

Consumption of *Ficus Grevei* Fruits (Endemic Plante) by *Treron Australis* (Endemic Bird) and Gain in the Dry Forest of Ankarana National Park Madagascar

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ABSTRACT: Ecological interactions between *Ficus grevei* and *Treron australis* in Ankarana National Park, Madagascar. This study explores the ecological interactions between *Ficus grevei*, an endemic fruit tree of Madagascar, and *Treron australis*, an endemic bird from the Colymbidae family, within the Ankarana National Park. The research provides insights into the physicochemical characteristics of the fruit and the benefits each species derives from their interaction. Characteristics of *Ficus grevei* Fruit. The fruits of *Ficus grevei* are notable for their red color, very soft texture, and smooth skin. They are attached to the tree by a peduncle. Although generally small, the fruits show relative homogeneity in terms of total mass and pulp content, with seeds representing a significant proportion of their mass. However, there is greater diversity in fruit diameter. The composition of the fruits is primarily water (80%) and carbohydrates (16.48 g), with very low amounts of lipids and proteins. This composition makes them light and hydrating, providing quick energy due to their carbohydrate content. The average mass per fruit is approximately 1.65 g, with each fruit offering 2.69 Kcal of energy. Despite their small size, these fruits can make a meaningful contribution to caloric intake when consumed in large quantities. Consumption Patterns by *Treron australis*. The number of fruits consumed, their total weight, and the consumption duration vary significantly. On average, about 10 fruits are consumed, with a total weight of approximately 18 g, over a period of 12 minutes. During this period, *Treron australis* consumes an average of: 1.85 g of lipids, 2.30 g of proteins and 35.86 g of carbohydrates. Caloric Intake Analysis, although each fruit contains only 2.69 Kcal, larger consumption volumes contribute significantly to energy intake. On average, the energy intake during a 12-minute feeding session is 47.16 Kcal. Over an observation period ranging from 1 to 15 minutes, *Treron australis* consumes a total of 843.18 Kcal on average. Conclusion: the results highlight that *Ficus grevei* fruits are primarily a source of carbohydrates with only modest contributions from proteins and lipids. These fruits play an essential role in the diet of *Treron australis*, providing quick energy and hydration, despite their small size. The interaction between these two endemic species illustrates the importance of this fruit tree for the bird's nutritional needs within the Ankarana National Park ecosystem.

KEYWORDS: Consumption, *Ficus grevei*, *Treron australis*, Ankarana National Park Madagascar

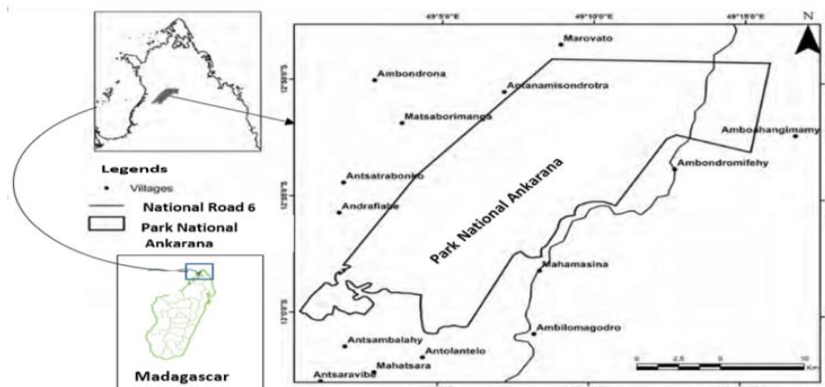
I. INTRODUCTION

Madagascar green pigeon (*Treron australis*) is a bird endemic to Madagascar, belonging to the family Columbidae. Frugivorous bird whose population is in decline [14] and has returned to different forests in Madagascar (primary and secondary forest). In terms of the number of fig-eating species and genera and the number of fig species consumed, the avian families that interact most with *Ficus* are Columbidae, Psittacidae, Pycnonotidae, Bucerotidae, Sturnidae and Lybiidae [12], [15], [11]. The *Ficus* plant of the Moraceae family includes approximately 750 species and is distributed in tropical and subtropical areas across the world [13]. Madagascar presents 24 species of *Ficus* divided into 4 subgenera and 6 sections. 15 species are endemic to the island and 4 (*F. sycomorus*, *F. trychopoda*, *F. polita* and *F. lutea*) are African and Malagasy [7]. *Ficus grevei* is among the 15 species of *Ficus* endemic to Madagascar and recorded in the Ankarana national park in the North of Madagascar. Of these 7 species of *Ficus* listed in Ankarana, it is representative (Pers. obs, 2014). *Treron australis* is the only species of the Columbidae family in Ankarana National Park [15]. Known locally as "bird *Ficus*", which is always found on the *Ficus* fruit tree. This behavior raises our question, what does *Treron australis* gain from its presence of *Ficus*? For this, we were interested in the fruits of *Ficus* since the bird is frugivorous.

