NOTES

Frugivory and facilitation of seed germination by the Velvet Asity, *Philepitta castanea* (Müller, 1776), in the rainforest understory of Ranomafana National Park, Madagascar

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Abstract

During a 12-month study over two years of the only locally occurring avian understory frugivore, the endemic Velvet Asity (*Philepitta castanea*), in the humid forests of the Ranomafana National Park, 23 species of food plant were recorded. Half of the fruit eaten were from two families (Rubiaceae and Myrsinaceae), and the balance in 11 other families. During each month, 2–8 plant species with small, fleshy fruits provided the bulk of the diet for this species. We conducted seed germination trials of the four most eaten fruit species. The experiment showed that *P. castanea* does not affect seed germination for two species, but the regurgitated seeds of *Piper* sp. (Piperaceae) and defecated seeds for *Aphloia theiformis* (Aphloiaceae) had significantly higher germination rates than peeled or unpeeled fruits.

Key words: Frugivory, seed germination, *Philepitta castanea*, Ranomafana National Park, Madagascar

Résumé

Douze mois d'observation durant deux années de la Philépitte velouté (*Philepitta castanea*), unique oiseau frugivore du sous-bois forestier du Parc National de Ranomafana, forêt humide de l'Est de Madagascar, ont permis d'identifier 23 espèces de plantes dont les fruits sont consommés par cet oiseau. La moitié de ces plantes appartiennent à deux familles (Rubiaceae et Myrsinaceae), les autres étant distribuées dans 11 autres familles. Deux à huit espèces de plantes avec des petits fruits charnus constituent la nourriture mensuelle de cet oiseau. Nous avons effectué des expériences de germination des graines pour les quatre espèces les plus consommées. Les résultats ont montré que *P. castanea* n'affecte pas la germination de deux d'entre eux. Toutefois, les graines régurgitées de *Piper* sp. (Piperaceae) et celles déféquées de *Aphloia theiformis* (Aphloiaceae) ont montré un taux de germination significativement plus élevé, que celui des graines non ingérées (fruits décortiqués ou non).

Introduction

Madagascar is poor in the number of resident bird species as compared to continental Africa or other large tropical islands such as Borneo. However, in terms of endemism the island has high levels for both bird genera (25%) and species (51%) (Hawkins & Goodman, 2003). Madagascar's rainforest is unusual in having a diverse flora, but a depauperate frugivore community. Unlike some tropical regions, Madagascar possesses very few frugivorous animal species. For example, Costa Rica has numerous frugivorous mammals, reptiles and fish, and at least 70 understory frugivorous birds (Wheelwright *et al*., 1984; Levey *et al*., 1994). In contrast, Madagascar, specifically the Ranomafana National Park within the eastern rainforest, has only six frugivorous lemurs (Dew & Wright, 1998). Only six out of 114 bird species recorded in Ranomafana National Park eat primarily fruits [Madagascar Bulbul (*Hypsipetes madagascariensis*), Greater Vasa Parrot (*Coracopsis vasa*), Lesser Vasa Parrot (*C. nigra*), Madagascar Green Pigeon (*Treron australis*), Madagascar Blue Pigeon (*Alectroenas madagascariensis*), and Velvet Asity (*Philepitta castanea*)] (Langrand, 1990).

In the rainforests of South America, primates, bats, and birds act as seed dispersers. Although fruit bats (Megachiroptera) occur in Madagascar and one large species, *Eidolon dupreanum*, has been observed outside the forest near Ranomafana National Park, no bats have been observed eating fruits inside this forest (Dew & Wright, 1998). From our observations, *P. castanea* is the only frugivorous bird in the

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understory of the rainforest in Ranomafana National Park. This pattern is noteworthy, as according to Levey *et al*. (1994) and Schatz & Malcomber (1993), the diversity of plant families producing fleshy fruits is similar between the Neotropics (Costa Rica) and Madagascar. This current paper examines the food resources and germination of seeds regurgitated or defecated by *P*. *castanea*.

