

Nutritional content of *Ficus benjamina* fruits consumed by Frugivorous birds in Taman Botani Johor

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Abstract. *Ficus benjamina* is a common tree in Taman Botani Johor and a food source for many frugivorous birds. This study investigated the nutrient content of *F. benjamina* fruits by analyzing the fruits of 7 species of birds that were observed safely feeding on the tree. The fruits were collected and analyzed for their nutrient content using a standard method for nutritional composition determination. The results showed that the fruits have a high carbohydrate content (19.7%), a low fat content (0.6%), and a moderate protein content (1.5%). The fruits also have a high moisture content (76.7%) and a low ash content (1.6%). The high carbohydrate content of fruits is likely attractive to frugivorous birds, as carbohydrates are an important energy source for reproduction, growth, and development. The low-fat content may also be beneficial to the birds, as excess fat can be harmful to their health. The results of this study provide valuable information on the nutrient content of *F. benjamina* fruits, which can be used to better understand the feeding ecology of frugivorous birds in Taman Botani Johor in a safe manner.

1 Introduction

Plants and frugivorous birds have a mutualistic relationship since they both gain from the exchange. Birds that participate in mutualism and the weeping fig (*Ficus benjamina*) spread the plant's seeds to other locations while the figs supply the birds with fruits to eat [1]. Given that the spread of plant propagules can solely depend on their capacity to draw in frugivorous birds, the importance of bird-plant mutualisms is well recognized [2]. The advantages of consuming a particular fruit determine the birds' preferences [2]. In addition to the advantages of seed dissemination, pollination is greatly aided by bird-plant interactions [3].

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Chemical composition is another factor to consider when selecting food for frugivorous birds. The appropriate diet helps birds thrive, reproduce, and survive. This is especially true for several kinds of birds. Frugivorous birds must, therefore, be extremely selective about what they eat. The diversity in food production reflects the complexity of the foods consumed and the range of animal species. There are two types of metabolites involved in plants: primary and secondary. Primary metabolites are directly involved in growth and metabolism, while plant secondary compounds (PSC), also known as chemical defenses, avoid herbivory due to their toxic effects [4].

Proteins, lipids, and carbohydrates make up primary metabolites. Certain species rely on the carbohydrates found in seeds and fruits for reproduction [5]. This is due to the fact that animal tissues depend on carbohydrates for both structure and function. Glucose and its metabolites serve as mammalian cells' primary energy transfer axis. In most birds, especially migratory ones, energy is stored as lipids. Lipid reserves are essential for sustaining young birds until they are able to go forage on their own. Protein in a bird's diet is to maintain the nitrogen requirement. It depends on the physiological condition of the birds, being lowest for adults and highest for hatchlings and females that lay eggs [6].

It is critical to determine the nutrient content of the *F. benjamina* fruit that the birds are consuming because it affects their survival, growth, and development. Identifying the many kinds of frugivorous birds that eat weeping figs is crucial for promoting *Ficus benjamina* conservation in Taman Botani Johor. This study aims to investigate how frugivorous birds and *F. benjamina* interact during eating in Taman Botani Johor and examine the nutritional value of the fruit that frugivorous birds eat from *F. benjamina*. The management of Taman Botani Johor can use the research data to conserve the different bird species that feed on *F. benjamina*.

2 Material and method

2.1 Study site

Taman Botani Johor is located in Batu Pahat, Johor (1°58'47.0"N 102°57'37.5"E). The study of the feeding interaction of frugivorous birds and *Ficus benjamina* was conducted for two months using visual observation. There were 21 plots in the study area, and the Weeping Fig tree only existed in Plots 1 and 16. The observation was carried out in Plot 1, called "Plot Pejabat & Bangunan Herbarium," because only the Weeping Fig in Plot 1 has the fruits while Plot 16 lacks *F. benjamina* fruits.