II. MATERIAL AND METHODS

Study site

This study was carried out in Ankarana national park, located in the north of Madagascar (12°50'-13°01'S and 49°01'-49°14'E), during the dry season. This park has an area of 25,354 ha. The area receives an average annual precipitation of approximately 1012 mm and an average temperature of 26°C [8]. The dry season lasts 8 months of the year and the rainy season lasts 4 months (December to March). Ankarana is part of the Western Madagascar ecoregion. The natural formation is characterized by a dry deciduous forest. But several types of plant formations are distinguished in Ankarana (deciduous/dry deciduous forest of the west, semi-evergreen forest, bamboo, xerophytes on limestone rock and savannahs) [1].



Methods of collecting information

The combination of physical measurements, laboratory analyses, and behavioral observations offers a comprehensive understanding of the interaction between *Treron australis* and *Ficus grevei*. This approach allows us to analyze both the nutritional contributions of the fruits and the bird's feeding behavior, contributing valuable data to support conservation efforts and a deeper understanding of the ecological role these species play within Ankarana National Park. To gather relevant data on *Treron australis* and *Ficus grevei*, we employed various information-gathering techniques. Each method was tailored to specific research objectives.

Description of Fruits and Seeds (Measurement and Examination)

This method was used to determine the physical characteristics of *Ficus grevei* fruits. Recording qualitative characteristics: non-measurable attributes such as color, odor, and skin texture (smooth or knurled) were noted during field observations. Measuring Physical Parameters: weight and diameter: the weight of the whole fruit and pulp, as well as the diameter of the fruits, were measured. Seed Extraction and Weighing: ripe fruits were cut in half, and seeds were carefully extracted and weighed. This provided additional information about the mass contribution of seeds to the total fruit weight. This method offers insight into the physical characteristics of the fruit.

Nutritional Analysis of *Ficus grevei* Fruits

To understand the nutritional benefits of the fruits for *Treron australis*, samples of ripe *Ficus grevei* fruits were collected and sent to the National Center for Research and Environment (CNRO) in Madagascar for analysis. The laboratory analyzed the fruits for: primary Metabolites, levels of proteins, carbohydrates, lipids, and water content were determined. These analyses provided essential data on the chemical composition of the fruits and the potential nutritional gains for *Treron australis* when consuming them.

Focal Observation Method

The focal observation method was used to collect behavioral data on *Treron australis*' feeding habits and fruit consumption patterns. Procedure: observers stood under *Ficus grevei* trees bearing ripe fruits to monitor the behavior of *Treron australis*. All activities, including consumption patterns and the duration of consumption, were recorded in detail. This method helped track the bird's feeding behavior in a natural setting and provided valuable insights into fruit consumption rates and energy intake.

Energy Conversion Calculation

To estimate the energy intake of *Treron australis* from the consumption of *Ficus grevei* fruits, the following formula was used: Energy (Kcal) = [Carbohydrates (g) × 4] + [Proteins (g) × 4] + [Lipids (g) × 9]

Carbohydrates: 1 gram = 4 Kcal; Proteins: 1 gram = 4 Kcal; Lipids: 1 gram = 9 Kcal.

This formula provided an estimate of the total energy value of the fruits based on their macronutrient content.

The conversion formula from Kcal to KJ is: 1 Kcal = 4.184 KJ

To convert kilocalories (Kcal) to kilojoules (KJ), multiply the number of Kcal by 4.184.

III. RESULTS

3.1. Physical and Chemical Characteristics of *Ficus grevei* fruit

3.1.1. Non-metric description of *Ficus grevei* fruit

The recorded characteristic elements (skin color, resistance, attachment, and odor) are considered attractive criteria for fruit consumption by frugivores, particularly *Treron australis*. These attractive qualitative characteristics are reported in Table I.

