Towards Greater Knowledge of the Brazilian Semi-arid Biodiversity

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Towards Greater Knowledge of the Brazilian Semi-arid Biodiversity

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Summary

Facing the endangered situation of drylands, the United Nations General Assembly proclaimed 2006 the International Year of Deserts and Desertification, which is extended to the sub-humid lands. This book was then a demand of MCT to make research projects on the Brazilian Semi-arid biodiversity public at COP-8 meeting. We face the challenge to gather information of different research groups in the Northeast Brazil in a period of one month. The result is this book which presents a brief summary of ongoing projects dealing with different aspects of Semi-arid biodiversity.

Brazil holds the largest biodiversity on the planet, accounting for around 13% of total world biota. Recent works estimate a known Brazilian biota of 170,000 to 210,000 species. These estimates increase to 1.8 to 2.4 million species if we take undiscovered species into consideration. Given that the Neotropics is the least-studied major region of the world, we feel these figures realistic or even underestimated. If these figures are compared with the paucity of trained taxonomists we can realize the huge task we have just to take a glimpse of our biodiversity.

Brazilian drylands are concentrated in the semi-arid region of NE Brazil. It presents the most diverse landscape in Brazil, both in geomorphological features and vegetation types. This environmental diversity must reflect in increasing biodiversity, complicated taxonomy and complex biogeographical patterns occurring in a relatively small scale. This situation of landscapes, vegetations and biodiversity happening in mosaics are a huge challenge not only for taxonomic and ecological studies but, especially, for conservation purposes. More recently, Brazilian government put forward some initiatives in order to better preserve Caatinga biodiversity. However, these strategies suffer with lack of confident taxonomic data. In the Semi-arid, taxonomic background is worse than that found in other Brazilian regions, even in the Northeast region, which have most teaching and research institutes in the coast. Empirical data had shown that efficiency to establish protect areas increases when species lists for each candidate area are available and that advantage of taxonomic surveys long surpass their costs.

This book will present, along 27 chapters, a small portion of ongoing initiatives aiming to provide data about Brazilian Semi-arid biodiversity. A general view of the physical and biotic features of the Semi-arid can be found in the introductory section 'To Set the Scene'.

In the first section, two network initiatives are presented: IMSEAR and PPBio/Semi-árido, both funding by MCT. The former presents some results after four years of project; whereas the latter presents the component structure and its main goals.

The second section contains three chapters about biological collections in the semi-arid region. Chapter 3 presents a broad coverage of the herbaria in NE Brazil and gives a good idea of their history, main collections and problems. Chapter 4 deals of culture collections of microorganisms which are assuming strategic position in biotechnology development. An initiative of repatriation of historical collection data from a European herbarium (that of the RBG-Kew) to herbaria in NE Brazil is presented in Chapter 5. This highlight the value of historical collections, mostly in the largest European herbaria, for taxonomic works carried out in the megadiverse countries, mostly in the tropics, and shows the need to establish partnerships between Brazilian and international agencies. Unfortunately, we could not gather information about zoological collections.

The third section presents the current situation of inventories of different groups and areas in the Semi-arid. Although it is not an extensive coverage, it gives us a picture of the ongoing inventories. For the flowering plants, it is introduced a general view of this large group in the main vegetation types in the Semi-arid (Chapter 6) besides floristic works in the States of Bahia (Chapter 7) and Paraíba (Chapter 8), and in special environments that hold particular floras and ecological processes, such as the 'campos rupestres' in the uplands of the Chapada Diamantina (Chapter 9), inselbergs (Chapter 10) and water bodies (Chapter 11) embedded in the Semi-arid. This section also presents projects dealing with taxonomic surveys of two families of flowering plants: Polygonaceae (Chapters 12) and Rhamnaceae (Chapters 13).

Current situation on the knowledge of the fungi in the Semi-arid is presented in the Chapter 14. Data about biodiversity of animals were gathered for a few groups. A general situation of biodiversity of insects in the Semi-arid is presented in Chapter 15, followed by treatments of two megadiverse orders, Diptera (the flies; Chapter 16) and Coleoptera (the beetles; Chapter 17). Data on vertebrates are presented for fishes (Chapters 18) and birds (Chapters 19). Data about fishes highlight the ongoing inventories and the risks of alien species introduction for local ichthyofauna inhabiting isolated basins. The chapter about birds brings the sad report of a recent extinction of the last natural population of the little blue macaw, a species known only for the caatinga of northern Bahia.

Study cases about traditional uses of animals of the Semi-arid as source of food and for folk medicine by Pankararé Indians and local people are provided in Chapter 20.

The fourth section presents studies on molecular plant systematics being carried out in the Semi-arid. Chapter 21 brings information about projects on phylogenetic studies in different groups of plants and about the 'DNA-bank', which holds samples of more than 1,000 species. This is certainly the largest DNA

bank in Brazil and is a valuable record of genetic diversity of plants in the Semi-arid and an outstanding source for studies on plant systematics using modern approaches. Chapter 22 presents the goals of a project intending to produce short diagnostic sequences of DNA that act as barcodings for species prompt identification. If successful, this project will provide researchers with accurate identifications of land plants, particularly those of the Caatinga, most of which lack leaves or flowers during the long dry season and usually rise difficult to confident identification.

The fifth section presents some of the graduate programmes in Northeast Brazil that deal with different aspects of Semi-arid biodiversity: Botany at UEFS (Chapter 23), Plant Biology at UFPE (Chapter 24), Biology of Fungi at UFPE (Chapter 25) and Biotechnology at UEFS (Chapter 26). Unfortunately, the short schedule to prepare this book did not allow us to gather extensive information from all graduate courses. Our deep apologies for the noteworthy absences of the graduate programmes at UFBA, UFC, UFPB e UFRPE.

The last section presents a project that combines techniques of satellite image analysis with field observations in order to prepare maps of natural remnants of vegetation and land use in the Caatingas (Chapter 27).

We thank authors for prompt contribution and hope this book provides useful information about ongoing researches on the Semi-arid biodiversity carried out in the Northeast Brazil. Most of the sound results presented here were obtained in the last ten years following a more regular funding for taxonomic and ecological studies. This highlights how a significant seed money and continuing funding dramatically improve the regional background for biological research.

Luciano Paganucci de Queiroz

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To Set the Scene

Ana Maria Giulietti, Raymond Mervin Harley, Luciano Paganucci de Queiroz & Alessandro Rapini

The Brazilian semi-arid zone is located almost exclusively in the Northeast of the country. This is one of the five geopolitical regions into which the country is divided, and which includes nine States. Only eight of these, at least in part, fall within the semi-arid zone, together with the northern sector of Minas Gerais State (Southeast Region) which borders its southern boundary. These eight States are Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe e Bahia. Only Maranhão State, bordering the Northern Region, which includes the Amazon basin, falls outside the Semi-arid zone. This large expanse of drylands, which stretches between 3–17°S and 35–45°W and covers almost 8% of the territory of Brazil, occupies an area of about 900.000 km^2: that is larger than Texas or the entire Iberian Peninsula, including Spain and Portugal.

Commiphora leptophloeos, the 'umburana-de-cambão', a typical tree of the Brazilian drylands, Dunes of Rio São Francisco.

The climate of Northeast Brazil is one of the most complex systems in the world. This is due not only to the size of the huge land mass involved, and its diverse physiography, but also to the conjunction of two major weather systems, provided by the NE and SE trade winds, which create an enormous diversity and instability in rainfall patterns.

The precipitation within the region varies from being extremely wet, with an annual rainfall of up to around 2,000 mm along the coast, to only 300–500 mm in the semi-arid zone, where the rainfall is usually restricted to a few months during the year. It is indeed this factor of water availability, which is the controlling influence over the vegetation and fauna, as well as, to a great extent, human exploitation of natural resources, throughout the region.

Although the region is dissected by many rivers, both large and small, distributed through the river basins of the Rio São Francisco, the Rio Parnaíba, and the smaller systems which feed the NE and E Atlantic coasts, only the larger of these normally remain flowing throughout the year. In the major part

of the semi-arid zone, as soon as the drought months get under way, the smaller rivers become ever more sluggish, eventually drying up completely. The Rio São Francisco, the largest in the region and one of the great rivers of Brazil, has its source in the Serra da Canastra, in Minas Gerais, flowing north and then east for about 2,700 km (almost 1,700 miles). It crosses a large part of Minas Gerais before entering Bahia, which contains 48.2 % of its river basin, bordering Pernambuco to its north (10% of its basin) then finally flowing into the Atlantic Ocean further north between the States of Sergipe (1.1%) and Alagoas (2.3%). The second largest river in NE Brazil, the Rio Parnaíba, with an extent of 1,400 km (870 miles) has its basin almost entirely within the State of Piauí (90%), with 10% in the neighbouring State of Ceará. The hydrography of this region is of special interest, owing to the aquiferous rocks, which store large underground reserves of water, of the utmost economic potential for the area. Further east, the hydrographic region 'Nordeste Oriental' includes much of the northern part of the region with five of the State Capitals ranged along the eastern seaboard, and a great part of the semi-arid interior. Here, a number of smaller rivers shed their waters into the Atlantic. The principal States which are included in this region are: Ceará (46%) mainly with the Rio Jaguaribe, Paraíba (20%) and Pernambuco (10%). In the hydrographic region 'Atlântico Leste', further south, the rivers which flow eastwards into the Atlantic, mostly rise in the mountain ranges of the interior of Bahia and Minas Gerais: the Espinhaço Range. The Rio Jequitinhonha, flows mainly through Minas Gerais and is more or less at the southern limit of the semi-arid zone, its water-catchment area occupying 26.2 % of the region. Another 66.8%, however, is occupied by the rivers that have their source in or near the Chapada Diamantina of Bahia: rivers such as the Jacuípe, Paraguassu, Contas e Pardo.

This set of contrasting physical and climatic factors have combined to provide the astonishing diversity of vegetation types that characterize the semi-arid region and appear as a mosaic, reflecting the local conditions which are encountered. If we make a journey from the Atlantic coast westwards towards the Rio São Francisco; a transect through the interior, we can readily observe the changes that take place. We can note a gradual increase in altitude, which stabilizes at around 500 m, and this is paralleled by a reduction in rainfall, dropping from 2000–1000 mm per annum and levelling out at between 500–700 mm, associated with a very irregular distribution during the course of the year, with several (seven to nine) months of drought.

This gradual change of rainfall and altitude, as one moves inland, can be modified, however, by local orographic changes, such as those caused by the presence of hills or mountains, providing a range of local conditions such as cooler temperatures with altitude, increased rainfall on slopes with an easterly

aspect and dryer conditions in the rain-shadow of the hills. Such situations can be observed on the Borborema Plateau and in other mountain areas in the Semi-arid, especially in the Chapada Diamantina, where striking changes occur, as the altitude rises from 1000–2000m, and annual rainfall can reach up to 1,500 mm.

These changes, as one moves westwards are also associated with changes in the landscape. From the coast to about 100 to 200 km inland, the vegetation is (or in many areas was, until recently) dominated by Atlantic Forest, with its lush, evergreen canopy of leaves. Further inland, as rainfall decreases, the rain forest gives way to a forest in which the canopy is semideciduous, with some species losing their leaves during the dry season. Then, with increasingly dry conditions, this in turn is replaced by a deciduous forest, in which, during the dry season the bare branches, devoid of leaves, are bleached by the full intensity of the sun. These last two forest types can be used to delimit the semi-arid region and together, constitute the Caatinga Biome. The predominant vegetation type in this region is composed of several forms of caatinga, from which the biome gets its name. The word is derived from the Tupi dialect: "caa" meaning forest and "tinga" meaning white. The structure of these forests can vary considerably from forests composed of often spiny trees, 6 to 10 m tall, deciduous to semideciduous, and often with a ground-layer of small deciduous shrubs and annual herbs, with a predominance of Leguminosae, to deciduous woodland of lower stature, with a high proportion of shrubs and subshrubs and characterized by the presence of many cacti, bromeliads and Euphorbiaceae. With the coming of the first rains, there is a miraculous transformation from bare, bleached branches and the dusty, brown, scorched and lifeless earth, which characterizes the dry season. Almost suddenly, there is an exuberance of green foliage clothing the trees, the ground is moist and hazy green with annual herbs, or with small pools of water filled with myriad life-forms, and the sounds of insects fill the air. Soon, the green is accompanied by a tapestry of colours as the caatinga trees and shrubs burst into flower. If we consider only the flowering plants of the caatingas of the Semi-arid, we now know that there are more than 5,000 species present, of which over 300 species and 23 genera are found to be uniquely growing there[1]. However, as we ascend into the mountain zone, we begin to notice a gradual change in humidity which, associated with changes in the type of soils, produces enclaves of a very different type of vegetation. At altitudes between 800 and 1000 m, especially in the northern part of the Semi-arid, Altitudinal Evergreen Forest, locally known as Brejo forest and which can provide protection for the springs of water, from which some of the important caatinga rivers have their source. Many of these brejos gave rise to human settlements,

1 Giulietti, A.M., R.M. Harley, L.P. de Queiroz, M.R.V. Barbosa, A.L. Bocage-Neta & M.A. Figueiredo. 2002. Espécies endêmicas da caatinga. *In* E.V.C.B. Sampaio, A.M. Giulietti, J. Virginio & C.F.L. Gamarra-Rojas (eds.) *Vegetação & Flora da Caatinga*. Associação Plantas do Nordeste, CNIP, Recife, pp. 103-108.

some of which are now large towns, such as Juazeiro do Norte and Crato in Ceará, Campina Grande in Paraíba and Garanhuns and Pesqueira in Pernambuco. In the southern part of the Semi-arid, this gradient can be observed principally in areas dominated by the Chapada Diamantina massif. Here the Caatinga can be seen gradually giving way to other plant formations, such as Cerrado, Evergreen Altitudinal, or Montane, Forests, Cloud Forests and Campos Rupestres, these last two being restricted to altitudes in excess of 1000 m and extending upwards to 2000 m. The Cerrados of the region, in spite of generally being less vigorous than those of Central Brazil and of western Bahia, display a range of species exclusive to the region, as well as others which are typical of the cerrados throughout Brazil. The Montane forests are usually composed of trees between 10 and 15 m high, often evergreen, with an species-rich understorey and, especially at higher altitudes a very diverse epiphytic flora which includes a large number of orchids. In general, the northern montane forests display greater floristic affinities with the Atlantic Forests of similar latitudes, along the coast of NE Brazil, while the Southern montane forests, as might be expected, considering their occurrence at generally higher altitudes, show most floristic affinity with the Atlantic Forests of SE Brazil, where the climate is somewhat more temperate. Such genera as *Drimys* (Winteraceae), *Weimannia* (Cunoniaceae) and *Podocarpus* (Podocarpaceae) are common to these regions. The Campos Rupestres represent a specialized form of savannah vegetation whose physiognomy has been likened to that of the Fynbos of the Cape Region of South Africa. Its various components include herbs, evergreen shrubs and subshrubs, characterized by families such as Velloziaceae (Canela-de-ema) and Eriocaulaceae (sempre-viva) and numerous epilithic species of Orchidaceae and Bromeliaceae. The formation is mainly restricted to the Espinhaço Range, which extends from Minas Gerais State to Bahia (Chapada Diamantina) and is renowned for its rich biodiversity associated with a very high degree of endemism. As mentioned above, the Espinhaço Range, where many rivers have their source, plays a vital role in furnishing water to the semi-arid zone.

Caatinga covers about 735,000 km2. It is the most degraded vegetation type in the semi-arid, and has less than 1% of it protected in permanent reserves. More recently, Brazilian government put forward some initiatives in order to better preserve its biodiversity. Areas of extreme biological interest were selected overlapping information of different groups of organisms[2] and ecoregions were proposed for the biome combining biotic and abiotic information[3]. The Caatinga Biome was divided in eight proposed Natural Ecoregions: Campo Maior Complex (Piauí and Maranhão), Ibiapaba Complex (basically compri-

2 da Silva, J.M.C., M. Tabarelli, M.T. da Fonseca & L.V. Lins (orgs.) 2004. *Biodiversidade da Caatinga: Áreas e Ações Prioritárias para Conservação*. Ministério do Meio Ambiente, Brasília - DF.

3 Velloso, A.L., E.V.S.B. Sampaio, A.M. Giulietti, M.R.V. Barbosa, A.A.J.F. Castro, L.P. de Queiroz, A. Fernandes, D.C. Oren, L.A. Cestaro, A.J.E. Castro, F.G.C. Pareyn, F.B.R. Silva, E.E. Miranda, S. Keel & R.S. Gondim. 2002. *Ecorregiões Propostas para o Bioma Caatinga*. TNC-Brasil, Associção Plantas do Nordeste, Recife.

sing Piauí and Ceará); Northern Sertaneja Depression (basically comprising Rio Grande do Norte, Paraíba and Pernambuco); Borborema Plateau (basically comprising Paraíba and Pernambuco); Raso da Catarina, Southern Sertaneja Depression, Chapada Diamantina Complex and Dunes of the Rio São Francisco, particularly in Bahia. Associated with these ecoregions, 57 areas were delimited within the Caatinga Biome, which considered to be of Exceptional Importance for conservation, 27 of which were designated as of Extreme Importance (see map, Chapter 2).

Unlike many other Semi-arid of the world, that in Brazil is densely populated, with over 20 million inhabitants, representing more than 10% of the total population of the country. Life expectancy and per capita income in this region are the lowest in Brazil, while the illiteracy rate is the highest. Because of these low levels of human development, the traditional 'Sertanejo' – or inhabitant of the Semi-arid – is considered an 'iron man'. In order to survive such hard conditions, he has developed a peculiar socio-cultural structure and has a close relation with his environment, and a good knowledge of the uses of natural resources available in the region. Characteristic features of the Sertanejo include the robust leather riding outfit which protects him and his horse from the spiny vegetation and from the heat and the burning rays of the sun; the 'forró', their typical dance, always played with the accordion, the triangle and the 'zabumba'; the 'pau-de-arara', a truck adapted for carrying many people, which has been the main means of transportation in the region.

Chapter 1 – IMSEAR: Millennium Institute of the Semi-arid – Actions in its Four Years

Ana Maria Giulietti & Luciano Paganucci de Queiroz

Program of Biodiversity: Flowering plants from the Brazilian Semi-arid: Orthophytum albopictum, Micranthocereus purpureus, Syphocampilus imbricatus, Calliandra hygrophila, Pavonia macrostyla, Calliandra asplenioides, Palicourea marcgravii, Manettia cordifolia, Esterrhazia splendida (from right to left, top to bottom)

The proposal to implant Millennium Institutes in certain strategic regions of Brazil: the Semi-arid, Amazonia and the Oceans, was undoubtedly due to the recognition, on the part of the MCT, that the regions chosen shared a backwardness in relation to other parts of the country in terms of their scientific and technological development, while at the same time, displaying a significant lack of basic information on the potential of their rich natural resources. This situation had resulted in a failure of adequate scientific and technological progress in these regions, compared to the progress made in other parts of Brazil.

In order to overcome this situation, a call for specific program proposals was published, designed to address the lack of information within these regions. In July 2001, our proposal was selected for funding and in February 2002, we started our activities at the 'Instituto do Milênio do Semi-Árido' (IMSEAR) designed to be completed by June 2006. The IMSEAR has received R$ 4,900,000 as funds from MCT; R$ 1,300,000 in scholarships from CNPq, and has gathered 23 participating institutions (see CD), 20 of which in the NE Brazil.

The 23 collaborating institutions met to consider what were the major problems affecting the 20 million inhabitants of the region, and how using scientific research, these could best be addressed. Two of the

greatest challenges faced in the region are the degradation of the environment, due to inappropriate and uncontrolled land-use over the last four centuries, and coupled with it, a serious lack of knowledge of the biodiversity of the Caatinga Biome, with its highly specialized environmental factors, where the majority of the inhabitants make a living. Water resources and their rational utilization can help combat the fragile nature of agriculture in the region, while a better understanding of the region's unique biota and its sustainable use, especially to combat disease, can also provide a rich source of income for, as well as promoting the health of, local communities, and at the same time help to preserve the environment.

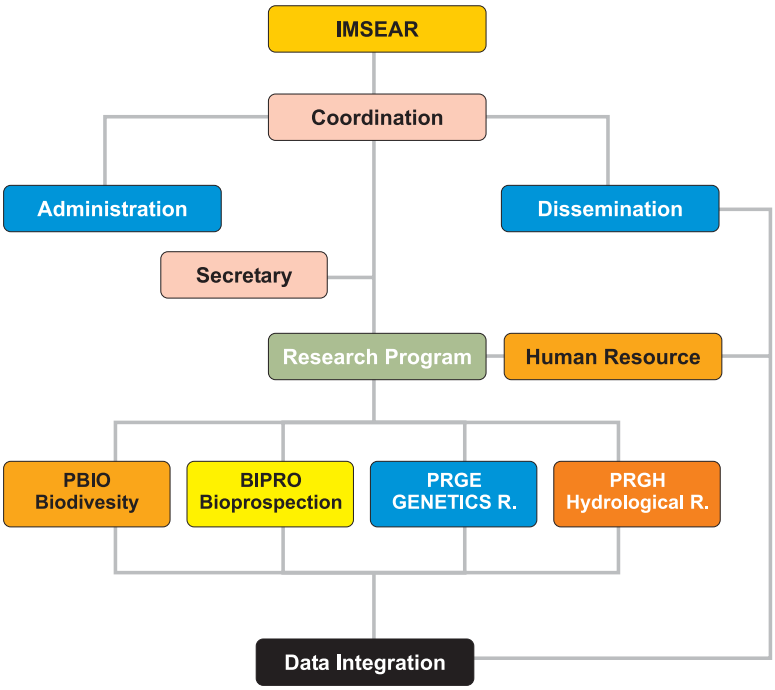
IMSEAR has two major foci of research. The first of these is on Biological studies and is divided into three different Programs. The **Program of Biodiversity** aims at elaborating databanks and publishing the knowledge obtained in the process. The plan has been to gather information on, to catalogue and map the biodiversity of the Caatinga Biome, as well as detecting the hotspots of biodiversity in the region and those endemic species that are threatened by extinction. In order to survey the fauna, the primary approach was a study of the zoological literature on the area and the specimens previously sampled in the Northeast, available in Brazilian museums. In order to survey the flora and fungi, besides the literature and the specimens encountered in local herbaria, a program of intensive collecting was undertaken in selected areas in Piauí, Ceará, Paraíba, Pernambuco, Alagoas and Bahia, by the participating institutions.

This Biodiversity Program has gone hand in hand with a major **Program of Bioprospection**, to assay this biodiversity in a search for biologically active substances which could alleviate the problems caused by some of the major diseases of the region, such as Cutaneous and Visceral Leishmaniasis, Chagas´ disease, Schistostomiasis and Malaria. At the same time, compounds were tested for their antibiotic and anticancer activity.

Consequent on this second program, a **Program of Genetic Resources** was developed, firstly to characterize those species which showed greatest potential, in terms of their genetic make-up and molecular biology, and secondly to conserve them '*ex situ*', by means of seed collection, propagation and the formation of germplasm banks. At the same time, the DNA of a high proportion of the plants species collected in the field was extracted and is stored in LAMOL's DNA bank (Chapter 21) at UEFS, for future analysis.

The second focus of IMSEAR is the study of different aspects of the hydrology of two large river basins, which feed the caatinga region in NE Brazil: the São Francisco and Contas Rivers. Studies on the former involve remote orbital sensing in order to analyse the process of sedimentation which is a serious problem at present occurring along the river bed. In the Contas River, the phyto- and zooplankton is being studied and monitored, from its source near the Serra do Barbado (c. 2,000 m high) to the middle reaches of the

river, where it crosses various types of caatinga. Also being studied are the dimensions of the subterranean water table known to exist in the South of Piauí, the largest in NE Brasil, and its potential for utilisation. Three projects form the **Program of Hydrological Resources**. They were selected because they can be used as models of management for these resources thus providing as essential giving great contribution for the politics of distribution and conservation of water in the semi-arid.



One of the main goals of IMSEAR is the improvement of the Northeastern institutions by providing them with top-of-line equipment, some of which has never been used in the region before, thus allowing researches to make use of the most advanced methodologies available in several fields. Such equipment is shared by all participating institutions and whenever possible by other institutions in the region.

Another focal point for IMSEAR is the formation of human resources at the level of undergraduate studies in the fields covered by the project. Meanwhile it helps to keep researchers in the region and attracts others to the Northeast, from different parts of the country. This association of local and incoming researchers is already crating a new generation of scientists who know how to work cooperatively, are trained in modern techniques and, above all, use their teamwork to provide solutions for regional problems.

Despite being a young project, running for only four years, and despite the innovative nature of the collaborative network, and the methodologies employed, IMSEAR can be judged a success. Several positive results of the project can be observed

Program of Biodiversity

1. a) A list with 8,116 species of seed plants from the Semi-arid was prepared based on herbarium collections; b) During the project 3,899 specimens of flowering plants and ferns from the Semi-arid were collected; c) A catalogue was prepared of 677 plant species in 353 genera from Caatinga of Bahia whose flowers are visited by bees.

2. A list of 981 species of fungi from the semi-arid was prepared, based on herbarium records, of which 500 specimens were collected during the project;

3. Based on literature and museum records, a species list from the semi-arid was produced, contains a record of 439 birds, 233 fishes, 66 reptiles and amphibians, 237 bees and 36 wasps, adding 210 species of vertebrate to the known fauna of the region.

Program of Bioprospection

1. Extraction of 536 components obtained from 90 species of plant native to the semi-arid:

   - 62 samples - 60% inhibition NO production;

   - 213 samples - 70% inhibition of lympho-proliferation;

   - 54 samples - 30% anti-*T. cruzi;*

   - 22 samples - 30% anti-*Leishmania*;

   - 27 samples - bactericide activity on *S. aureus*/*E. coli*.

2. Isolation of 103 pure substances, including: flavonoids, terpenoids, alkaloids, naphthoquinones, phenyl propanones and others:

   - 33 samples - 60% inhibition of NO production;

   - 54 samples - 70% inhibition of lympho-proliferation;

   - 4 samples - 30% anti-*T. cruzi*;

   - 9 samples - 30% anti-*Leishmania*;

   - 10 samples: bactericide activity on *S. aureus*/*E. coli*.

3. Fourteen new substances were discovered;

4. Twenty semi-synthetic derivatives were produced.

Program of Genetic Resources

1. DNA bank (Chapter 21) of plants from the Brazilian semi-arid:

- 1,995 samples, representing 1,029 species, 414 genera and 107 families;

- Intraspecific genetic variability of 12 species of the 31 with pharmacological potential and sampling of four populations of the 31 species with pharmacological potential;

2. Protocols for propagation of 15 of the 31 plant species with pharmacological potential;

3. Seed bank of the 31 species with pharmacological potential;

4. Bank of germoplasm 'ex-situ' of plant species with pharmacological potential, 20 in greenhouses and one in the field.

Program of Hydrological Resources:

1. Survey of subterraneous aquiferous wells in the State of Piauí:

- List of 2,165 wells, of which 255 were periodically evaluated concerning their bacteriological and physic-chemical quality;

2. Monitoring of the silting up in the Rio São Francisco;

3. Limnological characterization of Rio de Contas;

4. Elaboration of theme maps for the high and medium course of the Contas River basin;

5. Six expeditions in the States of Piauí and Bahia.

The following are examples of the impact IMSEAR has already had at the regional and national level:

1. Establishment of a sequential network of bioprospection comprising Botany, Phytochemistry, Pharmacology and genetic resources;

2. Formation of an integrated network of researchers who share the infrastructure offered by the Institution with the construction of new laboratories and new technology;

3. Development of strategies and protocols for planning and sustainable use of hydrological resources;

4. Creation of a new Graduate Program in Biotechnology (Master degree and Doctorate) including UEFS, FIOCRUZ and UFBA (Chapter 26), and making use of the network of researchers and several resources of IMSEAR;

5. Discovery of high diversity and a potential sustainable use of flora and fauna resources from the Caatinga Biome, namely: new endemic species; hotspots for conservation; high proportion of species with chemically active compounds, and the discovery of new drugs of potential use against diseases that affect local population which has already resulted in the register of two new trademarked drugs.

CHAPTER 2 – PPBio: The Program of Research on Biodiversity in the Brazilian Semi-arid

Alessandro Rapini, Luciano Paganucci de Queiroz & Ana Maria Giulietti

Fieldwork in the Dunes of the Rio São Francisco: inventory of insects (above) and fishes (below)

After more than two centuries of taxonomic studies and a resulting 1.5 million species described in the scientific literature, it is still impossible to give an accurate estimate of the number of species inhabiting our planet. At present these estimates vary from three million to thirty million species, with the largest gap in our knowledge centred firmly in the Tropics. The problems are further compounded by the intensity of environmental destruction, which is at its greatest in developing countries, such as Brazil, which are essentially tropical and highly bio-diverse[1]. The rate of habitat destruction is now alarming, with many species becoming extinct before they can be discovered or described by the scientific community. For these reasons, there is an urgent need for an expansion of taxonomic research, especially in the tropics. However, what we are observing at the present time is a gradual devaluation of taxonomy in favour of disciplines which are less effective in securing the future of world biodiversity. The marked decrease of investment in the area of Taxonomy is a worldwide problem and the decline of research and training is leading to a shortfall of qualified taxonomists.