2.2 Feeding interaction

The feeding interaction of frugivorous birds and *Ficus benjamina* was observed from 8:00 AM until 11:30 AM and 3:00 PM until 5:30 PM. Individual birds (focal bird) were observed on the *F. benjamina* tree by using binoculars (Nikon Monarch M511 (12X42)5°), and stopwatch, the foraging time, foraging substrate (the material or plants eaten by the birds) and foraging process were recorded [7]. The video was recorded using a high-resolution camera (Canon Powershot SX740 HS 4K 40X Optical Zoom). The feeding methods are categorized into two groups: (1) Pick and reach up. (2) Pick, reach up, and reach down [8].

2.3 Nutritional composition determination

Fruits of *Ficus benjamina* were sent to Bio Synergy Laboratories Sdn Bhd for nutritional determination analysis. The method used to analyze the carbohydrate content is Phenol-Sulfuric Acid method [9]. The total carbohydrate content was calculated in Equation 1 [9]:

$$\% \text{ Carbohydrate} = 100\% - (\% \text{ Protein} + \% \text{ Fat} + \% \text{ Ash} + \% \text{ Moisture}) \quad (1)$$

The method used to analyze the fat content is acid hydrolysis [9]. The total fat content in the sample was calculated in Equation (2) and Equation (3) [9]:

$$\text{Weight of fat in sample} = (\text{Beaker} + \text{Fat}) - \text{Beaker} \quad (2)$$

$$\% \text{ Fat on dry weight basis} = \frac{\text{weight of fat in sample}}{\text{weight of dried sample}} \times 100 \quad (3)$$

The Kjeldahl method was used to determine the protein content of the fruits *Ficus benjamina* [9]. The amount of total nitrogen in the sample was multiplied with the traditional conversion factor of 6.25 as in Equation (4) and (5) [9].

$$\% N = \text{Normality of HCl} \times \frac{\text{Corrected acid volume}}{\text{weight of sample}} \times \frac{14 \text{ g N}}{\text{mol}} \times 100 \quad (4)$$

where,

N = mol / 1000 mL,

Corrected acid volume = (volume of standard acid for sample) – (volume of standard acid for blank)

$$\% \text{ Protein} = \% N - \text{Protein factor} \quad (5)$$

AOAC Official Method 934.06 was used to determine moisture content. The amount of moisture content in the sample was calculated as in Equation (6), Equation (7), and Equation (8) [9]:

$$\% \text{ Moisture} = \frac{\text{weight H}_2\text{O in sample}}{\text{weight of wet sample}} \times 100 \quad (6)$$

$$\% \text{ Moisture} = \frac{\text{weight of wet sample} - \text{wt of dry sample}}{\text{weight of wet sample}} \times 100 \quad (7)$$

$$\% \text{ Total solids} = \frac{\text{weight of dry sample}}{\text{weight of wet sample}} \times 100 \quad (8)$$

The ash content of the sample was measured using 10 grams. The sample will undergo a specific process, such as being placed in a muffle furnace and ignited for about 12 to 18 hours at approximately 550 °C [9]. The ash content is calculated using Equation (9) [9]:

$$\% \text{ Ash (dry basis)} = \frac{\text{weight after ashing} - \text{tare wt of crucible}}{\text{original sample wt} \times \text{dry matter coefficient}} \times 100 \quad (9)$$

2.4 Data analysis

All data analyses were performed using Microsoft Excel software. Analyses of behavioral data were conducted on variables including time, date, bird species, and number of individuals. Nutritional content analyses were based on triplicates of each sample reading per test.

3 Results and discussion

Table 1. List of bird species that feed on fruits of *Ficus benjamina* with its IUCN status, species abundance, and distribution status in Taman Botani Johor

No.	Common name	ScientificName	Species abundance	Family	IUCN status	Distribution status
1	Asian Glossy Starling	<i>Aplonis panayensis</i>	307	Sturnidae	LC	Resident
2	Asian Koel	<i>Eudynamys scolopaceus</i>	4	Cuculidae	LC	Resident, Migrant
3	Black-naped oriole	<i>Oriolus chinensis</i>	5	Oriolidae	LC	Resident, Migrant
4	Coppersmith Barbet	<i>Psilopogon haemaceph</i>	70	Megalaimidae	LC	Resident
5	Javan myna	<i>Acridotheres javanicus</i>	5	Sturnidae	VU	Resident
6	Little Green Pigeon	<i>Treron olax</i>	78	Columbidae	LC	Resident
7	Yellow-vented Bulbul	<i>Pycnonotus goiavier</i>	55	Pycnonotidae	LC	Resident