Table I. Physical and sensory description of the Fruits

Fruit Characteristics	<i>Ficus grevei</i>
Color of ripe fruit	Red
Fruit skin	Smooth
Fruit resistance	Very soft
Fruit attachment	Peduncle
Fruit odor	Good, strong
Fruit taste	-

This table shows the descriptive characteristics of the fig tree fruits: *Ficus grevei*. The ripe fruits of this species are red. Their skin surface is smooth. These fruits are very soft, meaning they are easily crushable or have a very tender texture. These fruits are attached by a peduncle, which is a very small stem connecting the fruit to the small branch of the tree. They emit a good odor, which is strong and probably very noticeable. They do not have a taste. In summary, the fruits of *Ficus grevei* are distinguished by their red color, very soft texture, and strong pleasant odor. They have smooth skin and are attached to the tree by a peduncle.

3.1.2. Morphometric description of Fruit

This table presents the measurable characteristics of this *Ficus* species, in terms of fruit mass, pulp, seeds, and fruit diameters.

Table II. Morphometric Description of *Ficus grevei* Fruit

Espèces de Ficus	Measurable Characteristics	Min	Mean	Max	St.D	Var
<i>F. grevei</i>	Fruit mass (g)	0.40	1.65	3.00	0.65	0.42
	Pulp mass (g)	0.20	1.03	1.75	0.38	0.14
	Seed mass (g)	0.20	0.71	1.90	0.35	0.12
	Fruit diameter (mm)	8.12	14.39	17.50	2.29	5.24
Mean: Average Min : Minimum Max : Maximum St.D : standard déviation Var : Variance						

The fruits of *Ficus grevei* are generally small, with masses ranging from 0.40 g to 3.00 g. A variance of 0.42 and a standard deviation of 0.65 g indicate a fairly homogeneous distribution of fruit sizes. Most fruits do not deviate significantly from the average of 1.65 g. The pulp mass ranges from 0.2 g to 1.75 g, with an average of 1.03 g. A low standard deviation of 0.38 g and a variance of 0.14 suggest that the amount of pulp per fruit is relatively stable, with little significant variation. Seeds have a mass between 0.2 g and 1.9 g, with an average of 0.71 g. Seeds constitute a notable part of the total fruit mass. The moderate variance of 0.12 indicates a moderate dispersion of values, suggesting some consistency in the proportion of seed mass relative to the total fruit mass. The fruit diameter varies from 8.12 mm to 17.5 mm, with an average of 14.39 mm. The standard deviation of 2.29 mm and the variance of 5.24 show a notable diversity in fruit sizes, indicating greater variability in fruit diameter compared to other characteristics. In summary, the fruits of *Ficus grevei*, although generally small, show relative homogeneity in terms of total mass and pulp. Seeds represent a significant proportion of this mass. However, there is greater diversity in fruit diameter.

3.1.3. Chemical Characteristics of *Ficus grevei* Fruits

3.1.3.1. Primary metabolite mass (g/100g)

The chemical composition of *Ficus grevei* fruits reveals significant differences in lipids, proteins, carbohydrates, and moisture, highlighting the importance of these nutrients in their ecological roles and interactions (their attractiveness and usefulness) with local frugivorous species. The results of the metabolite analyses are reported in the table III.

Table III. Chemical Characteristics of *Ficus grevei*

Parameters	<i>F. grevei</i> (g/100g)
Lipids	00.85
Proteins	01.06
Carbohydrates	16.48
Moisture	80.09

The nutritional parameters table for *Ficus grevei* indicates the following proportions per 100 grams of fruit: *Ficus grevei* fruits contain a very low amount of lipids, making them a low-fat food (00.85g). The protein content is also low (01.06g), but it contributes to the overall nutritional value of the fruit. Carbohydrates are the main energy component of the fruits, with a notable proportion (16.48g), indicating that the fruit is primarily a source of sugars and energy. The majority of the fruit is composed of water (80.09g), which is typical for fresh fruits, making them hydrating and low in calories. In summary, the fruits of *Ficus grevei* are mainly composed of water (80%) and carbohydrates (16.48g), with very low amounts of lipids and proteins. This makes them a light, hydrating fruit and a good source of quick energy due to their carbohydrate content.

3.1.3.2. Energy Production (Kcal or Kj) of Fruit

Each *Ficus grevei* fruit has an average fresh mass of 1.65 g, indicating a small fruit size. It provides a small amount of energy. In terms of calories, each fruit provides 2.69 Kcal, equivalent to 11.24 Kj. This value (47.16 Kcal) represents the total energy obtained per 100g of fresh fruit. The fruits are small, with an average mass of 1.65g per fruit. Each fruit provides a low amount of energy, about 2.69 Kcal. Despite their small size, they can contribute significantly to caloric intake if consumed in large quantities.

