Bromeliads in Trinidad: How to Get a High out of Research

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INTRODUCTION

This commentary is long overdue, as I have been promising my friends and collaborators in Trinidad an account which would explain my continuing fascination for the bromeliads and other epiphytes here for over 20 years. This is a token attempt to give thanks for the extraordinary support that many in the University of the West Indies (UWI) and at Simla have provided over this period, enabling us to develop innovative approaches and show how the physiological ecology of epiphytes can genuinely span field and laboratory experimentation.

Getting started

It all began 1980, when as a postgraduate I had the opportunity of joining an expedition organised by staff at Dundee University. I had set up a mass spectrometer to measure the stable isotopes in carbon (13C/12C), and when Prof Barry Osmond FRS was visiting, I enquired about the possibilities of working on Crassulacean acid metabolism (CAM) and was met with the resounding rejoinder “Bromeliads”.

Using stable isotopes, we set about distinguishing the conventional “C3” pathway of photosynthesis from CAM using samples from the field or herbarium. The latter was more normally associated with succulent plants, like cacti, from semi-arid desert regions, since CAM plants open their leaf pores (stomata) at night to allow CO2 uptake when water loss is low. With no sunlight to make sugars at this time, the fixed carbon is stored as malic acid, leading to the simple diagnostic of CAM activity as the dawn to dusk change in titratable acidity of leaf sap.

We were armed with the pioneering work of Colin Pittendrigh, equipped by Prof. Charles McDavid at UWI and aided by the skills of the young curator of the National Herbarium, Yasmin Baksh. We then set out to sample bromeliads day and night-time patterns of water relations under natural conditions over two successive nights in upper and lower montane and seasonal forests in Trinidad at Morne Bleu, Simla and Arena.

Of fevers, feverish activity and fevered speculation

Starting in July-August 1981, the work was undertaken in conjunction with Andrew Smith (now a Professor at Oxford) and an undergraduate, Mark Bassett, ably assisted by my then wife, Nina. Had I not convinced Andy to join us, with his authoritative expertise on plant water relations and CAM, I am sure that the course of my career would not have led me to Cambridge, but then I have always been a great believer in serendipity. In the field, I was the tree climber who scaled two trees at each site to provide bromeliads leaves for determination of daily changes in water deficit using a pressure chamber, and for extraction of leaf-sap acidity to determine CAM activity.

Whilst I had been taken out with a 40 degree fever on the evening that Andy arrived, and carted off to hospital in Port of Spain, four days later we were up surveying sites and building a shelter on the approach to Morne Bleu, where for three nights we scuttled along the ridge for sampling and reprovisioning. Oh, how I remember that royal wedding, when exhausted on the last morning we could find nothing else on the radio when driving back at 5 am! However, we wrote the work up in good time, using the amazing Pittendrigh studies as a framework for showing the distribution of C3 and CAM bromeliads in relation to exposure and rainfall zone across Trinidad. I ended up getting a lectureship at Newcastle, from whence Colin Pittendrigh had originally graduated in Botany, and I had the great thrill of meeting him and showing him his native Northumberland when we awarded him an honorary degree in 1986 (Pittendrigh C. S. 1993. Temporal organisation: reflections of a Darwinian clock-watcher. Ann. Rev. of Physiology, 55: 17-54).

We then persuaded Andy’s collaborator, Professor Ulrich Luettge, that a return to Trinidad in 1983 would be a worthy aim, armed with a combined porometer and infra red gas analyser to measure photosynthetic gas exchange in real time. This second expedition, again based at Simla but sampling bromeliads within forest canopies at six sites from Point Gourde and Tucker Valley to the Morne Bleu Ridge, led to an entire special issue of Plant, Cell and Environment in 1986.

Developments at Newcastle: on bromeliads, strangling figs, world records and tadpoles

Realising that it was time to stamp my own unique organisational skills on an expedition of my own, in 1990 we flew back down to arrive at Simla only to find that my cursory note advising them of our imminent arrival had been sent to the wrong postbag.

With Annie Borland, Mark Broadmeadow and Kate Maxwell, we were armed with the (then) latest equipment for investigating photosynthesis, the Hansatech leaf disc electrode. When hooked up to the Simla water supply, as the dry season progressed, to our amazement a tadpole popped into the sink and down the drain after circulating through the entire water-cooling system. Hoping to study photoinhibition (the loss of photosynthetic activity induced under high light, which we intended to induced artificially), we could not understand why Guzmania monostachia was so unresponsive when sampled direct from the field. Answer: it was already severely photoinhibited under the natural high light of the Trinidad dry season!

At that time, David Attenborough was filming his series “Trials of Life” up at Simla. They had specially imported a moth-eaten, stuffed, hummingbird to try to capture the aggressive behaviour of two males defending adjoining territories. Since nothing was happening, I sauntered past and went to check the oil in the old car we were hiring at that time. With a twisted “hood”, it made a terrible noise on opening- at the precise moment they finally were about to capture this avian battle sequence on film. The words of the cameraman graphically explained their annoyance, and the two birds did not return- and so no such sequence appeared in the series. Sorry!

Francis Morean had already identified an amazing stand of the
hemiepiphytic strangler *Clusia minor*, growing epilithically around a small quarry on Dalep Singh's land below Simla. This genus was attracting much excitement at the time as the only tree to show CAM. We set about a programme of repeated sampling at dawn and dusk as the dry season progressed, only to determine an astonishing day-night change of leaf-sap titratable acidity of 1500mM (1.5 molar H⁺). Subsequent trips in 1992 and 1995 revealed that in fact *Clusia* leaf sap acidity tends to be maximal not at dawn, as in conventional CAM plants, but by mid-morning, so imagine what we might have found if we had sampled a few hours later! Mark’s work with stable isotopes in forest canopies led to subsequent important developments with Kirsty Harwood and Jim Gillon on *Piper aduncum*, whilst Andy Roberts proved himself a star at manipulating *Clusia* under field and laboratory conditions.

**Refining the biochemical and molecular approaches**

Much of the work we undertook in the laboratory at Newcastle upon Tyne and now Department of Plant Sciences, Cambridge, has set out to investigate the physiology and molecular responses underlying acclimation to changing environmental conditions. Dr. Annie Borland, now a Reader in Newcastle, continues to undertake pioneering work on the metabolic and molecular regulation of the CAM cycle in a range of *Clusia* species. For anyone who has ever tried to wash *Clusia* latex out of clothes (don’t even try), imagine the difficulty of refining assays to allow proteins and RNA to be extracted without adulteration. Dr. Kate Maxwell, currently a Royal Society Research Fellow at Cambridge, is now showing the extraordinary restructuring of photosynthetic apparatus which occurs in *Guzmania* at biochemical and molecular levels when the plant is challenged by high light.

**Back to the field in 2004**

Now old enough to know better, the allure of working in Trinidad still holds, and looking back I recognise what an important stimulus it has been for my well-being throughout- so the highs have been still holds, and looking back I recognise what an important stimulus it has been for my well-being throughout- so the highs have been...

