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Annual Report of Activities

EFFECTS OF FOREST FRAGMENTATION ON SEED DISPERSAL RATES AND MAINTENANCE OF TROPICAL TREE DIVERSITY: A CASE STUDY FROM A SOUTH EASTERN MEXICAN TROPICAL FORESTS.

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Abstract

In this study we propose to investigate how forest fragmentation affect plant-animal interactions such as seed dispersal and herbivoy as well as how disruptions on these process affect the long term maintenance of tree diversity in a fragmented landscape in a South-eastern Mexican tropical forest also known as Mayan forest. We will measure diferential seed dispersal rates, seedling recruitment and herbivory on tree seedlings within forest fragments with different sizes and fauna composition. The main goal of this project is to assess how tropical forest fragmentation and defaunation affect the long term maintenance of tree species diversity in a tropical fragmented landscape. Results will document the consequences of the loss and/or alterations of plant-animal interactions on plant recruitment and, potentially, future trajectories of tropical forest tree diversity. This information in turn can help plan conservation strategies based on the maintenance of ecological processes such as biotic interactions for one of the most endangered and diverse tropical forests of the world.

Background

Growing human population and economical pressures are leading to a wide conversion of continuous tropical forests into a mosaic of disturbed habitats and isolated remnants. Most of the ecology studies have been focused in the loss of species and few works have assessed the fragmentation effects on biological process such as plant-animal interactions, although some of these process have been documented as crucial for the maintenance of tree species diversity in tropical forests. Indeed, plant-animal interactions such as seed dispersal and herbivory play a fundamental role in promoting and maintaining tree species diversity in the tropics. Seed dispersal enhance seedling recruitment by reducing density-dependent mortality. Because herbivory tend to be higher on non-dispersed seedlings near parent trees, seed dispersal may be crucial. Therefore, it is reasonable to expect that disruptions on seed dispersal services due to extirpation of vertebrate dispersers in forest fragments may enhance herbivory on seedlings, so reducing recruitment. On the other hand, drastic fragmentation and defaunation may reduce herbivory rates due to low densities of herbivores, thus favoring some competitive tree species with some ability to recruit near parents. Praticularly, large seeded tree species dispersed by vertebrates may be more prone to suffer the consequences of disruptions on seed dispersal services resulted from fragmentation. They depend upon medium to large-bodied vertebrates to disperse their seeds and its generally spread spatial distribution (<1 adult per hectare) may be viewed as an evidence of high density (distance)-dependence mortality of seedlings. Moreover, many timber woods such as some from Sapotaceae, Lauraceae and Crysobalanaceae plant families are all large seeded trees mostly dispersed by medium to large-bodied vertebrates and respond for a significative part of tropical tree species richness. Therefore, to know to which extent different levels of fragmentation and defaunation affect those process and which ecological groups of tree species are mostly affected by these disruptions is crucial to develop management plans in a fragmented landscape where human activities are still exploiting natural resources resources.

Up-to date summary of the scholarly knowledge in the field of the project

Hundreds of books and scientific articles have descibed several effects of tropical forest fragmentation on different organisms, microclimate within fragments, and some ecological process (see Laurence & Bierregaard, 1997; Bierregaard et al., 2001 for compilations). For plants, it is documented that large trees die in the forest edges due to desication and/or wind breakage, and seedling assemblages are affected in terms of composition, density and richness by fragmentation (Larance et al., 2002). For animals, medium to large-bodied vertebrates have their densities strongly reduced or are extirpated from small to medium-sized fragments (Chiarello, 1999). The consequences of these alteration in both plant and animal communities have just been documented in regard to its ecological interactions such as seed dispersal ad herbivory (Asquit el al., 1999; Terborg et al., 2001). For example, it is predicted that in predator-free fragments takes place an ecological release of herbivores what causes an increment of herbivory on plants. Cordeiro & Howe (2003) documented that forest fragmentation severs mutualisms between trees and its seed dispersers resulting in lower seedling recruitment in small fragments where seed disperser is absent with possible further extinction of tree species. The importance of seed dispersal may be evidenced by the fact that seedlings originated from dispersed seeds respond for up to 68% of the recruitments in an undisturbed forest (Webb & Peart 2001) suggesting that disruptions on seed dispersal services may have strong consequences on plant diversity. It is also documented that recruitment distance to parent tree decreases in the absence seed/seedling predators, what may cause a long term effect on the spatial distribution of future cohorts and on the maintenance of tree species diversity in a small spatial scale (Wyatt & Silman 2004). Therefore, once studies on effects of forest fragmentation have well documented effects on organisms, only recently made studies have moved further to a direction where compreension of ecological interaction between plants and animals have gained strong importance in the long-term maintenance ecological process in fragmented landscapes.

