Journal of the Arkansas Academy of Science

Volume 72 Article 10

2018

Avian Frugivory in a Fruiting Mulberry Tree (Morus rubra) in Arkansas

J. L. Jackson II
University of Arkansas - Fort Smith

Ragupathy Kannan
University of Arkansas--Fort Smith, ragupathy.kannan@uafs.edu

Avian Frugivory in a Fruiting Mulberry Tree (*Morus rubra*) in Arkansas

J.L. Jackson, II[1] and R. Kannan[2*]

[1]*Department of Mathematics, University of Arkansas - Fort Smith, Fort Smith, AR 72913*
[2]*Department of Biology, University of Arkansas - Fort Smith, Fort Smith, AR 72913*

[*]Correspondence: ragupathy.kannan@uafs.edu

Running title: Avian Frugivory in a Fruiting Mulberry Tree

Abstract

A fruiting Mulberry tree (*Morus rubra*) was observed for 67 hours in the spring of 2016 and 2017 in Fort Smith, Arkansas. A total of 172 five-minute scans were performed, during which the following parameters were recorded: species visited, number of individuals of each species, time of visitations, and foraging tier. Between each scan, the foraging rate (number of fruits consumed/min) and inter- and intra- specific aggressive interactions were recorded. A total of 3465 observations of individual birds from 32 species was recorded. Species diversity index was higher in the upper half of the tree. The mean foraging rates for the 6 most commonly observed species ranged from 1.2-2.3 fruits/min. A total of 346 aggressive interactions was observed of which 68% were intraspecific.

Introduction

Many studies have characterized bird communities in tropical (e.g. Eshiamwata *et al*. 2006; Coates-Estrada and Estrada 1986) and temperate (e.g. Snow and Snow 1988; Herrera 1998) fruiting trees. In temperate latitudes, fruits constitute an important food resource for birds, especially in the fall (Rybczynski and Riker 1981; Logan 1987; Smith and Riley 1990) and spring (Martin *et al*. 1951; Stapanian 1982). There have been two avian frugivory studies from Arkansas, both from the northwestern part of the state. Prather *et al.* (2000) studied characteristics of some fall fruiting tree species and their avian assemblages. Smith and Riley (1990) quantified avian removal of fruits from a pokeweed (*Phytolacca americana*) in late summer and fall. Neither of these studies investigated spring fruiting plants.

The Red Mulberry (*Morus rubra*) is a common deciduous tree native to eastern North America (Flora of North America 2018). In Arkansas, it is commonly found both in gardens as a planted ornamental, and in the wild, especially in fencerows and disturbed early or mid-successional habitats. When the tree fruits in the spring (April-May), it attracts hordes of migratory and resident birds. The fleshy aggregate fruit of the mulberry tree is synchronously produced, turning from pink to blackish during the approximately three weeks of fruiting. These fruits are consumed even by birds like Swainson's Thrush *Catharus ustulatus* (Wiley *et al*. 2015) and Eastern Kingbird *Tyrannus tyrannus* (Murphy 1996) that are usually insectivorous in their breeding range. Many rare or declining neotropical migrants like Eastern Kingbird, Scarlet Tanager *Piranga olivacea*, and Swainson's Thrush, eat mulberry fruits during spring when they are in migration or after they have arrived at their breeding grounds (Murphy 1996; Mowbray 1999; Mack and Yong 2000). Despite this apparent importance of the tree as a food source for birds, only one systematic study has been conducted to study avian frugivore assemblages in a mulberry tree in North America (Robbins *et al*. 1975), and this was in Michigan. Stapanian (1982) studied the effectiveness of fruiting displays of mulberry trees for seed dispersal by birds in Kansas.

We observed a fruiting Mulberry tree for 67 hours in the spring of 2016 and 2017 in Fort Smith, Arkansas (Sebastian Co.). The 15-year old, 12-meter (40-feet) tall tree stood by itself in a suburban lawn. This study had three main objectives: 1) to characterize the species composition and abundance of birds visiting the fruiting tree in the spring, 2) to quantify the foraging behavior of bird species in terms of foraging rate and foraging tier in the canopy, and 3) to study inter- and intra-specific aggressive interactions in the avian frugivore community.

Materials and Methods

In both years, we started formal observations immediately after commencement of significant bird frugivory activity, and observations ceased when bird activity declined. Observations were conducted from a porch about 20 meters from the tree in the early morning

(0700-0900 hrs) or late evening (1800-2000 hrs) using 10x42 binoculars and Olympus WS-852 digital voice recorders. We conducted five-minute scans (after Athreya 1997), during which the following parameters were recorded: species visited, number of individuals of each species, and foraging tier (upper half of canopy, lower half of canopy, and ground). Scans were done three times an hour, the first at the top of the hour, the second starting 20 minutes past the hour, and third starting 40 minutes past the hour. Every effort was made to avoid double counts. In instances where there was a lot of influx and egress of flocks, only the maximum number in the tree at any one time during that scan period was recorded. A total of 172 five-minute scans of the tree was performed, with 56 scans in 2016 and 116 scans in 2017. Of these, 105 scans were in the morning and 67 in the evening. These scans give snapshots of which birds were present together. In the 15-minute intervals between the scans, observations of aggressive interactions and foraging behaviors were recorded. Aggressive interactions were recognized when one bird chased or attacked another. Both the aggressor and supplanted species were recorded.

