Darwin Fellowship - Final Report

(Please check guidance for submission deadlines, max 6 pages.)

Darwin Project Ref No.	EIDPS035
Darwin Project Title	Building Capacity for Plant Biodiversity, Inventory and Conservation in Nepal (12-030)
Name of Darwin Fellow	Dr Sangeeta Rajbhandary
UK Organisation	Royal Botanic Garden Edinburgh
Your Organisation	Central Department of Botany, Tribhuvan University
Your role in your Organisation	Senior Lecturer
Start/end date of Fellowship	15/9/2013 – 14/9/2013
Location	Royal Botanic Garden Edinburgh
Darwin Fellowship funding (£)	18,500
Type of work (e.g. research, training, other, please specify)	Research and training
Main contact in UK Organisation	Dr Mark Watson
Author(s), date	Dr Sangeeta Rajbhandary and Dr Mark Watson

1. Background

- Briefly describe your involvement in the Darwin project before the start of your fellowship.

  I was one of the Darwin Scholars trained during the Darwin project 'Transfer of Plant Information and Technology for Nepal (1998-1999; 162/06/052) carried out at The Natural History Museum, London. Later I was one of the Darwin Scholars trained during the Darwin project Building Capacity for Plant Biodiversity, Inventory and Conservation in Nepal (2003-2006; 162/12/030). I was one of the top performers in the project and went on to undertake a PhD degree jointly between Tribhuvan University and Royal Botanic Garden Edinburgh. I was awarded my PhD in 2010 and continue to develop my botanical biodiversity research and university teaching.

- Describe aim and objectives of the Fellowship, and programme of work.

  This Fellowship will produce a photographic field guide and web resource for the ferns of Nepal. Ferns are a significant component of Nepalese biodiversity, with 534 species from an estimated total of 7000 species of vascular plants. However, they are understudied relative to other plant groups, primarily because there are no publications which allow non-experts to identify ferns. The reference collections at the National Herbarium, Kathmandu (KATH), are often badly named, poorly curated, and are consequently difficult to use for identification.

It is impractical to produce a comprehensive field guide to the ferns of the whole of Nepal within one year, so this Fellowship concentrates on the photographic field guide for ferns of Nepal which will include introduction, collection technique, glossary, keys to genera and families, types of leaf, venation, sori, etc. However, the key to genera will include all genera known from Nepal, and so it will be useful throughout the country. The field guide will be published in Nepal, where high quality colour publications can now be printed at very reasonable costs. The web resource will be hosted at RBGE and based on data held in RBGE's Flora of Nepal Padme database. This database has been purpose designed at RBGE and manages all data for the publication of the Flora of Nepal. District-level distribution maps will be generated by databasing representative specimens at RBGE, the Natural History Museum, London and RBG Kew.

For several years I have been collecting data and images suitable for a field guide of Nepalese ferns and am currently working on fern projects at two locations in Central Nepal, Daman in the Mid Hills and Manaslu in the High Himalaya. Some 200 species have already been photographed, and many other species have also been photographed by RBGE collectors on other collecting expeditions.

- Briefly describe the roles of the UK and Fellow's institutions.

RBGE's mission statement is 'to explore and explain the world of plants'. It has an international reputation as a centre for excellence in plant taxonomy, molecular systematics and biodiversity science based on its rich herbarium, living collections, library and archives. RBGE has wide-ranging education activities which include PhD, MSc, BSc, HND courses as well as diverse public education programmes. RBGE contributes to many Flora projects worldwide, and coordinated the completed European Garden Flora (2000), Flora of Bhutan (2002) and Ethnoflora of the Socotra Archipelago (2004). The Floras Group manages the Flora of Nepal in collaboration with the University of Tokyo and the Nepal Academy of Science and Technology, Tribhuvan University and the Department of Plant Resources in Kathmandu. The Group is developing innovative biodiversity informatics tools to aid compilation of Floras and has an active fieldwork schedule. In addition to the Nepal project RBGE has successfully undertaken Darwin projects in Bhutan, Vietnam, Turkey, Laos, Peru, Chile, etc.

Tribhuvan University, the largest university in Nepal, has campuses located across the country. The Central Department of Botany (CDB) is responsible for all academic programs in botany throughout the university, and itself specialises in M.Sc. and Ph.D. level education. Postgraduate courses include plant taxonomy, ecology, biotechnology, and other related fields in botany. CDB is the only place in Nepal where students can study for an MSc in plant taxonomy, and CDB has an excellent track record in producing high quality graduates who find work in the biodiversity sector or go on to further research. As one of the three collaborating institutes in Nepal on the international Flora of Nepal programme, staff and students are involved in contributing information, undertaking expeditions and writing accounts. CDB staff are co-authors of Flora of Nepal accounts for their specialist groups, and are involved in the mentoring of other co-authors.

