Determination and Comparison of Fruiting Phenology Patterns of Forest Trees in Rustic Cacao and Tropical Broadleaf Forest Habitats in Belize, Central America

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Principal Ecological Questions Addressed:

1. Do forest trees at BFREE show seasonal fruiting patterns?
2. Do differences in tree diversity and fruiting phenology exist between the rustic cacao and the nearby tropical broadleaf forest habitat?

Student Outcomes

1. Be familiar with tropical tree identification
2. Be familiar with observation techniques for determination of tropical tree flowering and fruiting.
3. Be able to understand the ecological ramifications of fruit production and dispersal systems in tropical forest communities.

Introduction

One of the most important ecological processes in tropical forests is the mutualistic relationship between fruit-eating animals (*frugivores*) and plants that produce palatable fruit for animal consumption. A large proportion of tropical plant species depend on animals (birds, mammals) for seed dispersal (Frankie et al. 1974, Howe and Smallwood 1982). Either by defecation, regurgitation, or scatter hoarding, these animals are responsible for moving seeds away from the parent tree and siblings, thus increasing their chances of survival. In this way these dispersal agents are continually modifying the structure and composition of a tropical forest. Wherever you find a tree that produces animal-dispersed fruit, it is likely that it arrived in that spot courtesy of an animal.

The importance of fruits in the diet of tropical birds is well known (Wheelwright et al.1984). In a study in Costa Rica, frugivores of 69 species accounted for 57% of the total mist net captures (Levey 1988). In addition to tropical resident frugivores such as toucans, trogons, manikins, and euphonias, migrant frugivores such as thrushes, catbirds, tanagers, and orioles add to the tropical frugivore guild during the winter. The variety of fruit types and forms among tropical plants is also important. Differences in shape, presentation, and size may affect frugivore preferences. Larger birds such as toucans and trogons may favor larger fruits while smaller birds such as manikins and euphonias may prefer smaller fruits (Wheelwright 1986). Clearly with so many bird-dispersed plants and frugivore species the tropical bird-fruit system is a complex one.

No less important in the tropical animal-fruit dispersal system are mammals. The diets of many species of bats, monkeys, and rodents include fruit and their role in seed dispersal has been well established (Wunderle 1997). Bats, in particular, have been shown to play a critical part in the re-colonization of cleared land with their "seed rain" as they defecate while in flight (Fleming and Heithaus 1981).

While many birds and mammals have a mutualistic relationship with fruit, some animals such as parrots and rodents take more of an interest in the seeds of the fruit. Certain birds, such as parrots, are not dispersal agents but instead eat the seeds and are thus *seed predators*. A flock of parrots descending upon a fruiting tree may cause significant reduction of a tree's fruit crop (Villaseñor-Sánchez et al. 2010). Thus, just as trees may attract frugivores that disperse their seeds, they may also attract animals that eat their seeds. Therefore seed eating birds, including parrots, are constantly searching the forests for fruiting trees, moving from one area to another and from one tree to another.

Mammals such the agouti (*Dasyprocta agouti),* have a more complex relationship with fruiting trees as they are both seed predators and dispersal agents (Haugaasen et al. 2010). Agoutis scatter hoard seeds in the same manner as squirrels in our temperate forests. Moving seeds away from the parent tree is vital for seedling survival and agoutis appear to do this quite well (Jansen 2012). Indeed, studies have suggested that the agouti may be critical for the long-term survival of the tropical tree *Hymenaea courbaril* (Howe 1984). Moreover, changes in mammal community composition, including the loss of agouti, appear to have played an important role in the reduction of forest diversity on islands in Lago Gatun, Panama (Asquith et al. 1997, Leigh et al. 1993). Poaching of seed dispersing rodents may also impact seed dispersal and seedling survival (Wright 2000). Thus the agouti appears to be a critical part of certain tree species' regeneration ecology, such that the loss of this rodent may ultimately precipitate the local extinction of these trees.

Another rodent of interest is the forest spiny pocket mouse (*Heteromys desmarestianus).* Studies in the Bladen Nature Reserve (near BFREE) showed that forest spiny pocket mice are significant seed dispersers and predators of tree seeds (Brewer and Rejmanek 1999). Early trapping results from the BFREE Small Mammal Project have found this mouse to be common in the undisturbed tropical forest habitat, but uncommon in the cacao (Sara Ash personal communication). Whether this is due to lack of relevant seeds in the cacao or other factors remains to be seen.

