in the feeder was calculated for each visitor, both with the eight individuals that preceded it and the eight that arrived after it.

The interactions between birds can be very complex (Senar *et al.* 1989, Hurd & Enquist 2001, Rose & Soole 2020), but for the purposes of the study only two possibilities were considered: 1. Displacement, when a bird evicts or expels another completely out of the feeder, and 2. Sharing, when the bird or birds remain for a time together in the feeder, even when there may be threats, fighting postures and even attacks between them, but which do not end (at least for a time) with the abandonment of the feeder from any of the contenders. In the first case, when individuals display fighting postures and threats between them, the one that retreats from the feeder was considered the loser and the one that remains the winner (Wojczulanis-Jakubas *et al.* 2015); however, interactions are not always one-to-one. Sometimes two or more individuals at the feeder were simultaneously displaced by a bird arriving suddenly or flying low towards them. In these cases, the newcomer was considered the winner and all those that leave the feeder as losers. We expected to find a hierarchy of dominance between species in relation to body weight, where larger species dominate over the smaller ones (Levin *et al.* 2000, Sheley *et al.* 2004, Levin & Sainz-Borgo 2012, Wojczulanis-Jakubas *et al.* 2015).

The exclusivity of use of the feeder (%Exc) was defined as the percentage of time the individuals of a particular species used the feeder without sharing it with individuals of other species. Similarly, it was also calculated the percentage of time a species share the feeder with individuals of its own species (%Own) in respect to the total time shared with all individuals of same or different species.

In this research some variables were not under control, as the progressive changes in rainfall frequency and temperature associated with the advance of the dry season, and the phenological changes of both plants (flowering, fruit and seed production) and birds, surely as a consequence of the changes of the first variable. We are aware that without controls we cannot eliminate the possibility that some factors other than those considered in this study may have affected the results. Trials started in the early dry season in December 2019 and ended in mid-May 2020, when some sporadic rainfall had already occurred. Throughout the treatments, some birds were observed carrying food from the feeder to their chicks, which was particularly noticeable in the case of the Tropical Mockingbird (*Mimus gilvus*), a species whose adults came down accompanied by juveniles on numerous occasions. On the other hand, Caimito (*Chrysophilum* sp.) fruits ripen in February 2020 and served as food for all the frugivores until the first week of March. The mango season started in April and possibly other plants in the vicinity may have offered their fruit to the birds. The peak of ripening of the Pomagás fruits occurred in the second and third week of May. Some neighbors also offer fruits or other food types to the birds, although they do not do that routinely. All of these factors may have influenced the frequency of visits of different bird species, but one can only speculate on the magnitude of their effects.

A dominance matrix was produced (Levin *et al.* 2000, Sainz-Borgo 2017) that shows the number of times that the different species win (displace) or lose (are displaced) their interactions in the feeder. The hierarchical structure obtained was correlated with the weight of the birds. These variables were in turn correlated with the exclusivity of use of the feeder by each species (%Exc) and the percentage of time not shared with individuals of others species (%Own).

Statistical analyses

The number of visits and the time spent by each species in the consumption of the two pieces of fruits offered simultaneously were calculated and compared. Two-sample paired tests (Wilcoxon) were performed to determine the significance of the differences in times used by each species in the consumption of the two pieces of fruit offered simultaneously. This test was also performed to compare the frequency of visits to the feeder (v/min) on alternate days when it was placed either beneath the open sky or under the canopy of a tree.

Contingency tables analyses were performed to determine if the frequency of use of the feeder by solitary individuals or by birds in groups was independent of the way the pieces of fruit were placed (together or separate). For these analyses, the birds that first arrived to the feeder in each recording session were not included, since they are inevitably alone at the time of arrival.

The differences between the numbers of birds visiting the feeder when the pieces of fruit were together or separate were evaluated with a tests of simple proportions, under the null hypothesis (Ho) that those numbers should be proportional to the recording times (effort) in each condition. Given that the recordings were started and stopped manually, recording times in each condition were not exactly identical, so that under the null hypothesis (no effect) the proportion of birds expected when the pieces were together, departed slightly from 0.5, as will be indicated in each case.

Statistical analyses were carried out with the open access program Past 4.02 (Hammer *et al.* 2001, Hammer 2020). The statistical results were rated as highly significant (P <0.01), significant (0.01 ≤ P <0.05) or marginally significant (0.05 ≤ P <0.1).

RESULTS

A total of 203 recording sessions were carried out, with a cumulative gross time of 27.6 hours and an effective duration of 25.9 hours. Sixteen species of birds arrived at the feeder for a total of 2,493 visits and a cumulative occupation time of 18.063 hours/birds (Table 2). There was no correlation between the average duration of visits and bird weights (Spearman r_s = 0.075, P = 0.80, n = 14). There were wide variations in the relative abundances of species in the different trials, as will be shown later, but when the results of all sessions are pooled together, individuals of only three species, the Blue-gray tanager (*Thraupis episcopus*), the Pale-breasted thrush (*Turdus leucomelas)*, and the Tropical Mockingbird (*M gilvus)* accounted for 66% of the total time spent by all species at the feeder. In contrast, eight species represented less than 10% of the total accumulated time. The first three mentioned species, together with the Yellow-rumped Cacique (*Cacicus cela*) and Stripe-backed Wren (*Capylorhynchus nuchalis*) used the feeder a high percentage the time without sharing it with other species (%Exc). On the other hand, individuals of some species, predominantly the Tropical Mockingbird, shared the feeder mostly with individuals of their own species (%Own) whereas other did not share it at all, as it was the case with the thrushes (Fig. 2). Other species that shared a high percentage of their time with individuals of

Table 2. Use of the feeder by different species of birds and their relationship with their body weight. Total accumulated time 18.063 hours. See definitions of %Exc and %Own in the text. Means in seconds. Body weights according to Hilty (2003). When two figures of weight are offered, the first is for the female the second for the male.