- If you have undertaken a formal course of training, please provide a brief explanation of the course and a link to the course website if available.

2. Achievements

- Summarise the work undertaken during your Fellowship. What were the main activities undertaken. Highlight any work undertaken but not originally planned and explain why this happened. Highlight any problems encountered and how they were overcome.

1. ***Arrival at RBGE (Sept)***
   I arrived at RBGE on 25th September 2013

2. ***Consultation, planning and herbarium research (Sept-Oct)***
I met frequently with Drs Mark Watson and Colin Pendry to establish a detailed work plan for the Fellowship, prioritise training and research over the first months, and be guided on issues that came up. A fern and fern allies checklist from the book 'Pteridophytes of Nepal' was made and compared with the list from Flora of China and Flora of Thailand to check the nomenclature.

3. ***Library and herbarium research revising the checklist (Dec - Feb)***
I was trained in the use of electronic catalogues; on-line and web-based searches of library databases; scanning technique of useful resources especially for ferns and fern allies for references.

I completed the revision of the checklist of ferns of Nepal, and sorted out some nomenclatural problems with Dr Mark Watson. Recent years have seen several changes to generic concepts and so deciding which genera to accept in the checklist was a challenge but a useful basis for future work. Several taxonomically complex groups were identified as in need of further research and will form the subject of future MSc and PhD student projects in Nepal.

The 2002 Nepal fern checklist reports 534 species of fern and fern-allies, whilst in 2010, including subspecies and their varieties, the total number of ferns and fern allies account have been recorded as 556 taxa as specific and subspecific rank are accepted here from Nepal (534 species, 22 extra subspecies). In the recently published Flora of China fern volumes they have adopted the most recent family-level treatments of pteridophytes, but at generic level they have used several generic treatments based on molecular and morphological evidence. These needed to be considered for Nepal as they would involve many changes in scientific names.

In my revised checklist the number of genera in Nepal has increased from 102 (compared to the 2002 checklist) to 117 genera. For some genera depending on the morphological character decisions have been made to retain the existing genera even though it has been moved to different genera in Flora of China treatment. For example, Flora of Thailand includes all *Polypodioides* in *Goniophlebium*, a treatment not accepted by Flora of China. Flora of China separates one Nepalese species as *Metapolypodium*, but from observations it is difficult to maintain this, so including all within *Polypodioides* is preferred for Nepal. Similarly, for some general like *Thelypteris* has been split into 13 genera based on its molecular and morphological character in Flora of China, which based on the morphological character, has been considered for the Flora of Nepal as well. But there are several genera belonging to Dryopteridaceae has been moved to *Dryopteris* and the genera upgraded to section example genera *Nothoperanema* has been moved to *Dryopteris* and the species under section *Nothoperanema*.

So far records of 22 species new to Nepal have been identified, but on completion of data entry from BM and K specimens, there might be more.

4. ***RBGE Herbarium specimen study, imaging, data capture (Nov-Feb)***

I was trained by specialist Dr. Elspeth Haston, Assistant Curator: Digitisation, in the production of high resolution images of micro elements (venations, leaf margin, sorus, indusium, trichomes, mega and microspores, etc.) from specimens using a digital camera on microscopes; manipulation of the images using Photoshop software. RBGE Flora of Nepal team also trained me in the use of the Flora of Nepal database Padme, entering and accessing data; linking data and developing maps; constructing and preparing reports; constructing keys for the genera.

The working of a major herbarium was important work experience for me, especially experiencing the different types of storage and arrangement of specimens in three major herbaria (Royal Botanic Garden Edinburgh (E); The Natural History Museum, London (BM), Royal Botanic Gardens, Kew (K) and identification of species.

Library and herbarium training was consolidated through research experience in locating literature; abstracting information from specimens; organising information into the form most suitable for entering into the databases used in the project; synonymy; specimen and literature citation.

All the specimens of fern and fern allies deposited at RBGE were consulted and recorded. All the fern specimen information from Wallich's Nepalese specimens listed in his Wallich Catalogue was recorded, in advance of consulting the original specimens held mainly in the herbarium at Kew. A total of 1700 Nepalese specimens of fern and fern allies held in the RBGE herbarium was databased into Padme. A Key to 117 fern and fern allies genera and 31 fern and fern allies families has been developed, including a glossary of around 261 descriptive terms with illustrations. 8150 micro photographs of around 500 species have been taken for use in the illustrated guide.

5. ***Natural History Museum herbarium specimen research (March)***

At the Natural History Museum, London, training was provided by NHM curation staff on use of their Herbarium, Library, other collections as well as help in accessing the materials. All Nepalese specimens of 6088 ferns and fern allies at the Natural History Museum herbarium were consulted and recorded. This included the Buchanan-Hamilton collections from Nepal dated 1802-3 (and duplicates at the Linnaean Society) – these are among the most important historical collection of those relating to Nepal and contain numerous type specimens.

