Flora & Biotresures from Nine Ecosystems in Brazilian Northeastern Region. Flora & Bioschätze aus 9 Ökosystemen in Nordost-Brasilien (Valorization II)

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Introduction Besides the insects, flowering plants are the most diverse group of organisms of our planet, being extremely important for land life, since they provide primary organic matter and outline environmental landscapes. Plants also deliver the main resources for human populations, including the ones that inhabit the Brazilian semi-arid region, providing food, medical products, construction material, fuel and forage.

Because plants are sessile and therefore cannot move in response to biotic or abiotic insults, they respond to these cues by triggering appropriate responses, usually by secreting a mixture of chemical compounds (Prithiviraj et al., 2007). They also communicate with neighboring plants and other organisms by secreting compounds or a bouquet of volatile organic compounds (Reinhard et al., 2004). For example, floral scents attract insects that aid in pollination while plants attacked by herbivores emit a cocktail of volatiles that attract enemies of the herbivores (Pare and Tumlinson, 1999).

Brazil presents the richest flora of the world with more than 56,000 plant species (about 20% of the world flora). Besides, many plant species remain uncovered to the science. Actual estimative numbers indicate a total of about 55.000-60.000 angiosperm, 3,100 bryophyte, 1,200-1,300 pteridophyte, 525 marine algae and 5-10 gymnosperm species (MMA, 1998). The total number of species can also reach about 65,000 or more if collection and research efforts could be intensified. These numbers do not include fungi and lichen, these last estimated to include about 2,800 species in Brazil (Marcelli, 1998).

After a superficial sight one can suppose that the Northeastern (NE) Brazilian region presents low floristic diversity. This results from the strong impression made by the overlooking the '*Caatinga'* vegetation that is prevalent in the region. The Brazilian semi-arid zone corresponds to approximately 60% of the Northeast region and occupies an area of about 800,000 km², including, in whole or in part, the nine states of the region (Maranhão, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe and Bahia), in addition to northern Minas Gerais state (Figure 1). Some of the vegetation types found in the region occur within the established limits of the semi-arid zone.

The vegetation seen today is the result of a series of geological and evolutionary processes over the primordial forests that in the early times covered the whole Brazilian northern region, from Amazonas to the coast. There are concrete fossil evidences from botanical (Mori, 1989) and faunistic (Costa, 2003) similarities confirming that the Amazon and the Atlantic rainforests have been linked together as a unique large humid forest formation, probably covering the whole northern half of Brazil.

Climatic and geological forces acted over the vegetation inducing evolutionary processes and adaptation to the new environmental conditions. Many species disappeared but many were able to survive using different strategies and giving place to new species, creating many diversity hotspots in the remaining humid and arid environments. After a superficial examination of the '*Caatinga'* one may have a strong impression of dead vegetation. However, the Brazilian Northeast region holds high levels of endemism and more types of vegetation than any other Brazilian region. Moreover, researchers have observed that this biotope is highly diverse, with profuse endemic species (Harley, 1996; Giulietti et al., 2002).

The naturally dry scenarios are transformed during the short rain season with a boost of green and flowering, similar to the spring in the northern hemisphere. By the other hand, during the mid dry season that prevails throughout the year, vegetation is composed by trees and tiny shrubs with few or no leaves. Besides the '*Caatinga'* one can find in this region also the Atlantic rainforest, seasonal forests and inland mountain forests, '*Restingas'* and shore dunes, mangroves, '*Cerrados'* (savannah-like vegetation) and '*Campos Rupestres*' (specialized highland rocky savannas). A special vegetation type can be also