Foraging rate was recorded by following individual birds in the tree canopy. Each bird was followed for a maximum of 5 observations of fruit consumed, to avoid the dependency bias associated with sequential observations (Morrison 1984; Wiley *et al*. 2015). The number of fruits consumed was divided by the number of seconds the individual bird was tracked and then converted to fruits per minute. Because the act of plucking a fruit often drew the observer's attention to the bird, it produced a bias when the observation period was small, by overestimating foraging rates. To correct for this bias, 132 observations lasting less than 30 seconds were discarded from the analysis, leaving 349 viable observations. Qualitative information was noted regarding fruit procuring behavior.

Excel, Minitab, and SPSS were used in the statistical analysis. Quartiles were computed using the Minitab/SPSS method. The letter s represents the standard deviation of the number of individual birds in the sample. Numbers listed in brackets represent 95% confidence intervals. All hypothesis tests used an alpha level of 0.05. Because of large sample sizes, sample means are approximately normal, so hypothesis tests of means are two-tailed, two independent sample t-tests. Tests of proportions used a binomial distribution to compute two-tailed p-values. The Shannon-Weiner Diversity Index (Molles 2016) was used as a measure of species diversity.

Results

Species Composition

During the 172 scans a total of 3325 observations of individual birds of 30 species was recorded (Table 1). Two additional bird species were observed between scans. A complete list of all 32 species, along with number of observations, mean number per scan, and the percentage of scans with at least one bird of the species, is presented in Table 1.

Nearly 77% of observed birds represented just two species: Cedar Waxwings (51.4%) and American Robins (25.4%). Most of the data analysis here pertains to the 9 most abundant species. Collectively, the 23 species which are not part of this top 9 accounted for only 4% of the total observations of individual birds, with each of the 23 species making up less than 1% of the total observations and occurring in fewer than 14% of the scans.

Number of Birds

The tree often teemed with bird activity. The total number of birds per scan ranged from 2 to 66 with a mean of 19.3 ([17.8, 20.9], s = 10.1) and median of 18 [16, 19]. The distribution of total number of birds per scan is approximately normal, with most of the scans having 8-29 total birds and few scans having either fewer or more birds (Fig. 1).

In contrast, when disaggregated by species, the distributions of birds per scan are highly skewed to the right (Fig. 2). For all the species, the most frequent number of birds per scan was 0 with the number of scans decreasing as the number of birds per scan increased.

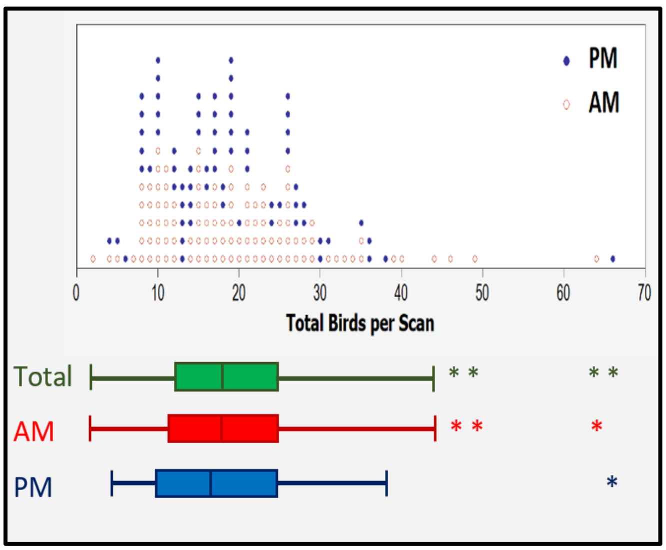

Fig. 1. Total birds per scan (all species combined, one dot per scan).

https://scholarworks.uark.edu/jaas/vol72/iss1/10
DOI: https://doi.org/10.54119/jaas.2018.7219

Table 1. Frequency of observations of birds in the tree, by species, and their method(s) of feeding.

Rank	Common Name	Scientific Name	Number observed during scans	Mean number per scan	Percentage of scans present	Fruit Procuring Method*
1	Cedar Waxwing	*Bombycilla cedrorum*	1709	9.94	76	a, e
2	American Robin	*Turdus migratorius*	843	4.90	87	a, c, e
3	Northern Mockingbird	*Mimus polyglottos*	177	1.03	57	a, c, e
4	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	131	0.76	44	b
5	Swainson's Thrush	*Catharus ustulatus*	90	0.52	42	a, e
6	Gray Catbird	*Dumetella carolinensis*	73	0.42	31	a
7	House Finch	*Haemorhous mexicanus*	67	0.39	23	a
8	Eurasian Starling	*Sturnus vulgaris*	54	0.31	17	a, c
9	Baltimore Oriole	*Icterus galbula*	41	0.24	14	a
10	Mourning Dove	*Zenaida macroura*	22	0.13	11	
11	Northern Cardinal	*Cardinalis cardinalis*	22	0.13	10	a
12	Red-bellied Woodpecker	*Melanerpes carolinus*	17	0.10	9	a
13	House Sparrow	*Passer domesticus*	14	0.08	6	
14	Eastern Kingbird	*Tyrannus tyrannus*	11	0.06	3	d
15	Tennessee Warbler	*Oreothlypis peregrina*	11	0.06	6	
16	Brown Thrasher	*Toxostoma rufum*	7	0.04	4	a
17	Nashville Warbler	*Oreothlypis ruficapilla*	7	0.04	3	
18	Brown-headed Cowbird	*Molothrus ater*	5	0.03	2	
19	Painted Bunting	*Passerina ciris*	5	0.03	3	a
20	White-crowned Sparrow	*Zonotrichia leucophrys*	4	0.02	2	a
21	Summer Tanager	*Piranga rubra*	3	0.02	2	a
22	American Goldfinch	*Spinus tristis*	2	0.01	1	a
23	Pine Siskin	*Spinus pinus*	2	0.01	1	
24	White-throated Sparrow	*Zonotrichia albicollis*	2	0.01	1	
25	Chipping Sparrow	*Spizella passerina*	1	0.01	1	
26	Indigo Bunting	*Passerina cyanea*	1	0.01	1	
27	Lincoln's Sparrow	*Melospiza lincolnii*	1	0.01	1	
28	Magnolia Warbler	*Setophaga magnolia*	1	0.01	1	
29	Yellow-bellied Sapsucker	*Sphyrapicus varius*	1	0.01	1	
30	American Crow	*Corvus brachyrhynchos*	1	0.01	1	
31	Downy Woodpecker	*Picoides pubescens*	0	0	0	
32	Scarlet Tanager	*Piranga olivacea*	0	0	0	

