DAVIS EXPEDITION FUND

REPORT ON EXPEDITION / PROJECT

Expedition/Project Title:	Categorising the environmental niche of Peruvian *Begonia* species
Travel Dates:	
Location:	Peru – Cajamarca, Cuzco, Junín, Lima, & Pasco Regions
Group Members:	Peter Moonlight
Aims:	

Outcome (not less than 300 words):-

Peru Expedition 2014

Royal Botanic Garden Edinburgh

with

La Universidad Agraria La Molina (Lima)

The University of Glasgow

Introduction

The expedition to Cajamarca, Cuzco, Huanuco, Junin, Lima, and Pasco Regions of Peru was led by Peter Moonlight of the Royal Botanic Garden Edinburgh and University of Glasgow in conjunction with Universidad Agraria La Molina.

The main purpose of the expedition was to collect and determine the ecological niches of Andean *Begonia* species and to use the criteria developed by Joly et al (2014) to determine whether niche evolution in Andean *Begonia* is consistent with an adaptive radiation.

Further aims included the collection of herbarium, seed, and silica gel samples of all species of *Begonia* encountered and other key RBGE study groups; to visit Peruvian herbaria, identify *Begonia* specimens, and database them in RBGE's PADME *Begonia* database; and to develop relationships with Universidad La Molina.

Expedition Participants & Associates

Peter Moonlight (leader), RBGE & University of Edinburgh
Aniceto Daza, Universidad Agraria La Molina
Dr Carlos Reynel, Universidad Agraria La Molina
Eduardo de la Cadena, Ulcumanu Ecolodge

Expedition Itinerary

The itinerary of the expedition was significantly altered due to problems locating species, mainly arising from misidentifications by previous botanists. Consequently, we were not able to locate the planned six species of *Begonia* Sect. *Cyathocnemis* (Klotzsch) A.DC. in the two sites in Junín Region as only two species of this group live in the area. We are therefore monitoring the environment temperature, humidiy, and light environments of two species at the Universidad Agraria La Molina's La Genova research station in Satipo Province, Junín and four further species at Ulcumano Ecolodge in Oxapampa Province, Pasco. These sites were visited periodically throughout the expedition to download data from data loggers. Temperature and humidity data loggers have been left in situ for one year.

In between visits to data loggers, a number of herbaria were visited and collection trips to the Cajamarca, Cuzco, and Lima Regions were undertaken.

The following sites were visited:

Date	**Details**
15th-19th June	Arrive in Lima. Meet with counterparts. Visit Peruvian Environment Ministry and present collection permit Collect and purchase expedition equipment.
19th-23rd June	Travel to Junín Region. Visit Universidad Agraria La Molina's La Genova research station & Puyu Sacha Collect specimens at these and nearby sites
23rd-28th June	Travel to Lima. Discuss potential field sites with collaborators. Work in USM, MOL, & MOL-WEB herbaria
28th June-7th July	Travel to Pasco Region Visit Ulcumanu Ecolodge Place data loggers in Ulcumanu Ecolodge Visit HOXA herbarium Collect specimens around Oxapampa
7th July	Travel to Junín Region. Place data loggers at La Genova research station
8th July	Travel to Lima Collect specimens in Lima Region
10th July	Travel to Pasco Region. Download data from data loggers at Ulcumanu
11th July	Travel to Junín Region Download data from data loggers at La Genova
12th-17th July	Travel to Lima Work in USM herbarium
17th July	Travel to Trujillo

	Work in HUT herbarium
18th-19th July	Travel to Lima Work in USM herbarium
20th July	Travel to Pasco Region Download data from data loggers at Ulcumanu
21st July	Travel to Junín Region Download data from data loggers at La Genova
22nd July	Travel to Lima
23rd-28th July	Travel to Cajamarca Region Collect specimens In Cajamarca Region Work in CPUN herbarium
28th July	Travel to Lima
29th July	Travel to Junín Region Download data from data loggers at La Genova
30th July	Travel to Pasco Region Download data from data loggers at Ulcumanu Collect specimens in Pasco region
1st July	Travel to Lima
2nd-9th July	Travel to Cuzco Region Collect specimens in Cuzco Region
9th July	Travel to Pasco Region Download data from data loggers at Ulcumanu
10th July	Travel to Junín Region Download data from data loggers at La Genova
10th-15th July	Travel to Lima Drying and curation of specimens
15th-23rd July	Personal holiday Return to UK

