Aquatic Plants

Kerri Ritchey

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Chapter- 1

Aquatic Plant

Nymphaea alba, a species of water lily

Aquatic plants are plants that have adapted to living within aquatic environments. They are also referred to as **hydrophytes** or **aquatic macrophytes**. These plants require special adaptations for living submerged in water or at the water's surface. Aquatic plants can only grow in water or in soil that is permanently saturated with water. Aquatic vascular plants can be ferns or angiosperms (from a variety of families, including among the monocots and dicots). Seaweeds are not vascular plants but multicellular marine algae, and therefore not typically included in the category of aquatic plants. As opposed to plant types such as mesophytes and xerophytes, hydrophytes do not have a problem in retaining water, due to the abundance of water in their environment. This means that aquatic plants have less need to regulate transpiration, which would require more energy and be of little benefit to the plant.

Characteristics of aquatic plants:

- A thin cuticle. Cuticles primarily discourage water loss; thus most hydrophytes have no need for cuticles.
- Stomata that are open most of time because water is abundant and therefore there is no need for it to be retained in the plant. This means that guard cells on the stomata are generally inactive.
- An increased number of stomata, that can be on either side of leaves.
- A less rigid structure: water pressure supports them.
- Flat leaves on surface plants for flotation.
- Air sacs for flotation.
- Smaller roots: water can diffuse directly into leaves.
- Feathery roots: no need to support the plant.
- Specialized roots able to take in oxygen.

For example, some species of buttercup (genus *Ranunculus*) float slightly submerged in water; only the flowers extend above the water. Their leaves and roots are long and thin and almost hair-like; this helps spread the mass of the plant over a wide area, making it more buoyant. Long roots and thin leaves also provide a greater surface area for uptake of mineral solutes and oxygen.

Wide flat leaves in water lilies (family Nymphaeaceae) help distribute weight over a large area, thus helping them float near surface.

Many fish keepers keep aquatic plants in their tanks to control phytoplankton and moss by removing metabolites.

Many species of aquatic plant are invasive species. Aquatic plants make particularly good weeds because they reproduce vegetatively from fragments.

Adaptations

- Floating plants: In an outdoor body of water, these receive more sunlight than submerged plants do. They also rarely have to compete with one another for sunlight
- Submerged plants: The leaves of submerged plants receive lower levels of sunlight because light energy diminishes while passing through a water column.

All floating plants

- Either have air spaces trapped in their roots, or else air spaces in their bodies (aerenchyma) to help them to float, thus receiving adequate sunshine
- Have hair on their leaves that traps air
- Structural adaptations

Duckweed, water cabbage

- Chloroplast found on the top surface of the leaves
- Upper Surface has a thick, waxy cuticle to repel water and to help keep the stomata open and clear
- Structural adaptation
- Small and light

Water lily

- Structural material to reach higher points and receive more sunlight
- Structural adaptation

Floating heart, water lily, lotus, yellow pond lily, water-shield

- Their leaves tend to be broader without major lobing, to remain flat on water surface, to enlarge their surface area, and to make use of as much sunlight as possible. Their chloroplasts are found on the tops of their leaves.
- Structural/ behavioral adaptations

Most partially-submerged ("emersed") plants

- Air spaces within their tissues to keep them buoyant so that their leaves can reach the top of the body of water, in order to receive an adequate amount of sunlight
- Structural adaptation

Dissected: Parrot's Feather, Hornwort
Thread-like: ditch-grass, quillwort

- Highly dissected/ divided leaves or thread-like ones, allows for a bigger surface area (surface to volume ratio)
- Structural adaptation

Hydrilla

- Elongates rapidly to reach water surface and branches out at water surface; more light can be obtained at water surface
- Structural/ behavioral adaptation
- Xylem tubes are absent

Human nutrition

Many aquatic plants are used by humans as a food source. Note that especially in (South-east) Asia edible but uncooked hydrophytes are implicated in the transmission of fasciolopsiasis.

- Wild rice (*Zizania*)
- Water caltrop (*Trapa natans*)
- Chinese water chestnut (*Eleocharis dulcis*)
- Indian Lotus (*Nelumbo nucifera*)
- Water spinach (*Ipomoea aquatica*)
- Watercress (*Rorippa nasturtium-aquaticum*)
- Watermimose, Water mimosa ? (*Neptunia natans*)
- Taro (*Colocasia esculenta*)
- Rice (*Oryza*) is originally not an aquatic plant.
- Bullrush, Cattail, (*Typha*)
- Water-pepper (*Polygonum hydropiper*)
- Wasabi (*Wasabia japonica*)

Animal nutrition

Some examples of aquatic plants

- Water hyacinth (*Eichhornia*)
- Duckweed: *Lemna, Spirodela and Wolffia*
- *Trichanthera gigantea*

Some examples of aquatic plants

- Most algae, and all seaweed and kelp

- *Utricularia* (from the Latin, *utriculus*, a little bag or bottle) is a genus of slender aquatic plants, the leaves of which contain floating air bladders. They are called bladderworts.

- Water lettuce

Chapter- 2

Lemnaoideae

Lemnaoideae	
	
Close up of two different duckweeds: *Spirodela polyrrhiza* and *Wolffia globosa*. The latter are less than 2 mm long.	
Scientific classification	
Kingdom:	Plantae
(unranked):	Angiosperms
(unranked):	Monocots
Order:	Alismatales
Family:	Araceae
Subfamily:	**Lemnoideae**
Genus	

- *Spirodela*
- *Landoltia*
- *Lemna*
- *Wolffiella*
- *Wolffia*

Duckweeds, or water lentils, are aquatic plants which float on or just beneath the surface of still or slow-moving fresh water bodies. They arose from within the arum or aroid family, (Araceae), and therefore, often are classified as the subfamily **Lemnoideae** within the Araceae. Classifications created prior to the approximate end of the twentieth century tend to classify them as a separate family, **Lemnaceae**.

These plants are very simple, lacking an obvious stem or leaves. They consist of a small 'thalloid' or plate-like structure that floats on or just under the water surface, with or without simple rootlets. The plants are highly reduced from their earlier relatives in Araceae.

Reproduction is mostly by asexual budding, but occasionally three tiny 'flowers' consisting of two stamens and a pistil are produced and sexual reproduction occurs. Some view this 'flower' as a pseudanthium, or reduced inflorescence, with three flowers that are distinctly either female or male and which are derived from the spadix in Araceae. Anatomical research regarding the mechanics of this process has not been completed or remains ambiguous due to considerable evolutionary reduction of these plants from their earlier relatives. The flower of *Wolffia* is the smallest known flower in the world, measuring merely 0.3 mm long. The fruit produced through this occasional sexual reproduction is a *utricle*, and a seed is produced in a sac containing air that facilitates flotation.

Duckweed in various environments

Duckweed is an important high-protein food source for waterfowl and also is eaten by humans in some parts of Southeast Asia (as *khai-nam*). As it contains more protein than soybeans, it is sometimes cited as a significant potential food source.