Objectives

The objective of this study is to assess to which extent different levels of forest fragmentation and defaunation can affect seed dispersal rates, seedling herbivory and the consequent maintenance of tree species diversity. More especifically, this study will experimentally evaluate three ecological process in cascade: 1) How can fragment size and/or disperser fauna composition affect seed rain features such as proportion of seeds whithin different sizes, dispersal mode and the proportion of seeds and seed species that are activelly dispersed (i.e. not dropped from parent crown); 2) How is seed rain patterns reflected in the recruitment of seedlings regarding the same features as for seed rain (i.e. seed size, dispersal mode, etc.) and 3) How patterns of herbivory on seedlings differentially affect seedling originated from dispersed and undispersed seeds and which ecological groups of seedlings (regarding seed size and/or dispersal mode) may be competitively disadvantaged by these previously cited dispruptions.

Hypothesis

In tis study I propose to test the hypothesis that fragmentation and/or defaunation diferentialy affect large seeded tree species by: first, reducing seed dispersal rates; second, reducing recrutiment of non-dispersed seeds and third, depending on the level of fragmentation reducing (small fragments) or enhancing (large fragments) herbivory on seedlings originated from non-dipsersed seeds.

Expected outputs of the project

The imediate outputs of this project is my PhD thesis and at least 3 scientific articles published in international journals of biodiversity conservation. Results will document the consequences of the loss and/or alterations of plant-animal interactions on plant recruitment and, potentially, future trajectories of tropical forest tree diversity. This information in turn can help plan conservation strategies based on the maintenance of ecological processes such as biotic interactions for one of the most endangered and diverse tropical forests of the world. Moreover, in acting in collaboration with other NGOs and conservation projects currently in progress in the zone it is expected to increase the conservation network for the Northern Mesoamerican biodiversity corridor. As a final result we expect to include the study site, Ejido Palmar, in the schedule of conservation efforts in the region.

Practical objectives for the first year of the project

I started my work stating the following objectives for the subsequent 12 months since RSG funds were available in early January 2006:

1) To establish a closer contact with the social environment of the Ejido Palmar, state of Qintana Roo, Mexico.
2) To buy equipment and material necessary to work.
3) To establish all the natural experiments related with the measure of the seed rain and seed dispersal in several contrasting forest fragments differing in area and fauna composition.

Progress in attaining these objectives

1) Contact with social environment

The contact with the administration of the *Ejido Palmar* was easy and feasible. The *Ejido* community immediately accepted my presence there and shortly invited me to give a speech in the local high-school. This speech was key for the acceptance of the work I was proposing to execute in their lands. I tried to clarify that the emerging results of my research are part of a developing strategy for the zone and that benefits are long-lasting. Since this day in February 20th of 2006 I gave four speeches in different high-schools of the zone including other in different *Ejidos*. Moreover, I could include the *Ejido Palmar* in the attention zone of the Friends of Calakmul Society who distributed their first publication of environmental education to the local children.

All of these actions served as a good start and helped us to get the confidence of the people. The results were evident when we wanted the help of local people to help in data collection. Actually we have 2 persons with monthly salaries that follow the experiments in course with a work journey of only 20h/month, what permit them to dedicate time to their own lands and help us with the field work.

2) *Acquisition of equipments*

All equipment necessary to work was purchased with RSG funds. All material and salaries resources were used. A personal computer was purchased and also was a motorcycle. The last one was not included in the initial budget but field conditions demanded the use of a vehicle that could face wet roads. Finally, salaries, cooking, and 6 travels airfares were all funded with RSG resources.

