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Carnivory in pitcher plants: An enigmatic meat eating plant

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ABSTRACT

Pitcher plants are chiefly carnivorous by nature, as per the name they are meat eater plants. They mainly feed on small insects, small animals and often some small birds which are attracted towards these mysterious meat eater plant. They have admirable colors property, sweet secretion, and production of secondary metabolite for digesting their prey. There habitat on which they grow in scantily developed soil and obtain main nutrient through entrapping their prey. They produce extra nitogen and it contains largest group of pitcher plant families. Nepenthaceae and Sarraceniaceae are the best-known and leading groups of pitcher plants and in India three families are known. Involvement of the mechanism and Digestion are related to these two main leading families. For the medicinal purposes they are mostly used and often as ornamental plants they are mostly preferred. Future need of these plants could replace pesticides; these plants could be grown in between the other crops in order to entrap pest and other insects which are mainly responsible for annihilation of crops.

KEYWORDS

Pitcher plant families;
Trapping mechanism;
Digestion;
Importance;
Uses.

INTRODUCTION

Have you ever heard of meat-eating plants? Just like several animal species, various plant species are carnivorous—that is, they consume insects and other small animals for a primary source of nutrients and minerals for growth. Instead of actually eating insects, carnivorous plants trap them by various means, depending on the kind of plant. After animals such as flies, grasshoppers, and spiders are trapped, a pool of enzymes secreted by the plant digests the prey. They are also known as pitcher plants, Carnivorous plants, and Insectivorous plants. The insectivorous plants often have numerous attractions such as dazzling colors, sweet secretion and other prying to lures their innocent victims.[1]

Carnivorous plants have adaptations to draw in and trap animals, and absorb nutrients from their bodies. Most carnivorous plants are moderately diminutive, and incapable of preying on anything superior than insects (the term "insectivorous plant" is sometimes used), though a few are known to trap lizards, rodents, and small birds. Carnivorous plants contain chlorophyll and can use photosynthesis to make carbohydrates, like common plants. But, they grow in habitats with poor soil, and benefit from the extra nitrogen and other nutrients that they can obtain from capturing animals. The purpose of carnivory may be to advance the competitive advantage of the plant through increased biomass or through flowering and seed set[2-4]

Here the leaf lamina is modified into a pitcher like structure the leaf apex is modified in to the lid of the pitcher. The colourful closure is lined with a ring of nectar glands. The upper region of the pitcher bears many digestive glands followed by a slippery surface. Its bottom contains acidic fluid. Insects trapped by the pitcher are digested by the enzymes secreted by the glands and absorbed by the pitcher. Carnivorous plants are found in many parts of the U.S., but are particularly abundant and diverse in some floodplains and small wetlands in the South-east. Pitcher plant available in India is *Nepenthes khasiana*.[5-10]

Pitcher plants are carnivorous plants whose prey-trapping mechanism features a deep cavity filled with liquid known as a pitfall trap. It is far and wide implicit pitfall traps evolved by epiascidiation (infolding of the leaf with the axadial or upper surface becoming the inside of the pitcher), with selection pressure favoring more deeply cupped leaves over evolutionary time. The pitcher trap evolved in independently in three eudicot lineages and one monocot lineage, representing a case of convergent evolution. Some pitcher plant families (such as Nepenthaceae) are placed within clades consisting mostly of flypaper traps, signifying that some pitchers may have evolved from the common ancestors of today's flypaper traps by loss of mucilage.[11-13]

Foraging, flying or crawling insects such as flies are attracted to the cavity formed by the cupped leaf, often by visual lures such as anthocyanin pigments, and nectar bribes. The rim of the pitcher (peristome) is slippery, when moistened by condensation or nectar, causing insects to fall into the entrap. Pitcher plants may also contain waxy scales, protruding aldehyde crystals, cuticular folds, downward pointing hairs, or guard-cell-originating lunate cells on the inside of the pitcher to ensure that insects cannot climb out. The small bodies of liquid contained within the pitcher traps are called phytotelmata. They drown the insect, and the body of it is gradually dissolved. This may occur by bacterial action (the bacteria being washed into the pitcher by rainfall) or by enzymes secreted by the plant itself. Furthermore, some pitcher plants contain mutualistic insect larvae which feed on trapped prey, and whose excreta the plant absorbs. Whatever the mechanism of digestion, the prey items are converted into a solution of amino acids, peptides, phosphates, ammonium and urea, from which the plant obtains its mineral nutrition (particularly nitrogen and phosphorus). Like all carnivorous plants, they grow in habitat where the soil is too poor in minerals and/or too acidic for most plants to survive.[11,14]