3.2. Effect of *Ficus grevei* fruit on *Treron australis* in the Park

3.2.1. Descriptive analysis of Ficus Fruit Consumption

To determine the amount of fruit consumed by the Madagascar green pigeon (*Treron australis*) per unit of time, the data were subjected to a descriptive analysis. The results of this statistical analysis are presented in Table IV.

Table IV. Descriptive Analysis of *Ficus grevei* Fruit Consumption by *Treron australis*

	Number of fruit consumed	Equivalent masse (g)	observation duration (1mn-15mn)
<i>F. grevei</i>	Mean	09.99	11'71''
	Std.Deviation	10.84	04'98''
	Minimum	01.00	1'15''
	Maximum	44.00	15'00''
	Mean ± Std.	09.99 ± 10.84	17.88 ± 19.40

Std : Standard Deviation

This table presents data on the number of *Ficus grevei* fruits consumed, their equivalent mass, and the observation duration. There is a wide variation in the number of fruits consumed, ranging from just 1 to 44 fruits, with an average of about 10 fruits. The high standard deviation (10.84) indicates significant data dispersion. The total mass of fruits consumed also varies widely, from 1.79 g to 78.76 g, with an average of 17.88 g. As with the number of fruits, the high standard deviation (19.40) shows significant variability. The observed consumption time ranges from 1 minute and 15 seconds to 15 minutes, with an average of about 12 minutes. The standard deviation of nearly 5 minutes shows some variability in the observation duration. In summary, there is great variability in the number of *Ficus grevei* fruits consumed, their equivalent mass, and the consumption duration. On average, about 10 fruits are consumed, weighing approximately 18 g, over about 12 minutes. The high standard deviations in each category indicate significant data dispersion, reflecting very varied consumption habits among the observed individuals.

3.2.2. Primary metabolites per fruit and the amounts obtained per minute

The table presents the quantities of primary metabolites (lipids, proteins, and carbohydrates) per fruit and the amounts obtained per minute of consumption of *Ficus grevei*.

Table V: Primary metabolites of *Ficus grevei* Fruits, gain per unit of time

Metabolite	Per fruit (g)	Per minute (g/mn)
Lipids	0.014	0.152
Proteins	0.017	0.189
Carbohydrates	0.27	2.945

The table presents data on the primary metabolites (lipids, proteins, carbohydrates) of *Ficus grevei* fruits, both per fruit and per minute of consumption. Each fruit contains a very small amount of lipids (0.014 g). During consumption, about 0.152 g of lipids are ingested per minute. The protein content per fruit is also low (0.0175 g). During consumption, 0.189 g of proteins are ingested per minute. These fruits are richer in carbohydrates (0.272 g) compared to lipids and proteins. Approximately 2.945 g of carbohydrates are consumed per minute. The average consumption duration of *Ficus grevei* fruits is about 12 minutes. *Ficus grevei* fruits have very low lipid and protein contents per fruit, but a relatively higher carbohydrate content. During consumption, the quantities ingested per minute reflect this composition. On average, *Treron australis* consumes about 1.85 g of lipids, 2.30 g of proteins, and 35.86 g of carbohydrates over a duration of about 12 minutes. These data show that *Ficus grevei* is primarily a source of carbohydrates with a modest contribution of proteins and lipids.

3.2.3. Energy gain (Kcal or Kj) Obtained by *Treron australis*

The table presents data on the mass of fresh fruits, energy per fruit in kilojoules and kilocalories, and the average energy obtained per unit of time (1 to 15 minutes) for *F. grevei*.

Table VI: Energy gain from *Ficus grevei* Fruits

Fruit	Fresh Fruit Mass (g)	Energy (Kj/fruit)	Energy (Kcal/fruit)	Average Energy Obtained per Unit of Time (Kcal/t)
<i>F. grevei</i>	1.65	2.69	47.16	843.18

t: time (1 min - 15 min)

The table presents data on the mass of fresh *Ficus grevei* fruits and their energy contribution per fruit, as well as the average energy obtained per unit of time (1 minute to 15 minutes). Each *Ficus grevei* fruit has an average fresh mass of 1.65 g, indicating a small fruit size. It provides a small amount of energy. In terms of calories, each fruit provides 47.16 Kcal, equivalent to 2.69 Kj. This value (843.18 Kcal) represents the total energy obtained on average during an observation period (1 minute to 15 minutes). This suggests that on average, over this observation period, a total of 843.18 Kcal is consumed. The fruits are small, with an average mass of 1.65 g per fruit. Each fruit provides a low amount of energy, about 47.16 Kcal. During an observation period ranging from 1 to 15 minutes, on average, a total of 843.18 Kcal is consumed. This high average energy consumption over the observation period might indicate the consumption of many fruits during this time. Despite their small size, *Ficus grevei* fruits can significantly contribute to caloric intake if consumed in large quantities.