*a: berry plucked, then swallowed whole
b: bits of berry plucked and eaten, without removing from branch
c: berry plucked and taken away from tree
d: berry removed from branch while bird in flight
e: fallen berries eaten from ground
blank: species that may have visited the tree for arthropod prey, or whose frugivory method was unclear

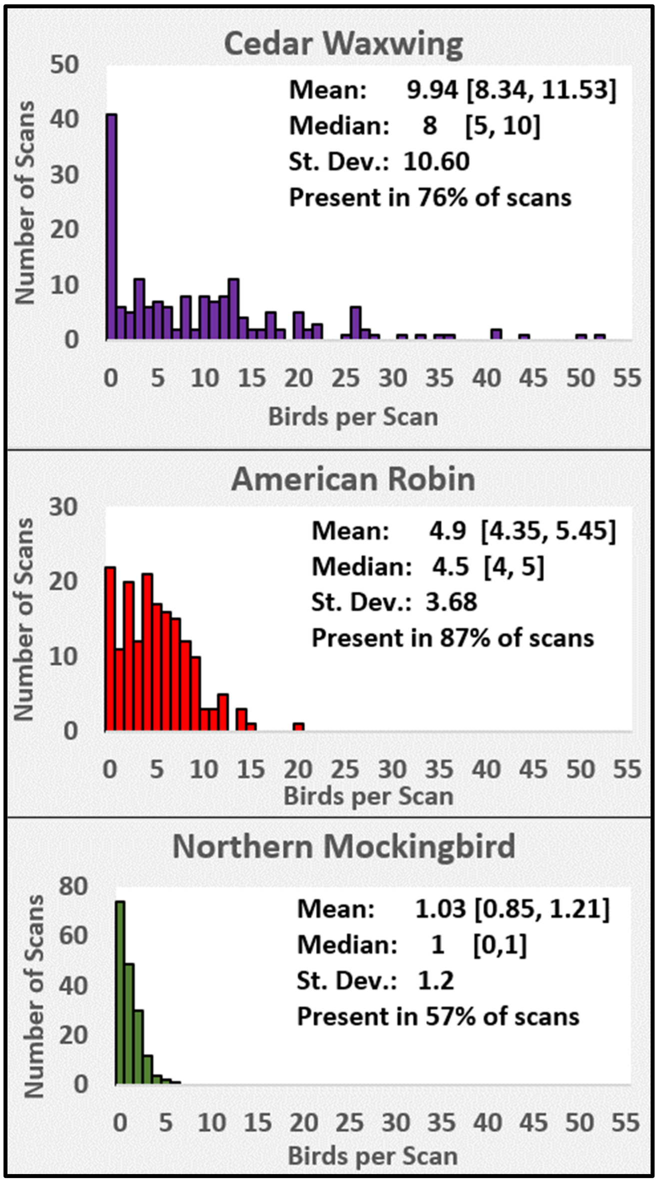

Fig. 2: Birds per scan for the 3 most common species. See Appendix for sample sizes.

Northern Mockingbirds exhibited this typical pattern, being absent in 43% of the scans and typically appearing with 1-3 birds per scan when present (Fig. 2). American Robins were present in the most scans, but almostalways appeared fewer than 12 at a time (Fig. 2). The most observed species, Cedar Waxwings, appeared in fewer scans than American Robins, but often appeared in larger groups of 15 or more at a time. All the outliers in the total birds per scan (Fig. 1) are explained by the presence of large flocks of up to 52 Cedar Waxwings (Fig. 2), whose numbers per scan was the most variable of all species. They typically appeared in groups of 2-20 birds, with an approximately uniform distribution within this common range (Fig. 2). The rest of the species each appeared in fewer than 45% of the scans and rarely showed more than 2 at a time when present, making histograms uninformative (Table 1).

Temporal Pattern of Visitations

Unlike the studies of Athreya (1997) and Stapanian (1982), which found a significant peak in bird activity in the morning hours, our data showed no significant difference ($p = 0.615$) in total birds per scan between morning (AM) and evening (PM) hours (Fig. 1). The overall mean number of birds per scan was 19.6 AM and 18.9 PM.

