SECOND CONFERENCE OF THE
INTERNATIONAL CARNIVOROUS PLANT SOCIETY
MAY 30 - JUNE 1, 1998
BOTANISCHER GARTEN BONN, GERMANY
GESELLSCHAFT FÜR FLEISCHFRESSENDE PFLANZEN

PROCEEDINGS

Edited by Jan Schlauer and Barry Meyers-Rice

Second edition

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Organized by Jan Schlauer, Frank Gallep, Wolfram Lobin, and Wolfram Diester

FINAL PROGRAMME

BEGIN of conference: Saturday, **30 May, 1998, 12:00** CEST; Botanischer Garten der Rheinischen Friedrich-Wilhelms-Universität Bonn, Meckenheimer Allee 171, 53115 Bonn, Germany

WELCOME

Speaker

W. Barthlott (Germany, Director Botanical Garden Bonn)
F. Gallep (Germany, GFP President)
J. Schlauer (Germany, ICPS Co-Editor)

SESSION I (Sat. **30 May, 1998, 13:00**): Morphology, Physiology & Cytology
Chair: P. Temple

Speaker	Topic
K. Kondo (Japan)	Diffused Centromeric Chromosomes and Speciation in *Drosera*
D.M. Joel (Israel)	Structure and Function of Digestive Glands
H. Rischer (Germany)	*in vitro* Cultivation and Experiments with Carnivorous Plants

YOUNG SCIENTIST LAUREATES

C. Lippuner (Switzerland)	The Effect of *Bacillus cereus* on the Digestion of Prey by Carnivorous Plants
C. Scherber (Germany)	Flora and Fauna of the "Bernrieder Filz" Nature Reserve

SESSION II (Sun. **31 May, 1998, 9:00**): *Pinguicula*
Chair: K. Kondo

Speaker	Topic
P. Temple (England)	The *Pinguicula* of the Caribbean
H. Luhrs (Netherlands)	Features of the Genus *Pinguicula* from México
L. Mellichamp (USA)	*Sarracenia* Species and their Habitats in the Southeastern United States
J. Steiger (Switzerland)	*Pinguicula*: The Cool Climate Species of the Northern Hemisphere - Distribution, Morphology, Habitat, Cultivation

POSTER VIEWING I (Sun. **31 May, 1998, 14:00**)

SESSION III (Sun. **31 May, 1998, 15:00**): Sarraceniaceae and Lentibulariaceae
Chair: A. Culham

Speaker	Topic
M. Groves (USA)	Atlanta Botanical Garden's Conservation Program
L. Adamec (Czech Republic)/ **C. Breckpot** (Belgium)	Recent View on the Biology and Protection of *Aldrovanda vesiculosa*
M.K. Janarthanam (India)	Ecology and Distribution of *Utricularia* Species in India
S. Porembski (Germany)	The Diversity of Plant Communities on Tropical Inselbergs

SESSION IV (Mon. **1 June, 1998, 9:00**): *Nepenthes*
Chair: C. Clarke

Speaker	Topic
R. Schmid-Hollinger (Switzerland)	Morphological and Phylogenetical Studies in the Genus *Nepenthes*
A. Culham (England)	Patterns and Phylogenies in *Drosera*; a Critical Review of Current knowledge
G. Eitz (South Africa)	*Drosera* in South Africa
F. Rivadavia (Brazil)	Brazilian Drosera and Molecular Phylogeny of the Droseraceae

POSTER VIEWING II (Mon. **1 June, 1998, 14:00**)

SESSION V (Mon. **1 June, 1998, 15:00**): Droseraceae
Chair: J. Schlauer

Speaker	Topic
C. Clarke (China)	Ecology and Conservation of Bornean *Nepenthes*
J. Nerz (Germany)	Nepenthaceae in their Habitats
A. Wistuba (Germany)	*Nepenthes* from New Guinea

CONCLUSION

END of conference: Monday, **1 June, 1998, 19:00** CEST

Some Thoughts about the International Cooperation between the Carnivorous Plant Societies

Frank Gallep (President of GFP); Zweibrückenstr. 31, Düsseldorf, Germany

Current Situation

In general the present cooperation between the different C. P. Societies is limited to the exchange of journals. That's it. Why?

Possible Fields for More Cooperation

Sure there are many fields where we could have more exchange and more cooperation. More cooperation would bring advantages for all: For our societies, for our members, for science and for our common hobby.

The following ideas might not all be realistic, but they are all worth pondering.

- Official admission to all events (for example: annual meetings, plant sales and exchanges, excursions) for all members of the other C. P. Societies. Therefore a quicker exchange of information between the societies would be necessary.
- General permit for other societies to translate and reprint the articles of their journals.
- Common database and / or
- Large index of all articles of the C. P. journals
- Exchange of plants and seed not only between the societies but also immediately between their members.
- There are surely many other possibilities of more cooperation. Proposals are welcome. But where to perform and discuss them?

Problem: Lack of Communication

We are missing a platform for discussing these ideas. A platform where representatives of all C. P. Societies could participate without having too many costs and without losing too much time. Phone calls and letters are not practical.

Possible Solution: Carnivorous Plant Societies' Mail-list

The new technologies offer us the solution: A *Carnivorous Plant Societies' Mail-list* as a platform for discussing the above mentioned subjects. A new mail-list, working together with the large international C. P. Discussion Group (which is too large for our purposes - our goals would be drowned in the flood of information) and with mail-lists of the societies. A brainstorming of the C. P. Societies. A platform for discussing problems shared by the other societies in the past, present or future, and new ideas. And a platform for the exchange of information about events and other important subjects.

Just some suggestions. It's up to you - to us - to think about them and perhaps to realize some of them.

Diffused Centromeric Chromosomes and Speciation in *Drosera*

Katsuhiko Kondo, Yoshikazu Hoshi, Takane Furuta; Laboratory of Plant Chromosome and Gene Stock, Faculty of Science, Hiroshima University, 1-4-3 Kagamiyama, Higashi-Hiroshima City 739, Japan
Sheikh Shamimul Alam; Department of Botany, Dhaka University, Dhaka 1000, Bangladesh

Like most higher living organisms, dicot plants have a localized centromere in the chromosomes, except for the members of the dicot *Drosera* that have a diffused centromere. *Drosera* chromosomes also have diffused properties of the telomeric repeat sequences $(TTTAGGG)_n$ of *Arabidopsis thaliana*, which have already been proved to hybridize with the chromosome DNA of human, *Leucanthemella linearis*, *Scorzonera austriaca*, *Zea mays* and so on. This phenomenon was found by southern and dot hybridizations. Those diffused telomeres may be required as a functional structure to make the diffused-centromeric chromosomes divide safely into the poles at late metaphase to anaphase. However, they have the rDNA region localized at the nucleolar organizing region like usual higher plants, as detected by the pTa71 probe. The pTa71 contains a 9-kb Eco-RI fragment of rDNA isolated from wheat (*Triticum aestivum*) and recloned into pUC19. Thus, each species of *Drosera* has a specific number of rDNA signals or nucleolar organizing regions. A meiotic chromosome configuration in *Drosera* called "Drosera type pairing" is mainly found in Australian pygmy *Drosera*, while those *Drosera* species distributed in the Northern Hemisphere show exactly the same chromosome pairing configuration as organisms with localized-centromeric chromosomes.

If *Drosera* is exposed to radiation at relatively high doses, its diffused-centromeric chromosomes break to produce multifragments. The best performance was obtained by gamma (γ) irradiation at 50 Gy. Each fragment was still active and continued usual cell division. Thus, many plants exposed to γ-rays show mixoploidy with different chromosome numbers in the cells of the same individual. The natural *D. roseana* has mixoplidy with 2n=5, 6, 7, 8, and 9 perhaps caused by natural radioactive substances. Chromosome aberrations exhibited are the same as those observed in localized-centromeric chromosomes, such as breaks, fusions, gaps, multipolarity, non-disjunction, pulvilization, rings and sister chromatid exchanges. These phenomena artificially produced genetic mutations, such as albino and yellow-colored plants, jelly-like plants, densely-leaved, very flat rosulate-formed plants, and plants with leaves that produced another leaf at the center of lamina. The albino plants were mixoploid.

The chromosomes of 47 species of *Drosera* studied up to the present display a diversified aneuploid series which is well progressed and is still under process especially in the pygmy *Drosera* in Australia, although those of the species in the Northern Hemisphere display always a stable polyploid series with X=10.

Many more new species of *Drosera* may be taxonomically described in Australia and many more new cultivars may be synthesized in the near future.

Structure and Function of Digestive Glands

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By definition, carnivorous plants possess glandular structures that absorb digestion products. In most cases these glands also secrete digestive fluids.

The digestive glands of all genera are composed of two main components, glandular and endodermoid. Depending on the species, both components are composed of either single cells or groups of cells. The cells that are directly involved in the synthesis and release of enzymes, as well as in digest uptake, are the glandular cells. These cells possess a typical glandular cytoplasm with a large nucleus and active organelles, and have a thin outer cell wall with a thin cuticle which is commonly porous, providing the gland with an external boundary of low diffusive resistance.

The endodermoid cells mediate between the glandular unit and the leaf tissues. Their radial walls are typically impregnated with cutin, where their plasma membrane is tightly attached to the cell wall. This unique structure blocks all extracellular transport across the endodermoid layer from the glandular cells and to them, allowing water and solute movement that is controlled by the endodermoid cytoplasm. The

glandular unit can therefore be regarded as the digestive pump, and the endodermoid unit - as its main valve.

In addition, digestive glands are often provided with auxiliary elements such as reservoir cells, stalks, and conductive cells.

Carnivorous glands operate under different digestive strategies . In some species digestive cycles take place only when prey is available to the trap, in other species the glands show a continuous digestive activity. The former strategy is employed by the snap-traps of *Dionaea* and *Aldrovanda*, where digestive fluid is secreted by all trap glands when prey is available and the trap shuts, or by the adhesive traps of *Drosera* and *Pinguicula*, where digestive fluid is secreted only by glands that are stimulated by entrapped prey. The latter strategy is employed by pitcher plants and by *Utricularia*, where the main volume of the digestive fluid is spontaneously secreted during the maturation of the trap. In this latter case the entrapment of prey often operates additional secretion of enzymes and leads to a decrease in the pH of the digestive fluid. We therefore see that digestive gland activity is usually stimulated by the presence of prey even if the trap is passive.