Thus whether an animal is eating fruits or seeds, their presence in any forest may be dependent on the availability of fruit. In 2009 an abundant prickly yellow (*Zanthoxylum riedelianum*) fruit crop in January attracted Scarlet Macaws to the Bladen. In 2010 however prickly yellow did not fruit and the macaws were a rare sight (Jacob Marlin personal communication). Therefore determining when trees produce fruit as well as what trees are fruiting is critical to the understanding of the overall tropical forest ecology.

When tropical plants produce fruit (*phenology)* depends on numerous factors including type of tropical forest (Bullock 1990), climate (Khorsand Rosa et al. 2013), soil composition (Cardoso et al. 2012), insect abundance (Levey 1988), and availability of frugivores (van Schaik et al. 1993). Studies in Costa Rica have shown clear seasonal differences in fruit production (Opler et al. 1980). Nonetheless, while most species of trees produce when other fruits are readily available in the forest, others (e.g. *Casearia corymbosa* in Costa Rican rainforest and *Virola sebifera* in Panamanian rainforest) bear fruits during annual periods of fruit scarcity, and consequently maintain species of fruit-eating birds and mammals which are critical for the dispersal and ultimate recruitment of many tree species at other times of the year (Howe 1977). Thus fruiting trees should be evident year-round.

Finally, anthropogenic effects such as forest fragmentation may also affect fruiting phenology (Athayde, and Morella 2014). Of particular concern is the impact that global warming will have on the timing of fruit production (Chapman et al. 2005, Corlett and Lafrankie 1998). Thus it is of great importance to initiate phenological studies at BFEE to determine if fruiting patterns shift in the coming decades.

Objectives

For this exercise, you will record the presence or absence of flowers and fruits for 100 canopy and sub-canopy trees in the cacao agroforest and 100 canopy and sub-canopy trees in the undisturbed tropical broadleaf forest. You will add these results to the BFREE long-term flower/fruit monitoring data set. You will also compare tree diversity and richness between the two forest sites.

Prior to field work

In addition to this guide, your instructor will assign applicable readings for you in preparation for this project. You should research tropical seed dispersal ecology and tropical forest structure. Your instructor will also discuss with you the measures you should take while in the field to maintain your health and safety.

Hypotheses and Predictions

After reading some background information assigned by your instructor and before you collect any data, think about the following questions: At what time of year should the majority of canopy trees bear fruit? Should individuals of the same species fruit at the same time? Will there be any differences in fruiting phenology between the two forest habitats? Will the two habitats show overlap in tree species? Explain your predictions. Discuss your hypotheses and predictions with members of your group.

Methods

Materials and supplies

Binoculars
Cacao and Forest Tree Species List
Phenology Data Sheets
Canopy Tree List
Measuring Tape
Camera

Study sites

1) BFREE's Rustic Cacao Agroforest. This area while centered on Cacao production, has retained the majority of its canopy trees. Comparative studies on birds and small mammals has shown that this forest, while similar to neighboring forests, does show differences in bird and mammal diversity and abundance. This study along with other studies hope to determine how and why this agroforest differs from the surrounding natural forests in its biodiversity. This forest currently has one hundred and thirty-four tagged trees.

2) Tropical Broadleaf Forest. Forest stratification is obvious in this forest with high canopy trees and a well-developed sub-story of trees and shrubs. Lianas are also common. This forested habitat is located approximately 0.5km from the Cacao Agroforest (Figure 1). This forest currently has one hundred and twenty-four tagged trees.

These two forest tracts are also being used for the BFREE Small Mammal Study and will be a major focus for future ecological comparative studies.

In both forest tracts, trees have been tagged with numbered, round metal tags and red flagging.