Methods

Temperature and humidity data loggers were left adjacent to two species of *Begonia* at Universidad Agraria La Molina's La Genova research station in Satipo Province, Junín (*B. humilis*, *B. maynensis*) and four species at Ulcumano Ecolodge in Oxapampa Province, Pasco (*B. peruviana*, *B. parviflora*, *B. subciliata*, *B. monadelpha*) for a period of 42 days. Data points were taken at 4 minute intervals throughout the study period. At the end of the 42 day period, the data loggers were reset and programmed to take a data point every 30 minutes for 11 months. Data loggers will be removed by Peruvian counterparts in July 2015 and combined with data from the initial 42 days to provide a year of continuous data.

Hemispherical photographs were taken with a Nikon D300 camera and a Sigma 8mm fisheye lens from a level tripod facing directly upwards with the bottom of the camera

facing due north. Images taken with aperture priority at f22 to ensure all levels of the canopy were in focus and bracketed at five ±1EV intervals. The camera was placed 5cm above the growing point of the plant, which varied from 10cm to 1.5m height.

At least four collections of each herbarium specimen were made where possible to allow distribution between our partner herbarium in Peru (MOL), the Peruvian National Herbarium (USM), the Royal Botanic Garden Edinburgh (E), and relevant taxonomic specialists. Specimens were initially dried in 70% alcohol in the field before transfer to Universidad La Molina where they were dried over kerosene stoves. Where possible, seed was collected and dried in tea bags and silica gel samples were taken to facilitate phylogenetic study. Field data was entered into a spreadsheet and imported into RBGE's PADME *Begonia* dataset and BGBase.