The pitcher epithelium of *Sarracenia* is composed of a glandular epidermis that continuously occupies the inner surface of the bottom zone of the pitcher, with an endodermoid sub-epidermis that constitutes a physical barrier of extracellular leakage of water and solutes. This unique surface-gland serves not only as a digestive gland but also plays a key role in helping associated fauna to coexist in the pitcher. The epithelium was shown to control the levels of oxygen, carbon dioxide and various other solutes in the digestive pool. The role played by associated organisms in prey breakdown and digestion is significant mainly in pitcher plants.

The structure of the cuticle covering the outer surface of digestive glands corresponds to the trapping strategy. When the fluid is secreted spontaneously, as in the pitcher plants, the cuticle also opens spontaneously during gland maturation. When the fluid is secreted only in response to trapping, the cuticle also opens only when stimulated by prey. Cuticular opening seems to develop as a result of wall stretching, that in turn is caused by an increase in the ionic content of the outer glandular cells. In *Dionaea* it was shown that a wave of chloride transport precedes cuticular opening, and this ion was shown to accumulate in turn in the various layers of the glands: first in the basal cells, then in the endodermoid cells and later in the glandular cells. Chloride ions were followed under the electron microscope and were seen to move from one cell to another both via plasmodesmata, that serve as plasmatic connections between cells that bridge across cell walls, and via the tangential cell walls that are located between endodermoid cells and the basal cells or glandular cells. In the basal cells chloride is accumulated in special organelles.

The uptake of digestion products from the gland surface is an active, energy consuming process, in which ATPase is involved. Some products are immediately consumed or metabolized in the gland itself, whereas others are transferred to other plant organs.

The digestive glands of carnivorous plants are interesting not only because of the special nature of the plants that carry them, but also because these structures secrete enzymes to the plant surface as the result of simple external chemical signals, in contrast to most other cases in the plant kingdom where stimulated secretion of enzymes is restricted to internal structure only. This quality of the digestive glands makes them an ideal model for research of glandular mechanisms in plants.

In vitro Cultivation and Experiments with Carnivorous Plants

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Porter (1940) reported germination and growth of sterile sown *Nepenthes maxima*. This work marks the very starting point of growing carnivorous plants *in vitro*, published only a few years after the final

establishment of plant organ cultures. Since then protocols have been developed for cultivating many genera of carnivorous plants *in vitro*, including: *Aldrovanda*, *Byblis*, *Cephalotus*, *Darlingtonia*, *Dionaea*, *Drosera*, *Drosophyllum*, *Genlisea*, *Heliamphora*, *Nepenthes*, *Pinguicula*, *Sarracenia*, and *Utricularia*.

However, the purposes for growing carnivorous plants *in vitro* are quite diverse. It is useful to subdivide these in the following categories:

- commercial mass propagation
- *ex situ* conservation
- physiological examination under sterile conditions, especially for understanding the nutrition of carnivorous plants
- study and production of secondary metabolites.

The applied techniques and the exploited mechanisms for reaching a particular goal are consequently as different as the purposes themselves. For the first two categories clonal propagation is achieved using techniques which minimize somaclonal variation e.g. the shoot tip culture or the single node technique. Organ cultures are used for the third category, whereas undifferentiated fast growing cell cultures are preferred for the production of natural products.

In our laboratory, we have established *in vitro* cultures of several carnivorous plants and their close non-carnivorous relatives in the order Nepenthales (incl. Polygonaceae, Plumbaginaceae, Nepenthaceae, Ancistrocladaceae, Dioncophyllaceae, Drosophyllaceae, and Droseraceae) for the purpose of studies on their secondary metabolism. The members of this group are marked by their ability to produce acetogenic quinones like plumbagin, 7-methyljuglone, or emodin. Furthermore, the families Ancistrocladaceae and Dioncophyllaceae (incl. *Triphyophyllum peltatum*) are notable for containing the unique naphthylisoquinoline alkaloids (Bringmann & Pokorny 1995) investigated in our group.

First experiments with callus cultures have shown that acetogenic metabolite production can be elicited by exogenous stimuli.

The carnivorous syndrome of one of the above mentioned species, *viz. T. peltatum* has hitherto not been demonstrated conclusively because the uptake of organic matter was not proven experimentally. For this reason labelled alanine (an amino acid commonly found in animal protein) was fed to the insect-trapping organs of *T. peltatum* during a field trip to the Taï National Park in Ivory Coast (Bringmann & al. 1996). After GC/MS analysis of extracts from different parts of fed and control plants, incorporation and redistribution of the label was demonstrated unambiguously. *T. peltatum* is a part time carnivorous plant with all required attributes.

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The Effect of *Bacillus cereus* on the Digestion of Prey by Carnivorous Plants

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Winner of the "9th European Contest for Young Scientists" 1997

Carnivorous plants catch and digest insects. This digestion of prey is due to enzymes produced by the carnivorous plants, to enzymes produced by bacteria, or a combination of both, depending on the species. Carnivorous plants rarely secrete all the enzymes needed for total digestion of prey (Juniper 1989, p.190;

Heslop-Harrison 1976, p.119). Thus, bacterial enzymes improve the digestive system of most carnivorous plants.

I tested the bacterial influence on the digestion of the prey, using *Bacillus cereus* as a test organism, in a project for the "Swiss Contest for Young Scientists". Many different carnivorous plants were examined in order to find out if *Bacillus cereus* lives in the digestive system. The occurrence of *Bacillus cereus* was tested using agar plates in 131 samples of digestive liquids and trap partitions of carnivorous plants (samples of *Heliamphora*, *Cephalotus*, *Nepenthes*, *Sarracenia*, *Dionaea*, *Pinguicula*, *Drosera*, *Drosophyllum*), 15 samples from substrate around the carnivorous plants (water, soil, moss), and 20 samples from potential prey. In the samples of *Heliamphora*, *Bacillus cereus* was always present. It was proven that *Bacillus cereus* is ubiquitous. Moreover, it was confirmed with special cultures that *Bacillus cereus* is a facultative anaerobic bacterium. Experiments have also shown that *Bacillus cereus* produces and secretes amylases (method: "coloured starch-agar-plates", Birkenbeil, 1983, p.95), lipases (method: "optical change and change of the pH-value of a supernatant-oil-mixture", Stellmach, 1988) and proteases which can digest polypeptides and peptides (photospectroscopical measurements and gel electrophoresis). Besides there was an effort to clean and measure the size of the amylases of *Bacillus cereus* and to compare the size with the protein sizes in different digestive liquids of carnivorous plants. By different plate-cultures we observed that when numerous colonies of *Bacillus cereus* are present, nearly no other bacteria were able to grow. Final conclusion: *Bacillus cereus* and other bacteria probably play an important role in the digestive system of carnivorous plants.

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Flora and Fauna of the "Bernrieder Filz" Nature Reserve (Southern Bavaria, Municipality of Seeshaupt)

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Winner of the German young scientists' contest "Jugend Forscht" 1997

The "Bernrieder Filz" is a characteristic prealpine raised bog with a vegetation dominated by mountain pine (*Pinus mugo* TURRA), heath (*Calluna vulgaris*) and different *Sphagnum* communities.

The high diversity of habitats makes it suitable not only for most of the native carnivorous plant species, but also for a large quantity of other plants and animals adapted to bog ecosystems.

During a research period of two years, the author investigated the flora and fauna of the "Bernrieder Filz" and the local mobility of the animal and plant species found. Special emphasis was laid on the vegetation and fauna of the different biotope types lying on the edge of the asymmetric peat bog.

About 400 different species were found in an area of approx. 0.5 km^2 (130 acres) and mapped out in a topographical 1:5000 map. Furthermore, aerial pictures were analyzed and the vegetation communities found were assigned to 17 sub-units.

For each of the subunits, the percentage of endangered animal and plant species was calculated using the "red lists" of endangered species for Bavaria (P. Schönfelder, 1988; G. Heusinger, 1992). In addition, the extent of their local mobility was measured.

Using these data, a protection and management concept for the "Bernrieder Filz" was developed and an extension of the nature reserve area was proposed.

In the southern part of the "Bernrieder Filz" there lies a small lake called "Schwarze Lache" with large areas of floating vegetation (quaking mat) and sedge-dominated aspects in which different endangered dragonfly species such as *Nehalennia speciosa* and *Sympecma paedisca* can be found. The "Schwarze Lache" area can be classed as the heartland of the bog.

The northern parts of the "Bernrieder Filz" are dominated by the *Pinus mugo-Vaccinetum* plant community, with decaying draining ditches and a lake remnant with transitional peatland vegetation. Most of the drainage ditches have been blocked by local naturalists in order to rewet dried-out areas. About 60% of the species of the lake remnant region can be regarded as highly endangered.

On the edge of the nature reserve, a great variety of different biotope types can be found: fishponds, spruce and beech woods with thermophilic edge vegetation, meadowlands with cattle breeding and extensively cultivated flat bogs (meadows) on slightly acid, mesotrophic peat.

Especially the meadows, which are cut only once a year in order to harvest straw, are inhabited by interesting sedge (Cyperaceae), rush (Juncaceae), orchid (Orchidaceae) and gentian (Gentianaceae) species as well as butterflies (Lepidoptera), grasshoppers (Saltatoria) and beetles (Coleoptera). This meadow area plays an important role in the interrelations between tyrphobiotic species and those of the edge biotopes, 50% of which are endangered.

After two years of field research, it can be concluded that not only the heartlands of the bog itself, but also the edge biotopes are inhabited by valuable and peculiar animal and plant species. In summary, one can say that the nature reserve area should be extended in order to create a biotope complex of sufficient expanse. The rewetting measures in the Northern parts as well as the extensive cutting of the "Streuwiesen" should be promoted.

The *Pinguicula* of the Caribbean

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Cristina Panfet Valdes; Jardin Botanico Nacional, Universidad de la Habana, Cuba.

The six *Pinguicula* species found in Cuba and the Dominican Republic are discussed. Cuba is the largest and oldest Caribbean Island, and contains three mountain ranges which reach approximately 3000 metres elevation. The five species of *Pinguicula* (*P. filifolia, P. albida, P. jackii, P. benedicta* and *P. lignicola*) listed for Cuba are all endemic.