IV. DISCUSSIONS

Physical and Chemical Characteristics of *Ficus grevei* fruit and the energize produce

The selection of fruits by birds relies heavily on visual cues such as color and size [3]; [16]. Research suggests that birds prefer red and dark-colored fruits over green ones [2]; [4]. Birds typically have a narrow bill opening and a limited sense of smell, which influences their selection of fruits that are small, soft, and visually conspicuous (e.g., red, purple, or black). These fruits are usually presented along the branches, making them easily accessible to frugivorous birds [10].

The fruits of *Ficus grevei* in Ankarana possess several attractive physical traits for frugivores. Their color varies from yellow to red as they ripen, and they feature a round, juicy, and pulpy texture with smooth skin hanging from a peduncle. The sweet flavor and strong fragrance of the red fruits make them especially appealing to a wide range of frugivores. Our findings show that *Ficus grevei* fruits are consumed in greater numbers compared to *Ficus polita*, a species with light green to yellow fruits at maturity.

While color is an important factor in fruit selection, size also plays a critical role, as it determines whether the fruit can fit within the bird's beak opening. Research in Papua New Guinea confirms that size is a decisive factor in fruit choice [9]. Our study supports this finding: smaller fruits of *Ficus grevei* (average diameter of 16.23 mm) are more frequently consumed than the larger fruits of *Ficus polita* (average diameter of 29.34 mm). Consumption Pattern: *Ficus grevei* fruits are swallowed whole, making them easier to eat for birds with small bills. *Ficus polita* fruits, being larger, are often consumed in portions or more slowly.

In our observations, *Treron australis* (Madagascar green pigeon) consumed an average of 12.31 pieces of *Ficus grevei* in less than 15 minutes, demonstrating a preference for smaller fruits. In contrast, only 1.53 pieces of the larger *Ficus polita* were consumed on average. These results align with previous research on the relationship between fruit size and consumption rates [9]; [18].

The chemical composition of fruits, particularly their carbohydrate, protein, and lipid content, plays a significant role in determining their energy value for frugivores. Most fruits, including figs, consist of more than 80% water along with varying amounts of primary metabolites (carbohydrates, proteins, and lipids). For comparison: *Ficus perforata* (Urostigma) contains 0.44% protein and 0.30% lipids, contributing to about 11% and 9% of the digestible fraction, respectively [19]. In our study, each fruit of *Ficus grevei* contains 0.014 g of lipids and 0.01749 g of proteins. The differences in nutrient composition affect the energy yield of the fruits. For example: Ugandan figs (*Ficus exasperata*)

yield 2.78 Kcal per gram, making them an excellent source of protein [5]. In contrast, the fruits of *Ficus grevei* produce about 3.11 kJ/g (~0.74 Kcal/g), making them superior in energy yield compared to Ugandan figs

Ficus grevei is a particularly good source of carbohydrates, which makes it ideal for rapid energy release. This characteristic is beneficial for frugivores like *Treron australis* that require quick energy sources to sustain their activity levels. The high carbohydrate content provides immediate energy, while the small fruit size allows for quick consumption, maximizing energy intake within a short period.

V. CONCLUSION

In conclusion, the fruits of *Ficus grevei* found in the national park are particularly appealing to birds due to their color and size, and are highly nutritious, being rich in carbohydrates. This makes them an excellent source of quick energy. Moreover, their water content exceeds 80%, providing a significant hydration source for frugivores. The Madagascar Green Pigeon (*Treron australis*), attracted by these physical and chemical qualities, can consume 10 fruits, equivalent to a mass of 17.88 grams, in less than 12 minutes. From this intake, the bird gains approximately 2 grams of lipids, 2.30 grams of proteins, and 35.86 grams of carbohydrates, totaling around 843.18 Kcal in just 12 minutes.

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