In cultivation, carnivorous plants require specialized conditions. The soil should be acidic and low in nutrients: here at the UConn greenhouses, they grow most species in a mix of five parts sphagnum peat moss, two parts perlite, and one part horticultural charcoal. Almost all carnivores do paramount in humid conditions, and soil that is constantly wet. The plants should be watered with rain or deionized water, to avoid mineral accumulation in the soil. Most species also require high intensity light levels, and the bulk of the UConn collection is kept in the very sunniest part of the greenhouse complex. Carnivorous plants are also grown by in-vitro propagation method.

Trapping mechanisms of pitcher plants

Carnivorous plants comprise six essential trapping mechanisms (among representative genera or species).

Adhesive trap

The simplest trapping mechanism is the adhesive trap. it aiso contains three mechanism Flypaper trap(e.g.*Pinguicula*), Fixed tentacles (e.g.*Roridula*, *Drosophyllum*, *Triphyophyllum*, *Byblis*), and Mobile tentacles (e.g.*Drosera*) but the flypaper-like leaves of *Pinguicula* have specific short stalked glands that secrete sticky mucilage that traps miniature creatures. The glands are stalked so the leaf itself doesn't smother in slime while it waits for a prey.[15-21]

Pitfall trap

Figure 1 : *Pinguicula gigantea* leaf showing the residue of fungus gnats. This slippery sticky leaf is an example of an adhesive trap.

Pitfall trap also have two different mechanism like Open with pool of water (e.g.*Heliamphora*, *Nepenthes*, *Brocchinia*, *Cephalotus*, *Catopsis*, *Sarracenia*

Review

purpurea and *S. rosea*) and Covered or no pool of water (e.g.*Darlingtonia and* most *Sarracenia*). Pitfall traps of pitcher plants leaves are folded into deep, slimy pools filled with digestive enzymes. Pitfall traps are leaves adapted into pit-like structures. Pitfall traps have vastly modified leaves where each leaf have separate trap. The traps may have nectaries, bright colors, or a flower-like perfume to attract prey. The traps may have hairs to direct prey to the trap opening or cause the prey to fall into the trap. The edge of the trap is usually smooth and the inside of the trap waxy. The open pool traps have pools of water to sink victims. Pitfall traps are thought to have evolved autonomously on at least four occasions. In all-purpose they are phytotelmata, water bodies composed or secreted into specialised containers, and in due course under arrest by plants for assorted functions such as in particular, the trapping and digestion of prey[15-21]

Lobster pot trap

Figure 2 : *Nepenthes hamata* leaf. This is an example of a pitfall trap among a pool of water at the bottom.

Lobster-pot traps of corkscrew plants are twisted tubular channels lined with hairs and glands. *Darlingtonia* and *Sarracenia psittacina* have a trap like to the traps used to grab lobsters. A lobster pot has an entrance prey can easily find on the exterior and penetrate, but the entrance is tricky to find or exit from the inside. like e.g. of lobster trap are (*Sarracenia psittacina, Darlingtonia*)[15-21]

Pigeon trap

Genlisea plants are established in water or water soaked soil. Primary preys are protozoans. The prey enter the trap by pushing past inward pointing hairs. Once inside the trap they cannot get back out past the hairs. This is the way pigeon traps work except thin metal rods are used instead of hairs.like e.g.of pigeon trap are (*Sarracenia psittacina, Genlisea*).[15-21]

Figure 3 : *Sarracenia psittacina* leaves have difficult traps. In the lobster pot part, preys prick the hole in the trap but are incapable to find their way out.

Snap trap

Figure 4 : *Genlisea violacea* seedlings showing the fork-shaped Pigeon trap. The white trap is actually a highly modified rolled underground leaf. You need a microscope to observe the mechanism of the trap. The "stomach" is up near green leaf-like structures.

Snap trap (or steel traps) of the Venus flytrap and waterwheel plant are hinged leaves that snap shut when activate hairs are touched. Snap traps leave little to the imagination. A prey moves into the trap, brushes against the trigger hairs, and you see the trap extremely quickly enclose the prey. Unlike hinged snap traps made by humans, this snap trap bends the halves of the trap to surround the prey. The trap closes by almost explosively intensifying the cells on the outer surface of the leaf. You can confirm this by noting that before the trap is triggered, each half of the leaf is flat. After being triggered the halves are cupped. The traps will then slowly seal and digest the prey, reopening when it is done. (e.g.*Aldrovanda, Dionaea*).[15-21]

Suction trap

Figure 5 : *Dionaea muscipula* leaf is a snap trap. Notice the three trigger hairs on each half of the inner trap surface. The trap has nectar glands regarding where the red transitions to green in this trap.