There was no clear pattern to either the number of birds per scan or number of species per scan through the various days of observation (Fig. 3). Apparently, the abundant and synchronously produced fruit attracted a random assortment of frugivorous bird species present in the area. The variation in the number of birds per scans was influenced largely by the nomadic movements of Cedar Waxwings (Fig. 4).

The mean total number of birds per scan was not significantly different for the two years (20.6 in 2016 and 18.7 in 2017, $p = 0.26$). However, except for House Finches, the number of birds/scan between the two years was significantly different for each of the 9 common species (Table 2). Cedar Waxwings were more abundant in 2016 (mean 16.5 [13.6, 19.5]) than in 2017 (mean 6.8 [5.2, 8.5]), with all the outliers occurring in

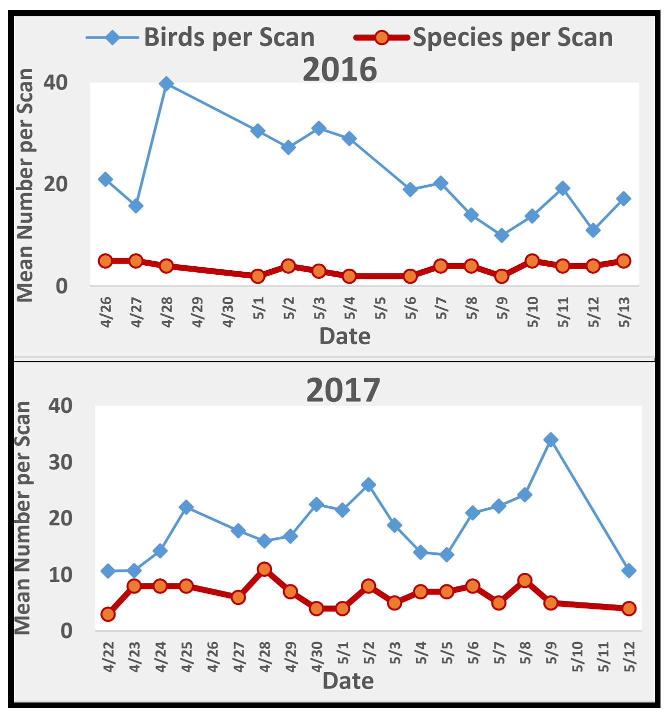

Fig. 3. Mean number of birds per scan and mean number of species per scan by date.

https://scholarworks.uark.edu/jaas/vol72/iss1/10
DOI: https://doi.org/10.54119/jaas.2018.7219

Table 2. Mean number of birds per scan by year*.

Species	2016	2017	*p*-value
Cedar Waxwing	**16.53**	6.84	0.000
American Robin	1.93	**6.30**	0.000
Northern Mockingbird	0.36	**1.34**	0.000
Rose-breasted Grosbeak	0.33	**0.97**	0.000
Swainson's Thrush	0.09	**0.73**	0.000
Gray Catbird	0.11	**0.57**	0.000
House Finch	0.33	0.42	0.472
Eurasian Starling	0.00	**0.46**	0.000
Baltimore Oriole	0.04	**0.33**	0.000

*Numbers in bold indicate significant difference between the years.

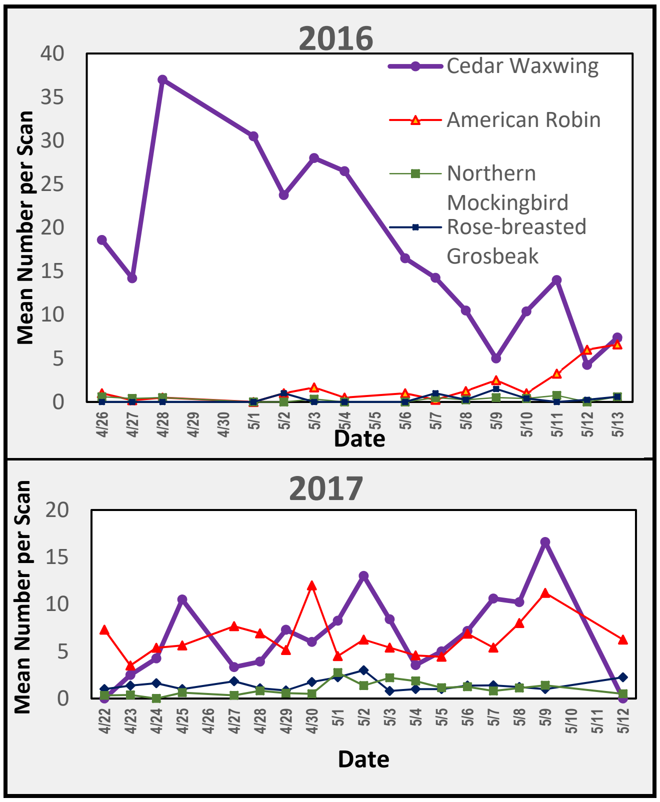

Fig. 4. Mean number of birds per scan by species and date.

2016 (Figs. 1, 2, 4, Table 2). They were also considerably more abundant than the next most abundant species in 2016, but they were similar in numbers with American Robins in 2017 (Fig. 4). The 7 other prevalent species showed little variation in the mean number of birds per scan for each day in 2016 and 2017. Since the *p*-values for the comparisons for these species are all less than 0.0005, even if applying a Bonferroni-Holm correction for multiple tests, these species were significantly more abundant in 2017 than in 2016 (Fig. 4, Table 2). Note that Figure 4 shows only the top four species to reduce clutter.