1 N.E. In 2005, a series of papers on Brazilian mega-diversity, with new estimates of, for example, size of its flora, was published in *Conservation Biology* 19(3).

Fortunately, interest in Brazilian biodiversity has been fostered by MCT, who have instituted a Research Program (PPBio) to counter the prevailing neglect of taxonomy and to coordinate studies on national biodiversity. Objectives have been established under the principles of the Convention on Biological Diversity and the Directives of the National Politics on Biodiversity. Biodiversity research is to be developed through a multi-institutional network, preparing inventories of the various ecosystems and assembling new biological collections in poorly known areas. This network will provide support for research institutions and help to stimulate the growth of a dedicated human resource.

PPBio has already been initiated in the Amazon region and in the Semi-arid Northeast. Biological data will be digitized and integrated, to provide a powerful tool for environmental decision-making, with the entire information package soon to be made available online. By articulating the scientific knowledge gained from coordinated biodiversity research, the Program will optimize its accessibility, thus promoting the sustainable use of natural resources and consequently the conservation of our national biodiversity.

PPBio of the Semi-arid

The proposed actions, coordinated by the Brazilian government, are already augmenting our knowledge of the Semi-arid, and recently, eight ecoregions have been recognized, with 57 high priority areas identified for special conservation. Of these, 27 are considered to be of Extreme Biological Importance[2]. It was these decisions which prompted the MCT to promote the IMSEAR (Chapter 1) and more recently the PPBio of the Semi-arid.

The knowledge of the biodiversity of the region, together with the biotic and abiotic processes that affect the region and its flora and fauna, are among the first steps towards introducing systems of sustainable use of natural resources. Such systems will not only reduce environmental degradation within the region, but will also improve the quality of life of the communities that live and make a living there. IMSEAR has created the first large-scale Brazilian network of taxonomists, herbaria and museums, all working towards a common goal: to inventory the regional biodiversity, researching endemic species, especially to identify those in danger of extinction, to search out and evaluate those of potential economic importance, and to detect those areas, which are hotspots of intense biodiversity, to ensure that these may be guarded for the benefit of future generations.

2 Velloso, A.L., E.V.S.B. Sampaio, F.G.C. Pereyn (eds). 2002. *Ecorregiões Propostas para o Bioma Caatinga*. Associação Plantas do Nordeste, Recife.

PPBio of the Semi-arid has further continued the biodiversity studies initiated by IMSEAR. Its objective is to articulate the operation of regional research institutes, who are actively engaged producing a network of inventories of biodiversity, cataloguing and characterizing the many species of plants, fungi and animals of the Semi-arid. At the same time, the reference collections of animals and plants that form the holdings in herbaria and museums are enriched, for both research and teaching. Samples from the field are also being used for biochemical and phylogenetic studies on a range of organisms, which will improve our understanding of relationships between species and between their populations, scattered through the Caatinga. PPBio, which is planned as a ten year program, will not only help to increase our knowledge of the biodiversity of the region, but will also stimulate areas of scientific excellence within regional institutions, promoting high quality training programmes and attracting bright, new teaching and research staff.

The objectives of PPBio of the Semi-arid are implemented by a group of universities and other research institutions from Northeast Brazil. The Program is divided into three main components: Inventories, Collections and Theme Projects. The first two components are subdivided into four classes of organism: (1) fungi and microorganisms, (2) plants, (3) invertebrates and (4) vertebrates. The Theme Projects have four lines of research: (1) Genetic variability and phylogeny of plants with ornamental and foraging potential, (2) chemical taxonomy, (3) bioprospection on fungi and (4) reproductive biology of animals.

Inventories

The area held by the semi-arid region is large, comprising more than 1,000 municipalities. Thus areas considered of Extreme Biological Importance whose biodiversity is still little known will be the first ones to be inventoried. Currently, each area selected for being inventoried represents a different ecoregion of the Caatinga Biome:

Buíque/Ipojuca Valley (Pernambuco) – Borborema Plateau Ecoregion

Dunes of the Rio São Francisco (Bahia) – Dunes of the Rio São Francisco Ecoregion

Raso da Catarina (Bahia) – Raso da Catarina Ecoregion

Senhor do Bonfim (Bahia) – Southern Sertaneja Depression Ecoregion

Seridó (Paraíba e Rio Grande do Norte) – Northern Sertaneja Depression Ecoregion

Serra das Confusões (Piauí) – Ibiapaba-Araripe Complex Ecoregion

Progressively, new areas will be added to the network of inventories.

Every sample is georeferenced. Organisms collected are properly characterized and photographed in the field. Duplicates of plant collections will be distributed among the herbaria participating in the network; samples will be dehydrated in order to have their DNA extracted which will then be incorporated to the DNA bank of LAMOL (Chapter 21). The material extracted is then available for studies of molecular phylogeny. Seeds and eventually seedlings of groups under study will also be collected in order to be cultivated.

Collections

Brazil is one of the richest countries in number of species. However, most of its historical collections, which are essential for decision-making in taxonomy, are placed abroad. This paradox has created significant difficulties for studies on biodiversity carried out in the country. In order to minimize this situation, international programs have made their data available online or through repatriation of types (Chapter 5). In this line, PPBio is creating conditions in order to keep, modernize and increase biological collections in the NE Brazil as well as promoting the digitization of their data. All biological information will be integrated and will soon be made available on the internet, being accessible worldwide.

Representative and well organized biological collections are priceless. They provide us with data on the distribution of species throughout time. In some cases, they are the only evidence of biological diversity of natural areas which no longer exist. In the NE Brazil, taxonomists are trained at different levels, from undergraduate up to post doctoral (Chapters 23-26). PPBio of the Semi-arid helps the formation of specialists and encourage exchange among them, contributing to the correct identification of collections and consequently to the reliability of the biological data which are being generated and made available to society.

Theme Projects

Deep knowledge on the biodiversity of the Semi-arid can lead to conservation of the natural heritage. Following this, theme studies have been carried out in order to contribute to the conservation of natural landscapes, ecosystems, species and genetic diversity of endangered species.

In its first year, PPBio of the Semi-arid has funded a diverse range of projects:

1. (a) studies on molecular phylogeny of orchids and 'sempre-vivas' (plants of the family Eriocaulaceae known as 'everlasting') and (b) genetic variability in species of orchids, 'sempre-vivas' and cacti;

2. (a) analyses on chemical composition of aromatic plants of Verbenaceae, also determining microbiological activity of its volatile oils and (b) identification of alkaloids in orchids and their use in systematics;

3. biochemical analyses and evaluation of biological activities in fungi in order to bioprospect their products, and;

4. (a) investigation on the reproductive biology of Anura and fishes and (b) investigations on the natural history of wasps and bees.

CHAPTER 3 – Botanical Collections of Northeast Brazil[1]: History and Evolution

Maria Regina de Vasconcelos Barbosa & Luciano Paganucci de Queiroz

Collected plants are herborized and field information is recorded

The botanical collections of the Northeast Brazil are composed by collections of 30 herbaria, distributed throughout the nine States in the region. All together, these herbaria gather more than 820 thousand specimens from all large groups of plants (Bryophytes, Pteridophytes and Seed Plants), algae and fungi. Nearly 80% of the specimens housed at the herbaria in the Northeast region (about 660 thousand specimens) are found in only nine herbaria in the States of Bahia, Pernambuco, Paraíba and Ceará.

The whole content of these collections from Northeast region comprise a priceless heritage of the flora of the Brazilian Semi-arid, since most of the specimens come from this region, particularly the plants from the Caatinga (Introduction and Chapter 6), seasonal forests, cerrado (savannah-like vegetation) and campos rupestres (Chapters 6 and 9).

The herbaria of the Northeast Brazil are rather new when compared to those in other regions of the country or abroad, most of them created from the 1950's. Many of these herbaria are linked to teaching institutions, some having more of a didactic profile rather than a research one. Since the history of these herbaria is not actually known, this article presents some facts following chronological order per State.

Pernambuco

The first herbarium in the Northeast region started in 1916, when Dom Bento Pickel organized a botanical collection with around 3,500 species, at the Escola Superior de Agricultura, in São Lourenço. In 1944, the collection was transferred to Escola Superior de Agricultura de Pernambuco, where it remained until

1 See CD for the complete list of herbaria with acronyms, institution, city and size of collection in number of sheets.

the decade of 1950's, when it was merged to the collection of the Instituto de Pesquisas Agronômicas de Pernambuco (IPA) by Dárdano de Andrade Lima.

Founded in 1935, the IPA herbarium is closely linked to the very history of the institute. Its creator was Professor Vasconcelos Sobrinho, who also founded and leaded the Botanical Section of the IPA between 1935 and 1937. In 1938, along with the Instituto de Pesquisas Agronômicas, the herbarium was transferred to the buildings of the Escola Superior de Agricultura de Pernambuco, where nowadays the UFRPE is located. In 1960, the collection was transferred to its own headquarters.

From the decade of 1950 on, the herbarium was supervised by Professor Dárdano de Andrade-Lima. Under his management the IPA herbarium boosted greatly, becoming internationally known through scientific exchanges among Brazilian and international botanists. The greatest improvement of the collection happened in the period of 1979 to 1985, mostly because of the CNPq's Programa Flora.

The IPA herbarium is the oldest source of botanical information on the flora of the Northeast Brazil. Nowadays, it has a collection of about 70 thousand sheets, mostly of plants from the Caatinga including a great number of specimens of Palm trees from Brazil.

Due to the efforts of Professor Vasconcelos Sobrinho, a herbarium was created at UFRPE in which is now known under the acronym of PEUFR. Most of the samples are typical of the Caatinga Biome, having been collected in different kinds of caatinga and in montane forests (locally known as Brejos) which outstand as islands within the Caatinga. It is also worth mentioning as outstanding collections: Sudene herbarium (HSDB), whose collection was incorporated to the one of PEUFR in 1981; the collection of the flora of the region of Xingó; and the collection of the flora of different mountain forests of Pernambuco.

Also linked to UFRPE, there is the Sergio Tavares herbarium (HST), which had as its initial nucleus the collection organized by the researcher Sergio Tavares, linked to SUDENE and to ITEP, containing 4,600 specimens. This collection started with a forest inventory of the Northeast region promoted by SUDENE in the decades of 1960 and 1970. This collection also includes the wood collections of SUDENE (about 80 thousand samples) and of the ITEP (approximately 4,600 samples).

Also in Pernambuco, there is the Pe. Camille Torrand herbarium (URM), founded in1954 along with the former Instituto de Micologia linked to UFPE. This is nowadays considered the largest one in South America in its area, with about 79 thousand specimens, representative of the mycoflora of several parts of the World. Because of the importance of its collection, the URM herbarium is worldwide known as one of the most important mycological herbaria of the Tropics. Important collections belong to the

herbarium, such as: Pe. Camille Torrend, von Petrak, Augusto Chaves Batista and others. Among the samples in Brazil it is worth mentioning the ones from the Amazon region, Central Brazilian Plateau and from the State of Pernambuco. The specimens housed are representatives of several groups, from Myxomycetes to Lichens, particularly the Lichens formed by anamorphic Ascomycota. The Lichens collection left by Chaves Batista and his team has been acknowledged for its great significance. In the collection, there are specimens from nearly all groups of fungi particularly foliose Ascomycota, Basidiomycota and foliose Lichens.

Also at UFPE, the UFP herbarium was founded by the pharmacist botanist Dr. Geraldo Mariz in 1968, which belongs to the Department of Botany. UFP herbarium focuses on the Caatinga and Atlantic Forest, since these are the most representative ecosystems of the State. The collections of Bryophytes, Pteridophytes and Myxomicetes deserve special attention for having around 21 thousand specimens. The UFP herbarium holds an interesting collection of sea algae sampled in Rio de Janeiro between 1866 and 1868.

Paraíba

In Paraíba, the first organized collections date from 1938 and began with the collections of Lauro Pires Xavier, who was then in charge of the Serviço Florestal na Paraíba (nowadays, Herbário Lauro Pires Xavier – JPB), which belongs to the Department of Systematics and Ecology at UFPB. Also pioneer in the State is the collection made by Jaime Coelho de Moraes (currently, Herbário EAN, also at UFPB), who was professor of Botany at the former Escola de Agronomia do Nordeste. In the 1980's, JPB herbarium joined the network of the CNPq's Projeto Flora, which boosted the herbarium. From 1997 on, JPB became the reference herbarium of the Projeto Flora Paraibana, also supported by CNPq. In 2002, JPB herbarium became the first herbarium in the Northeast region to be accredited by CGEN as a faithful depositary of the Brazilian flora.

JPB herbarium has as its main objective support studies on the flora of Paraíba, keeping a rich collection of its plant diversity. It is the main floristic collection of Paraíba, working as a reference herbarium to the botanic studies and other researches dealing with local plants.

Since 2001, JPB herbarium has settled a cooperative agreement with the recently founded Botanical Garden of João Pessoa, as its associate herbarium.

Ceará

In Ceará, Prisco Bezerra herbarium (EAC) was founded at Escola de Agronomia. Its founder, the botanist Prisco Bezerra, accomplished its first collections in different Brazilian regions and ecosystems, giving

emphasis to leguminous of the Northeast region, which was his specialty. Later, the botanists Afrânio Fernandes, also specialist in leguminous, and José de Ribamar joined the EAC herbarium and continued the survey on the phanerogamic flora of the Northeast region. The expansion of the botanic collection at EAC herbarium started with the implementation of CNPq's Projeto Flora, at the end of the 1970's with the efforts of Professor Édson Nunes. The main collection of the State of Ceará is housed at EAC herbarium, being a reference on the regional floral.

Bahia

The history of the current botanic collections present in Bahia began in1950, when Prof. Alexandre Leal Costa founded the herbarium of UFBA (acronym ALCB), incorporating to it specimens brought from the Caminhoá herbarium, herbarium of the Faculdade de Filosofia da Universidade da Bahia and herbarium of the Colégio Antônio Vieira, the last organized by Priest Camilo Torrend. Later, under the curator of Prof. Lectícia S. S. Farias, the collection of the herbarium at the former Instituto Agronômico do Leste (IAL), organized by Prof. Geraldo Carlos Pereira Pinto, was also incorporated to the herbarium at UFBA. Currently, the herbarium has a collection of about 81 thousand specimens from different areas in Bahia, including one of the main collections of bryophytes in the Northeast region. There is also a significant collection of plants from Chapada Diamantina, the result of an inter-institutional project for the study of the flora in this region, coordinated by Professor Maria Lenise S. Guedes.

In 1965, the herbarium at the Centro de Pesquisas do Cacau (CEPEC) was created. Dr. Sérgio G. da Vinha was its first curator, but it is also worth mentioning the contribution of Mr. Talmon T. Santos, a great empirical collector with deep knowledge on the vegetation of the cocoa region of Bahia, later one of the greatest Brazilian parataxonomists. In the early 1970's, the CEPEC herbarium organized an intensive sampling program in the region of Chapada Diamantina, Bahia, in cooperation with RBG-Kew. With such partnership, the collection has reached international status. In 1979, the fast growth of the collection led CEPLAC to hire Dr. Scott A. Mori from NYBG for three years to the position of curator. That was a decisive period to the increase of CEPEC herbarium and its recognition as a model collection. The increase of the collection and the intensive exchange with other institutions and specialists made the collection at CEPEC one of the most important Brazilian regional collections.

In the early 1980's, André M. de Carvalho, CEPEC's curator at the time, implemented a pioneer project of digitalization of its collection with partial funding by CNPq. He has also started an ongoing partnership project with NYBG in order to study the Atlantic Forest in the South of Bahia. In 2005, the CEPEC herbarium reached the number of over 100,000 samples, one of the most important collections focused

on the Atlantic Biome nowadays.

At CEPEC herbarium, the floras of the main federal and state reserves of the State of Bahia are documented, as well as samples of Raymond M. Harley, Scott A. Mori, G. Hatschbach, André M. Carvalho, Wm. Wayt Thomas, among others. The collection of types at CEPEC makes a total of 1,700 sheets. Pictures of nomenclatural types and historical collections of Bahia are also housed at CEPEC as part of a partnership project with Kew Gardens (see Chapter 5).

On the decade of 1970's, the RADAMBRASIL Project was started. At first it was implemented in the Amazon region and later expanded its activities to other regions of the country. In the beginning of its activities, the RADAM Project sent botanic material to institutions already widely recognized, such as the Botanical Garden of Rio de Janeiro, Instituto Nacional de Pesquisas da Amazônia and Museu Paraense Emilio Goeldi. However, in 1980, a herbarium directly linked to the project was founded in Bahia, named Radambrasil herbarium (HRB).

The herbarium of UEFS (HUEFS) was created in 1980, having the biologist Larry Ronald Noblick as its first curator. Its activities focused on the flora of the microregion of Feira de Santana. In August of 1986, the biologist Luciano Paganucci de Queiroz took over the position and defined as priorities for the herbarium the increase of sampled area represented in the collection and its digitalization of the collection. Alongside the process of digitalization, there was the intensification of the sampling in the semi-arid region of Bahia, including the caatinga and the campos rupestres of Chapada Diamantina. In the beginning of the 1990's, the projects of the floristic surveys in the caatinga (a partnership with RBG-Kew) and in Chapada Diamantina (CNPq) got financial support. Vacancies for professors were also opened then and these professionals joined the herbarium team, which has had nowadays the largest number of taxonomists of the Northeast Brazil.

Currently, HUEFS is the center of large projects such as the IMSEAR (MCT/CNPq, Chapter 1) and PPBIO (MCT, Chapter 2) of the semi-arid region. As the IMSEAR main herbarium, it gathers material of the Semi-arid sampled by the 17 institutions that take part on the project, what makes its collection one of the most important for the flora of the Caatinga. There are also important reference collections for the flora of Bahia, including mainly the Leguminosae, Cactaceae, Eriocaulaceae and Palmae collections. About 800 nomenclatural types are housed at HUEFS, in addition to around 2,000 cibachromes of types of plants collected in the Northeast region (Chapter 5). The current collection holds to around 103,000 specimens, the second largest herbarium of the Northeast and of the main collections of the Biome of Caatingas. Notably, all collection is now digitized, being one of the few Brazilian herbaria in such situation.

Other collections from Bahia include those of UESC herbarium, in Ilhéus, started in1983, and of UESB, created in 2002, in Jequié.

The herbaria of Bahia have experience on the formation of inventory networks. In 1996, a network for the accomplishment of Chapada Diamantina Project was structured, coordinated by UFBA and funded by RBG-Kew. Later, this network was enlarged for a big project, Flora da Bahia (Chapter 7), coordinated by UEFS and that joins all botanical institutions of the State.

More recent Collections in other States of the Northeast Region

In the States of Piauí, Rio Grande do Norte and Alagoas, the collections are more recent.

Graziela Barroso herbarium (TEPB), at UFPI, was founded in September 1977, and it is currently the most representative of the flora in the States of Piauí and Maranhão. There are two herbaria in Maranhão, UFMA and SLS, both at UFMA, however, none of them has been working regularly lately.

The herbarium of the Escola Superior de Agricultura de Mossoró (MOSS), in Rio Grande do Norte State, was founded in 1973 by professor Odaci Fernandes de Oliveira. Nowadays, this herbarium holds around 7,600 specimens from several groups of vegetation. Great part of it was collected in the decade of 1980 with the projects Flora do Rio Grande do Norte and Flora do Parque das Dunas. Thus, the collection of MOSS herbarium is the most representative one of the Sate flora, since the State does not have another herbarium of such magnitude.

The second herbarium of Rio Grande do Norte State belongs to UFRN and was founded in 1984, with the main objective of registering the vegetal specimens that occurs along the seashore of the capital city of Natal. It is a little herbarium that is being structured having recently with hired a taxonomist.

In Alagoas, the herbarium of the Instituto do Meio Ambiente (MAC), main center of botanical reference in the State, was founded in 1978 under the orientation of Dr. Dárdano de Andrade-Lima of IPA. The most important collections at MAC come from restinga and Atlantic Forest areas, where the largest number of surveys took place.

In Sergipe, the herbarium of UFS (ASE) holds 7,000 exsiccates, coming mostly from the shore and the Caatinga, particularly from the region of the Serra de Itabaiana. This herbarium is also being structured with the recent recruitment of a taxonomist.

Considerations

The botanical collections of the Northeast region of Brazil have been housed in ten medium sized herbaria (collections between 30 and 110 thousand specimens) which make up a total of about 660 thousand specimens. Besides these ones, there are 20 other small herbaria (less than 30 thousand specimens), that hold more 135 thousand sheets. The majority of the samples deposited in these herbaria come from the Semi-arid, representing a priceless collection of the flora in this region.

It is worth noticing that some of these collections are in poor conditions due to the lack of taxonomists. Besides that, many of theses collections need funding to boost the sampling activities and to form taxonomists and, on the other hand, to improve its infra-structure. Part of these demands have been met by projects which have included institutions of the Northeast region, such as IMSEAR (Chapter 1) and, more recently, PPBIO of the Semi-arid (Chapter 2). We hope that these actions help increase the integration of these herbaria, including the digitization of collections all together and the availability of their information on the network.

CHAPTER 4 – Importance of Culture Collections of Microorganisms (CCMs) for the Conservation of Microbial Biotechnological Resources of the Brazilian Semi-arid Region

Ana Paula Trovatti Uetanabaro and Aristóteles Góes-Neto

Culture of fungus mycelium

Culture Collections of Microorganisms (CCMs) are centers of conservation of *ex-situ* genetical resources, which have acquisition, characterization, maintenance, and distribution of microorganisms, authenticated cell cultures and certified biological reagents as their main roles. These collections also provide specialized services and are centers of information. Different types of culture collections – research, institutional and mainly service collections – are highly important for the conservation and exploitation of genetic and metabolic diversity[1].

CCMs have an important role on the development of biotechnological products because they are depositories for the conservation and maintenance of their characteristics. Products from microbial origin are used in the agriculture (increase of soil fertility; biological fixation of nitrogen; biological control of insects and pathogens; growth promoters in plants); pharmacy (production of antibiotics, antifungal and antiviral agents, and biopolymers of medical application), food production (production of drinks) and in chemical industry (production of biosurfactants; polysaccharides; enzymes for use in detergents; textile products; paper and cellulose). Some microorganisms are related to energy production since they are excellent alcohol producers. They are also used in the environmental sanitation, notably in advanced techniques of bioremediation of toxic

1 Canhos, V.P. & G.P. Manfio 2000. Microbial resource centres and *ex-situ* conservation. *In* F.G. Priest & M. Goodfellow (eds.) *Applied Microbial Systematics*. Kluwer Academic Publishers, pp. 421- 446.

residues. Besides these applications, cultures of microorganisms are also used in teaching, taxonomic studies, identification of pathogens and tests for quality control of products and materials[2].

Because of the important applications of microorganisms, microbiological collections are strategic resources of national security, which can be part in the innovating infrastructure of a country. Information on these collections is a key resource the country can make use of in order to establish fast and efficient strategies for scientific and technological development[3].

In Brazil, there are few collections whose data are totally or partially digitized, or even available on the internet[4]. Although information can be easily obtained contacting their curators, complete digitization of microbial collections will make the access to the material even easier and will improve quality and efficiency of the documentation procedures, collection management and specialized services.

In order to know and support CCMs placed in the Brazilian Semi-arid, which hold material from this area, PPBio (Chapter 2) is carrying out a survey on their infrastructure, collection and needs so that their services can be improved. Up to now, a preliminary survey of the CCMs situated in the region has been carried out. Information was obtained via an electronic form sent to the collections or through visits to some participating collections. According to the information provided, four of them make microbial cultures of prokaryotes and eukaryotes available under request by the academic and productive sectors.

These collections are very important since they are composed of microbial strains isolated in the Brazilian Semi-arid, a region which has been little explored regarding its microbial diversity. Collections can be contacted via their curators. Considering collections and services provided, it is worth mentioning the following collections in the Brazilian semi-arid region (see CD for contacts):

(i) Culture Collection of Microorganisms of Bahia (CCMB), UEFS;

(ii) Mycotheca of UFPE (URM);

(iii) Collection of Microorganisms of the Department of Antibiotics (DAUFPE), UFPE;

(iv) Culture Collection and Preservation of Genomes of Zoosporic Fungi (CCPGFZ), UFPI.

2 Canhos, V. P. & R.F. Vazoller. 2004. *A Importância das Coleções Biológicas*. http://www.comciencia.br/reportagens/framereport.htm.

3 Ministério de Ciências e Tecnologia, 2002. *Programa de Biotecnologia e Recursos Genéticos – Definição de Metas*. Ministério da Ciência e Tecnologia, Brasília-DF.

4 Canhos, V.P., C. Umino & G.P. Manfio. 1999. Coleções de culturas de microrganismos. In M.C.W. de Brito e C.A. Joly (eds.) *Biodiversidade do Estado de São Paulo, Brasil: Síntese do Conhecimento no Final do Século XX. Volume 7: Infra-estrutura de Conservação in-situ e ex-situ*. Fundação de Amparo à Pesquisa do Estado de São Paulo, pp. 81-101; http://www.biota.org.br

Up to September of 2005, the CCMB collection had 256 samples (bacteria, filamentous fungi and yeast); DAUFPE had around 4,000 samples of actinomycetes and 500 of other bacteria; the one at URM had 200 species of yeast and around 1,100 species of filamentous fungi and; CCPGFZ had 77 strains of zoosporic fungi. Preliminary results showed that the main needs of these collections are related to the lack of staff and computers for digitization of the data. Currently, PPBio of the Semi-arid has supported the digitization of the collection aforementioned but with multi-user servers of the institutions. In order to improve the service, as well as online availability of the collections at the CCMs, we suggest the acquisition of one server for each collection.

CHAPTER 5 – Repatriating Data from Kew Herbarium to Northeast Brazil

Daniela C. Zappi, Eimear Nic Lughadha, Teonildes S. Nunes, Elaine Miranda, Marlon Machado, Nicholas Hind, Gwilym Peter Lewis, Simon Mayo, Maria Regina Vasconcelos Barbosa, Fabrício Juchum & Edgley Adriano César

Herbarium exsiccates of repatriated type specimens: *Encholirium harleyii* (Bromeliaceae; left) and *Lychnophora blanchetii* (Compositae; right)

Northeastern Brazil is frequently associated with periodical droughts and low levels of human development, which gives the false idea of constancy in the landscape and low biological diversity. However, from the coast to the countryside, a gradient of decreasing humidity makes vegetation change from moist forest up to the driest caatinga (Introduction).

The first attempts made by the Plantas do Nortdeste Programme indicate there are about 20 thousand flowering plants in the region[1], approximately 40% of the total estimate for Brazil. However, information on the identity of these species and how they are distributed is not available. Most of these data are scattered in the herbaria of Northeast Brazil and some herbaria abroad which hold historical collections from Brazil. Herbaria[2] are collections of dried pressed plants which hold records of species occurring worldwide, such as large international herbaria[3] or regional ones. The Herbarium at the Royal Botanic Gardens, Kew (RBG-Kew), holds 7 million specimens and is amongst the four largest ones in the world.

Repatriation Project Background

Europeans who collected specimens during historical expeditions, particularly in the 19th century, did not leave duplicates in Brazilian herbaria. At that time, politics in botany involved reciprocity to access collec-

1 Barbosa, M. R. V. *et al*. 1996. Checklist preliminar das angiospermas. *In* E.V.S.B. Sampaio, S. Mayo & M.R.V. Barbosa (eds.) *Pesquisa Botânica Nordestina*: Progresso e Perspectivas. Sociedade de Botânica do Brasil, S. Reg. Pernambuco, Editora Universitária, p. 253–415
2 http://www.funsci.com/fun3_en/herb/herb.htm
3 http://www.nybg.org/bsci/const/ and http://www.kew.org/collections/herbcol.html

tions in Europe via loans and donations of specimens or visits. Neither of these ways of access allowed for establishment of high quality reference collections in Brazil. The project Repatriation of Herbarium Data from the Kew Herbarium to Herbaria in Northeast[4] was created in order to meet this need, while promoting opportunities of training for botanists from the NE Brazil at Kew.

Considering that Kew Herbarium has a high number of collections accurately identified, as well as huge amount of historical specimens (including many types), the transference of images, databases and related literature is an important contribution for the herbaria in the NE. The project provides access to database on all specimens of selected families at Kew, images of relevant type specimens and copies of original descriptions, which are publications where the type specimen is linked to the name of the species.

The project has the collaboration of Brazilian institutions, as part of the Project for Taxonomic Support (PATAX), within the research area of Biodiversity and Conservation of APNE, and the packages of information have been deposited at three of the largest regional herbaria in NE Brazil, CEPEC, IPA and UEFS.

First Phase

The first phase of the project (1998–1999) was funded by the Darwin Initiative for the Survival of Species. Data and images of eight families of plants were repatriated, namely Cactaceae, Gramineae, Loranthaceae, Myrtaceae, Passifloraceae, Rubiaceae, Verbenaceae and Viscaceae. It is estimated that about 15% of the flora of the NE Brazil at RBG-Kew was repatriated during this phase.

Second Phase

This stage was funded by BAT (British American Tobacco). Between 2000-2004, almost 50% of the data, images and specimen types collected in the States of NE were repatriated. Selected groups include those of high economical and ecological importance such as the Compositae, the family of the sunflower; the Leguminosae[5], family of the beans and soy, as well as others of high diversity in the region, such as the Eriocaulaceae (family of the everlasting flowers), Araceae, Bromeliaceae (of the pineapple), Orchidaceae (of the orchids), Cyperaceae (of papyrus) and Polygalaceae.