P. filifolia grows in the West of Cuba in the Pinar del Rio region. *P. filifolia* appears to compete with the grasses, and there is evidence that grazing may create suitable habitat. The plant itself is grass-like, upright to about 20 cm with long but erect leaves. Flowers are held high above the leaves on thin stalks and are varying shades of blue, white or yellow. *P. filifolia* is threatened because its environment is rapidly being damaged by citrus farming.

P. albida is found in the same area. This is a small rosetted plant, barely five cm in diameter. The leaves are very thin, almost transparent. It hugs the ground under the shade of juvenile palm trees. This plant is an annual and can be found only near the start of the rainy season. White flowers are produced throughout the plant's life cycle. *P. albida* grows in areas poorly suited to cultivation, so the plant is not severely threatened. However, expanded farming or draining would quickly threaten the Pinar del Rio colonies.

P. jackii grows in the Trinidad mountains. It is a large rosetted plant which grows flat against vertical cliff faces and bears purple flowers. Very few sightings and no recent collections of this species have been made despite two visits and an enthusiastic search throughout the area. One site known to have plants in 1995 has been lost to vegetation and soil damage from pigs.

The small plant *P. benedicta* was found at high altitude. Its habitat may be threatened by pollution from nearby mining.

P. lignicola is a rare and stunning example of an epiphytic *Pinguicula.* Plants less than 5 cm in size were found at high elevation growing attached directly to the bark of trees. At this high altitude, temperatures are high during the day but fall rapidly at night, resulting in fog each night. The altitude also

results in a constant breeze. The night humidity provides all the moisture the plant requires. The main threat to this plant's survival is air pollution.

Mount Casibito in the Dominican Republic is the home for *P. casabitoana*. Another epiphyte nourished by night humidity, it is similar in habit and ecology to *P. lignicola,* although twice as big. The plant has sword shaped leaves and white flowers. *P. casabitoana* is found in much deeper shade than *P. lignicola*, although direct sunlight is tolerated as well.

Features of the Genus *Pinguicula* from México

Hans Luhrs; Krayenhoffstr. 51, 1018 RJ Amsterdam, Holland

Features of the Mexican *Pinguicula´*s will be discussed here in combination with colour slides taken in habitat during several field trips. Due to many recent publications of new species, half of the genus´s number (38) occur in the mountains of México. This has given the author a growing motivation to study these plants as he has done for the last ten years.

Geographical ranges of species and their habitats will be the main topics of the lecture, followed by a discussion of features different between herbarium specimens and living plants in taxonomy.

New Discoveries and Habitats of *Pinguicula* in México

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Editor's note: Dr. Lau was unfortunately not able to attend the conference;
we are nonetheless printing the abstract he submitted before the conference.

Having to contend with the epithet "King of Cactus", my first botanical outreach and love, I also added in the list of plant families attractive groups of plants like orchids, bromeliads, passion flowers, gesneriads, palms, cycads, agaves, Mexican asclepiads, crassulaceas and finally *Pinguicula*.

In 1974 in the course of climbing the highest mountain in the State of Oaxaca, Cerro Zempoatepetl, we climbed over very steep walls that were covered by a beautiful, yellow moss, probably related to *Sphagnum*. Out of the moss protruded a *P. moranensis*-related flower of deep red color, the only really red *Pinguicula* of a group that is almost always purple, growing at 2300 m altitude underneath pine and oak trees on almost perpendicular rocks an sheer walls. It was years later that Franz Fuchs from Linz, Austria, visited us and was aghast at looking at a wall in my garden that was covered with this plant. Several years ago, at a conference in Birmingham, England, the plants were sold for 16 Pounds Sterling a piece, which surprised me. Dr. Franz Speta has published the plant under the name *P. laueana*. When we continued on the road from Cerro Zempoatepetl to Zaragoza, we examined a huge rock in a curve of the dirt road. One of our boys spotted a strange-looking *Pinguicula* that was not *P. laueana*. Without alpine equipment we could not reach it and had to give up the discovery.

Santa Maria Yucuhiti, close to Santiago Nuyoo, Oaxaca, there is a locality on which one large triangular granitic rock has three different *Pinguicula* species, one on each wall. To get there, one has to pass the altitude of 3000 m. The area is often shrouded in fog. A most beautiful form is covering the south-east side densely, leaves as well as flowers with long spur, and another red color. Some of the flowers tended towards purple. Old leaves of oak covered some of the plants. The north side was covered with a *P. moranensis* form, the South West side showed another difficult to define species - ?*P. mirandae* - with flowers that are white with light purple edges. The winter rosette is quite small, almost invisible, but when the rainy season begins, in May-June, they triple in size, and become covered with tiny flies. Not far away, near Yosundua, there grows a very thin-leaved *Pinguicula* which forms new plants at the

leaf-tips. I have not seen yet the flower. During hibernating season you can still see the old, dry leaves attached to the winter rosette.

On the road from Jalapa de Diaz to Ayautla, we saw yellow blotches of plants far away on the steep walls. Oaxaca has many surprises in store. With my binoculars I could recognize that these were *Pinguicula*, but of a very large size, growing in groups, together with *Agave* and *Tillandsia streptophylla*, in the hot tropical sun, fully exposed. We climbed the steep hill and I took these most beautiful pictures from different angles. What amazed us were the undersides of the large leaves that revealed that insects are also caught, on the reverse of the leaves. In habitat they grow at about 350 m altitude. The walls are yellow with large populations of this *Pinguicula* that was published recently under the name *P. gigantea*.

P. orchidioides I found in abundance in the Sierra de Juarez, Oaxaca. It is also easy in cultivation, preferring cool conditions.

On the difficult dirt road to Dulces Nombres, beginning at Santa Engracia in Tamaulipas, at an altitude of about 2000-2500 m is the habitat of *P. cyclosecta*. These plants cover the rocks and hills completely.

Gypsum hills have always been a major attraction in finding new species. Near Juxtlahuaca in Oaxaca State there is a solid gypsum hill about 1500-2000 m above sea level, close to a very deep lake. When the rainy season starts, there are thousands upon thousands of narrow-leaved *Pinguicula heterophylla*. The flowers have purple edges. They are difficult in cultivation. Near Concepcion Papalo, Oaxaca State, and near Canoas, Durango, at 2700 m on clay I came upon other *P. heterophylla* forms.

Another gypsum region is close to Zaragoza, Nuevo Leon, at 1500 m. There are tiny plants with quite succulent leaves, the flower being larger than the individual plant, white in color. I have only photos in the sterile condition. It is called *P. immaculata*. Near Novillo, Tamaulipas, on a very remote hill in clayish soil, underneath pine trees, there grows a *Pinguicula*, which I supposed is *P. lilacina*. I have never found traces of the plant during the dry season and wonder whether this is an annual. The same is true with a new discovery in the Pine Ridge area of Belize. This latter one is now under discussion and investigation. This little white flowering *Pinguicula* grows together with *Utricularia hispida* and *Drosera brevifolia*. The area is 1000 m high on bog soil condition.

One of the most attractive landscapes all over Latin America is the Sierra Obscura of Chihuahua. Getting there is almost impossible. The weather has to be dry. Once being there in 1972, it was a breathtaking view. Almost all plants, even nolinas, grow hanging, as there is no level ground. On the same permanently moist wall with a yellowish, chalk like soil with *Tacitus bellus* (*Graptopetalum bellum*), there grows a most attractive *Pinguicula*. We have never been able to cultivate this *Pinguicula*, not even in their own substrate. A friend in Australia, Mr. Bond, tried it on tissue culture and succeeded. As far as I know, this beautiful *Pinguicula* was never yet described. Elongated brownish leaves and. light purple flowers give it a distinctive look within the genus.

P. reticulata is easy in cultivation, growing in semi-desert conditions near Ascension at 2300 m altitude, a very easy bloomer. The State is Nuevo Leon.

One *Pinguicula* I found in the Sierra Huichol in Nayarit which I do not know. Discussions about this plant would be appreciated, as it is a plant that you cannot ignore.

In the region around Buenavista in San Luis Potosi State I found plants which I tentatively identified as *P. takakii*. Between strange-looking specimens of *Selaginella*, near Buenavista, S.L.P. *P. gypsicola* abound.

A most beautiful *Pinguicula agnata* grows at 3000 m altitude on granite rocks on the Cerro del Viejo, border of Tamaulipas and Nuevo Leon.

The desert of the Sierra Salamanca is another locality of *P. esseriana* populations in semi-shade.

In the Sierra de Tamaulipas are large occurrences - albeit hard to reach on foot - of a *Pinguicula* (?*P. rotundiflora*) which is very easy to grow and flower. The flowers are on long pedicels, very abundant, almost white with a trace of purple.

Most of the *Pinguicula* populations are confined to 2000 - 3000 m altitude from the Chihuahua-Sonora border to Oaxaca (and Chiapas, continued in Guatemala and Belize), and from Jalisco on the West to Tamaulipas in the Northeast. Botanists will certainly discover still more species in Mexico heretofore unknown and undescribed.

Sarracenia Species and their Habitats in the Southeastern United States

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There are some ten species, and numerous subspecies and forms, of carnivorous pitcher plants in the genus *Sarracenia* (Sarraceniaceae) endemic to the Southeastern United States. The species are *S. alata*, *S. alabamensis (*includes *S. alabamensis* subsp. *wherryi)*, *S. flava*, *S. jonesii*, *S. leucophylla*, *S. minor*, *S. oreophila*, *S. psittacina*, and *S. rubra*. *Sarracenia purpurea* subsp. *venosa* also grows in this area although the range of the species is larger than just the southeastern states. They grow in open, sunny, moist, nutrient-poor meadows with grasses, wildflowers and long-leaf pine trees. These habitats must remain moist and must be periodically burned. The soils are usually highly organic and acidic, creating habitats that harbor rare orchids and a tremendous diversity of wildflowers. Other carnivorous plants occur there as well, such as *Dionaea muscipula* in North Carolina, and several species of *Drosera*, *Pinguicula* and *Utricularia*. Nowhere else in the world do so many different genera of carnivorous plants occur together. Many color forms of *Sarracenia* have been identified across the range, which extends from Virginia south to Florida, then west along the Gulf Coast and inland to eastern Texas. In many cases the habitats are disappearing due to development and draining. Several species are endangered; all are rare, their numbers declining annually. A rather unique feature of these species is that they freely hybridize with one another, and the hybrids produce backcrosses and hybrid swarms, especially in disturbed habitats. This ability has allowed the author, with Mr. Rob Gardener of the North Carolina Botanical Garden, to make artificial hybrids and select unusual clones for tissue culture for the horticulture trade. The plants that will be shown include the cultivar 'Dixie Lace' (description in press) and several other clones being studied for possible establishment as cultivars.