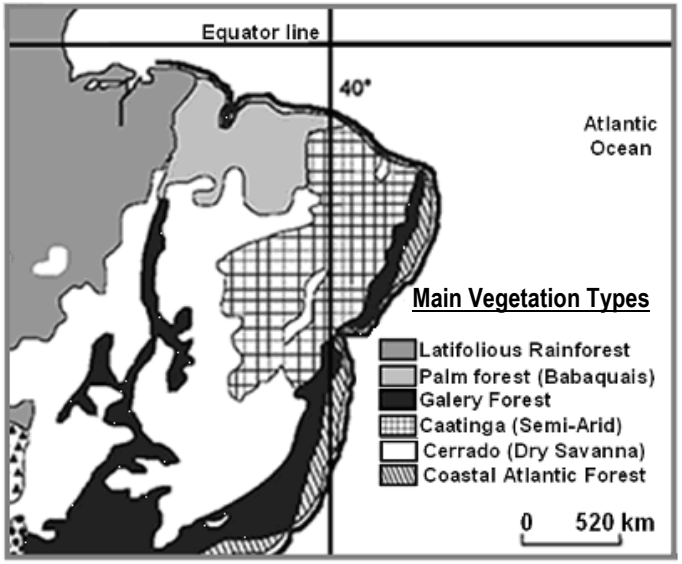

Figure 1. Brazilian Northeastern region and prevalent vegetation types. Adapted from IBGE (2000), with modifications.

observed in the so called "Inselbergs", isolated outcrops observed in lower plain, probably more than 20 million years old and characteristic made of gneiss and granite (França and Mello, 2006). These "vegetation islands" are considered to shelter relict vegetation of a time when the entire region was covered by dense forests.

Within this mosaic of vegetational types plants also present special strategies to face biotic (plagues and pathogen attack) and abiotic (drought, heat, temperature inversion) stresses. Therefore it is not surprising that plants from dry environments (or surrounded by them) present generally many secondary compounds, not present in their forest relatives, many of them useful for medicinal and industrial purposes. Hence, exiting diversity of environments regarding the Brazilian NE region bear adequate conditions for sheltering new plant forms, new physiological processes and, off course, also unique chemical compounds.

The region is the nearest of South America to Europe and was the first in Brazil to be colonized from European. But occupation and use by men is much more ancient, since archeological funds indicate that the Brazilian NE region has been occupied by humans in different intensity levels since over 10,000 years ago (Guidon et al., 1998), already using artifacts and evidences of traditional phytomedicinal practices (Gonçalves et al., 2003).

Until today local populations have a large dependence of natural resources, with emphasis on plants for various purposes, including food and phytomedicine. The parallel loss of biodiversity in diverse, fragile ecosystems by the unsustainable extraction of natural resources is obvious. The high number of endemic species in Brazil reveals the great diversity of the region, creating at the same time a worrisome scene for the preservation of natural habitats. These facts demonstrate the urgent need for enforcement of laws for the protection of national biomes and the need to expand the existing system of conservation areas (Castelletti et al., 2003).

Looking Inside the Treasure Chest of Biodiversity

Despite the invaluable existing resources, few investments have still been done in research and product development regarding the plants of the Brazilian NE region. A simple walk through the '*Caatinga'* vegetation reveals many plants that bear unique essential oils, with leaves, flowers or fruits scenting exquisite aromas, many of them already used by the local population.

Our group has been studying plants in the region during the last 12 years, accumulating field information regarding indications and form of uses, with concomitant genetic evaluation (cytogenetics and molecular markers) of the existing diversity. We also have carried out many experiments in order to propagate and cultivate these plants under glasshouse conditions, raising important information for their cultivation and reforestation projects.

Main angiosperm families studied by our group include following plant families: Dicotyledonous: Annonaceae, Compositae, Euphorbiaceae, Leguminosae, Marcgraviaceae and Solanaceae; Monocotyledonous: Araceae, Bromeliaceae, Eriocaulaceae, Iridaceae and Xyridaceae.

Additionally, the knowledge accumulated by local populations throughout the centuries can not be dismissed. Many books and articles relate different aspects of plant use and indications have also been considered. Community leaders and plant sailors (called "*erveiros*") are disappearing with advent of modern medical

allopathic practices. Having this in mind, we decided to create a data bank to compile and organize our data as well as data from available literature sources for traditional use of the native flora of the Brazilian NE region.
The Brazilian NE region comprises a special situation where natural products are still procured, especially by the population with lower income. We have also carried out specific evaluation in market places, in order to observe forms of commercialization, plant parts commercialized and in addition to evaluate the way they are produced or collected and brought to different markets (results not shown here). Figure 2 presents some aspects of such market places, showing the different forms the raw or processed materials are disposed for sale.