Suction traps distinctive to bladderworts, are enormously modified leaves in the shape of a bladder with a hinged door lined with trigger hairs. It has been argued the most complex plant leaf on this planet is the *Utricularia* suction trap. The traps ready themselves by pumping water out of the sealed trap creating what would be considered a vacuum if air were involved. When triggered, they work so quickly that the highest speed video cameras show the prey outside the trap in one frame and already sucked inside on the next frame. Once indoors the prey is digested and the trap rearms itself. (e.g.*Utricularia*).[15-21]

Figure 6 : *Utricularia inflata* suction trap leaves.

TABLE 1 : Digestion mechanism of carnivorous plant[22-32]

Digestion part	Different mechanism	Examples
Leaf surface	Leaf rolls and tentacles bend for increased prey contact	*Drosera*
	Leaf rolls or is rolled to contain digestion fluid	*Pinguicula*
	Leaf doesn't move	*Drosophyllum, Triphyophyllum*
Sealed trap	-	*Dionaea, Utricularia*
Pit or stomach	-	*Sarracenia, Genlisea*
Water pool	-	*Nepenthes, Darlingtonia*
Commensal organism	-	*Byblis, Roridula*

Evolution and distribution of pitcher plants

Carnivorous plants have evolved separately in numerous families. Approximately 600 carnivorous species are known, belonging to six angiosperm subclasses and including monocotyledons and eudicotyledon[33,34]. These comprise about 600 species that attract and trap prey, produce digestive enzymes, and suck up the resulting available nutrients. Additionally, over 300s protocarnivorous plant species in several genera show some but not all these characteristics. Carnivorous plants occur worldwide, but species richness and abundance are highest in wet, open, nutrient-poor habitats – Guyana Highlands, the southeastern United States, and Western Australia[35]. Recently, substantial carnivorous plant diversity has been discovered in wet, treeless, ephemeral-flush vegetation on granitic and gneissic outcrops in parts of West Africa[36,37]. Carnivorous plants have fascinated evolutionary ecologists, botanists, and horticulturists for centuries. Darwin (1875) provided the first detailed experimental evidence for carnivory in a number of plant genera and established once and for all that true heterotrophy existed in an autotrophic Kingdom.[38] The insectivorous plants are found in nine angiosper-

TABLE 2 : Pitcher plant families and its species[1]

Families	Species
Bromeliaceae	*B. reducta, Catopsis berteroniana* of the *Neotropics* and *Brocchinia hectioides*
Byblidaceae	*B. liniflora* of Australia and New Guinea and *Byblis gigantea*
Cephalotaceae	one species, *Cephalotus follicularis*, endemic to Australia
Dioncophyllaceae	*Triphyophyllum peltatum* of western Africa
Droseraceae	about 110 species; *Dionaea, Aldrovanda, Drosera,and Drosophyllum*
Lentibulariaceae	*Genlisea, Utricularia, Pinguicula*
Nepenthaceae	*Nepenthes*, 70 spp. of Southeast Asia and Madagascar
Sarraceniaceae	*Sarracenia, Heliamphora, Darlingtonia*

Review

mous families. But the families Nepenthaceae and Sarraceniaceae are the best-known and largest groups of pitcher plants and in India three families are known. The families are given in the TABLE 2

Insectivorous plants of India belong mainly to three families: Droseraceae, Nepenthaceae and Lentibulariaceae. These families are given below:

Nepenthaceae and sarraceniaceae are the best-known and largest groups of pitcher plants

Nepenthaceae

The Nepenthaceae family contains a single genus, *Nepenthes*, containing over 100 species and numerous hybrids and cultivars. In these Old World pitcher plants, the pitchers are borne at the end of tendrils that extend from the midrib of an otherwise unexceptional leaf. So in the Nepenthaceae, the pitcher arises from the terminal segment of the leaf. The plants themselves are often climbers, accessing the canopy of their habitats using the aforementioned tendrils, although others are found on the ground in forest clearings, or as epiphytes on tree.[39]