Keynote words: LC – Least Concern, VU – Vulnerable

Over the course of 14 days, 126 hours of sample time were spent overall. With an average of six hours and thirty minutes each day, the total observation time came to ninety-one hours. Five hundred and twenty-four birds, representing seven different species, were identified in Taman Botani Johor: Javan Myna (*Acridotheres javanicus*), Asian Koel (*Eudynamys scolopaceus*), Asian Glossy Starling (*Aplonis panayensis*), Little Green Pigeon (*Treron olax*), Coppersmith Barbet (*Psilopogon haemacephalus*), Yellow-vented Bulbul (*Pycnonotus goiavier*), and Black-naped Oriole (*Oriolus chinensis*) (Table 1). A one-way ANOVA with the following results showed no significant difference between the species: F (1, 12) = 2.77, p = 0.122. According to a correlation analysis, there is no significant link (R= 0.544, p > 0.05) between the amount of time spent eating and the quantity of fruits that each species of

frugivorous bird consumes (Figure 1). The study's findings indicate no statistically significant variation in the amount of time frugivorous birds spend feeding. In contrast to other species, the data shows that the Little Green Pigeon (*Treron olax*) feeds for the longest duration, while the Black-naped Oriole (*Oriolus chinensis*) feeds for the least amount of time. This phenomenon is explained by the Little Green Pigeon's unique feeding schedule, which sets it apart from other species. The Little Green Pigeon is most likely to visit the Ficus tree early in the morning and late in the evening. It is thought that the peak of foraging activity early in the morning restores energy stores that were used up during the fasting night before, lowering the danger of famine [10].

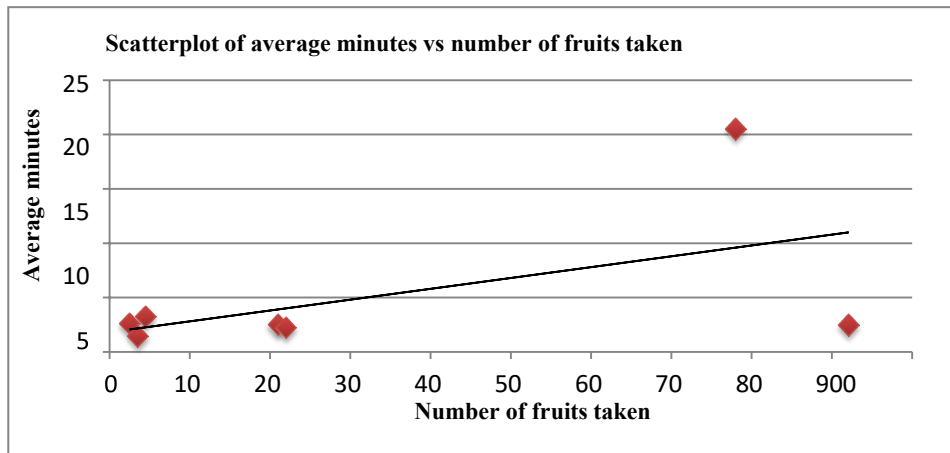


Fig. 1. Scatterplot between times spent for foraging and number of fruits taken by frugivorous birds

This study also shows no relationship between the quantity of fruits eaten by frugivorous birds and the amount of time they spend feeding. Nonetheless, the findings show that while the Asian Koel (*Eudynamis scolopaceus*) takes the fewest fruits but needs more time to feed, the Asian Glossy Starling (*Aplonis panayensis*) recorded the greatest number of fruits consumed despite having a short eating period. The disparity is because the two species have different numbers of individuals; Asian Glossy Starling has the most individuals overall, while Asian Koel has the fewest. Furthermore, the fact that young Asian Glossy Starlings feed on *F. benjamina* is a factor in the higher fruit consumption. In addition, the Asian Glossy Starling is smaller than the Asian Koel in size. The size of the frugivore's body is frequently associated with the quantity of fruit consumed during a feeding session [11].