I was able to discuss taxonomic and floristic problems relating to Nepalese ferns with NHM staff especially with Alison Paul, Curator of Pteridophytes, Department of Life Sciences and visitors Prof. Edward Salgado from US working on Asian *Asplenium* at NHM and Kew. Specimen annotations by C.R. Fraser-Jenkins were particularly useful when studying the species.

6. ***RBG Kew herbarium specimen research (April)***

At Kew I was also training on the use of the Kew collections (Wallich, general herbaria and library) by Kew staff. All Nepalese specimens of 2021 ferns and fern allies held in the Wallich and Kew herbarium were consulted and recorded. Useful discussion was made with Peter Edward fern specialist at Kew regarding the nomenclature and treatment of fern and fern allies.

Total of 8109 photographs of specimens from BM and Kew were taken. Data entry of the occurrence data from these is ongoing.

The earliest scientific natural history collections from Nepal were made by Francis Buchanan in 1802-3, and later by Edward Gardner in 1817-1820: including flowering plants, fern and fern allies. The historical herbarium specimens are deposited at Natural History Museum and Linnean Society of London. I could not see the specimens at Linnean Society of London due to time constrain but was able to see the original manuscripts by Francis Buchanan and to capture the image of 17 paintings of fern and fern allies. My visit to the Linnean Society was in addition to that in the original plan as the information and collections only came to light during the study period. I also had an opportunity to attend a special lecture by Prof. Blackmore entitled 'The Darwin Initiative: simple formula amazing impact' on 17th April 2014. I also met Linnean Society Fellows and many visitors from different institutes, with whom I can collaborate for future work. I have now applied and been accepted as a Fellow of the Linnean Society.

7. ***RBG Edinburgh herbarium specimen research (May-Sep)***

After the work at K and BM, the remaining months of my Fellowship was back in Edinburgh consolidating and completing the research. The work centred on synthesising the information ready for producing the guide book, and producing the necessary reports.

Most important during this period was being trained and using the Scanning Electron Microscope at RBGE to examine in more detail some interesting discoveries that I have made using the dissecting microscope, with a view to revising the generic placements of some difficult species. This was not originally planned, but as I have mentioned above, in other to revise the checklist I needed to try to follow the recent treatment for the classification and nomenclature adopted in the recently published Flora of China fern volume. They have adopted the most recent family-level treatments of pteridophytes, but at generic level they have used several generic treatments based on molecular and morphological evidence. These needed to be considered for Nepal as they would involve many changes in scientific names. In order to confirm the changes at the generic level the SEM of spores has been very useful (Example in Appendix). The Scanning Electron Microscope was mainly used to examine spores of 111 genera of fern and fern allies of Nepal, which really helped in understanding the generic placements. Total of 570 SEM spore images was captured.

The main aim of the Fellowship is to produce photographic field guide which requires photograph of live plants, even though I have photographs of many species from the field I needed close up of some parts of the plants to use it for both for generic and family keys, glossary as well as for the plates to show different types of venation, types of sorus, arrangements of sori, etc. For this purpose 1165 digital photographs have been captured of fern and fern allies and their detailed morphology using the living collections in the RBGE glasshouses – this is in addition to what was originally planned in the fellowship. This had helped greatly to secure the material and information I required to produce the field manual.

After the training by Dr. Elspeth Haston, 8150 high resolution images of micro elements (venations, leaf margin, sorus, indusium, trichomes, mega and microspores, etc.) for around 500 species have been taken for use in the illustrated guide, which was also not originally planned.

The final stage is to complete the introductory portion of the field guide and formatting so as to finalise it. During the fellowship, not only the data or training was received, but most important was the collaborative links which is very important for future work and collaboration with RBGE.

In the coming months I will be working on the final stages of databasing the herbarium specimens, making this data available via the Flora of Nepal website and publishing the field guide. These were slightly delayed during my fellowship as it was necessary (and scientifically very interesting) to study the new generic limits as applied to Nepalese ferns, so that I could produce a stable classification to use for these identification manuals.

Whilst in Edinburgh I also worked with Dr Colin Pendry to contribute a chapter on the Pteridophytes of Nepal to the Introduction to the Plants of Nepal – a companion volume to the Flora of Nepal. I am the sole author of this chapter, which has now been accepted and the volume is being prepared for publication. I will also be preparing journal articles to publish the changes to the fern checklist of Nepal: new classifications and new records.

- What have been the main achievements of your fellowship? Key documents should be annexed to this report.

