Chapter 9
A Reappraisal of the Fruit-Taking and Fruit-Handling Behaviors of Neotropical Birds

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9.1 Introduction

The techniques used by frugivorous birds to take and handle fruits is a research topic that, though superficially known, does not get the attention of researchers interested in the behavioral ecology of frugivorous birds. Notwithstanding, empirical observations and experimental studies conducted mostly in the 1980s revealed that the fruit-taking and fruit-handling behaviors of birds affect their feeding and digestion rates (Levey 1987), the profitability of fruits (Avery et al. 1993; Foster 1987), and, ultimately, which fruits they eat and which seeds they disperse (Denslow and Moermond 1982; Levey et al. 1984; Moermond and Denslow 1983, 1985; Pratt and Stiles 1985).

As factors in the equation of fruit choice by birds, fruit-taking and fruit-handling behaviors are influenced by the interaction between the structure of plants and their fruits and the bird's anatomy. The placement of the fruit on the plant (e.g., terminal, axillary, or cauliflorous), for instance, influences fruit accessibility or the "ease with which a given bird can reach and take fruits presented in different ways" (Moermond and Denslow 1983). Although, as Moermond et al. (1986) noted, most small frugivorous birds are agile enough to render any fruit accessible, this is not so for large birds with more limited maneuverability, and even small birds have to balance the energy cost of taking a fruit against its energy and nutrient rewards (Moermond

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and Denslow 1983). Energetic costs are influenced by the fruit-taking technique used, with aerial maneuvers in general costlier than perched maneuvers. As a consequence, birds taking fruits on flight tend to be more selective in relation to fruit traits that bear on the fruit energetic profitability (e.g., ripeness; Moermond et al. 1986). Fruit and seed sizes, on the other hand, are traits that interact with bill dimensions to influence the fruit-handling behavior of birds (Moermond and Denslow 1985). It is expected that the larger the bird and its bill, the greater the chance of swallowing the fruit whole, while small birds are mechanically constrained by correspondingly small bills, being only able to eat large fruits piecemeal. However, bird size and bill dimensions alone are not sufficient to predict the way a bird handle fruits since certain bird clades are constrained to certain handling techniques (Foster 1987). For instance, manakins (Pipridae) are characteristically "gulpers" (i.e., swallow fruits whole), while tanagers (Thraupidae) are "mashers" (i.e., crush the fruits in the bill prior to ingestion; Levey 1987). The extent to which evolutionary history determines the fruit-taking or fruit-handling behaviors of frugivorous birds in a broad phylogenetic perspective is, however, unknown.

The fruit-taking and fruit-handling behaviors of birds have implications for seed dispersal, either by influencing fruit selection or the fate of seeds (Moermond and Denslow 1985; Levey 1987). In a Mediterranean network involving frugivorous birds and fruits, Jordano et al. (2003) found that 6.1% of the interactions did not occur due to structural constraints of the plants (i.e., branch architecture or fruit display limiting accessibility to the fruits). In a concrete example, Greenberg (1981) suggested that the capsulated fruits of *Lindackeria laurina* (Achariaceae), that generally open downward from the end of a long branch, restrict access to birds able to fly to grab the fruits. Therefore, fruit accessibility is an additional, poorly known factor contributing to the so-called forbidden interactions, i.e., interactions that for some biological reason do not occur but shape the topology of networks involving plants and frugivores, often forming a non-trivial part of them (Olesen et al. 2011). On the other hand, the way the birds handle fruits influences their feeding rate and where the seeds are deposited, thus affecting the quantity and quality components of seed dispersal effectiveness (Levey 1987; Jordano and Schupp 2000; Palacio et al. 2017; Loayza and Knight 2010).