Table 3. Vertical separation of species within the tree.

Species	% Ground	% Upper	*p*-value*
Significantly more in the upper half of the tree			
Brown Thrasher**		100	0.016
House Finch		96	0.000
Red-bellied Woodpecker**		94	0.000
Baltimore Oriole		90	0.000
Rose-breasted Grosbeak		87	0.000
House Sparrow**		86	0.013
Eastern Kingbird**		82	0.012
Tennessee Warbler**		82	0.012
Cedar Waxwing		63	0.000
Significantly less in the upper half of the tree			
Northern Mockingbird	18	40	0.010
American Robin	43	35	0.000
Swainson's Thrush	8	31	0.000
Mourning Dove	91	9	0.000

*The alternate hypothesis is that the percentage in the upper tier is not equal to 50%.
**Species appeared in less than 10% of scans.

Foraging Tier of Tree

Based upon anecdotal observations from 2015 and earlier we knew that there were many birds of many species foraging in the tree simultaneously. We suspected that this might be facilitated in part by different species using different parts of this mature tree. To test this hypothesis and to gain information about preferred foraging habits of different species, we investigated if there were any spatial differences in bird usage among various tiers of the tree canopy. Among the 4 most prevalent species, Cedar Waxwings and Rose-breasted Grosbeaks were significantly more often in upper half of tree than lower. American Robins and Northern Mockingbirds were significantly more often in lower half or on the ground (Table 3). There were high percentages of observations of American Robins and Mourning Doves on the ground (Table 3), where they often forage. Even if applying a Bonferroni-Holm correction for multiple tests, the 8 species in Table 3 which appeared in more than 10% of the scans show significant vertical separation within the tree. Because of the smaller sample size, the conclusions for the 5 species appearing in fewer than 10% of the scans is less conclusive. The 18 species not listed in Table 3 showed no significant vertical separation.

Species Diversity

The number of species per scan (Fig. 3) varied from 1 to 9 with a mean of 4.6 ([4.3, 4.8], s = 1.8) and median 5 [4, 5]. The mean number of species per scan was significantly higher in 2017 than in 2016 (p = 0.00) (Table 4).

The species diversity increased with height of foraging tier (Table 4). The mean number of species per scan was significantly higher in upper half of canopy than lower (p = 0.00), and mean number of species per scan was significantly higher in lower half of tree than ground (p = 0.00). There was no significant difference in mean number of species per scan by time of day (p = 0.27), even though there was a higher diversity index in morning (Table 4).

Aggressive Interactions

All 346 recorded aggressive interactions are portrayed in the weighted directed graph (Fig. 5). To rank species by aggressiveness (Table 5), we adjusted for number of birds recorded. While aggressive interactions were primarily observed between the 5-minute scans, the total number of times that a bird of that species was observed in aggressive action against another bird was divided by the total number of times birds of that species was observed during scans. These percentages (column 2 of Table 5), were the basis by which we ranked aggressiveness.

Of the 16 species observed in aggressive interactions, Northern Mockingbird was the most aggressive (Table 5). American Robins ranked third in aggression largely due to their aggressive behavior toward other American Robins. This species was the victim of interspecific aggression more than it was the instigator. Cedar Waxwing, Swainson's Thrush, Gray Catbird, and House Finch were among the least aggressive species (Fig. 5, Table 5). We once even observed a Cedar Waxwing feeding another Cedar Waxwing.

The proportion of intraspecific aggression (68%) was significantly higher than that of interspecific aggression (p = 0.00) (Fig. 5, Table 5).

Table 4. Species Diversity Measures.

	Total number of species	Mean number of species per scan	Shannon-Weiner Diversity Index
Upper half	27	3.3	1.21
Lower half	20	2.1	0.76
Ground	10	1.2	0.46
AM	26	4.4	1.24
PM	22	4.8	1.00
2016	21	3.2	0.67
2017	25	5.2	1.45