Species	Visits	Time at the feeder				Weight (g)
		Total (%)	Mean (S.E.)	%Exc	%Own	
Thraupis episcopus	949	24.78	17.0(0.54)	68.4	68.9	35
Turdus leucomelas	515	22.85	28.9(1.37)	76.4	0	62
Mimus gilvus	255	18.35	46.8(2.29)	86.0	91.6	54
Stilpnia cayana	186	7.44	26.0(1.57)	35.2	47.2	19
Cacicus cela	90	4.50	32.5(2.22)	61.5	23.0	60-104
Turdus nudigenis	107	4.19	25.5(3.37)	49.5	0	60
Thraupis palmarum	101	4.17	26.9(3.40)	24.2	34.9	36
Sicalis flaveola	79	3.83	31.5(2.61)	30.6	28.9	20
Euphonia laniirostris	75	2.69	23.3(2.13)	30.8	15.2	13.5
Saltator coerulescens	40	1.72	28.0(3.04)	50.3	12.1	55
Melanerpes rubricapillus	25	1.59	41.4(5.74)	13.0	0	48
*Sporophila intermedia**	16	1.37	55.6(12.6)	9.1	0	12
Campylorhynchus nuchalis	38	1.20	20.6(1.79)	65.3	64.6	25
*Coereba flaveola**	4	0.58	94.3(43.8)	5.8	0	9
*Raphocellus carbo**	10	0.55	35.8(14.8)	0.6	15.0	25
*Psarcolius decumanus**	3	0.19	40.7(18.7)	100	-	180-300

* Due to small sample size, data for these species were not analyzed.

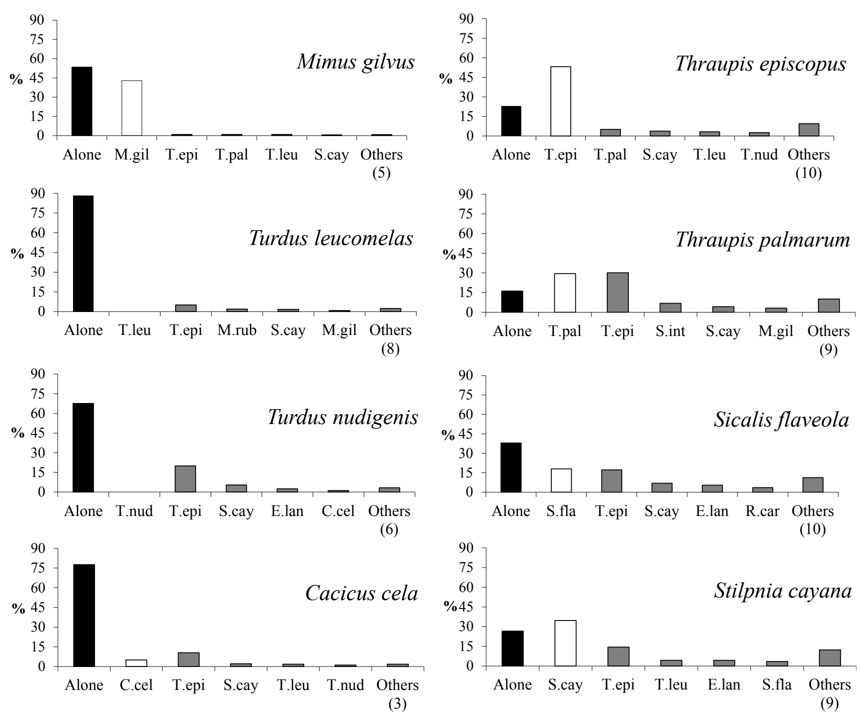

Figure 2. Time spent at the feeder (as %) of each bird species as solitary individuals (alone, black bar), sharing with individuals of their own species (white bar) or with other species (gray bars). Charts to the left are for birds relatively large (body weight of 54 g or more), whereas those to the right belong to smaller birds (from 19 to 36 g). Notice that the Turdidae did not share the feeder with individuals of their own species.

their own species were the Blue-grey Tanager (68.9%), the Burnished-buff tanager (*Stilpnia cayana*; 47.2%) and the Palm tanager (*Thraupis palmarum*; 35.07%). There were no correlations of %Exc and %Own with the weight of the birds (n=12; r_s = 0.399, *P* =0.199, and r_s = -0.423, *P* =0.171, respectively).

Bird interactions

The winner-loser dominance matrix (Table 3) shows that the Yellow-rumped Cacique (*Cacicus cela*) and the Tropical Mockingbird were the most dominant species. However, in interactions between these two birds, it was *C. cela* that won the majority of the encounters. At the base of the hierarchical structure were the Thick-billed Euphonia (*Euphonia laniirostris*) and the Gray seedeater (*Sporophila intermedia*), species between which no interactions were recorded (Table 3). The hierarchy was positively correlated with the weight of the birds and with %Exc (n=12; r_s = 0.745, *P* =0.005, and r_s = 0.731, *P* =0.007, respectively).