Some duckweeds are introduced into freshwater aquariums and ponds where they may spread rapidly. This introduction may be deliberate or unintended and once established in a large pond, may be difficult to eradicate. Occurring naturally by being carried on the feathers, shells, and coats of native species, the plant is introduced readily by birds, turtles, reptiles, and aquatic mammals visiting multiple ponds, rivers, and lakes. In water bodies with constant currents or overflow, the plants are carried down the water channels and do not proliferate greatly. In some locations a cyclical pattern driven by weather patterns exists in which the plants proliferate greatly during low water flow periods, yet are carried away as rainy periods ensue.

The tiny plants provide cover for fry of many aquatic species. The plants are used as shelter by pond water species such as bullfrogs and bluegills. They also provide shade and, although frequently confused with them, can reduce certain light-generated growths of photoautotrophic algae.

The plants can provide nitrate removal, if cropped, and the duckweeds are important in the process of bioremediation because they grow rapidly, absorbing excess mineral nutrients, particularly nitrogen and phosphates. For these reasons they are touted as water purifiers of untapped value.

The Swiss *Department of Water and Sanitation in Developing Countries*, SANDEC, associated with the Swiss Federal Institute for Environmental Science and Technology, asserts that as well as the food and agricultural values, duckweed also may be used for waste water treatment to capture toxins and for odor control, and, that if a mat of duckweed is maintained during harvesting for removal of the toxins captured thereby, it prevents the development of algae and controls the breeding of mosquitoes. The same publication provides an extensive list of references for many duckweed-related topics.

These plants also may play a role in conservation of water because a cover of duckweed will reduce evaporation of water when compared to the rate of a similar size water body with a clear surface.

Taxonomy

The duckweeds long have been a taxonomic mystery, and usually have been considered to be their own family, Lemnaceae. They primarily reproduce asexually. Flowers, if present at all, are small. Roots are either very much reduced, or absent entirely. They were suspected of being related to the Araceae as long ago as 1876, but until the advent of molecular phylogeny it was difficult to test this hypothesis. Starting in 1995 studies began to confirm their placement in the Araceae and since then, most systematists consider them to be part of that family.

Their position within their family has been slightly less clear, but several twenty-first century studies place them in the position shown below. They are not closely related to *Pistia*, however, which also is an aquatic plant in the family Araceae.

Research

In July 2008 the U.S. Department of Energy (DOE) Joint Genome Institute announced that the Community Sequencing Program would fund the sequencing the genome of the giant duckweed, *Spirodela polyrhiza*. This was a priority project for DOE in 2009. The research is intended to facilitate new biomass and bio-energy programs.

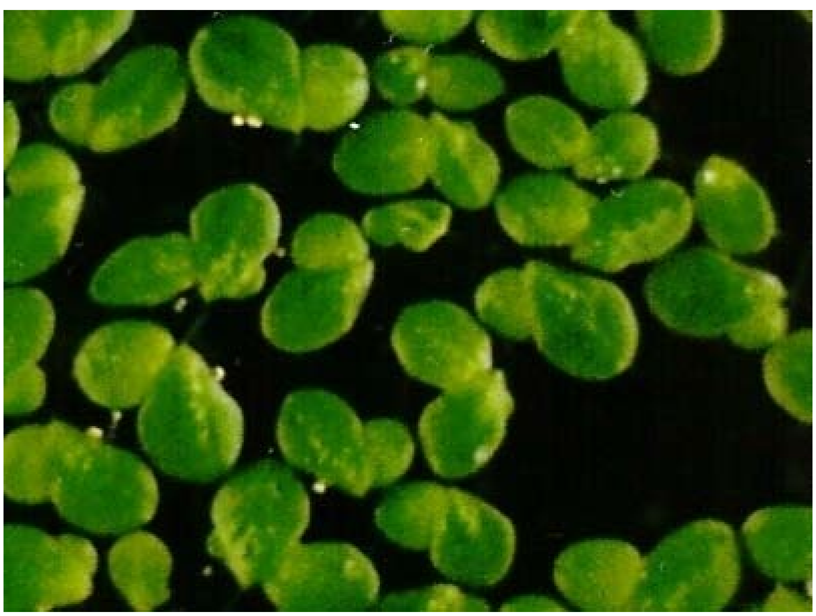
Duckweed is being studied by researchers around the world as a possible source of clean energy. In the United States, in addition to being the subject of study by the DOE, both Rutgers University and North Carolina State University have ongoing projects to determine if duckweed might be a source of cost-effective, clean, renewable energy.. In Rutgers duckweed is being studied under Rutgers' Waksman Students Scholar Program where high school students contribute to the genotyping of the duckweed. Currently 50 schools, along with Rutgers, are participating. The Frisch School is among those fifty schools participating in sequencing the genome. Students at the Frisch School sequencing the Duckweed include Kate Fishbein, the team leader, Aaron Dardik and Eric Tepper. Duckweed is a good candidate as a biofuel because as a biomass it grows rapidly, has 5 to 6 times as much starch as corn, and does not contribute to global warming. Duckweed is considered a carbon neutral energy source, because unlike most fuels, it actually *removes* carbon dioxide from the atmosphere.

Duckweed also functions as a bioremediator by effectively filtering contaminants such as bacteria, nitrogen, phosphates, and other nutrients from naturally occurring bodies of water, constructed wetlands and waste water. One study in Australia surrounding aquaculture suggests that although duckweed is initially effective as a nutrient filter, over time some nutrient build-up returns.

