

Danish-Ecuadorian Collaboration in Botany as an example of North-South mutualism

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Abstract

The Danish-Ecuadorian collaboration in botany started as a coincidence when two undergraduate students from Aarhus University travelled to Ecuador on an adventure trip in 1968. Subsequently these two students became staff at Aarhus University and the collaboration changed into a formal inter-institutional collaboration with the private Pontificia Universidad Católica del Ecuador (PUCE) in Quito. It culminated with a twelve year (1990-2002) Danida-supported program for enhancement of research capacity at PUCE during which the initially 1000-specimen herbarium grew to a 200,000-specimen herbarium, and the completion of 45 Ecuadorian first-degree theses at PUCE and eight Ecuadorian PhDs and five MSc trained at Aarhus University. Following the Danida funded period, collaboration between PUCE and Aarhus University has continued through several research projects with funding raised by Ecuadorian as well as Danish partners.

Key Words: building herbaria, first degree training, MSc training, PhD training, research capacity building

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Ecuador is a megadiverse country with 19,000 species of vascular plants in a great variety of vegetation types, from semi-desert to rainforest, and distributed from sea level to more than 5000 m elevation. This richness has been an inspiration for the botanists from Aarhus University for nearly 50 years. Sharing this interest with Ecuadorian colleagues and students has inspired extensive collaboration to equal benefit of Aarhus University, the botanists of the Pontificia Universidad Católica del Ecuador (PUCE) and of The National University of Loja.

The Danish initiative was also inspired by the Swedish project *Flora of Ecuador* which was initiated 1968 by Gunnar Harling (University of Göteborg) and Benkt Sparre (Naturhistoriska Riksmuseet, Stockholm). The botanists from Aarhus became involved in the Editorial Board, by Lauritz B. Holm-Nielsen, and they contributed treatments of several families to the Flora. Simon Lægaard became co-ordinator for Gramineae, and Benjamin Øllgaard for Pteridophyta.

Danish Expeditions to Ecuador 1968–1976

In 1968 two third-year biology students, Lauritz B. Holm-Nielsen and Stig Jeppesen spent seven weeks in the field in Ecuador, and made more than 1600 general collections at 12 localities ranging from the Pacific coastal plain across the Andes to the Amazonian lowland. During this stay they caught special interest in the Passifloraceae and Helobiales, and the Lobeliaceae. These became the subject of their master theses, and later were published in *Flora of Ecuador* (Holm-Nielsen *et al.* 1988; Jeppesen 1981). At the time botany was new at Aarhus University, having been established five years earlier in 1963 by professor Kai Larsen, who had also established the Aarhus University Herbarium (AAU). He was keen on expanding the herbarium so he supported the expedition of the adventurous students with funding for shipment of specimens. This first expedition was also supported economically by the Danish amateur botanist Troels Myndel Pedersen who owned cattle farms in Argentina, and who wanted the two students to collect specimens of Amaranthaceae for his revisions of that family.

The collections of the 1968 expedition brought excitement to the botany group at AAU and inspired the planning of the next trip in 1973 after the participants' graduation. In addition to Lauritz B. Holm-Nielsen and Stig Jeppesen, Benjamin Øllgaard, who had special interest in ferns and lycopods (Øllgaard 1988; Øllgaard *et al.* 2001, Stolze *et al.* 1994) and Bernt Løjtnant with special interest in Orchids joined the activity. During three and a half months in the field in Ecuador about 5300 general and special collections were made at some 100 localities, including the Pacific coastal plain, and nearly a complete north-south transect of the Ecuadorian Andes. Again professor Kai Larsen and Troels Myndel Pedersen supported the activity, and the small Danish community in Ecuador was a great help. The expedition contacted PUCE and discussed the possibility to collaborate in a botany program, including teaching and development of the herbarium. They received a very positive response.

A third expedition in 1976 was funded by the Danish Natural Science Research Council with the aim to

focus on the diversity and ecology of Ecuadorian Lycopodiaceae. Benjamin Øllgaard had Henrik Balslev as field assistant, and he initiated a study of the Ecuadorian Juncaceae (Balslev 1979) that later was expanded to a monograph for *Flora Neotropica* (Balslev 1996). The field work was carried out during three and a half months, mainly in montane forest and páramo. Four hundred special and 1900 general collections were made, followed by 400 additional ones by Henrik Balslev after finishing the Lycopodiaceae project (Øllgaard & Balslev 1979). Again the small Danish community in Ecuador was a great help.