Nepenthes

Nepenthes popularly known as tropical pitcher plants or monkey cups, is a genus of carnivorous plants belong to the family Nepenthaceae. The name "monkey cups" refers to the fact that monkeys have been observed drinking rainwater from these plants. *Nepenthes* leaves are differentiated into a photosynthetically active lamina and a pitcher trap and the leaves of these plants are also mug-shaped organs specialized for attracting, capturing, retaining and digesting the prey. The pitchers frequently consist of different structural and functional zones: lid, peristome, and upper waxy and lower glandular zones within the pitcher.[40,41]

Carnivorous mechanism

Nepenthes Pitcher color, nectar, biochemicals, and aroma are the primary attractants in pitchers[41-43] *Nepenthes* pitcher resembles an elongated jar with an open lid, which is moderately filled with fluid that contains proteases, chitinases, and other enzymes in a watery medium.[44-47] This enzyme mix effects the digestion of the trapped prey. These enzymes also play a role in inhibiting microbial growth within the pitcher fluid.[44-47] Most *Nepenthes* are vines or subscandent shrubs in habit, attaching themselves to adjacent vegetation by the use of looped tendrils which build up from the tips

TABLE 3 : Indian pitcher plant families, genera, species and its economic uses[5-10]

Family	Genera	Species	Economic uses
1.Droseraceae	It contains two genera 1. Drosera or Sundew	*D. indica* *D. burmanni* *D. peltata*	*They* are important medicinally. Due to the rich content of organic acids and enzymes. Used in curdling milk. *D.pelata* is reported to be used by Ayurvedic practitioners in the preparation of 'gold-bhasma' considered an anti-syphilitic and tonic. A yellowish brown crystalline pigment from *D. peltata* is used for dyeing silk.
	2. Aldrovanda	1. *A. vesiculosa*	-
2. Nepenthaceae	It contains single genera 1.Nepenthes	1. *Nepenthes khasiana* *2. N. distillatoria* About 30 species are known	*Nepenthes* have some ethnomedical uses. Also treat cholera. The liquid inside the pitcher is consumed as a remedy for urinary troubles; it is also used as eye drops for treating redness and itching of eyes.
3. *Lentibulariaceae*	It contains 4 genera but 2 are occurring in India. 1. *Utricularia or* Bladderworts	from India *Utricularia inflexa* *U. aurea* *U. bifida* *U. caerulae* *U. stellaris* *U. flexuosa* *U. brachiata*	*U. aurea* and *U. reticulata* are ornamental, especially suitable for aquaria and rockeries. *U.stellaris* is useful against cough; *U. caerulae* is useful for dressing of wounds; *U. bifida* is used as a remedy for urinary disease.
	2. *Pinguicula*	1. *P. alpina*	-

of the leaf blades. The pitchers are in turn produced at the tips of the tendrils.[48,49] In general, the fluid-filled pitchers are produced to trap and digest invertebrate prey, and *Nepenthes* are notable for their dimorphism, i.e., the production of two distinct pitcher types. Young plants produce rosettes of "terrestrial" or "lower" pitchers. These are usually ovoid or globose in form, rest on the substrate, and are characterized by the presence of a pair of vertically-oriented, wing-like processes. It is usually held that these structures serve to channel prey from the pitcher base into the mouth, facilitating capture. However, this has been found not to be the case with *Nepenthes rafflesiana* Jack, the only species in which this idea appears to have been tested to date. As the plant grows, it may then manufacture a second pitcher type, the "aerial" or "upper" form. These pitchers are in general funnel-shaped or cylindrical, and lack the wing-like structures. Occasionally, pitchers of intermediate form are produced. In some species, the two pitcher types have been shown to target different prey taxa.[50-56]

Nepenthes khasiana

Nepenthes khasiana is a tropical pitcher plant of the genus *Nepenthes*. It comprises *app.* 70 species in the world it is the only *Nepenthes* species native to India and is largely endemic to the Khasi Hills in North East India.[57] and it is used for medicine. Additionally, it is thought to attract prey by emitting ultraviolet light. *N. khasiana* is a short, stout, prostrate to climbing under shrub with sub-cylindrical pitchers. These pitchers are modified leaf blades. The basal part of the long petiole is flattened into a leaf blade like structure 'phyllode'. The distal part of the petiole is a narrow wiry spring like structure called tendril that coils around supporting plants. The pitchers, colored bright red, green, yellow or a mosaic of all these, dangle in the air. They vary greatly in size, ranging from 5 to 30 cm in length. The mouth of the pitcher is furnished with a colorful half open lid. *Nepenthes* confirms to the pitfall type of trap. *Nepenthes khasiana* is propagated by Micropropagation method by using seed germination and nodal explants and a couple of thousand plants have been reintroduced in its habitats.[5-10]