Number and rate of visits

Throughout the six trials, the relative importance of each species at the feeder, measured either as visits per hour (v/h) or as total accumulated time (in minutes) per recording hour (min/h) was highly variable (Table 4). These measurements are highly correlated but not equivalent, since there are differences in the duration of the visits among the species (see mean values in Table 2). In the first trial, for example, when v/h is used, *T. episcopus* duplicates *T. leucomelas;* but if the unit of measurement is min/h, then it is this last species that surpasses *T. episcopus*.

The number of total visits per hour (v/h) decreased throughout the first four trials, going from a maximum of 186.4 v/h in in mid-December-mid-January (Papaya-plantain) to near of a third of that figure (62.9 v/h) from the end of March-beginning of April (Plantain-banana). In the fifth trial (Mango-banana) the number of v/h increased again (121.6 v/h) without reaching the levels of the initial treatment, to decrease again to 47 v/h in the last trial at mid-May (Only Mango).

No species showed a constant visit rate (v/h) or accumulated occupation time (min/h) throughout the trials. If we compare the changes in terms of accumulated time (min/h), we have that both *T. leucomelas* and *M. gilvus* increased their presence between the first and second trials (by 20.1% and 314.6%, respectively); but both species decreased their presence in successive treatments and reached the lowest values when only mango was offered. The accumulated times for *M. gilvus* showed their maximum values in the second and third trials (19.9 and 15.3

Table 3. Winner-loser dominance matrix for species that visited the feeder. The column "Hierarchy" accounts for the number of species for which the species heading each row won the majority of its interactions. The diagonal (underlined) indicates the number of times that an individual was displaced by another of its own species. This last value is not included in the accounts of "wins" or "losses".

Winners	Losers														Win	Lose	Hierarchy
	Cc	*Cn*	*El*	*Mg*	*Mr*	*Rc*	*Scoe*	*Sf*	*Scay*	*Si*	*Te*	*Tp*	*Tl*	*Tn*			
C. cela	<u>7</u>	2	4	14	2	0	1	0	6	0	20	7	14	6	76	4	10
C. nuchalis	0	<u>0</u>	0	0	1	0	0	1	3	0	2	0	7	2	16	7	5
E. laniirostris	0	0	<u>1</u>	0	0	0	0	0	0	0	0	0	0	0	0	34	0
M. gilvus	4	0	3	<u>2</u>	1	0	3	3	11	1	36	7	30	1	100	14	10
M. rubricapillus	0	0	0	0	<u>0</u>	0	0	0	1	0	5	0	7	1	14	4	4
R. carbo	0	0	0	0	0	<u>0</u>	0	1	0	0	1	0	0	0	2	7	2
S. coerulescens	0	0	2	0	0	0	<u>2</u>	0	1	0	10	1	5	1	20	6	6
S. flaveola	0	1	1	0	0	0	0	<u>6</u>	0	0	0	0	0	0	2	20	1
S. cayana	0	0	2	0	0	0	0	1	<u>0</u>	0	0	0	0	0	3	87	2
S. intermedia	0	0	0	0	0	0	0	0	0	<u>0</u>	0	0	0	0	0	6	0
T. episcopus	0	0	13	0	0	0	1	10	29	1	<u>218</u>	8	0	3	65	288	5
T. palmarum	0	0	2	0	0	0	0	1	0	2	6	<u>0</u>	0	2	13	42	4
T. leucomelas	0	3	5	0	0	7	1	2	36	2	184	18	<u>77</u>	32	290	64	8
T. nudigenis	0	1	2	0	0	0	0	1	0	0	24	1	1	<u>2</u>	30	48	3

Table 4. Visits per hour of recording (v/h) and time spend at the feeder (min/h) by the different bird species in each one of the trials. Values in parentheses (t_h) represent the effective time recorded in each treatment.

Species	Papaya-plantain (t_h = 4.357h)		Papaya (t_h= 2.584h)		Plantain (t_h = 3.699h)		Plantain-banana (t_h = 5.740h)		Mango- banana (t_h = 4.527h)		Mango (t_h = 4.998h)	
	v/h	min/h	v/h	min/h	v/h	min/h	v/h	min/h	v/h	min/h	v/h	min/h
C. cela	3.7	2.2	1.2	0.2	9.5	5.0	3.3	1.4	3.8	2.7	0	0
C. nuchalis	1.6	0.4	1.2	0.6	2.4	0.5	0.3	0.1	1.5	0.6	2	0.9
C. flaveola	0	0	0	0	0.0	0.0	0	0.0	0.7	1.1	0.2	0.3
E. laniirostris	1.8	0.4	0	0	0.8	0.2	2.6	0.8	10	4.6	0.6	0.3
M. rubricapillus	1.8	2	1.5	1	2.2	1.0	0.3	0.2	0.7	0.2	0	0
M. gilvus	4.8	4.8	22	19.9	19.2	15.3	8.7	5.6	12	7.8	0.8	0.5
P. decumanus	0.7	0.5	0	0	0.0	0.0	0	0.0	0	0.0	0	0
R. carbo	1.1	0.1	0	0	0.0	0.0	0	0.0	0.4	0.3	0.6	0.8
S. coerulescens	1.1	0.6	1.2	0.5	1.1	0.3	2.4	1.2	2.6	1.4	0.4	0.1
S. flaveola	0	0	0	0	0.3	0.0	0	0.0	6.4	3.7	9.6	4.9
S. intermedia	0	0	0	0	0.0	0.0	0	0.0	0.2	0.2	3	2.8
S. cayana	9.6	2.3	3.1	0.5	6.5	1.8	4.9	1.8	12	6.8	6.2	4.2
T. episcopus	99	21.7	1.5	0.1	7.6	1.9	24	8.0	57	16.1	17	9.5
T. palmarum	4.8	1.2	0.4	0	4.9	2.0	3	1.3	6.8	3.0	2.6	2.3
T. leucomelas	47	22.8	51	27.4	23.0	10.2	8.9	4.5	7.1	2.5	2.2	0.5
T. nudigenis	8.7	4	3.5	1.1	5.9	2.1	4.5	1.9	0.4	0.8	2	0.6
Globals	186.4	62.9	86	51.2	83.3	40.4	62.9	26.9	121.6	51.9	47	27.6