3) *Set up of experiments*

a) *Chapter 1-* **Effects of forest fragmentation on seed dispersal rates**

We started with delimiting the study plots in each of the 8 study sites. Our study sites comprised three fragmentation levels and a control site with few or no human-caused disturbance as follows: 1) Small fragments (3.5 and 4 ha); 2) Medium-sized fragments (32 and 36 ha); 3) Large-sized fragments (One 640 ha forest patch with two independent sites within it and finally, 4) Control site (Two independent sites within an undisturbed forest). In each of theses 8 sites (two per treatments), five 20x20m plots were demarcated. All trees (>10cm dbh) and saplings (> 1m heigh and < 10cm dbh) were mapped and identified. In each of the plots three $1m^2$ seed traps were placed at 1.2 m above the ground in order to assess seed rain. Therefore, a total of 15 seed traps were set up in each site, totaling 30 seed traps per treatment. The seed rain was followed for one complete year under a 15 day-interval. All seeds collected were identified into species level, were counted and separated by seed trap. We also separated seed according to dispersal mode, and seed size. Moreover, seeds were characterized as dispersed and non-dispersed comparing the list of seed species per trap with the list of tree species that would potentially be parents of these seeds. All seed whose coespecific reproductive adult was located as close as was possible to deposit seed into the traps by gravity were consided as non-dispersed. On the other hand, all seeds whose coespecific adult tree was not represented in the plot or was as far as that could not deposit seeds into the traps by gravity were considered as dispersed.

b) *Chapter 2 –* ***Effects of forest fragmentation on the proportion of dispersed seedlings.***

In order to assess how forest fragmentation reduces the proportion of dispersed seedling within seedling assemblages, we used the same plot described above to gather data for this chapter. Beside each of the seed traps we placed a 2x2m plot where all seedlings 10-50 cm were collected. Seedling were identified to species, counted and separated according dispersal mode and seed size of the species. Up to 1700 seedling of trees, herbs, lianas and palms were identified to species level and deposited in the National Herbarium of Mexico. Seedling were separated as originated from a dispersed seed or not, using the same criteria as for seeds.

c) *Chapter 3 –* ***Effects of forest fragmentation on the herbivory of dispersed seedling.***

To assess how forest fragmentation would affect the herbivory on tree seedling in contrasting situations of dispersed vs. non-dispersed we set up a natural experiment using transplanting seedling of two tree species. To date, we could use *Brosimum alicastrum* and *Manilkara zapota* seedling donated by the Vivero Florestal Othon P. Blanco to establish the experiment. Seedling of these two species were grown in similar conditions what may minimize effects of size, number of leaves and age on the natural experiments. Seedlings were transplanted into the study site in a way that simulates dispersal and non-dispersal patterns of aggregation. Simulation of dispersal consisted in sow 12 seedlings in a straight line at 2m intervals. Non-dispersed pattern consisted in sow 12 seedlings in a quadrangular disposal within a $1m^2$ plot in a paired design with the straight line that simulate dispersal. A total of 2x12 seedlings were used for each simulation in each of the eight study site. This comprises a total of 96 seedling of each species per fragment size. Before transplantation, seedlings were measured in height, number of leaves and proportion of leaf area damaged. The seedling are being followed in a 2 month basis in order to measure growth, number of leaves, and proportion of leaf area damaged in the fragmentation gradient comprised by our study sites. We hope to increase the number of species during 2007 to at least 4 species for this experiment.

Preliminary results

Chapter 1 - Effects of forest fragmentation on seed dispersal rates

A total of 14,255 seeds of 86 species were collected during one year in all fragments as a whole. The proportion of dispersed seeds varied greatly between fragments according to both dispersal syndrome and seed size. In the control plots, large sized seeds responded to the majority of dispersed seeds, followed by medium and small sized seeds (Fig. 1) and this proportion is reduced in other small fragments indicating that large seeded tree species have their dispersal probabilities reduced in these habitats as we propose.