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Various articles in Carniv. Pl. Newslett., 16, Number 2. June 1987, especially new cultivars on pp 39-42.
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Pinguicula (Lentibulariaceae): The Cool Climate Species of the Northern Hemisphere - Distribution, Morphology, Habitat, Cultivation

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The distribution of the genus *Pinguicula* ranges from Eurasia including Greenland, Iceland and Japan to North, Central and South America. However *Pinguicula* does not exist in New Zealand, Australia, Indonesia and Africa (except in its northernmost corner).

Considering the growth type *Pinguicula* may be divided into four groups: tropical-homophyllous, tropical-heterophyllous, temperate-homophyllous, and temperate-heterophyllous. The plants of tropical growth type form assimilating leaves all the year through. The temperate types hibernate by means of hibernacula. In the homophyllous growth type only one rosette type is formed, i.e. all leaves of the rosettes have morphologically the same characteristics. The heterophyllous type forms two different rosettes - either a larger rosette in summer and a smaller, morphologically different rosette in winter (tropical-heterophyllous type) or a smaller generative spring rosette followed by a larger vegetative summer rosette with different leaf morphology, which later forms the hibernaculum (temperate-heterophyllous type).

This contribution is focused on the *Pinguicula* species of the temperate-cool, (sub)alpine and (sub)arctic climate regions of Eurasia including three species also distributed in northern North America.

They belong to the following subgenera: (1) Subgenus *Isoloba* (*P. lusitanica* and the *P. crystallina/hirtiflora* group); (2) Subgenus *Temnoceras* (*P. alpina*, *variegata*, *ramosa* and probably *algida*); (3) Subgenus *Pinguicula* (*P. balcanica*, *corsica*, *dertosensis* (*submediterranea*), *fiorii*, *grandiflora*, *leptoceras*, *longifolia*, *macroceras*, *mundi*, *nevadensis*, *villosa*, *vallisneriifolia*, *vulgaris* and two or three yet unidentified species).

Several species (e.g. *P. algida*, *variegata*, *ramosa* and *villosa*, but also *P. dertosensis*, *P. mundi* and the *P. longifolia* group) are somewhat difficult to associate within their subgenus and will possibly require taxonomical refinements on the section level. Recently S.J. Casper identified new chromosome numbers in the *P. crystallina/hirtiflora* group which might lead to nomenclatural modifications. The taxonomical value of *P. bohemica* and *P. fontiqueriana* is controversial.

All above named species are presented by color slides, their distribution and habitat conditions are described and their taxonomical relationships are discussed.

The long-term cultivation of the (sub)alpine and (sub)arctic *Pinguicula* species is rather difficult for the following reasons: (1) They are much less resistant to fungal infestations than the tropical species; (2) While it is easy and cheap to create dry - or wet - (sub)tropical climate conditions, the creation of a cool climate with high air humidity is difficult and expensive; (3) In many species the hibernaculum stage lasts considerably longer than the vegetation period. If the summer growing conditions are not optimal the plants form weak hibernacula which easily decay. This is particularly the case if the plants are kept too warm and/or if they lack sufficient air humidity and ultraviolet light; (4) In the temperate growth type the flowering period is usually short and if growing conditions are not adequate from the very beginning no flowers and/or no seeds are produced.

Cultivation guidelines are presented which have proven to be successful for over 20 years.

Atlanta Botanical Garden's Conservation Program

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Officially incorporated in 1976 on land belonging to the City of Atlanta in Piedmont Park (the city's largest communal park), the Garden's mission is to develop and maintain plant collections for the purposes of display, education, conservation, research and enjoyment. ABG is a private, non-profit botanical garden overseen by a Board of Trustees, with over 40 staff, upward of 300 volunteers, and a 10,000-strong membership base. The centerpiece of the Garden is the Dorothy Fuqua Chapman Conservatory. Opened to the public in 1989, the Conservatory covers 16,000 square feet. The collections focus on under-represented and endangered plant groups, including Old World desert collections, Old World island palms that follow an island biogeographical theme, and other conservation collections including tropical conifers, orchids, cycads and carnivorous plants. ABG also houses a collection of poison dart frogs from South America.

ABG's Conservation Program encompasses a number of regional and international projects. Based on a hands-on and project-driven approach, ABG strives to work directly with local landowners, to bring as many of the relevant agencies, botanical institutes and organizations into collaboration, and to disseminate the staff's horticultural and botanical expertise to as wide a field as possible. One of its major goals is to use low-cost restoration and recovery techniques.

ABG plays an active role in the monitoring, restoration and conservation of the unique and species-rich bog communities that are found throughout the Coastal Plain and Southern Appalachian Mountains of the southeastern USA. Impacted by agricultural runoff, land conversion, soil erosion, drainage, herbicide use, invasive exotic species and the exclusion of many processes, such as fire, many of these plant communities have been reduced to small, fragmented plots of land. Bog habitat restoration involves controlling invasive woody species, both native and non-native, which eventually shade out the herbaceous layer. Restoring the herbaceous layer provides the fuel to 'carry' the fires that are associated with maintaining these open, nutrient-poor, and species diverse habitats. Controlling woody species can

be achieved through full-scale and/or selective burning and involves cutting back shrubs and trees in the winter or summer and scorching the resprouting stems with a simple, clean and highly effective propane-fuelled flame-thrower. However, years of anti-fire/anti-smoke propaganda, symbolized by 'Smokey the Bear', has produced a fear and intolerance of fire, and smoke easements are now hard to secure in many states.

Historically, these habitats would have been maintained through beaver activity. Many bogs, especially low-lying sites suitable for conversion to agriculture, have had drainage ditches or drainage tiles installed to lower the water table. ABG recreates beaver activity to restore and maintain the site's hydrology and soil structure. This is carried out with the minimum of soil disturbance so as not to create ruderal sites where weedy species can take hold. A simple, but effective restoration technique is to dam up ditches using the organic debris accumulated from clearing the site. This slows the entry of water into the bog, reducing erosion, and limiting the amount of silt deposited over the bog.

ABG carries out a number of restoration projects with the Georgia Plant Conservation Alliance (GPCA) which is a network of state, federal and private agencies and public gardens working to conserve endangered plant species and ecosystems in Georgia. ABG's tissue culture laboratory propagates rare and endangered native and non-native species. It also raises funds for the Conservation Program through the development and propagation of unusual and horticulturally interesting plant forms and cultivars. These include an all red form of the Venus flytrap 'Akai Ryu' (developed by ABG staff member, Ron Gagliardo) and an all green form of the Gulf Coast purple pitcher plant (Sarracenia purpurea subsp. venosa var. burkii).

Recent View on the Biology and Protection of *Aldrovanda vesiculosa*

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The free-floating aquatic *Aldrovanda vesiculosa* is unique within Droseraceae. It features active traps the structure and mechanism of which are comparable to those of *Dionaea*. The physiology of the rapid trap movement has not yet been fully understood. *Aldrovanda* is a thermophilous species spread from temperate to tropical zones in Europe, Asia, Africa, and Australia. Yet, its occurrence has always been sparse and irregular. In temperate countries, apical winter buds (turions) are formed in autumn. They overwinter on the bottom, float up to the water surface in spring, and resume the growth. Populations in Africa, tropical Asia and Australia richly flower and set seeds but they do not form turions and grow throughout the year. Temperate populations flower rarely in warmer seasons but flowering results mostly in production of abortive seeds.

Recent data on its distribution in Africa and Asia are not available (except for Japan - last site) and only a few recent sites are known from Australia. In Europe, it occurred more frequently and was recorded at about 150 sites in the last two centuries. It has declined dramatically in the last 30 years, vanishing from Germany, France, Italy, and Slovakia, and the number of its sites has decreased to about one-tenth. Two artificial sites are in Switzerland where it was successfully introduced in 1908. In all European countries, it has had a status of "critically endangered species" and has been under strict state protection. Yet, this has not helped much!

Aldrovanda is highly sensitive to competition with filamentous algae and higher aquatic plants that form denser stands. Fast apical growth and vegetative propagation by branching shoots are the only way to overcome the competition. The most important ecological requirements of *Aldrovanda* include: a) free-CO_2 concentration >0.1 mM as the plant is a strict CO_2 user; pH may be within 5.0-7.6; b) a medium humic acid concentration (2-30 $mg.l^{-1}$); c) high biomass of plant litter from reeds or sedges; d) water surface free of a dense biomass of submersed or floating macrophytes; e) transparent water free of suspended matter or phytoplankton; f) relative irradiance >20% of full sun; g) relatively warm water in summer (optimum 25-28 °C); h) shallow water (0.15-0.6 m, but summer minimum 5-10 cm); i) abundant

zooplankton as prey; j) oligo-mesotrophic water. *Aldrovanda* grows in shallow standing dystrophic waters, but only in loose stands of emergent vegetation (*Phragmites*, *Typha*, *Carex*) or in little bays among tussocks of denser vegetation. Generally, small habitat changes may result in the decline of *Aldrovanda*. Its decline has been caused mainly by water eutrophication, drainage, and filling in of water bodies.

Its outdoor culture mimics habitat conditions at natural sites. In a culture, about a 3 cm layer of litter of robust *Carex* species, placed over 5-8 cm of sand, is used as the bottom substrate. The container is loosely planted with sedges or common reed. Water depth is 20-30 cm. As *Aldrovanda* is susceptible to boron deficiency, boric acid must be added. Turions overwinter well in the refrigerator. As outdoor cultivation can be still problematic in-vitro culture offers hopeful perspectives to be used for scientific and nature conservation projects dealing with ecophysiological studies, keeping of gene-pool stock, and (re)introduction activities. Very recently, growing *Aldrovanda* in-vitro has been managed successfully.

Great effort has been made to select new suitable sites in the Czech Republic. The plants placed in nylon enclosures in three shallow dystrophic wetlands in N. and S. Bohemia grew rapidly and reproduced 8-34 times over the 1994 season. Approximately 10-50 % of the turions overwintered. When 30 *Aldrovanda* plants were introduced to the suitable sites in S. Bohemia (Trebon region) in 1995, the plants grew rapidly only in a *Carex rostrata*-dominated pool. Turions overwintered perfectly and in the 1996-1997 seasons, the plants propagated richly, forming an abundant population. Its total size was about 6,000 shoot apices in 1996 while 11,000 ones in 1997. Water level at the sites in summer has been found to be the crucial factor for rapid growth and propagation of *Aldrovanda*. The water level was very low in 1995, but high in 1996 and 1997. Thus, a new prolific site arose in S. Bohemia, where *Aldrovanda* had never grown.

