DAVIS EXPEDITION FUND

REPORT ON EXPEDITION/PROJECT

Expedition/Project Title: Differences in photosynthetic capacity in 4 species of trees in Tropical Montane Cloud Forest of Peru

Travel Dates: 20 of June 2009 to 28th of August 2009

Location: Kosñipata valley, Manu National Park, Cusco district, Peru

Group Members: Julia Weitnritt (RBGE/ University of Edinburgh, UK)

Aims: To understand natural variation in photosynthetic capacity in 4 dominant tree species in tropical montane rain forest in preparation for estimating canopy-scale photosynthesis by the forest.

OUTCOME (not less than 300 words):

The field work was conducted in montane cloud forest located in the Kosñipata valley, within Manu National Park, south-eastern Peru (13°11' 28"S, 71°35'24"E). Mean annual rainfall is 2500mm and mean annual temperature is 12.5°C. The site elevation is 3000m above sea level. Weather conditions fluctuate diurnally, generally with clear mornings and an onset of heavy cloud around 1200-1300h.

Aims/summary of background

The original aim of my study was to quantify transpiration from the rainforest canopy, but because of technical problems, I altered my aims to quantify the capacity of the canopy to absorb carbon dioxide. My new objective was to see how the maximum (light-saturated) photosynthesis rate changes with CO_2 concentration in leaves of 4 co-domninant tree species of tree in the cloud forest ecosystem at 3000 m. The method uses the principle that by varying the concentration of CO_2 in a leaf chamber in which the leaf is placed, the biochemical rate constants can be derived. Specifically, the widely-used Farquhar photosynthesis equation (Farquhar et al. 1980) requires a specification of the two main components of photosynthesis, the maximum rate of carboxylation ('V_{cmax}') and the maximum rate of electron transfer ('J_{max}'). The two parameters can be derived by simultaneously fitting response curves for both processes to a plot of assimilation rate against the concentration of CO_2 inside the leaf, obtained by measurement. The advantage of measuring these two parameters, even though the actual measurement is rather laborious, over measuring *in situ* photosynthesis is that V_{cmax} and J_{max} can be compared more easily with values from other ecosystems, since site specific climatic influences on stomatal conductance and hence photosynthesis are excluded.

Furthermore, V_{cmax} and J_{max} values are very widely used in vegetation models that predict the productivity of a forest or ecosystem.

Methods

The tree species were chosen on the basis of their relative contribution to the canopy, estimated by the density and size of stems. The four species were: *Weinmannia crassifolia*, *Schefflera allocotantha*, *Clethra revoluta*, *Clusia cretosa*. As leaf access was difficult above 2.5 m above the ground, branches were removed from each sampled tree, and then re-cut under water to reconstitute the water column. This method affects quantification of the conductance to water vapour transfer between leaves and atmosphere, but not the estimation of V_{cmax} and J_{max}. A PP-Systems CIRAS machine was used to make the measurements. This instrument controls the concentration of CO_2 and water vapour in a leaf chamber, and also enables the control of light intensity and temperature. Leaves were inserted into the chamber and subjected to ambient temperatures (~15 °C) and humidity (~70-85% relative humidity), and to saturating photon flux densities of 1000-2000 umol m^{-2} s^{-1}, depending on whether they were natural sun leaves or shade leaves. The CO_2 concentration in the chamber was then altered from 400 umol mol^{-1} down to 50 umol mol^{-1} and then up to 2000 umol mol^{-1}. Approximately ten points were taken over this range of CO_2 concentrations. The analysis of my data was done by following the method of Domingues et al. (2009): the non-linear model of Farquhar et al. (1980) was fitted to the data, using replicates of up to 3 leaves per tree species. The measurement protocol took longer than expected, partly because of the change in aims of this work, and as a consequence my field visit was extended from 2 to 3 months. The data obtained by my study will provide insight into the species variation in V_{cmax} and J_{max}, and enable an analysis of the photosynthetic functioning of the canopy of the tropical montane cloud forest.at this site.

