NEPENTHES - THE MARVELOUS HERB

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Sarracenia spp.

Heliamphora spp.

Darlingtonia californica

Carnivorous plants exhibit one of nature's wonderful adaptations for living in harsh environments. They have specialized mechanisms to obtain some or most of their nutrients by trapping vertebrates or invertebrates. Currently there are 630 carnivorous plants and over 300 photo-carnivorous plants. (plants which trap prey but do not have an ability to digest).

Carnivorous plants display various trapping mechanisms in capturing prey such as: Pitfall traps (Pitchers which trap prey in a leaf cup containing digestive enzymes), Flypaper traps (contains sticky mucilage), Snap traps (captures prey with rapid leaf movements), Bladder traps (sucks prey using a bladder like organ that creates a vacuum) and Lobster-pot traps (forces prey to move towards the digestive organ).

Pitcher plants are one of the common groups of carnivorous plants that use pitfall traps in capturing prey. They belong to Family Nepenthaceae (Tropical pitchers or monkey cups) and Sarraceniaceae with three genera *Sarracenia* spp. (North Americal pitchers or Trumpet pitchers), *Heliamphora* spp. (Sun pitchers) and *Darlingtonia californica* (California pitcher).

Among them Nepenthes is the most common group of carnivorous plants

Genus Nepenthes; Monkey cups

Nepenthes commonly known as monkey cups or pitcher plants are a genus of carnivorous plants in the family Nepenthaceae. It comprise of 140 species consisting of natural and cultivated hybrids. The name monkey cups originated due to the fact that monkeys have been observed drinking rainwater from the flower.

The earliest record of Nepenthes dates back to the 17th century. In 1658 French colonial governor Etienne de Flacourt described the plant Amramatico that later became *N. madagascariensis*. This was followed by *N. distillatoria*, endemic pitcher to Sri Lanka, in 1677. One of the earliest illustrations of the Nepenthes appeared in Leonard Plukenet's Almagestum Botanicum in1696.The name Nepenthes was first published in 1737 in Hortus Cliffortianus by Carolus Linnaeus.

Interest on Nepenthes grew throughout the 19thcentury and the 1880s are considered to be the "Golden age of Nepenthes" where most of the plants species were identified. However the popularity of the plants came down with World War II in the 20th century. In the 1960s the interest on cultivation and study on Nepenthes grew with the experiments of Japanese botanist Shigeo Kurata.

The Plant

Nepenthes is a liana-forming plant with a shallow root system. The stem is several meters long and from the stems arise alternate, sword-shaped leaves with entire leaf margins ending in an apical tendril. At the end of the tendril the pitcher forms. Flowers occur in racemes or rarely in panicles. The plants are unisexual.

The seed is a four sided capsule with 50-500 wind distributed seeds, a central embryo and two wings.