Study Area

The Ranomafana National Park Biological Station (21º16'S, 47º20'E), 25 km east of Fianarantsoa, is located inside a 43,500 ha largely intact submontane rainforest. The research reported herein was conducted in the park, along the Talatakely trail system, during 12 months between 1994 and 1995. The station is at 1000 m altitude and annual rainfall ranges from 2500 to 4000 mm (Hemingway, 1995; RNP records). Yearly minimum and maximum temperatures average 15.0ºC and 25.0ºC, respectively. The Ranomafana National Park has 114 species of birds distributed in 15 orders and 41 families.

Among trees with trunk diameter at breast height of ≥ 10 cm, the most important plant families in terms of trunk basal area, in the local forest are Lauraceae, Elaeocarpaceae, Sterculiaceae, Cunoniaceae, Moraceae, and Sapotaceae (Schatz & Malcomber, 1993). The understory of the Park National of Ranomafana has many shrubs, particularly in the families Euphorbiaceae, Rubiaceae, and Myrsinaceae (Turk, 1995).

Methods

Animal

Different studies have been conducted on the phylogeny and biology of the endemic *Philepitta castanea* (Eurylaimidae) (Prum, 1993; Prum *et al*., 1994; Razafindratsita, 1995; Rakotomanana *et al*., 2003; Prum & Razafindratsita, 1997, 2003). This species is a medium – sized bird (13 cm, 36 g) that is normally found in the forest understory. *Philepitta castanea* exhibits sexual and seasonal dimorphism in pelage coloration. This bird is restricted to the eastern rainforest and the northwest (Sambirano region) of Madagascar (Langrand, 1990; Raherilalao *et al*., 2002). Male *P. castanea* form leks (Prum & Razafindratsita, 1997), which provide an ideal locality to collect regurgitated and defecated seeds below these sites. Censuses (direct observation of a bird when feeding), and collection and identification of regurgitated and defecated seeds, were used to describe the diet of this species.

Plants and germination experiments

Fruits were categorized according to size (small fruits less than 10 mm in diameter and large fruits greater than 10 mm in diameter), color, and the number of seeds they contained (Table 1). Male *Philepitta castanea* had fixed territories during the breeding season (October – January). Germination experiments were conducted using regurgitated and defecated seeds collected from these territories. After the seeds were identified, ripe fruit collected from their parent plants were immediately used in the germination experiments, using the four most eaten fruit - *Psychotria* sp. (Rubiaceae), *Oncostemum* sp. (Myrsinaceae), *Aphloia theiformis* (Aphloiaceae), and *Piper* sp. (Piperaceae). Those fruits defined as the most eaten were not only based on the number of regurgitated and defecated seed observed during the study, but also, the frequency of feeding observation on those plants. Particular attention was given to the ripeness and the quality of fruits (e.g., not parasitized) collected for the germination experiment. For each plant species, the same number of completely unpeeled fruit and seeds from peeled fruits were sown as for regurgitated or defecated seeds. Seeds were planted on soil taken from near the study site, put in small plastic containers, and then placed in a shady area at the research station. No compost was used in the germination experiment.

Table 1. Fruit characteristics of different plants consumed by *Philepitta castanea* in the Ranomafana National Park.

Plant species	Color	Size	Number of seeds/fruit
Cucurbitaceae			
Raphidiocystis sp.	Dark blue	Large	1
Erythroxylaceae			
Erythroxylon sp. 1	Brown	Small	
Aphloiaceae			
Aphloia theiformis	White	Small	7 – 9
Loranthaceae			
Bakerella clavata	Green	Small	1
Euphorbiaceae			
Phyllanthus sp.	Dark blue	Small	
Monimiaceae			
Tambourissa sp.	Green	Large	Many
Moraceae			
Ficus sp. 1	Orange	Small	Many
Ficus sp. 2	Red	Large	Many
Myrsinaceae			
Oncostemum sp. 1	Red	Small	1
Oncostemum sp. 2	Rose	Small	1
Oncostemum sp. 3	Red	Small	1
Oncostemum sp. 4	Red	Small	1
Melastomataceae			
Clidemia hirta	Black	Small	1
Myrtaceae			
Eugenia sp.	Red	Large	1