4 Zappi, D. *et al*. 2003. Repatriamento dos dados do herbário de Kew para o Nordeste do Brasil. In M.A. Jardim, M.N.C. Bastos & J.U.M. Santos. *Desafios da Botânica Brasileira no Novo Milênio: Inventário, Sistematização e Conservação da Diversidade Vegetal*. 54 Congresso Nacional, Belém, Pará. Ed. MPEG/UFRA, Embrapa, pp. 55-57.

5 César, E.A., F.S. Juchum & G.P. Lewis (in press). Lista preliminar da família Leguminosae na Região Nordeste do Brasil/ reliminary list of the Leguminosae in Northeastern Brazil. *Repatriamento de Dados do Herbário de Kew para a Flora do Nordeste do Brasil/ Repatriation of Kew Herbarium Data for the Flora of Northeastern Brazil*, vol. 2.

In this second phase, the process of digitization of images was started. They were scanned and made available via in an interactive database on the web[6].

Repatriation of Kew Herbarium data has been making information available to scientific community with the objective of helping preserve the biodiversity by giving support to the botanists to identify and catalogue accurately species of native plants. Thus botanists can contribute directly for the objectives of the Convention on Biological Diversity.

New Initiatives of Data Repatriation

The activities of repatriation of Kew Herbarium have also been diversified, as for instance is the case of the cooperative project between RBG-Kew and the Natural History Museum of London (BM), where the object of the survey is the whole collection of single historic collector – the Project Spruce. Data available at the institution's files (field books) are also added to the images of specimens in the herbarium and specimens databases[7]. Another project aims to database and digitise all types of African Plants by 2006.

We hope that in the future it will be possible to offer this kind of service for a larger number of relevant collections for the study of the Flora of Brazil, such as collections made by the distinguished botanists Gardner and Burchell, also comprising other regions in Brazil and South America.

Estimating Number of Species from Herbarium Collection

From the checklists produced for each family and comparing them with the data available in different floristic treatment for NE Brazil, it is possible to estimate the number of species in the region. The family Rubiaceae is represented in Kew by 237 species from the NE[8]. Extrapolating this figure for the total flora, we reach an estimate of 4,500-6,200 species from the Northeast Brazilian flora deposited at the Kew Herbarium. This estimate assumes that the other families are equally represented at Kew (i.e. that the Rubiaceae are neither sub nor over represented comparing to the other families). Work carried out by other authors estimate that the number of species in the NE might be around 20,000 species. Obviously, neither Rubiaceae nor the other families have all the species that occur in Northeast Brazil represented

6 http://www.rbgkew.org.uk/data/repatbr/homepage.html
7 http://internt.nhm.ac.uk/jdsml/botany/spruce/index.dsml
8 Zappi, D. & T.S. Nunes. 2002. Lista preliminar da família Rubiaceae na Região Nordeste do Brasil/Preliminary list of the Rubiaceae in Northeastern Brazil. *Repatriamento de Dados do Herbário de Kew para a Flora do Nordeste do Brasil/ Repatriation of Kew Herbarium Data for the Flora of Northeastern Brazil*, vol. 1.

at Kew. We expect that many new registers are yet to be made by the Flora da Bahia project (Chapter 7), mainly in the southern and western of the State, including description of new species. The final result of these studies might add about 20% species to those already registered.

If one inverts the thought process and used the most conservative figures (3.8%) for the Rubiaceae in inventories, which represents the proportion of Rubiaceae within the flowering plants diversity in a very rich environment ('campos rupestre'), we calculate that, if the total number of species in the NE Brazil is around 15,000-20,000, there would be between 568 and 758 species of Rubiaceae in NE. The same calculation using the highest proportion of Rubiaceae (5,2%), obtained in a habitat where Rubiaceae diversity is more representative, would give us an estimate of 780-1,040 species of Rubiaceae in NE, which is up to four times the number registered during the project. We think it is rather unlikely that more than 400 species of Rubiaceae will ever be recorded for the region, therefore we consider the estimate of 15,000-20,000 species for Northeastern Brazil highly exaggerated.

Updated lists based on the literature report numbers of angiosperms for NE Brazil include approximately the same number of species of Rubiaceae found at Kew. However, they have a remarkable difference concerning species listed – a superimposition of less than 50% of the names. These comparisons were made at both generic and specific levels. That is because many species are known under several scientific names according to the States in the NE. This inflation of names can only be corrected if every species registered for the region is represented by one or more vouchers. Works aimed at simplifying and stabilising scientific names of Brazilian plants are necessary so that we can count with more realistic estimates on the diversity of the country.

Hence, based on these estimates, it is possible to infer that: (i) further basic taxonomic work must be carried out in order to allow a more accurate number of taxa in this list; (ii) present estimates for the number of plant species in NE Brazil seems to be inaccurate and, (iii) the total number of species of this flora might be around 10,000 species.

CHAPTER 6 – Flowering Plants of the Brazilian Semi-arid

Luciano Paganucci de Queiroz

The flowering plants (or angiosperms) are the most diverse group of organisms after the arthropods. They are extremely important for land life, being the main producers of organic matter. Because of the predominance of different life forms, they define the landscapes that nowadays cover most of the planet. Angiosperms also represent the main source of resources for human populations, including the ones that inhabit the Brazilian semi-arid region, providing food, medical products, construction material, fuel and forage.

The Northeast Brazil is usually said to have low floristic diversity. This results from the strong impression made by the overlooking the caatinga (Introduction) – predominant kind of vegetation in the region – in mid dry season, when vegetation is composed by trees and tiny shrubs with no leaves, giving a stark impression of dead vegetation. However, the Northeast region holds more types of vegetation than any

Flowers of Leguminosae, the most diverse plant family in the Brazilian Semi-arid: *Senna pendula* (top left), *Calliandra macrocalyx* (top right), *Cratylia* sp. nov. (bottom left); an open legume of *Dioclea marginata* (bottom right) [Photos by L.P. Queiroz]

other region in Brazil. We can find the Atlantic Rainforest, seasonal forests and inland mountain forests, *restinga* and shore dunes, mangroves, cerrados (savannah-like vegetation) and 'campos rupestres' (Chapter 9), not to mention the caatinga itself. Besides that, recent works have shown that caatinga are highly diverse.

In the Brazilian Semi-arid, the principal vegetation types are the caatingas, seasonal forests, campos rupestres and cerrado, and they can be characterized according to their flowering plant composition. The flora of the cerrados and the seasonal forests represent an extension of that of the Central and SE Brazil, respectively. However, the floras of caatinga and campos rupestres present many autochthone elements and will be more detailed further in this chapter.

Caatinga

Caatinga occupies most of the 900 thousand km^2 in the Northeast Semi-arid. It is characterized by a relatively low tree stratum (generally up to 5 m high) without a continuous canopy, trees and shrubs usually with thin stems, frequently thorny, with small or composite leaves, deciduous in the dry season. Cactus and terrestrial bromeliads are also important elements of the caatinga landscape. The herbaceous stratum is short-lived and mainly constituted by therophytes and geophytes that occur only in the short rainy season.

Some authors have considered the caatinga as having a small number of species, poor in endemism at generic and specific levels and not presenting an autochthonous flora, but derived from the floras of the Chaco and of the Atlantic Forest. However, recent systematic studies have shown a very different situation[1,2], . Around 1,012 species of angiosperms were registered for the Caatinga Biome[3], 318 species (around 31%) of which were considered endemic, besides 18 genera referred to as endemic to the caatinga[2,4], (see the updated list of genera in the CD). The distribution of this floristic diversity was the main aspect responsible for the recognition of ecoregions in the Caatinga Biome[5].

1 Harley, R.M. 1996. Examples of endemism and phytogeographical elements in the caatinga flora. Anais da Reunião Especial da SBPC, Feira de Santana, pp 219-227.
2 Giulietti, A.M. et al. 2002. Espécies endêmicas da caatinga. In E.V.C.B. Sampaio et al. (eds.) *Vegetação & Flora da Caatinga*. Associação Plantas do Nordeste, CNIP, Recife.
3 Gamarra-Rojas, C.F.L. & E.V.S.B. Sampaio. 2002. Espécies da caatinga no banco de dados do CNIP. In E.V.C.B. Sampaio *et al*. (eds.) *Vegetação & Flora da Caatinga*. Associacão Plantas do Nordeste, CNIP, Recife.
4 Queiroz, L.P. 2006. The Brazilian caatinga: phytogeographical patterns inferred from distribution data of the Leguminosae. *In* R.T. Penninigton, G.P. Lewis & J.A. Ratter (eds.) *Neotropical Dry Forests and Savannas*. Royal Botanical Garden, Edinburgh, pp 113-149.
5 Velloso, A.L. *et al*. 2002. *Ecorregiões Propostas para o Bioma Caatinga*. TNC-Brasil, Associação Plantas do Nordeste, Recife.

Tacinga inamoena with flowers and fruits, a cactus belonging to a genus endemic to the Brazilian Semi-arid. [Photo by A. Rapini]

Some families present great diversity in the caatinga. Leguminosae is the most diverse, with 293 species in 77 genera, 144 of which are endemic of the caatinga[5]. Species of many genera of Leguminosae contribute for the formation of the tree and shrub stratum that shapes the caatinga landscape, such as *Mimosa*, *Acacia*, *Caesalpinia* and *Senna*. Other floristically important family is the Euphorbiaceae, with a great diversity of species of the genera *Croton* ('velames'), *Cnidoscolus* ('cansansões' or 'favelas') and *Jatropha* ('pinhões'). Cactaceae also constitutes an important element of the landscape, with their succulent, aphyllous and thorny stems. Fifty-eight species have been registered for the caatinga, 42 endemic to the biome[6]. Typical genera are *Cereus* ('mandacarus'), *Pilosocereus* ('facheiros'), *Melocactus* ('cabeças-de-frade') and *Tacinga* ('palmas'), this last one endemic to the caatinga. The family Bignoniaceae is also well represented, especially with liana species of the genera *Arrabidaea*, *Adenocalymma* and *Piriadacus*, the last one endemic to the caatinga.

Taxonomy of many groups of caatinga is still incipient. Only recently, systematic efforts have been done to teaching taxonomy in the NE Brazil, which has improved the knowledge of the flora and increased the description of new species in different families. Yet, there are few inventories along the region and this gap is worse if we have in mind that the caatinga is highly heterogeneous, with some centers of floristic endemism different from which is considered typical caatinga, like the regions of Raso da Catarina, Dunes of the Rio São Francisco and the Ibiapaba moutain range[5]. Preliminary inventories made in these areas have shown new taxa and interesting biogeographical links.

Campos Rupestres (see also Chapter 9)

In the NE Brazil, campos rupestres are restricted to the plateau of the Chapada Diamantina in the State of Bahia, representing an extension of the Espinhaço Range in the State of Minas Gerais. Campos rupestres are predominantly herbaceous-shrubby vegetation that occur above 900 m, on sandstones and quartzite, usually under moister weather conditions than in the surrounding caatinga.

6 Taylor, N.P. & D.C. Zappi. 2002. Distibuição das espécies de Cactaceae na caatinga. *In* E.V.C.B. Sampaio *et al*. (eds.), *Vegetação & Flora da Caatinga*. Associação Plantas do Nordeste, CNIP, Recife, Pp 123-126.

Vegetation in the campos rupestres is shaped in a mosaic of different physiognomies that occur side by side, reflecting different topographic conditions, depth and composition of the soil and different microclimates. Thus, in the same environment one can find extremes: from island of herbaceous vegetation on almost naked rocks to herbaceous swamps or shrubby scrub. Within typical groups of the shrubby and subshrubby stratum, representatives of families of eudicots are common. These species usually have thin branches and thick leaves, often with revolute margins and clustered in the apex of the branches. Such characteristics can be seen in species of Melastomataceae, a very diverse family in the campos rupestres of the Chapada Diamantina, which is the center of diversity for several genera, such as *Marcetia*, *Microlicia*, *Cambessedesia* and *Lavoisiera*. Other very important family in this stratum is the Asteraceae, perhaps the most diverse in the campos rupestres, with several large and endemic genera, such as *Acritopappus*, *Agrianthus*, *Catolesia*, *Chromolaena*, *Lasiolaena*, *Lychnophora* and *Semiria*. Leguminosae is also among the most diverse families, but the more diverse genera are different from those found in the caatinga, such as *Calliandra*, *Chamaecrista*, *Mimosa* and *Camptosema*. For the Labiatae, the Chapada Diamantina is an important center of diversity for genera like *Eriope* and *Hyptis*.

Flowers of *Norantea brasiliensis* (top left), *Aristolochia* (top right), *Metternichia princeps* (center left), *Acanthaceae* (center right), *Sorocea* (bottom left), *Vellozia* (bottom right) [Photos by L.P. Queiroz]

In the herbaceous stratum, families of monocots are predominant. A very diverse family is Orchidaceae, with several species growing on rocks, such as: *Sophronitis* (= *Laelia*), *Cattleya*, *Epidendrum* and *Encyclia*; in other environments, species of these genera occur as epiphytes. In swampy areas, there is great abundance of species of *Habenaria*. Besides the orchids, the Chapada Diamantina is an important center of diversity for the family Eriocaulaceae, particularly for the genera *Paepalanthus*, *Syngonathus* and *Actinocephalus*. Inflorescences of these plants are commercialized as 'dry flowers', being known popularly as everlastings. Velloziaceae ('canelas-de-ema') and Xyridaceae are other two families of monocots whose main center of diversity is also in campos rupestres.

One of the main biogeographical characteristics of the campos rupestres are their high local (alpha) diversity and also the high diversity among areas (beta diversity). For this reason, each surveyed area of campos rupestres reveals a particular group of species that does not occur in any other area. Good examples of this fact can be found in two floras recently published. The Flora of the Pico das Almas[7] (in the region of Rio de Contas) surveyed 1,044 species in an area of 170 km^2 (what corresponds to a square with only 13 km in each side). Another survey carried out in the region of Catolés[8] resulted in 1,713 species in an area of 667 km^2 (equivalent to a square of only 25.8 km in each side). Although being apart by only 80 km in a straight line, the areas of Catolés and Pico das Almas share only 614 species, being therefore 1,086 species exclusive of Catolés and 435 exclusive of Pico das Almas[8]. That is why it is very hard to estimate the number of species in the campos rupestres of the Chapada Diamantina before a larger coverage of inventories. The available data (the ones mentioned above, plus the surveys at Morro do Pai Inácio and Serra da Chapadinha[9,10]) have already registered more than 2,700 species of angiosperms.

Importance to Man

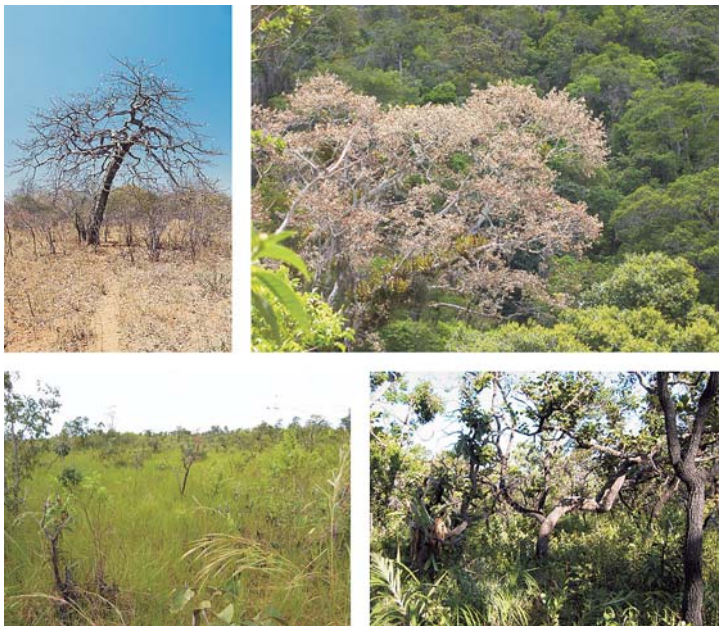
Plant species from the Brazilian Semi-arid are an important resource to human populations, mainly to the ones who live in the caatinga. The 'sertanejos', native inhabitants of caatinga, are able to survive the hard conditions imposed by the caatinga because of their ability to interact with the environment, taking from it a substantial part of their bare necessities. Most of the animal farming in the caatinga is extensive and the animals, particularly goats and cattle, feed on several native species of legumes, grasses and 'velames' (species of *Croton*). Besides that, the main source of energy is the wood from several species of plants.

Traditional medicine is very strong among the sertanejos and most medical products are teas and unguents made directly from several native plants of the caatinga. Within the edible ones, it is worth mentioning fruits such as 'umbu' (*Spondias tuberosa*) and 'licuri' (*Syagrus coronata*).

7 Stannard, B.L. (ed.). 1995. *Flora of the Pico das Almas, Chapada Diamantina, Bahia, Brazil*. Royal Botanic Gardens, Kew.
8 Zappi, D.C. *et al*. 2003. Lista das plantas vasculares de Catolés, Chapada Diamantina, Bahia, Brasil. *Boletim de Botânica da Universidade de São Paulo* 21: 345-398.
9 Guedes, M.L.S. & D. Orgue. 1998. *Checklist das Espécies Vasculares do Morro do Pai Inácio (Palmeiras) e Serra da Chapadinha (Lençóis), Chapada Diamantina, Bahia – Brasil*. Universidade Federal da Bahia, Salvador.
10 Conceição, A.A. & J.R. Pirani. 2005. Delimitação de habitats em campos rupestres na Chapada Diamantina, Bahia: substratos, composição florística e aspectos estruturais. *Boletim de Botânica da Universidade de São Paulo* 21: 85-111.v

CHAPTER 7 – Flora of the State of Bahia: History and Organization

Tânia Regina dos Santos Silva, Ana Maria Giulietti, Raymond Mervyn Harley, Luciano Paganucci de Queiroz & Flávio França



Examples of vegetation types in the State of Bahia: open caatinga (top left), semideciduous forest (top right), open field (bottom left) and cerrado (bottom right) [second photo by D. Cardoso, the remaining by L.P. Queiroz]

The State of Bahia has an area of 567,295.3 km², representing about 6.6% of the Brazilian territory and approximately 36.3% of the Northeast Region. Bahia displays a great variety of habitats, representing almost all of the existing biomes of Brazil. In the eastern portion there is a predominance of Atlantic Forest, restingas[1], and mangroves. To the west, the semi-arid region covers more than 50% of the State, including Caatingas (Introduction and Chapter 6) and seasonally dry forests at lower elevations, and the massif of the Chapada Diamantina where can be found a mosaic of different vegetation types, including cerrado (savannah-like vegetation), different types of forest and the campos rupestres (see Chapters 6 e 9). The westernmost portion of the State is covered by a large area of cerrado, which represents an extension of the Central Brazilian vegetation.

In spite of the range of vegetation types and the exuberant flora, the State of Bahia has only 6.68% of its area in permanent, protected reserves. The structure of conservation areas in the State consists of 39 environmental protected areas (APA), 34 permanent protection reserves, 29 private reserves (RPPN) and seven areas in several others categories[2]. In theory there are many areas under protection, but they still lack proper settlements concerning ownership of land property, effective management plans, trained staff and adequate surveillance.

1 NE – Restinga is a Brazilian word used to refer to the low forests and open scrub that grow on the coastal sands that border the Atlantic Ocean.
2 NE – Information about conservation areas in the State of Bahia could be found in the site www.sei.ba.gov.br.

Botanical Fieldwork since the 19th Century

Although previous estimates of the angiosperm flora of the State of Bahia have suggested that there may be about 10 thousand species[3] – by any standards a very large figure – it now seems probable that this is an underestimate. A good example of the species richness of the flora can be found in the Flora of the Pico das Almas[4], which, in a relatively small area, records 1,123 taxa, 9.3% of which (105 species) were new to science. An extrapolation of this figure for the whole State, suggests a total of around 12 thousand species of vascular plants. Such a rich flora has attracted the attention of many botanists to Bahia, since the early part of the 19th century, as, for example, Martius, Neuwied, Blanchet, Sellow and Gardner, among others, while botanists such as Ule and Luetzelburg were active in Bahia at beginning of 20th century. The earlier collections can be found in that monumental work, the *Flora Brasiliensis*.

Network of Botanic Institutions in Bahia

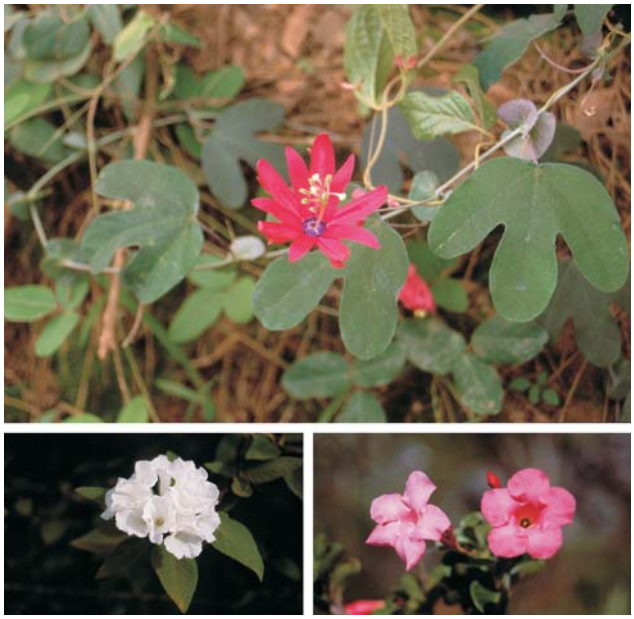
From the 1970s, many plant novelties from Bahia came to light with the expeditions carried out by Howard Irwin and collaborators of NYBG (USA) and by Raymond Harley from RBG-Kew (UK). This provoked a renewal of interest, among botanists, in the flora of Bahia. A partnership between CEPEC and RBG-Kew started a series of expeditions to several regions of the State, commencing in the early 1970s. The collected material was used as a basis for 'Towards a Checklist of the Flora of State of Bahia'[3], the first published checklist of the entire flora of Bahia since the *Flora Brasiliensis* more than one hundred years ago.

Another important partnership was agreed between CEPEC, RGB-Kew and IB-USP to perform a survey of the flora of the campos rupestres of the Cadeia do Espinhaço in the States of Minas Gerais (Espinhaço Range) and Bahia (the Chapada Diamantina). The material which resulted from the many joint expeditions was used to prepare the floras of the Pico das Almas[4], Grão Mogol[5] and Catolés[6].

In 1994, the 'Projeto Chapada Diamantina' (PCD) united several institutions of Bahia, such as UEFS, IBGE and CEPEC, under the coordination of UFBA, with the collaboration of RBG-Kew and IB-USP. Besides the formation of a network, the partnership has resulted in the publication of a *Checklist* of vascular plants

3 Harley, R.M. & S.J. Mayo 1980. *Towards a Checklist of the Flora of Bahia*. Royal Botanic Gardens, Kew.
4 Stannard, B.L. (ed.). 1995. *Flora of the Pico das Almas Chapada Diamantina, Bahia, Brazil*. Royal Botanic Gardens, Kew.
5 Pirani, J.R., R. Mello-Silva. & A.M. Giulietti. 2003. Flora de Grão-Mogol., Minas Gerais, Brasil. *Boletim de Botânica da Universidade de São Paulo* 21: 1-24.
6 Zappi, D.C. *et al*. 2003. Lista das plantas vasculares de Catolés, Chapada Diamantina, Bahia, Brasil. *Boletim de Botânica da Universidade de São Paulo* 21: 345-398.

from the Morro do Pai Inácio (Palmeiras) and Serra da Chapadinha (Lençóis), Chapada Diamantina, Bahia[7] and a book on useful plants from Chapada Diamantina[8].



Flowering plants from Bahia: *Passiflora edmundoi* (top), *Cordia leucocephala* (bottom left) and *Mandevilla* (bottom right).

The Flora of Bahia Project

The Flora of Bahia Project was planned between 1999 and 2001, being sponsored by CNPq and CAPES through the Northeast Program of Research and Post-graduate Studies, and has been responsible for keeping the PCD ongoing. Besides PCD members, the new network grew up to include UNEB, UESC, UESB, EBDA, NYBG and the non-governmental organization APNE, under the coordination of UEFS.

The project's main objectives include: (i) sampling a series of less well-known or species-rich areas in the State, further enriching Bahian herbarium collections, (ii) improving the infra-structure and working practices of local herbaria, and (iii) the elaboration of species-lists from several areas of Atlantic Forest, restinga and campos rupestres. The development and stimulation of research on the flora of Bahia was one of the main outcomes, and led to the implementation of the Graduate Program in Botany at UEFS (Chapter 23), firstly M.Sc. (2000) and Ph.D. (2002) levels, with a series of studies giving a special emphasis on the Flora of Bahia. Following the Flora of Bahia Project, CNPq (2001–2003) supported a project on Taxonomic Studies in Groups of the Flora of Bahia, which centred efforts on sampling areas at that time scarcely studied and performing taxonomic studies on different groups of flowering plants in order to produce the first monographs on the flora of Bahia.

In 2003, the project got new funds from CNPq, now focusing on publication of monographs in UEFS's institutional journal *Sitientibus*[9]. To date, eight monographs have been concluded and 12 are now almost ready for submission (listed in the CD). The first volume of monographs will be published in the

7 Guedes, M.L. & M.D.R. Orge. 1998. *Check-list das espécies vasculares de Morro do pai Inácio (Palmeiras) e Serra da Chapadinha (Lençóis), Chapada Diamantina, Bahia, Brasil*. Universidade Federal da Bahia, Salvador.

8 Funch, L.S., R.M. Harley, R.R. Funch, A.M. Giulietti & E. Melo. 2004. *Plantas Úteis – Chapada Diamantina*. Ed. Rima, São Carlos.

9 NE - This journal is freely available online through the website http://www.uefs.br/dcbio/revistabiologia

first semester of 2006 in a special issue dedicated to the Flora of Bahia, including an introductory article about the vegetation and the history of systematic botany on the Bahian flora. Later, the articles will be published in regular issues of the journal.

In order to evaluate and support the publication of the monographs, an executive board was established in 2004, which decided that the project would cover all plant groups (as traditionally known), including angiosperms, gymnosperms, pteridophytes, bryophytes, algae and fungi[10]. The board includes members of CEPEC, IBGE, UEFS, UESB, UESC, UFBA, UNEB and the recently created Salvador Botanical Garden (JBSSA).

10 NE - Information about the development of the project and a map service for plotting species distribution can be found at the website www.uefs.br/floradabahia; in the future, monographs will also be available at this website.

CHAPTER 8 – Flora of Paraíba

Maria Regina de V. Barbosa, Maria de Fátima Agra & Rita Baltazar de Lima

The Flora Paraibana Project integrates researches and graduate students in Biology and Pharmaceutical Sciences from UFPB, graduate students of Plant Biology from UFPE and botanists contributing from several institutions in Brazil or abroad.

Its main goals are:

1. Identify the plant species that occur in the State of Paraíba, with data on their geographic distribution in the State;
2. Make available scientific information of the herbaria JPB and EAN;
3. Publish illustrated monographs on plant families from the State of Paraíba;
4. Increase the database on the flora of Paraíba through more intensive sampling in remnants of native vegetation;
5. Prepare new plant taxonomists in Paraíba.

The legume *Mimosa paraibana*, a specie endemic to the Paraíba

The activities began informally in 1994, with the survey of the family Asteraceae from Paraíba and the gathering of efforts in order to improve knowledge on the local flora. At that time, sampling of plants of medical interest was intensified in the 'caatinga' of Paraíba, with support of PREBELAC/NYBG and the Northeast Plant Program (CNPq/APNE/RBG-Kew). Floristic surveys were also carried out in two protected areas, State Park of Pico do Jabre (funded by National Geographic Society; in collaboration with Missouri Botanical Garden, USA) and the Mata do Buraquinho. However, only on March of 1997, the Flora Paraibana Project was formalized.

The popular cactus `xiquexique` (*Pilosocereus gounelei*)

The Project was planned in five stages: (1) identification of the material housed in the herbaria of Paraíba (JPB e EAN); (2) nomenclatural revision; (3) elaboration of preliminary checklists by family; (4) complementary field work; and (5) elaboration of floristic monographs. The three first stages are almost finished, and the other two are being developed, with some taxonomic treatments already published (below).

The Flora Paraibana Project has contributed for the enrichment of the JPB collection and the knowledge of the local flora as a whole. It has also supported ethnobotanic, pharmacobotanic, phytochemistry and pharmacological studies on species with medical interest carried out at the Laboratory of Pharmaceutical Technology (LTF) at UFPB.

Project activities have been supported by scholarship grantees and trainees. In this sense, several students have been trained in curatorial activities and taxonomic procedures.

Main Results

All angiosperm sheets from JPB were examined, the identification of the species updated, and its data digitized. The digitized information stored in the database of the JPB herbarium has contributed for several other botanical projects and correlated areas, such as the survey of Caatinga from Paraíba for IMSEAR (Chapter 1) and the Checklist of Angiosperm from the Northeast Brazil[1], (APNE/CNIP), among others.