Experimental studies were decisive to reveal the behavioral subtleties and costs associated with the interaction with fruits, but, as expected, have dealt with a few bird species: (Denslow and Moermond 1982; Moermond and Denslow 1983; Levey et al. 1984; Levey 1987). Observational studies involved a greater number of species, but the information they provide are scattered in the literature, some of which hard to access. Here we compile such information from the literature to reveal broad patterns of fruit-taking and fruit-handling behaviors observed in the wild for a variety of bird species representing a wide spectrum of the bird phylogeny. With this dataset, we tested the influence of phylogeny on fruit-taking and fruit-handling behaviors, and also investigate the previously unexplored relationship between the flexibility in fruit-taking and fruit-handling behaviors with body size and degree of frugivory (i.e., a measure of the importance of fruits in the diet). Embedded in the concept of frugivory specialization is the notion that highly frugivorous birds consume a variety of fruits with diverse morphologies and presentation modes that necessarily require a variety of feeding techniques to be exploited. Therefore, positive relationships between the degree of frugivory and the flexibility of fruit-taking and fruit-handling behaviors are expected. As with many other biological aspects (Bonner 2011), body size plays an important role in frugivory and the demise of large frugivorous birds has been of conservation concern for its consequence on seed dispersal and plant recruitment (Galetti et al. 2018). Therefore, instead of exploring the many morphological traits that in a complex way may influence fruit-taking and fruit-handling behaviors (e.g., several wing and bill dimensions), some of them hard to obtain (e.g., the development of leg musculature that affects the fruit-taking behavior of birds; Moermond and Denslow 1985), we focused on body mass. Body mass is expected to be negatively correlated to behavioral flexibility in fruit-taking since large body sizes should restrict the ability to perform certain foraging maneuvers (e.g., aerial maneuvers) to take fruits. Similarly, the positive correlation between body mass and gape width (Wheelwright 1985) should make large birds able to swallow whole the majority of fruits they interact with, thus reducing the array of handling techniques they use and their flexibility of fruit-handling behavior. We are ultimately interested in stimulating further studies that incorporate the often neglected behaviors used by birds to take and handle fruits to investigate the reciprocal ecological and evolutionary consequences between birds and plants (Palacio et al. 2017; Loayza and Knight 2010).

9.2 Methods

We searched the literature (i.e., papers in peer-reviewed indexed journals as well as dissertations and theses) for studies that reported quantitative data on the fruit-taking and fruit-handling behavior of birds (i.e., the frequency of each behavior adopted to take and handle each fruit species). We found 29 studies conducted in different biomes (Atlantic Forest, Cerrado, and Amazonian Forest). To this dataset we added our own unpublished observations (Appendix). Data came invariably from plant-oriented studies that focused on fruiting plants to record the visiting bird species and their behaviors. The nomenclature adopted to designate fruit-taking behaviors was based on Moermond and Denslow (1985), as follows: (1) *stalling*—the bird takes the fruits in a single uninterrupted flight, losing the movement briefly in front of it, (2) *hovering*—the bird invests in the direction of the fruit hovering briefly in front of it, (3) *picking*—the bird picks the fruit from a perch without stretching its body or taking special positions for it, (4) *reaching*—the bird extends the body above or below the perch to take the fruit, and (5) *hanging*—the bird uses the legs and fingers to hang below the level of the feet to reach the fruit. Stalling and hovering are aerial maneuvers, while picking, reaching, and hanging are perched maneuvers. Two other maneuvers described by Moermond and Denslow (1985), swooping and snatching, were never reported, likely because they are easily confounded with each other, are rare and inconspicuous. Moermond and Denslow (1985) mentioned they saw cotingids and *Tytira* spp. swooping and snatching. For fruit-handling behavior, we adopted the terms (1) *swallowing*—when the bird eats the fruit whole with minimal, if any, previous mandibulation, (2) *mashing*—when the fruit is mandibulated to become flattened or crushed prior to ingestion, and (3) *pecking*—when the bird eats the fruit piecemeal by biting and tearing out chunks of pulp. Categories 1 and 2 correspond, respectively, to *gulpers* and *mashers* of Levey (1987), while categories 1 and 3 correspond, respectively, to *seed dispersers* and *pulp consumers* of Jordano and Schupp (2000).

The data often includes sequential maneuvers of a given foraging bird. As such records cannot be considered independent from each other for statistical purposes (Hejl et al. 1990), and we did not adopt any procedure to trim the data, the statistical tests should be interpreted with this caveat in mind.

To test for a phylogenetic signal in the fruit-taking and fruit-handling behaviors at the family level, we submitted the bird family list to "Bird tree" (birdtree.org) getting an output of 1000 random phylogenetic trees based in 10,000 Ericsson set of sequenced species in a multiphylo data. We then used the TreeAnnotator v1.8.4 to condense the multiphylo archive in a single phylogenetic tree by a parsimonious method (Bouckaert et al. 2014). Using the *vegan*, *FD*, and *ape* packages in R we performed the EM.Mantel function of Debastiani and Duarte (2017) to calculate the phylogenetic signal based on a Mantel test. This function generates an r.Mantel value expressing the power of the association between the proportion of each behavior adopted to take and handle fruits and the phylogeny. As aerial and perched maneuvers form two clearly distinct functional categories, they were used instead of the five fruit-taking behaviors listed above.