  The main achievements are detailed above in section 2. The main ones were:

  - Producing the revised checklist of ferns of Nepal (needed as the basis for deciding what to include in the guide and for all future fern research and its conservation)
  - Completing the examination of fern species, producing the key to genera and families along with illustrated glossary of terms (enhancing my knowledge of fern morphology, diversity and genera/species boundaries, and a major component of the guidebook)
  - Producing a dataset of detailed micro photographs of around 500 species (for illustrating the glossary and guide book, and as a knowledge base for future research)

- Recording all the fern specimens at RBGE, RBGK and NHM (providing accurate distributional data and completing the morphological examination)
- Producing distribution of all species represented in herbaria housed at UK to identify the collection gaps which could be targeted in the future fieldwork. Taxonomic problems can also be further studied by my MSc students in Nepal.

3. Outcomes, lessons and Impact

- Do you feel that the work undertaken during your Fellowship has improved skills that are relevant and important for your work in your organisation? How are you planning to apply those skills in future work?

  I have improved my skills in many areas, as mentioned in the sections above. Most importantly, I have enhanced my knowledge of fern morphology, diversity and genera/species boundaries. I will be able to pass on many of these skills to the people I work with and especially the M.Sc. Botany (Taxonomy) students that I supervise and teach at Tribhuvan University, Central Department of Botany.

  In addition to the planned programme of work, I attended the 111th Annual General Meeting of the British Pteridological Society held at the Natural History Museum, London on 12th April 2014 was also attended and got the opportunity to meet people working on Pteridophytes. This was very important for me to make contacts with experts on Pteridophytes to know more about current projects and the direction of future research. In April I also attended the 2-day study workshop of the Britain Nepal Academic Council in Oxford, where I presented a paper on the work undertaken in the Darwin Fellowship.

- What arrangements have been made for your future involvement, what more could be done, what discussions have taken place with your original employer to ensure that your new skills are utilised?

  The future involvement will be to develop complete profile for all the species of fern and fern allies of Nepal both by further consulting herbarium specimens deposited in other herbaria apart from UK and Nepal. The work will be carried out by consulting and collaborating with international pteridologists to understand the species in detail. Revised checklist, new records, and papers regarding the SEM of spores for different family and genera will be published in international journals. There are already a few students starting to work on pteridophytes under my supervision. I will continue to enhance my knowledge on ferns and to disseminate it to students and my peers. If I have any problems I know that I can depend upon my colleagues at RBGE for their suggestions and help.

- Has the Fellowship helped to improve your capacity to solve practical problems related to the sustainable use and/or conservation of biodiversity in your country?

  The Fellowship has been especially helpful in enhancing my knowledge and understanding the fern flora of Nepal as well as from the adjoining countries China and India. This has also helped me to critically analyse the fern collection deposited at K, BM and E and has strengthen my capacity to help me identify the specimens deposited in National Herbarium of Nepal (KATH) and Central herbarium of Tribhuvan University (TUCH). With proper identification of the species and its distribution will help the planners and decision makers to identify the species required for conservation not only for the species but also to identify the species which can be used as conserving agent for places with soil erosion. As ferns can help to control erosion, stabilize soils and slopes, builds soils where none exist, and often do these things in nature. Another important element to consider is capacity building of people required to identify ferns, as there are very few people working on the fern flora of Nepal. The increased level of knowledge and understanding on species identification, its distribution pattern will certainly make a major contribution to the conservation of fern flora of Nepal. Being unable to identify ferns been a major problem in conservation in Nepal.

- Have you had the opportunity to make contacts with other UK biodiversity institutions, intergovernmental organisations, NGOs or the private sector during your fellowship? Will these contacts be useful for your future work, and how are you planning to maintain them?

  Yes, working in three major botanical institutes at UK (K, BM and E), I met many experts and staff who helped me understand my work and with whom I can collaborate for future work. Meeting experts at the 111th Annual General Meeting of the British Pteridological Society has been a major bonus as I can always discuss problems in this specialist field with them through email. During my fellowship I also came across many visitors from different parts of the world in these three institute with whom I had discussed the subject matter, which has not only helped to enhance my knowledge but also to established contacts with them which will be very important for my future work. During the sorting of some nomenclatural problems with Dr Mark Watson, we had contacts with experts from China and Japan. All these contact will be helpful to build networks as well as for future project development for conservation and get funding to extend the work on the pteridophyte flora of Nepal.

- Any other issue emerging from your experience as Darwin Fellow that you would like to raise, or suggestions for improvements to the Darwin Initiative Fellowship scheme.

  The Darwin Initiative project and this Fellowship have been highly beneficial to raising capacity for biodiversity research and conservation in Nepal, and they have lasting legacies. In addition to the Fellowship scheme it would be good if there was an opportunity for follow up funding to build on the Fellowship in my home country, to enhance the knowledge more and filled the gap wherever possible.