Common duckweed in Galicia, Spain

Lemna minor

Lemna trisulca

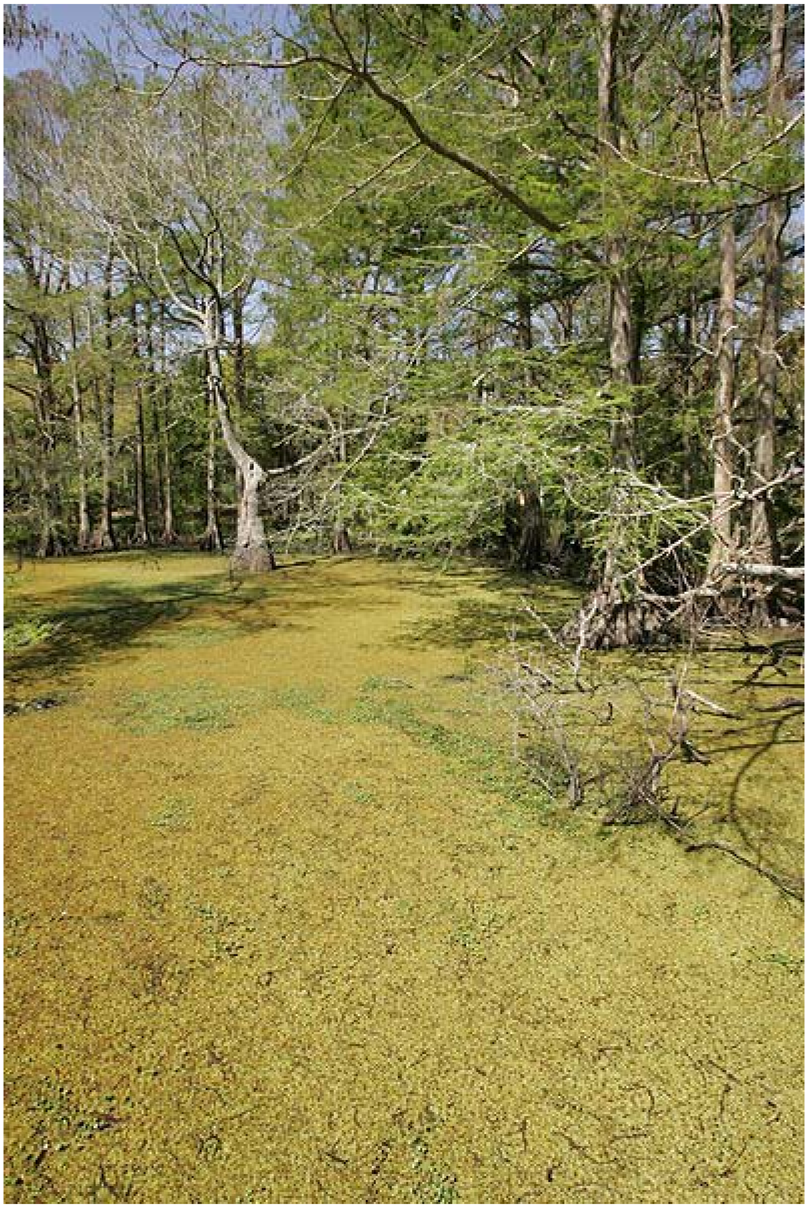


Lemna gibba.

Turning the canals of the Poitevin Marsh (Marais Poitevin, France) into the "Green Venice":

Spirodela polyrhiza

Canal green with duckweed



Duckweed-covered water edged with several bald cypress trees

Chapter- 3

Pistia and Nelumbo

Pistia

Pistia	
	
Scientific classification	
Kingdom:	Plantae
(unranked):	Angiosperms
(unranked):	Monocots
Order:	Alismatales
Family:	Araceae
Subfamily:	Aroideae
Tribe:	Pistieae
Genus:	***Pistia*** L.
Species:	***P. stratiotes***
Binomial name	
Pistia stratiotes L.	

Pistia is a genus of aquatic plant in the family Araceae, comprising a single species, ***Pistia stratiotes***, often called **water cabbage** or **water lettuce**. Its native distribution is uncertain, but probably pantropical; it was first described from the Nile near Lake Victoria in Africa. It is now present, either naturally or through human introduction, in nearly all tropical and subtropical fresh waterways.

Description

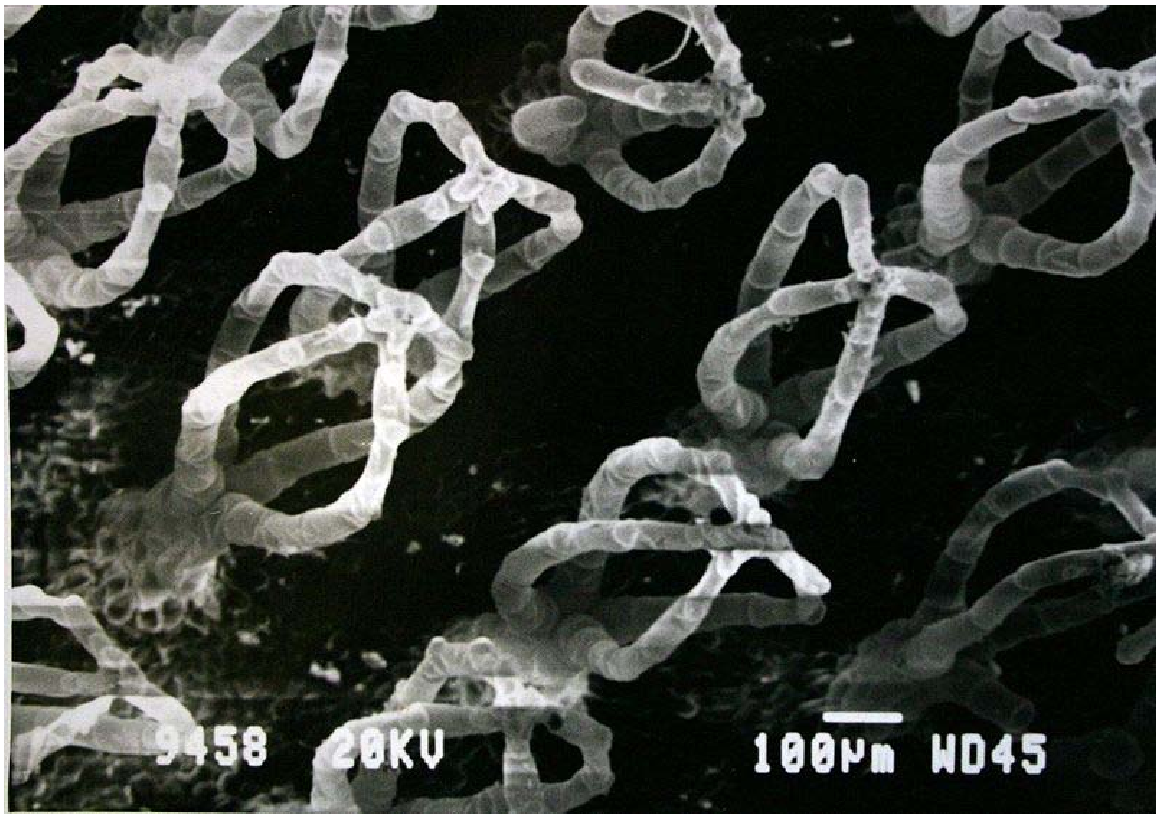
19th century illustration of *Pistia stratiotes*

It is a perennial monocotyledon with thick, soft leaves that form a rosette. It floats on the surface of the water its roots hanging submersed beneath floating leaves. The leaves can be up to 14 cm long and have no stem. They are light green, with parallel veins, wavy margins and are covered in short hairs which form basket-like structures which trap air bubbles, increasing the plant's buoyancy. The flowers are dioecious, and are hidden in the middle of the plant amongst the leaves. Small green berries form after successful fertilization. The plant can also undergo asexual reproduction. Mother and daughter plants are connected by a short stolon, forming dense mats.

Ecology

The growth habit can make it a weed in waterways. It is a common aquatic weed in the United States, particularly in Florida where it may clog waterways. It has the potential to reduce the biodiversity of a waterway. Mats of *Pistia* block gas exchange at the air-water interface, reducing the oxygen in the water and killing fish. They also block light, killing native submerged plants, and alter immersed plant communities by crushing them.

Pistia can be controlled by mechanical harvesters that remove the water lettuce from the water and transport it to disposal on shore. Aquatic herbicides may also be used. Two insects are also being used as a biological control. Adults and larvae of the South American weevil *Neohydronomous affinis* feed on *Pistia* leaves, and the larvae of moth *Spodoptera pectinicornis* from Thailand. Both are proving to be useful tools in the management of *Pistia*.