We used the Levins' index to characterize the foraging versatility of birds with ≥10 records (Levins 1968). This index varies from 0 to 1, with values closest to 0 indicating the most conservative birds in relation to the behaviors used to take and handle fruits, and 1 being related to the most flexible birds. Levins' indexes were correlated with body masses (log-transformed) and degree of frugivory, both metrics extracted from Wilman et al. (2014). We, however, modified the frugivory degree values for some species based on our field experience. We also correlated Levins' indexes with sample size (log-transformed) to explore the possibility that the greater the number of observations on a given bird species, the greater the chance of recording unusual behaviors that would increase the foraging flexibility. Psitacids were excluded from correlations because of their distinct morphology (bill shape and strong legs used to climb the branches to reach fruits) and foraging abilities (use of the feet to handle fruits). Bird nomenclature follows Remsen Jr. et al. (2018).

9.3 Results

9.3.1 Fruit-Taking

We got data for 188 bird species (115 genera, 26 families) that performed 42,159 maneuvers to eat 156 plant species (105 genera, 48 families) (Table 9.1). Perched predominated over aerial maneuvers, with picking (51.8%) and reaching (31.9%) being the most common maneuvers, followed by stalling (8.1%), hovering (7.2%),

Table 9.1 Number of bird genera and species included in the fruit-taking dataset for each bird family, the number of plant families, genera, and species with which they interacted, the proportions of aerial and perched maneuvers performed by each bird family, and their indexes of flexibility in fruit-taking given by the Levins' index

Bird families	Bird genera	Bird species	Plant families	Plant genera	Plant species	Aerial maneuvers		Picking	Perched maneuvers		*N*	Levins' index
						Stalling	Hovering		Reaching	Hanging		
Cardinalidae	2	2	7	7	8	0.21	0.05	0.40	0.35	0.00	35	0.53
Columbidae	4	7	13	14	15	0.00	0.00	0.68	0.32	0.00	220	0.19
Corvidae	1	4	21	24	24	0.01	0.00	0.38	0.61	0.00	354	0.23
Cotingidae	4	5	9	11	12	0.37	0.00	0.52	0.06	0.05	57	0.35
Cracidae	2	2	13	15	16	0.00	0.01	0.96	0.03	0.01	63	0.02
Cuculidae	2	2	2	2	2	0.00	0.00	1.00	0.00	0.00	2	0.00
Emberizidae	2	2	8	9	9	0.02	0.00	0.81	0.16	0.00	28	0.11
Fringillidae	1	5	14	17	19	0.00	0.00	0.07	0.92	0.00	684	0.04
Furnariidae	1	1	1	1	1	0.00	0.00	0.57	0.43	0.00	4	0.24
Icteridae	3	5	12	14	15	0.02	0.01	0.82	0.12	0.03	50	0.11
Mimidae	1	2	16	18	18	0.00	0.01	0.81	0.17	0.00	285	0.11
Momotidae	1	1	5	5	5	0.49	0.09	0.03	0.40	0.00	39	0.37
Oxyruncidae	1	1	3	3	3	0.08	0.00	0.42	0.25	0.25	9	0.57
Parulidae	2	2	3	3	3	0.00	0.00	0.36	0.43	0.21	12	0.45
Passeridae	1	1	2	2	2	0.00	0.00	1.00	0.00	0.00	2	0.00
Picidae	7	10	10	10	11	0.00	0.00	0.81	0.18	0.00	556	0.11
Pipridae	5	5	23	32	41	0.39	0.19	0.15	0.27	0.01	1140	0.64
Psittacidae	8	10	13	14	15	0.04	0.02	0.52	0.41	0.01	233	0.32
Ramphastidae	3	8	9	9	9	0.00	0.01	0.81	0.16	0.02	182	0.11
Thamnophilidae	1	3	4	5	5	0.09	0.00	0.27	0.64	0.00	13	0.26
Thraupidae	26	46	44	82	115	0.03	0.03	0.37	0.55	0.02	8468	0.31
Tityridae	3	7	20	23	25	0.51	0.07	0.34	0.08	0.01	231	0.40
Trogonidae	1	4	11	14	15	0.95	0.05	0.00	0.00	0.00	78	0.03
Turdidae	2	8	39	68	89	0.04	0.02	0.74	0.19	0.00	2715	0.17
Tyrannidae	28	41	39	56	76	0.21	0.26	0.34	0.17	0.01	5656	0.70
Vireonidae	3	4	20	27	30	0.11	0.06	0.33	0.45	0.05	652	0.51