The collection has been identified either by researchers and trainees of the project or by specialists who have collaborated on it. Some of those also visited Paraíba: Gustavo Martinelli (Bromeliaceae), Alain Chautems (Gesneriaceae), Haroldo Cavalcanti de Lima (Leguminosae), Tarciso Filgueiras (Poaceae), Wm. Wayt Thomas (Cyperaceae), Daniela Zappi (Cactaceae), Raymond Harley (Lamiaceae), Ana Maria Giulietti (Eriocaulaceae), G. Prance (Chrysobalanaceae), Maria Iracema Bezerra Loiola (Erythroxylaceae and Combretaceae), Armando Cervi (Passifloraceae), Genise Somner (Sapindaceae) and André Amorim (Malpighiaceae).

1 www.umbuzeiro.cnip.org.br/db/pnechk/check.html.

A general checklist of the flora of Paraíba was elaborated and, up to know, the monographs of Anonnaceae, Humiriaceae, Loganiaceae, Olacaceae; *Schwenckia*-(Solanaceae), *Sidastrum* (Malvaceae), *Tillandsia* (Bromeliaceae) were published (see CD for references). Taxonomic treatments in Rubiaceae, Myrtaceae, Malpighiaceae, Orchidaceae, Solanaceae, Polygalaceae, Turneraceae, Malvaceae, Bromeliaceae, Rhamnaceae, Phytolaccaceae, Erythroxylaceae and Combretaceae are being prepared. Besides that, three new species have been described based on specimens collected in Paraíba (e.g. *Solanum jabrense* – Solanaceae).

To elaborate the monographs other herbaria are being consulted, like IPA herbarium, which has a good collection of plants from Paraíba, including the Luetzelburg collection.

Systematic samplings have been carried out in several reserves (REBIO Guaribas, RPPNs Fazenda Almas and Fazenda Pacatuba, State Parks of Pedra da Boca, Pico do Jabre and Pau-Ferro and ESEC of Pau-Brasil) but other areas have also been visited.

Regarding the formation of human resources (see CD for detail), 19 undergraduate monographs have been defended, five master degree students, two doctoral student have begun their advisement and two other graduated students have started a co-advisement stage.

Although the Project is not receiving specific financial support by now, it has been able to maintain its activities thanks to articulation with other ongoing projects like IMSEAR (Chapter 1), PROBIO/Caatinga and PPBIO of the Semi-arid (Chapter 2).

CHAPTER 9 – Plant Ecology in 'Campos Rupestres'[1] of the Chapada Diamantina, Bahia

Abel Augusto Conceição

The Chapada Diamantina

Heterogeneity of vegetation on a rocky outcrop on Morro da Mãe Inácia, at 1,100 m high. Insular vegetation in the areas with high proportion of exposed rocks contrasts with continuous vegetation which lies among the rocks [Photo by A.A. Conceição]

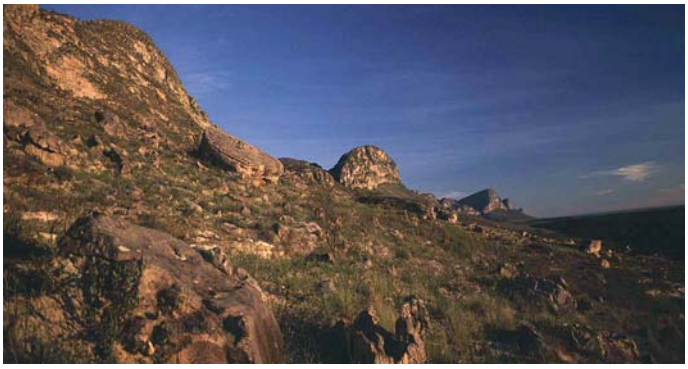
The orchid *Acianthera ochreata* on rock. This is one of the pioneer species in the succession of vegetation on rocky outcrops in the Chapada Diamantina National Park, along with other species of orchids, 'canelas-de-ema', bromeliads and sedges [Photo by A.A. Conceição]

In central Bahia, the Chapada Diamantina presents several kinds of ecosystems, resulting in a very species-rich area. Remarkable variations of substrate, relief and climate determine distinct kinds of vegetation, such as forests, caatingas (Introduction and Chapter 6), cerrados (savanna-like vegetation) and campos rupestres. Species composition and structure in each vegetation type also vary and are visually perceptible under extreme situations, such as between an open field and a dense bush-like vegetation, or between a seasonally semideciduous forest (plateau forest) and a moist montane forest (cloud forest). In campos rupestres, however, physiognomic variations are unclear, usually presenting subtle changes concerning their floristic composition and vegetation structure.

1 The expression 'campos rupestres' (literally rocky fields) refers to a kind of vegetation associated with mountains in tropical areas of Brazil, usually at altitudes above 900 m, overlying quartzites or sandstone, with elevated rainfall and cloudiness, among rock outcrops, damp sands and high altitude bogs (Harley, R.M. & A.M. Giulietti. 2004. *Wild Flowers of the Chapada Diamantina*. Ed. Rima, São Carlos).

The Campos Rupestres and the Importance of Scale

The campos rupestres are the predominant vegetation in higher portions of the Espinhaço Range, in the States of Minas Gerais and Bahia. They are present in large extensions, on rocky quartzite-sandstone substrate and sandy soils, which looks like a uniform landscape when seen from distance. Comprising large fields and portions of rocks with small vegetation islands, they are mainly composed by herbs and shrubs, with trees usually restricted to places with deeper soil and where the drying effect of weather is smaller.



Serra do Esbarrancado, west border of the Chapada Diamantina National Park. Cerrado vegetation changes gradually to the campos rupestres as one reaches upper levels on the mountain. On the peaks, there is the domain of campos rupestres [Photo by A.A. Conceição]

There is no exact concept for the vegetation of campos rupestres. Generally, definitions use floristic, physiognomic and geographic aspects, such as reported by Luetzelburg[1] for the Serra das Almas, Itobira and Três Morros, which are mountains of the Chapada Diamantina. He described gradual changes in landscape according to the rising altitude, characterizing the flora on the peak of Serra das Almas as *"scarce vegetation composed by Vellozias, Ericaceas, Compositas, Vochysiaceas and shrubs with hard leaves"*; and that on the peak of Itobira as *"composed by shrubs of Melastomataceas, sparse Eriocaulaceas, low Ericaceas and wooly leaved Compositas"*. Phytogeographical and ecological studies have shown that the campos rupestres are marked by a floristic unity with dominant families, such as Asteraceae, Bromeliaceae, Cyperaceae, Eriocaulaceae, Leguminosae, Melastomataceae, Orchidaceae, Poaceae and Velloziaceae[2], and a high number of endemic species.

Despite this generalized floristic unity, the campos rupestres present high spatial heterogeneity under a closer view. They include different habitats side by side, sometimes separated only by few centimeters, producing a high diversity in small areas[3,4,5]. Despite this heterogeneity, distinct places present environ-

1 Luetzelburg, P. 1922. *Estudo Botânico do Nordeste. Inspetoria federal de obras contra as secas* 57: 1-108.
2 NE – Many of these families are known by common representatives such as the daisies (Asteraceae), bromeliads (Bromeliaceae), sedges (Cyperaceae), everlasting flowers (Eriocaulaceae), legumes (Leguminosae), orchids (Orchidaceae) and grasses (Poaceae).
3 Conceição, A.A. & A.M. Giulietti. 2002. Composição florística e aspectos estruturais de campo rupestre em dois platôs do Morro do Pai Inácio, Chapada Diamantina, Bahia, Brasil. *Hoehnea* 29: 37-48.
4 Conceição, A.A. 2003. *Ecologia da Vegetação em Afloramentos Rochosos na Chapada Diamantina, Bahia, Brasil*. Ph.D. Thesis, Universidade de São Paulo, São Paulo.
5 Conceição, A.A. & J.R. Pirani. 2005. Delimitação de habitats em campos rupestres na Chapada Diamantina, Bahia: substratos, composição florística e aspectos estruturais. *Boletim de Botânica da Universidade de São Paulo* 23: 85-111.

mental conditions determining similar physiognomy, which makes scale decisive for analysis and interpretation of biological patterns of campos rupestres.

Habitats

There are large extensions of exposed rocks on the top of the mountains, characterizing the outcrop habitat, which is occupied by typical species, usually from the families Amaryllidaceae, Bromeliaceae, Clusiaceae, Cyperaceae, Orchidaceae and Velloziaceae[6]. These plants are able to survive under restrict water supply, severe variations of daily temperature, high sunlight incidence, strong winds and on shallow soils. In these rocky habitats, some of the most striking features of plants from the campos rupestres are found, such as: effective root systems that hold the plants to the rocks (orchids and bromeliads), even under the action of strong winds; reduced aerial growth with most species up to 1 m tall; small and densely crowded leaves (species of *Lychnophora* – Asteraceae, and *Cuphea* – Lythraceae), reducing the surface exposed to sunlight and evaporation; vegetative desiccation tolerance (species of *Vellozia* and *Barbacenia* – Velloziaceae, and *Trilepis lhotzkiana* – Cyperaceae), which enable them to occupy places with extremely low supply of water; CAM (crassulacean acid metabolism) photosynthetic mechanism (orchids, bromeliads, cacti and species of *Clusia* – Clusiaceae or Guttiferae), allowing accumulation of CO_2 in the thick leaves at night and so reducing the loss of water for gas exchanges during the light time; subterranean systems that allow plants to survive after fire or intense drought (species of *Hippeastrum* – Amaryllidaceae, and *Mandevilla* – Apocynaceae); and rosettes that stock water among the leaves (typically in bromeliads).

Around areas of exposed rocks there is the **'entremeio'** habitat, which is characterized by more continuous vegetation dominated by species of Cyperaceae and Poaceae on sandy soil, besides other families, such as Asteraceae, Leguminosae, Melastomataceae and Verbenaceae.

Clefts and **rock fragments** of different sizes support differentiated habitats. They are occupied by species with higher nutritional needs and less tolerant to sun and wind, such as ferns (Pteridophyta) and dicots from the families Aquifoliaceae, Asteraceae, Begoniaceae, Euphorbiaceae, Gesneriaceae, Labiatae, Melastomataceae, Myrtaceae, Piperaceae, Verbenaceae[7], among others.

6 NE – Some familiar examples are amaryllis (Amaryllidaceae), mangosteen (Clusiaceae). For examples of the other families, see NE 2.

7 NE – Examples of some of the cited families are holly plants (Aquifoliaceae), begonias (Begoniaceae), spurge family (Euphorbiaceae), African violets (Gesneriaceae), mint family (Labiatae), myrtle family (Myrtaceae), black pepper (Piperaceae) and verbena family (Verbenaceae).

In the low plains between the rocky outcrops on the top of the mountains, there is a kind of vegetation occupying large fields. It is locally known as '**gerais**' and is composed by many species of Cyperaceae, Eriocaulaceae, Poaceae, Xyridaceae and Gentianaceae. These **gerais** have deep soils periodically damp, providing good conditions for small invertebrates, some of which are sources of food for carnivorous bladderworts (species of *Utricularia* – Lentibulariaceae).

Although dominant families in particular habitats are usually the same in most mountains of the Chapada Diamantina, many species are distinct and exclusive to individual mountains. This is a remarkable aspect of the campos rupestres, and probably the most plausible cause for such a high richness. Most species present very low frequency, and some are restricted to only special habitats, suggesting how vulnerable this vegetation can be. Due to interactions among physical, chemical and biological factors, changes in one or more of these elements may damage the dynamic that maintain the natural biological diversity, reducing or extinguishing populations of species not yet described or of species whose economical potential is yet unknown.

Vegetation Dynamics

Phenology and syndromes of pollination and dispersal

A two-year survey of 58 islands of vegetation on rocky outcrops at the top of mountains (monthly observations[4]) has shown greater importance of biotic vectors to pollination (mainly bee and bird pollination) than those of dispersal (mainly wind and self dispersal). Analysis of the phenology at community level suggests that plants pollinated by biotic agents present continuous flowering through the year (always in flower with no or few brief interruptions), whereas those pollinated by the wind present one cycle of flowers per year (annual). In the case of dispersal, fruit related to abiotic agents were continuous, whereas those dispersed by animals were annual. Temporal patterns reveal that pollination depends mainly on animals and rain, whereas abiotic dispersal is mostly independent, occurring even during dry seasons. Blooming and fruiting seasons of different species provide continuous resources to the fauna, and the amount of rain does affect the production of flowers and fruits; so that rainy seasons are more favorable to the reproduction of plants pollinated and dispersed by animals.

Succession

Spatial patterns detected in campos rupestres of the Chapada Diamantina[3, 4, 5] and the phenological survey of vegetation islands on rocks can be used as base for inferences on spatial changes through time, and a successional model was elaborated for vegetation on the rocks[4]. Organisms better adapted to extreme en-

vironments colonize exposed rocks and are gradually replaced by those less tolerant to extreme conditions. The tendency is to reduce the level of isolation among vegetation islands until new disturbances, such as severe drought, fire, flood, or even death by aging or diseases, cause decrease of vegetation.

Lack of Knowledge

Most studies on the campos rupestres are floristic surveys, such as those carried out on the Pico das Almas[8], Catolés[9], Morro do Pai Inácio and Serra dos Brejões ('Chapadinha')[10]. The large number of species per site and variation of floristic composition among them suggest that several mountains yet unexplored represent potential sources of new taxa. However, a larger gap than the one posed by the floristic knowlegde is that concerning the structural and dynamic aspects of the campos rupestres.

Wasp visiting flowers of *Lychnophora triflora*. This and other species of the family Asteraceae represent important source of food for several species of bees and wasps [Photo by A.A. Conceição]

The campos rupestres form a peculiar environment with many species endemic to the Chapada Diamantina. They are distributed in a wide variety of environments spread through a mountains range. Each environment has its own characteristics and together they form a mosaic composition along mountain peaks isolated at different levels. They can be analyzed just like an archipelago, where the interactions of ecological processes are multifactorial and particular to each region. Knowing their spatial and temporal patterns is essential to determine the conservation importance of the campos rupestres besides enable us to test a series of hypotheses in this 'natural laboratory'.

The main disturbances in the campos rupestres are fires and intense drought. Therefore, continuous studies on vegetation are crucial. This must include continuous monitory of composition and structure as well as the abiotic factors that may affect the understanding of biological patterns of these communities, such as temperature, humidity, wind and light.

8 Stannard, B.L. (ed.). 1995. *Flora of the Pico das Almas Chapada Diamantina, Bahia, Brazil*. Royal Botanic Gardens, Kew.
9 Zappi, D.C. *et al*. 2003. Lista das plantas vasculares de Catolés, Chapada Diamantina, Bahia, Brasil. Boletim de Botânica da Universidade de São Paulo 21: 345-398.
10 Guedes, M.L. & M.D.R. Orge. 1998. *Check-list das Espécies Vasculares de Morro do pai Inácio (Palmeiras) e Serra da Chapadinha (Lençóis), Chapada Diamantina, Bahia, Brasil*. Universidade Federal da Bahia, Salvador.

CHAPTER 10 – Diversity in inselbergs in the Semi-arid of Bahia

Flávio França & Efigênia de Melo

Rock art [Photo by F.França].

Inselbergs (from German *Insel* = Island and *Berg* = Mountain) are isolated outcrops in a lower plain. The most accepted hypothesis is that they are the result of climatic action through pediplanation and pedimentation processes. They are characteristically made of gneiss-granite and can be more than 20 million years old. Although more frequent in arid and semi-arid lands, inselbergs can be found in humid areas, which may suggest past arid weather conditions[1].

The Importance of Inselbergs

The study of biodiversity in inselbergs is important in many ways. Since they are ecologically isolated from their surroundings, inselbergs function as islands, where processes of adaptation and speciation are favoured. Their biota is highly endangered due to the intense mining of granite for public paving and construction. Besides that, plants which are highly adapted to these hostile environments are appreciated for ornamental proposes. This creates an illegal commerce of plants extracted by local people and sold along the roads of the region.

Natural formations of rocky shelters in these outcrops were used by prehistoric populations of the semi-arid who let registers of their space use in many and diverse paintings (rock art). The study of modern and ancient flora can indicate the degree of influence that these people had in the local flora and will allow studies about their behaviour. Such studies in inselbergs will lead to public politics for the conservation of these areas and will offer economic alternatives to local communities.

1 Dörrstock, S., S. Porembski & W. Barthlott. 1996. Ephemeral flush vegetation on inselbergs in Ivory Cost (West Africa). *Candollea* 51: 407-419.

Life-forms and Endemism in Inselbergs

Inselbergs have been studied in other parts of the world. In Africa, researches have been carried out in inselbergs of Zimbabwe, Tanzania, Congo, Rwanda, Somalia, Namibia and South Africa[2]. Other examples of this kind of isolated remnants have been studied in islands, such as Madagascar and the Seychelles. In the Americas, studies have been carried out in Venezuela, Guianas, east Bolivia, Southeast Brazil and southern United States. There are also studies of inselbergs in Australia.

A very interesting aspect of these studies concerns the life-forms. In inselbergs of Zimbabwe, for instance, there is a high occurrence of therophytes, plants which die in unfavourable times, leaving seeds behind to start a new cycle of life in a better season. In SE Brazil the number of therophytes is extremely low, varying from 0.6-5.3%. It is also worth mentioning that the rate of endemism varies a lot. Comparing the rate of endemism in inselbergs to their surroundings, it was reported that in Zimbabwe, in Piemonte (Georgia, USA) and in the Seychelles, endemism in inselbergs is higher than the regional average, whereas in other places, such as Venezuelan Guiana, Guianas and Madagascar, it is below the regional average. Inselbergs in the Seychelles present the highest rates of endemism (78%).

Plant Biodiversity in Inselbergs of the Semi-arid of Bahia

Inselbergs in the Semi-arid of Bahia have been studied since 1995, when UEFS began the institutional 'Flora of the Inselbergs' project, which at first focused on the region of Milagres[3], famous for its landscape rich in inselbergs. Later, the project was extended to cover inselbergs in the regions of Feira de Santana, Santa Terezinha and Itaberaba, where ecological studies and floristic survey have been carried out.

So far, 600 species of vascular plants distributed in 93 families were registered. They are associated with several environments found in the inselbergs of the Semi-arid of Bahia. Families that presented the highest number of species were Leguminosae, Euphorbiaceae, Bromeliaceae and Malpighiaceae. About 13% of all species registered belong to these families. Leguminosae, which has the largest number of species, includes some representatives that are typical of inselbergs, such as 'jurema' or 'jerema' (*Mimosa arenosa*), 'catingueira' (*Caesalpinia pyramidalis*) among others. This family is richer in the base and lower slopes of the inselbergs. On the outcrop, there is a large number of Euphorbiaceae with interesting cactiform representatives (e.g. *Euphorbia phosphorea*) or the terrible acrid species such as 'cansanção'

2 Porembski, S. & W. Barthlott (eds.). 2000. *Inselbergs: Biotic Diversity of Isolated Rock Outcrops in Tropical and Temperate Regions*. Springer-Verlag, Berlin.
3 França, F., E. Melo & C. Santos. 1997. Flora de inselbergs da região de Milagres, Bahia, Brasil: caracterização da vegetação e lista de espécies de dois inselbergs. *Sitientibus* 17: 163-184.

(species of *Cnidoscolus*). Large populations of bromeliads are also very common on there, particularly the 'macambira-de-flecha' (*Encholirium spectabile*), whose curved prickles on the margin of the leaves along with the acrid 'cansanções' make walking in these environments extremely painful for the careless ones. Representatives of the Malpighiaceae family (the family of the 'acerola') are responsible for beautiful blooming. They are beautiful even when fruiting, indicating an ornamental potential so far underestimated for this group.

Many families are represented by less than 10 species. These families make up 80% of all species. Some representatives of them are important components of inselberg vegetation. However, rather than rich (with many species), they are abundant (many individuals). Species such as *Nanuza plicata* (Velloziaceae) are responsible for high rates of rock covering, besides being impressive for the beauty of its white flowers whose petals are shed to the lightest touch; *Encyclia dichroma* (Orchidaceae), *Melocactus bahiensis*, *Pilosocereus gouneleii* (Cactaceae) and *Begonia saxicola* (Begoniaceae) with pink flowers also help embellish these environments.

The dry outcrop typically presents succulent species of Cactaceae and Euphorbiaceae. Actually, this is the environment where large populations of 'xiquexiques' (*Pilosocereus gouneleii*) and 'cabeças-de-frade' (species of *Melocactus*) can be found. Orchids are also abundant. One species of this family (*Encyclia dichroma*) forms large populations, offering a beautiful sight in the period of blooming. These species are the target of predatory harvesting and finding them for sale by the roads is extremely common. This reinforces the need of further studies on the reproduction of these species for commercial production in order to reduce the present pressure on them.

The relationship between richness and abundance of species help assess the diversity in a certain area. Diversity of inselbergs in the region assessed by Shannon-Wiener index varied from 1.46-1.94 nats/individual in parcels of 100 m^2. Another important data inferred from these preliminary studies is that the rate of therophytes is extremely low, agreeing with data from inselbergs of SE Brazil[4].

Most species found in inselbergs in the Semi-arid of Bahia present wide geographical distribution, but there are species which are restricted to the caatinga, such as *Aristolochia birostris* (Aristolochiaceae), *Crotalaria holosericea* (Leguminosae), *Coccoloba schwackeana* (Polygonaceae), *Hohenbergia catingae* (Bromeliaceae) and *Leptoscela ruellioides* (Rubiaceae). This allows us to classify vegetation found there as a peculiar kind within the great Caatinga Biome.

4 França, F. et al. 2005. Estudos ecológico e florístico em ilhas de vegetação de um inselberg no Semi-árido da Bahia, Brasil. *Hoehnea* 32: 93-101.

Endemism is low in these inselbergs. Considering those species described or in process of being described and known only for the type specimen from the inselbergs (and so extremely rare) as local endemics, the rate of endemism is not above 1%.

Many species have been described from material collected in inselbergs, such as *Maranta zingiberina* (Marantaceae), described from material collected in Milagres, as well as *Tillandsia milagrensis* (Bromeliaceae), besides *Tibouchina lithophila* (Melastomataceae). After 10 years of work, samples of the project 'Flora of the inselbergs' have also allowed the discovery of previously unknown species. Up to now, three new species have been described: a species of cactiform *Euphorbia* (Euphorbiaceae), a species of *Heteropterys* (Malpighiaceae) and a species of *Chresta* (Asteraceae), this last one collected in the surroundings of Feira de Santana.

Future Developments

Studies on fauna diversity in the inselbergs of the Brazilian Semi-arid are rare. Some have been carried out on bees, in Milagres and Itatim, Bahia, showing their potential for honey production. Studies on the diversity of birds, reptiles, amphibians and mammals are lacking. This topic is urgent because the high poaching pressure (mainly for tortoises and tamarin monkeys) and the serious environmental damages caused by mining activities will very soon lead many of these species to disappear from the Semi-arid before they can be described and, more dramatic, even before proper mechanisms can be created for their protection.

Intensive survey on these rocks has allowed the registering of rock art sites previously unknown to IPHAN. Four rock art sites have already been found in two inselbergs and their files catalogued. The rock art found in inselbergs of the Semi-arid is mainly geometric with predominance of motifs executed in red pigment although the use of yellow, black and white pigment can be seen. The presence of rock art reinforces the need of protection for the inselbergs in order to guarantee its conservation.

The environment of inselbergs seems hostile but it holds a particular biodiversity and should be considered priority areas for conservation. Studies in these areas will contribute for their protection which necessarily requires the development of new economical options for the local population, such as ecotourism, archaeological tourism, formation of local guides, and reproduction of native plants with ornamental potential.

CHAPTER 11 – Aquatic Vascular Plants in the Semi-arid of Bahia

Flávio França & Efigênia de Melo

Lake with *Nymphaea ampla* during the blooming period. A flower is shown in detail.
[Photo by A.A, Conceição]

The Brazilian Semi-arid is remembered by most people for the images of its inhabitants in search of a minimum of water for their survival, consequence of long periods of drought. In this context, it would seem nonsense to work with aquatic plants in this area. Nevertheless, the Brazilian Semi-arid contains a great number of lentic aquatic bodies, mostly temporary, a few long lasting and rare permanent ones. Due to the severity of long periods of drought, it has become common the damming up of short creeks, usually temporary ones. The dams originated from this process maintain a well-diversified vascular flora. Besides these artificial dams, many dikings are natural, such as the lakes formed along the Rio São Francisco plain and the Marimbus swamps, between Lençóis and Andaraí, in the Chapada Diamantina, where the beauty of the aquatic vascular plants is part of the region's tourist scenery. Other lakes are located in the sertaneja depression[1], associated to residual relief. Therefore, at the base of inselbergs, quartzite crests and mountain ridges, formation of temporary lakes is common during the rainy season, when they embank great amounts of water and a constant and reflourishing flora.

1 NE – The sertaneja depression corresponds to the largest geomorphological feature of the semi-arid region, appearing as a large depressed plain bordered by elevated areas and mountain ranges.

Flora of Aquatic Bodies

Blooming vegetation of aquatic bodies was mostly unknown until a short time ago. However, in the rainy season, people travelling through the roads across the Semi-arid are surprised by the variety of flowers in the countless dams along the roadsides. Besides this aesthetic aspect, the knowledge of the aquatic vascular vegetation may help improve the use of water resources in the region, providing alternatives for depolluting water and feeding of farm animals[2], not to mention that some species may be use as pollution indicators. In spite of that, scientific knowledge of the physical, chemical and biological processes of aquatic bodies in the semi-arid region is deficient, and few studies about their aquatic vascular flora have been published. Currently, several research groups are mobilized to provide data about floristic composition as well as physical-chemical and ecological aspects of these environments.

Unlike most floristic surveys in terrestrial areas, aquatic environments in the Semi-arid present neither Leguminosae nor Euphorbiaceae as the main families in number of species. Despite the fact that these large families also have representatives in aquatic environments, the richest families in this environment are Cyperaceae (sedges) and Poaceae (grasses)[3].

The Cyperaceae have as their best-known representative the papyrus, which had a great importance in ancient times for the production of paper, being one of the main floristic components in fields and aquatic environments. In the Semi-arid, one of the most interesting species is the Oxycaryum cubense, which is an epiphyte of aquatic plants highly successful in number of individuals. Microphotographs of the roots show that in this species little trichomes (hairlike or bristlelike outgrowths) roll around similar structures of the host.

The Poaceae is the most economically important group of plants. Most of its representatives are in the base of human nourishment, such as wheat, oat and rice (by the way, an aquatic plant). The family is the richest one in aquatic environments. Species such as *Hymenachne amplexicaulis* and *Echinochloa colona* form dense populations in the lakes and dams of the semi-arid region.

Some species of vascular plants are always present in any floristic surveys of lentic aquatic environments in the Semi-arid, including *Pistia stratiotes* (Araceae), *Nymphaea ampla* (Nymphaeaceae), *Oxycarium cubense* (Cyperaceae) and *Echinocloa colona* (Poaceae). The last two have already been commented above; the other two deserve further commentaries. *Pistia stratiotes*, known as 'alface-d'água' (water

2 Albuquerque, B.W.P. 1981. Plantas forrageiras da Amazônia. I-Aquáticas Flutuantes, Livres. Acta Amazônica 11 (3): 457-472
3 França, F. et al.. 2003. Flora vascular de açudes de uma região do Semi-árido da Bahia, Brasil. Acta Botanica Brasilca 17: 549-559.

lettuce), sometimes forms populations which cover the entire water surface. *Nymphaea ampla*, usually called water lily, is a species well adapted to aquatic environments, forming large populations with beautiful flowers. Early in the morning, the buds show up in the water and soon the flowers bloom. After the pollination, the peduncle bends and submerges the developing fruit, which ripens and releases the seeds inside the water.

Life-Forms of Aquatic Plants

Flower of *Nymphoides indica*, a common species in temporary lakes of the Semi-arid of Bahia. [Photo by A.A. Conceição]

In aquatic environment, it is common to be in doubt whether a species is really 'aquatic' or only tolerant to temporary submersion. Thus, the following are generally accepted for life forms:

Amphibian: fixed species which maintain their vital cycle both in submerged and dry substrates. *Physalis pubescens* (Solanaceae) is an example. In fact, most species found in aquatic environments are placed in this kind of life form.

Emergent: fixed species which maintain a significant part of the vegetative body outside the water, usually not resistant to dehydration. Some of the most beautiful aquatic plants are found in this class, such as the well-known swordplants (*Echinodorus grandiflorus*, Alismataceae), with delicate white flowers, and *Eichhornia paniculata* (Pontederiaceae) with very beautiful blue flowers. When these two species bloom together in the dams, the whole environment gets a mixture of blue and white of a great beauty.

Floating fixed: exclusively aquatic species fixed in the substrate whose leaves have long petiole and blade floating on the water surface. The most typical example is the water lily *Nymphaea ampla*.

Free floaters: species that float freely on the water. Examples are the water hyacinth (*Eichhornia crassipes*, Pontederiaceae) and the salvinia (*Salvinia oblongifolia*, Salviniaceae).

Epiphyte: species that grow on other aquatic plants, usually without causing damage to them. The best example was the already mentioned sedge *Oxycaryum cubense*.

Submerged: species presenting most of their vegetative body submerged, but with flowers above the water surface. A good example is the bladderwort (*Utricularia gibba*, Lentibulariaceae).

