# *Seed carpets in Amazon flooded forests - a key seasonal resource for rainforest mammals?*

A report to the Rufford Foundation, February 2016

By: Ana Carolina Antunes

Biodiversity Section, National Amazon Research Institute (INPA), Manaus, Amazonas, Brazil.

***Igapó seasonally flooded forest – at the highwater season.***

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## INTRODUCTION

In the Amazon basin, blackwater floodplains along the Negro River and tributaries cover an area of approximately 118,000 km² (Melack & Hess 2010). Increasingly, igapó has been recognized as an important source of food resources for adjacent upland forests animals (Barnett *et al*. 2012, Beja *et al*. 2010, Haugaasen & Peres 2007, Ramos Pereira *et al.* 2013). Part of this resource base is seasonal, with two peaks of availability occurring annually: one at highest water levels, when most igapó trees are in fruit, and a second at the lowest water level, when many seeds that had been floating in the water lie exposed on the forest floor (Barnett *et al.* 2012; Haugaasen & Peres 2005, 2007). Both these periods coincide with times of reduced fruit availability in the adjacent unflooded (terra firme) forest (Haugaasen & Peres 2005). Due to this phenological asynchrony, arboreal (during the high water season) and the terrestrial animals (during the dry season) mammals move annually to the igapó forests to take advantage of these food resources (Bodmer 1990; Haugaasen & Peres 2007).

As the water level drops, seeds accumulate around obstacles such as floating logs and fallen trees (Barnett *et al.* 2012) (Figure 1). When the forest dried out, these floating seeds are deposited on the forest floor and many germinate. These dense, mat-like, multi-species patches of varying size, density and composition represent a food resource for golden-backed uacari (*Cacajao ouakary*, Pitheciidae) and arboreal rodents, but there are also evidence that this seed drafts attract peccaries and terrestrial rodents either (Barnett *et al.* 2012). The potential importance of these seed patches was only recently recognized (Barnett *et al.* 2012, Haugaasen & Peres 2007, Piedade *et al.* 2010) and it is not known how they affect the animals that inhabit the region. In this study we began such investigations by looking at how seed banks influence mammal occurrence in igapó forests. In addition, this could contribute in the future expansion of knowledge about the ecological dynamics of such seed banks:

consumption and seed dispersal by animals, as well as the importance of floodplain forests as source of key resources for terra firme vertebrates.

**Figure 1: Seedlings derived from seeds that formed a seed mat having accumulated around a fallen tree when both tree and seeds were floating in the flooded season in igapó.**

**AIMS**

Thus, this study has the main objective of evaluate if the presence of this seed and seedlings accumulated areas are related to mammal occurrence in igapó forest, as well as their interactions. Specifically, we aimed to: ‘

(1) compare rodents visitation frequency at seed patches and at areas of forest floor lacking seed patches (control areas),
(2) list the mammal species visiting igapó,
(3) evaluate the consumption frequency of individual seed species by the rodents,
(4) evaluate if the seed patch size, the density of seed patches per plot and the distance between the seed patch and the edge of the nearest terra firme forest influence on rodent visitation frequency.

## STUDY SITE AND METHODS

The study was conducted in Jaú National Park (Fig. 2) (01°54'-01°57' S to 61°27'-61°28' W), located between the cities of Barcelos and Novo Airão, 220km northwest of Manaus, capital city of Amazonas State, Brazil. The average annual temperature is 26.7°C, with annual average rainfall of approximately 2,400mm and two distinct seasons: rainy and dry, (Borges *et al.* 2004). The hydrological regime has a monomodal flood pulse with average amplitude of 6-10m (Borges *et al.* 2004). The maximum flood level occurs during the second half of June and the minimum water level in early November [PELD MAUA (peld-maua.inpa.gov.br); values calculated from the hydrological station data of Moura, from the Brazilian National Water Agency - ANA, located 70km downstream of the National Park. Jaú covers some 22,720km² of igapó (seasonally-flooded forest), terra firme (never-flooded lowland rainforest) and campinas (seasoannly briefly-flooded scrub forest on white sand soils). Some 12% of its area occupied by igapó forest, seasonally flooded by the Jaú River (Fundação Vitória Amazonica 1998). The study was conduct between September and November 2015, during the low water season, when the igapó was unflooded.