Sarraceniaceae

They are New World pitcher plants (Sarraceniaceae), which comprise three genera, are ground-dwelling herbs whose pitchers begin from a horizontal rhizome. In this family, the entire leaf forms the pitcher. It contains three genera *Sarracenia*, *Heliamphora*, and *Darlingtonia* The species of the genus *Heliamphora*, which are popularly known as marsh pitchers (or erroneously as sun pitchers), have a simple rolled-leaf pitcher, at the tip of which is a spoon-like structure that secretes nectar. They are restricted to areas of high rainfall in South America. The North American genus *Sarracenia* are the trumpet pitchers, which have a more complex trap than *Heliamphora*, with an operculum, which prevents excess accumulation of rainwater in most of the species. The single species in the Californian genus *Darlingtonia i*s commonly known as the cobra plant, due to its possession of an inflated "lid" with elegant false-exits, and a forked "tongue", which serves to ferry ants and other prey to the entrance of the pitcher.[58]

Figure 7 : Image of *Nepenthes khasiana*

Sarracenia pitcher plant

Sarracenia is a genus comprising 8 to 11 species of North American pitcher plants, commonly called trumpet pitchers. They are mostly grown in southern United States. The plant's leaves have evolved into a funnel in order to trap insects, digesting their prey with proteases and other enzymes. The insects are attracted by a nectar-like secretion on the lip of pitchers, as well as a combination of color and scent. slimy footing at the pitchers' rim, aided in at least one species by a narcotic drug lacing the nectar, causes insects to fall inside, where they die and are digested by the plant as a nutrient source. *Sarracenia* are herbaceous perennial plants that grow from a subterranean rhizome, with many tubular pitcher-shaped leaves radiating out from the growing point, and then turning upwards with their trap openings facing the center of the crown. The trap is a vertical tube with a 'hood' (the operculum)

Review

extending over its entrance; and below it the top of the tube usually has a rolled lip (the peristome) which secretes nectar and scents. The hood itself frequently produces nectar too, but in lesser quantities. The inside of the pitcher tube, regardless of species, can be divided into three to five distinguishable zones: zone 1 is the operculum (or hood), zone 2 is the peristome and rest of the trap entrance, while zones 3 and 4 (which in some species are combined) and 5 (only present in *S. purpurea*) are further divisions of the actual tube. Each of these zones has a specific function, with corresponding morphophysiological characteristics.[58-62]

Carnivorous trapping mechanism

All *Sarracenia* trap insects and other prey without the use of moving parts. Their traps are static and are based on a combination of lures (including color, scent, and nectar) and inescapability. Most species use a combination of scent, drugged nectar, waxy deposits (to clog insect feet) and gravity to topple insect prey into their pitcher. Coniine, an alkaloid drug narcotic to insects, has been discovered in the nectar-like secretions of at least *S. flava*. Once inside, the insect finds the footing very slippery with a waxy surface covering the walls of the pitcher. Further down the tube, downward-pointing hairs build retreat impossible, and in the lowest region of the tube, a pool of liquid containing digestive enzymes and wetting agents quickly drowns the prey and begins digestion. The exoskeletons are usually not digested, and over the course of the summer fill up the pitcher tube.[58-62]

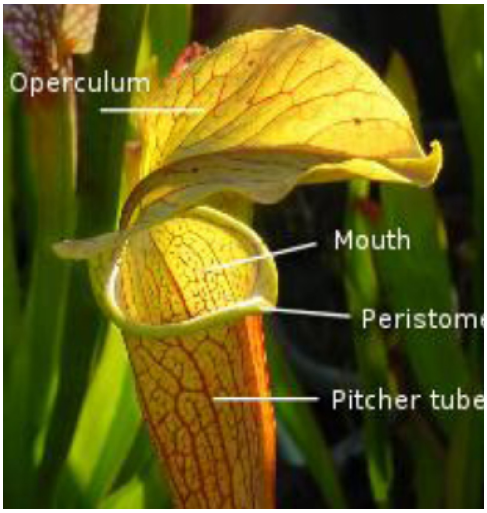

Figure 8 : *Sarracenia* trap insects by pitchers with nectar and slippery footing around the lip.

