**Frugivorous butterfly abundance, diversity and distribution patterns in relation to habitat characteristics of Mayan forest**

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Lepidoptera – butterflies and moths – are the second most diverse order of insects. Currently 165,000 species have been described and many more await description. Diversity of Lepidoptera can reflect overall biodiversity within an area due to their dependence on specific larval host plants, interactions with predators, and their role as long-distance pollinators. This dependence of butterflies on site diversity, coupled with their rapid life cycle which means they respond to changes in the environment very quickly, make them excellent bio-indicators (Bonebrake et al., 2010). For this reason, the monitoring of Neotropical butterflies as indicators of environmental change is well established (Uehara- Prado et al. 2007: Hayes et al., 2009). Frugivorous butterflies from the Charaxinae family are often used as indicators of forest disturbance as their abundance and diversity is directly impacted by changes to the forest environment and the only persist in high numbers in primary forest.

However, in Calakmul, these butterflies appear to behave differently. A pilot study indicated that Charaxinae abundance and diversity do not vary in relation to disturbance factors, but do appear to vary considerably across different locations in the forest. This unusual behaviour is likely an artefact of the unique forest in Calakmul created by Ancient Mayan agroforestry. The tropical semi-deciduous forest in Calakmul Biosphere Reserve is unusual in that areas close to Mayan Ruins contain unusually high densities of large fruiting trees in comparison to other areas (Ross & Rangel, 2011). Moreover, the Yucatan Peninsula of Mexico contains naturally fragmented forest and savannah due to variation in rainfall patterns (Montiel et al., 2006). In addition, the tradition farming techniques of the indigenous Mayan communities have resulted in a mosaic landscape of old growth forest, regenerating forest of varying ages and farmland (Hartter et al., 2008). Much of the wildlife appears to be adapted to this changing habitat with little variation in bat (Montiel et al., 2006), butterfly (Vester et al., 2007) and herpetofaunal (Luja et al., 2008) diversity between old growth and regenerating forest.

Tropical forest are highly structured environments with the majority of the biomass being in the canopy, meaning the canopy and understorey are likely to contain different Lepidoptera communities (Schulze *et al.* 2011, Fermon et al. 2005). Lepidoptera also respond to environmental characteristics at very small scales, so you could investigate responses to vegetation structural characteristics, air temperature or fruit availability. Although the Charaxinae butterflies do not appear to be affected by disturbance factors such as access roads in the reserve, they are not distributed evenly across the reserve and therefore abundance and diversity is likely linked to forest structure and food availability.

**Methods**

The relationship between forest structure and tree species composition with butterfly community structure will be investigated by placing a series of conical traps in different forest locations which is a well-established survey method (Hughes et al. 1998). Traps will be made from mosquito netting rolled into a large cylinder with a plastic plate hung from the bottom. The plastic plate will be baited with rotten bananas and other fruit each morning at 10-11am and then checked in the afternoon between 3-4pm. Traps will be hung from suitable trees in different areas of the forest and a 20m x 20m habitat plot (using the previously described methods) will be conducted around each trap in order to record forest structure variables and tree species composition. A total

of 10 traps (5 understorey and 5 canopy) will be used in the research camps of KM20, Mancolona and Hormiguero (Figure 1). Each butterfly caught in the trap will be identified and will then be released.

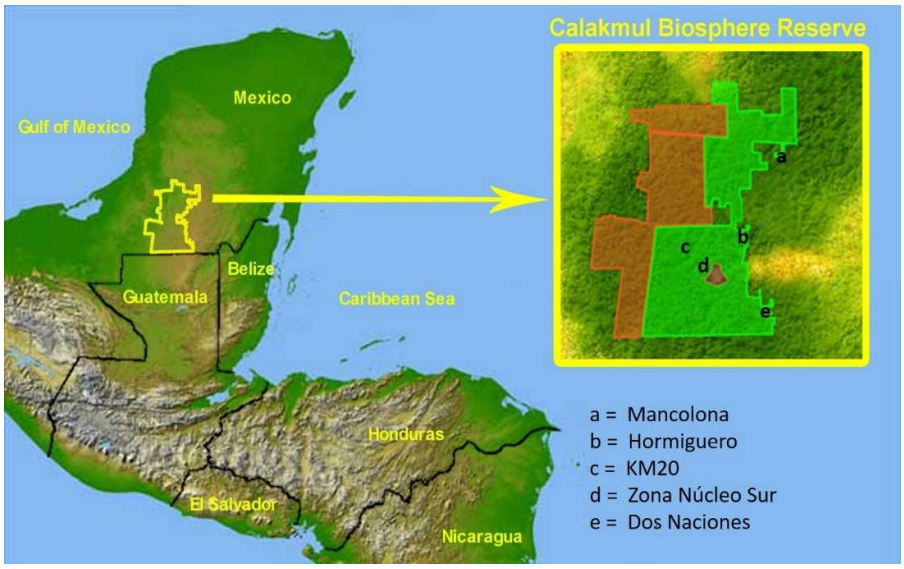

Figure 1: Location of research camps in Calakmul

Trap data can be combined with walked transect counts (Calades and Robbins, 2003) which is also a validated method for use by students and volunteers but which often records different, but complementary species. In order to protect the rich biodiversity of the Calakmul reserve the collection of specimens is not permitted. However, the use of morphospecies (where species are described in the field and given a number) is common in the tropics, especially since the biodiversity is so high and many species are still undescribed to science. The use of morphospecies has been shown to be a useful tool in the analysis of insect communities when identification to species is not always possible and has been demonstrated to be especially accurate for butterflies (Derraik et al, 2002) compared to other insect groups.

Habitat surveys will be conducted in each of 20m x 20m survey sites to investigate tree diversity and forest structure. The number of saplings (trees with circumference <15cm and a minimum height of 3 metres), and epiphytes will be counted for each plot. For each tree in the plot with a circumference >15 the species and DBH of the tree, and whether the tree is alive or dead will be recorded on datasheets. For each tree with a circumference >30cm, height of the tree will also be recorded on datasheets. The DBH and length of each fallen tree within the plot will also be recorded. Forest structure measurements include understorey vegetation, canopy cover and leaf litter depth. To measure understorey vegetation, the plot will be bisected to produce the four quadrants. A 3m pole marked in 0.5m segments will be used to record the number of vegetation touches on the pole in each 0.5m segment every 1m along these bisecting tapes. The openness of the canopy will be measured by taking a reading with a canopy scope from the centre of each of the four quadrants and one from the centre of the overall 20m X 20m square. Leaf litter depth will be recorded in each of the 4 quadrants and in the centre of the plot using a ruler to give 5 separate leaf litter measurements (mm) per plot.

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