Results and Discussion

Although some difficulties were encountered in the measurements, clear species differences were observed among the four species (Fig. 1.). These measurements yielded a range of average V_{cmax} values from12.99 µmol m^{-2} s^{-1} (± SE 5.15) to 73.73 µmol m^{-2} s^{-1} (± SE 10.3) (Table 1). These data suggest that maximum photosynthetic rates are not substantially lower than those found for lowland rainforests, but that photosynthesis is constrained at high altitude by the lower temperature. These data will be used for more detailed modelling analysis of the CO_2 exchange of montane rainforest by the Andes Biodiversity Ecosystem Research Group (URL; http://darwin.winston.wfu.edu/andes/).

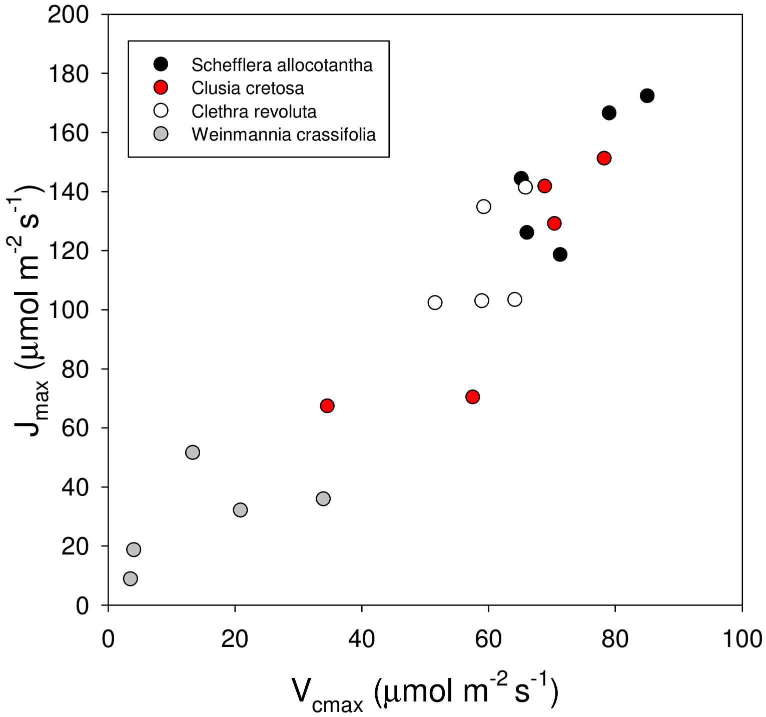

Fig. 1. The measured values for V_{cmax} and J_{max} for four species at 3000 m a.s.l. in the Kosñipata valley in Peru. Each data point represents one analysed leaf.

Table 1. Average V_{cmax} and J_{max} per species and their standard error (n=5) on an area basis.

Species	**Average V_{cmax} (µmol m^{-2} s^{-1})**	**Average $_{Jmax}$ (µmol m^{-2} s^{-1})**
Weinmannia crassifolia	12.99 ± 5.15	25.67± 5.15
Schefflera allocotantha	73.73 ± 10.3	85.17± 5.15
Clethra revoluta	58.25 ± 2.42	117.34± 5.15
Clusia cretosa	61.99 ± 7.59	111.85± 5.15

References:

Domingues TF, Meir P, Saiz G, Feldpausch TR, Veenendaal EM, Schrodt F, Bird M, Djagbletey G, Hien F, Compaore H, Diallo A, Grace J & Lloyd J. Co-limitation of photosynthetic capacity by nitrogen and phosphorus along a precipitation gradient in West Africa. Plant Cell and Environment (accept-minor)

Farquhar G.D., von Caemmerer S. & Berry J.A. (1980) A biochemical model of photosynthetic CO2 assimilation in leaves of C3 species. Planta 149, 78-90.