Ecology and Distribution of *Utricularia* Species in India

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The genus *Utricularia* is known to occur in almost every country of the world, but the majority of the species are mostly distributed in seasonally wet and high rainfall receiving tropical and subtropical regions (Taylor 1989). India is known for its varied habitats and climate which is responsible for the high diversity in species of *Utricularia*. About 35 species are recognised under the genus for the Indian political boundary (Janarthanam & Henry, 1992). These belong to eight sections with high diversity seen in section *Oligocista* with 18 species for the region followed by section *Phyllaria* and *Utricularia* with five species each. Remaining sections are represented by either one or two species each.

Based on their habitats, the species can be broadly classified into one of the following categories: i) floating / suspended aquatics, ii) rooted marshy terrestrials and iii) partial epiphytes. The floating or suspended aquatics are distributed almost throughout the country, at least sporadically. Their habitat is usually stagnant or slow flowing fresh water. Rooted marshy terrestrials show high diversity in their habitats varying from wet lateritic rocks to moss covered water dripping rocks and fast flowing streams in which black boulders form the substrate. The whole of section *Oligocista* belong to this type. Most of these are distributed along the Western Ghats and West Coast of Southern India. There is lot of variation in microhabitats which is also reflected in inter and intraspecific variation. A high amount of intraspecific variation is seen in the species which are distributed widely and in several microhabitats. However, it is noticed that the marshy terrestrial species which are recorded across the continents are very rare and that two are recorded from lower to medium elevations from the inland. Based on the distribution and diversity, the following two centres of species diversity is recognised for the genus *Utricularia* in India: 1) Eastern Himalayas, where the partial epiphytes with appendaged seeds (sect. *Phyllaria*) are mostly distributed and 2) the Western Ghats and West Coast, where the species of section *Oligocista* with several endemic species are distributed. It is observed that the world's highest rainfall receiving station situated in the state of Meghalaya in North East is very poor in species diversity, suggesting that high rainfall alone

does not increase the species diversity in this group. The present paper deals with the ecology and distribution of the species of *Utricularia* in India and the observed positive correlation between the intra and interspecific variation on one hand and ecology and distribution on the other.

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The Diversity of Plant Communities on Tropical Inselbergs

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Inselbergs occur as frequently dome-shaped rock outcrops (like the "Sugar Loaf" of Rio de Janeiro) in all climatic and vegetational zones of the tropics. They comprise a broad spectrum of size classes with the largest inselbergs attaining a height of several hundred metres and covering several square kilometres. Consisting of Precambrian rocks, they form ancient (i.e. millions of years old) and stable landscape elements. Due to the lack of soil and desert-like microclimatic conditions, the vegetation of inselbergs differs markedly from that of the surroundings. During the last years the conceptual framework for an assessment and monitoring of the vegetation of inselbergs on a worldwide scale has been developed and floristic as well as ecological data were acquired for a number of tropical countries (e.g. Côte d'Ivoire, Zimbabwe, Venezuela, Brazil, Seychelles). The ecology of carnivorous plants occurring on inselbergs has largely been neglected hitherto.

Clearly defined inselberg plant communities (e.g. cryptogamic crusts, seasonal rock pools, monocotyledonous mats, ephemeral flush vegetation, wet flush vegetation) can be distinguished based on their physiognomy. Mats consisting of monocotyledonous plants (such as grasses and sedges), which occur like carpets on exposed and frequently steeply inclined slopes, are one of the most conspicuous communities of the inselberg ecosystem. Characteristically these mostly species-poor mats form clearly delimited, isolated vegetation fragments. Situated at the feet of steep slopes and benefiting from nutrient-poor seepage water, the ephemeral flush vegetation is characterized by the occurrence of a large number of short-lived species.

On African inselbergs the ephemeral flush vegetation is the most speciose plant community. The high number of carnivorous species (*Utricularia*, *Genlisea*, *Drosera*) is remarkable. In particular small-sized species of *Utricularia* (e.g. *U. pubescens*, *U. subulata*) may form dense stands over very shallow soil. Similarly, the genus *Genlisea* is a characteristic component of the ephemeral flush vegetation both on African and South American inselbergs. Most *Genlisea* species possess a small rosette of spathulate leaves and highly modified achlorophyllous subterranean leaves. It is traditionally assumed that these specialised leaves are traps for catching prey, but there has not been proof of carnivory. The dimensions of the traps led us to postulate that the subterranean leaves may function as highly specialised traps for catching protozoa. Both laboratory experiments and field studies proved that *Genlisea* can be regarded as a highly specialized protozoan trap.

Morphological and Phylogenetical Studies in the Genus *Nepenthes*

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After investigations of the systematic position of the Dioncophyllaceae (Schmid, 1964), the homologies of the pitcher of *Nepenthes* are discussed again (Schmid-Hollinger, 1970). The lid is interpreted as the apical part of the lamina and the spur as true apex of the leaf. Two strong lateral veins only enter the lid and form - by basal branching and fusing - a false midvein.

Special (teratological) bracts of *N. distillatoria* (Schmid-Hollinger, 1974) favour the hypothesis of micro-evolution rather than that of saltation, that means that such an elaborate organ like a pitcher was built up step by step and not by of macro-evolution.

The hairs of the Nepenthaceae (Schmid-Hollinger, 1971) show a great diversity: Simple multicellular, toothed tufted, rosette and arachnoid hairs. Simple, unbranched hairs are considered as primitive, arachnoid ones as derived. Phylogenetically derived species show branched hairs already in early ontogenetic stages. Below the peristome on the outside of the pitcher wall every species has a stripe of peculiar hairs. This is the zone where the developing lid is pressed on the outside of the pitcher wall.

The western species of the genus *Nepenthes* form a natural group. They are a model for phylogenetic research (Schmid-Hollinger, 1979). The recently described species *N. masoalensis* (Schmid-Hollinger, 1982) is a close relative to *N. madagascariensis*. Androphores and seeds are significantly shorter in this new species than in *N. madagascariensis*. The western group as a whole is characterized by panicles and has always unbranched hairs. among this group *N. pervillei* is highly derived and shows many reductions. Long shoot pitchers are normally suppressed. Differences concern the shape of the ovary, the tendency to reduce the number of carpels per female flower and the reduction of the wings of the seeds. The latter feature may be easily interpreted as analogous to the wingless flies on the islands of Kerguelen.

In this fascinating family many gaps of knowledge exist (Schmid-Hollinger, 1994). They should be filled in the near future. A deeper understanding of the pitcher is required, but the relations between pitchers and animals need more observations (Schmid-Hollinger, 1997) and experiments as well.

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Patterns and Phylogenies in *Drosera*; a Critical Review of Current Knowledge

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The Family Droseraceae has variously included *Drosera*, *Aldrovanda*, *Dionaea* and *Drosophyllum* amongst others. Only the genus *Drosera* is sufficiently speciose to form an opinion of its origin and dispersal through time.

This talk will review the historical classification of the family Droseraceae, the classification of *Drosera* per se and the impact of modern knowledge on our understandings of the relationships of the family and the genus. The various classifications curently offered will be compared with data from vegetative and floral morphology, micromorphology of the pollen and seeds, phytochemistry, cytology and molecular evidence.

Drosera in South Africa

Günter Eitz; 3 Cockle Close, Richwood, South Africa

South Africa has four climatic regions:

1. Summer rain areas as in the Transvaal with 600 to 750 mm rain mainly in summer.
2. Winter rain areas as in the Cape province with 500 to 750 mm rain mainly in winter.
3. Sub-tropical areas as in Natal with up to 1000 mm rain per year.
4. Semi-desert areas as in the Karoo with less than 250 mm rain per year with 90 % of the rain falling from July to September.

In all climatic regions *Drosera*, *Utricularia* and *Genlisea* grow during different seasons.

Due to these climatic differences we have also four groups of growing times:

First Group

Summer growing, winter dormant *Drosera* species in Transvaal as *D. dielsiana*, *D. natalensis*, *D. burkeana*. In cultivation these plants are evergreen, only lack of water makes them go dormant in winter.

Second Group

Winter growing, summer dormant *Drosera* species in the Cape as *D. cistiflora*, *D. pauciflora*, *D. alba*, *D. acaulis*, where *D. acaulis* is growing on mountains 2000 m and more high with winter temperatures below 0 °C and with snow, so this *Drosera* starts growing only at the end of September, flowers in December and then goes dormant. This group needs a dormant period in cultivation.

Third Group

Winter dormant due to temperatures between +5 °C and -1 °C and summer growing: *D. regia*. This *Drosera* hibernates in wither with one or two small leaves and grows from spring to summer with heights up to 70 cm and flowers in February. *Drosera regia* nearly disappeared in nature . Only tissue culture saved this plant from near extinction.

Fourth Group

Evergreen *Drosera* species as *D. collinsiae*, *D. aliciae*, *D. admirabilis*, *D. capensis*, *D. hilaris*, *D. cuneifolia*, *D. slackii*, *D. ramentacea*, *D. curviscapa*, *D. venusta*. This group can go dormant due to lack of water but this occurs quite rarely.

150 slides of *Drosera*, *Genlisea*, and *Utricularia* growing in their natural habitats will be shown.

Brazilian *Drosera* and Molecular Phylogeny of the Droseraceae

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Four carnivorous plant genera occur in Brazil: *Drosera*, *Genlisea*, *Utricularia*, and *Heliamphora*. Of *Drosera*, there are circa twelve recognized species in Brazil south of the Amazon Basin, and anywhere between seven and fifteen in northern Brazil. Many more species are likely to be discovered in both these regions and several already have been, but have not yet been published.

Starting in 1990, I began studying carnivorous plants in their native habitats in Brazil south of the Amazon Basin. Except for *D. intermedia* HAYNE, all the *Drosera* taxa known to be native to this region were located and studied at innumerable natural populations. These are: *D. brevifolia* PURSH., *D. capillaris* POIR., *D. chrysolepis* TAUB., *D. colombiana* FERNANDEZ-PEREZ, *D. communis* ST. HIL., *D. graminifolia* ST. HIL., *D. graomogolensis* T. SILVA, *D. hirtella* ST. HIL. var. *hirtella*, *D. hirtella* var. *lutescens* ST. HIL., *D. montana* ST. HIL. var. *montana*, *D. montana* var. *schwackei* DIELS, *D. montana* var. *tomentosa* (ST. HIL.) DIELS, *D. sessilifolia* ST. HIL., and *D. villosa* ST. HIL.