Plant species	Color	Size	Number of seeds/fruit
Piperaceae			
Piper sp.	Orange	Small	1
Pittosporaceae			
Pittosporum sp. 1	Orange	Large	
Rubiaceae			
Psychotria sp. 1	Red	Small	2
Psychotria sp. 2	Yellow/orange	Small	2
Psychotria sp. 3	Red	Small	2
Psychotria sp. 4	Dark blue	Small	2
Psychotria sp. 5	Blue	Small	2
Mussaenda arenata	Red	Small	2
Unknown family	Red/orange	Small	1

The number of seeds planted was respectively 80, 50, 100, and 7 for *Psychotria* sp., *Oncostemum* sp., *Aphloia theiformis*, and *Piper* sp. The small number of planted seeds from *Piper* was due to the difficulty of finding fruits of this plant as they generally occur from the understory to 25 m off the forest floor. However, ripe fruits in the understory part of the forest were rare because of ingestion by frugivores, and, hence, only fruits in the canopy part were available for the seed germination experiment. Number of germinated seeds was recorded and the X^2 (Zar, 1984) was used to compare the germination success of regurgitated or defecated versus peeled fruit and regurgitated or defecated versus unpeeled fruit.

Results

Feeding

During the study, fruits of 23 species of herbs, vines, shrubs, epiphytes, and trees were identified as food resources for *Philepitta castanea*. However, the fruits of only nine species were frequently eaten (Table 2), and the rest were occasionally consumed. The diet of *P. castanea* is composed generally of small fleshy fruit with 1 or 2 seeds. The color was variable (red, orange, yellow, white, and dark blue/black), with 56.5% of the fruit species eaten by this bird being red or orange. These observations are in agreement with Janson (1983) who reported that the most common combination of characteristics for the fruits of bird-dispersed species are small unprotected fruit with red, white or black color. Half of the fruits consumed by *Philepitta* were from two families (Rubiaceae and Myrsinaceae). The rest were distributed between 11 different families (Figure 1). Apparently, *P. castanea* does not specialize on one fruit even if the fruit