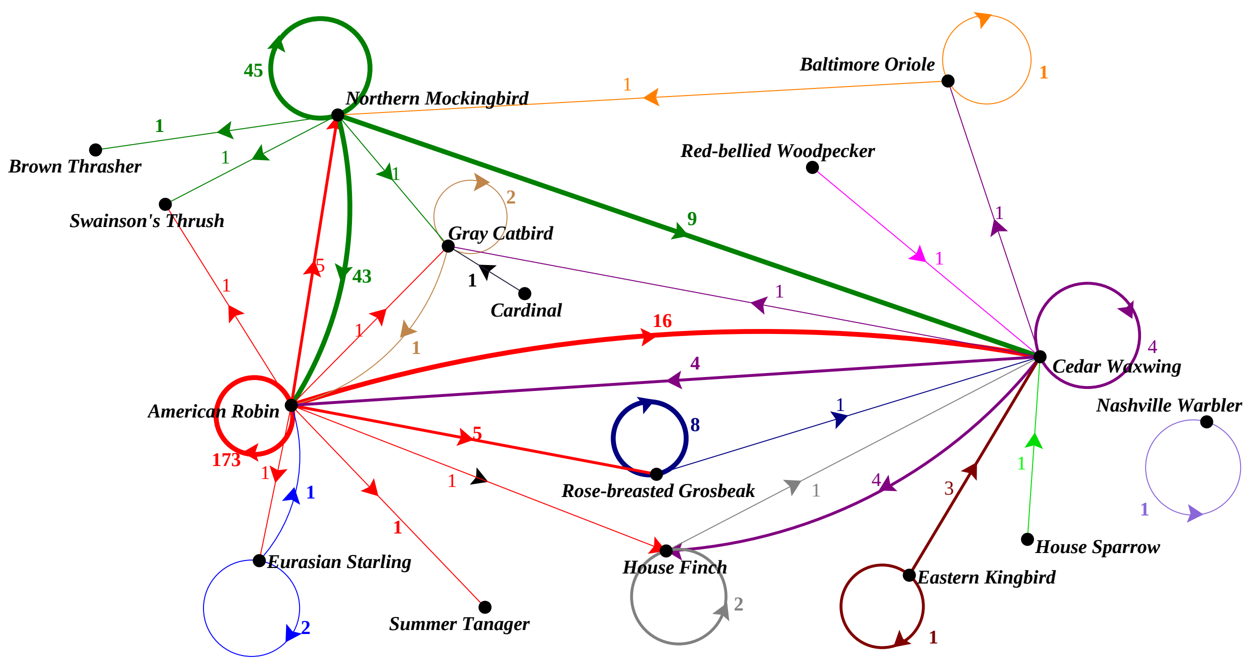

Fig. 5. Weighted directed graph of aggressive interactions. Arrows point from aggressive species to supplanted species. Weights indicate number of observations. Thicker lines indicate higher number of observations. Loops (circles) are intraspecific aggressions and other edges are interspecific aggressions.

https://scholarworks.uark.edu/jaas/vol72/iss1/10
DOI: https://doi.org/10.54119/jaas.2018.7219

Table 5. Aggressive interactions by species.

Species (most aggressive to least aggressive)	Percentage of aggressions per number scanned	Total times aggressor	Intra-specific aggressions	Inter-specific aggressions	Number of species aggressed	Number of times supplanted by another species	Number of species supplanted by
Northern Mockingbird	56	100	45	55	6	6	5
Eastern Kingbird	36	4	1	3	2	0	3
American Robin	24	204	173	31	9	49	8
Nashville Warbler	14	1	1	0	1	0	3
House Sparrow	7	1	0	1	1	0	1
Rose-breasted Grosbeak	7	9	8	1	2	5	3
Red-bellied Woodpecker	6	1	0	1	1	0	1
Eurasian Starling	6	3	2	1	2	1	3
Baltimore Oriole	5	2	1	1	2	1	3
Cardinal	5	1	0	1	1	0	2
House Finch	4	3	2	1	2	5	3
Gray Catbird	4	3	2	1	2	4	3
Cedar Waxwing	1	14	4	10	5	32	5
Swainson's Thrush	0	0	0	0	0	2	0
Brown Thrasher	0	0	0	0	0	1	0
Summer Tanager	0	0	0	0	0	1	0
Total (16 species)		**346**	**234 (68%)**	**112 (32%)**	**13**		

Foraging Rates

Of the six species with at least 20 observed foraging sequences of at least 30 seconds, American Robins were the fastest foragers (mean 2.3 fruits/minute [2.0, 2.6], $s = 1.27$) and Rose-breasted Grosbeaks were the slowest (mean 1.2 fruits/minute [1.0, 1.3], $s = 0.61$) (Fig. 6). See Fig. 8 for sample sizes.

American Robins, the fastest foragers, were tracked for the second least time (mean sequence of 43 sec.) (Fig. 7). Rose-breasted Grosbeaks were not only the slowest foragers, they were also tracked the longest (mean observed foraging sequence of 178 seconds). The true foraging sequence length for Rose-breasted Grosbeaks is bound to be much higher, because in 10 of the 54

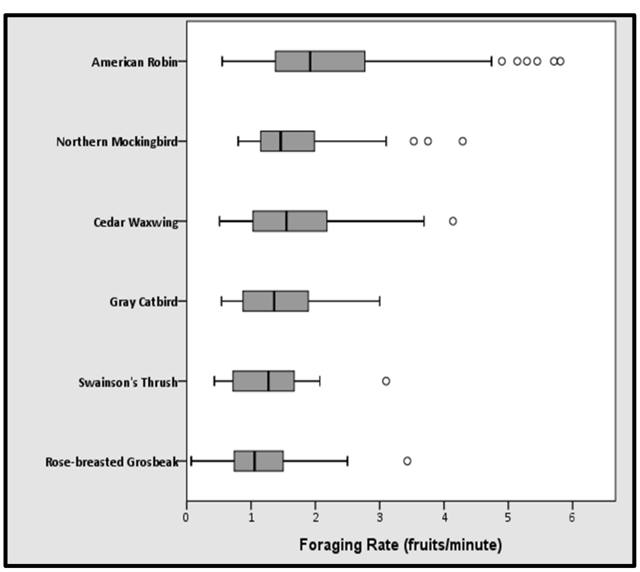

Fig. 6. Foraging rates of the top 6 species.