Permanent Danish Staff in Ecuador 1979–1989

A formal and obliging collaboration with the biology department at PUCE began in 1979 when Lauritz Holm-Nielsen, funded by a Danida grant, moved to Quito to stay for two years in order to build up botanical teaching and to improve the herbarium for the purpose of education and reference. Zoological and ecological disciplines had good levels, but botany was only now included in the biology program. Holm-Nielsen contributed botanical courses and engaged Ecuadorian students in extensive field work in order to expand the existing 1000-specimen herbarium to a more representative status. During his two years he added more than 14,000 specimens, representing most of the Ecuadorian vegetation types, especially together with Jaime Jaramillo and Flavio Coello. During the same period visiting Danish and local Ecuadorian students and other collaborators added another ca. 6000 specimens. Jaime Jaramillo and Flavio Coello subsequently stayed one and a half year in Denmark, undertaking taxonomic revisions of Ecuadorian plants at herbarium AAU.

When Holm-Nielsen left Quito, Henrik Balslev, with a PhD degree from The City University of New York took over, this time on a local contract with the university in Quito, to carry on the teaching of first-degree students and to organize the newly accumulated plant collections for practical and scientific use. He increased its floristic coverage with more than 4000 new collections.

He added practical activities to the formerly mainly theoretical teaching attitude, and engaged first-degree students in field courses on flora and vegetation, páramo vegetation, Amazonian rain forest of Cuyabeno, and supervised several first-degree theses in taxonomy and ethnobotany.

During this period several people from Aarhus served the functions and activities established during the previous period, and at the same time pursued personal research interest. Funding was from a variety of sources and young Danish botanists were employed in Quito mainly on local conditions, whereas Aarhus University staff spent their sabbatical leave, or some even worked in Ecuador based on small grants and personal economic investment.

At the end of this phase Herbarium QCA had reached close to 100,000 specimens, and 40–50 students had acquired local first-degrees, ‘licenciado’ in biology with specialization in botany. Simon Lægaard stayed at herbarium QCA 1984–1985 during a sabbatical from the University of Aarhus, and made extensive field studies of native grass species (Lægaard 1997; Lægaard & Peterson 2001; Lægaard & Balslev 2014). Bo Boysen Larsen continued studies of the Valerianaceae 1985–1986 while teaching and curating the Quito herbarium (Boysen Larsen 1986). Peter Møller Jørgensen established studies of forest diversity and ecology in sample plots in Volcán Pasochoa and in the montane forest on the western Andean slopes during 1986–1989, parallel with teaching botany in the laboratory and in the field to many Ecuadorian students (Møller Jørgensen & Ulloa Ulloa 1994; Møller Jørgensen & León Yáñez 1999). Henrik Borgtoft Pedersen and Birgitte Bergmann took over the post and taught botany and curated the herbarium during 1989–1990 while they also studied the ethnobotany and economic botany of palms, especially the vegetable ivory palm (Brokamp *et al.* 2014). At the end of this period, Jens Elgaard Madsen collaborated for two years with the Herbarium of the National University of Loja, and the forestry department about a reforestation project with native species from the Podocarpus National Park (Aguirre *et al.* 2002); he also carried out studies of the Cactaceae (Madsen 1989).

The Enreca Program

The Universities in Quito (Ecuador), Loja (Ecuador), and Aarhus (Denmark) entered a formal collaboration during 1990–2002 in a Danida funded Enreca project entitled ‘Natural Resources for Development – a research collaboration between Denmark and Ecuador.’ Danida’s Enreca programme was established in 1990 to **Enhance Research Capacity** in developing countries. Enreca functioned through *twinning arrangements* between a developing country and Danish research institutes and they included research and training in order to promote capacity building through long term collaborations, up to several phases each of three years duration. A basic idea of this program was that sustained development is based on the capacity to find and apply existing knowledge, to create new knowledge, and to remain updated by connection to relevant international specialist networks. The first grant for the Danish-Ecuadorian Enreca program was given in 1990 and subsequently extended for three additional three-year periods until 2002. During the program, permanent Aarhus staff was seconded to Ecuador under the project management of Henrik Balslev with the aims (Balslev & Paz y Miño 1991):

- to consolidate herbarium QCA to about 150,000 specimens.
- to provide adequate technology and methods (computers, microscopes, databases, etc.)
- to train students to local first-degrees ‘licenciado en biología’ with specialization in botany
- to train Ecuadorian PhDs and MSc at Aarhus University.
- to strengthen taxonomic research in Ecuador
- to expand research into vegetation ecology, ethnoecology, systematics and biodiversity studies, and relating to ecosystems services.