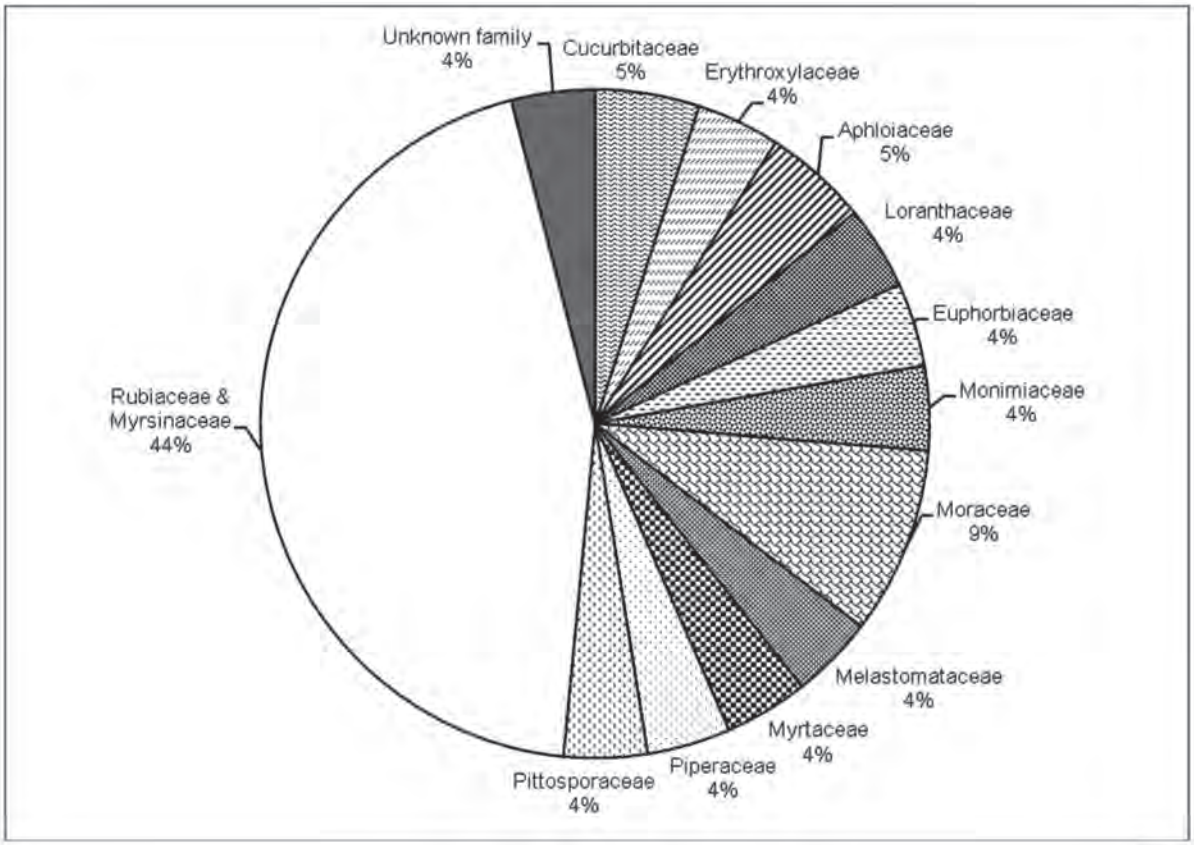

Figure 1. Graph showing the percentage of fruit consumed at the family level by *Philepitta castanea* in the Ranomafana National Park.

Table 2. Food resources for *Philepitta castanea* throughout the year in the Ranomafana National Park.

Month / Plant species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Raphidiocystis sp.										+	+	+
Erythroxylon sp. 1		+										
Aphloia theiformis	+++	+++	+++									
Bakerella clavata	++	++									++	++
Phyllanthus sp.			+	+								
Tambourissa sp.	++	++									++	++
Ficus sp. 1										+	+	
Ficus sp. 2												+
Oncostemum sp. 1					+++							
Oncostemum sp. 2								+++	+++		+++	+++
Oncostemum sp. 3										+++		
Oncostemum sp. 4		+			++	++	++	++	++		++	++
Clidemia hirta				+	+	+						
Eugenia sp.												+
Piper sp.	+++	+++									+++	+++
Pittosporum sp. 1										+		
Psychotria sp. 1				+++	+++					+++		
Psychotria sp. 2				+++	+++							
Psychotria sp. 3											+	+
Psychotria sp. 4			+	+	+	+						
Psychotria sp. 5				++	++	++						
Mussaenda arenata									+	+	+	
Unknown family										+	+	+

+++: Frequently consumed
++ : Consumed
+ : Rarely consumed (seen once)

is abundant but feeds on different fruiting plants. However, it seems to feed more on certain species such as *Psychotria* sp., *Oncostemum* sp., and *Piper* sp. when fruits of these plants are available. *Philepitta castanea* regurgitated or defecated intact seeds 20 -- 90 mm after swallowing the fruits. Small seeds up to 1 – 2 mm were defecated, whereas larger seeds were usually regurgitated. During the breeding season, males regurgitated or defecated seeds in their territory usually within 5 – 30 m from the feeding site.

Germination

Percent germination for the seeds for the four experimental species varied from 16% to 86 % for the regurgitated or defecated seeds, 13% to 77.5% for the unpeeled fruits, and 6% to 71% for the peeled fruit. When the results from all species were combined, germination success for the three types of seeds was not significantly different (Table 3). However, defecated seeds for *Aphloia theiformis* had a significantly higher

Table 3. Germination success for each species. R: regurgitated or defecated; Ri: ripe fruit; Up: unpeeled fruit; and Pe: peeled fruit.