Figure 2. General view of raw material and products sold in the popular local market places in Pernambuco (cities of Recife and Caruaru). In **A**, at the left side plants sold in bottles as infusion, known as "*garrafadas*". **B** shows the way dried roots, rhizomes and bark pieces (sometimes also dried aerial plant parts) are exposed. **C**. An "*erveiro*" processing and packing plant material for commercialization. **D**. General view of a market herbal store.

Besides selling natural medicinal products, the "*erveiros*" act also as religious advisors in spiritual matters, selling plants and animal products for different kinds of ritualistic purposes. Often the "*garrafadas*" (infusion of one or many plant species in alcohol, see Fig. 2A) are supposed to help solving emotional or financial problems, or also to frighten bad spirits or bad luck. Despite of this conviviality among medicine and belief, our observations indicate that many of the medicinal indications given to plants are supported by real effects.

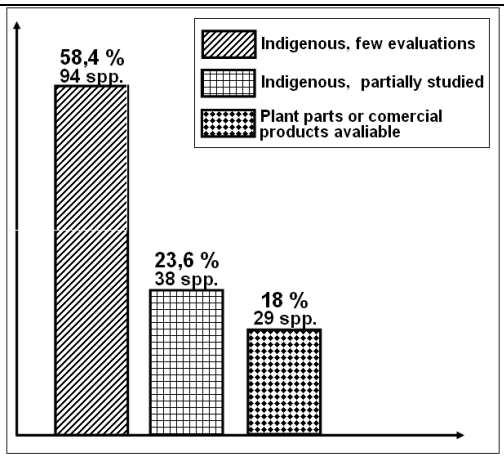

Figure 3. Graphic representation of species distribution according to their known commercial use

Information collected by our group, including application of questionnaires in different Pernambuco communities and in market plant sailors, as well as the inclusion of data from 55 literature resources, resulted in a data Bank regarding uses of 160 native plant species from different ecosystems of the Brazilian NE region. After an evaluation of the data bank (Figure 3), we observed that only 29 species (18%) have effects confirmed by

previous scientific evaluations and are already available for sale as handmade local products (e.g. soaps, pills, tea, "*garrafadas"*, etc.) and also as raw material.
The second group of plants (38 spp.) has been object to simple evaluations or essays while the third group include most of the potential useful species (94 spp.) that are only scarcely studied and lack evaluations confirming (or not) popular indications and potential uses by humans (Figure 3).

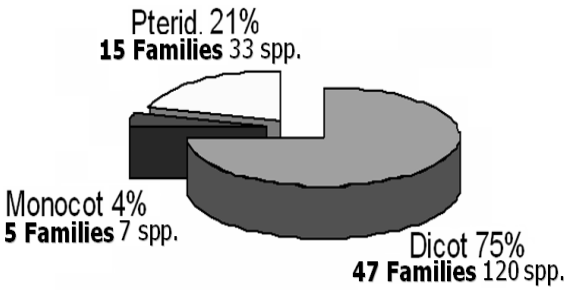

Figure 4. Graphic representation of high taxonomic affiliation of useful species in Brazilian northeastern region.