min/h, respectively), when adults visited the feeder accompanied by juveniles as we will show later. In any case, *T. episcopus* was the species that showed the widest fluctuations in visit rates (v/h) throughout the trials (Fig. 3), particularly between the first and second, with a decrease of 98.5%. The changes in the total number of birds that visited the feeder largely reflect variations in the relative abundance of this species.

The Tropical Mockingbird and the Blue-gray Tanager were the species with the highest number of records of individuals carrying food from the feeder (Fig. 4). The maximum for *M. gilvus* in this regard (9.7 CF/hour) occurred in late January to early February. The maximum number of visits of the juveniles of this species (4.6 j/h) occurred in the following trial, in between February-15 to March-8. The Blue-gray Tanager's carries occurred later, peaking at the end of April-beginning of May (14.4 carries/hour) but only a few juveniles of this species (0.2 j/h) could be identified in the last trial, in mid-May, 2020. Pale-breasted thrushes carrying food out of the feeder were observed in between March-14 and May-3 and the first juvenile visits were observed in between May-8 to 17. In addition to *C. cela* and *S. cayana*, individuals of other five species carried food in their bills or visit the feeder as juveniles in a very low frequency and were not analyzed in detail.

Location of fruit pieces and feeder

In treatments with two pieces of the same fruit, birds pecked more times from the piece on the right, the side of the feeder facing to the garden (Wilcoxon paired test; n = 530, z = 2.996, P = 0.003). This behavior was especially marked in the case of *C. cela* (n = 38, z = 3.716, P <0.001) and of C. *nuchalis* (n = 12, z = 2.198, P = 0.028). If the data for these two species are removed from the analyses, the average time spent by the remaining birds eating from the piece at the right side (17.423 sec/visit) was still greater than that spent on the piece on the left (14.743 sec/visit), but the differences were just marginally significant (n = 479, z = 1.757, P = 0.079).

After pooling the data of the first three trials, when the arrangement of the fruit pieces in the feeder were alternated on consecutive recording days (the first day together and the next separate, or vice versa), there were a greater number of visits to the feeder when the pieces of fruit were separated (738) than when they were together (608). Statistical analyses were performed for each trial separately.

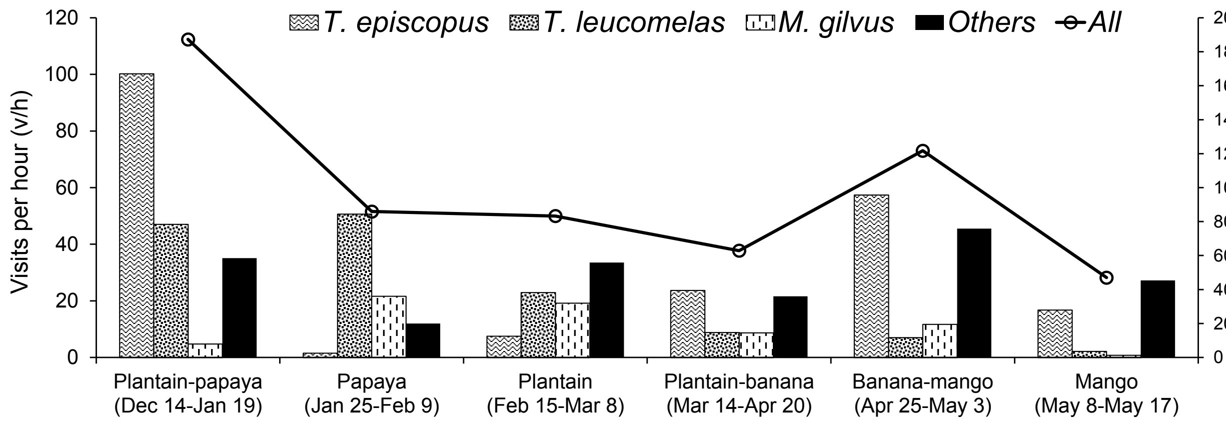

Figure 3. Visits per recording hour (v/h) of the three most common bird species at the feeder in each one of the trails. The scale on the right (v/h) is for all birds together.