Northern pitcher plant (*Sarracenia purpurea*)

They are also well-known as Purple Pitcher Plant. Only *S. purpurea* usually contains significant amounts of rainwater in its tubular pitchers. The Purple Pitcher Plant is the most ordinary carnivorous plant in North America. It can be found in the Florida panhandle all the way up to Canada. The plant can vary in color, from lime green to dark purple. Purple Pitcher produces red and purple flowers. Rainwater collects at the bottom of the tube, drowning any insects that fall in. *Sarracenia purpurea* has a rhizome that produces a tuft of 4–10 hollow leaves, forming pitchers that trap insects and other small prey. The hood is curved around the mouth of the pitcher. Mechanism of trapping is pitfall trap.[1]

Figure 9 : Image of *Sarracenia purpurea*

Parrot pitcher plant (*S. psittacina*)

S. psittacina, the parrot pitcher, uses a lobster-pot style trap that will admit prey (including tadpoles and small fish during floods) but not permit it to find its way out; and sharp inward-pointing hairs force the victim gradually down to the base of the pitcher where it is digested. They are found in wetter areas of low-lying savanna that often flood during heavy rains. The pitchers of this species lie flat along the ground and end in hollow, puffed, beaked hoods that are baited with nectar. Insects and small animals that enter the tubes are forced to proceed into the pitcher by numerous long needlelike hairs that point toward the base of the leaf, preventing escape.[1]

Green hooded pitcher plant (*Sarracenia minor*)

The Green Hooded Pitcher Plant, *Sarracenia minor*, provides a good example of the pitcher plant way of life. The Green Hooded Pitcher Plant has hollow, green, hood-like leaves. The hood prevents the pitcher from filling with water. Hooded Pitcher Plants are found

between southeastern North Carolina and the Florida panhandle. They can reach heights between 13 to 19 inches. Hooded Pitcher Plants produce yellow flowers that bloom as the first leaves are sprouting. The top of the tube has a canopy or a "hood" over it. When the insect falls under the shade of the hood, it is alarmed by the darkness and moves deeper into the plant where it is more translucent.[1]

Figure 10 : Image of *Sarracenia psittacina*

Sweet pitcher plant (*Sarracenia rubra*)

The Sweet Pitcher Plant (*Sarracenia rubra)* has narrow, hollow red-veined leaves. This pitcher plant has a fractional hood, which doesn't quite cover the top the leaves, so the pitcher often fills with rainwater. The flower is a deep red to maroon color on a leafless stem. It occurs not only in pocosins and wet pine savannas but also along Carolina bay margins and in sand hill seep areas. Sweet Trumpet grows in northern Florida; The Sweet Trumpet has minor and weaker tubes in the spring. The summer tubes are larger and stand tall, from 5 to 19 inches. Sweet Trumpet produces a sweet smell, like a rose. It produces small red flowers in spring.[1]

Figure 11 : Image of *Sarracenia minor*

Yellow trumpet (*Sarracenia flava*)

The Yellow Trumpet produces large tall flowers and bright yellow leaves. This plant will grow 20 to 36 inches tall. The Yellow Trumpet's nectar has a chemical in it that produces paralysis when an insect consumes a large quantity. Yellow Trumpets *(Sarracenia flava*) have a diverse strategy for capturing insects. This pitcher plant does not have hooded leaves. Instead, the vertical hollow leaves will fill with rainwater. Insects attracted to its nectar will fall in, drown, and be broken down by the mixture of rain water and digestive juices. Yellow Trumpets' flowers have pale yellow, droopy petals. They grow best in open wet pine savannas.[1]

Figure 12 : Image of *Sarracenia rubra*

White trumpet (*Sarracenia leucophylla*)

The White Trumpet (*Sarracenia leucophylla*) is considered by many to be the most stunning of the American pitcher plant species. As the name implies, White Trumpets have pitchers that are green toward the bottom while the upper portion of the pitcher and the pitcher lid are bright white, laced with green or red veins. The flowers of this species are large and red. This species has become rare in some areas where it once occurred due to habitat loss and overharvesting for the cut-flower trade.[1]

Figure 13 : Image of *Sarracenia flava*

Green pitcher plant (*Sarracenia oreophila)*

It is a carnivorous perennial (lives more than 2 years)

Review

herb with yellowish-green, hollow, pitcher-shaped leaves. The pitchers have liquid and enzymes which help the plant digest insects that climb or fall into the plant. Short, stiff hairs inside the pitcher pointing downwards allow insects into the plant but prevent them from crawling out. The lid or hood is at the top of the plant. Its purpose is to stop too much rain water from diluting the enzymes in the pitcher. The main body is the pitcher shaped tube. The plant produces nectar that entices insects inside the pitcher. The insects become trapped and are digested by enzymes. The pitcher ranges from 8-30 inches tall and has purple veins. Basal leaves are shorter flat sickle shaped leaves at the bottom of the plant.[1]