Observations revealed that solitary feeders were the most popular feeding association, which accounted for 57% of all feeding associations. Group and solitary feeders came in second place with 29%, and group feeders with 14%. Since the Little Green Pigeon (*Treron olax*) typically travels in groups, either in the morning or evening, to and from the *F. benjamina* tree, it is categorized as a group feeder. The feeding habits of group-feeding birds are generally slower than solitary feeders. Compared to solitary feeders, group-feeding individuals can prolong the foraging period by decreasing the protection and increasing the rate of forage intake [12]. The study's findings indicate that solitary feeders are the most representative frugivorous birds in the area because they use this strategy to reduce the likelihood of intense competition when feeding. There are two species that feed both alone and in groups: the Asian Koel (*Eudynamis scolopaceus*) and the Asian Glossy Starling (*Aplonis panayensis*). While group travel is done to escape predators, solitary travel is done to prevent the spread of disease or during the non-breeding season. Many bird species use communal roosts solely during the non-breeding season and breed alone, whereas some may

be more solitary at all times [13]. Several bird species roost and breed in colonies throughout the year.

The Asian Koel (*Eudynamys scolopaceus*) is the only species that uses the pick and reach up feeding technique. The other six species use the pick, reach up, and reach down feeding techniques (Figure 2). These species include the Javan Myna (*Acridotheres javanicus*), Asian Glossy Starling (*Aplonis panayensis*), Little Green Pigeon (*Treron olax*), Coppersmith Barbet (*Psilopogon haemacephalus*), Yellow-vented Bulbul (*Pycnonotus goiavier*), and Black-naped Oriole (*Oriolus chinensis*).

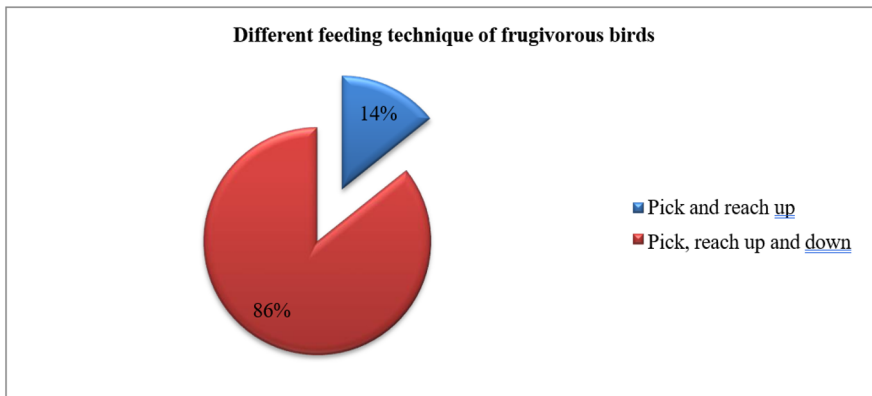


Fig. 2. The different feeding techniques of various frugivorous bird species

Except for the Asian Koel, which prefers the pick-and-reach-up strategy, all species discovered in the study area prefer to use three different feeding techniques [8]. Most frugivorous bird species will often swoop down to pluck a fruit, perhaps dropping the fruit before moving on to get more. In addition, after eating fruit from the tree, most frugivorous birds clean their bills. Several bird species wipe their bills to remove food particles that have adhered to their surface after feeding, and it has been noted that bill-wiping reflects interactions with unappealing meals [14]. Fruit that has been plucked and swallowed whole typically travels from the tip of the bill to the back of the throat in a matter of seconds in species that employ this strategy. Generally, it takes only a few seconds or less to choose and swallow whole fruits [15]. The only bird species in our study that crushed the fruits with its bill before ingesting them was the Coppersmith Barbet. The fundamental method of feeding birds is to use cut or mash feeders, where the fruit is held in the tip of the bill and frequently impales or sinks into the pulp of the upper mandible [15]. When it comes to Asian Glossy Starlings, parents feed their young until they are able to go food hunting independently. It is a normal aspect of a child's growth for them to beg for food from their parents [16].