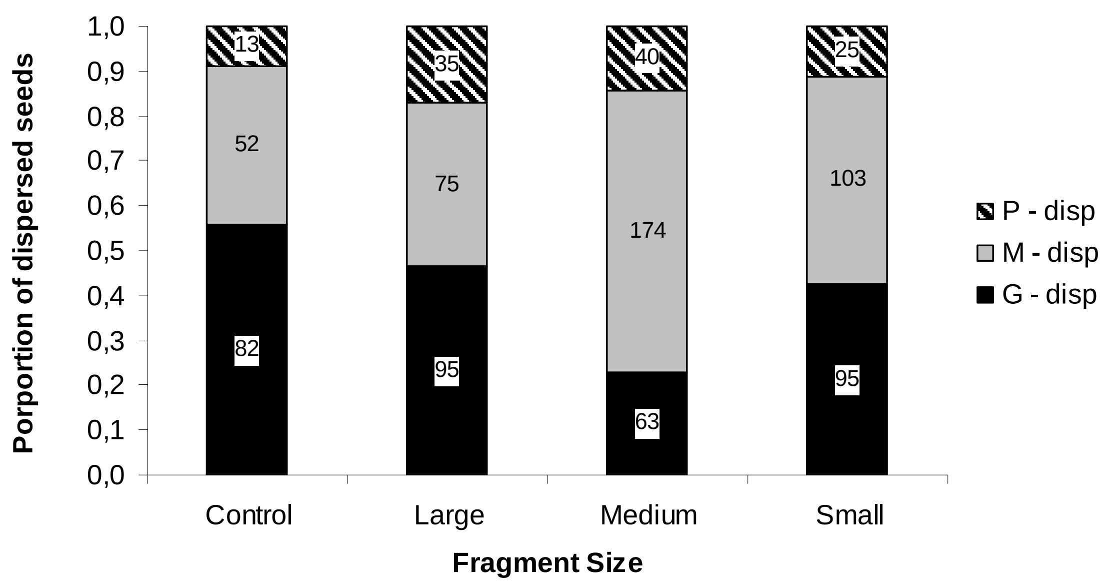

Figure 1. Proportion of zoochorous dispersed seeds according to seed size among fragments and control site. Numbers into the bars indicate total of seeds. P, M and G represented the seed sizes according to the largest length of the seed. The suffix “disp” refers to “dispersed”.

Moreover, the contribution of dispersed seed species to the total number of species collected per plot was strongly influenced by the inmigrant seeds or dispersed seeds in all sites but small fragments (Fig.2). This suggests that seed rain in small fragments have few species that came from disperser and most of seed species are from coespecific adults that deposited seeds in the traps by gravity. This means that seed rain in small forest fragments is most comprised by local seeds.