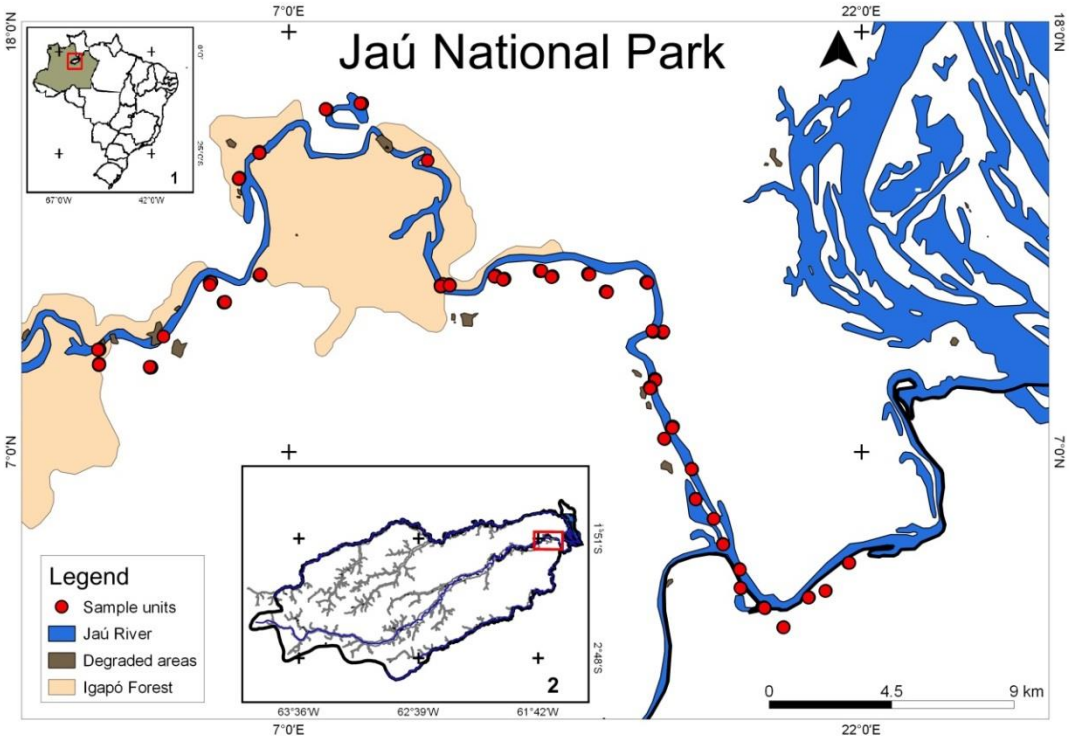


**Figure 2: Location of Jaú National Park, Brazil (inset top upper left), of the study site within Jaú (inset bottom centre) and of the sample sites along the Jaú River (main map).**

To study the interactions between rodents and seed patches, we used 36 plots (50 X 20m) on the floor of unflooded igapó forest. Within each plot we:

(I) recorded the size of all seed banks;

(II) randomly selected a seed bank per plot (so that banks of various sizes were sampled), then positioned a camera trap there for 15 days. To test whether animals were selectively visiting the area of forest floor with seed patches more often than random, an equal number of camera traps was also positioned covering areas where no seed banks were present (Fig. 3);

**(III)** determined density and identified the seed/seedling composing. We sampled each seed bank using 1m X 1m sub-plots within the seed bank and its size-paired control area (Fig. 4). Seedlings and seeds were identified at the Max Planck Institute herbarium, Manaus, with the assistance of parataxonomists from INPA.

**Figure 3: Control area of unflooded igapó (left) with no seed mats; (right) a seed mat close to which a camera trap will be positioned.**

**Figure 4.: 1m X 1m sub-plots used to sample the density and composition of each seed bank.**

## RESULTS

We found 89 seed patches of which 36 were randomly selected for camera traps placement. Seeds and seedlings from 64 identified species (and a further 8 remain unidentified) were recorded from the seed mats (Table 1). The sampling effort was of 540 camera-trap*day. We obtained 152 photographic records of 8 rodent species, 12 other mammal species and 12 bird species (Table 2). In relation to objective I, there was no significant difference ($p$=0.53) in rodents visitation frequency in areas with and without seed patches at the igapó forest studied. This may be because the animals do not hold territories in the áreas they are visiting, and the day-to-day composition of the seed mats will change as other species eat from them. Thus, the animals may transitt through the general region searching for resources, rather than being attracted to a specific patch or patch comtaining area.