SEM image of basket-like structures on surface of leaf

Water lettuce is often used in tropical aquariums to provide cover for fry and small fish. It is also helpful as it outcompetes algae for nutrients in the water, thereby preventing massive algal blooms.

Public health importance

Mosquitoes of the genus *Mansonioides* complete their life cycle only in the presence of aquatic plants like *Pistia*, *Eihcornia*, *Salvinia*, etc. These mosquitoes lay their eggs under the *Pistia* leaf.It will appear just like rosette. The emerging larva fall into the water with in 24 houurs and stay attached to the *Pistia* root (which is rich with air sacs) with the help of a serrated siphon tube for respiration and develop into pupa. The pupa is also attached to the pistia root with the serrated piercing siphon tube. The egg to adult mosquito development will be completed with in 7 days. These mosquitoes transmit the *Brugia malayi* type of Lymphatic filariasis in Kerala, India.

Nelumbo

Nelumbo

Nelumbo nucifera

Scientific classification	
Kingdom:	Plantae
Division:	Angiosperms
(unranked):	Eudicots
Order:	Proteales
Family:	**Nelumbonaceae**
Genus:	***Nelumbo*** Adans.

Species

- †*Nelumbo aureavallis*
- *Nelumbo lutea*
- *Nelumbo nucifera*

Nelumbo is a genus of aquatic plants with large, showy, water lily-like flowers commonly known as **lotus**. The generic name is derived from the Sinhalese word *Nelum*. There are two living species in the genus, the better known of which, the Sacred Lotus (*N. nucifera*), is the national flower of Egypt, India and Vietnam. An extinct species, *Nelumbo aureavallis* has been described from leaves found in the Golden Valley Formation in North Dakota, USA.

There is residual disagreement over which family the genus should be placed in. Traditional classification systems recognized *Nelumbo* as part of the Nymphaeaceae (water lily) family, but traditional taxonomists were likely misled by evolutionary convergences associated with an evolutionary shift from a terrestrial to an aquatic lifestyle. In the older classification systems it was recognized under the biological order Nymphaeales or Nelumbonales. *Nelumbo* is currently recognized as its own family, Nelumbonaceae, as one of several distinctive families in the eudicot order Proteales. Its closest living relatives are shrubs or trees (Proteaceae and Platanaceae).

These plants are unrelated to the bird's-foot trefoils and deer-vetches of the genus *Lotus*.

Species

- †*Nelumbo aureavallis* Hickey – Eocene (North Dakota)

- *Nelumbo lutea* Willd. – American Lotus (Eastern United States, Mexico, Greater Antilles, Honduras)

- *Nelumbo nucifera* Gaertn. – Sacred or Indian Lotus, also known as the Rose of India and the Sacred Water Lily of Hinduism and Buddhism. It is the national flower of India and Vietnam. Its roots and seeds are also used widely in Asian cooking.

Classification

Most academic botanists recognize *Nelumbo* in the family Nelumbonaceae, comprising only the single genus, *Nelumbo*, with probably two species of aquatic plants, found in North America and Asia (and perhaps some adjacent areas, but widely cultivated elsewhere).

The leaves of *Nelumbo* can be distinguished from those of genera in the Nymphaeaceae as they are peltate, that is they have fully circular leaves. *Nymphaea*, on the other hand, has a single characteristic notch from the edge in to the center of the lily pad. The seedpod of *Nelumbo* is very distinctive.

APG

The APG II system of 2003, recognizes Nelumbonaceae as a distinct family and places it in the order Proteales, in the eudicot clade.

Earlier classification systems

The Cronquist system of 1981, recognizes the family but places it in the water lily order Nymphaeales. The Dahlgren system of 1985 and Thorne system (1992) both recognize the family and place it in its own order, Nelumbonales.

Thermoregulation

N. nucifera regulates its temperature in order to benefit insects that are needed for it to reproduce. When the plant flowers, it heats its blossoms to above 30 °C (86 °F) for as long as four days even when the air is as cool as 10 °C (50 °F). The heat releases an aroma that attracts certain insects, which fly into the flower to feed on nectar and pollen. According to Roger Seymour and Paul Schultze-Motel of Australia’s University of Adelaide, the heat also rewards insects with a stable environment that enhances their ability to eat, mate, and prepare for flight.

Different views & aspects

Nelumbo lutea

Nelumbo nucifera- A lotus blossom in full bloom.

Nelumbo nucifera- A lotus blossom in full bloom.

Nelumbo nucifera- An example of the lotus effect after rain.

Lotus bud

Nelumbo nucifera- A blossom opening.

Young seed pod

Dried seed pod

Chapter- 4

Nuphar lutea and Hydrilla

Nuphar lutea

Nuphar lutea	

Nuphar lutea

Scientific classification	
Kingdom:	Plantae
(unranked):	Angiosperms
Order:	Nymphaeales
Family:	Nymphaeaceae
Genus:	*Nuphar*
Species:	***N. lutea***

Binomial name

Nuphar lutea
(L.) Sm.

Nuphar lutea, the **spatterdock**, **yellow water-lily**, **cow lily**, or **yellow pond-lily**, is an aquatic plant of the family Nymphaeaceae, native to Eurasia and North America. It grows in eutrophic freshwater beds, with its roots fixed into the ground and its leaves floating on the water's surface.

Growth

The plant's inflorescence is a solitary, terminal hermaphrodite flower, pollinated by insects, which blooms from June to September in the Northern Hemisphere. The flower is followed by achenes which are distributed by the water current. It can grow in water up to 40 cm (16 in) deep.