Observing the taxonomic distribution of the species that compose our data bank (Figure 4) we observed that most of them (127 species) are flowering plants (angiosperms), from which 120 species belonged to 47 dicot families (75% of the total) while seven species (4%) are members of five monocot families.
We observed that the number of fern species (33, from 15 families) represents a relative high proportion (21%) in comparison to the number of angiosperm species. This result may be surprising to one that is not aware of the local conditions and of the background of our data bank. This number may be justified by the fact that intensive evaluation was carried out in local remaining communities (including Amerindian tribes in Brazilian Northeast), searching exclusively for the uses of the fern flora (see Barros and Andrade, 1997). This result demonstrates that research efforts may reveal a much higher number of plant species and potential uses regarding the local flora.
Considering the largest dicot species group, it is interesting to note that some plant families appear as main delivers of useful species (Figure 5) and that these include large and diversified plant groups well known for their recognized medicinal value also considering species from other world regions. The most represented family was the Leguminosae (16 spp.: 7 Caesalpinioideae, 4 Faboidae, 4 Mimosoidae and 1 Papilionoidae), including mostly woody species, followed by Ateraceae (14 species), Euphorbiaceae (12 species) and Lamiaceae (11 species). Four other families (Anacardiaceae, Malvaceae, Myrtaceae and Rubiaceae) appear each one with four useful species. The remaining 51 dicot families are represented by three to one species each (included in the group "other" in Figure 5), also most of them including native woody plant species distributed in different ecosystems.
It is interesting to note that most species and sometimes genera used are endemic of the region. Therefore their chemical composition probably differs from the known substances described for their relatives from other regions. Genetic evaluation carried out in some plant groups by our group indicate isolation and diversity in many groups including dicots (Morawetz and Benko-Iseppon, 2003; Souza and Benko-Iseppon, 2004), monocots (Giulietti et al., 2000; Benko-Iseppon and Wanderley, 2002; Gitaí et al., 2005) and also ferns (Benko-Iseppon and Fonsêca Dias, 2000).
The importance of aggregating data from macromolecules diversity and physiology in the bioprospection of natural products is known (Briskin, 2000), but is still scarcely realized regarding the Brazilian flora.

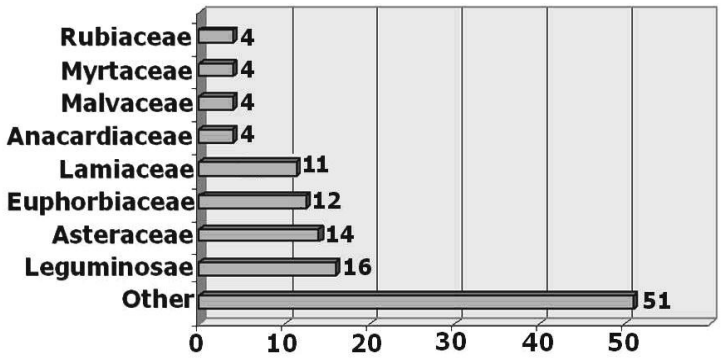

Figure 5. Main families represented in the data bank considering the distribution of 120 dicotyledonous species.

For the identification of most commonly commercialized plant parts, we evaluated a subgroup of 50 plant species available in market places as raw plant material. For this purpose eight "*erveiros*" from local markets in three cities of Pernambuco (Recife, Jaboatão dos Guararapes and Caruaru) have been interviewed for the identification of plant parts and commercialization form, as well as origin of sold plants. Results regarding sold plant parts are presented in Figure 6 and only in few cases different plant parts have been indicated by different sailors.

Considering the sold plant parts, most of them (30%) included dry bark from woody plants. This kind of material is normally acquired from natural plant populations and their excessive harvesting may result in serious problem for most woody species (Monteiro et al., 2006).
The second most commonly used plant organs were the leaves, the case of the 25% of the species,

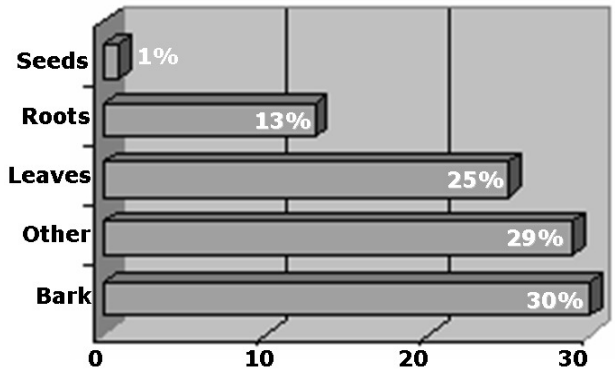

Figure 6. Evaluation of 50 native species regarding plant parts or organs sold as raw or dry material in the market places of Pernambuco.

followed by roots (normally as dry matter) for 13% of the species. Seeds were rarely sold for direct use (1%) while 29% of the sold material (in Figure 6 indicated as "other") included a mixture of different organs or whole plants.
Evaluating indicative uses of the 160 species that compose the whole data bank, we observed that for many species more than one type of indication could be identified.