Most of these *Drosera* grow on sandstone highlands, at 500-2500m of altitude, often in what is known as "campo rupestre" (rocky field) vegetation. This consists of herbaceous or low woody plants occurring in sandy soils, and is actually very similar to what is found on the famous Venezuelan tepuis. A few species are common in disturbed areas of rainforest-covered highlands of Eastern Brazil and three species are even found in coastal sandy swampy areas known as "restingas". Some are perennial but at least one species is annual. Several often go through a winter dormancy period (which corresponds to the dry season).

These and numerous other species of *Drosera* from around the world -- including also the closely related *Aldrovanda vesiculosa* L. and two species of *Genlisea* -- have been sequenced for rbcL, a chloroplast gene, for a phylogenetic study. The results so far obtained will be used to discuss -- together with the existing DNA sequencing data -- phylogenetic relationships of carnivorous plants, especially at the subgeneric and section level in the genus *Drosera*.

Ecology and Conservation of Bornean *Nepenthes* (Nepenthaceae)

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Borneo is the centre of diversity for *Nepenthes* with 31 species currently recognised (Clarke 1997, Jebb & Cheek 1997). This represents the largest assembly of *Nepenthes* for any single landmass, with 24 species endemic to the island. Diversity in Bornean *Nepenthes* is greatest in montane forests (those which generally occur above 1000 metres above sea level (a.s.l.)). The majority of the montane species persist as a few small populations isolated on mountain ridges or summits, whereas the lowland species tend to be more widespread. A small number of species are the subject of taxonomic debate and uncertainty–no opinion on these taxa is advanced here, but for obvious convenience the interpretations of Clarke (1997) are followed.

The ecology of *Nepenthes* is complex. Although generally confined to acidic, nutrient-deficient soils, they occur in a variety of habitats from maritime rocks and beaches to ericaceous scrub more than 3000 m a.s.l. Lowland habitats in which they are common include peat swamp forests, *kerangas* (heath forests), *padang* (cleared areas or those with sparse secondary vegetation) and limestone. *Kerangas* and *padang* vegetation are the strongholds for lowland *Nepenthes* in Borneo and can be used as indicators of their presence. Interactions with animals range from prey capture and digestion to the provision of habitats for invertebrates. Prey capture strategies vary among different species, but remain little-studied. The invertebrate faunas comprise a wide array of different metazoan types, the community structure of which

has been examined in detail by several authors. Contradictory observations and theories abound in this field. New research into the roles of extra-floral nectaries promises to add considerably to our knowledge in *Nepenthes* ecology.

Published surveys of the conservation status of Bornean *Nepenthes* remain few. The most thorough estimates are provided by Simpson (1995) and by Clarke (1997), whose estimates are based on recent field observations. However, inaccuracies persist due to a continuing lack of knowledge of the distributions of several taxa. The species from Sabah, Sarawak and Brunei are reasonably well understood, but information from much of Kalimantan remains scant. Moreover, the recent effects of devastating forest fires upon the lowland species there are yet to be determined. Fortunately, most of the highland taxa from Kalimantan do not seem to have been affected by the 1997 fires, but the re-occurrence of severe fires in East Kalimantan this year, coupled with an ongoing drought, poses a further, enhanced threat. From a horticultural perspective, the role of CITES and the IUCN in the conservation of *Nepenthes* remains controversial, but often this reflects a lack of understanding of the objectives and functions of these institutions. Increased public awareness of the conservation status of *Nepenthes* is therefore essential in ensuring the preservation of remaining wild populations.

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Nepenthaceae in their Habitats

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Nepenthaceae (pitcher plants) are distributed especially in SE-Asia. Just single species also colonize Australia, New Caledonia, India, Sri Lanka, Seychelles and Madagascar. The highest degree of diversification is registered at the islands of Borneo and Sumatra. Nepenthaceae are usually inhabitants of poor soils in the tropics. Classically two ecological types of Nepenthaceae are distinguished: lowland species and highland species. Typical members of the lowland species are e.g. *Nepenthes mirabilis*, *Nepenthes gracilis* or *Nepenthes ampullaria*, which are growing in rather sunny and hot grassland areas, at the edge of lowland forests or swamp areas. Several of the lowland species are widely distributed. *Nepenthes mirabilis* has a vast distribution. This species can be found everywhere in SE-Asia and even in China and tropical Australia. Other species have been found just at some few locations, like *Nepenthes sumatrana* near Sibolga in Sumatra; *Nepenthes bellii* at single locations at Mindanao or *Nepenthes tomoriana* in Sulawesi. Many of these endemic lowland species are coastal, other endemic lowland species are restricted to a narrow area of limestone, as can be demonstrated e.g. at *Nepenthes northiana* or even more extremely in *Nepenthes campanulata*. Typical examples for highland species are *Nepenthes lowii*, *Nepenthes macrophylla* or *Nepenthes villosa*. These species are usually growing in between shrubs and low trees at higher altitudes on tropical mountains. Frequently they are highly endemic and have so far only been found at some very few or even single montane areas. So *Nepenthes dubia* is just recorded from one montane location in Central Sumatra; another highly endemic species is *Nepenthes aristolochioides*, which has just been recorded from some few specimens in a tiny habitat. Not all species that are known just from single locations have to be such strictly endemic. *Nepenthes ephippiata* has just been recorded from four expeditions at two locations in Central-Kalimantan, but it can be presumed that it could be rather common in that area. It remains very difficult to explore these areas. It is interesting to observe that frequently the same species shows slight but constant differences at different locations. So e.g. *Nepenthes singalana* is slightly but constantly different at nearly all known locations. It makes the taxonomy of *Nepenthes* rather complex, but it is a phantastic field to observe species diversification in

this young, vicariant family. It shall be demonstrated that the classification in highland and lowland species is rather rough. Besides these typical habitats, Nepenthaceae colonize several more ecological niches. Frequently these sites are very local and the typical *Nepenthes* species of these habitats are strictly endemic. *Nepenthes clipeata* for example is growing just at the edges of vertical cliffs at G. Kelam or *Nepenthes adnata* is growing just on shady, wet mossy walls in a tiny area in Central Sumatra. Several of these endemic species are in the meantime highly endangered or even extinct in their original habitats because of overcollection or habitat destruction. The original site of *Nepenthes campanulata* has been destroyed by fire and no other locations of it are known until now. One way to protect species of high demand from overcollection may be the artificial propagation of such species. It remains much more difficult to protect the original frequently very fragile habitats of *Nepenthes*.

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Nepenthes in Irian Jaya – A Field-Trip Report

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In 1994 I travelled to Irian Jaya as part of a group of 4 carnivorous-plant enthusiasts with the hope to find and study some of the very little known species of *Nepenthes* endemic to New-Guinea, such as *N. treubiana, N. vieillardii* (now *N. lamii*), *N. insignis*, *N. neoguineensis* and *N. danseriana*, yet undescribed at this time.

During our travel we visited various lowland habitats near Jayapura, were we found *N. neoguineensis*, *N. ampullaria,* a hybrid between both species and *N. mirabilis* which very frequently grows in open spots between secondary vegetation.

On Waigeo-Island we found the species now named *N. danseriana* by Jebb and Cheek in honour of the author of the most important work covering the genus *Nepenthes*. It was growing in a strange open habitat among lower vegetation.

The Anggi-lake-area is known for the extreme variability of *N. maxima* occurring there. We found a very impressive range of different forms of *N. maxima*, which seems to adapt to a wide variety of different habitats in the highlands of Irian Jaya. On open slopes *Drosera peltata* has also been observed occasionally.

Nepenthes insignis was found for the first time since many years, both near Tayeve, the *locus classicus* and on Biak-Island. The *N. insignis* on Biak-Island was very impressive since the habitat is located just a few hundred meters from the sea and the plants grow mainly as epiphytes in a mangrove-like forest. Plants from both locations differ slightly in size, pitcher shape and coloration.

After seeing *Nepenthes vieillardii* (now named *N. lamii* by Jebb and Cheek) in the wild on Mt. Doormans-Top it was quite obvious that the plant is not related to *N. vieillardii* from New Caledonia.

On a mountain near Mt. Doormans-Top, the location where we found *N. lamii*, a species which apparently is new to science was growing mainly at shady spots around 1800 m above sea level. Pictures of this species which is yet to be described formally will be presented during the talk.

On our trip to Mt. Doormans-Top we were unable to find *N. paniculata*, type material of which was collected on the mountain. Since our trip was on the mountain's southern slope, and the type specimen was collected by an expedition starting on the mountain's northern slope, we assume *N. paniculata* is restricted to the mountain's north face.

During the last part of our trip we studied *N. treubiana* in the McCluers-Gulf area. Plants were growing on rock faces of tiny islands just a few meters above sea-level

POSTERS

POSTER 1

Environmental Changes of the Natural Habitat and Growth of *Aldrovanda vesiculosa* L. at Hozoji Pond, Hanyu City

- Growth and Reproduction in *Aldrovanda vesiculosa* L.