Figure 14 : Image of *Sarracenia leucophylla*

Heliamphora pitcher plant

The genus *Heliamphora* contains 18 species of pitcher plants. The species are collectively known as sun pitchers. Scientific name would be marsh pitcher plants. *Heliamphora* grown nearby savannas in the Guayana Highlands of Venezuela, Guyana, and Brazil, Species in the genus *Heliamphora* are carnivorous plants that consist of a modified leaf form that is fused into a tubular shape. They have evolved mechanisms to avoid completely filling up with water and attract, trap, and kill insects. At least one species (H. tatei) produces its own proteolytic enzymes that allow it to digest its prey without the help of symbiotic bacteria. All *Heliamphora* are herbaceous perennial plants that grow from a subterranean rhizome. *H. tatei* grows as a shrub; up to four meters tall, all other species form prostrate rosettes. The leaf size ranges from a few centimeters (*H. minor*, *H. pulchella*) up to more than 50 cm (*H. ionasi*). *Heliamphora* possess tubular traps formed by rolled leaves with fused edges. Marsh pitcher plants are unusual among pitcher plants in that they lack lids (opercula), instead having a small "nectar spoon" on the upper posterior portion of the leaf. This spoon-like structure secretes a nectar-like substance, which serves as a lure for insects and small animals. Each pitcher also exhibits a small slit in its side that allows excess rainwater to drain away, similar to the overflow on a sink. This allows the marsh pitcher plants to maintain a constant maximum level of rainwater within the pitcher. The pitchers' inner surface is covered with downward-pointing hairs to force insects into the pitchers' lower parts. *Heliamphora* uses a more typical pollination scheme among flowering plants of having the stigma mature and lose receptivity before the anthers mature and release pollen. This isn't a detriment to long distance dispersal the way self incompatibility is since a

Figure 15 : Image of *Sarracenia oreophila*

Figure 16 : Image of *Heliamphora chimantensis*

large plant could have a number of flowers in the appropriate stage to efficiently self pollinate.[63,64]

Carnivorous trapping mechanism

The vast majority of plants in the genus *Heliamphora* do not produce their personal digestive enzymes (i.e. proteases, ribonucleases, phosphatases, *etc.*), relying instead on the enzymes of symbiotic bacteria to break down their prey. They do, however, attract prey through particular visual and chemical signals and trap and kill the prey through a typical pitfall trap. Field studies of *H. nutans*, *H. heterodoxa*, *H. minor*, and *H. ionasi* have determined that none of these species produce their own proteolytic enzymes. Most *Heliamphora* typically capture ants, while *H. tatei* 's improvements on the design allow it to capture and absorb nutrients from more flying insects.[65]

Darlingtonia californica

Darlingtonia californica also called the California pitcher plant, cobra lily, or cobra plant, is a species of carnivorous plant, the sole member of the genus *Darlingtonia* in the family Sarraceniaceae. It is native to Northern California and Oregon, growing in bogs and seeps with cold running water. California pitcher plant does not grow straight up, but turns left or right on its ascent, twisting itself and facing directly opposite from its base. Interestingly, each new pitcher grows in such a way so that its final position directs its hood as far away from the others as possible. Not only may this prevent new pitchers from growing into the hoods of older pitchers, but it also maximizes the total area "surveyed" by the hoods, the means by which the plant traps insect prey. The hood is the defining feature of the pitcher plant, in both form and function. The cobra head is the means by which the pitcher plant traps insects and there by supplements the impoverished soil it grows on. *Darlingtonia* is pollinated by a small bee that enters gaps between the petals and exits (or falls) through the lower part of flower.[66-68]

Carnivorous trapping mechanism

California pitcher plant does not produce digestive enzymes to decompose its prey. It relies on the metabolic activity of commensal bacteria in its pitcher fluid to break down organic matter in to transportable molecules, which it can absorb through the pitcher lining. The level of fluid and its acidity seem to be related to the density of organic matter in it, not the relative amount or chemical composition of precipitation. Thus the plant is not completely passive in its carnivorous metabolism.