Abiotic Factors

Abiotic aspects are important to understand the floristic composition and the variation of water quality. In these environments, water usually presents a high concentration of chlorides (saltiness), up to 170 mg/l in dams. In some dams of the Semi-arid, for instance, the pH[4] may vary from 4.75 (acid) to 6.03 (slightly alkaline) in a period of 24 hours. This may be dramatic to many organisms, considering that the pH varies in an exponential scale.

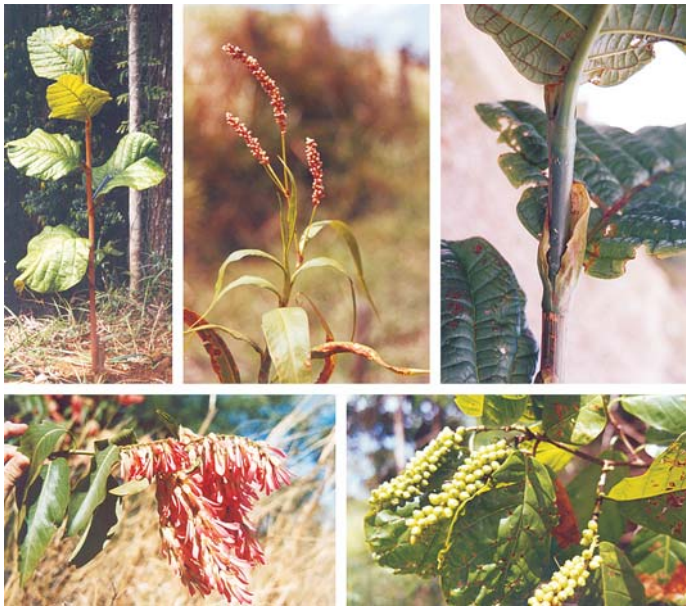
The relationship between floristic components and the physical-chemical parameters is difficult to be demonstrated, requiring controlled experiments with replicates and statistic treatments. In lentic environments of the Semi-arid, the sensitivity of the *Wolffiella welwitschii* (Araceae – Lemnoideae) to the concentration of chlorides was registered, showing that plant development is favoured by increased concentrations of these ions. Another example is bladderwort, which seems to have the development inhibited by high values of pH.

There is still much to be investigated about aquatic vascular plants. It is an open area to ecological, anatomical and limnological studies. They will allow researchers to uncover some of the most beautiful plants in the nature and to deal with problems of water resource in the Brazilian Semi-arid.

4 NA – pH is the potential of hydrogen, a measure of the acidity or alkalinity of a solution.

CHAPTER 12 – Polygonaceae in the Brazilian Semi-arid

Efigênia de Melo & Flávio França



Polygonaceae: young specimen of *Coccoloba rosea* (top left), *Polygonum ferrugineum* (top centre), *Coccoloba latifolia*, note the ocrea (top right), *Coccoloba alnifolia* with fruits (bottom left), *Triplaris gardneriana* with fruits (bottom right). [Photos by E. Melo]

Floristic surveys in the Brazilian Semi-arid have shown that the family Polygonaceae is an important component in the region both in number of species and abundance. The family includes about 1,100 species distributed in tropical and temperate areas in both hemispheres. They are either herbaceous or woody plants, easily recognized for their articulated stems, with well marked nodes and internodes, simple alternate leaves with ocrea. The articulated stems are often hollow and inhabited by ants.

Five of the nine genera found in Brazil occur in the Semi-arid: *Coccoloba* (with 18 species), *Polygonum* (6), *Rumex* (1), *Ruprechtia* (3) and *Triplaris* (1), besides *Antigonum leptopus*, *Coccoloba uvifera* and *Triplaris americana*, which are cultivated. Most species are found in forests and restingas along the coast. In the Semi-arid, they are important components of seasonal forests and caatingas, being found mainly on borders of seasonal rivers, sandy or flood plains and lakes. Some species are found embedded, among patches of cerrados and transitional areas, forming dense populations.

Characterization of Polygonaceae

Articulated stems and leaves with ocrea are exclusive in this family. The ocrea is present in every Brazilian species. Morphologically, they correspond to a pair of axillary stipules fused by both borders forming a single tubular piece around the node. They are persistent in *Polygonum* and *Rumex*, but deciduous or semideciduous in *Triplaris*, *Ruprechtia* and *Coccoloba*. This structure presents a great morphological variety. The inflorescences are thyrses (simple or branched), with flowers clustered into fascicles, each

one subtended by a bract and bracteoles (ocreolets), a persistent sheath. They are small, greenish and scented, with tepaloid perianth persistent on fructification. The fruit is quite visible, with pericarp surrounded by the accrescent perianth, usually coloured and showy when mature; it is fleshy in *Coccoloba*, but dry in other genera.

The Polygonaceae have often been used as ornamental plants in streets, yards and plazas. Some species are cultivated for medicinal proposes in the South, Southeast and Central-West Brazil, such as *Polygonum punctatum* ('erva-de-bicho'), used on the production of ointments. Although they are used in popular medicine, they should not be ingested since some species are toxic. Wood from some tree species can be used to produce broomsticks and handles and herbaceous genera, such as *Polygonum*, *Fagopyrum* and *Rumex*, can be invasive plants. Seeds can remain viable on the soil for a long time so that some species, such as *Rumex crispus*, *R. obtusifolius*, *Polygonum capitatum* and *P. punctatum* are often found in abandoned lands, river beds and lakes where the seeds were taken to. However, native species of *Coccoloba*, *Ruprechtia* and *Triplaris* are remnants of primary forests, restingas, caatingas and cerrados. As mentioned above, most species of *Coccoloba* and *Triplaris* are associated with ants, but this and other ecological relationships have not been explored yet.

Poplygonaceae in the Semi-arid

The Polygonaceae are represented in every ecoregion of the Semi-arid. Southern Sertaneja Depression is the richest one in number of species of Polygonaceae, with 22 species (about 76%), followed by the Chapada Diamantina Complex, with 17 species (58%). Some species of Polygonaceae are cosmopolites, such as those of *Polygonum*, though some of them are rare in the Semi-arid, such as *Coccoloba declinata* and *C. fastigiata,* and others endemic to the Semi-arid. *Coccoloba schwackeana*, for instance, is a widespread species, but restricted to the Caatinga, whereas Ruprechtia glauca is endemic to the dunes of São Francisco River.

CHAPTER 13 – Diversity of the Rhamnaceae Family in the Brazilian Semi-arid

Rita Baltazar de Lima & Ana Maria Giulietti

Different species of Rhamnaceae of the Semi-arid

The Rhamnaceae is a family that comprises plants of a wide variety of habits: from herbs to trees and lianas, which occur in tropical and subtropical forests all over the world. Despite this high diversity of habit, the species in this family are easily recognizable, because they share certain floral characters, such as sepals with midrib prominent beneath, petals unguiculate, convolute, cucullate or conchiform, the stamens opposite the petals and the nectar disc involving the floral receptacle.

The Rhamnaceae in Brazil

Originally, given the name "Rhamneae", the family was studied in 1861 by Reissek who wrote a thesis accounting for the tribes, genera and species which occurred in Brazil. The author identified 12 genera and 48 species of Rhamnaceae in the Brazilian flora, having proposed two new genera and 36 new species. Later, other taxa were proposed by Warming, Moore, Glaziou, Urban, Pilger, Mansfeld, Ducke, Suessenguth, Fróes, Rizzini and Grey-Wilson. Taxonomic reviews, including genera with a distribution in Brazil, were carried out in 1860 by Miers, and more recently by Johnston, Johnston & Johnston and Tortosa. Floristic studies for the family were also carried out by several contemporary authors. However, the most complete taxonomic study of the Rhamnaceae family in Brazil was carried out only in 2000, a century after Reissek's work, by the senior author of the present paper[1].

In Brazil, the Rhamnaceae have a wide distribution, occurring from North to South, with the semi-arid region being one of the Brazilian centres of diversity of the family. Here, 20 species (seven of them endemic) have been recorded, included in eight genera: *Alvimiantha*, *Colubrina*, *Crumenaria*, *Gouania*, *Reissekia*, *Rhamnidium*, *Rhamnus* and *Ziziphus*, and occurring in various vegetation formations in the

1 Lima, R.B. 2000. *Rhamnaceae* do Brasil. Ph.D. thesis. Universidade de São Paulo, São Paulo.

semi-arid region. Among the genera *Ziziphus* is certainly the one which is best known by local people, represented by *Z. joazeiro*, or the 'juazeiro' as it is popularly known by the 'sertanejos'[2], who highly prize this tree for its many uses in the region.

Economic Potential of the Rhamnaceae in the Brazilian Semi-arid

Although most species in this family have not yet had their economic potential properly recognized, many of its representatives are used as ornamental plants moreover for arborisation of gardens in town squares and for medicinal purposes, some being frequently used in popular medicine, in the manufacture of cosmetics, toothpaste and other antiseptic products. Some Rhamnaceae are also used for feeding goats, pigs and cattle during the dry season. Its wood is used in furniture and in the production of firewood and charcoal, while the stems of some liana species can be used in craftwork. The flowers of most species produce abundant nectar, important in honey production. Fruits, in some species, are sweet and have already been used in the production of sweets and jam. Pieces of bark of some species, locally known as 'juazeiros', are sold in local markets, as medicine for oral use in cases of gastritis and as an expectorant syrup, and also for topic use in cases of dandruff. However, some species do not form large populations, and as a result, conservation status is critical, often without having their economic potential investigated.

Before IMSEAR (Chapter 1), the diversity of Rhamnaceae for the Brazilian Semi-arid region was little known. No complete and reliable systematic study of the family had been carried out in the region and our knowledge about the species living there was minimal. Also, the lack of reliable bibliography resulted in many incorrect identifications, particularly due to the taxonomic problems involving a number of species, especially in genera such as *Gouania* and *Ziziphus*. The study carried out by the senior author has also gathered information on Rhamnaceae of the Semi-arid, which was previously fragmented and dispersed throughout the literature. Descriptions, illustrations, comments and maps, showing the geographical distribution of all species of Rhamnaceae in the Brazilian semi-arid region, have also now been made available (see CD for model example of one species). As a result, we now have the means to identify all Rhamnaceae, likely to be found in the Caatinga Biome, at both generic and species level. The availability of such a body of information has contributed significantly to extending our knowledge of the family and to supporting research aimed at conservation of the Caatinga and the adequate use of its natural resources. Particularly in the case of the Rhamnaceae, researches have provided us with information on

2 NT. People who live in the semiarid region.

local uses of species. From this popular knowledge it will be possible to determine the chemical profile of those species selected for their possible economic potential, widening the options for local communities who wish to improve their incomes and their way of life.

In these ways, the knowledge gained by IMSEAR has helped to produce new perspectives in the search to minimize ecological and social problems in the Semi-arid region. Meanwhile, the publication of the 'Serie Livros' will make the results of floristic inventories, carried out in the region, available to a wider public, initiating other research opportunities, particularly those aimed at conservation, and providing the catalyst to adapt scientific knowledge for popular use, and promoting sustainable development for the region.

CHAPTER 14 – Diversity of Fungi in the Brazilian Semi-arid

Luís Fernando Pascholati Gusmão & Marcos Fabio Oliveira Marques

Datronia caperata. [Photo by L.P. Queiroz]

Fungi are one of the most diverse groups of organisms on the planet. Like other megadiverse groups, fungi are among the least known[1]. They have an extremely important role in the environment and occur in diverse habitats, occupying different ecological niches, both in soil and water. The great majority of them are saprobes, decomposing any kind of organic matter able to be degraded, influencing and being influenced by several organisms and by physical-chemical environmental features. In a smaller number, some groups act as opportunist parasites in plants and animals; others have a symbiotic relationship with different organisms, where the degree of dependence between the fungus and its partner varies a lot.

Considering the range of environments and the versatility on the way fungi live, there is no geographical barrier to their distribution; fungi can be found thriving in extreme environments that have either high or low temperature, with lack of water or in highly humid environments, besides surviving in environments extremely poor in nutrients. However, conditions of high humidity and temperature are more suitable to the establishment and growth of these organisms.

The peculiar feeding traits of these heterotrophs are reasons for its large distribution, since the versatility of these organisms is linked to their ability to produce enzymes able to degrade almost all organic

1 Cannon, P.F. 1997. Strategies for rapid assessment of fungal diversity. *Biodiversity and Conservation* 6: 669-680.

substrates. The enzymatic activity, along with the capacity to produce several kinds of substances needed by different kinds of industries, such as the antagonistic substances (antibiotics, anti fungal, anti nematodes, etc.), have given fungi a biotechnological potential (see Chapter 4) not yet well explored in Brazil, moreover in the semi-arid region.

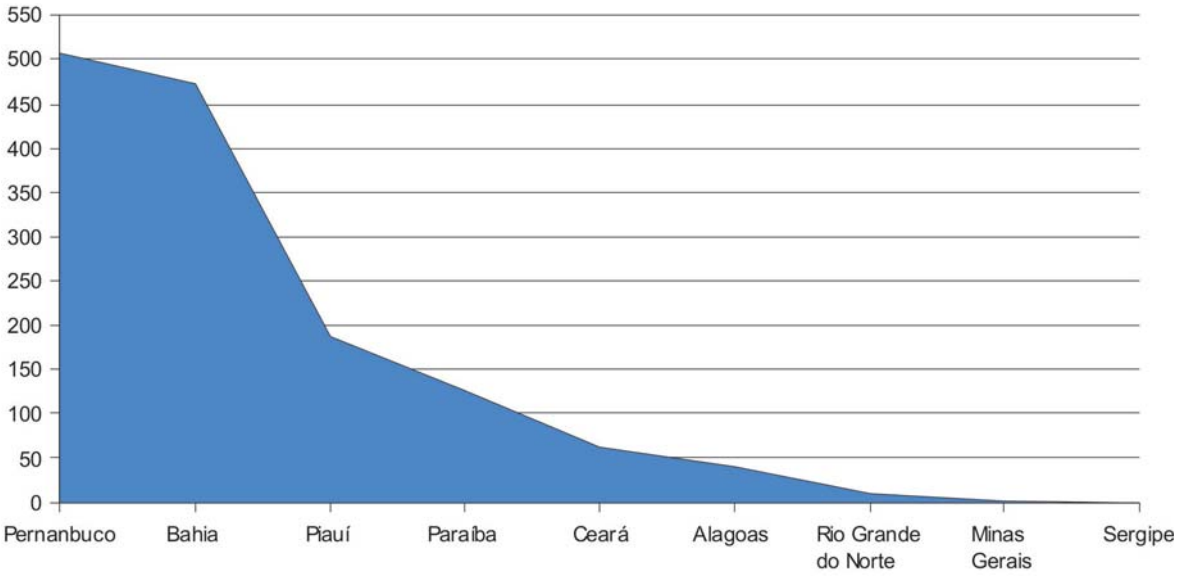
Number of Fungi on the Planet and in the Semi-arid: Current Situation

Hawksworth[2] estimates the existence of 1.5 million specimens of fungi on the planet. Other authors, however, presume the existence of 2.7 million. Although the real number is difficult to calculate, there is the consensus among mycologists that the estimate of 1.5 million specimens is conservative. Basically, three facts explain such agreement: (i) the number of 'orphan' specimens (deposited in collections, but not yet named); (ii) number of species associated to insects (which is the largest group in diversity, estimated in about three millions species); (iii) fungi existing in geographical regions either never or little explored (tropics and subtropics). Taking the estimate of 1.5 million of species into consideration, only 5-7% species have been described so far, since the figure for the known species is of around 80 thousand species[3].

Using the information from the list of municipalities in the Semi-arid published by SUDENE[4] with literature in the area and lists of fungi deposited in herbaria and in collections of cultures in several institutions of the Northeast region, we can see that the number of fungi known for the Semi-arid is extremely low when compared to the total number of species known (see CD for details).

However, these figures do not reflect either to the absence of fungi or in any way on the diversity of them in the Brazilian Semi-arid. There are phyla which have not been sampled yet. Being the most representative phyla worldwide, and also in the Semi-arid, the Basidiomycotas, Ascomycota and some Myxomycota which are easy to be sampled since most of them are macroscopical fungi and do not need specific techniques to be observed; the others are mostly microscopical fungi and need accurate techniques to be sampled and observed. Besides size, other features may increase such difference in numbers of fungi in the Semi-arid: (i) the geographical position of the research institutions that work with fungi (they are located in the coast, focusing their researches on the ecosystems nearby, Atlantic Forest, restinga, etc.); (ii) weather dry condition in the Semi-arid, which decreases the occurrence of fungi, although there are adapted species and; (iii) the main reason, the small number of fungi taxonomist in Brazil and therefore, the lack of human resources trained to do this kind of work.

2 Hawksworth, D.L. 2001.The magnitude of fungal diversity: the 1.5 million species estimate revised. *Mycological Research* 105: 1422-1432.
3 Kirk, P.M., P.F. Cannon, J.C. David & J.A. Stalpers. 2001. *Ainsworth and Bisby's Dictionary of the Fungi*. 9th Ed. CABI, Wallingford.
4 SUDENE, 1997. *Caracterização do Semi-árido Brasileiro*, avaiable on www. asabrasil.org.br.



Number of surveyed species of fungi by State in the Brazilian Semi-arid.

Distribution of Fungi in the Semi-arid

Considering the numbers for fungi in different States included in the list of SUDENE, the situation is even more dramatic. In some States like Sergipe, there are no registers of fungi and in the north of Minas Gerais, Rio Grande do Norte, Alagoas and Ceará, less than 100 species of fungi have been registered. Once again, this fact reflects the great need to form human resources. In places where there are either projects ongoing or studies concluded focusing on the diversity of fungi in the Semi-arid, the number of registers is larger, like in Pernambuco, Bahia and Piauí.

The State of Pernambuco is by far the most representative one because human resources have been trained in mycology there for decades (Capítulo 25). Only recently, more attention has been given to the fungi in the State of Bahia, with the recruitment of experienced professors of mycology, which guarantees the formation and training of human resources in this area.

Perspectives for the Study of Fungi in the Semi-arid

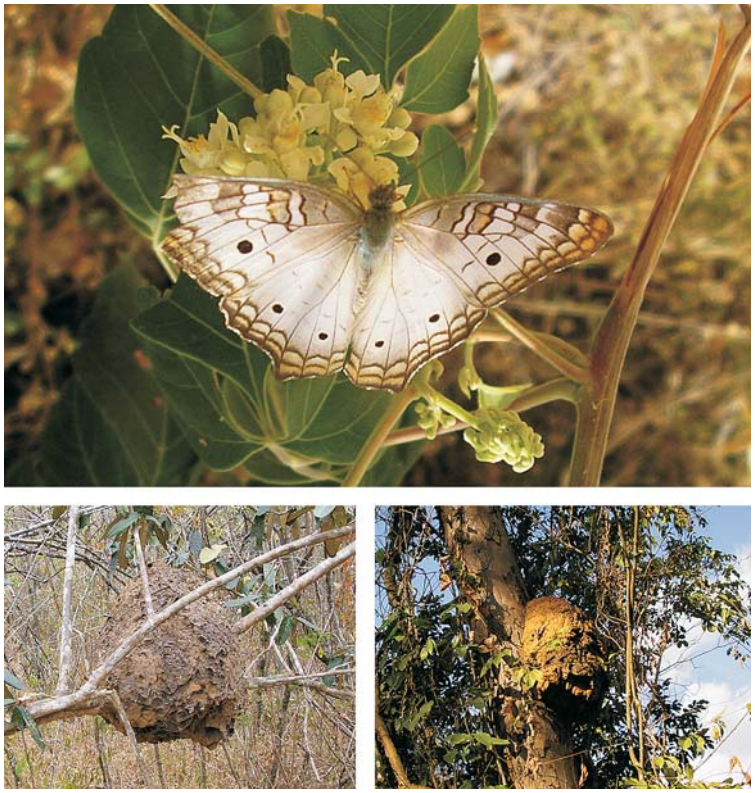
Results of projects on fungi diversity ongoing in the Semi-arid of Bahia have shown a surprisingly large number of new registers to Brazil and to the Semi-arid, not to mention new species; about 30% of collections already sampled and identified represent new registers or new species.

This current situation tends to change drastically with the efforts by PPBio of the Semi-arid (Chapter 2), which gathers groups of researchers from several institutions of the Northeast Brazil, such as UEFS, UFPE,

UFRN and UFPI. The implementation of sampling protocol elaborated by most groups researching on fungi and the inclusion of more taxonomists will also increase the number of known species and a better knowledge of their geographic distribution. Meanwhile, an important step for the field will be made since this work will also result in the formation of human resources trained to identify fungi.

CHAPTER 15 – Inventories and Situation of Insect Diversity in the Brazilian Semi-arid

Freddy Bravo & Cândida Maria Lima Aguiar



Some insects live alone or in groups, such as the butterflies (top), others are social, and live in colonies, such as termites (bottom left) and bees (bottom right)

Insects are the most diverse group in number of species, reaching the amazing one million species described in scientific literature. This huge diversity rises difficult to the systematics of the group. Several techniques are necessary in order to sample representatives of the different groups of insects, and the sorting and identification of samples are quite complex for most groups. Consequently, insect diversity is still scarcely known in the Tropics, and this is not different in the Northeast Brazil.

Previous Reports on Insect Diversity of the Semi-arid

In their book on the fauna of Northeast Brazil, Paiva and Campos[1] dedicated only one of the 273 pages to the insects, emphasizing the indigenous stingless bees. They presented a short list of endangered species without environment reference, so that they can be possibly coastal species.

The development of universities in the NE Brazil has increased the number of research groups interested in the fauna of the Semi-arid, particularly insects. A book published in 2003 about the ecology and conservation of the Caatinga[2], with four chapters on insect diversity of this biome (bees, beetles and ants),

1 Paiva, M.P. & E. Campos. 1995. *Fauna do Nordeste do Brasil: Conhecimento Científico e Popular*. Banco do Nordeste, Fortaleza.
2 Leal, I., M. Tabarelli & J.M.C. da Silva 2003. *Ecologia e Conservação da Caatinga*. Editora Universitária da Universidade Federal de Pernambuco, Recife.

and the last two Meetings of Zoology of the Northeast, in 2003 and 2005, with 21 works presented also on insect diversity in the Semi-arid, are examples of the recent interest on biodiversity studies of the insects in this region.

Current Reports

Three studies of inventories in the Brazilian Semi-arid were presented at the First Symposium of Biodiversity of Insects and their Interaction with Plants in Bahia, in September 2005, within the Meetings of Zoology of the Northeast. Pérez-Maluf[3] highlighted the situation of studies on the diversity of insects in the caatinga, and in the Semi-arid as a whole, and reported 11 groups of research registered at CNPq under the keyword 'fauna of caatinga'. It was observed an increase in the number of inventories of insects in the Caatinga; however, they are not enough yet for a reasonable knowledge on the entomofauna of this large Brazilian biome.

The theme of the second study presented at the Symposium was the entomofauna of the Chapada Diamantina[4], covering areas of caatinga, cerrados, campos rupestres and semideciduous forests. The survey was part of PROBIO and its results have been published recently[5]. The third study[6] summarized data of a regional collection of insects, the entomological collection of the Museum of Zoology at UEFS, in which insects of the Semi-arid of Bahia belonging to several orders are housed. Regional collections are being created in several universities of the NE Brazil and soon they will be important sources of information for the knowledge of the insect diversity in the region.

In general, what can be observed is the predominance of studies in geographically restricted areas, usually focusing on particular groups, representing a few families. Inventories covering more inclusive taxonomical groups or carried out in a broader geographical scale are recent. As a result, it is still impossible to have a realistic estimate of insect diversity in the Semi-arid. Bees (Apoidea, Hymenoptera) are among the most studied groups of insects in the Semi-arid. However, other groups are also object of study, such as termites (Isoptera), wasps (Vespidae, Hymenoptera), ants (Formicidae, Hymenoptera), beetles

3 Pérez-Maluf, R. 2005. Diversidade de insetos da caatinga. *In Livro de Resumos do XV Encontro de Zoologia do Nordeste*, Editora da Universidade Estadual da Bahia, Salvador, pp. 140-143.
4 Aguiar, C.M.L. *et al*. 2005. Diversidade de insetos na Chapada Diamantina (Bahia, Brasil). *In Livro de Resumos do XV Encontro de Zoologia do Nordeste*, Editora da Universidade Estadual da Bahia, Salvador, pp. 156-161.
5 Juncá, F.A., L. Funch & W. Rocha (eds). 2005. *Biodiversidade e Conservação da Chapada Diamantina*. Ministério do Meio Ambiente, Brasília-DF.
6 Bravo, F. 2005. Inventários entomofaunísticos e a coleção de insetos da Universidade Estadual de Feira de Santana. *In Livro de Resumos do XV Encontro de Zoologia do Nordeste*. Editora da Universidade Estadual da Bahia, Salvador, pp. 121-125.

(Coleoptera; Chapter 17), flies and mosquitoes (Diptera; Chapter 16), true bugs, cicadas and leafhoppers (Hemiptera, special focus on this group for families of medical or agricultural interest).

Currently, through the PPBIO of the Semi-arid (Chapter 2), updated data on the insect diversity from different portions of the Caatinga Biome have been produced. These results will certainly set up strong basis for more realistic estimates on the diversity of insects in the Brazilian Semi-arid.

CHAPTER 16 – Perspectives for the Study of Diptera (Insecta) in the Brazilian Semi-arid

Freddy Bravo

Among the methods to collect insects, the most used are the malaise (top left) and light (top right) traps; the former is probably the most efficient for Diptera. Examples of Diptera: *Lecania* (bottom left) and *Mallophora* (bottom right)

The Diptera include more than 125 thousand known species in the world, which are classified into 188 families and 10 thousand genera[1]. However, the total number of species has been estimated to almost 1.6 million. They are one of the megadiverse groups of insects, occupying the third place in diversity, after Coleoptera (Chapter 17) and Hymenoptera.

For the Neotropics, nearly 900 species were published per year between 1997 and 2003[2]. This number seems to be underestimated since tropical regions in general hold a huge diversity of insects, particularly dipterous. Coined by Brown[2], the crisis of the Neotropical dipterology has its basis on the small number or even lack of taxonomists in the area[3].

In Brazil, the knowledge of Diptera diversity is still fragmented and restricted only to specialized periodicals. The Catalogue of Diptera in South America[4] was elaborated in the 1960's and 1970's, and it has not been updated. Some books deal with the diversity of Diptera in South America including Brazilian species. The best known groups are those with medical or agricultural interests (e.g. Culicidae, Phlebotominae, Tephritidae). However, there are exceptions, such as Neotropical muscids flies[5].

1 NA - A worldwide initiative is attempting to organize the knowledge of the Diptera diversity: http://www.sel.barc.usda.gov/Diptera/diptera.htm.
2 Brown, B. 2005. Malaise trap catches and the crisis in Neotropical dipterology. *American Entomologist* 51: 180-183.
3 NA - A list of taxonomists in Diptera of Brazil and South America can de found on the website http://zoo.bio.ufpr.br/diptera/south/index.html.
4 Papavero, N. (ed.) 1966. *A Catalogue of the Diptera of the Americas South of the United States*. Secretaria da Agricultura do Estado de São Paulo [Museu de Zoologia da Universidade de São Paulo, São Paulo, published in 120 volumes].
5 De Carvalho, C.J.B. (ed.). 2002. *Muscidae (Diptera) of the Neotropical Region: Taxonomy*. Editora da Universidade Federal do Paraná, Curitiba.

Studies on Diptera in the Northeast Brazil

Historically, the biodiversity of Diptera in the NE Brazil has not been well explored, as reported by Papavero[6, 7] in his books on the history of Neotropical dipterology between 1750 and 1905. Only a few naturalists have sampled in the NE and none has been in the semi-arid region. After 1905, no inventory for Diptera has been registered, except for those of medical and agricultural interest. Recently, an inventory of Psychodidae in the humid forests of the shore in Bahia has been concluded with financial support of CNPq and FAPESB[8].

In 2004, UEFS carried out the project PROBIO 'Chapada Diamantina: Biodiversity'. Several groups of animals, including the Diptera were inventoried[9]. Samples were made trough the method of Rapid Ecological Assessment. Such methodology predicted less than a day of sampling for Diptera with insect nets in nine landscape units, including areas of cerrado, campos rupestres, caatinga and semideciduous forests. Every area was visited twice, once in the dry and another time in the rain season. However, the method was not efficient in inventorying diversity of Diptera since specimens of few families were collected (Bombilidae, Muscidae among the Brachycera and no specimen of Nematocera). Asilidae had the largest number of samples, with 14 species collected; most of them were new registers to the State of Bahia. The inventory of Psychodidae carried out by the Diptera team at UEFS was more successful when sampling several families of Diptera. Several methods of sampling were used, such as insect net, malaise and light traps. Although there are specific traps to collect certain groups of Diptera, specialists consider both malaise and luminous traps the ideal methods to catch Diptera because they are able to capture a major number of families.