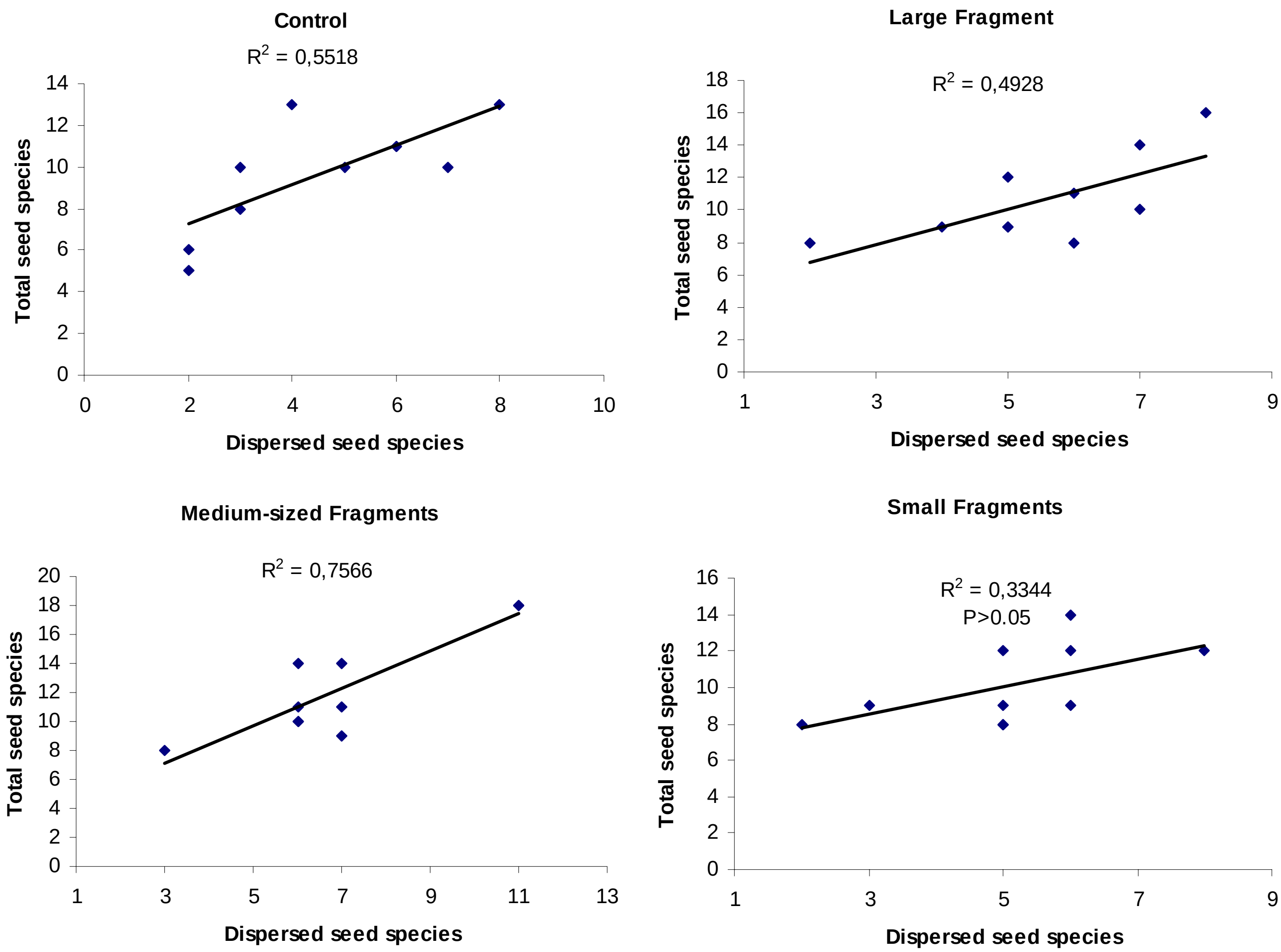

Figure 2. Relationship between total seed species collected per plot and the number of species that arrived the plot by dispersal. Note that small fragments did not presented such relationship indicating other factors as explanatory but number of dispersed seed species for the total number of species of these fragments.

Chapter 2 – Effects of forest fragmentation on the proportion of dispersed seedlings.

After identification of up to 1700 seedling to species level we were able to separate them into: trees, understory-trees, shrubs, palms, lianas and herbs. For these preliminary analyzes we used only tree seedlings in order to reduce error when comparing to the list of tree species in the plots and be more conservative in estimate de proportions of seedlings originated from dispersed seeds (hereafter referred as dispersed seedlings).

As for seeds, the distribution of dispersed seedling varied greatly among sites and the size of the seeds that originated them. Again, the control site presented the high proportion of seedlings originated from large dispersed seeds of all sites, suggesting the failure in recruit for large seeds not dispersed in small forest fragments (Fig.3).