Definitions of the aerial and perched maneuvers are in the text. Bird families are arranged in alphabetical order

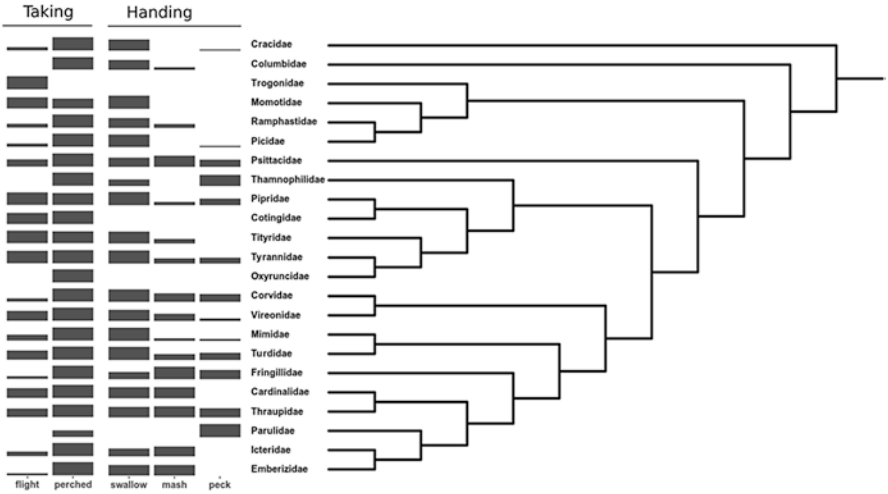

Fig. 9.1 The proportions of each of the fruit-taking and fruit-handling behavior performed by the different families of frugivorous birds arranged according to a bird phylogeny based on birdtree.org (Jetz et al. 2012). Behavioral categories are explained in the text. Numerical values and sample sizes for each family are in Tables 9.1 and 9.2. No handling data are available for Trogonidae, Cotingidae, and Oxyruncidae. Only families with >10 records are represented

and hanging (1.0%). The ability to take fruits on flight is well developed in few passerine and non-passerine clades. In the former, especially in the Tyrannida parvorder formed by families Pipridae, Tityridae, Cotingidae, and Tyrannidae, while among non-passerines the families Trogonidae and Momotidae take fruits exclusively or predominantly on flight (Fig. 9.1). Accordingly, we detected a significant though weak phylogenetic signal in the proportions of flight and perched maneuvers performed by bird families (r.Mantel = 0.2464, $p = 0.05$).

Tyrant flycatchers (Tyrannidae) were the most flexible family, while other families show low flexibility, taking fruits exclusively on flight (e.g., Trogonidae) or from perches (e.g., Cracidae, Columbidae) (Table 9.1, Fig. 9.1). Flexibility in fruit-taking behavior was not related to sample size ($r = 0.15$, $n = 126$, $P = 0.09$) or the degree of frugivory ($r = -0.06$, $n = 126$, $P = 0.47$), but body mass was negatively correlated to flexibility ($r = -0.26$, $n = 126$, $P = 0.003$) indicating that the pool of maneuvers used to take fruits diminishes as birds get larger (see the sharp decrease in flexibility index for birds heavier than 140 g in Fig. 9.2a). More specifically, the larger the bird, the greater its reliance on perched maneuvers (Fig. 9.2a).

9.3.2 *Fruit-Handling*

We got data for 122 bird species (85 genera, 22 families) handling 29,526 fruits from 72 plant species (54 genera, 38 families) (Table 9.2). Fruits were more frequently swallowed whole (79.7%) than mashed (15.4%) or pecked (4.9%)

Table 9.2 Number of bird genera and species included in the fruit-handling dataset for each bird family, the number of plant families, genera, and species with which they interacted, the proportions of each handling behavior performed by each bird family, and their indexes of flexibility in fruit-handling given by the Levins' index