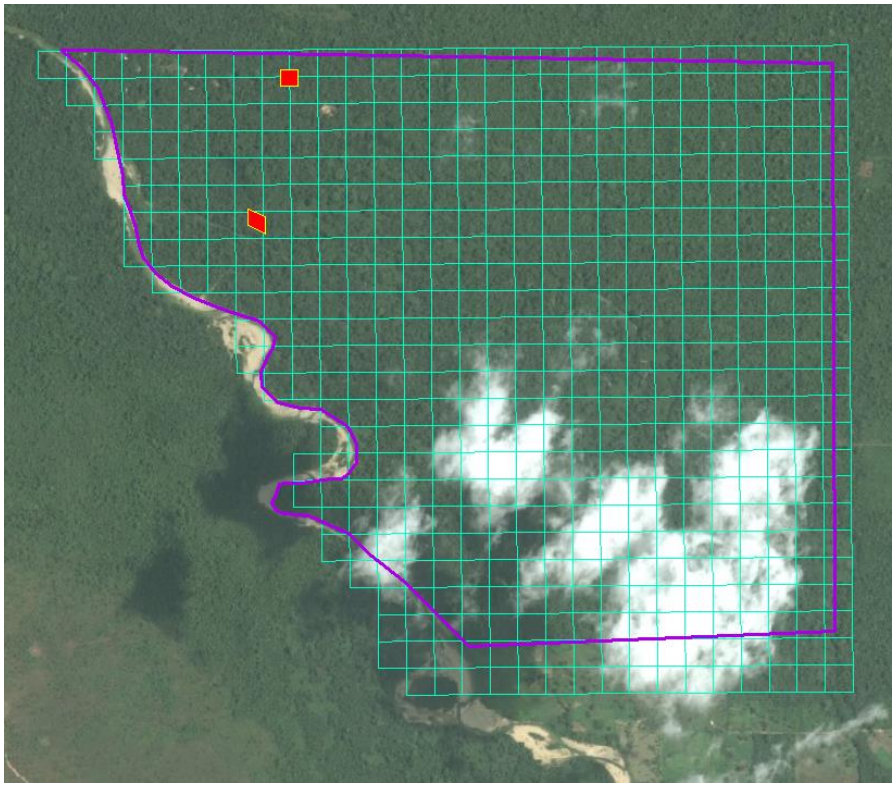

Figure 1. BFREE map (property outline in purple) with location of trapping grids indicated in red. Cacao grid is located approximately 0.5 km north of the forest grid.

Methods:

Working in groups, locate tree #1 in the plot. The numbered trees are in rows with the next row beginning at the end of the previous row. Using the provided tree species list, identify the tree. While the primary focus of this exercise is to obtain fruiting data, this is also a good opportunity to become familiar with the identification of the different tree species in the area. Take note of the following: Are the tree's leaves simple or compound? Opposite or alternate? What is the shape and size of the leaves? What is the bark texture?

Students should scan each tagged tree for fruits and flowers and record this data on the Fruit Phenology Data Sheet. Use of binoculars is essential as many of the trees are quite tall. Be careful to distinguish the tree's leaves and fruits from that of the many lianas (woody vines) that often cover individual trees. Record whether each tree has flowers (record in comments section), unripe fruits, ripe fruits, over-ripe fruits, or no fruits. If there is fruit on the ground around the base of a tree, record this in comments section. If a liana in the tree has fruit, record this in the comments section of the data sheet also. If fruit is accessible, take pictures of the fruit for positive identification if possible. If by chance the tree has birds feeding on the fruits and identification is possible, record the bird species.

Optional: Using the measuring tape, measure the Diameter Breast Height (DBH) for each tree.

Data

Trees fruit for only part of the year. Also individual plants and plant species may not fruit every year, instead producing a large mast crop intermittently. Therefore negative data (no fruit) is just as important as positive data (fruit) as we try to determine fruiting patterns of the community and individual species.

At some point, the class should transfer the hard data from their Fruit Phenology Data Sheet to an electronic document using the same data sheet. Also add the class data and date to the Fruit Phenology Master Sheet. Email these documents to the author, Stewart Skeate (skeate@lmc.edu). Your data will be compiled with the results of other student groups and made available on the BFREE website.

Data Analysis

Student Worksheets are provided that will allow you to interpret your results and compare them to results from other groups and other times of the year. Discussion questions are included that can be used in class or may be assigned as homework by your instructor.

Literature Cited and Additional Recommended Readings

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