Medicinal and food uses

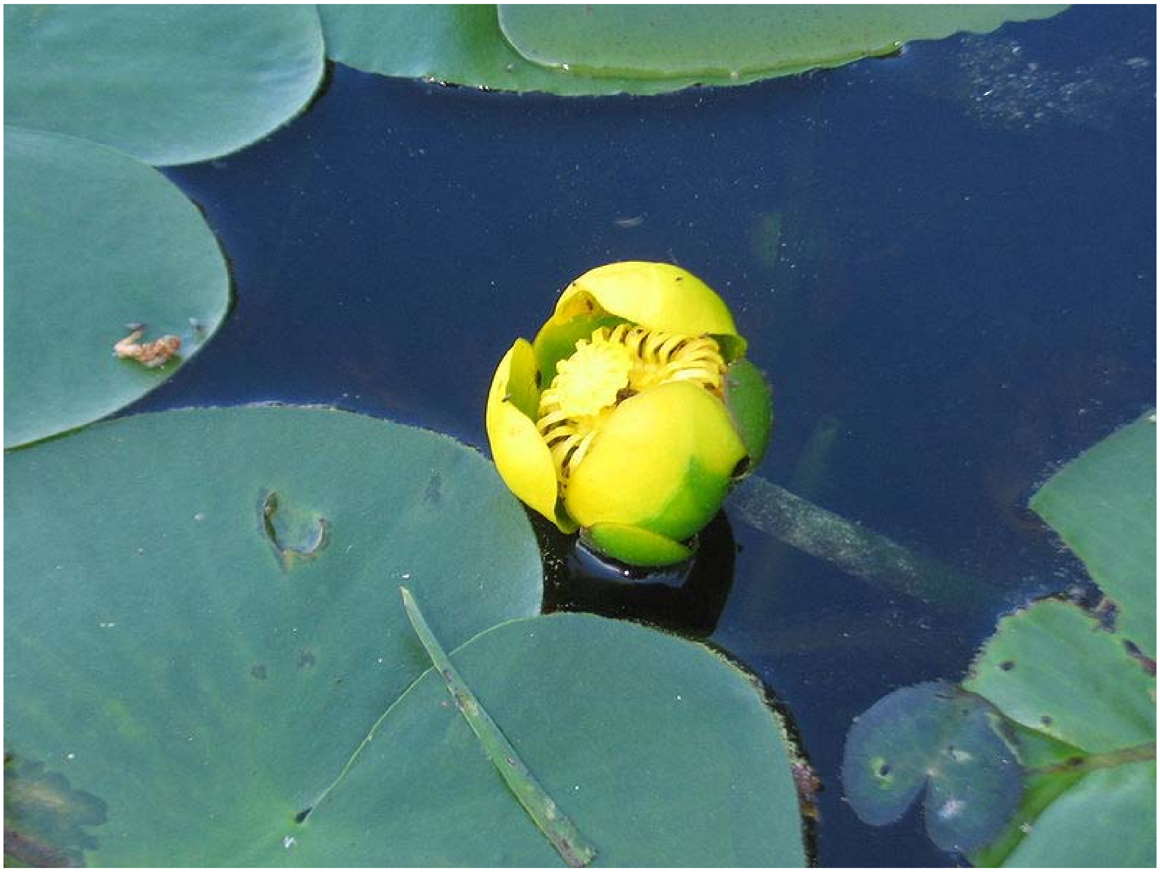
Spatterdock was long used in traditional medicine, with the root applied to the skin and/or both the root and seeds eaten for a variety of conditions. The seeds are edible, and can be ground into flour. The root is edible too, but can prove to be incredibly bitter in some plants.

Synonyms

Possible botanical synonyms include

- *Nuphar luteum* (L.) Sibth. & Sm.
- *Nuphar advena* Ait.
- *Nuphar variegata* Durand

Floating leaf habit



A Nuphar flower, New Hampshire

On Eglinton Loch, North Ayrshire, Scotland

Detail of leaf structure

Hydrilla

Hydrilla	
	
Scientific classification	
Kingdom:	Plantae
(unranked):	Monocots
Order:	Alismatales
Family:	Hydrocharitaceae
Genus:	***Hydrilla*** Rich.
Species:	***H. verticillata***
Binomial name	
Hydrilla verticillata (L.f.) Royle	

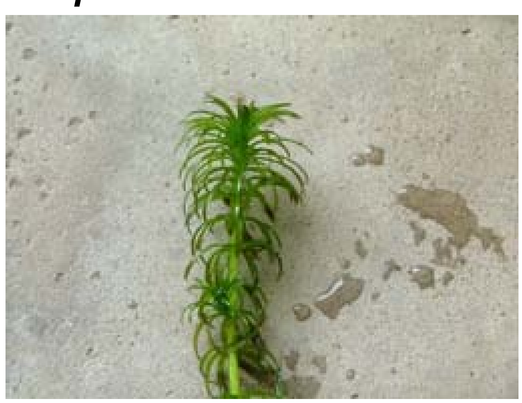
Hydrilla (**Esthwaite Waterweed** or **Hydrilla**) is an aquatic plant genus, usually treated as containing just one species, *Hydrilla verticillata*, though some botanists divide it into several species. Synonyms include *H. asiatica*, *H. japonica*, *H. lithuanica*, and *H. ovalifolica*. It is native to the cool and warm waters of the Old World in Asia, Europe, Africa and Australia, with a sparse, scattered distribution; in Europe, it is reported from Ireland, Great Britain, Germany, and the Baltic States, and in Australia from Northern Territory, Queensland, and New South Wales.

It has off-white to yellowish rhizomes growing in sediments at the water bottom at up to 2 m depth. The stems grow up to 1–2 m long. The leaves are arranged in whorls of two to eight around the stem, each leaf 5–20 mm long and 0.7–2 mm broad, with serrations or small spines along the leaf margins; the leaf midrib is often reddish when fresh. It is monoecious (sometimes dioecious), with male and female flowers produced separately on a single plant; the flowers are small, with three sepals and three petals, the petals 3–5 mm long, transparent with red streaks. It reproduces primarily vegetatively by fragmentation and by rhizomes and turions (overwintering buds), and flowers are rarely seen.

Hydrilla has a high resistance to salinity (>9-10ppt) compared to many other freshwater associated aquatic plants.

The name Esthwaite Waterweed derives from its occurrence in Esthwaite Water in northwestern England, the only English site where it is native, but now presumed extinct, having not been seen since 1941. *Hydrilla* closely resembles some other related aquatic plants, including *Egeria* and *Elodea*.

Status as an invasive plant



Foliage detail

in Lotus Pond, Hyderabad, India.

Hydrilla is naturalised and invasive in the United States following release in the 1960s from aquariums into waterways in Florida. It is now established in the southeast from Connecticut to Texas, and also in California. By the 1990s control and management were costing millions of dollars each year.

Hydrilla can be controlled by the application of aquatic herbicides and it is also eaten by grass carp, itself an invasive species in North America. Insects used as biological pest control for this plant include weevils of genus *Bagous* and the Asian hydrilla leaf-mining fly (*Hydrellia pakistanae*). Tubers pose a problem to control as they can lay dormant for a number of years. This has made it even more difficult to remove from waterways and estuaries.

As an invasive species in Florida, Hydrilla has become the most serious aquatic weed problem for Florida and most of the U.S. Because it was such a threat as an invasive species, restrictions were placed, only allowing a single type of chemical, fluridone, to be used as an herbicide. This was done to prevent the evolution of multiple mutants. The result is fluridone resistant Hyrdilla. "As hydrilla spread rapidly to lakes across the southern United States in the past, the expansion of resistant biotypes is likely to pose significant environmental challenges in the future."

Phytoremediation

This abundant source of biomas is a known bioremediation hyperaccumulator of Mercury, Cadmium, Chromium and Lead, and as such can be used in phytoremediation.