Species	No. tested	Germination			R-Up		R-Pe	
		R	Ri	Pe	X^2	P	X^2	P
Psychotria sp.	80	59	62	57	0.31	0.58	1.26	0.26
Aphloia theiformis	100	16	13	6	0.36	0.54	5.11	0.02*
Piper sp.	7	6	5	1	7.14	0.008*	.42	0.5148
Oncostemum sp.	50	23	17	15	1.50	0.2207	2.72	0.0993

*: significant difference

germination rate than peeled fruit (X^2 = 5.11, P = 0.02). Likewise, for *Piper* sp. the regurgitated seeds had significantly higher germination rates than the unpeeled fruit (X^2 = 7.14, P = 0.008).

Discussion

Different studies have shown the importance of different species or classes of frugivores in seed dispersal and forest maintenance in Madagascar (Overdorff, 1991, 1993; White *et al*., 1995; Atsalis, 1996; Dew & Wright, 1998; Goodman *et al*., 1997; Rakotomanana *et al.*, 2003; Picot *et al*., 2007). While frugivorous lemurs have been studied in Ranomafana National Park (Overdorff, 1991, 1993; White *et al*., 1995; Atsalis, 1996; Dew & Wright, 1998), few studies have been done on frugivorous birds (Goodman *et al*., 1997; Rakotomanana *et al.*, 2003).

Philepitta are different from the majority of Neotropical frugivorous birds in several respects. First, they have never been either seen or recorded to feed on insects like most frugivore birds, for example in La Selva, Costa Rica (Levey *et al*., 1994). *Philepitta* are similar to some manakins (Family Pipridae) and one tanager (*Piranga olivacea*, Family Thraupidae), which feed exclusively on fruits (Levey *et al*., 1994). Further, *Philepitta* also differ from most avian frugivores in the Neotropics because they feed mostly on red or orange fruits rather than preferring black fruits (Razafindratsita, per. obs.) In Costa Rica, 50 out of 101 understory fruits have black or dark blue ripe fruit (Denslow *et al*., 1986; Levey 1988 in Levey *et al*., 1994), whereas in Ranomafana 13 out of 23 observed species have red, pink, and orange color, and only five of those 23 species have dark blue or brown fruits.

The passage of fruits and seeds through the digestive system of *P. castanea* does not affect the germination success for two of the four experimental plant species, but for the other two (*Aphloia theiformis* and *Piper* sp.), there is an increase in the germination rate. For *Piper*, it seems that germination of this plant is greatly facilitated by this bird as the difference between the germination rate for the peeled and unpeeled fruit is significant (86% vs. 14%, P = 0.008). In addition, *Philepitta* is the only bird in the Ranomafana forests that peels the fruit of the *Piper*, apparently through the regurgitation process. Hence, even if these birds do not increase the germination rate for some species, they are certainly important for seed dispersal away from the parent plant (Lieberman & Lieberman, 1986).

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The diet of the endemic bat *Myzopoda aurita* (Myzopodidae) based on fecal analysis

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Abstract

Fieldwork was undertaken in the station forestière d'Ivoloina, eastern Madagascar, north of Toamasina, during four months between April 2007 and May 2008 to study aspects of the natural history of *Myzopoda aurita*, including its dietary regime. Fecal samples from 11 adults were analyzed and three orders of insects (Lepidoptera, Coleoptera, and Blattaria) and one order of Arachnida (Araneae) were identified. There are differences in the importance of each insect order in the diet of *M. aurita*; Lepidoptera have the highest mean percentage volume and were identified in all samples. The mean percentage volume of Coleoptera and Blattaria were largely equal. There is similarity in the diet of *M. aurita* and *M. schliemanni* (occurring along the western portion of the island), with Lepidoptera being the dominant prey type. Fecal pellet analysis was found to be a good method to assess the diet of *M. aurita* and is applicable to dietary studies of Malagasy bats in general.

Key words: diet, *Myzopoda aurita*, scats, station forestière d'Ivoloina, eastern Madagascar

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