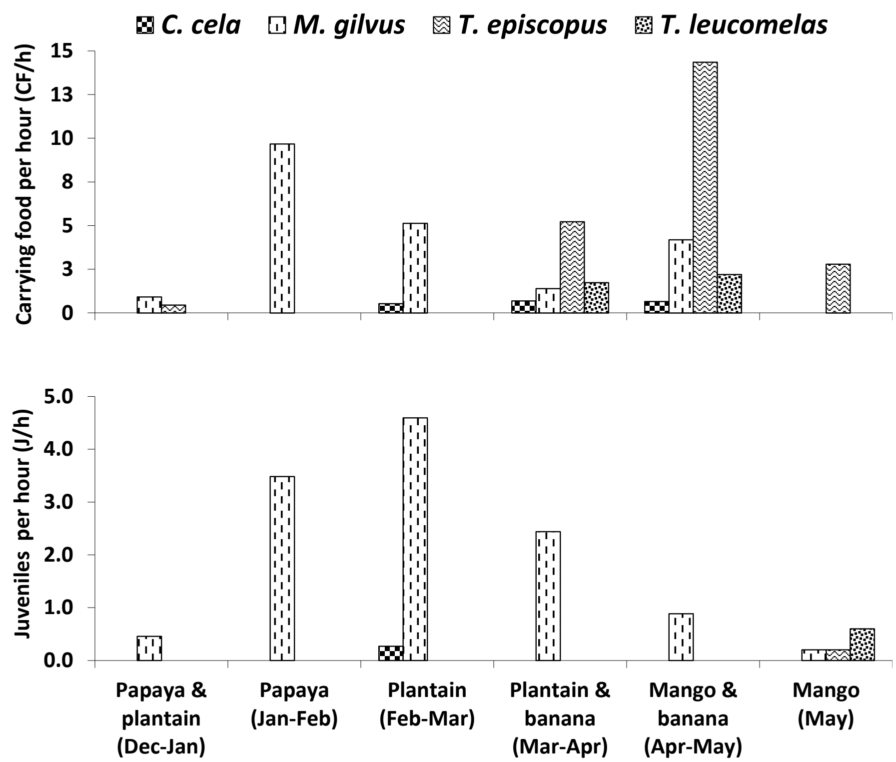

Figure 4. Above: Frequency of adults of some species leaving the feeder with food in their bills. Below: Frequency of juveniles visiting the feeder.

In the Papaya-plantain treatment, the values for together: separate were 355:461; a highly significant disproportion (expected proportion = 0.485; z = -2.834, P <0.005). In the case of the trial with only Papaya the disproportion (98:124) was significant (expected proportion = 0.517; z = -2.164, P = 0.030) and not significant in the case of only Plantain (155:153) (expected proportion = 0.493; z = 0.364; P = 0.716). If the birds are divided into two groups according to their weight, only for those <40g the disproportion was significant in the Papaya-plantain trial (220:300; z = -2.809, P <0.005) and the Only papaya trial (2:14; z = -3,136, P = 0.002). There were no significant disproportions in any of the treatments for birds >40g (P> 0.1).

The way birds visited the feeder (in solitary or in company of other birds) was not independent of how the pieces of fruits were disposed (together or separated). That was particularly so when the data of the three trials are pooled together (Global data) (Pearson χ^2 = 11.431, P <0.001); that is, the arrangement of the fruit pieces influences the frequency with which the birds are in the feeder alone or accompanied by other birds (Table 5). The results of these analyses when each trial is taken separately pointed in the same direction, although the probability values in two of them (Papaya-plantain and only papaya) are marginally significant.

Fruit preferences

In all the trials in which two type of fruits were offered, three or more birds consumed one of the options in a higher frequency than expected by chance. In the first treatment, the Blue-gray tanagers, Palm tanager, and Yellow-rumped caciques consumed plantain in preference over papaya (Fig. 5A). Even though most species decreased their feeder occupancy rate (min/h) in the next trial (when only papaya, the non-preferred fruit in first trial was offered), these three species were the ones with the more accentuated reduction, with decrease values of 99.5%, 90.1% and 100%, respectively. In contrast, *T. leucomelas* and *M. gilvus*, birds that had not shown preference for papaya or plantain, increased their time in the feeder (min/h) when it was offered only papaya, the first of these species in only 20.2%, but the Tropical Mockingbird did it in 314.6%. Species with less than 12 visits were not used in the analyses.

When plantain and banana were offered, five species preferred the first fruit (Fig. 5B). However, when the birds had to choose between banana or mango six species favored the banana and only one, the Saffron Finch (*Sicalis flaveola*), a species that have not consumed any fruit in the four previous trials, ate almost exclusively mango (Fig. 5C).

In the last trial, when only mango was presented to the birds, the Saffron Finch was the second most common species, only below to the Blue-gray Tanager. It is necessary to point out that in the two tryouts in which mango was offered, 15 species visited the feeder, the maximum number in all this study. The three additional species that appeared when this fruit was presented were the already mentioned Saffron Finch, the Gray Seedeater (*Sporophila intermedia*), and the Bananaquit (*Coereba flaveola*). These three species consumed exclusively mango.