- Hyperaccumulators table – 3

Chapter- 5

Water Hyacinth and Lemna

Water hyacinth

Water Hyacinth	
	
Common Water Hyacinth (*E. crassipes*)	
Scientific classification	
Kingdom:	Plantae
(unranked):	Angiosperms
(unranked):	Monocots
(unranked):	Commelinids
Order:	Commelinales
Family:	Pontederiaceae
Genus:	***Eichhornia*** Kunth
Species	
Seven species, including: *E. azurea* - Anchored Water Hyacinth *E. crassipes* - Common Water Hyacinth	

E. diversifolia - Variableleaf
Water Hyacinth
E. paniculata - Brazilian Water
Hyacinth

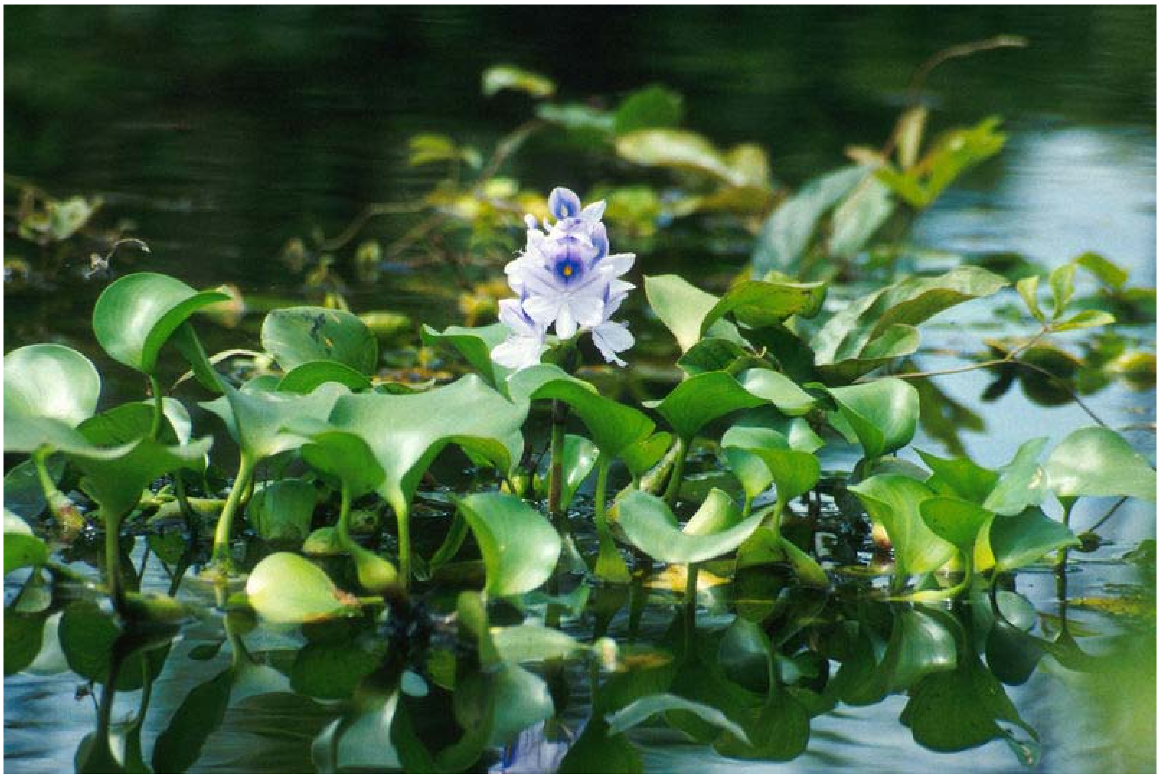
The seven species of **water hyacinth** comprise the genus ***Eichhornia***. Water hyacinth are a free-floating perennial aquatic plant native to tropical and sub-tropical South America. With broad, thick, glossy, ovate leaves, water hyacinth may rise above the surface of the water as much as 1 meter in height. The leaves are 10–20 cm across, and float above the water surface. They have long, spongy and bulbous stalks. The feathery, freely hanging roots are purple-black. An erect stalk supports a single spike of 8-15 conspicuously attractive flowers, mostly lavender to pink in colour with six petals. When not in bloom, water hyacinth may be mistaken for frog's-bit (*Limnobium spongia*).

One of the fastest growing plants known, water hyacinth reproduces primarily by way of runners or stolons, which eventually form daughter plants. It also produces large quantities of seeds, and these are viable up to thirty years. The common water hyacinth (*Eichhornia crassipes*) are vigorous growers known to double their population in two weeks.

In Assamese they are known as ***Meteka***. In Sinhala they are known as **Japan Jabara** due to their use in World War II to fool Japanese pilots into thinking lakes were fields usable to land their aircraft, leading to crashes. In Burmese they are known as ***Baydar***.

In Southern Pakistan, they are the provincial flower of Sindh.

Invasiveness as an exotic plant



Common water hyacinth in flower

Water hyacinth has been widely introduced throughout North America, Asia, Australia and Africa. They can be found in large water areas such as Louisiana, or in the Kerala Backwaters in India. In many areas it, particularly *E. crassipes*, is an important and pernicious invasive species. First introduced to North America in 1884, an estimated 50 kilograms per square metre of hyacinth once choked Florida's waterways, although the problem there has since been mitigated. When not controlled, water hyacinth will cover lakes and ponds entirely; this dramatically impacts water flow, blocks sunlight from reaching native aquatic plants, and starves the water of oxygen, often killing fish (or turtles). The plants also create a prime habitat for mosquitos, the classic vectors of disease, and a species of snail known to host a parasitic flatworm which causes schistosomiasis (snail fever). Directly blamed for starving subsistence farmers in Papua New Guinea, water hyacinth remains a major problem where effective control programs are not in place. Water hyacinth is often problematic in man-made ponds if uncontrolled, but can also provide a food source for gold fish, keep water clean and help to provide oxygen to man-made ponds.

Water hyacinth often invades bodies of water that have been impacted by human activities. For example, the plants can unbalance natural lifecycles in artificial reservoirs or in eutrophied lakes that receive large amounts of nutrients.

They are being found for the abundant plants, such as for cattle food and in biogas production. Recently, they have also begun to be used in wastewater treatment due to their fast growth and ability to tolerate high levels of pollution. Parts of the plant are also used in the production of traditional handicrafts in Southeast Asia. In Bangladesh, farmers have started producing fertilizer using Water Hyacinth or Kochuripana as it is known there locally.

As chemical and mechanical removal is often too expensive and ineffective, researchers have turned to biological control agents to deal with water hyacinth. The effort began in the 1970s when USDA researchers released three species of weevil known to feed on water hyacinth into the United States, *Neochetina bruchi*, *N. eichhorniae*, and the water hyacinth borer *Sameodes albiguttalis*. Although meeting with limited success, the weevils have since been released in more than 20 other countries. However, the most effective control method remains the control of excessive nutrients and prevention of the spread of this species.

In 2010 the insect Megamelus scutellaris was released by the Agricultural Research Service as a biological control for the invasive species *Eichhornia crassipes*, more commonly known as waterhyacinth. (United States Department of Agriculture, Agricultural Research Service,)

In May of 2010 the USDA's Agricultural Research Service released *Megamelus scutellaris* as a biological control insect for the invasive waterhyacinth species. *Megamelus scutellaris* is a small planthopper insect native to Argentina. Researchers have been studying the effects of the biological control agent in extensive host-range studies since 2006 and concluded that the insect is highly host-specific and will not pose a threat to any other plant population other than the targeted water hyacinth. Researchers also hope that the biological control will be more resilient than existing biological controls to the herbicides that are already in place to combat the invasive water hyacinth.