Currently, an inventory of Diptera in the semi-arid region has been carried out by PPBio (Chapter 2), and four kinds of sampling have been used: insect nets and malaise, luminous and pitfall traps. The project gathers several universities of the NE Brazil. Preliminary results are sound. Specimens from several families have been sampled, such as Tipulidae, Psychodidae, Simulidae, Culicidae, Asilidae, Bombylidae, Tabanidae, Calliphoridae and Muscidae. Up to now, the Psychodidae and Asilidae species have been studied, and that has resulted in new specie of Psychodidae and presented new registers of Psychodidae and Asilidae for the region. Considering the first results, the ongoing sampling in the Semi-arid will provide valuable information on the knowledge of Diptera and will allow understanding the biogeography of the region which includes the Amazon, the Atlantic Forest and the Caatinga.

6 Papavero, N. 1971. *Essays on the History of Neotropical Dipterology, with Special Reference to the Collectors (1750-1905)*, vol. 1. Museu de Zoologia, Universidade de São Paulo, São Paulo.
7 Papavero, N. 1973. *Essays on the History of Neotropical Dipterology, with Special Reference to the Collectors (1750-1905)*, vol. 2. Museu de Zoologia, Universidade de São Paulo, São Paulo.
8 Results can be checked at http://www.uefs.br/dcbio/lent_sis/psycho_bahia.htm.
9 Juncá, F.A., L. Funch & W. Rocha (eds). 2005. *Biodiversidade e Conservação da Chapada Diamantina*. Ministério do Meio Ambiente, Brasília, DF.

CHAPTER 17 – Beetles in the Brazilian Semi-arid: Remarkable, but Almost Unknown

Priscila Paixão Lopes

The presence of endangered species, high biodiversity, high rate of endemism or a set of these factors are criteria for the selection of conservation areas. The employment of these criteria frequently results in the protection of a high number of species. Even with the protection of an umbrella species (a target species), many others that inhabit the same area are equally benefited. Whatever criteria are used to select conservation areas, the knowledge of biodiversity is essential. The best way to obtain this knowledge is through systematic surveys of flora and fauna.

Among Brazilian biomes, moist forests, such as the Amazon and the Atlantic Forest, have their biodiversity better known. In general, the knowledge of the fauna in the Semi-arid is very little for both vertebrates (i.e. birds and mammals), which have a higher conservationist appeal, and several groups of invertebrates. Such little understanding has made the delimitation of conservation areas difficult. At first, the main reason to protect areas of caatinga was the need to search for information about its flora and fauna before they were totally destroyed.

The most frequently faunistic inventories used to support the creation of conservation areas are those dealing with diversity of vertebrates. Birds and mammals are often used for both the establishment of target species and as indicator of hotspot areas. Although extremely relevant, the survey of these organisms is expensive and estimates of diversity usually take longer. The survey of insects would be an alternative to assess biodiversity. Insects amount to almost half of the total number of species currently described and are noticeable for their multiple ecological activities in many ecosystems. Thus, insect surveys would provide a more realistic assessment of biodiversity.

Importance of the Coleoptera

Among the insects, the beetles (Order Coleoptera) are the largest group (around 40% of the insects). Concerning the total species of plants and animals, they amount to around 20% of the described species. Considering such a huge diversity, these insects are thought to be the most successful in nature. They present sizes that vary from 1 mm to giants of 15 cm. They are also very important

ecologically[1], having different roles in the environment, acting as pollinators, herbivorous, scavenger, necrophagous or predators.

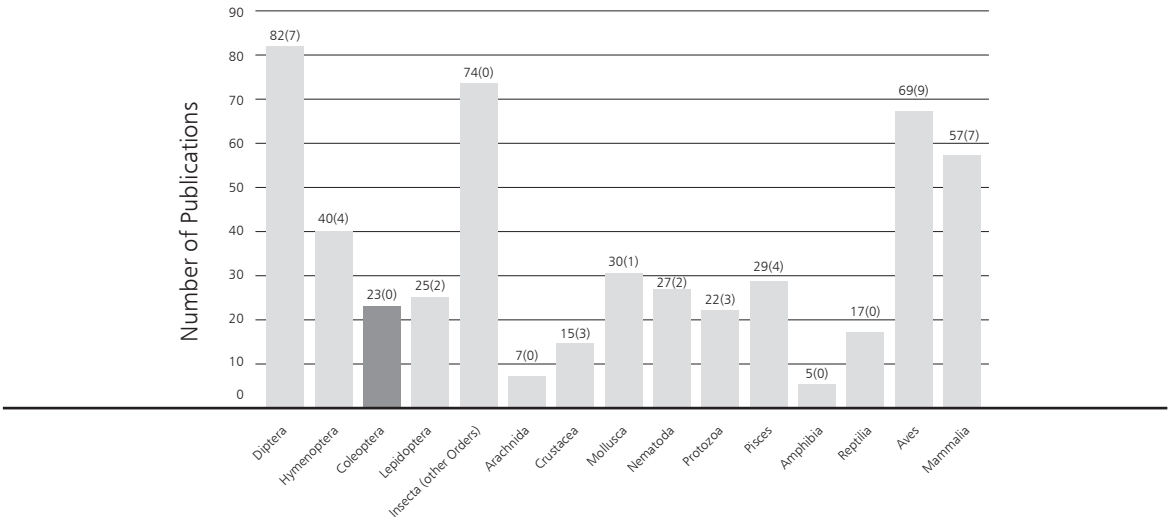
Present in almost all environments (except sea environments), beetles are different from one another in amazing ways. They are important contributors for the biodiversity of moist forests, arid or semi-arid areas, streams and lakes. It can be said that while the fauna of beetles is not known, the biodiversity of that area is certainly underestimated.

The knowledge of the fauna in the Northeast Brazil is focused on its coastal areas; there are few studies on the Semi-arid. A survey on the current situation of biological research on biodiversity in Brazil[2] has shown a huge absence of studies in the region, mainly in areas of caatinga. Considering taxonomic groups studied, it is clear that the beetles are very little known; no survey work was published for fifteen years. One reason for this gap is the small number of researchers and taxonomists of beetles in the region. Considering the great contribution of these insects to the world biodiversity, this gap needs to be fulfilled as soon as possible. In order to do this, it is necessary to perform surveys of insects, as well as interchange and hosting of taxonomist in the NE Brazil.

Arthropods are excellent indicators when estimating the local diversity[3]. Whereas the survey of vertebrates is expensive and time consuming, the survey of insects is relatively fast and cheaper. Beetles sampled with fly interception and pitfall traps generally present high correlation with the total diversity of the sampled areas, providing a shortcut for biodiversity estimates, and so increasing efficiency in the selection of conservation areas.

Most of the State of Bahia is included in the Semi-arid, which do lack survey of insects (Chapter 15). Such problem was mainly linked to the small number of taxonomists in the NE Brazil[2], perhaps to the small aesthetic appeal of the regional formations (e.g. physiognomies characterized by dense thorny trees) when compared to the luxuriant humid formations, besides the logistic difficulties to develop studies in this area. The misconception of low diversity of species in the Caatinga has started to be gradually undone from an increasing gathering of scientific information that has revealed high levels of endemism in the caatinga. Knowledge on the insect diversity, however, is still little. From every new sample, new species are discovered. Most of them, however, continue hiding in piles of sample pots due to the lack of specialists able to describe or identify them correctly.

1 Borror, D.J. & D.M. DeLong. 1969. *Introdução ao Estudo dos Insetos*. Ed. Edgard Blücher, São Paulo.
2 Lewinsohn, T.M. & P.I. Prado. 2002. *Biodiversidade Brasileira: Síntese do Estado Atual do Conhecimento*. Ministério do Meio Ambiente, CIB, Ed. Contexto, São Paulo.
3 Duelli, P. & M.K. Obrist. 1998. In search of the best correlates for local organismal biodiversity in cultivated areas. *Biodiversity and Conservation* 7: 297-309.



Number of publications on several groups of organisms surveyed in Brazil and in the NE Brazil until 20022; numbers above columns are works based in inventories carried out in Brazil (and those in the NE Brazil). Note the scarcity of publications on beetles, particularly in the NE

Studies on Beetles in the Brazilian Semi-arid

Recent surveys of insects are being carried out in the Semi-arid. Two studies were carried out in the hydroelectric building of Xingo (states of Alagoas and Sergipe). One explored the abundance of families of Coleoptera[4] and the other the richness of species of Cerambycidae[5]. Ongoing surveys in the Semi-arid of Bahia comprises areas, such as the Chapada Diamantina and the Northwest of the State, linked with PROBIO (MMA) and PPBio of the Semi-arid (MCT, Chapter 2), respectively, and include several physiognomies of caatinga, semideciduous forests, cerrados and campos rupestres. Beetles have been sampled mainly in decomposing medium (carrion and feces); a few generalist species were observed. Among the sampled beetles, the Scarabaeidae (more than 30 species of "rola-bosta", dung beetles), Nitidulidae, Scolytidae (mostly scavengers), Histeridae (more than 10 species) and Staphylinidae (predators of fly larvae and other little insects, more than 10 species), besides Carabidae, Curculionidae, Tenebrionidae and others are present.

4 Iannuzzi, L.*et al*. 2003. Padrões locais de diversidade de Coleoptera (Insecta) em vegetação de caatinga. *In* I. Leal, M. Tabarelli & J.M.C. da Silva (eds.) *Ecologia e Conservação da Caatinga*. Editora Universitária da Universidade Federal de Pernambuco, Recife, pp. 367-390.

5 Maia, A.C.D. *et al*. 2003. Padrões de diversidade de Cerambycidae (Insecta: Coleoptera) em vegetação de caatinga. *In* I. Leal, M. Tabarelli & J.M.C. da Silva (eds.) *Ecologia e Conservação da Caatinga*. Editora Universitária da Universidade Federal de Pernambuco, Recife, pp. 391-433.

Samples were carried out exclusively through traps with baits. Few traps used only few times a year and for short periods in the field were enough to show that every kind of vegetation presents an important component of habitat specialist species. Vegetations are frequently shaped in a mosaic, following environment nuances. As the vegetation is modified due to variations of the physical environment (humidity, intensity, distribution and seasonal regime of rain; medium and maximum temperatures and kind of soil), the same happens with beetles communities. Such exclusivity of species that end up forming a mosaic of compositions suggests that, in order to optimize the conservation of biodiversity, the protection of a set of environments with complementary biodiversity would be ideal.

Surveys, although restricted in time and space, suggest that the diversification of methods and intensification of sampling will increase significantly the species diversity recorded in the Semi-arid. This information will be able to help on the delimitation of priority areas for conservation and for the comprehension of the features which determine the spatial patterns of diversity, also helping elaborate management plans for these areas.

CHAPTER 18 – Fishes in the Brazilian Semi-arid

Alexandre Clistenes de Alcântara Santos & Angela Maria Zanata

View of the São José River, showing the destruction caused by mechanized mining of diamond. [Photo by R. Funch]

The hydrographic network of the Brazilian Semi-arid (Introduction) is modest when compared to other Brazilian regions. It presents peculiar features, such as being intermittent and seasonal. However, this does not apply to all rivers in the caatinga; the main ones, São Francisco and Parnaíba, are perennial rivers[1]. Besides, there are mid-sized perennial ones which have their sources in the Chapada Diamantina, such as the Paraguaçu, Contas and Itapicuru. These rivers have intermittent tributaries and flow to the Atlantic Ocean after crossing large areas of the semi-arid land.

The species of fish that occurs in the Semi-arid are the result of evolutionary processes driven by climatic factors and by the hydrologic regime of the region. However, human influence through environmental changes and the introduction of alien species might have modified the very structure of the original fauna. Nowadays, around 240 species have been registered in this biome[1,2], but this number is supposed to increase once efforts to survey hydrographic basins in the semi-arid region also increases. In the last years, UEFS has carried out a significant research work focusing this region, taking part and coordinating projects aimed at acquiring further knowledge on its biodiversity. In what it concerns the ichthyofauna, the UFBA and the UFPB have also carried out expeditions and scientific activities dealing with fishes in the Semi-arid. It is here presented a brief comment on the present stage of knowledge of the ichthyofauna in the Brazilian Semi-arid. Recent or yet ongoing works are briefly discussed and suggestions for future studies about the ichthyofauna of the region are made.

Current Knowledge of the Ichthyofauna in the Brazilian Semi-arid

Although inventories of ichthyofauna in the Brazilian Semi-arid began in the 19th century (see CD for a list of expeditions), knowledge on the diversity and the taxonomy of most aquatic environments in this region is still incipient[1,2]. Despite the importance of knowing the ichthyofauna of the NE Brazil, most expeditions and works accomplished in the first half of the 20th century present taxonomic problems such as wrong identifications, inadequate descriptions, lack of accuracy on the origin of the material, or have had only part of the samples scientifically analyzed. Recent studies have increased the knowledge on the ichthyofauna mainly through sampling and descriptions of species and, systematic reviews, quotations and compilation of literature on fishes from the region. Only recently, the first workshops on diversity, conservation, ecology and the origin of the fauna in the Semi-arid have been accomplished.

Around 240 species of fish occur in the Brazilian Semi-arid. Although the region is less diverse when compared to other regions in Brazil, it presents at least 56 endemic species. The total number of species registered for the main basins (e.g., São Francisco and Parnaíba) might be underestimated due to problems in determining which species do come from the Semi-arid, since these rivers have part of their courses out of the region. The lack of accuracy in the knowledge of the ichthyofauna is also due to the lack of surveys in river sources and the lack of precise information on the systematics and distribution of most taxa. Knowledge on the state of conservation of species has also been considered scarce since only four species have been classified as endangered[3]. However, most of the ichthyofauna has not yet been assessed.

Aspidoras psammatides is one of the ten new species found in the Chapada Diamantina, Bahia. [Photo by M. Britto]

Recently, a series of programs supporting the study of ichthyofauna biodiversity in the Semi-arid have been carried out: (i) studies in the Espinhaço Range have produced a list of species and assessment of conservation in the area under study; (ii) IMSEAR (Chapter 1) has defined priority basins to be surveyed through comparative studies among the drainages in the Semi-arid; (iii) PPBio of the

1 Rosa, R.S. et al. 2003. Diversidade, padrões de distribuição e conservação dos peixes da caatinga. *In* I.R. Leal, M. Tabarelli & J.M.C. da Silva (Orgs.) *Ecologia e Conservação da Caatinga*. Editora Universitária da Universidade Federal de Pernambuco, Recife.

2 Rosa, R.S. 2004. Diversidade e conservação dos peixes da caatinga. *In* J.M.C. da Silva, M. Tabarelli, M.T. Fonseca, L.V. Lins (Orgs.) *Biodiversidade da Caatinga: Áreas e Ações Prioritárias para a Conservação*. Ministério do Meio Ambiente, Brasília-DF.

3 Rosa, R.S. & N.A. Menezes 1996. Relação preliminar das espécies de peixes (Pisces: Elasmobranchii e Actinopterygii) ameaçadas no Brasil. *Revista Brasileira de Zoologia* 13(3):647-667.

Semi-arid (Chapter 2) has created a network of inventories; increased and modernized scientific collections in the NE Brazil; promoted theme studies on reproductive aspects of mid Paraguaçu River and, fomented on the formation of specialized professionals in the region; (iv) 'The Paraguaçu and Itapicuru Catfish Expedition' has sampled areas scientifically little explored in search for new species of fishes and samples of rare species for trying to solve taxonomic problems; (v) survey on the species of fish in the basins of Inhambupe, Itapicuru and Real deals with species from the shore mouths of rivers which have part of its course in the semi-arid region.

Projects on the Ichthyofauna in the Semi-arid

'Studies on the Flora and Fauna from the Espinhaço Range of Bahia and Definition of Strategies for Conservation' (CNPq): This project was coordinated by UEFS and had as its main objective to perform surveys of the fauna and flora in the region of the Chapada Diamantina, Bahia, besides elaborating strategies for the conservation of the area and its species. Its main results on the ichthyofauna were presented in a doctorate dissertation in zoology at the National Museum in Rio de Janeiro[4]. This work registered 63 species in 36 places of the upper Paraguaçu River. Ten new specie were identified, two of which (*Myxiops aphos and Aspidoras psammatides*) were described[5,6], and two others are in the process of description. Among the main threats to the local ichthyofauna we can list the destruction of riverbed vegetation by mechanized mining of diamond in the past and the replacement of native forests for grazing land nowadays. Another important threat is the presence of exotic species from other South American basins which endanger native species.

Suggestions of possible actions of management and conservation of rivers and fishes in this region require (i) the implementation of long term projects; (ii) the recognition of how important this environment and its ichthyofauna is; (iii) support for the implementation of research nuclei focusing on the maintenance of biodiversity and environmental education, besides (iv) the support for programs for the conservation of native vegetation.

IMSEAR (MCT): A study on the present state of knowledge on the ichthyofauna of the Semi-arid of the State of Bahia was carried out between 2003 and 2005 through the biodiversity program of IMSEAR.

4 Santos A.C.A. 2003. *Caracterização da Ictiofauna do Alto Rio Paraguaçu, com Ênfase nos Rios Santo Antônio e São José (Chapada Diamantina, Bahia)*. Tese de Doutorado, Museu Nacional da Universidade Federal do Rio de Janeiro, Rio de Janeiro.

5 Zanata, A.M. & A. Akama. 2004. *Myxiops aphos*, new characid genus and species (Characiformes: Characidae) from the rio Lençóis, Bahia, Brazil. *Neotropical Ichthyology* 2(2):45-54.

6 Britto, M.R., F.C.T. Lima & A.C.A. Santos. 2005. A new Aspidoras (Siluriformes: Callichthyidae) from rio Paraguaçu basin, Chapada Diamantina, Bahia, Brazil. *Neotropical Ichthyology* 3(4): 473-479.

It was accomplished having the material from the collections deposited at Museu de Zoologia – UEFS, Museu Nacional do Rio de Janeiro and Museu de Zoologia – USP as basis.

Data on the occurrence of fishes in 43 municipalities were collected. That corresponds to about 16.47% of the total number of municipalities in the Semi-arid of Bahia. Data on species from the São Francisco River and other important basins in the State, such as the Paraguaçu and Contas were collected. Other important rivers which are part of the East basin such as Itapicuru, Vaza-Barris and Pardo Rivers as well as their tributaries were also included in this research.

A total of 239 species were registered, 21 of which are annual fishes from temporary lakes in the semi-arid land. Ten alien species were registered. This work has increased the number of species recorded for the São Francisco and East basins to 29 species.

Comparative analysis of the fauna of the basins shows low level of similarity between the fauna of the São Francisco and East basins which is probably related to a greater length and number of species in the first one. Among rivers in the East basin, the Paraguaçu is worth noticing for its number of species and for the increased knowledge we have acquired on its ichthyofauna in recent years. High similarity between the Contas, Pardo and Vaza-Barris Rivers is related to the low number of species registered in them, maybe a result of our little knowledge on their ichthyofauna. On the other hand, the Itapicuru River presents a high number of exclusive species which makes it a singularity among the rivers in the East basin.

Considering the results of the project, it can be inferred that the low number of species in the Contas, Pardo and Vaza-Barris Rivers is related to our little knowledge of the basins in the region under study, which reinforces the need of research on the ichthyofauna of these rivers. On the other hand, the high number of species exclusively distributed in the Itapicuru River emphasizes the importance of its basin and makes further research on its ichthyofauna urgent. This can prevent species from getting extinct even before being described.

Results accomplished by IMSEAR for the main rivers in the East basin emphasize the need of a better understanding of the basins of Contas, Pardo, Itapicuru and Vaza-barris Rivers, as well as parts of the middle and low Paraguaçu River.

PPBio of the Semi-arid (MCT): This project aims at continuing biodiversity studies started by IMSEAR. It coordinates activities among several institutions, mainly in the NE Brazil. In what it concerns to the ichthyofauna, the project aims at producing a diagnostic of the present knowledge on the biodiversity of fishes in the Semi-arid in two years. The activities scheduled for the first year are:

(i) Inventories: a review of the literature on the ichthyofauna of the region is being concluded. Meanwhile, areas of extreme biological importance are being inventoried and new areas will be progressively added during the development of the project. Sampling focuses on the rain season (November-March), but sampling during the dry season (April-October) will also be carried out.

(ii) Collections: the process of digitizing the collection of the Fish Section at the Museu de Zoologia – UEFS and other important collections in the NE will continue aiming at making information available on the internet.

(iii) Theme Studies: The project has developed systematic studies for the description of new species; on the composition of the ichthyofauna of the region and, on reproductive aspects of fishes from middle Paraguaçu River. Actions on the conservation of aquatic ecosystems of the region will be carried out. These will support sustainable harvesting of fishes and the consequent maintenance of fishing stocks of the Semi-arid.

The Paraguaçu and Itapicuru Catfish Expedition: Funded by the National Science Foundation, USA, through the program 'All Catfish Species Inventory', this expedition was coordinated by UFBA. It had as the main objective sampling areas previously scarcely surveyed in search for new species of fish and material from rare species for phylogenetic studies which will help solve taxonomic problems. Its team included six researchers from UFBA, UEFS and USP. Field work was carried out in July 2005, reaching 37 places in the courses of the Paraguaçu, Jacuípe and Itapicuru Rivers, mainly in the sources and small tributaries. Over 8,000 specimens were sampled making up 59 species. Several new species were collected and are being described. Important information and material from endemic species were also collected. It is worth mentioning siluriform species, such as *Conorhynchus conirostris*, *Parotocinclus bahiensis*, *Pimelodella bahianus* and *Kalyptodoras bahiensis*. The later is an endangered species which is currently theme of a study on its distribution and ecology funded by Fundação Biodiversitas.

Survey on the Species of Fishes from the Basins of the Inhambupe, Itapicuru and Real Rivers: This project was developed as part of the Program for Regional Scientific Development by CNPq, via UFBA. It aims at surveying the species of fishes from the courses of rivers in the costal region of Bahia to the North of Salvador; describing new species; defining priority areas for conservation and, producing a catalogue for the species in the region. Most of the rivers sampled have part of their courses in the semi-arid region, seasonal regime and are highly anthropicised. Sampling was carried out in the period of 2004-2005 and found 53 species of fish from fresh water. Among these, five are probably new and the description of two of them (a new species of *Hyphessobrycon* and another of *Parotocinclus*) is being carried out. Further

information on the distribution of species was also collected. Species such as *Mimagoniates* cf. *sylvicola* previously known to exist only in the South of Bahia were registered in the area under study.

Final Considerations

Information gathered from the literature and partial results of the study indicate the extreme need of elaborating inventories of the ichthyofauna in the Brazilian Semi-arid followed by the analysis of the material collected under new systematic reviews. It is also recommend urgent actions for the conservation of fish biodiversity in the Semi-arid since several aquatic ecosystems and basins are under pressure over almost all areas. Ongoing studies hosted mainly by UEFS and UFPB have produced important contributions for both the elaboration of inventories and the definition of strategies for conservation. Besides that, we expect that present programs of incentive for the knowledge of biodiversity in the NE Brazil continue producing significant results for the understanding of the dynamics of the Brazilian Semi-arid as well as information that can effectively help environmental conservation in the region.

CHAPTER 19 – Birds of the Semi-arid of Bahia

Caio Graco Machado

Lear's Macaw (*Anodorhynchus leari*, Psittacidae) is endemic to Raso da Catarina, Bahia

Birds are the best known vertebrates since they can be easily spotted in any environment for having, in general, very noticeable colours and vocalization, for being diurnal in most species and, for occurring in a great number of individuals and species.

Among all regions in Brazil, the Semi-arid has the least known bird fauna. There are large gaps of knowledge on the distribution, composition and patterns of different communities of birds, besides being few the numbers of studies on their ecology and natural history. However, in the last years, we have noticed an increasing interest in the bird fauna of this region, particularly in the caatinga, the only exclusively Brazilian biome. In 2000, a *workshop* was carried out (PROBIO/MMA) in Petrolina, Pernambuco, which resulted in a document entitled 'Assessment and identification of priority actions for conservation, sustainable use and distribution of benefits of the biodiversity of the Caatinga Biome'[1]. Concerning birds, the workshop produced a complete and excellent review of the literature on the history and the state of the knowledge on the bird fauna in the caatinga region: 'Aves da Caatinga – Apreciação Histórica do Processo de Conhecimento'. Such document along with others are part of the book 'Biodiversidade da caatinga: áreas e ações prioritárias para a conservação', published by MMA in 2004.

1 Avaliação e identificação de ações prioritárias para conservação, utilização sustentável e repartição de benefícios da biodiversidade do Bioma Caatinga', coordinated by José Fernando Pacheco and Claudia Bauer.

Interactions among Birds and Plants

Studies have shown the interaction among birds and plants, mainly the hummingbirds and their floral resources, and seed dispersal by birds. These were carried out in areas of campos rupestres and, more recently, in areas of caatinga and cerrado in the Chapada Diamantina massif. Funded by FAPESB, MMA/PROBIO, CNPq and FNMA, these studies have also proved that great part of the resources used by birds (nectar and fruit) is available throughout the year, keeping the population of pollinators and dispersers of seeds in the region, thus maximizing the reproductive process of the plants.

Red-cowled cardinal (*Paroaria dominicana*, Emberizidae) is a typical bird in semi-arid region

Out of Chapada Diamantina, yet in the semi-arid of Bahia, studies were and have still been carried out in areas which are considered priority for biological survey. In Raso da Catarina, a study funded by FNMA was developed, concerning the use of birds by the Pankararé Indians. Almost all species of local birds are used by this ethnic group, mainly as food, except the 'urubus' (the vultures *Cathartes aura*, *C. burrovianus* and *Coragyps atratus*), because of the bad odour in its meat, and the 'lavandeiras' (masked water-tyrant, *Fluvicola nengeta*), which are believed to be blessed birds.

Bird Inventories in the Chapada Diamantina

Since 1997, UEFS has developed projects involving bird fauna inventories and studies focusing on the interaction between birds and local flora with the objective of developing the knowledge on the bird fauna in the Semi-arid, particularly in Bahia. Such knowledge becomes important when strategies for the conservation of biodiversity are discussed, since birds are excellent bioindicators for environmental quality.

The Semi-arid of Bahia occupies around 40% of the area in the State and includes a vegetational mosaic composed by areas of cerrado, inland mesophile forests, campos rupestres, continental dunes and predominantly caatinga. Most of the phytophysiognomic diversity of the Semi-arid of Bahia occurs in Chapada Diamatina, which has been the focus of most investigations by LORMA (Laboratory of

Ornithology and Mastozoology) at UEFS. Inventories accomplished through projects funded by CNPq ('Studies on the Flora and Fauna from the Espinhaço Range of Bahia and Definition of Strategies for Conservation')[2] and PROBIO/MMA ('Chapada Diamantina: biodiversity') have achieved the register of around 370 species of birds so far.

Chapada Diamantina National Park is considered a key area for the conservation of rare and vulnerable species, such as 'jandaia' (golden-capped parakeet, *Aratinga auricapilla*), 'tiriba' (blue-throated conure, *Pyrrhura cruentata*), 'bico-virado-da-caatinga' (great xenops, *Megaxenops parnaguae*) and 'chorozinho-de-papo-preto' (pectoral antwren, *Herpsilochmus pectoralis*). The region also hosts other endangered species recognized by IBAMA such as the 'águia-cinzenta' (crowned eagle, *Harpyhaliaetus coronatus*), 'gavião-pomba' (white-necked hawk, *Leucopternis lacernulata*), 'jacucaca' (white-browed guan, *Penelope jacucaca*), 'papagaio-de-peito-roxo' (vinaceous amazon, *Amazona vinacea*), 'formigueiro-do-nordeste' (narrow-billed antwren, *Formicivora iheringi*), 'pavó' (red-ruffed fruitcrow, *Pyroderus scutatus*) and 'coroinha' (yellow-faced 'siskin', *Carduelis yarrelli*).

Despite its singularity, the bird fauna of Chapada Diamantina is poor in endemism. There are only three species endemic to the Espinhaço Range: the 'papa-moscas-de-costas-cinzentas' (grey-backed tachuri, *Polystictus superciliaris*), the 'felipe-estulinha' (pale-throated serra-finch, *Embernagra longicauda*) and the 'beija-flor-de-gravatinha-vermelha' (hooded visorbearer, *Augastes lumachellus*). Only the last one is exclusive of Chapada Diamantina, what suggests it to be elected as its symbol bird.

Chapada Diamantina National Park is an extremely important area for the conservation of the bird fauna because besides holding the regional species, it is a primary spot for many migratory species on their migration routes. The importance and the urgent need of conservation of its bird fauna can be noticed through the results: 33 are migratory species, 40 are endemic of Brazil (in different levels of distribution) and 20 are endangered.

Bird Inventories in the Caatinga

Supported by PPBio of the Semi-arid (MCT; Chapter 2), inventories of birds in the regions of Senhor do Bonfim and dunes of São Francisco River is being accomplished. So far, 141 species of birds have been

2 Estudos de Flora e Fauna na Cadeia do Espinhaço da Bahia e Definição de Estratégias de Preservação.

registered in the former and 91 in the latter. Such diversity is probably larger. The surveys are still ongoing and partial results are limited only to registers during the dry season. Expeditions in the rainy season will be carried out, when resources in the caatinga are abundant, what consequently might attract populations of different species of birds.

The ornithology team of UEFS has carried out detailed survey on the studies accomplished on the bird fauna in the Semi-arid of Bahia, along with IMSEAR (Chapter 1), resulting in a *check-list* of 456 species of birds recorded for the Semi-arid of Bahia. Such species were obtained by checking 154 references in literature, performing a total of 3,289 registers of species of birds. From this variety, 57 families have been registered. Two of them, Tyrannidae and Emberizidae, contributed with 72 and 67 species, respectively. Both occur in a great diversity of environments, being Tyrannidae endemic to the American continent.