Feeder location

In the fourth and fifth trials, the two pieces of food were placed separated, but the location of the feeder was alternated: one day at open sky and the next under a tree canopy (or vice versa). There were no differences in the frequency of bird visits between this two conditions (Wilcoxon paired test: n =10; z = 1.23, P = 0.218). On the other hand, there were positive correlations between the cumulative times spent by each bird species (min/h) when the feeder was located at the open sky or under the tree (Table 6: Spearman Rank correlation: r_s = 0.879, P < 0.001 for Plantain-banana; r_s = 0.920, P < 0.001 for Mango-banana).

DISCUSSION

Frequency of visits and preferences for fruit

In the five months covered by this research (the entire dry season) the relative frequency of bird species that visited the feeder was highly variable. Sixteen species visited the feeder, but the number of species varied between 10, in the second trial (when only papaya was offered) and 15 in the fifth (when mango and banana were offered). Taken together the six trials carried out, only three species, the Blue-gray tanager, the Tropical Mockingbird and the Pale-breasted thrush, accounted for the vast majority of visits, with a maximum that exceeded 80% in the first two treatments and a minimum of 42% in the last one. This dominance is comparable to the one reported by Galbraith *et al.* (2017) for feeder in Auckland, New Zealand, but in their case, two of the three dominant species were exotic.

Throughout the study, the type of fruit offered varied, and due to the abrupt changes between one trial and the one that followed, it is unavoidable to conclude that in

Table 5. Frequency of bird visiting the feeder in solitary or accompanied by other birds when the pieces of fruit were together or separated. Results of the analysis with contingency tables (Chi-square).

	Global data		Papaya-plantain		Only papaya		Only plantain	
	Together	Separated	Together	Separated	Together	Separated	Together	Separated
In solitary	286	286	120	130	70	77	96	79
Accompanied	273	402	214	309	17	35	42	58
Pearson χ^2	11.431		3.457		3.478		4.209	
P value	<0. 001		0.063		0.062		0.040	

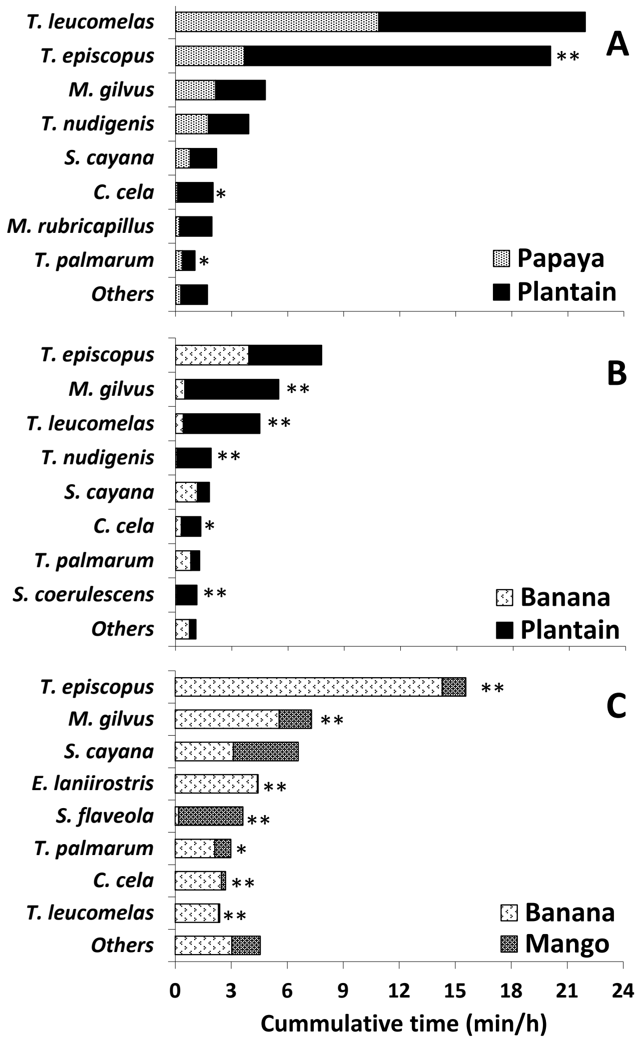

Figure 5. Time spent by birds at the feeder consuming different fruits. At the end of the bar is indicated if the differences are significant (*) or highly significant (**).

some cases the type of fruit(s) placed in the feeder decisively influenced the frequency of visits of some species. That was clearly the case of the last two trials, when mango was offered to the birds. The Saffron Finch did not visit the feeder in any of the previous four tryouts, despite the fact that this species is a permanent occupant of the garden (Seijas & Seijas-Falkenhagen 2020). Visits of *S. flaveola* to the feeder began in the fifth trial, when mango was offered as one of the options, and the relative importance of this bird reached to 20.4% of the total visits when that fruit was offered in exclusivity, only below the Blue-gray Tanager, with 35.7 % of visits.

It is necessary to discuss a little more our findings with *S. flaveola,* a species regarded as granivore (Hilty 2003, Sainz-Borgo *et al.* 2018). This is a very common species in the garden and throughout the city of Guanare (Seijas *et al.* 2011*,* Seijas & Seijas-Falkenhagen 2020). During this investigation, dozens of individuals were permanently observed foraging in the lawn, a few meters from the feeder. We have already reported that *S. flaveola* consumes fruits, and we keep photographs of some individuals eating papaya and banana at the feeder, as well as fruits of *Chrysophilum* sp. on the tree. However, those observations were not properly evaluated. The only reference we found in the literature on the consumption of fruit by the Saffron Finch was that of Soriano *et al.* (1999) who reported evidence of consumption of a cactus fruit by this species. It is worth mentioning that this finch has also been observed catching flying termites.