Water hyacinth in Lake Victoria, Africa

Hyacinth-choked lakeshore at Ndere Island, Lake Victoria, Kenya

Botanists and gardeners carry plants with them in their travels, and experts suspect that this is how the water hyacinth came to East Africa in the 1980s. Its flowers are beautiful; it was probably brought over as an ornamental for garden ponds (United Nations News, 2000). The consensus is that Water Hyacinth entered Lake Victoria from Rwanda via the river Kagera (Ambrose 1997). The exact time and place of introduction has been debated, but the plant is native to South America, and therefore reached Lake Victoria due to human activity. It has spread prolifically, due to lack of natural enemies, an abundance of space, agreeable temperature conditions, and abundant nutrients (Opande et al., 2004). It increased rapidly between 1992-1998, was greatly reduced by 2001, and has since resurged to a lesser degree. Management techniques include (hyacinth-eating) insect controls and manual beach cleanup efforts (Kateregga/Sterner 2007). A water hyacinth infestation is seldom totally eradicated. Instead, it is a situation that must be continually managed (LVEMP, 2004) (United Nations News, 2000)).

Water Hyacinth affects the Lake Victorian population in many negative ways. There are economic impacts when the weed blocks boat access. The effects on transportation and fishing are immediately felt. Where the weed is prolific, there is a general increase in several diseases, as the weed creates excellent breeding areas for mosquitoes and other insects. There are increased incidents of skin rash, cough, malaria, encephalitis, bilharzias, gastro intestinal disorders, and schistosomiasis. Water hyacinth also interferes with water treatment, irrigation, and water supply (Opande et al., 2004)). It can smother aquatic life by deoxygenating the water, and it reduces nutrients for young fish in sheltered bays. It has blocked supply intakes for the hydroelectric plant, interrupting electrical power for entire cities. The weed also interrupts local subsistence fishing, blocking access to the beaches (LVEMP, 2004).

Industrial utilization

Since the plant has abundant nitrogen content, it can be used a substrate for biogas production and the sludge obtained from the biogas. However, due to easy accumulation of toxins, the plant is prone to get contaminated when used as feed.

Exogenous

The plant is extremely tolerant of, and has a high capacity for, the uptake of heavy metals, including Cd, Cr, Co, Ni, Pb and Hg, which could make it suitable for the biocleaning of industrial wastewater ' ' ' . In addition to heavy metals, *Eichhornia crassipes* can also remove other toxins, such as cyanide, which is environmentally beneficial in areas that have endured gold mining operations .

Water hyacinth is also observed to enhance nitrification in waste water treatment cells of living technology. Their root zones are superb micro-sites for bacterial communities.

Lemna

Lemna

Common Duckweed (*Lemna minor*)

Scientific classification

Kingdom:	Plantae
(unranked):	Angiosperms
(unranked):	Monocots
Order:	Alismatales
Family:	Araceae

Subfamily:	Lemnoideae
Tribe:	Lemneae
Genus:	***Lemna*** L.

Species

About 13, including:

- *Lemna gibba* : Gibbous Duckweed
- *Lemna minor* : Common Duckweed
- *Lemna minuta* : Least Duckweed
- *Lemna trisulca* : Ivy Duckweed
- *Lemna valdiviana* : Valdivia Duckweed

Lemna is a genus of free-floating aquatic plants from the duckweed family. These rapidly-growing plants have found uses as a model system for studies in community ecology, basic plant biology, in ecotoxicology, in production of biopharmaceuticals, and as a source of animal feeds for agriculture and aquaculture.

Taxonomy and growth habits

The duckweeds have been classified as a separate family, the Lemnaceae, but some researchers (the AGP II) consider the duckweeds members of the Araceae.

Lemna species grow as simple free-floating thalli on or just beneath the water surface. Most are small, not exceeding 5 mm in length, except *Lemna trisulca* which is elongated and has a branched structure. *Lemna* thalli have a single root, which distinguishes them from related genera *Spirodela* and *Landoltia*

The plants grow mainly by vegetative reproduction: two daughter plants bud off from the adult plant. This form of growth allows very rapid colonisation of new water. Duckweeds are flowering plants, and nearly all of them are known to reproduce sexually, flowering and producing seed under appropriate conditions. Certain duckweeds (e.g. *L. gibba*) are long day plants, while others (e.g. *L. minor*) are short day plants.

When *Lemna* invades a waterway, it can be removed mechanically, by the addition of herbivorous fish (e.g. grass carp) or treated with a herbicide.

The rapid growth of duckweeds finds application in bioremediation of polluted waters and as test organisms for environmental studies. It is also being used as an expression system for economical production of complex biopharmaceuticals.

Duckweed meal (dried duckweed) is a good cattle feed. It contains 25-45% proteins (depending on the growth conditions), 4.4% fat, and 8-10% fibre, measured by dry weight.

Assessing the toxicity of chemicals with Lemna

Organisation for Economic Cooperation and Development and U.S. Environmental Protection Agency (US EPA) guidelines describe toxicity testing using *Lemna gibba* or *Lemna minor* as test organisms. Both of these species have been studied extensively for use in phytotoxicity tests. Genetic variability in responses to toxicants can occur in Lemna, and there are insufficient data to recommend a specific clone for testing. The US EPA test uses aseptic technique. The OECD test is not conducted axenically, but steps are taken at stages during the test procedure to keep contamination by other organisms to a minimum. Depending on the objectives of the test and the regulatory requirements, testing may be performed with renewal (semi-static and flow-through) or without renewal (static) of the test solution. Renewal is useful for substances that are rapidly lost from solution as a result of volatilisation, photodegradation, precipitation or biodegradation.

Production of biopharmaceuticals

Lemna has been transformed by molecular biologists to express proteins of pharmaceutical interest. Expression constructs were engineered to cause *Lemna* to secrete the transformed proteins into the growth medium at high yield. Since the *Lemna* is grown on a simple medium, this substantially reduces the burden of protein purification in preparing such proteins for medical use, promising substantial reductions in manufacturing costs. In addition, the host *Lemna* can be engineered to cause secretion of proteins with human patterns of glycosylation, an improvement over conventional plant gene-expression systems. Several such products are being developed, including monoclonal antibodies.

Duckweed farming

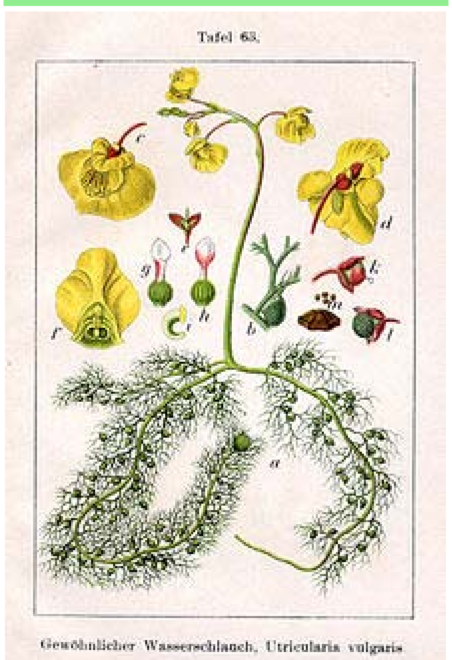
High yields of duckweed with a high protein content can be achieved by careful control of growth conditions. Although duckweed can tolerate temperatures ranging from 6 to 33 °C, the optimal growth range is 20 to 28 °C. The acceptable pH range is 5 to 9, but better growth is obtained in the pH range of 6.5 to 7.5. A minimum water depth of 1 ft is desirable to prevent excessive temperature swings. High nitrogen levels, for example 20 mM urea, have provided a protein content in the range of 45% by weight. The water may typically contain 60 mg/L of soluble nitrogen and 1 mg/L of phosphorus. Fertiliser is required on a daily basis for optimal growth.