						Handling behavior				
Bird families	Bird genera	Bird species	Plant families	Plant genera	Plant species	Swallowing	Mashing	Pecking	*N*	Levins' index
Cardinalidae	2	2	4	4	4	0.51	0.49	0.00	67	0.50
Columbidae	2	3	7	7	7	0.97	0.03	0.00	133	0.03
Corvidae	1	2	16	17	18	0.75	0.15	0.10	468	0.33
Cracidae	1	1	11	12	13	1.00	0.00	0.00	461	0.01
Emberizidae	2	2	6	6	6	0.49	0.51	0.00	77	0.50
Fringillidae	1	3	5	5	6	0.07	0.79	0.14	643	0.27
Icteridae	3	3	3	3	3	0.30	0.70	0.00	69	0.37
Mimidae	1	1	14	15	16	0.99	0.00	0.00	1258	0.01
Momotidae	1	1	4	4	4	1.00	0.00	0.00	34	0.00
Parulidae	1	1	1	1	1	0.00	0.00	1.00	221	0.01
Picidae	5	7	7	7	7	1.00	0.00	0.00	2595	<0.01
Pipridae	4	4	13	16	19	0.97	0.01	0.03	982	0.04
Psittacidae	4	6	5	5	5	0.28	0.61	0.10	229	0.57
Ramphastidae	1	3	7	7	7	0.95	0.05	0.00	165	0.06
Thamnophilidae	1	3	4	4	4	0.30	0.00	0.70	10	0.36
Thraupidae	22	30	35	50	64	0.34	0.55	0.11	7118	0.67
Tityridae	3	4	16	18	20	0.95	0.05	0.00	137	0.05
Trogonidae	1	1	1	2	2	1.00	0.00	0.00	5	0.00
Turdidae	2	7	27	39	50	0.98	0.01	0.02	8784	0.03
Tyrannidae	24	33	33	44	61	0.99	0.01	0.01	5643	0.01
Vireonidae	3	4	11	17	18	0.88	0.11	0.01	427	0.14

Definitions of the handling behavior are in the text. Bird families are arranged in alphabetical order

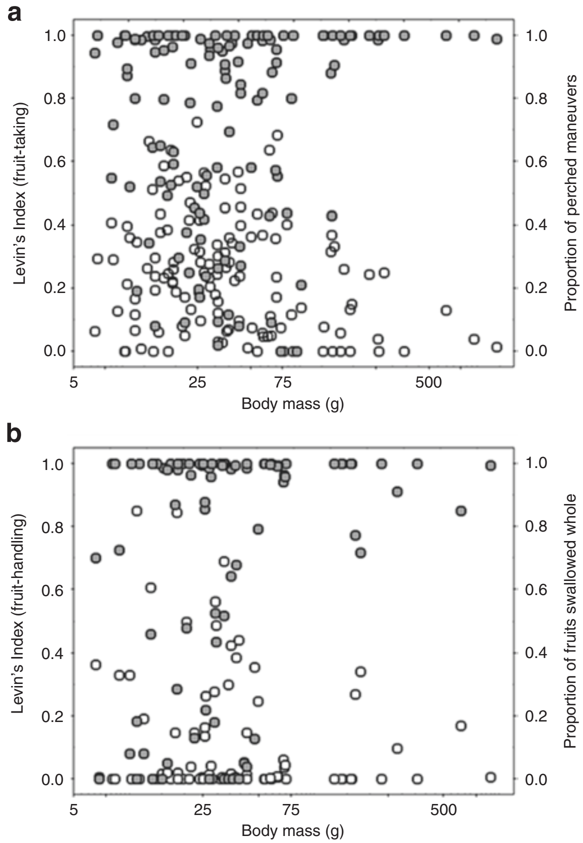

Fig. 9.2 The relationship between body masses of frugivorous birds and their flexibility in (**a**) fruit-taking and (**b**) fruit-handling behavior, as measured by Levins' index represented by white dots. Gray dots illustrate the relationship between body masses and the proportions of perched maneuvers performed by birds to take fruits (**a**), and the proportions of fruits swallowed whole (**b**). Note the logarithmic scale in the body mass axis

(Table 9.2). Contrary to fruit-taking, no phylogenetic signal was detected for any of the fruit-handling behaviors at the family level (all $p > 0.75$).