It was another surprise to observe the Grey seedeater (*Sporophila intermedia*) consuming mango. In the 16 records of visits of this bird to the feeder it was always a female, probably the same individual. Hilty (2003) indicated that, unlike other *Sporophila*, *S. intermedia* has quite varied eating habits that include insects, even caught in flight. The other species that only went down to consume mango was the Bananaquit, although only four times. Another unexpected visitor to the feeder was *C. nuchalis*,

Table 6. Cumulative time at the feeder (min/h) by different bird species when it was located at open sky or under a tree canopy. Effective recording time for each trial and condition in shown in parentheses.

Species	Plantain-banana		Mango-banana	
	Open sky (2.90h)	Under a tree (2.84h)	Open sky (1.98h)	Under a tree (2.03h)
C. cela	1.018	1.760	1.010	3.399
C. flaveola	-	-	2.525	0.000
C. nuchalis	0.000	0.246	0.732	0.418
E. laniirostris	1.052	0.475	3.004	6.897
M. gilvus	6.273	4.992	8.020	6.725
M. rubricapilus	0.477	0.000	0.446	0.000
R. carbo	-	-	0.000	0.696
S. coerolescens	1.035	1.320	1.018	1.491
S. flaveola	0.017	0.000	4.418	4.005
S. intermedia	-	-	0.446	0.000
S. cayana	1.644	2.030	6.404	8.568
T. episcopus	8.343	7.732	15.619	14.883
T. palmarum	1.489	1.097	3.854	2.310
T. leucomelas	4.180	4.887	2.281	3.104
T. nudigenis	1.230	2.605	1.161	0.541
All	26.760	27.143	50.937	53.038

a species regarded as an insectivore (Phelps 1999, Sainz-Borgo *et al*. 2018).

Changes in the frequency of Blue-gray Tanager are more difficult to associate exclusively with the type of fruit offered. It was the most abundant species in the first trial (Plantain-papaya) and practically disappeared from the feeder when it was offered exclusively papaya, fruit that had not been its favorite in the previous trial; but this bird did not show the return that would have been expected when plantain was offered again. The relative importance of *T. episcopus* increased in the fourth and fifth treatments, to show a further decrease when only mango was offered. We believe that, in addition to the type of fruit offered, these fluctuations were influenced by the presence of the Tropical Mockingbird. This last bird is at the top of the hierarchical structure among the birds that visit the feeder. It exercises its dominion very aggressively. The v/h of the Tropical Mockingbird increased more than four-fold between the first and the second trials, when the juveniles started visiting the feeder with their parents. At these times, adults Tropical Mockingbirds seem to be particularly feisty and intolerant to the presence of other birds. Although the Blue-gray Tanager (and also the Palm Tanager) consumes papaya, perhaps accessing that non-preferred fruit would mean to compete with *M. gilvus*, which would imply an effort that would not offset the benefits obtained in terms of energy and nutrition. When the Tropical Mockingbird prominently occupied the feeder, in the second and third trials, not only did *T. episcopus* decrease its presence, so did most of the small species, among which it is worth noting the Burnished-buff Tanager, which reduced its presence in a 78.3%.

It could be argued that *T. leucomelas* could also have influenced the reduction in the number of visits to the Blue-gray Tanager and other birds, but the increase in the occupation time of the Pale-breasted thrush was of only 20.2% between the first and second trials. Rather, this small increase could be due to the drastic reduction in the number of *T. episcopus* visits, because it would lighten the burden on the first species of competing with a very numerous bird. In support of this argument is the fact that the mean time of *T. leucomelas* visits between these two trials increased, although the difference was not significant. In addition, there were 137 interactions between these two species in the first trial, all of them won by *T. leucomelas*, which did not prevent *T. episcopus* from being the most frequent species in the initial treatment. The marked decline in the time of occupation of *T. leucomelas* after the second trial is difficult to explain and could have some relationship with the reproductive activity of the species, whose courtship, nesting, incubation and chick attendance take place in the first months of the year (Seijas & Seijas-Falkenhagen 2020). Klem (2008) noted that birds in northern latitudes increase their frequency of visits to feeders when they are not breeding. This could be the case of the Pale-breasted Thrush in our study, but we have already seen that in the case of the Tropical Mockingbird frequency of visits increased considerably when the species was raising its chicks.

Surely all species respond by increasing or decreasing their frequency of visits to the feeder based on the existence or not of alternative feeding sources in the vicinity, as has been documented for frugivorous birds in different regions of the Neotropics (Leck 1972, Fleming 1979). An increase in the number of visits of some birds would have been expected when only plantain was placed in the feeder (as of February 15, 2020), the fruit that had been selected in preference by Blue-grey Tanager, Yellow-rumped Cacique and Palm Tanager in the first trial. This was not the case, as discussed in previous paragraphs. One factor that could have influenced this 'no return' was the entry into full production of fruits of a Caimito (*Chrysophilum* sp.) tree (after February 8) just 20 meters from the feeder. The production of this tree was very copious (personal observation). All the species that visit the feeder were observed consuming this fruit and the most abundant of them was *T. episcopus*. The production of caimitos ended at the beginning of March, however, this fact was not reflected in the number of birds visiting the feeder in the trial that was carried out immediately (when Plantain-banana were offered), since though the visit rate of *C. cela* increased slightly compared to the previous trial, the number of v/h of other species, especially *T. leucomelas* and *M. gilvus* continued to decline.