The number of endemism among the birds of the Semi-arid region in Bahia is low. Only two species are considered endemic of the region: the two Psitacidae 'ararinha-azul' (little blue macaw, *Cyanopsitta spixi*), and the 'arara-azul-de-lear' (Lear's Macaw, *Anodorhynchus leari*) (ambas Psitacidae). Besides, the previously cited *Augastes lumachellus* is endemic to the Chapada Diamantina replacing its co-generic from the south portion, *Augastes scutattus*. In Chapada Diamantina, *A. lumachellus* seems to be restricted to altitudes above 1,000 m. The little blue macaw is already considered extinct in the nature. It used to occur in the region of Cuaraçá, whereas the Lear's macaw occurs in the region of Raso da Catarina. Although the efforts to protect the little blue macaw were great, they were also late and hopeless. The Lear's macaw and the white-browed guan (*Penelope jacucaca*), endemic to the caatinga though not restricted to the State of Bahia, are listed as endangered.

Conservation of Birds

Due to the large area occupied by the Semi-arid of Bahia, there are still gaps to be explored. Yet, some factors have contributed to the extinction of species, such as (i) lack of knowledge on the bird fauna of this region; (ii) poaching, that aims not only the use of birds as food, but also for the illegal (national and international) commerce of wild animals and, (iii) the destruction of environments. It is important to remark that the State of Bahia presents the highest numbers of poaching in the whole country. The recent extinction of the little blue macaw in the nature is a good example of such damage.

Thus, UEFS has been adding efforts for the scientific investigation on birds in the Semi-arid of Bahia. Studies promoted by the university focus on composition, richness, distribution, use of habitats, interac-

tions with the flora, behaviour and reproduction, aiming at contributing with quality of knowledge on the bird fauna, moreover committing to the discussion of goals for the conservation and management of the species and their environments.

Crested caracara (*Caracara plancus*, Falconidae) occurs in open and semi-open fields, foraging on the ground.

CHAPTER 20 – Ethnozoology of the Semi-arid of Bahia: Study Cases

Eraldo Medeiros Costa Neto

Larvae of the coconut caterpillar *Pachymerus nucleorum*, which are eventually used as direct source of food in the Semi-arid

Studies on ethnozoology are still scarce in Brazil when compared to those aimed at ethnobotany. Teixeira[1] stresses that research on ethnozoology in the country is incipient at the same time as he admits that one of the most serious problems on the study of ethnozoology lies in the lack of the most elementary and descriptive information on Brazilian fauna along with highly deficient sampling.

The State of Bahia presents a very significant socio-biodiversity. Different ethnic groups such as indigenous societies, quilombolas[2], fishery and rural communities inhabit the State keeping a range of interactions with local fauna resources. Bahia presents predominantly a semi-arid climate and caatinga vegetation dominates most of the landscape. Up to the 1950's, poor rural population used to take almost all of their basic needs of food, clothing, medicine, energy and housing at the expenses of the natural resources[3]. Because of that, native inhabitants have ethnobiological knowledge adapted to the natural resources of the region.

Zootherapy: Medicinal Use of Animals

Studies on ethnozoology developed in the Semi-arid of Bahia have approached the perception, classification and use of animals by the human communities present there. The use of fauna resources

1 Teixeira, D.M. 1992. Perspectivas da etno-ornitologia no Brasil: o exemplo de um estudo sobre a tapiragem. *Boletim do Museu Paraense Emílio Göeldi, série Zoologia* 8(1): 113-121.
2 N.T. Quilombos or quilombolas are rural communities of Afro-Brazilian groups that began to be formed in the 17th century with individuals who escaped slavery. Many of their descendants still live in the villages and keep part or most of the traditions and culture inherited from their ancestors.
3 Mendes, B.V. 1997. *Biodiversidade e Desenvolvimento Sustentável do Semi-árido.* SEMACE, Fortaleza.

in traditional medicine was studied by Costa Neto[4] based on the ethnobiology research of Pankararé Indians in the village of Brejo do Burgo[5], The 49 animals used for medicinal purposes are distributed in five taxonomic categories: insects (37%), mammals (29%), birds (20%), reptiles (12%) and amphibians (2%). Sixty-eight raw materials were registered and these are used in the elaboration of folk medicines prescribed for the treatment of different diseases locally diagnosed. Many diseases and illnesses reported by the informants are part of the cultural context and were taken accordingly to the inside perspective of the group, being recorded in the same way they were narrated (emic approach). Their interpretation and possible parallelisms with pathologies known by western scientific medicine need deeper studies. The most mentioned diseases were 'mal do tempo' (a cardio-vascular disease), rheumatism and respiratory diseases such as asthma and bronchitis. Maybe these are the most common diseases in the population. Folk medicines are prescribed by the 'caecó' or healer of the village who has learned about the healing properties of plants and animals from the 'Encantados' (supernatural beings taken as the guardian of the natural resources). The learning takes place during the meetings at the 'Poró' (the House of Science), or even at their homes in occasions when the 'Encantados' are summoned and manifest themselves giving advice, attending patients, teaching about medicine and praying for the ones in the house. The most difficult cases are sent to the 'white shirt' (western physician) in the near towns.

Another study on popular zootherapy[6] has registered the medicinal use of 34 animals in the town of Tanquinho. Folk medicine based on animals came from insects (8), spiders (2), amphibians (1), reptiles (4), birds (8) and mammals (11). These resources provide 46 kinds of raw material and are prescribed to treat diseases of the poor population. Knowledge on the medicinal use of cockroaches seems to be very persistent since 90% of the interviewees have mentioned the use of these insects for the treatment of asthma. About 78% of the interviewees have mentioned the use of animals as different as dogs, porcupines, anteaters, emus, tortoises, scorpions, frogs, bees, rattlesnakes, chicken and 'tanajuras' (reproductive adults of *Atta* ants).

A third study carried out in the city of Feira de Santana[4] has produced an interesting discovery: a crustacean popularly known as 'barata-do-mar' (sea cockroach, *Cloridopsis dubia*) is locally prescribed for the treatment of asthma, being this the first time this Stomatopoda has been registered as medicinal resource in Brazil. This crustacean is collected in the seashore and sold as zootherapeutical product in the open markets.

4 Costa-Neto, E.M. 1999. *Barata é um Santo Remédio: Introdução à Zooterapia Popular no Estado da Bahia*. Universidade Estadual de Feira de Santana, Feira de Santana.
5 Bandeira, F.P.S. 1993. *Etnobiologia Pankararé*. Monografia de Bacharelado em Ciências Biológicas. Universidade Federal da Bahia, Salvador.

The recording of medicinal use of animals in the State of Bahia provides us with relevant contribution on the phenomenon of zootherapy. It suggests the implementation of biochemical as well as pharmacological studies in order to promote new drugs for the industry. Besides, it also triggers the discussion on the sustainable use of animal species, particularly those endangered.

Systems of Ethnozoological Classification

Considering the ethnotaxonomic studies carried out in the Semi-arid of Bahia, these have focused mainly on insects. For the Pankararé Indians, wasps and bees are an important source of food[7]. A total of 23 ethnospecies were registered. 'Abeia' is the word used for both bees and wasps which produce and store honey. They are classified in two subgroups, 'abeias-brabas' (wild or ferocious bees) and 'abeias-mansas' (mild bees), and divided in three ethnofamilies depending on the existence of the sting. Eleven ethnospecies are sources of folk medicine and honey is the main raw material used in the treatment of diseases and as food. Honey is also a very important source of income for the Pankararé; we observed that insects play significant roles in the social, economic and cultural life of this indigenous group.

The perception and the construction of the ethnozoological concept for 'insect' were also investigated in different social contexts. It has found out that the word 'insect' is used as a wide enthnotaxonomic category that comprises different organisms taxonomically not related, such as mice, snakes, lizards, etc., besides the real insects. Based on the information registered and on literature of the area, it can be assumed that the 'insect' domain occurs as a pattern in the systems of ethnobiological classification. This pattern was explained by the hypothesis of entomoprojective ambivalence according to which human beings tend to project feelings of noxiousness, danger, gall, loathing and despise to non-insect animals (including people), classifying them in the category 'insect' which is culturally determined[8].

Entomophagy: Use of Insects as Food

People who live in the Semi-arid of Bahia know where, how and when to find species of edible insects and know different ways to prepare and conserve them in order to have these resources during dry seasons[9]. The use of insects as food happens directly and indirectly. Direct use happens through the ingestion of larvae of beetles, bees and wasps or the ingestion of ants, while indirect use happens with

6 Costa-Neto, E.M. & M.V. Oliveira. 2000. Cockroach is good for asthma: zootherapeutic practices in the county of Tanquinho, northeastern of Bahia State, Brazil. *Human Ecology Review* 7(2): 41-51.
7 Costa-Neto, E.M. 1998. Folk taxonomy and cultural significance of "abeia" (Insecta, Hymenoptera) to the Pankararé, northeastern Bahia State, Brazil. *Journal of Ethnobiology* 18(1): 1-13.
8 Costa-Neto, E.M. 2002. *Manual de etnoentomología*. Manuales & Tesis SEA, 4: 1-104.

the ingestion of honey from bees and wasps. Entomophagy however is neither a daily practice, nor a common habit to all individuals.

In the Semi-arid, the species of bees are source of food, medicine and income. Occasionally, honey produced by *Brachygastra lecheguana* wasp is collected by burning cattle dung under its nest. With the smoke insects either get away or hide inside the nest making the harvesting of honey possible. As for the use of beetles, we could register the ingestion of a kind of larvae known as 'lagarta-do-coco' (coconut caterpillar, *Pachymerus nucleorum*) which lives inside the seed of the 'licuri' palm tree (*Syagrus coronata*). Likewise, the females of tanajura ant (*Atta* spp.) in the mating season are usually collected and processed as food, although its use happens seasonally since these ants only show up after tropical storms known as 'trovoadas'. People who make use of them either grill or fry their abdomens in their own fat. After that, they use this to prepare a farofa[10] with or without salt.

Use of Traditional Zoological Knowledge

The Caatinga Biome has suffered with anthropic pressure, and projects of sustainable development need to be planned for the semi-arid region. However, they should be based on the cultural, political and economic perspective of each group involved. Traditional zoological knowledge possessed by the communities from the Semi-arid should be technically used in order to complement other fields such as research and assessment of environmental impact, management of resources and sustainable development. In this sense, bromatological analyses on animal species traditionally used by the populations who live in the Semi-arid of Bahia can assess percentages of minerals and vitamins. Those species with higher nutritional value could then be managed and included in the market in a culturally acceptable way.

9 Costa-Neto, E.M. 2004. Insetos como recursos alimentares nativos no semi-árido do estado da Bahia, nordeste do Brasil. *Zonas Áridas* 8: 33-40.

10 NT. 'Farofa' is a typical dish made of manioc flour and fat.

CHAPTER 21 – Molecular Systematics

Alessandra Selbach Schnadelbach & Cássio van den Berg

Systematics is the branch of science that studies this biological diversity and organizes this information into a classification. The first classification appeared in Ancient Greece, notably with Aristotle. In 1758, Linnaeus created the hierarchical system of classification still employed in taxonomy. With the advent of Darwin's theory of evolution in the 19th century, biological diversity began being explained as the result of the divergence of species from a common ancestor. The phylogenetic systematics, established by Hennig between the decades of 1950 and 1960, incorporated this paradigm, changing the principles of biological classification. Taxonomy started to reflect ancestry, and the systems of classification to accept only monophyletic taxa (groups of organisms with a common and exclusive ancestor).

A thesis on the 'Systematics of *Raddia* and related genera' is being carried out at LAMOL. Examples of these grasses are *Raddia portoi* (top) and *R. stolonifera* (bottom); the latter is a new species endemic to the southern Bahia. [Photos by P.R. Oliveira]

Morphology was largely used to reconstruct the evolutionary history of organisms. Morphological characters have been useful to the recognition of large groups, as well as to the description of families, genera and species, constituting the basis of any classification. However, with the advent of molecular biology, countless techniques to access genetic material were developed, among them the immunological assays, the electrophoresis of enzymes and proteins, the hybridization of DNA and the DNA polymerase chain reaction (PCR). More recently, the sequencing of specific regions of DNA has opened new opportunity to access DNA information, allowing comparisons between individuals representing different taxonomic levels.

The term *molecular phylogeny* refers to ancestral relationships inferred from molecular data. Molecular characters are extremely useful for phylogenetic inferences, composing an almost unlimited set of intrinsic data. Since then, molecular characters along with morphological ones have subsidized the systematicians in refining the classification of the living beings.

The first broad angiosperm (flowering plants) phylogenetic study based on DNA sequences[1] became a landmark for plant systematics. Sequences of *rbcL*[2] representing hundreds of species were compared and the taxonomic delimitation of many angiosperm groups was modified. Since then, several studies have sought to amplify and deepen the understanding of phylogenetic relationships in angiosperms at different levels, significantly refining their taxonomy. The Laboratory of Molecular Systematics of Plants (LAMOL, see also Chapter 22) at UEFS is inserted in this context.

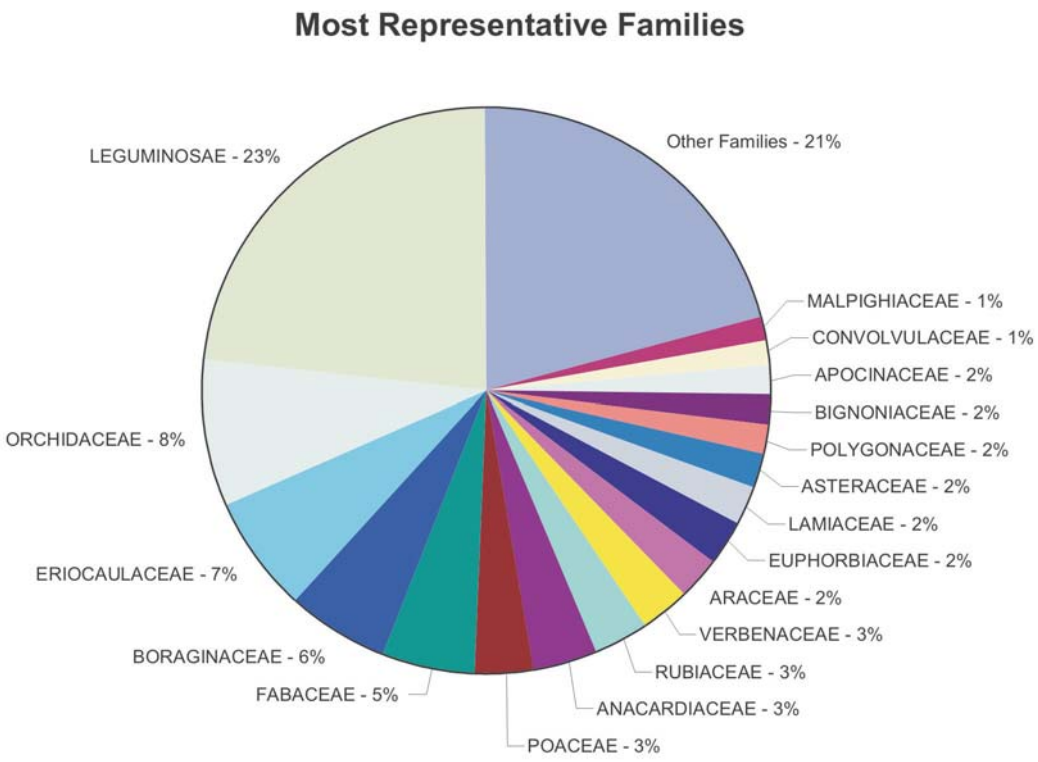
Molecular Phylogenetic Studies of Plants at LAMOL

Molecular phylogeny studies developed at LAMOL involve the following stages:

1st) collection of material for DNA extraction (leaves or flowers, preferably). Every sample contains a voucher material that is housed in the herbarium, guaranteeing the reliability of the identifications; 2nd) extraction of total DNA; 3rd) evaluation of quality and quantity of the DNA extracted; 4th) amplification of specific regions of the DNA[3] through PCR reaction; 5th) automated sequencing of the amplified regions through PCR and; 6th) comparative analyses of sequences to reconstruct phylogenies with methods of inference, such as maximum parsimony, maximum likelihood and Bayesian analyses.

Studies on plant molecular phylogeny are still rare in Brazil, especially with plant groups from the Semi-arid. The need for sophisticated equipment, the high cost and the difficulties to acquire reagents and equipments, beside the lack of specialists in several angiosperm families are the main obstacles in the implementation of molecular phylogeny studies. The molecular phylogeny projects developed at UEFS, in addition to refining the understanding of the phylogenetic relationships of plants that occur in Brazilian Semi-arid, also contribute to the formation of trained staff in many angiosperm families. Nowadays, there are several projects on molecular phylogeny of plants being carried out at LAMOL (listed in the CD), especially species-rich groups in the Semi-arid, such as orchids and legumes.

1 Chase, M.W. *et al*. 1993. Phylogenetics of seed plants: an analysis of nucleotide sequences from the plastid gene *rbcL*. *Annals of the Missouri Botanical Garden* 80: 528-580.
2 NT – *rbcL* is a plastid gene that encodes the larger subunit of the ribulose 1,5-bisphosphate carboxilase-oxigenase enzyme.
3 The ribosomal nuclear region ITS (Internal Transcribed Spacers) and the plastid regions, gene matK and trnL-trnF spacer are examples.



Percentage of total samples per family in LAMOL's DNA bank.

The DNA Bank

LAMOL includes also a DNA bank. Nowadays, this bank keeps around 3,000 samples representing more than 1,000 species, 500 genera and 130 families. The most representative families in the DNA bank are Leguminosae, Orchidaceae, Eriocaulaceae, Boraginaceae and Poaceae. These samples comprise even species not yet described, such as a new species of bamboo endemic to the Atlantic Rainforest of southern Bahia (Raddia sp.), taxa endemic to the semi-arid region, such as *Calliandra leptopoda* and *C. macrocalyx* var. *aucta*, and even endemic genera such as the recently published *Adamantinia*, an orchid endemic to the Chapada Diamantina, and a genus of Leguminosae endemic to the caatinga.

The DNA bank constitutes a rich source of material for plant systematics. It allows the improvement of the graduate programs (Chapters 23 and 26) as well as represents a treasure for the community as a whole, since it guarantees the preservation of the genetic patrimony of several rare plants, many of them endangered species.

CHAPTER 22 – DNA Barcoding

Cássio van den Berg & Alessandra Selbach-Schnadelbach

LAMOL is joining other ten institutions to find a standard barcode region for the land plants. LAMOL's target group is orchids. These are flowers of *Cattleya elongata*, a species endemic to the Chapada Diamantina, Bahia

The identification of biological specimens is essential to many areas of science and the lack of accuracy can pose obstacles to scientific progress. Traditional methods of taxonomic identification are slow and nowadays there is a lack of taxonomists able to meet the increasing demand of this activity. Universal barcoding will provide us with an alternative solution to overcome this limitation, allowing fast and precise identification based on DNA sequences. However, the production of a large set of barcodes is not an easy task. The correct use of names will require advanced knowledge on taxonomy and specific genetic markers, besides the development of large databanks and search algorithms. Thus, the implementation of a fast and precise method of identification by DNA demands improvement in several areas simultaneously. The use of barcoding requires both traditional taxonomic abilities and modern knowledge of molecular biology techniques which can help find unique markers for each species.

What are Barcodes of DNA?

They are short regions of DNA sequence (less than 800 base pairs) which present enough variability to discriminate between species and which can be obtained through a single protocol even from samples whose taxonomic group is still unknown. Thus, the sequence can be compared to a database, in order to identify the species it belongs to or indicating the existence of possible new species.

Characteristics for an ideal DNA barcode marker have already been discussed by several authors and there is general consensus that it should be:

- variable enough to allow the identification of species but with low level of intraspecific variation;
- universally amplifiable and sequenced with standard primers;
- technically easy to be sequenced (it cannot contain regions with long repetitions of a single base);

- short enough to allow sequencing with a single reaction using current technology;
- easily alignable (i.e. having few insertions and deletions – indels);
- ready to be used from herbarium materials and other degraded DNA samples (i.e. forensic material).

Research on DNA Barcoding Worldwide

The Consortium for the Barcode of Life (CBOL) was created in 2004 with the objective of promoting the identification of all species of plants and animals through the use of short sequences of standard DNA. CBOL has accomplished solid progress with animal species making use of the mitochondrial gene from Cytochrome Oxidase I (COI), which seems to be promising also in fungi and algae although it requires different primers for those groups. Unfortunately, COI cannot be used in land plants due to the extremely low rates of nucleotide divergence in plant mitochondrial DNA. Therefore, the discovery of a DNA region suitable for barcoding in plants is extremely important.

Possible Regions for Barcoding in Land Plants

In land plants the plastome is a logical choice for COI mitochondrial gene. Plastid genomes present conserved order, large number of copies and variable regions of spacers and introns that have potential for the development of primers flanking polymorphic regions. Thus these genes can be easily amplified and sequenced in taxonomic groups which are little related evolutionarily and should work on degraded DNA. However, plastid sequences in land plants are characterized by low rates of divergence when compared to mitochondrial DNA in animals and other organisms.

At a recent meeting of CBOL-PWG (Plant Working Group) in London, discussions pointed out the *psbA-trnH* spacer, a non-coding plastid region between two very conserved genes, and the ITS (intergenic transcribed spacers of ribosomal DNA) as good options for barcoding angiosperms. This conclusion was based on recently published preliminary study with 20 regions of plastome. However these regions also present disadvantages, such as great variability of size in *psbA-trnH* (less than 100 up to more than 1,000 base pairs in angiosperms), what causes difficulties in aligning the sequences and problems with the algorithms of identification, which do not occur in COI and other coding loci. ITS region is not very practical for it present peculiarities in molecular evolution of several angiosperm groups as well as polymorphism (i.e. divergent copies in the same individual). These problems are also presented by other land plants since *psbA-trnH* has less than 220 base pairs in liverworts and multiple copies that prevent its use in ferns.

Construction of a Database[1]

Some requirements were established by CBOL for the construction and use of a database for barcoding identification:

(a) It must have at least five reference samples for each species;

(b) Samples must preferably come from different localities;

(c) Every sample must have voucher with digitized images available;

(d) Searches must be made by specific software (BOLD).

On going Projects at LAMOL

Due to the interest in developing DNA barcodes in order to support the study of biodiversity, many actions are being developed along with phylogenetic studies as attempts to integrate this technique to ongoing projects at UEFS:

(a) IMSEAR (Chapter 1): all samples collected during IMSEAR were dehydrated in silica. Total DNA from these samples was extracted and stored at a large DNA bank located at LAMOL – UEFS (Chapter 21). This bank has great potential for the construction of a representative barcoding database of species from the Semi-arid. Such implementation is planned for the new phase of the project which includes access to genetic material of these samples;

(b) PPBio of Semi-arid (Chapter 2): Whenever possible, plant material collected in PPBio's inventories have DNA sampling in the same way it was made for material collected by IMSEAR, enriching the bank available at LAMOL.

(c) 'Establishment of a universal barcode for land plants'. This project aims at establishing a pattern region for the use as barcode in plants since the regions proposed so far are not ideal. One-hundred different regions have been already tested (at the University of Reading, UK) in approximately 100 pairs of species in several taxonomic plant groups. The most promising regions will be tested in larger taxonomic groups

1 N.A. Pilot projects, including Birds of North America, some groups of insects and fishes, are already available online at http://www.barcodeoflife.org/.

to evaluate its efficiency. This project is funded by the Gordon and Betty Moore Foundation and Alfred P. Sloan Foundation under auspices of CBOL and includes a network of about ten institutions worldwide (Brazil, UK, USA, South Africa, Denmark, Mexico and Colombia) in a collective effort to suggest CBOL a new pattern for barcoding. UEFS research team represents Brazil in this project. Our target groups will be genera of Brazilian orchids whose material can be easily obtained from both public and private collections.

CHAPTER 23 – PPGBot: Graduate Program in Botany[1], UEFS

Francisco de Assis Ribeiro dos Santos

The Graduate Program in Botany (PPGBot) was created in 2000 by the Department of Biological Sciences at UEFS, in collaboration with RBG-Kew. PPGBot's main objective is the formation and training of human resources to research and teach in Botany. It brings forth systematic knowledge on the flora and natural resources with emphasis on the Northeast region thus contributing to the preservation of regional ecosystems.

PPGBot's master degree course is recommended by CAPES at grade 4. In 2001, the doctorate program was implemented, also being assessed at grade 4 at the last evaluation by CAPES.

Building of the Biology's labs (top left), Conference Room (top right) and details of LAMOL's equipments: thermocycler, or PCR machine (bottom left), electrophoresis equipment (bottom centre) and automated sequencer machine (bottom right).

Faculty

The faculty is formed by permanent professors (listed in the CD) from the Department of Biological Sciences – UEFS, besides other researchers form the RBG-Kew and other teaching Brazilian institutes as UESC, UFBA, UFMG, UFRGS and UNESP-Rio Claro.

Professors at PPGBot act in the most varied fields of Botany. Most of them focus their research on the biodiversity of the Semi-arid through taxonomic studies, floristic surveys and of biological interactions in different ecosystems of the region. All professors have experience in academic advisement not only at graduate level, but also in undergraduate studies. This link between undergraduate and graduate activities helps improve scientific production of future graduate students once these will already have had experience in the area by the time they are required to work on their M.Sc. and Ph.D. thesis.

1 Complementary information and more details on PPGBot are available at www.uefs.br/dcbio/ppgb.

Research Lines

PPGBot has as one of its main characteristics the integration of its Research lines, projects and courses offered in two areas of concentration: 'Systematics and floristics with emphasis on the Northeast region' and 'Ecology, physiology and use of plant resources of the Northeast region'. The strengthening of these two areas of concentration is priority to PPGBot. The program aims at increasing the knowledge, sustainable use and conservation of plant resources of the Northeast by hiring more advisors and particularly by improving and diversifying the following lines of research:

- *Systematics and floristics with emphasis on the Northeast region:*

Flora and floristics of ecosystems in the Northeast – floristic surveys and biogeographical analysis of groups that occur in ecosystems of the NE Brazil, particularly in caatingas (Introduction and Chapter 6), forests and campos rupestres (Chapter 9).

Morphology applied to the systematics – anatomic and macromorphological studies are developed aimed mainly at the use of their results in systematics of selected groups.

Palinology of plants in the Semi-arid – characterization of pollen of plants from the Semi-arid, particularly those with melliferous potential, as well as the palinological and biochemical characterization of melliferous plants.

Molecular systematics of plants and fungi – this line deals with DNA sequences in order to infer phylogenetic relationships, providing a better understand of character evolution and establishing basis for the classification of organisms.

Taxonomy and phylogeny of angiosperms – taxonomic, phylogenetic and biogeographical studies of angiosperms from Brazil, focusing particularly groups of the NE Brazil, especially of Bahia.

- *Ecology, physiology and use of vegetation resources of the Northeast region:*

Ecophysiology of plants from the Northeast – this line focuses on the study of physiologic adaptations of plants from Semi-arid; physiologic aspects of the adaptation of plantlets produced in laboratory to external conditions and, aspects of the physiology of germination.

Ethnobotany, use and conservation of plant resources of the Northeast – this line studies the identification, sustainable use and conservation of plant resources of the Northeast region, particularly of Bahia. Ethnobotanic studies are also carried out in traditional communities in the Northeast.

Phenology, pollination and phytosociology of plant communities in the Northeast – this line works with morphological and ecological aspects of pollination and phenology of species from Northeast as well as with the phytosociology of areas in the Northeast focusing particularly on the Semi-arid.

Physiology, genetics and biotechnology of species of economic or ecological interest – This line tries to identify genetic potentials of different populations of species economically or ecologically interesting through genetic and molecular markers. Its aim is the diffusion or conservation of these species.

Characterization of Biodiversity

Most of the studies carried out by graduate students of PPGBot characterize the plant biodiversity of ecosystems in the Semi-arid. Their majority is already available to the scientific community since most of the 44 thesis concluded (see CD) have already been published. Many of theses deal with peculiar aspects of biodiversity in the Semi-arid, mainly in the Chapada Diamantina (Central Bahia). Besides promoting the formation of human resources, these studies have brought great contribution to the knowledge of biodiversity of the area under study.

CHAPTER 24 – PPGBV: Graduate Program in Plant Biology[1], UFPE

Marccus Alves

The Graduate Program in Plant Biology – PPGBV is offered by the Department of Botany at UFPE. It was created in September 1991 with the Master Degree Course in Plant Biology and in August 1998 expanded into a Graduate Program with the inclusion of the Doctorate Course. It qualifies professionals in two areas of Concentration: **Floristics and Systematics** and **Plant Ecology**, being the only graduate program in Northeastern Brazil with such a profile.

Currently, the program is coordinated by Prof. Dr. Marccus Alves, and in his absence by the dean of the Department of Botany, Prof. Dr. Laíse de Holanda Cavalcanti Andrade.

The main focus of the research carried out by the team of PPGBV is the study of plant diversity in the extreme east of the NE Brazil. Research projects deal with registering, cataloguing and describing diversity, as well as analyzing biological relationships according to the local biodiversity. Several research projects are also related with economic botany including important crops for the NE region.