Tanagers (Thraupidae) form the most flexible family in what concerns fruit-handling. While swallowing whole or mashing fruits predominate for several birds families, Parulidae was the only family for which pecking predominates (Table 9.2). Flexibility in fruit-handling behavior was not correlated to sample size ($r = 0.18$, $n = 87$, $P = 0.10$), to degree of frugivory ($r = 0.17$, $n = 87$, $P = 0.11$), or body mass ($r = -0.14$, $n = 87$, $P = 0.19$), although a tendency for birds larger than 50 g to swallow fruits whole is clear in Fig. 9.2b.

9.4 Discussion

We have provided details on the foraging abilities that expanded and complemented the information available for Neotropical birds, even for well-known and frequent frugivores as tanagers (Thraupidae). Moermond and Denslow (1985) provided so far the most comprehensive dataset of fruit-taking behaviors of Neotropical birds. From their data and subsequent information from others (Moermond and Denslow 1983; Naoki 2007), we are informed that tanagers use almost exclusively perched maneuvers to take fruits. We have shown, however, that they are able to take fruits also on flight, doing so in 8.4% of their foraging attempts, which potentially permit them to exploit a greater variety of fruit morphologies and presentation modes than previously thought.

Body size was negatively correlated with fruit-taking flexibility, indicating that large birds are restricted in the ways they take fruits, using mostly perched maneuvers. Therefore, although such birds are able to eat a greater range of fruit sizes than small birds (Moermond and Denslow 1985), they are likely constrained by certain fruit presentation modes, such as fruits in long and thin stalks requiring flight maneuvers to be taken (Greenberg 1981). From a conservation perspective, large frugivorous birds are of much concern since they are able to disperse large seeds which remain undispersed when they are absent (Galetti et al. 2018). Fruit accessibility, however, can make small birds that are able to take fruits on flight equally essential for the dispersal of plant species with fruits in long and thin stalks.

Different from fruit-taking, body size did not correlate with flexibility in fruit-handling, though a tendency for smaller flexibility among larger birds was apparent. Indeed, Foster (1987) has already noted that handling method and body size are not necessarily correlated, and that although bill dimensions do reflect body size, increases in each are not necessarily proportional. Such imperfect correlation, together with the importance of fruit attributes other than fruit size to influence fruit-handling by birds (e.g., exocarp hardness), makes bird body size a weaker predictor of the fruit-handling behavior adopted by birds. This result could also stem from the influence of phylogeny on fruit-handling behavior, with certain families adopting stereotyped modes of handling fruits irrespective of body size as is clearly the case for fruit-taking behaviors. But we have found no phylogenetic signal in fruit-handling behavior at the family level, with several families frequently employing the three fruit-handling behaviors considered. In this aspect, once again tanagers should be highlighted. Likely from the work of Levey (1987), which studied a few species in captivity, tanagers are sometimes taken as mashers and, as such, poor seed dispersers for dropping the seeds below parent plants while mashing fruits. We have shown, however, that tanagers may employ a variety of fruit-handling behaviors, which is not surprising for such a diverse bird family. Tanagers thus constitute an alert of how one can erroneously assign a functional category to birds without knowing their actual behavior towards fruits in the field.

Contrary to expected, the degree of frugivory was not related to feeding flexibility. One of the most frugivorous taxa analyzed, euphonias (Fringillidae) have a low fruit-taking flexibility (0.04), indicating that even if they eat a variety of fruit species they use a few stereotyped ways to take them (in the case of euphonias, mainly reaching; Fig. 9.1, Table 9.1). Do some fruits are uneaten by euphonias due to accessibility constraints? A positive answer to this question is somehow counterintuitive to the general concept of a highly frugivorous bird as a bird capable of exploiting a great variety of fruits adopting whatever maneuver is necessary to take them.

Interestingly, among the most flexible bird families are families that are predominantly insectivorous (e.g., Tyrannidae: average frugivory degree 24.1 ± 20.6, $N = 32$; Vireonidae: 15.0 ± 7.1, $N = 2$). It is possible that the maneuverability required to prey on arthropods, food sources that conceal themselves and are much harder to catch than fruits, have provided these birds with the behavioral flexibility to take fruits on different ways. Predominantly insectivorous birds that use frequently flight maneuvers to catch fruits are expected to be particularly selective in relation to the fruits they eat. First, as previously noted, compared to perched maneuvers flight maneuvers are particularly costly, making fruit energetic reward a greater issue for birds that take them on flight (Moermond et al. 1986). Second, compared to frugivorous birds, predominantly insectivorous birds have a longer seed retention time, thus a greater commitment to fruit processing (Milton 1981; Levey and Martinez del Rio 2001). They are then expected to select high quality fruits (either in terms of nutrition and/or energy rewarding) to compensate for their comparatively costly foraging and gut processing of fruits. Does this lead to a smaller variety of fruits eaten by such particularly selective birds, as previously suggested for the quetzal (*Pharomachrus mocinno*, an aerial feeder) in comparison with a toucanet (*Aulacorhynchus prasinus*, a perched feeder) (Santana and Milligan 1984), is a question still open to investigation.