In fact, some species are used for different applications, as skin diseases, hair falling and also respiratory problems, for example. In other cases, different parts of the plant were indicated as useful for different symptoms or indications, for example, for lowering blood pressure and weight loss. In order to generate an overall evaluation of main uses, we decided to rely on most frequent indications confirmed by our field questionnaires and also literature data, when available.
Figure 7 presents the distribution of the 160 species in nine groups according to their known popular uses, including reports from "*erveiros*", from the population and literature data. The most frequent indication was against diseases of the respiratory tract (61 species, 19.5%), followed by skin problems (including wounding, infections, cosmetic uses and hair care) with 58 species (18.5%).

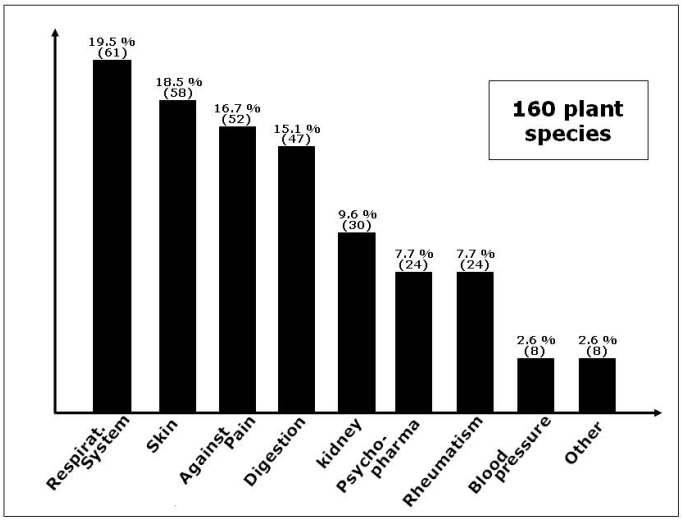

Figure 7. Main groups of indication regarding the 160 plant species that compose the data bank.

The third group included 52 plant species (16.7%) used against pain (analgesic potential), in most cases against headache, but also muscular-, back- and also internal aches.
Digestive problems composed the fourth group, with 47 species (15.1%) followed by kidney or urinary problems with 30 species (9.6%). We were surprised by the relatively large number of species (24, corresponding to 7.7%) of plants used due to their psycho pharmaceutical effect, including species indicated as calming and other as stimulating agents.
The last two groups included plants indicated for bone problems, with emphasis on rheumatic diseases (24 species, 7.7%) and as agents to control high blood pressure (eight species, 2.6%), while remaining eight species (2.6%) presented different indications (here designated as "other"). Examples of plants for each indication group are presented during the 6th European Colloquium of Ethnopharmacology.
Altogether the available data show how scarce knowledge on many aspects of the plant biology from Brazilian NE region is, as well as the potential of this natural resources for future research programs and product development. We are now establishing a workgroup on taxonomy, genetics, folkmedicine, propagation and conservation with emphasis on some plant groups, but much more interdisciplinary work is needed.
The first integrative approach includes interdisciplinary studies on native species of the genus *Croton*, that bears the diversity and endemism center in Brazilian northeastern region. Actual state of our efforts and needs for collaborative research are described in Alves et al. (in press).

Conservation planning and genetic banks including *in vivo* (plants and seeds) and *in vitro* conserved species would be important for the successful development of a research network. Also partnerships with the private sector at national and international levels would be desirable and has been encouraged by local governmental institutions. Our group is open for new cooperation and to develop new strategies for mining these biotresures!

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