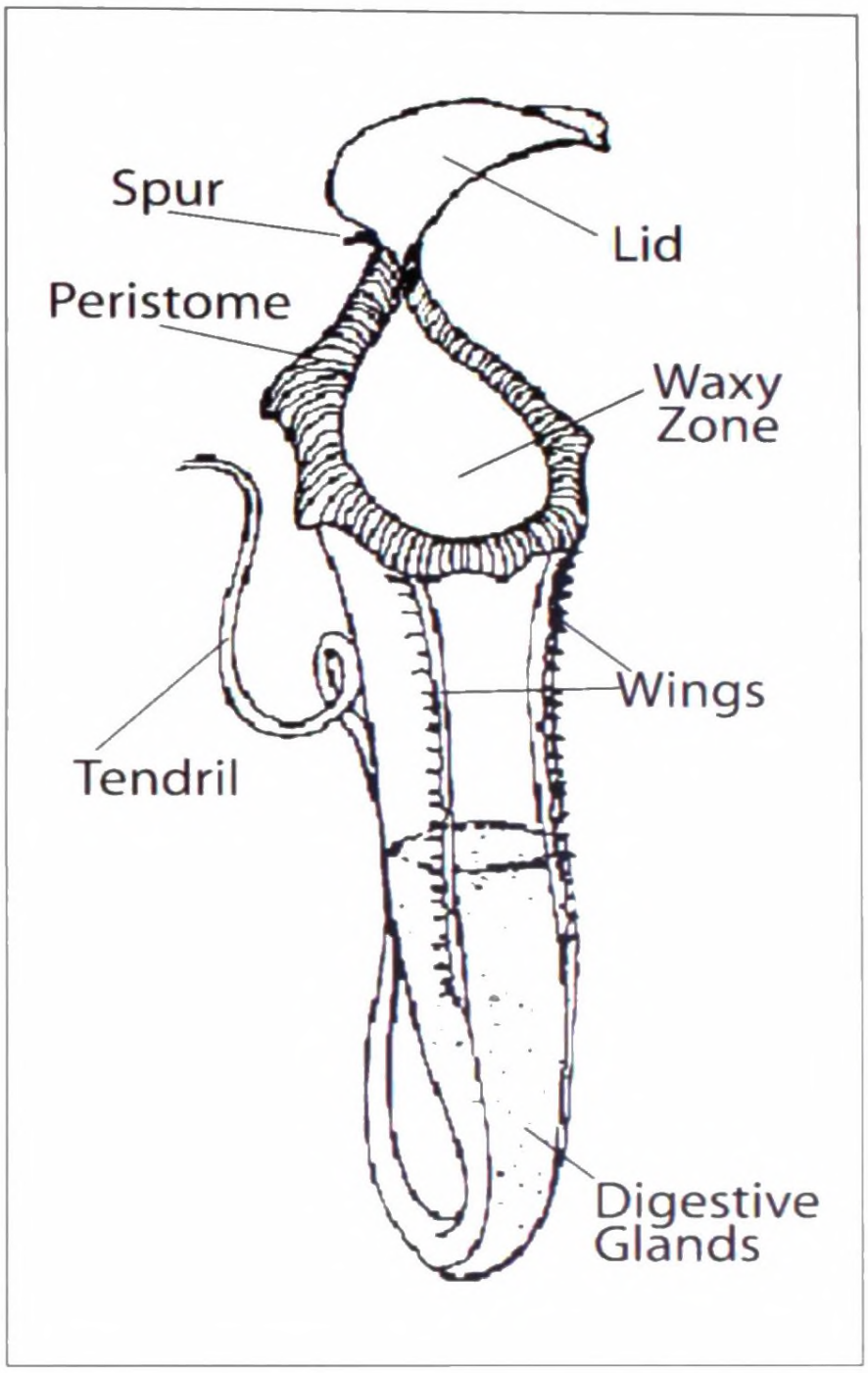
Classification

Kingdom: Plantae
Order: Caryophyllales
Family: Nepenthaceae
Genus Nepenthes

The Deadly Trap

The pitcher starts as a small bud in the beginning which then expands to form a tube or globe shaped trap.

The Peristome, which is a lip like structure surrounding the entrance area is slippery and often colourful, attracting prey to the trap. The lid, or operculum contains nectar glands underneath, being another attractant to prey. The upper inside part of the trap has a waxy coating that prevents prey from escaping and the bottom inside part contains glands which absorb nutrients from the captured prey.



The trap is of two types (dimorphic). Pitchers at the base of the plant are large and low and sit on the ground whereas the pitchers in the upper part are smaller and differently coloured from the base pitchers. This factor makes identification of species difficult.

In a recent study Ulrike Bauer et.al., found that the capture efficiency of the pitchers varies with the peristome wetness which is dependent on rain, condensation and nectar secreted from peristome nectarines. Further it was found through studies, that capturing of the prey is most efficient during the evening, night and early morning and is highly ineffective when the nectarines are removed. The trapping efficiency of the plant remains high although it is diluted by the rain.

A B

Nepenthes distillatoria

a) Aerial / upper pitcher & b) rosette bottom pitcher

(www.joachim-nerz.de/distillatoria1.htm)

The Fluid

The picher contains a watery or syrupy fluid that is produced by the plant. Proteases are the major group of enzymes found in the pitcher fluid. According to Fraizer[8] the first enzyme in the pitcher fluid was studied by Steckelberg et al followed by Nakayama[7] who identified 'Nepenthesin,' the first protease. Later Athauda et al[2] purified Nepenthesin I and II from *N. distillatoria*. Hatano et al[9] identified seven proteases; β-D-xylosidase, chitinase, β-1,3-glucanase, thaumatin-like protein, Nepenthesin I and II in *Nepenthes alata*.

Different Napthoquinones including plumbagin[11,13,14] 5-O-methyl droserone[11] 2-methylnapthazarin[11] droserone[11,14] octadecyl caffeate[11,14] isoshinanolone[11,14] etc that possess antimicrobial properties were also identified.

Apart from the protease activity, lipase activity was recorded in *N. distillatoria*[4] and *N. macferlanei*[10] and alkaline phosphatase, phosphoamidase, esterase C4 and C8 activities were recorded in *N. hybrida*[9].

Nepenthes distillatoria

This is the only pitcher species found in Sri Lanka and the plant is endemic to Sri Lanka. This plant was described as *Miranda herba* (marvelous herb) in 1677 by Bartholinus as the second pitcher identified. It is described as *Bandura zingalensium* by Dutch Merchant Jacob Breyne in 1680 and in 1737 Linnaeus named this plant genus as Nepenthes. In 1683 it was again described by H.N. Grimm and that was the first illustration of the tropical pitcher plant.

According to the recent studies on *Nepenthes distillatoria* it was found that the pitcher fluid was composed of viscoelastic biopolymers including proteinases (Nepenthesin I, Nepenthesin II)[2] DNases (DNase1, DNase2, DNase3, DNase4)[3] lipases[4] glycosidases[5] and phosphatases[6]

Prey and Inhabitants

Prey of pitchers usually consists of insects, but some pitchers like *N. rajah* have recorded the capture of large prey such as rats, lizards and small birds.