Figure 17 : Image of *Darlingtonia californica*

Importance and uses of pitcher plants

Pitcher plants are generally used for medicinal purposes. *Sarracenia purpurea* dried-leaf tea used to treat fever and chills, and Root ingested to treat smallpox, lung, and liver ailments. Also used as an aid in childbirth and as a diuretic. A study published in 2009 by researchers from Tel Aviv University indicates that secretions produced by carnivorous plants contain compounds (Secondary metabolites) that have anti-fungal properties and may lead to the development of a new class of anti-fungal drugs that will be effective against infections that are resistant to current anti-fungal drugs. Pitcher plant is used for digestive disorders, particularly constipation, urinary tract diseases, as a diuretic, a cure for smallpox, and to prevent scar formation. By injection, pitcher plant extract (Sarapin) is used as a trigger point injection to luxury pain including sciatic pain, intercostal pain, alcoholic or occipital neuritis, brachial plexus neuralgia, meralgia paresthetica, and lumbar or trigeminal neuralgia. Pitcher plant extract (Sarapin) has been used by injection in mixture with bupivacaine hydrochloride 0.5% (Marcaine) and gamma globulin to treat the omohyoideus myofascial pain syndrome. Combinations of injection (extract triamcinolone and lidocaine with adrenalin) to treat migraine cephalagia, for diagnosis and dealing of forms of sciatic pain including piriformis syndrome (extract and lidocaine), quadratus lumborum syndrome (extract and corticosteroid), and in combination with physiotherapy and an intraoral splint to treat the Ernest Syndrome that is often mistaken for temporomandibular joint problems. It is also used in prolotherapy (phenol and extract) to cause inflammation at the site where the ligaments and tendons attach to the

Review

bone to stimulate the body to proliferate stronger, shorter, and less painful ligaments and/or tendons. Pitcher plant contains tannins and other chemicals that are thought to assist with some digestive tract problems. There is some evidence that suggests that pitcher plant extract may affect nerves involved in pain sensation. Carnivory provides a means for plants to augment mineral uptake in nutrient-poor environments there by allowing carnivorous plants to compete profitably in such sites. *Drocera* spp are used in ethno-medicine the bruised leaves, with or without ordinary salt, are applied on blisters. *Nepenthes khasiana* is use as medicinally. The powder of the roots and pitcher is applied in skin diseases, juice from unopened pitchers is used as eye-drops against eye diseases and the pitcher with the juice and crushed insects and administered to cholera patients. *Sarracenia purpurea* used as Tonic, laxative, stomachic, diuretic. Used in the southern United States in dyspepsia. Native American Indians used *Sarracenia purpurea* for a variety of medicinal purposes, including as a diuretic and in childbirth, menstruation and treatment of fevers, chills, whooping cough and smallpox.[5-10]

Pest control

Pitcher plants offer excellent pest control by killing bugs such as ants, flies, wasps, bees, beetles, slugs and snails. Some species of pitcher plants can even catch and kill small animals like rats and frogs. Pitcher plants lure bugs into their "pitcher," a cylindrical leaf, with nectar and scent. The bugs then walk into the slippery cylinder trying to reach the nectar, but ultimately slip or become tired and fall down into the bottom of the pitcher, which is filled with water, and drown. Once the bug is dead, glands located inside the cylinder excrete digestive enzymes to liquefy the prey. The pitcher plant then absorbs this nutritive liquid.

Medicinal uses of the root and leaves together

Pitcher plant is sold in health and drugstores in the form of tablets, liquids and teas. Derivatives of the roots and leaves are used to treat stomach and digestive problems and urinary tract infections. Pitcher plant leaves and roots contain tannins, which are chemicals thought to help overall digestive tract problems.

Medicinal uses of the leaves

Pitcher plant leaves are also frequently used as an herbal medicine. They can be saturated or steeped in water to create an infusion. This infusion is used in the treatment of fevers, shakiness, throughout labor and as a fertility aid in the absence of a menstrual cycle. The infusion was also previously used as a treatment for smallpox.

Medicinal uses of the roots

Pitcher plant roots can be saturated or steeped in water to generate a pitcher plant root infusion. Before soaking the roots are cut release to expose their interiors, the place supposed to contain the medicinal compounds. The root infusion was once used to treat smallpox. Pitcher plant roots can also be boiled down over a long period of time to produce a decoction. This decoction is often given to women for the duration of labor to help expel the placenta and after birth. The decoction is also used as a treatment for coughing up blood and pulmonary complaints.

As an ornamental plant

Pitcher plants in attendance themselves as strange-looking and attractive plants. So they are used in garden as an ornamental plant.

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