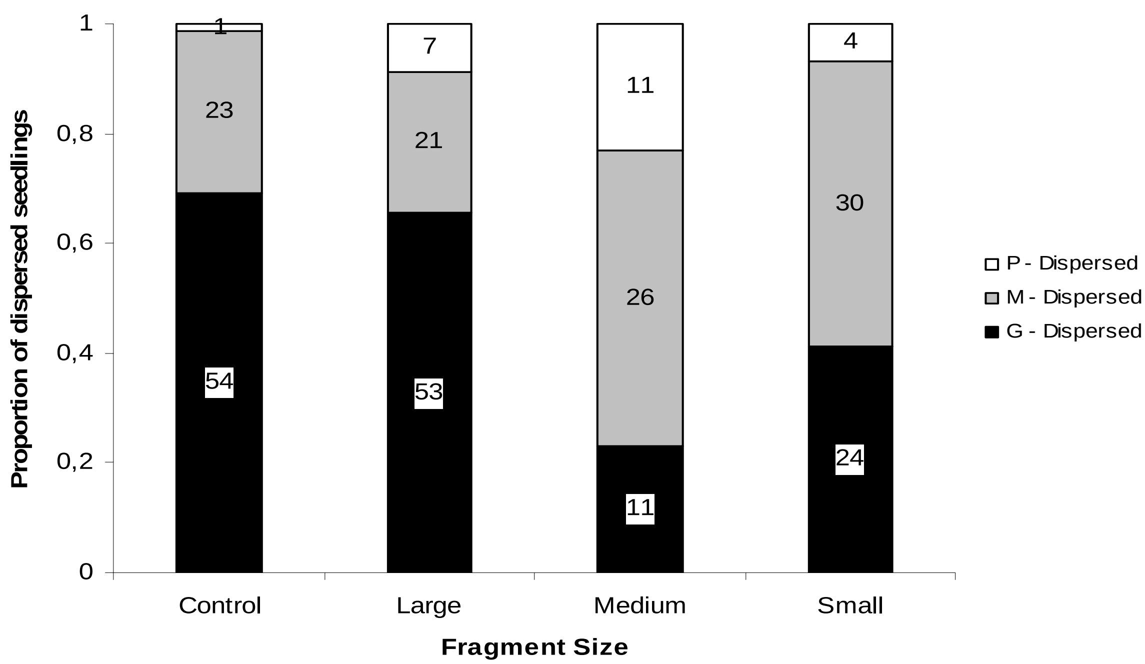

Figure 3. Proportion of zoochorous dispersed seedlings according to seed size among fragments and control site. Numbers into the bars indicate total of seeds. P, M and G represented the seed sizes according to the largest length of the seed.

As well as for seeds, the total number of seedlings per plots was strongly influenced by the seedling originated from dispersed seeds (dispersed seedlings). Here the difference is that also small fragments have their number of seedlings species per plot significantly influenced by number of dispersed seedlings (Fig.4). This suggests that the negative pressure over the non-dispersed seedlings is also acting in small fragments despite the expected and documented in the literature reduction in herbivory levels in small fragments. However, we must highlight the reduction the R squared in the model with the reduction of fragment size suggesting at least a tendency in the reduction of the contribution of dispersed seeds in originating seedling in small fragments.