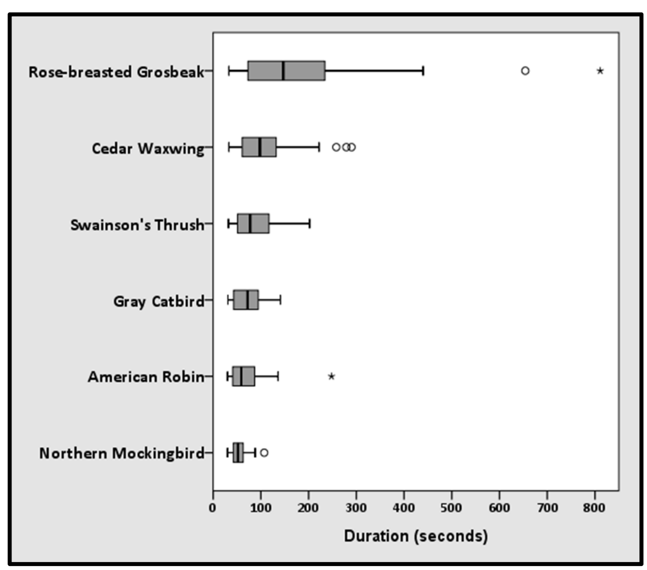

Fig. 7. Length of foraging sequence observed (up to 5 fruits).

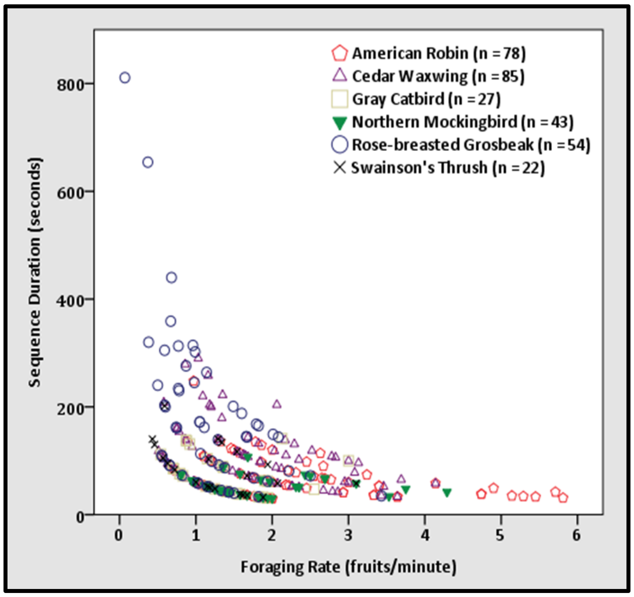

Fig. 8. Relationship between foraging rate and observed foraging sequence for the top 6 species. Each symbol represents one observation.

observed foraging sequences we ceased observations of this species when the self-imposed maximum of 5 fruits was reached. Overall, birds that ate fruits at a slower rate tended to be observed for longer periods of time, and those that foraged faster tended to disappear in the foliage faster and thus could not be tracked longer (Fig. 8).

Fruit Procuring Behavior

Five distinct types of fruit obtaining maneuvers were recognized: 1. berry plucked, then swallowed whole, 2. bits of berry plucked and eaten, without removing from branch, 3. berry plucked and taken away from tree, 4. berry removed from branch while bird in flight, and 5. fallen berries eaten from ground (after Robbins *et al*. 1975). These qualitative notes are given in Table 1.

Discussion

The synchronously produced abundance of fruit on the mulberry tree attracted many birds. In particular, Cedar Waxwings and American Robins were attracted to the tree in large numbers. Many other local and migratory species were also attracted. Despite some aggressive interactions among the birds, the fruit was abundant enough to support multiple species simultaneously.

Most of the aggressive behavior was between birds of the same species, suggesting that territoriality, rather than interspecific competition, shapes these behaviors in synchronously fruiting trees. Some degree of species coexistence was facilitated by species foraging in different vertical zones of the canopy. The two most abundant species, Cedar Waxwings and American Robins, were typically separated in this manner, with American Robins often feeding on fruit which had fallen to the ground, and most Cedar Waxwings foraging near the top of the tree. Even though the presence of the more aggressive American Robins tended to decrease the presence of Cedar Waxwings, their interactions were typically limited to the middle of the tree, allowing both species to appear in most of the scans.

There were few strong temporal patterns to the visitations. This suggests that birds take advantage of the easy and abundant source of food, with little need for temporal separation to minimize competition. This general lack of interspecific exclusion from the tree was also observed in a fruiting mulberry tree in Michigan (Robbins *et al*. 1975) and in a fruiting *Ficus* in India (Athreya 1997). The presence of predominantly insectivorous birds in the tree, such as Eastern Kingbird and three species of warblers, indicates that mulberry fruits may be consumed opportunistically by some migrants (Murphy 1996; Mowbray 1999; Mack and Yong 2000; Wiley *et al*. 2015). The unpredictability in the number of birds present at different times can be largely explained by the nomadic behavior of flocks of Cedar Waxwings, which account for over half of the data. This also explains the low species diversity index in 2016 when Cedar Waxwings dominated the community.

This study was limited to a single tree in a suburban location. Care should be taken to not overgeneralize the results reported here. Factors such as location (urban, suburban, forest, as well as geographic location within the migratory path of certain species), presence of other fruiting trees of the same or different species, size of the tree, and other factors which we did not investigate would likely vary the makeup of species foraging in a mulberry tree.