Results

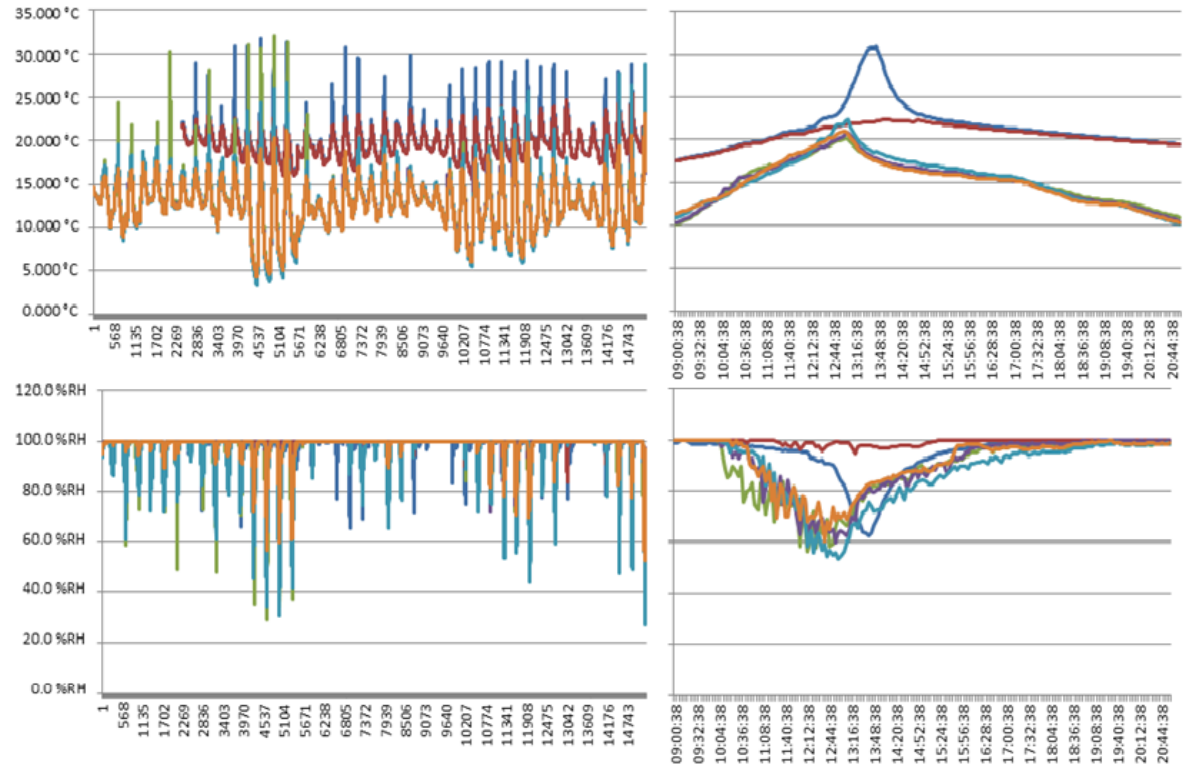

Figure 1– Plots of temperature (top) and humidity (bottom) against time for 42 days (left) and a representative day (right) for data loggers adjacent to B. humilis (blue), B. maynensis (red), B. monadelpha (green), B. parviflora (purple), B. peruviana (lt. blue)

Preliminary analyses of temperature and humidity from the initial 42 days show that the largest source of variation in temperature and humidity is between sites. However, it is clear that there are differences between the environments inhabited by species within sites. These differences do not manifest on cloudy days (e.g. see Fig.1 example day at the Pasco site) but on cloudless days (see Fig. 1 example day at the Junín site) temperature differs by up to 9ºC between species while relative humidity differs by up to 70%. This is despite all species growing within 100m of each other at both sites. The addition of 11 months of further data in July 2015 will allow these observations to

Figure 2 - Map of herbarium specimens made during the expedition

be expanded and Repeat Measure ANOVA tests to determine whether environmental conditions differ significantly between species' localities.

Due to financial constraints, it was not possible to place data loggers next to multiple plants of each species; however, hemispherical photographs were taken above multiple plants of each species at both sites and species elsewhere (see Fig. 3). Analysis of these images is ongoing and will allow the categorisation of the light environment of the species.

A total of 82 herbarium specimens of *Begonia*, Gesneriaceae, *Calceolaria*, and Solanaceae were made (see Fig. 2). These specimens currently remain in Peru due to problems attaining an export permit while the Peruvian environment ministry undergoes a reshuffle. Specimens will be exported to RBGE in April 2015. Sixteen *Begonia* species collected, which were:

- *Begonia maynensis* A.DC.
- *Begonia humilis* Dryand.
- *Begonia parviflora* Poepp. & Endl.
- *Begonia subciliata* A.DC.
- *Begonia bracteosa* A.DC.
- *Begonia erythrocarpa* A.DC.
- *Begonia octopetala* L'Hér
- *Begonia altoperuviana* A.DC.
- *Begonia peruviana* A.DC.
- *Begonia monadelpha* Ruiz & Pav. ex A.DC.
- *Begonia glabra* Poepp. & Endl.
- *Begonia semiovata* Liebm.
- *Begonia urticae* L.f.
- *Begonia acerifolia* Kunth.
- *Begonia fischeri* Schrank.
- *Begonia veitchii* Hook.f.

These *Begonia* species were anecdotally observed to live in highly different environments; for example, *B. octopetala* is a species lomas formations in the

Atacama desert at an altitude of 400-600m, which derive all their moisture during a 4-6 month period of almost constant fog. The closely related *B. veitchii*, however, is a species of high altitude grasslands and was collected at 3750m in an unseasonal El Niño snowstorm. Other species including *B. peruviana*, *B. parviflora*, *B. subciliata*, and *B. monodelpha* were collected in mid-altitude cloud forest whereas *B. humilis* and *B. altoperuviana* were collected in lower-altitude rainforest.