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Hozoji Pond in Hanyu City, approximately 50 km (30 miles) north of Tokyo in Saitama prefecture, was the last *A. vesiculosa* (waterwheel plant) habitat in Japan. In 1967, the plant vanished from the site because of serious water pollution and a flood which caused ecosystem destruction (Komiya and Shibata, 1982). Since 1964, through cooperation with local organizations, the authors have been attempting various efforts to restore the environment and to conserve the species at the site. Ecological observations on *A. vesiculosa* at Hozoji Pond, particularly plant growth and reproduction recorded both before and after the extinction, are reported. In 1964, plants were collected at Hozoji Pond, and then the plants were put into floating baskets which were placed on the surface of the pond. During the period of May to October, stem length and the number of whorls were recorded regularly. In 1980, the same study, but using cultivated plants, was repeated. Plants were replaced every 2 to 4 weeks after each growth measurement. The observations were repeated 7 times over the same period. Stem length, lateral shoot length, the number of whorls and the number of daughter plants were recorded regularly. The main stem elongation rate was approximately 0.4 cm day^{-1} $plant^{-1}$ in both observations. The sharp decrease in the growth rate observed in July and August 1980 was due to lower water temperature and damage caused by herbivorous fish. The mean increasing whorl-number day^{-1} $plant^{-1}$ was 0.65 in 1964 and 0.68 in 1980. Statistical analysis showed no significant difference on the mean whorl-number / stem-elongation ratio between the two studies, 1.5 whorls cm^{-1} $plant^{-1}$ in 1964 and 1.8 whorls cm^{-1} $plant^{-1}$ in 1980. The results showed that the plant produced a lateral shoot on the stem every 3 to 4 cm (or 5 to 7 whorls) under optimum conditions. Consequently, reproduction by lateral shoots was accelerated and up to 20 daughter plants were reproduced from one plant when the growth rate was higher. Although the plant flowers in summer, no record of seed reproduction has been reported. It is surprising that no significant difference was seen on the growth rate between the two studies. However, water pollution and eutrophication of the pond have actually become more serious. Without artificial protections, conserving the species at the site will be impossible. In 1994, as a result of reintroduction of plants to the pond, a number of turions successfully overwintered, but in the following spring all the plants were eaten by herbivorous fish and tadpoles which have increased in number in recent years (Komiya, 1996). These problems illustrate that it is difficult to restore an ecosystem which has been disturbed.

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POSTER 2

A Comparative-Study of *Pinguicula ramosa* MIYOSHI and *P. variegata* TURCZ. Ecology and Morphology

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Pinguicula ramosa MIYOSHI and *P. variegata* TURCZ., both classified in the subgenus Temnoceras, are considered to be distinct species (Casper, 1966). Even though there are some morphological differences between the two species, Ernst (1961) considered that the former was a 'form' of the latter species. In 1997, the authors studied the little-known species *P. variegata* in habitat on the Russian island of Sakhalin. The ecological and morphological differences between *P. ramosa* and *P. variegata* are discussed.

Ecology. *P. ramosa*, an extremely rare Japanese endemic species, is confined to the Nikko Mts., at an altitude of between 1,500 and 2,000 m (4,500-6,000 feet), and grows upon wet vertical or overhanging rocks. This species usually occurs as scattered individual plants. *P. variegata*, widely distributed across eastern Russia, grows in bogs and wet grassland, and often forms colonies of up to 20 plants.

Morphology. Both species are very small perennial rosette herbs. A very clear morphological difference between the two species can be seen in the flower stalks. The flower stalks of *P. ramosa* are often branching, hence the Latin name (*ramosa* = branching), i.e. Y- or Ψ-shape, and the length is usually not more than 8 cm. *P. variegata*, on the other hand, has a single straight flower stalk reaching up to 13 cm. The flower colour of the two species is similar being pale reddish/purple to white. However, the corolla of *P. variegata* is slightly larger and the corolla lobes are longer in comparison to *P. ramosa*. The central lobe of *P. variegata* (6-7 × 4-5 mm) is wider than that of *P. ramosa* (3.5-5 × 2.5-4 mm), and has a single large yellow spot, while that of *P. ramosa* has two small yellow spots. The spur of *P. variegata* is sometimes longer and only slightly thicker (4-5 × 1.5-2 mm) than that of *P. ramosa* (3-5 × 0.8-1 mm). The calyx of *P. ramosa* is clearly divided into 3 upper lobes and 2 lower lobes, but that of *P. variegata* is radially symmetric. The leaf-blade of *P. ramosa* is ellipsoidal to oblong (10-15 × 5-10 mm), bright yellowish green, while that of *P. variegata* is orbicular (5-7 mm), tinged with dark red. *P. ramosa* forms short petioles, but *P. variegata* forms long underground petioles, which sheathe the base of the flower stalk. The numbers of chromosomes, 2n=18 in *P. ramosa* (Yoshimura, 1973) and 2n=64 in *P. variegata* (Zhukova and Tikhonova, 1971), shows a great difference. Although a taxonomically close relationship has been pointed out, many differences can likewise be seen between the two species. Ernst (1961) suggested that *P. ramosa* was a 'form' of *P. variegata*, without having seen any flowers of *P. ramosa*. The authors consider that *P. ramosa* made its speciation at a relatively early evolutionary stage.

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POSTER 3

Nepenthes - from Carnivory to Myrmecophyty

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The genus *Nepenthes* L. is well known for its carnivorous lifestyle. Recent research indicates the relationship between *Nepenthes* and visiting animals to be much more complex then just a predator-prey interaction (Clarke 1997; Clarke and Kitching 1995). *Nepenthes bicalcarata* HOOK. f. is outstanding because of the combination of carnivory and myrmecophyty. The phytotelmata of the pitchers and their faunal diversity have been studied recently by various authors (*e.g.* Beaver 1983). Much less attention has been paid to the obviously diverse *Nepenthes*-ant-interactions "outside the pitcher". For understanding these, the investigation of *Nepenthes bicalcarata* - ant relationships appear especially appropriate. These as well as interactions between ants and selected *Nepenthes* species (*N. albomarginata., N. ampullaria, N. gracilis, N. mirabilis var. echinostomata, N. rafflesiana*) were performed in Brunei.

Predator-prey: Predator-prey interactions obviously are an important part of the relationships between *Nepenthes* and ants. For a considerable number of *Nepenthes* species (*e.g. N. mirabilis*, *N. rafflesiana*) ants are the principal animal group trapped in the pitchers (Moran 1996; own observations). Nevertheless, only parts of the visiting ant species get trapped easily, others move safely on the plants. Some features of *Nepenthes* and special ant species are fundamental not only for coexistence and unspecific (mutual?) relationships but also for specific interactions between *N. bicalcarata* and *Camponotus schmitzi* STÄRKE.

Myrmecophytic features: Three characters observed in *Nepenthes* and visiting ants are regarded as most important for the evolutionary development of myrmecophyty and carnivory: extrafloral nectaries (EFN), nesting sites provided by the plants and moving abilities of ants on the plants.

EFN are - as attractant - of principal importance for ant-plant-relationships and are regularly visited by several ant species. Some *Nepenthes* species appear to be especially attractive to ants. Most nectaries are easily accessible except for those located in the peristome area. Ant species have different "moving abilities" in this zone. Some species lack the ability to move on the peristome and frequently fall into the pitchers. In addition to *C. schmitzi* also other ants move safely in this area and usually do not get trapped. A third group is able to move on the peristome but nevertheless constitutes a considerable part of the prey. Old, often dried pitchers provide nesting sites for ants and are colonised. Structures like hollow tendrils are not unique to *N. bicalcarata*. N. rafflesiana (giant form) has hollow tendrils too and is sometimes colonized. The studied ant - *Nepenthes* - systems display a variety of interactions with different tendencies towards carnivory or myrmecophyty.

Herbivore damage: Observations on herbivore damage revealed differences among the species. *N. bicalcarata* proved to have the least herbivore damage among the observed species. This fact in combination with a comparatively long pitcher "life" (Clarke 1997) suggests a protective function of ants.

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POSTER 4

The Model Case *Nepenthes bicalcarata* HOOK. f. - Structure and Function of the Nectaries of a Carnivorous Ant-Plant

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Extrafloral nectaries (EFN) occur in species of Nepenthes in all parts of the plant above ground. Unique nectar secreting structures are found in Nepenthes bicalcarata where the upper part of the peristome is enlarged forming two thornlike structures. Their function is up to now unclear. The following explanations have been discussed: role in attracting/trapping of prey (Clarke 1993), protecting against pitcher exploiting animals (Burbidge 1880) and no specific function (Dodd, C. 1982). Our studies revealed that the structure of the thorns and the patterns of nectar secretion are extraordinary in the genus *Nepenthes*. An interpretation of these nectaries seems only possible in the context of the system *N. bicalcarata* - *Camponotus schmitzi* STÄRKE.

Temporal and spatial pattern of nectar secretion in *Nepenthes bicalcarata*

The amount of nectar secreted proved to be extraordinary high in *N. bicalcarata*. Even more striking was the temporal and spatial pattern of secretion observed in the leaves of this species. Nectar is secreted in large amounts and for a considerable time before the pitcher is opened, and in parts of the leaf distant from the pitcher. In other words, a large amount of "costly" nectar is secreted without direct connection to prey trapping. We regard this feature - occurring only in *Nepenthes bicalcarata* - as additional evidence for the presence of a myrmecophytic system in *N. bicalcarata* and *C. schmitzi* (see also Fiala, Linsenmair & Maschwitz 1994). This hypothesis was confirmed by field studies. The nectaries are regularly visited by *C. schmitzi* and various other ant species. While the formers only very exceptionally get trapped in the pitchers, other observed ants form an important part of the trapped prey. So far, the relationship of *N. bicalcarata* and ants is by no means clear. The plant produces large amounts of nectar, which is harvested by *C. schmitzi* and several other species. While the advantages to *C. schmitzi* are quite obvious, the benefits to *N. bicalcarata* are still questionable.

Nectary types in *Nepenthes bicalcarata*

3 principal types of EFN occur in *Nepenthes*. *N. bicalcarata* is unique in having 4 nectary types: by far the largest single nectaries are located in each of the two thornlike peristome structures. The latter secrete considerable amount of nectar, often visible as droplets hanging from the tip of the teeth. The function of these structures is difficult to interpret. Keeping their energetic costs in mind, an exclusively protective function (against animals exploiting traps, Burbidge 1880) or no function at all (Dodd 1982) can be excluded. The only convincing explanation is that the structures are of importance for attracting prey or/and for the *N. bicalcarata* - *C. schmitzi* interaction. We regard the latter as especially important, for these structures have only evolved within one species obviously in combination with myrmecophyty.

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POSTER 5

Atlanta Botanical Garden – Collections and Conservation Program

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Officially incorporated in 1976 on land belonging to the City of Atlanta in Piedmont Park (the city's largest communal park), the Garden's mission is to develop and maintain plant collections for the purposes of display, education, conservation, research and enjoyment. ABG is a private, non-profit botanical garden overseen by a Board of Trustees, with over 40 staff, upward of 300 volunteers, and a 10,000-strong membership base.

Collections

Like many urban botanic gardens, ABG makes the most of the 30 acres it occupies within a busy metropolis. The outdoor collections offer botanists, horticulturists, and the general public a series of different landscapes to explore. These range from the traditional, such as the Japanese and Rose Gardens, to the more informal, such as the Woodland Garden and Storza Woods. The latter is an example of the few remaining acres of mature hardwood forest found within the metropolitan area.