In relation to objective II, indirect records of the animals presence in the dry igapó forest was also obtained from pawprints, burrows, feces, and seeds and seedlings consumed (Fig. 5). These traces are further evidence that the animals leave the terra firme forest and use the igapó during the low water and dry period at Jaú floodplains, as well as indicating which species do so. Analyzes were also made by comparing the mammal community visitation to areas where there are seed deposition, to control areas. No Significant differences were found ($p$> 0.05). However, given the abundance of mammals and birds reprted and the fact that all but seven were either partially or completely frugivorous or granivorous we feel this preliminar investigatiin has, indeed

shown that unflooded igapó and the concentrated resources on its floor provide food resources to mammals of a hitherto unrecognised level of importance. That these have impacts at higher trophic levels is, we believe, evidenced by the very high encounter rates with predator species – for example 25 of the mammal records (21.9% of total mammal images) were of wild cat species..

Analysis are still being performed on data relating to objectives III and IV and data will be submitted in a second report.

**Fig. 5: Seeds consumed by a rodent on floor of unflooded igapó forest**


**Fig. 6A: Having retrieved it from a seed mat on the unflooded igapó forest floor, a tree-rat uses a vine to carry a a seed up into the canopy:, Jaú National Park, Oct. 2015**


**Fig. 6B: A Paca (*Cuniculus paca*), a terrier-sized frugivorous and granivorous rainforest rodent, photographed by camera trap while visiting unflooded igapó, Jaú National Park, Oct. 2015**


**Fig. 6C: The presence of prey species like the paca attracts predators: black jaguar in unlooded igapó - Jaú National Park, October 2015.**

**NEXT STEPS**

Once the full analysis is completed it is intended to publish at least three articles as a result of the study. One (now nearly complete) will look at the relationship between tooth width (as determined from museum specimens) and bite impressions on fruit collected from the floor of the unflooded igapó. Part of the data was collected under the auspices of an earlier grant from the Fund to Adrian Barnett. It is intended to publish this in *Mammalia*. It is hoped the data under analysis will yield two more papers, one of the use of the forest floor by rodents and another on the overall importance of igapó to the region's rainforest mammals, based on the camera trap data. It is intended to submit one paper to the *Journal of Zoology* and another to the *Biological Journal of the Linnean Society*. Currently, there are few studies that address the issue of mammals in igapó forests occurrence and distribution, so these papers will, it is hoped be of value both ecologically and in conservation terms.

Overall this study appears to corroborate others in showing that igapó forest while still very understudied and so little understood. During the dry season these animals move to the igapó forest in search for food resources, roosts sites (bats), and water. Consequently it is a key Amazonian environment both for the animals that are

endemic to it, and for those which spend the majority of their time in the adjacent terra firme.

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**TABLES**

**Table 1: Plants with recorded from seed mats**

| |
|---|
| **ARECACEAE** |
| *Geonoma* sp. 1 |
| *Iriartella setigera* |
| *Leopoldina pulchra* |
| *Oenocarpus mapora* |
| **BIGNONIACEAE** |
| *Tabebuia barbata* |
| **CHRYSOBALANACEAE** |
| *Couepia paraense* |
| *Hirtella* sp. 1 |
| *Hirtella* sp. 2 |
| Cf. *Hirtella* sp. 2 |
| *Licania apetala* |
| *Licania heterophyla* |
| *Licania* sp. 1 |
| *Licania* sp. 2 |
| *Licania* sp. 4 |
| *Licania* sp. 5 |
| *Licania* sp. 6 |
| **CLUSIACEAE** |
| *Calophyllum brasiliense* |
| *Garcinia* sp. 1 |
| **COMBRETACEAE** |
| *Buchenavia* sp. 1 |
| *Combretum* sp.1 |
| *Combretum* sp.2 |
| *Combretum* sp.3 |
| *Combretum* sp.4 |
| **CONNARACEAE** |
| *Connarus* sp.1 |
| *Rourea* sp.1 |
| **EBENACEAE** |
| *Diospyros* sp.1 |
| **EUPHORBIACEAE** |
| *Alchornea* sp.1 |
| *Amaioa* sp.1 |
| *Amaioa* sp.2 |
| *Mabea nitida* |
| *Mabea* sp. 2 |
| *Mabea* sp. 3 |
| **FABACEAE** |
| *Acosmium* sp.1 |
| *Cynometra* cf. *bauhinifolia* |
| *Cynometra* sp.1 |
| *Cynometra* sp.2 |
| Cf. *Cynometra* sp.2 |
| *Dipytex odorata* |
| *Dalbergia* sp. 1 |
| *Hydrocorea* sp.1 |
| *Hydrocorea* sp.3 |
| *Ormosea* sp.1 |
| *Ormosea* sp.3 |