The interplay between fruit accessibility or fruit morphology and the feeding abilities of frugivorous birds is not the only or even the chief factor influencing the complex issue of fruit choice by birds, seed fate, or the structure of bird–plant interaction networks, but it is certainly an important one. As such, the fruit-taking and fruit-handling behaviors of frugivorous birds are functional traits to be considered in empirical studies and theoretical models to improve our understanding of the process operating at the community level. Recent studies, for instance, explored the match of bird and plant functional traits revealing that birds appear to consume fruits of plant species that closely match their traits (González-Castro et al. 2015; Donoso et al. 2017). The focus of these studies has been on bird morphological traits (e.g., gape width), but the behaviors explored here, not easily predicted by bird morphology, are additional functional traits to consider due to its potential to influence fruit choice and the fate of seeds. We expect our compilation and analyses of literature data encompassing a broad range of bird families provoke a renewed interest on the fruit-taking and fruit-handling behaviors for a thorough understanding of the ecological and evolutionary relationships between frugivorous birds and plants.

Appendix

Sources of Data Used in the Analyses for Fruit-Taking (T) and Fruit-Handling (H) Behaviors with Information on the Number and Identity of Plant Species Studied

Source	Plant species (Families)
Argel de Oliveira (1999) (T)	21 species (13 families)
Athiê (2009) (T)	13 species (10 families)
Basler (2005) (T)	*Myrsine coriacea* (Primulaceae)
Batista EC (unpubl. data) (T, H)	*Cinnamomum zeylanicum* (Lauraceae)
Colussi and Prestes (2011) (T)	3 species (2 families)
Correia (1997) (T)	13 species (10 families)
Faustino and Machado (2006) (H)	10 species (9 families)
Francisco and Galetti (2001) (T)	*Myrsine lancifolia* (Primulaceae)
Francisco and Galetti (2002a) (H)	*Ocotea pulchella* (Lauraceae)
Francisco and Galetti (2002b) (T)	*Davilla rugosa* (Dilleniaceae)
Francisco et al. (2007) (T, H)	*Pera glabrata* (Peraceae)
Gondim (1995) (T, H)	4 species of Trichilia (Meliaceae)
Gondim (2002) (T, H)	40 species (27 families)
Gridi-Papp et al. (2004) (H)	2 species (Melastomataceae)
Guimarães (2003) (T, H)	*Tapirira guianensis* (Anacardiaceae)
Jacomassa (2016) (T)	*Solanum granulosoleprosum* (Solanaceae)
Lamberti et al. (2012) (T, H)	*Eugenia uniflora* (Myrtaceae)
Lopes (2000)	4 species (4 families)
Marcondes-Machado (2002)	*Miconia rubiginosa* (Melastomataceae)
Masteguin and Figueiredo (1995) (H)	*Prunus reflexa* (Rosaceae)
Melo and Oliveira (2009) (H)	*Lacistema hasslerianum* (Lacistemataceae)
Motta (1991) (T, H)	19 species (14 families)
Muller (2006) (T)	4 species (4 families)
Oliveira AP et al. (2013a) (T)	*Matayba guianensis* (Sapindaceae)
Oliveira DSF et al. (2013b) (H)	*Michelia champaca* (Magnoliaceae)
Pascotto (2006) (T, H)	*Alchornea glandulosa* (Euphorbiaceae)
Pascotto (2007) (T, H)	*Myrsine coriacea* (Primulaceae)
Pascotto et al. (2012) (T)	*Curatella americana* (Dilleniaceae)
Pizo MA (unpubl. data) (T)	62 species (35 families)
Purificação et al. (2015) (T)	*Schefflera morototoni* (Araliaceae)
Robinson (2015) (T)	6 species (6 families)
Silva (2010) (H)	*Ficus organensis* (Moraceae)
Silva et al. (2013) (T, H)	*Psidium guajava* (Myrtaceae)
Valente (2001) (H)	*Alchornea glandulosa* (Euphorbiaceae)

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