There are over 100 species recorded as inhabiting the Nepenthes species of plants and these are classified as

- Nepenthebionts: Organisms specialized to live inside and are dependent on them at least during some stage of their lives.
- Nepenthephiles: Organisms that are frequently found but not dependent on pitchers.
- Nepenthexenes: Organisms that are occasionally encountered in pitchers.

Distribution and Habitat

These plants are inhabited mostly in old world tropics ranging from South China to Madagascar. The greatest diversity is found in Borneo and Sumathra, with many endemic species.

Depending on the area they occupy Nepenthes are graded into Lowland and Highland species.

Figure 1: Distribution of Genus Nepenthes

Lowland *Nepenthes* require continuous warm climates with little variation between day and night whereas highland species need warm days and cooler nights. Many of the Nepenthes spp are lowland species and most of them prefer areas with high humidity and precipitation and moderate to high light levels. They are often found in soils that are acidic and low in nutrients such as peat, white sand, sandstone and volcanic soils. Some of them are also found at soils with high heavy metal content *(N. rajah)*, sandy beaches, sea spray zone *(N. Albomarginata)*, inselbergs and as lithophytes and epiphytes *(N. inermis)*.

Uses of Nepenthes

• Ecological Value:

Nepenthes play an important role in its niche. It builds symbiotic relationships with many fauna such as providing tendrils for Carpenter ants to build nests. Carpenter ants consume large prey of the pitcher benefiting the pitcher by reducing the harmful nitrogenous waste load. It also provides niche for insect fauna of various types including spiders, mites, ants, etc.

• Medicinal Value

Prey of Nepenthes provides a good source of food for the plant as well as for other macro and microorganisms. To prevent insects from decomposing due to fungal activity before the plant is able to digest them,secondary metabolites are produced by the plant. These are used for the development of novel drugs for microorganisms.

Jessica et al[11] reported that *N. khasiana*, produces pure antifungal compounds (napthoquinones) which are able to kill *Candida albicans*. Napthoquinones also demonstrate antiviral, anticancer, anti-allergic, anti-inflammatory and anti-bacterial properties.

Likhitwitayawuid[12] has isolated 5 secondary metabolites from *N. thorelii:* isoshinanolone, plumbagin, octadecylcaffeate, 2-methylnaphthazarin, and droserone that demonstrate anti-malarial potential.

In his study Shin[13] has reported that plumbagin, one of the Napthoquinone that can be isolated from *N. rafflesiana, N. thorelii, N. gracilis and N. insignis,* exhibit insect antifeedant, cardiotonic, anticancer, antimicrobial and antimalaria activities.

It is known that in the traditional treatment of whooping cough in Sri Lanka the contents of the cup in Nepenthes has been popularly used.

• Ethno-cultural Value:

Nepenthes spp. is being used over centuries by the tribal people in many areas of the world for various cultural activities. Tribes in Philippines use it as a container, whereas Indonesian tribes use Nepenthes for making ropes. Papua New Guinian tribes use Nepenthes as a cultural accessory to garments worn at their festivals[15].

• Economic Value:

Propagation for the ornamental plant trade for Nepenthes is a new trend in many areas where they grow.

• Other Uses:

Nepenthes are used for horticultural purposes, as a garden plant and as a tourist attractant in many countries (eg: Sabah, Malaysia).

Pitchers under Threat

One of the major issues of concern is that all the carnivorous species including Pitchers are under increasing threats of extinction. Some of the pitchers (eg: *N. khasiana*) are included in the endangered list of IUCN Red list and CITES Appendices 1 & 2. The threat is mainly due to the collection of specimens and habitat destruction. Thus it is our responsibility to avoid over exploitation of these marvelous plants and conserve them to maintain the ecological balance of nature.

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A Dilemma

Nitrogen is one of the most abundant elements of nature. It is the key to modern agriculture. Without this element the machinery of photosynthesis cannot function and no protein can form and no plant can grow. The crops, on which the bulk of humanity depends for survival, Rice, Wheat, and corn are among the most nitrogen hungry of all crops. They demand more than nature alone can provide. Modern chemical technology comes to our aid trapping nitrogen from the atmosphere to produce the nitrogen fertiliser which is abundantly used to sustain modern agricultural production. More than a hundred million tons applied worldwide every year fuels bountiful harvest of grain. Our planets' soil could not without the aid of artificial fertiliser provide sufficient food crops to feed seven billion of us. Yet this modern miracle exacts a price. Runaway nitrogen is suffocating wildlife in lakes and estuaries, contaminating ground water and even warming the globe's climate. As the world looks to feed the oncoming billions of more mouths, the question arises how much clean water and clean air will survive the demand for fertile fields. This is the Nitrogen dilemma.