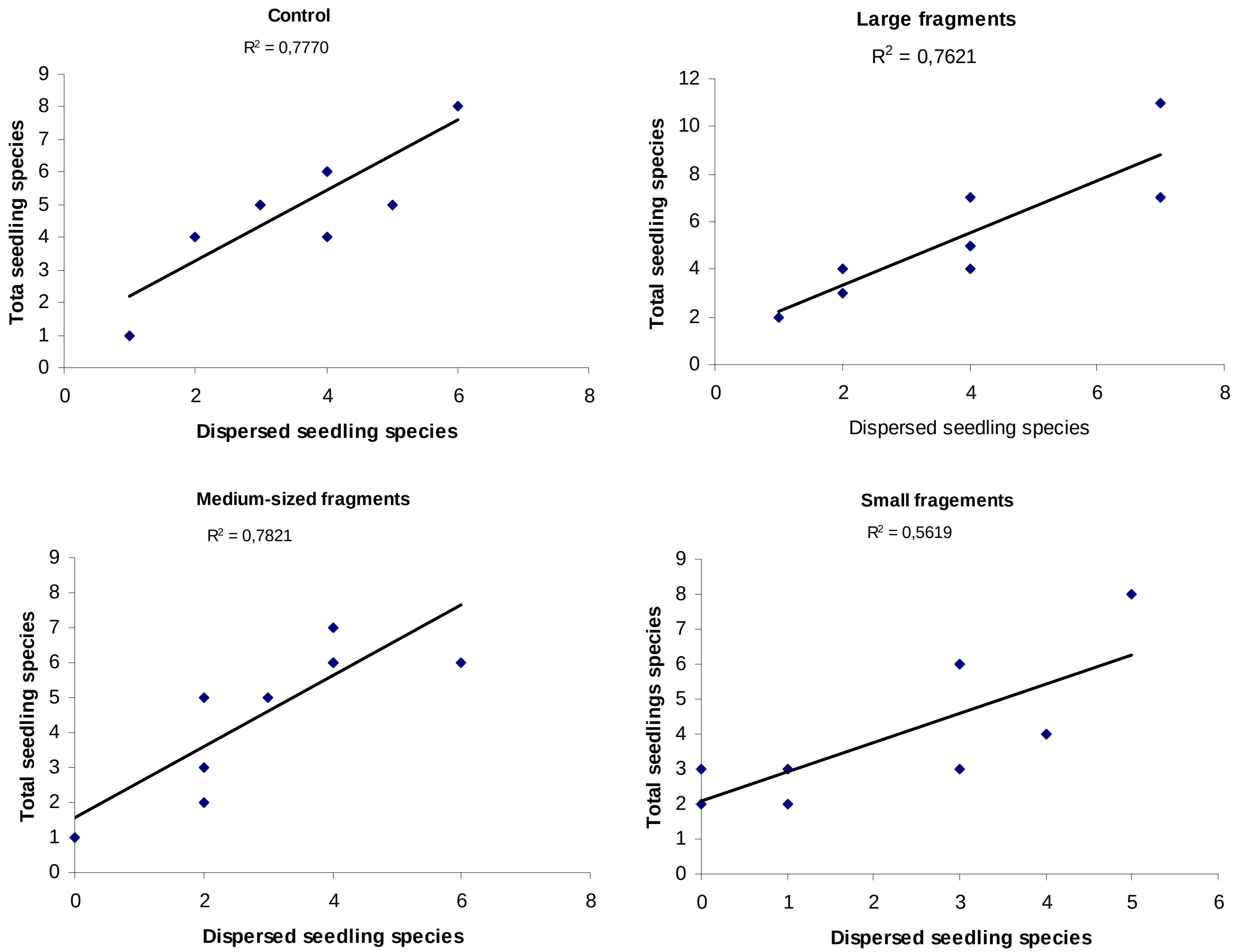

Figure 4. Relationship between total seed species collected per plot and the number of species that arrived the plot by dispersal. Note that small fragments did not presented such relationship indicating other factors as explanatory but number of dispersed seed species for the total number of species of these fragments.

Chapter 3 – Effects of forest fragmentation on the herbivory of dispersed seedling.

This chapter has no preliminary results yet. The experiments were recently established and in a few months the first data will emerge from the initial measures.

What come next?

I probably will finish my PhD studies in the following 18 months and publish at least a pair of papers with results until the end of 2007. The seed rain is still being followed until two completed years, more seedling plots will be established to increase the number of seedling for the analyzes and at least two more species will be added to the hebivory experiment (chapter 3). Moreover, results on seed rain inspired a new chapter about the role of bats as large seed dispersed in fragmented landscapes. This additional chapter is being written with the help of another RSG grantee Bernal Rodriguez Herrera from Costa Rica.

Fortunately, the project had won additional financial support from IFS (International Foundation for Science) in June 2006 that could help us to pay salaries, more airfare travel and equipment as well as material. However, we plan to apply for additional support to improve the quality of experiments, maybe a second RSG.

Budget

1. Personnel	*$ Mexican Pesos*	*£ Estelline Pounds*
1 field assitent £102.56/month/ 6 months*	$ 12,000.00	£ 615.38
SUBTOTAL	$ 12,000.00	£ 615.38

2. Equipment

1 Laptop Dell Dimension 8300, Pentium IV, 2.8 GHz, 256 MB, Windows XP.	$ 17,850.00	£ 915.38
30 Sherman traps Large Folding Galvanized Trap 3 x 3.5 x 9" 30 ga. galv. .8 lb	$ 4,400.00	£ 225.64
5 Camera-traps model Sony CyberShot DSC-P41 4.1: 5 x £102.56	$ 10,000.00	£ 512.82
SUBTOTAL	$ 32,250.00	£ 1,653.85

3. Materials and Supplies

600 m of plastic mosquitoe net 1 mm space	$ 4,000.00	£ 205.13
240 m of galvanized wire net 1 cm space	$ 7,000.00	£ 358.97
SUBTOTAL	$ 11,000.00	£ 564.10

3. Travels

4 Air fare for field work: México - Chetumal - México 4 x £177.64	$ 13,856.00	£ 710.56
Local trasportation £2.56/ day/ 180 days*	$ 9,000.00	£ 461.54
Living stippends £10.25/day/180 days	$ 36,000.00	£ 1,846.15
SUBTOTAL	$ 58,856.00	£ 3,018.26

4. Others

paper, disks, ink, flags, wood stakes	$ 2,300.00	£ 117.95
alcohol and laboratory material	$ 1,200.00	£ 61.54
SUBTOTAL	$ 3,500.00	£ 179.49

GRAND TOTAL	**$ 96,606.00**	£ 4,954.15

All funds were used as planned in the budget and most airfares than the previewed could be purchased due to offs in flight companies. Also, an used motorcycle could be bought with no defect for the project as a whole.

Photos from the field work

Photo 1. One out three seed traps used per plot to collect the seed rain in the study sites.


Photo 2. Collecting seeds from the trap.


Photo 3. Measuring herbivory in seedling immediately after transplantation.


Photo 4. Studied forest fragments completed surrounded by sugar-cane fields.

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