The disappearance of *C. cela* from the feeder when only papaya was offered cannot be explained by the presence of *M. gilvus*, since Yellow-rumped Cacique dominates over the Tropical Mockingbird (and over all the other species with which it interacts). It is possible that the almost zero consumption of papaya by this icterid is a consequence of the characteristics of its beak, which may not be very efficient for eating this fruit. This of course is speculative, but the 16 species that visited the feeder show wide variation in bird size and shape, and there is likely to be a close relationship between the size and shape of the birds' beaks, on the one hand, and foraging activities, on the other (Kantak 1979, Grant 1986, Foster 1987). In this sense, the clear preference of *S. flaveola* and *S. intermedia* for mango could also be due to the possession of efficient picks to cut the fibers of this fruit. Preferences may be based on, or depend on, the protein and nutritional content of the fruits (Levey 1987, Schaefer *et al.* 2003, Corlett 2011) or on which other food sources are or are not available in the vicinity at the same time. Bosque & Calchi (2003), for example, pointed out that in captivity, the *T. episcopus* is able to discriminate between diets with different protein percentage and select the one with the highest protein content. We did not obtain information on the protein content of the banana, but the aforementioned authors indicated that those of the banana and the papaya are 3.5% and 5.1%, respectively. If the protein content of the plantain is similar to that of the banana, then it is surprising that the Blue-grey Tanager preferred this fruit instead of the papaya. To finish this discussion of fruit preferences is interesting to note that *S. cayana* was the most generalist species of all, not showing a preference for any of the options offered.

Dominance and timeshare

It must be taken into account that the pie charts where the accumulated times in the visits of all the birds are shown and compared (Fig. 2) were elaborated from trials carried out over more than five months, during which the fruits presented to the birds were periodically changed. The chart would look be very different if each of the trials carried out were analyzed separately, as evidenced in Fig. 3. This warns of the risk of drawing conclusions based on very short-term studies and that it is necessary to continue investigating the dynamics of the assembly of birds that are attracted to the feeder and the factors that influence that dynamics.

The dominance of the species was mainly determined by their sizes, as has been shown in several bird studies (Wallace & Temple 1987*,* Shelley *et al.* 2004*,* Wojczulanis-Jakubas *et al.* 2015, Galbraith *et al.* 2017). Relatively large species do not share much the feeder with individuals of other species. Relatively small species, on the other hand, showed few negative interactions among them and generally share the feeder, a strategy that allows them to consume the fruits in the occasions where larger and dominant species are out of the feeder. In the case of the Turdidae, our results differ from those of Sainz-Borgo (2017) who found that *T. leucomelas* and *T. nudigenis* share most of their time at the feeder with other bird species, but this author registers her data in the afternoon (from 15:00-17:00). It is possible that early in the morning birds are less prone to share the feeder because they may be hungrier than in the afternoon, after they have been several hours foraging.

Behavior also plays a very important role in the establishment of the hierarchies, when we see that individuals of an aggressive species like *M. gilvus* largely dominates individuals of species slightly larger than them, such as those of the genus *Turdus*. In the case of the Tropical Mockingbird, its dominance seems to increase when the species goes to the feeder with its offspring.

MANAGEMENT RECOMMENDATIONS

The results of this study show that it is possible to manipulate the functioning of the feeder to: 1) increase the diversity of species and the number of individuals that visit it; 2) to favor those desirable species, and create conditions not to attract undesirable ones. All the species that approached the feeder are native and although none of them is threatened in any degree, several are affected by the urbanization process, if we take into account their absence or scarcity in more central areas of the city of Guanare, according to the study by Seijas *et al.* (2011). This is the case of large birds such as the Crested Oropendola (*Psaracolius decumanus*) and the Yellow-rumped Cacique; or medium and small size birds such as the Silver-beaked Tanager (*Ramphocellus carbo*) or the Thick-billed Euphonia. According to the aforementioned study, very common species in the city also came to the feeder, such as the Tropical Mockingbird, the Blue-gray Tanager or the Saffron Finch; but the use of fruits exclusively to attract birds to the feeder, we suppose, have kept away omnivorous birds such as the domestic pigeon (*Columba livia*) and the Grackle (*Quiscalus lugubris*), species very common in Guanare.

We found that both the type of fruit offered and the way the pieces are arranged in the feeder influence the abundance and diversity of species that visit it, and although there is still much to know about how these variables interact, an obvious recommendation is to place several types of fruit simultaneously and to separate them, to reduce negative interactions among birds. In the few recommendations that have been published in Venezuela on the installation of bird feeders, the convenience of locating them near bushes or even in the shade of trees has been pointed out (Phelps 1999*,* Caula & Manara *2*015). In our study we did not detect differences in the abundance and variety of birds that visit the feeder when it was in the open sky or under the shade of a tree, but our observations were always made during the first hour after sunrise. Practical reasons, such as protecting food from drying out or from rain, suggest that placement in the shade is convenient.

This research on birds visiting a feeder is only intended to be a beginning. Hopefully, it will encourage other researchers to conduct new studies that overcome its failures and limitations to answer new questions. In our case, the execution and analysis of new efforts to cover the rainy season are pending.

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