Under the Danish-Ecuadorian Enreca program residence in Quito was attended by Benjamin Øllgaard (1990–1992), Finn Borchsenius (1992–1994) and Henrik Balslev (1994–1999). After the third project period Danida judged the achievements at PUCE to warrant

a more independent continuation of the project on the part of PUCE, with a reduced funding, and subsequent collaboration on equal terms with Aarhus. During the second three-year period Aarhus became involved in a research enhancement project in the regional university in Loja in southern Ecuador, where Aarhus had collaborated about five years earlier (Aguirre *et al.* 2002). Residence in Loja was attended by Henrik Borgtoft Pedersen (1993–1996, with spouse Birgitte Bergmann teaching seven months in 1994), Bente Bang Klitgaard (1996–1998, with spouse Gwilym P. Lewis), Simon Lægaard (1998–2000), and Jens E. Madsen (2000–2001). In Loja the most urgent need was to improve the infrastructure, and to organize the existing collections and incorporate them in the general herbarium.

During the period several PhD students were inscribed from the start of the project at PUCE: Guillermo Paz y Miño (lowland Amazonian forest diversity and ecology, Cuyabeno, after two years appointed Undersecretary of Environmental Affairs to the Minister of Energy and Mines); Renato Valencia (forest diversity and ecology; Valencia *et al.* 2000, 2004, 2013); Carmen Ulloa Ulloa (high Andean arborescent flora and diversity; Ulloa Ulloa & Møller Jørgensen 1993; Møller Jørgensen & Ulloa Ulloa 1994); Katya Romoleroux (Ecuadorian Rosaceae and related families; Romoleroux 1996; Freire-Fiero & Romoleroux 2004); Carmen Josse (coastal lowland cloud forests, diversity and ecology; Josse & Balslev 1994); Lucia de la Torre (Catalogue of Useful plants of Ecuador; de la Torre *et al.* 2008, 2009, 2012). Two students were inscribed in local PhD programs at PUCE: Hugo Navarrete (fern taxonomy and diversity) and Esteban Terneus (limnology). Four students were inscribed in the Aarhus MSc program: Priscilla Muriel and Tatiana Jaramillo (taxonomy of the genus *Virola*, Myristicaceae, in Ecuador; Jaramillo *et al.* 2000, 2004); Selene Baez (palm ecology, continued to the PhD programme at Gainesville, Florida; Baez & Balslev 2007); Rommel Montúfar (Palm community ecology, continued to the PhD programme at Montpellier, France; Brokamp *et al.* 2014; Montúfar *et al.* 2011). The programme for each of the participants was designed as a sandwich with

up to nine months yearly dedicated to field work in Ecuador and work with collections in the herbarium, and at least three months in Aarhus with access to library, herbarium and laboratory facilities, specialized supervision, and participation in international conferences in order to connect with specialist networks.

The Danish DIVA projects collaborated 1994–1998 with Herbarium QCA as a counterpart and other institutions in Peru and Bolivia in order to investigate the cultural and biological diversity of Andean rainforests. At Aarhus University, Flemming Skov and Benjamin Øllgaard were involved, while Renato Valencia and Hugo Navarrete participated as Ecuadorian counterparts to the program for QCA. This activity provided a great number of herbarium collections to both QCA and AAU.

In conclusion the Danish-Ecuadorian Enreca project achieved the enhancement of research capacity in Ecuador, not least through the training of 45 first-degree graduates in botany and of eight Ecuadorians for the PhD and five for the MSc degrees in Denmark. In sheer numbers the collections in the herbarium QCA of the university in Quito increased from 100,000 to 150,000 (Fig. 1) which makes it one of the most important collections of Ecuadorian plants. The Enreca project also provided field and laboratory equipment for studies in plant taxonomy and ecology.