72% of the species employed the method of swallowing the entire fruit. Little Green Pigeon (*Treron olax*), Yellow-vented Bulbul (*Pycnonotus goiavier*), Black-naped Oriole (*Oriolus chinensis*), Asian Koel (*Eudynamys scolopaceus*), and Javan Myna (*Acridotheres javanicus*) are some of these species. One species (14%) crushed the fruits before swallowing them, the Coppersmith Barbet (*Psilopogon haemacephalus*). The Asian Glossy Starling (*Aplonis panayensis*), a different species that makes up 14% of the population, occasionally feeds on its young in addition to using the method of ingesting whole fruits (Figure 3).

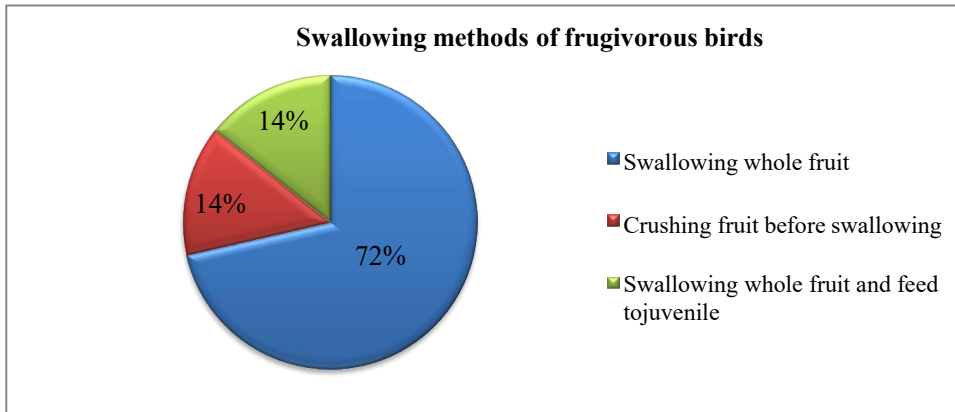


Fig. 3. The differences in swallowing methods of frugivorous birds

These birds are frugivores; they usually forage up and down, dropping fruits occasionally before moving on to other fruits. In addition, after eating fruit from the tree, the majority of frugivorous birds clean their bills. Many bird species have been observed wiping their bills for various reasons, one being to remove particles that have adhered to the bill's surface, particularly after digesting messy foods. It has been observed that interactions with unappealing items may also be reflected in bill-wiping [14]. During feeding, the Asian Koel loves to pick and reach up, traveling from branch to branch. Only the Asian Koel uses the picking technique during feeding [8]. As for the Asian Glossy Starling, they sometimes feed their juveniles with fruits picked by the adults.

The fruits of the *F. benjamina* tree provide vital nutrients for the survival, growth, and development of folivorous birds that use the tree as a food source (Figure 4). The diversity of nutrients found in *F. benjamina* fruits is essential to the survival, growth, and procreation of birds that eat fruits. The three main nutrients that make up a frugivorous bird's diet are proteins, fats, and carbs. Moisture and ash content are two other essential nutrients for birds. *Ficus benjamina* fruits were subjected to tests for primary metabolites, such as total carbs, total fat, protein, ash, and moisture. The outcomes of each test were documented. The tests were run three times for every nutrient content, and the outcomes were averaged.