Figure 3 - Hemispherical photograph showing the canopy above *B. urticae* in Cutervo, Cajamarca, Peru.

Silica gel samples were taken of all collections and molecular work is ongoing at RBGE to incorporate all *Begonia* samples into a well-sampled, global phylogeny of *Begonia* (Moonlight et al 2015, *in press*).

The following herbaria were also visited:

- CPUN – Herbario Universidad Nacional de Cajamarca
- HOXA – Herbario Estacion biológica del Jardin Botanico de Missouri, Oxapampa
- HUT – Herbario Universidad Nacional de La Libertad, Trujillo
- MOL – Herbario forestal, Universidad Nacional Agraria La Molina, Lima
- MOL-WEB – Herbario Weberbauer, Universidad Nacional Agraria La Molina, Lima
- USM – Herbario Universidad Nacional Mayor de San Marcos, Lima

Where possible, all *Begonia* specimens in these institutions were determined, which has led to the identification of 2 new species records for Peru, multiple species records for individual Peruvian regions, and six new species for science. Work to describe these species is ongoing. All specimens have also been entered into the RBGE's PADME *Begonia* database, which is due to be published online in 2015. This has further allowed MaxEnt species distribution models to be produced to test whether *Begonia* species live in significantly different environments (see. Fig 4) and to allow the reconstruction of niche variables across a phylogeny of *Begonia*.

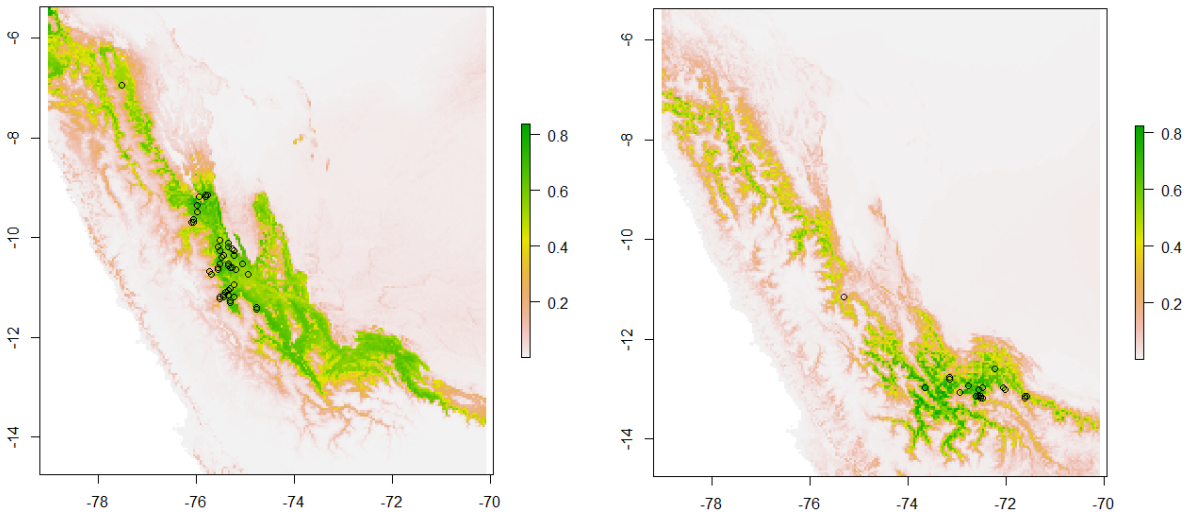

Figure 4 – Significantly-different species distribution models (p = >0.99) and distributions of the closely related species *Begonia subciliata* A.DC. (left) and *Begonia bracteosa* A.DC. (right) showing the likelihood of finding habitat suitable for those species plotted against geography.

References

Joly *et al*. (2014) Species Radiation by Niche Shifts in New Zealand's Rockcresses (*Pachycladon*, Brassicaceae) *Systematic Biology* 63(2): 192-202.

Moonlight *et al*. (2015) Continental-scale diversification patterns in a megadiverse genus: the biogeography of Neotropical *Begonia*. In Press.