Subsequent Careers of Ecuadorians in the Enreca Project

Training of human resources is obviously important to any capacity building project. But it is equally important that those who are trained end up in meaningful positions afterwards, and this has actually happened with the Enreca trained Ecuadorians, though many of them have moved on to other institutions than the one they were trained in. Carmen Ulloa Ulloa has moved on to become a curator at the Missouri Botanical Garden, where she continues her research in Ecuadorian plants and actually carries out important capacity building in Ecuador as part of that. Carmen Josse worked for more than a decade as Senior Regional Ecologist at the NatureServe, Wash-



Fig. 1. The herbarium QCA at Pontificia Universidad Católica del Ecuador (PUCE), in Quito. A, B, C. Compactors for storing and sorting tables. D. Specimen of *Myrcia magnoliifolia* DC. (Myrtaceae). E. Specimen of *Magnolia* sp. (Magnoliaceae).

ington, where she handled many Latin American programs for conservation on a regional scale; now she works for Ecociencia, and Ecuadorian NGO dedicated to research for conservation of nature. Renato Valencia, became the first Ecuadorian director of the herbarium QCA at PUCE in Quito 1994–2001, and he has since functioned as professor of botany at the same place, and has been involved in higher level administration at the university as vice dean of the Faculty of Natural Science; he also was the Scientific Director of the Ecuadorian Research Council (FUNDACYT, later SENEYC) for over two years, 2002–2004. Katya Romoleroux returned to teach botany at PUCE and was named director of the herbari-

um in 2012. Priscilla Muriel has returned to the university as herbarium database manager and specialist and became professor of botany in 2011. Lucia de la Torre functions as an independent consultant in Quito and has many projects together with the university. After her MSc at Aarhus University Selene Baez went on to do a PhD at Gainesville University in Florida and is now back as a professor of botany in the National Polytechnic University in Quito. Hugo Navarrete became professor of botany at PUCE and also director of the herbarium (2001–2011), and was for a long period dean of the Faculty of Natural Sciences, before returning back to teaching botany and doing research at the Biology department. In general all those



Fig. 2. The reference collection with 18,000 specimens kept at the Yasuni Scientific Research Station in Amazonian Ecuador, where it is used in the identification of the more than 1000 tree species registered in a 50 ha plot which is part of the international network of large forest plots. Front left: A. Perez, back row right (dark green shirt): Renato Valencia.

trained have subsequently served in positions where their training was important.

In the south Ecuadorian town of Loja the urgent needs of improvement of the infrastructure for proper storage, preparation, organization, and documentation of herbarium specimens, establishment of library function, and databasing of collections have been filled. In addition, ordinary mail, and electronic communication was established. The collections have increased substantially, from an estimated 6500 specimens to now perhaps 20,000 partly by means of local collectors, in part by means of deposition of duplicate material from Ecuadorian and Danish collectors. Limited knowledge of English both of staff and students was a impeding the use of international sources of information, so staff and students were offered lan-

guage courses, in order to overcome this problem. Several courses of basic botany were given by the Danish botanists, in addition to local forestry courses. In addition, the students were offered to participate in relevant courses given at PUCE in Quito

Flying Alone since 2002

During the last several years of the Enreca project in Ecuador the leadership of the botanical teaching and research at PUCE was taken over by Ecuadorians trained in the project. Danish senior staff was present as advisors and also helped with the teaching and the large research projects related to the botanical collections in the herbarium. They also help in the curation of the collections and in making them useful to re-

search by Ecuadorians and a growing number of international scientists who consulted and used the collections.

The same period saw increasing independent research and fund raising for scientific projects that were entirely free of support from the Enreca-project. Maybe the most important of those projects was the large-scale forest dynamics plot at the Yasuni field station in the Amazon part of Ecuador. That project was carried out in collaboration with the Smithsonian Tropical Research Institute at Balboa, Panama. It has produced a number of high-level publications in scientific journals (Valencia *et al.* 2004, *etc.*) as well as high quality publications with scientific content in an easily accessible format (Perez *et al.* 2014). The Yasuni forest dynamics project has all the time been closely related to the herbarium and has used the herbarium for identification of the megadiverse tree flora and also for the deposit of voucher specimens. It also maintains a reference collection at the Yasuni Scientific Station that consists in about 18,000 specimens (Fig. 2). This collection documents the morphological variation of each of the 1150 species found in the large 50-ha forest plot and the seeds and fruits collected during the last 22 years of continuous research.

Another project carried out independently at PUCE/QCA is the inventory and ecology of dry inter-Andean forests. The project was funded by the Ecuadorian Government and it included a PhD scholarship to Catalina Quintana to study at Aarhus University. This PhD study 2012–2015 (Quintana *et al.* 2017) hence is an example of Danish-Ecuadorian research collaboration funded by Ecuador.

Conclusions

- The collaborating partner has achieved considerable scientific independence and now functions as an equal research partner
- It is possible to build capacity through scientific collaboration
- It takes time
- It takes mutual interest and engagement to achieve the goals

- The scientists' drive to achieve research results must be considered as an important driver of the process
- Cross disciplinary research including natural and social aspects provide important knowledge concerning ecosystem services

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