Professionals qualified by PPGBV are highly competent, being certified to work as professors, researchers and/or specialized technicians in any public or private, high-level institute. A good number of PPGBV graduates have been working for IES and other research institutions or institutions dealing with environmental issues.

In its 15 years of work, PPGBV has graduated 114 masters and 19 doctors. It is classified by CAPES in the area of Biological Sciences I, being graded 4 by their assessment system. There are 61 current students, 31 master degree students and 30 doctorate students.

Faculty and Research Projects at PPGBV – UFPE

The faculty comprises 23 professors, 18 belonging to the institution's permanent board. UFPE is the origin of most professors at PPGBV, but the program also counts on the contribution of professor from

1 PPGBV's office works from Monday to Friday, between 8:00 am-5:00 pm having two officers to help the faculty, students and the public in general. Headquarters are located at av. Moraes Rego s/n. Cidade Universitária. CEP 50670-901 – Recife, Pernambuco – Brazil. Phone/fax: +55 (81) 2126-8348. (secretaria_ppgbv@hotmail.com). For further information on PPGBV, check: www.ufpe.br/ppgbv.

other IES in NE Brazil such as UFRPE and UFPB. PPGBV's faculty is distinguished by the diversity of research lines in botany offered by the program and in its excellence. Counting on professors graduated at the best universities in the country and abroad, the program is characterized by high scientific productivity of both their associate and chair professors. Around 70% of them have been granted productivity grants by CNPq, most graded by the Council and two graded 1A. PPGBV balances recently graduated professors with more experienced ones in its faculty. This stimulates motivation for new researchers to introduce new methodologies and updates to the research lines of the program. PPGBV takes part in scientific exchanges with several research institutions in Brazil and in other countries, such as Germany, Argentina, Australia, Austria, Canada, Spain, France, USA, UK, and Mexico.

Having their projects funded by several sources (federal and state governments; national and foreign NGOs, etc.), the faculty is skilled in acquiring resources for their research. Recently, PPGBV has been granted funds by two national institutional programs: PROCAD by CAPES (in association with the UFMG) and the 'Taxonomia' by CNPq/CAPES/MCT. Both projects aim at supporting and strengthening solid research lines and those with potential for growth at national and/or international levels. Another example of support for research work led by the faculty of PPGBV is the wide range of projects funded by 'Fundação O Boticário' for Nature Conservation. Among these projects, it is worth mentioning works on registering and cataloguing plant diversity in natural environments in some areas of the NE Brazil.

Despite its long tradition in studies focusing on the northeastern semi-arid region, PPGBV's scientific production has continuously increased its range of action, approaching other ecosystems as important as the *Caatinga* for the region. In recent years, interdisciplinary projects in the Atlantic Rainforest and *Caatinga* have provided a better understanding of the local flora. Another example of the remarkable effort of students and professors at PPGBV is the successful 'Projeto Serra Grande', which gathers several national and international partner institutions in order to study the biodiversity of several fragments of Atlantic Rainforest at different levels. Besides these, several projects approved by PROBIO have allowed significant increase of the knowledge of the biodiversity of the region.

Scientific production by PPGBV's team counts on the participation of members at all levels (professors, graduate and undergraduate students) when publishing results of their work in national and foreign journals. Most of these are refereed journals with great relevance in the scientific community for the several fields examined by PPGBV's research lines. Additionally, many of its members have been working in projects of cataloguing, registering and describing the diversity of plants such as: Flora of São Paulo, Flora of DF, Flora Neotropica, Bryophytes of Brazil, List of Endangered Species, Plants of the Semi-Arid Region, Flora of Paraíba (Chapter 8), among others.

In addition to this scientific production, it is also worth mentioning the publication of books and scientific collections whose organization, editing and/or authorship can be credited to the faculty of PPGBV. These publications are related to interdisciplinary research projects carried out in partnership with other Brazilian and foreign IES, research institutes, and NGOs. Among others, we can mention publications on a fragment of urban Atlantic Rainforest in Recife, on the northeastern *Caatinga* and on upland swamps in Pernambuco and Paraíba.

PPGBV has two areas of concentration – **Floristics and Systematics** and **Plant Ecology**, which are divided into four research lines each (see CD for details). These lines focus on the knowledge of plant diversity and on biological aspects of ecosystems in the extreme east of the northeastern region.

Graduate Students at PPGBV – UFPE

Typically, students enrolling at PPGBV come from good IES all over the country, but particularly from N-NE regions. Many of them have already had experience in research in their undergrad courses, a good number of them former grantees of scientific initiation scholarships at their former institutions. Besides receiving outstanding Brazilian students, PPGBV has also been chosen by foreign students from Argentina, Canada, Colombia and France. Some students and former students are technicians or professors at IES and research institutions such as EMBRAPA.

Most students are CAPES and CNPq scholarship grantees, but some others are granted scholarships by state foundations for support of research and NGOs. Temporary scholarships (sandwich type) for short period studies abroad are often received by students of the program.

Facilities and Subjects Offered at PPGBV – UFPE

PPGBV's facilities include nine research laboratories within the Department of Botany and three other laboratories at UFPE (Departments of Biochemistry, Genetics and Oceanography). Two other laboratories at UFRPE and UFPB whose chair professors are members of PPGBV faculty also host graduate students of the program. The research labs are equipped with several resources, including high tech equipment, high resolution microscopy, photographic equipment and computers, besides instruments required for field work. Additionally, PPGBV's team also has access to facilities offered by the Laboratory of Electronic Microscopy (LIKA) at UFPE.

Furthermore, PPGBV's facilities include two exclusive lecture rooms for theoretical classes equipped with multimedia equipment (computer; data-show, overhead and slide projectors) and an exclusive lecture

room for practical classes with basic scientific glassware and microscopy (optical microscopes and stereo microscopes). It also offers two study rooms for students and visiting professors who are invited to teach elective courses or to take part in assessment boards. Both rooms have computer equipment and full access to the Internet.

Infrastructure for virtual access and services of literature exchange are provided by the Libraries at UFPE. However, PPGBV also has a reference library on plant biology and related themes comprising 300 books, 200 theses, the collection of Flora Neotropica and several national and foreign journals. This collection is housed at the office of the program.

Professors and students receive continuous support from the Geraldo Mariz Herbarium (UFP) at UFPE for their research, besides other herbaria at partner institutions – UFRPE (PEUFR) and UFPB (JPB). The UFP herbarium holds 40 thousand catalogued specimens and has optical equipment. It also offers basic mandatory literature on taxonomy for reference such as *Flora Brasiliensis* by Martius, Flora Ilustrada Catarinense, Flora da Guayana Venezuelana, Flora Mesoamericana, among others. The UFP herbarium and others from NE Brazil (Chapter 3) has recently been granted support via the project 'Apoio à Coleções Científicas' by CNPq which aims to improve biological collections which reference the national biodiversity.

Didactic and scientific expeditions are frequent and fundamental for several projects in which students and faculty of PPGBV take part. Receiving funds from many sources, these projects have access to three vehicles: a Land Rover, a Kombi and a Toyota (for 9, 10 and 5 passengers, respectively), which are continuously used for scientific expeditions to areas of Atlantic Rainforest, *Caatinga*, mangroves, marshes, and inselbergs in the NE.

Subjects offered by PPGBV try to offer students updated themes related to the research lines on which the program's professors work. The reduced number of mandatory subjects and the wide range of elective subjects provide more dynamism and diversity in the professional qualification of its graduate students. Usually subjects are taught by PPGBV's faculty (preferably the mandatory ones in the first semester and the elective ones in the second semester), but also by visiting professors. Recently, a new subject was created 'Seminários Integrados do PPGBV' at which preliminary results of ongoing projects are presented by the grad students. This activity has been praised by institutions assessing the courses since it works as a linking element for different research lines and laboratories involved at PPGBV. It is also widely supported by the faculty, graduate and undergraduate students.

Another distinction of PPGBV is the formation of its assessment boards. Great effort has been made in order to bring qualified guest professors from several institutions in the country in order to take part of the assessment of theses and dissertations. PPGBV's team believes that this is a crucial moment of the qualification process of the professional graduating from the program and thus whenever possible it promotes the interchange among professionals.

Selection for enrollment at PPGBV is annual, happening twice a year whenever scholarships are available. The average number of vacancies is 12 for the master degree and eight for the doctorate. Candidates for the selection enroll between September and October, tests for selection happen in the months of November (doctorate) and December (masters degree).

CHAPTER 25 – Graduate Program in Biology of Fungi

Leonor Costa Maia & Norma Buarque de Gusmão

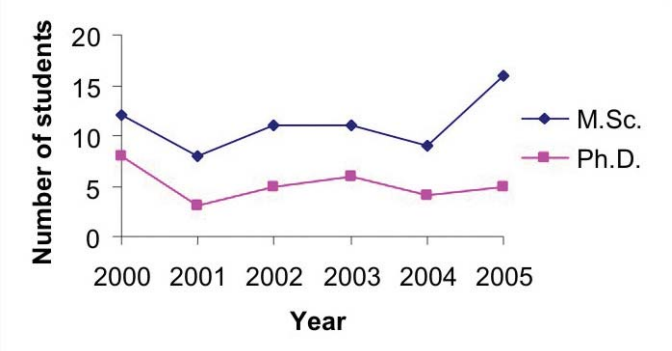
The Graduate Program in Biology of Fungi is offered by the Department of Mycology at the Centre of Biological Sciences of UFPE and has as its main objective the formation of human resources in the several areas of Mycology. It has been authorized by MEC and was graded level 5 by CAPES.

The course was founded by the Departments of Mycology and Botany in 1980, and then named Master Degree in Cryptogams with three concentration areas: Mycology, Phycology and Bryology/Pteridology. In 1997, the course structure was modified following advice by CAPES. The area of Mycology was kept and the course was then named Master Degree in Biology of Fungi. The other areas were transferred to the Graduate Program in Plant Biology at the same university.

Research Lines

When the course was restructured, two areas of concentration were created. The first one, Basic Mycology, has the following research lines: (i) Taxonomy and Ecology of Fungi; (ii) Biochemistry and Physiology of Fungi; (iii) Genetics and Cytology of Fungi. The second one, Applied Mycology, has the following research lines: (i) Fungi of Farming Interest; (ii) Fungi of Industrial Interest and, (iii) Fungi of Medical Interest. With the increasing demand for professionals in the area, the Doctorate degree in Mycology was created in 2000 (see CD for the list of researchers).

Master degree students are required to take 14 mandatory and 10 elective courses (24 credits) in the period of 12-24 months whereas doctorate students are required to take seven mandatory and 17 elective



Numbers of enrollment between 2000 and 2005.

courses (24 credits) within 24-48 months. They must also carry out research work and have a thesis or dissertation approved in the area of concentration chosen.

Infrastructure

The program provides proper facilities for the development of thesis and dissertations. Besides several specialized laboratories (Medical Mycology, Phytopathology, Biological Control, Mycorrhizas, Molecular Genetics, Taxonomy and others), the Department also has a herbarium (URM) with over 74 thousand specimens and a Collection (Micoteca URM) with over 7,000 cultures of fungi. Students also have access to specific literature in the area at the specialized library of the Center of Biological Sciences which holds a large collection of publications in Mycology.

Graduates

The Program has formed professionals who work in several regions of country, particularly in the North and Northeast. There are masters and doctors graduated in our courses working in institutions of the following States: Bahia (UEFS), Ceará (URCA, UVA), Rio Grande do Norte (UFRN) Paraíba (UFPB) Piauí (CEFET, UFPI), Alagoas (UFAL), Pernambuco (MAPA, SEDUC, FAFIRE, FUNESO, FABEJA, IBAMA, UPE, UFRPE, UFPE, UNICAP), Pará (UFPA, Emílio Goeldi Museum), Rondônia (UFRR), Amazonas (UFAM, Cathedral University), Goiás (UFG, UEG) and Rio Grande do Sul (UNISC).

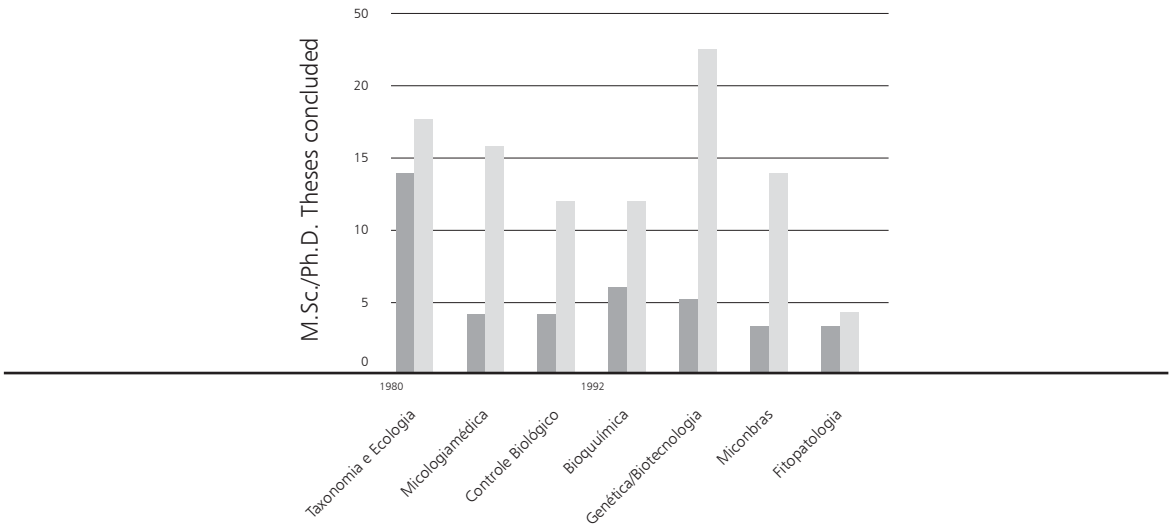
So far, 130 masters and 10 doctors in Mycology have graduated by Program. Considering the increase on the number of professors and the demand for vacancies, enrollment has increased, which will allow the formation of a larger number of mycologists in the next years.

Most of the theses/dissertations defended deal with Genetics/Biotechnology, Taxonomy and Medical Mycology among all lines of the program. This tendency is still noticeable since most students enrolled today focus their attention in the same research lines.

Many finished and ongoing researches are related to the Brazilian Semi-arid (see a list of selected thesis in the CD), increasing knowledge of fungi in the area which will allow better use of these organisms as well as provide support for politics of environmental conservation.

Among the goals of the Program, it is worth mentioning the intensification of national and international interchange; reinforcement on the formation of taxonomists; increase and incentive of activities related to the scientific collections, including the digitization of collections, and increasing interaction of under-

graduate and graduate students. We hope we can continue contributing significantly to the formation of human resources specialized in mycology, an area which has great potential due to the importance fungi have in several human activities and in the preservation of the aquatic and terrestrial ecosystems (see Chapters 4 and 14).



M.Sc./Ph.D. theses concluded per research lines

CHAPTER 26 – PPGBiotec: Graduate Program in Biotechnology

Aristóteles Góes-Neto

The Graduate Program in Biotechnology with emphasis in natural resources of the Brazilian Northeast region was conceived from the experience achieved through the integrated work of researchers participating in the activities of biodiversity and bioprospection of IMSEAR (Chapter 1). The accomplishment of this project has made possible the development of integrated work that comprised (i) survey of plant and fungal biodiversity; (ii) sampling, identification, and conservation of material for chemical and pharmacological studies; (iii) the test of extracts and pure compounds for pharmacological activities in order to produce new drugs against some important diseases in the Northeast Semi-arid such as visceral and cutaneous leishmaniasis, schistosomiasis, chagas disease and malaria. These studies also involved genetic characterization and the establishment of active germplasm banks of plants with pharmacological properties.

A network of institutions in the Brazilian Northeast is responsible for putting through these studies in a collaborative effort mainly led by research groups of three institutions in the State of Bahia: (1) UEFS, which has important research groups working on plants and fungi diversity; molecular biology and genetics of plants, fungi and bacteria; studies in plant propagation; (2) FIOCRUZ, through their research groups in pharmacology, immunology and toxicology; and (3) groups of chemistry of natural products from UFBA. IMSEAR also provided the participating institutions with the necessary infrastructure, especially top-of-line equipments which are essential for the development of future activities of this graduating program.

These three institutions has settled partnership agreements with private biotechnology companies which have recently opened branch units in Bahia in order to run for and get official funds, through which the group will be granted the necessary conditions to perform tests of new drugs in a scale that will enable them to assess costs and benefits of production in industrial scale.

In the beginning of 2004, SECTI in the State of Bahia urged the group to propose a graduate program in biotechnology which could meet the needs of the State for well trained professionals whose scientific knowledge would help boost technological development in the State. Thus, answering to the State's need and counting on support from the Secretary, a proposal for a graduate program (M.Sc. and Ph.D. degrees) in Biotechnology was made to CAPES, considering that the institutions involved have qualified

professionals for teaching classes and supervising grad students as well as they have laboratories and equipment up to the task of supporting a graduate program in biotechnology applied to health, plant and microbiologic biotechnology.

Structure of the PPGBiotec

The PPGBiotec was approved by CAPES in May 2005, having been assigned to the area of Biological Sciences I and authorized to graduate students in two levels: master and doctorate degree, both classified with grade 4 ('good').

The academic-administrative office of the PPGBiotec are at UEFS, but it works in a multi-institutional model that involves UEFS, FIOCRUZ's unit in Bahia, CPqGM, besides partner institutions whose professionals participate teaching courses as well as supervising students at PPGBiotec: UFBA, UESC and UFMG.

PPGBiotec presents only a single concentrating area, namely Biotechnology with Emphasis in Natural Resources of the Northeastern Region, divided in three interrelated sub-areas: Biotechnology of Microorganisms, Biotechnology in Health and Plant Biotechnology. These have five lines of research: (i) biological activities of natural, recombinant and synthetic products, (ii) tissue bio-engineering, (iii) immunopathology and immuno-intervention, (iv) characterization and management of genetic resources with biotechnological potential, and (v) functional and structural analysis of genome and proteome of plants and microorganisms. Nowadays, it offers 35 courses, 20 of them in the three sub-areas and 15 inter-area courses.

Objectives

PPGBiotec aims at forming masters and doctors to work in (i) teaching undergraduate and graduate courses; (ii) scientific development in Biotechnology, besides (iii) the applicability of products and processes, including the use of technology in productive sectors. The main characteristics seek in the graduates of the PPGBiotec are:

1. qualification for working in teaching, researching and development of products;
2. multidisciplinary vision and ability to integrate teams with the objective of developing biotechnological processes and products with emphasis in natural resources of the Northeastern region;
3. capacity to promote integration with the industrial sector as a means to make the transference of technology, processes and bioproducts to the productive sectors easier.

At the master degree level, the program objectives to prepare students so that they will be able to apply the main techniques used in biotechnological processes in the line of research of their thesis.

The doctorate program aims at forming researchers with a broader view of biotechnology including its fundamental principals and its potential for scientific and technological development of the country, with special emphasis on the Northeastern region.

Faculty

The Faculty is formed by 26 doctors, 50% of them with post-doctorate, 35% of these previously qualified as doctorate advisors. Eleven professors (42%) are CNPq grantees, having received this benefit for their productivity. A total of eight professors (31%) have finished their doctorates over ten years ago, six of the doctors (23%) have got their degrees between five and ten years ago and 12 (46%) have finished their doctorate less than five years ago.

Most of the professors (18) belong to UEFS, three to FIOCRUZ, two to UFBA, two to UESC and one to UFMG. These Professors work on five different areas of knowledge: Molecular Biology, Genetics, Botany, Immunology, Microbiology and Chemistry of Natural Products

Between 2001 and 2005, these professors produced and published an average of ten articles per author in specialized journals classified as level A according to the Qualis evaluation criteria of the CAPES.

Infrastructure

Students can develop their master and doctorate research activities in 15 research units and laboratories associated with the PPGBiotec. Ten of these are at UEFS, eight at the Department of Biological Sciences: Laboratory of Microbiology (LAPEM), Laboratory of Mycology (LAMIC), Collection of Cultures of Microorganisms of Bahia (CCMB), Laboratory of Molecular Systematics of Plants (LAMOL), Unit of Applied Research in Botany, Laboratory of Plant Taxonomy (TAXON) and Herbarium (HUEFS), Laboratory of Toxicological Genetics (LAGENTOX); one at the Department of Exact Sciences: Laboratory of Chemistry of Natural and Bioactive Products (LAPRON); and one at the Department of Health: Laboratory of Pharmaceutical Chemistry and Enzymology (LQFE).

Two laboratories belong to CPqGM/FIOCRUZ: Laboratory of Tissue Engineering and Immuno-pharmacology (LETI), Laboratory of Electronic Microscopy (LME). Two labs belong to UFBA: Laboratory of Chemistry of

Natural Products (LQPN), Laboratory of Research on Natural Products (LPPN) and, one belongs to UESC, the Laboratory of Genomics and Genetic Expression (LGEG).

Present Situation of the PPGBiotec

Since May 2005, when the course was approved by CAPES, it was selected the first group of grads for the level of master in July 2005. The first class is formed by 12 students, 59% from the area of Biological Sciences, 33% from the area of Pharmaceutical Sciences and 8% from the area of Physical Education, all coming from teaching and research institutions in different States of Brazil. The second selection was carried out in February 2006 for the master and doctoral levels.

Interaction among Professors

Professors at PPGBiotec take part in different national research networks in the areas of Biological and Health Sciences with projects funded by MCT and MMA (CNPq, FINEP) and FAPESB. These projects are IMSEAR (Chapter 1) and PPBIO (Chapter 2), RENORBIO (Northeast Network of Biotechnology) and projects on the genome and proteome of *Crinipellis perniciosa*, the fungus that causes the witches' broom disease in cocoa trees.

CHAPTER 27 – Plant Coverage and Soil Usage in the Biome of Caatingas

Washington Franca-Rocha, Ardemírio de Barros Silva, Joselisa Maria Chaves, Marjorie Cseko Nolasco, Luciano José de O. Accioly, Iêdo Bezerra Sá & Frans G.C. Pareyn

Amongst the Brazilian biomes, the Caatinga is one of the least known from scientific standpoint and has been treated with low priority for purposes of biodiversity conservation. In spite of it, the Biome of Caatingas is highly endangered because of inadequate use of natural resources and the little area (less than 1%) under the protection of conservation units.

Recently, the Biome of Caatingas was divided into eight ecoregions (Introduction), helping strategies for biodiversity conservation. This ecoregion approach for conservation encourages taking into consideration links between species and natural communities. By the other hand, every ecoregion embraces different natural communities. They have heterogeneous compositions and lack an updated cartographic basis, constraining the recognition of smaller natural units which are more suitable for reserves.

The only data and cartographic information of caatinga are derived from the soil and agroecological surveys performed by EMBRAPA and the project RADAMBRASIL. They were carried out in the decades 1970 and 1980 and have very small scale (less than 1:1,000,000). Only for few areas of the Biome of Caatingas, there are newer surveys and in greater scale focusing on the remnants of natural vegetation, such as in those surveys carried out in the States of Bahia and Pernambuco.

The project for survey the plant coverage and soil usage in the Biome of Caatingas was approved by the program PROBIO of the MMA and started its activities in 2005. It is executed through a network of research institutions under the coordination of UEFS and APNE. It aims to fill the gap of geographical information through the creation of georeferenced database in mesoscale, allowing different themes according to the official cartography and the presentation of theme maps of vegetation and soil usage following IBGE nomenclature.

The main goal of this project is to acquire confident data about caatinga, creating maps of natural remnants of vegetation and land usage in 1:250,000 scale, including basic characterisation of the vegetation typologies mapped. To achieve this goal, many techniques of satellite image analysis and geoprocessing (treatment and analysis of digital maps) with the support of field work are being used.

The implemented activities were (i) the survey of previous initiatives for mapping caatinga; (ii) the processing of satellite digital images; (iii) the validation of the interpreted classification; and (iv) the integration of the data.

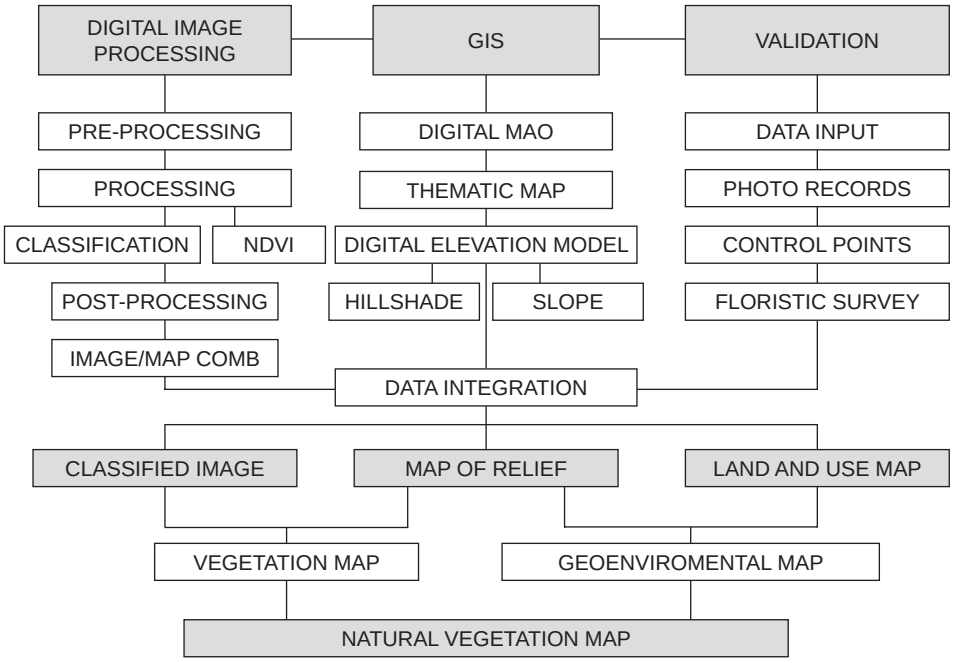
Technical Patterns of Mapping

To ensure the quality of the final products, the following technical patterns of mapping were used:

- Cartographic projection: geographic and UTM, with Datum SAD 69, with the vector files attached with the projection files;
- Minimal mapping unit (MMU) was < 40 ha, taking into consideration the final scale of 1:250,000;
- Digital data for verification fit 1:1,000,000 scale;
- The accuracy of classification ("theme accuracy") used the Kappa statistics with the lowest limits of 85% of agreement;
- The assumed Standard Cartographic Exactness was 0.5 mm of the scale, that is, 125 m in the ground;
- The vector files were build with topological consistency; that is, without overlapping or gaps between the polygons; absence of empty polygons or polygons with area equal to zero; absence of loops or arcs, etc.
- The vegetation was classified according to the IBGE technical manual of vegetation;
- The edition of the charts followed the layout of IBGE with minor alterations;
- The map-image was composed in digital format (.pdf) using colour balance R-3, G-4, B-5.

Partial Results

This project is carried out by a team of several institutes involving 47 persons (15 researchers, 12 technicians, 18 undergraduate students and two advisors) acting in the following disciplines: geoprocessing, phytogeography and evaluation of altered areas. This team is working in three geoprocessing labs under the coordination of the UEFS, Embrapa/Solos and Embrapa/Semi-árido (details in the CD).



Fluxgram of the project activities

Fifty-four scenes of Landsat sattelite was processed generating 55 charts. Final maps include the creation of map-images of vegetation remnants at 1:250.000 scale, besides semi-mosaics and one synthesis map. Products are available in digital media within SIG environment with a supporting database which contains basic and accessory information. Files prepared for plotting will be available, helping the diffusion of final products. Maps resulted from classification assisted by computer upon the satellite images LANDSAT 7 ETM+ made in 2002 and geoprocessing NASA's digital models[1] of land surface after being validated by field works performed by the specialists in floristics, phytogeography and phytosociology who check at selected points using probabilistic criteria to give confidence to the mapping at working scale.

To the present, the following results were obtained:

- Methodological results: (i) standardization of a method to be applied to map caatinga vegetation; (ii) production of a procedure manual; (iii) production of use guide for the software; (iv) a library of checkpoints; (v) training of people.

- Operative results: (i) digital elevation modelling for the caatinga area; (ii) mapping of about 70% of the total area; (iii) validation of one third of the charts.

1 NA – The models derived from shuttle's mission with topographic radar.

Final Remarks

The production of caatinga maps in mesoscale, with theme information about vegetation, is a remarkable initiative for the knowledge of this biome. It has valuable consequences to several areas of research on the Brazilian biodiversity and for surveys of natural resources. The use of satellite images and other digital products allowed short-term results and the comparison between patterns found in caatinga to those in other Brazilian regions, besides provide a synthetic vision of transitions between the ecoregions.

The availability of a database in GIS (Geographic Information Systems) format opens a perspective of a vast array of new analyses and correlation between the biodiversity data and the environmental conditions, not to mention the possibility of a continuous updating, including inclusion of new data.

Despite the short time of execution, this project presents consistent results pointing to core remnants of native vegetation that deserve protection, besides important areas for maintenance of ecosystems and that are currently under tension. It emphasizes the need to convert this initiative to a long term program with periodical updates and mapping in larger scales, as 1:100.000, approaching the conservation of caatinga at different levels.