| |
|---|
| *Swartzia poliphyla* |
| *Swartzia* sp. 1 |
| *Swartzia* sp. 2 |
| *Swartzia* sp. 3 |
| *Tachigalia* sp. 1 |
| *Tachigalia* sp. 2 |
| *Tachigalia* sp. 3 |
| **HUMIRIACEAE** |
| *Sacoglotes* sp..1 |
| *Sacoglotes* sp.. 2 |
| **LECYTHIDACEAE** |
| *Eschweilera tenuifolia* |
| **LAURACEAE** |
| *Ocotea* sp.1 |
| *Ocotea* sp.2 |
| **LOGANACEAE** |
| *Strychnos* sp. 1 |
| **MALPHIGIACEAE** |
| *Byrsonima* sp.1 |
| **MYRTACEAE** |
| *Eugenia* sp. 1 |
| *Eugenia* sp. 2 |
| **PASSIFLORACEAE** |
| *Passiflora* sp.1 |
| **RUBIACEAE** |
| *Coussarea* sp.1 |
| **SAPINDACEAE** |
| *Allomphylus* sp.1 |
| **SAPOTACEAE** |
| *Elaeolyma* sp.1 |
| *Elaeolyma* sp.2 |

**Table 2: Animals recorded by camera trap**

| **SPECIES** | **FRUIT/ SEEDS IN DIET ?** | **NUMBER OF RECORDS** |
|---|---|---|
| **Rodents (N=33)** | | |
| *Hydrochoerus hydrochaeris* | Some | 1 |
| *cf Oecomys sp* | Yes | 3 |
| *Cuniculus paca* | Yes | 10 |
| *Dasyprocta leporina* | Yes | 1 |
| *Isothrix cf bistriata* | Yes | 1 |
| *cf Makalata sp* | Yes | 8 |
| *Proechimys sp.* | Yes | 5 |
| *cf Proechimys sp.* | Yes | 5 |
| **Other Mammals (N = 81)** | | |
| *Didelphis marsupialis* | Some | 14 |
| *Philander* sp | Some | 21 |
| *Tapirus terrestris* | Yes | 1 |
| *Mazama guazoubira* | Yes | 1 |
| *Mazama nemorivaga* | Yes | 5 |
| *Tayassu tajacu* | Yes | 4 |

| | | |
|---|---|---|
| *Pteronura brasiliensis* | No | 2 |
| *Leopardus pardalis* | No | 13 |
| *Leopardus wiedii* | No | 8 |
| *Leopardus cf. wiedii* | No | 1 |
| *Panthera onca* | No | 4 |
| *Cebus albifrons* | Yes | 7 |
| **Birds (N=38)** | | |
| *Psophia leucoptera* | Yes | 1 |
| *Crypturellus undulatus* | Yes | 5 |
| *Crypturellus* sp. | Yes | 2 |
| *Tinamus* cf. *guttatus* | Yes | 2 |
| *Tinamus major* | Yes | 4 |
| *Tinamus* sp. | Yes | 1 |
| *Pauxi tuberosa* | Yes | 8 |
| *Tigrisoma lineatum* | No | 2 |
| *Cairina moschata* | No | 2 |
| *Geotrygon montana* | Yes | 2 |
| *Leptotila rufaxilla* | Yes | 8 |
| *Leptotila* sp. | Yes | 2 |