Fig. 4. Fruits of *F. benjamina* tree that contain a variety of nutrient content and being consumed by the frugivorous birds

Carbohydrates are the most important of the three essential nutrients that frugivorous birds require, followed by proteins and fats. Frugivorous birds obtain carbohydrates from

their food for reproduction, growth, and development. Moreover, carbohydrates are the main energy source in frugivorous birds' bodies. All living things depend on energy, and birds are no exception. Their ability to fly and reproduce depends on it. For their reproductive activities, certain species of frugivorous birds notably depend on the carbohydrates found in seeds and fruits [5]. Since carbohydrates are involved in the formation and operation of animal tissues, they are necessary for reproduction. Carbohydrates affect the structure and function of animal tissues [5]. The average readings were as follows: carbohydrates (19.7%), fat (0.6%), protein (1.5%), ash (1.6%), and moisture (76.7%) (Table 2).

Table 2. Nutrient content in fruits of *Ficus benjamina*

Test parameter	Average reading (%)
Total carbohydrate	19.7
Total fat	0.6
Protein	1.5
Ash	1.6
Moisture	76.7

Ficus benjamina fruits have an intermediate protein level, suggesting that frugivorous birds may not be particularly fond of protein in their diet. This inclination could be explained by the possible problems—such as visceral and articular gout—that come with consuming too much protein. Birds that consume too much protein may develop articular and visceral gout due to not eliminating enough excess nitrogen from their diets through uric acid [6]. However, since birds need protein to fly and find food, protein is crucial for maintaining a healthy animal body weight. For this reason, a sufficient quantity of protein is essential in a frugivorous bird's diet. Amino acids make up protein, and during periods of feather growth and maturation, there is an increased need for amino acids [6]. This helps to explain why the young Asian Glossy Starlings eat these fruits; they need protein for their transformation into adulthood, particularly for the development of their feathers.

The lowest nutrient content is found in the fats, or lipids, in *Ficus benjamina* fruits. This suggests that various frugivorous bird species may not need a large quantity of fat in their regular diet. In a bird's physiology, lipids largely function as stored energy [17]. If lipids are not used appropriately, an excessive buildup of lipids in the body might cause problems. Large lipid stores don't need to be stored by birds who migrate slowly and feed along the route, as this could cause major problems with wing-loading [17]. Frugivorous birds in the study area, mostly resident, do not require large amounts of lipids for long-distance travel.

Among the nutrients, *Ficus benjamina* fruits have the highest moisture content. One may argue that fruits constitute a relatively low-nutrient food source because of their high water content [18]. But for birds living in tropical climates, consuming food rich in moisture is essential to keeping their bodies properly hydrated. *Ficus benjamina* fruits have a high moisture content that helps frugivorous birds stay hydrated and avoid acute dehydration, especially during long-distance travel.

Ash content is nevertheless significant since it contains various minerals, even if it is not a primary nutrient required by birds. Iron and calcium are two important minerals necessary to maintain the general health of frugivorous birds. Therefore, even though ash is not a primary nutrient, its presence contributes to the birds' well-being by providing necessary minerals.

4 Conclusion

In summary, interactions between seven species and the Weeping Fig (*Ficus benjamina*) were noted through fruit consumption. Asian Glossy Starling (*Aplonis panayensis*), Black-naped Oriole (*Oriolus chinensis*), Javan Myna (*Acridotheres javanicus*), Little Green Pigeon (*Treron olax*), Asian Koel (*Eudynamys scolopaceus*), Coppersmith Barbet (*Psilopogon haemacephalus*), and Yellow-vented Bulbul (*Pycnonotus goiavier*) are some of these species. These species' choices of feeding strategies are determined by variations in their shape and behavior, which are, in turn, influenced by feeding associations.

The most representative frugivorous birds in the research area were discovered to be solitary feeders. This preference could be explained by the fact that many of these birds do not have set eating periods, and there is less likelihood of competition with other individuals for food resources. Therefore, acting as solitary feeders is considered optimal for them.

Given that carbohydrates comprise most of the major nutrients, it follows that frugivorous birds eat the fruits of the *Ficus benjamina* plant for their high carbohydrate content, which facilitates reproduction and energy provision. On the other hand, the lowest amount is found for fats or lipids, suggesting that frugivorous birds typically avoid consuming lipids. Given the decreased protein level, it is possible that frugivorous birds do not favor high-protein diets to prevent potential damage to their visceral and articular structures.

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