The centerpiece of the Garden is the Dorothy Fuqua Chapman Conservatory that was opened to the public in 1989. The Conservatory covers 1500 m^2 (16,000 square feet) and is serviced by backup greenhouses covering 930 m^2 (10,000 square feet). The collections focus on under-represented and endangered plant groups. They include Old World desert collections, Old World island palms that follow an island biogeographical theme, and other conservation collections including tropical conifers, orchids, cycads and carnivorous plants, ABG also houses a collection of poison dart frogs that are on public display with interpretive signage, in the Conservatory lobby.

Conservation Program

ABG's Conservation Program encompasses a number of regional and international projects and is based on a hands-on and project-driven approach. The key to this Program has been to work directly with local landowners, to bring as many of the relevant agencies, botanical institutes and organizations into collaboration, and to disseminate the staff's horticultural and botanical expertise to as wide a field as possible. One of its major goals is to use low-cost restoration and recovery techniques.

Projects include:

- Monitoring, restoration and conservation of unique and species-rich bog communities – these are found throughout the Coastal Plain and Southern Appalachian Mountains of the southeastern USA, ABG has developed restoration, management and propagation techniques to restore these communities and re-establish certain processes crucial to the maintenance of species diversity.
- Georgia Plant Conservation Alliance (GPCA) - ABG is a charter member of this network of government, private and public gardens and organizations that are working to conserve the endangered flora and ecosystems of the state of Georgia, including many rare carnivorous plant species.
- Micropropagation Laboratory – ABG not only propagates plants for recovery projects, but raises money for its Conservation Program through the development and marketing of unusual plant forms and cultivars, including an all red form of the Venus flytrap ('Akai Ryu' - Red Dragon developed by ABG staff member, Ron Gagliardo).
- Maquipucuna Foundation, Ecuador – ABG has a mutual collaboration with the Maquipucuna Foundation in order to exchange expertise, plant collections, and carry out field research. Staff from Ecuador can come to ABG through ABG's International Intern Program to develop their horticultural and botanical training.
- International Intern Program – To date, ABG has funded interns from Sabah, UK, China, Brazil and Ecuador to carry out conservation and horticultural projects.

POSTER 6

The Naples Botanical Garden: Educational Itinerary Achieving its Goals through the Observation of Insect-Eating Plants

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A carefully prepared educational itinerary, the initial approach to which involves the observation of insect-eating plants, can be used to raise the environmental awareness of schoolchildren through the combined efforts of University Research Institutes, such as the Naples botanical gardens, and the local schools.

POSTER 7

Pinguicula hirtiflora TEN.: An Insect-Eating Plant in Need of Protection in the Campania Region

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The Naples botanical gardens has long been committed to projects aiming to safeguard and reintroduce endangered plant species, especially as far as the Campania region is concerned. These technical scientific programs pay particular attention to the local endemic flora. One example is *Pinguicula hirtiflora* TEN., which is found in relatively high numbers in the Valle di Bonea and the Vallone delle Ferriere areas of Salerno province.

Paolo De Luca: Professor of botany with the Naples University, Director of Naples botanical garden since 1981.
Edoardo Pinto: Technical Collaborator with the botanical garden of Naples University since 1984, CITES responsible, he is in charge of the educational project itinerary of carnivorous plants in the Naples botanical garden.
Ottavio Iovane: External collaborator with Naples botanical garden concerning carnivorous plants.

POSTER 8

Some Field Information about South Spanish Carnivorous Plants

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Five genera of carnivorous plants are native to Europe (*Aldrovanda*, *Drosera*, *Drosophyllum*, *Pinguicula* and *Utricularia*). Except for the very rare *Aldrovanda vesiculosa* L., 4 of them are growing in Spain. This poster shares some experience gained during two field trips in South Spain between 1994 and 1996. Three species will be considered:

- the Portuguese Sundew *Drosophyllum lusitanicum* (L.) LINK, a pioneer plant, growing alone in extremely dry and hot conditions.
- the butterwort *Pinguicula vallisneriifolia* WEBB, the leaves of which can reach a length of 30 cm, with a lizard that is an unexpected thief of the prey.
- and also the new species *Pinguicula mundi* BLANCA, JAMILENA, RUIZ-REJON & ZAMORA with several photographs of its biotope alongside the Rio Mundo river.

POSTER 9

Bugs and Insectivorous Plants - A Current Review

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Paul Debbert; München, Germany
Renate Burda; Sauerlach, Germany
Markus Fischer; München, Germany

Since the last century bugs living on insectivorous plants have been described. In the last years some new species were found. We know bugs on following plant genera:

- *Roridula*
- *Drosera*
- *Byblis*

Only carnivorous bugs live on these plants in a special kind of 3-dimensional symbiosis. During the last 3 years we have studied these bugs in nature, in cultivation and by literature research and we compared their biology with the biology of some Reduviidae.

The results showed us that the carnivorous plant bugs are highly specialized to the plants and they are not able to live without these plants.

The symbiosis enables the bugs to eat insects 100 times heavier than themselves.

POSTER 10

Secondary Metabolism of Nepenthales

Jan Schlauer, Heiko Rischer, Michael Wohlfarth, Markus Rückert, Matthias Wenzel,
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The order Nepenthales has only recently been redefined on the basis of homology comparison studies of the rbcL (Fay & al., 1997) and 18S rDNA (Soltis & al., 1997) genes, which revealed a close phylogenetical relationship between families that have formerly been assigned to widely separate positions in the natural system. It comprises the families Polygonaceae, Plumbaginaceae, Simmondsiaceae, Nepenthaceae, Droseraceae, Drosophyllaceae, Dioncophyllaceae, Ancistrocladaceae, Frankeniaceae, and Tamaricaceae. Including more different carnivorous plant families than any other order of flowering plants, Nepenthales is a sister group to Caryophyllales. All carnivorous and some of the non-carnivorous Nepenthales have unique glands in which the secretory tissues are separated from the tissues beneath by one or few endodermoid cell layers. These glands are vascularized in the carnivorous members. While Caryophyllales are characterized phytochemically by the widespread presence of betalain pigments, which are not found in other flowering plants, Nepenthales are almost as distinct by the common possession of polyketide metabolites, which are found only in a few cases outside this order. Thus, studies of their secondary metabolism yield valuable information both on the physiology and the systematics of these plants.

The metabolites most widespread in Nepenthales are naphthoquinones like plumbagin, which are formally composed of six molecules of acetate (hexaketides). Other widespread compounds are isoshinanolone, droserone, and 7-methyljuglone. Naphthylisoquinoline alkaloids (Bringmann & Pokorny, 1995), unique biaryl componds sharing important structural properties with the naphthalene derivatives mentioned, probably originate from similar biosynthetic precursors. These alkaloids are only known from two small families of Nepenthales, *viz*. Dioncophyllaceae (three monotypic genera in W Africa, among which *Triphyophyllum* is carnivorous) and Ancistrocladaceae (only genus, *Ancistrocladus*, with 20 species from W Africa to Borneo), which confirms their close relationship.

Feeding experiments in which ^{13}C labelled alanine was applied to the insect-trapping organs of *Triphyophyllum peltatum*, the label has been detected in shoots and leaves after an incubation of three days

(Bringmann & al., 1998). This proved the uptake and the redistribution of the amino acid (a common digestion product of animal proteins), completing the carnivorous syndrome of this species.

The acetogenic nature of plumbagin and isoshinanolone has been established by feeding ^{13}C labelled acetate to callus cultures of *A. heyneanus* and NMR investigations of the formed metabolites (Bringmann & al., 1998). The folding pattern of the intermediate polyketide that has likewise been deduced from these studies suggests a hypothesis on the biosynthesis of isoquinoline derivatives and naphthylisoquinoline alkaloids.

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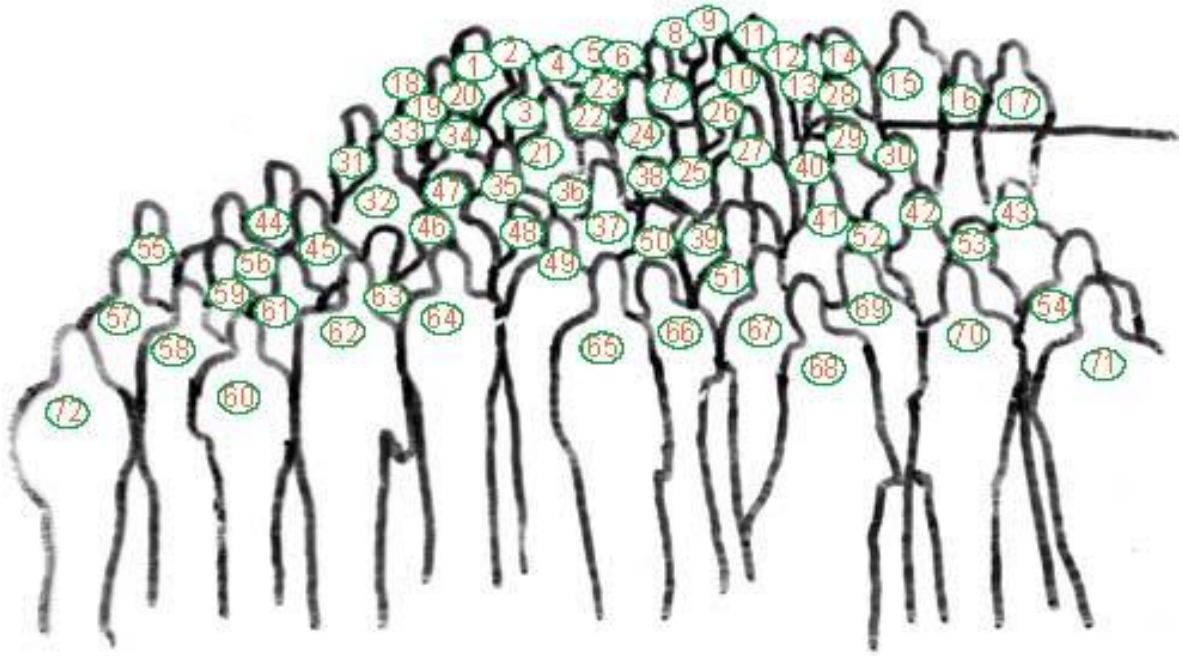

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