Furthermore, there were significant differences in species composition foraging in the tree between the two years of study. Given this marked interannual variation, we suggest that future such studies should ideally be conducted over multiple years to get a better picture of the composition of these bird assemblages. Most studies cited in this paper were conducted over a single fruiting season. Although much of the annual variation in this study can be explained by the presence of larger flocks of Cedar Waxwings in 2016, more significant differences could occur if (as in 2018) the

https://scholarworks.uark.edu/jaas/vol72/iss1/10
DOI: https://doi.org/10.54119/jaas.2018.7219

time of fruiting is significantly delayed due to late cold weather, so that the fruiting phenology may interact differently with migratory patterns.

The 32 species we recorded from the tree is similar to some tropical bird species richness in fruiting *Ficus* (Athreya 1997; Tello 2003) and *Cecropia* trees (Estrada *et al*. 1984). The data we presented in this paper clearly showed that the abundant fruit of the mulberry is a popular and easy source of fuel for many species passing through on migration, as well as for summer residents in the area. Given that this tree was such a magnet for birds, it is ironic that more research has not been done to document this spectacular annual phenomenon of avian frugivory in North America.

Acknowledgments

Lindsey Rice and Ashley Cooper helped with data collection as part of the Undergraduate Research course at the University of Arkansas - Fort Smith (UAFS). Lindsey also assisted with some data entry and analysis. The UAFS Department of Biology provided equipment and financial support for conference travel. This paper is dedicated to the memory of the late Dr. Kimberly G. Smith, who served as an inspiration, mentor, and valued colleague to the authors and many others throughout his career.

Literature Cited

Athreya V. 1997. Temporal patterns of visitation among avian frugivores at fruiting strangler figs in a tropical evergreen forest in the Western Ghats, Southern India. Current Science 72:405-408.

Coates-Estrada R and **A Estrada.** 1986. Fruiting and frugivores at a strangler fig in the tropical rain forest of Los Tuxtlas, Mexico. Journal of Tropical Ecology 2:349-357.

Eshiamwata GW, DG Berens, B Bleher, WRJ Dean, and **K Bohning-Gaese.** 2006. Bird assemblages in isolated *Ficus* trees in Kenyan farmland. Journal of Tropical Ecology 22:723-726.

Estrada A, R Coates-Estrada, and **C Vazquez-Yanes.** 1984. Observations on fruiting and dispersers of *Cecropia obtusifolia* at Los Tuxtlas, Mexico. Biotropica 16:315-318.

Flora of North America. 2018. *Morus rubra* Linnaeus.http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=233500782. Accessed 10 March 2018.

Herrera CM. 1998. Long-term dynamics of Mediterranean frugivorous birds and fleshy fruits: A 12-year study. Ecological Monographs 68:511-538.

Logan CA. 1987. Fluctuations in fall and winter territory size in the Northern Mockingbird (*Mimus polyglottos*). Journal of Field Ornithology 58:297-305.

Mack DE and **W Yong.** 2000. Swainson's Thrush (*Catharus ustulatus*), v2.0. *In:* The Birds of North America (A.F. Poole and F.B. Gill, eds.). Cornell Lab of Ornithology, Ithaca, NY, USA. https://birdsna.org.

Martin AC, HS Zim, and **AL Nelson.** 1951. American wildlife and plants. McGraw-Hill (NY).

Molles MC. 2016. Ecology. Concepts & Applications. 7th edition. McGraw-Hill Education (NY). 592 p

Morrison ML. 1984. Influence of sample size and sampling design on analysis of avian foraging behavior. The Condor 86:146-150.

Mowbray TB. 1999. Scarlet Tanager (*Piranga olivacea*), v2.0. *In*: The Birds of North America, (A. Poole and F. Gill, eds.). Cornell Lab of Ornithology, Ithaca, NY, USA. https://birdsna.org.

Murphy MT. 1996. Eastern Kingbird (*Tyrannus tyrannus*) v2.0. *In:* The Birds of North America, (A. Poole and F. Gill, eds.). Cornell Lab of Ornithology, Ithaca, NY, USA. https://birdsna.org.

Prather JW, KG Smith, ML Mlodinow, and **CM Riley.** 2000. Characteristics of some fruiting plant species in northwest Arkansas, and the avian assemblages that feed on them. Journal of the Arkansas Academy of Science 54:103-108.

Robbins RJ, C Casbon, and **GE Hattis.** 1975. Observations of birds exploiting a central Michigan fruit tree. Jack-Pine Warbler 53:118-125

Rybczynski R and **DK Riker.** 1981. A temperate species-rich assemblage of migrant frugivorous birds. Auk 98:176-179.

Smith KG and **CM Riley.** 1990. Avian removal of fruits from a pokeweed in northwestern Arkansas. Wilson Bulletin 102:163-166.

Snow BK and **DW Snow.** 1988. Birds and Berries: A study of an ecological interaction. T. & A.D. Poyser (Calton, U.K.)

Stapanian MA. 1982. A model for fruiting display: seed dispersal by birds for Mulberry trees. Ecology 63:1432-1443.

Tello JG. 2003. Frugivores at a fruiting *Ficus* in south-eastern Peru. Journal of Tropical Ecology 19:717-721.

Wiley S, R Kannan, DA James, and **A Deshwal.** 2015. Foraging behavior of Swainson's Thrushes (*Catharus ustulatus*) during spring migration through Arkansas. Journal of the Arkansas Academy of Science 69:124-129.