Duckweed can be farmed organically, with nutrients being supplied from a variety of sources, for example cattle dung, pig waste, biogas plant slurry, or other organic matter in slurry form. Because of the rapid growth of duckweed, daily harvesting is necessary to achieve optimal yields. Harvesting is done such that less than a kilogram per square metre of duckweed remains. Under optimal conditions, a duckweed farm can produce 10 to 30 tons of dried duckweed per hectare per year.

Chapter- 6

Utricularia

Utricularia	



Utricularia vulgaris illustration from Jakob Sturm's *"Deutschlands Flora in Abbildungen"*, Stuttgart (1796)

Scientific classification	
Kingdom:	Plantae
(unranked):	Angiosperms
(unranked):	Eudicots
(unranked):	Asterids
Order:	Lamiales
Family:	Lentibulariaceae
Genus:	***Utricularia***

L.

Subgenera

Bivalvaria
Polypompholyx
Utricularia

Diversity

227 species

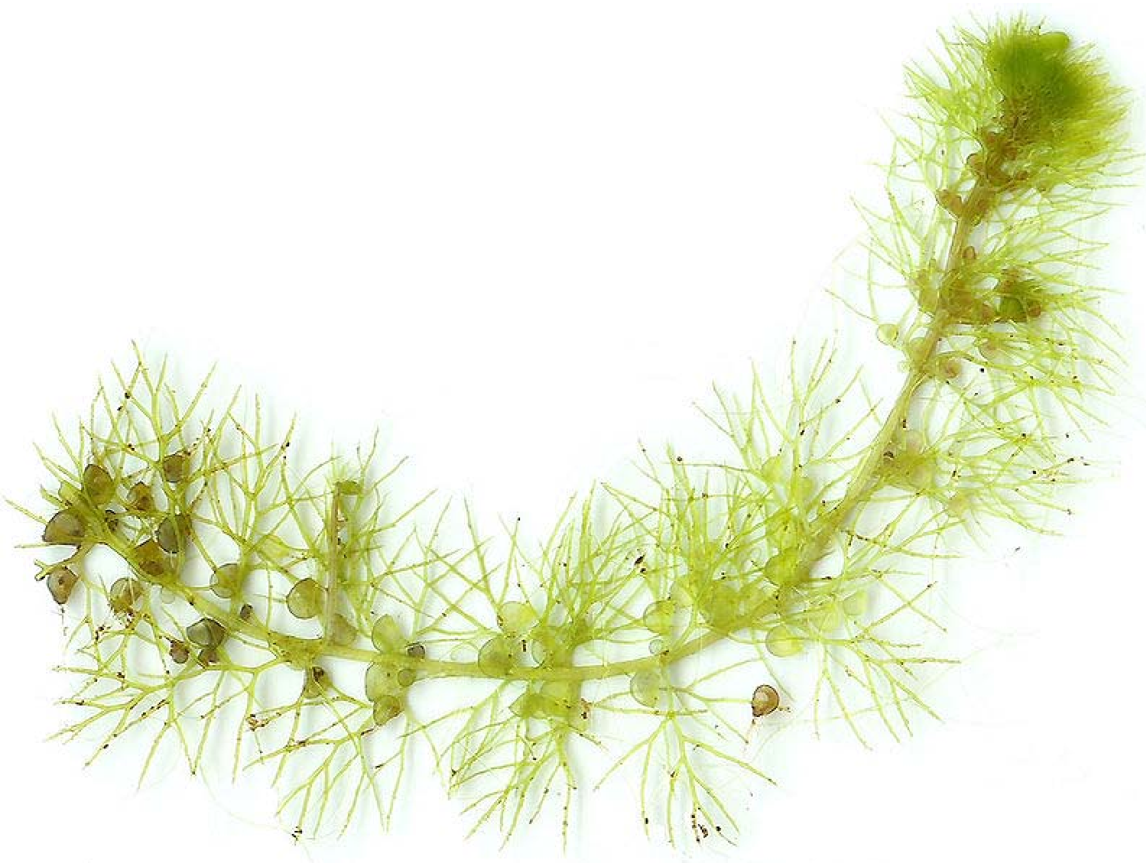
Bladderwort distribution

Utricularia, commonly and collectively called the **bladderworts**, is a genus of carnivorous plants consisting of approximately 227 species (precise counts differ based on classification opinions; one recent publication lists 215 species). They occur in fresh water and wet soil as terrestrial or aquatic species across every continent except Antarctica. *Utricularia* are cultivated for their flowers, which are often compared with those of snapdragons and orchids, and among carnivorous plant enthusiasts.

All *Utricularia* are carnivorous and capture small organisms by means of bladder-like traps. Terrestrial species tend to have tiny traps that feed on minute prey such as protozoa and rotifers swimming in water-saturated soil. The traps can range in size from 0.2 mm to 1.2 cm. Aquatic species, such as *U. vulgaris* (common bladderwort), possess bladders that are usually larger and can feed on more substantial prey such as water fleas *(Daphnia)*, nematodes and even fish fry, mosquito larvae and young tadpoles. Despite their small size, the traps are extremely sophisticated. In the active traps of the aquatic species, prey brush against trigger hairs connected to the trapdoor. The bladder, when "set", is under negative pressure in relation to its environment so that when the trapdoor is mechanically triggered, the prey, along with the water surrounding it, is swept into the bladder. Once the bladder is full of water, the door closes again, the whole process taking only ten to fifteen thousandths of a second.

Bladderworts are unusual and highly specialized plants, and the vegetative organs are not clearly separated into roots, leaves , and stems as in most other angiosperms. The bladder traps, conversely, are recognized as one of the most sophisticated structures in the plant kingdom.

Physical description



The tip of one stolon from a U.K. instance of *U. vulgaris*, showing stolon, branching leaf-shoots and transparent bladder traps.

The main part of a bladderwort plant always lies beneath the surface of its substrate. Terrestrial species sometimes produce a few photosynthetic leaf-shoots which lie unobtrusively flat against the surface of their soil, but in all species only the flowering stems rise above and are prominent. This means that the terrestrial species are generally visible only while they are in flower, although aquatic species can be observed below the surfaces of ponds and streams.

Plant structure

Most species form long, thin, sometimes branching stems or *stolons* beneath the surface of their substrate, whether that be pond water or dripping moss in the canopy of a tropical rainforest. To these stolons are attached both the bladder traps and photosynthetic leaf-shoots, and in terrestrial species the shoots are thrust upward through the soil into the air or along the surface.

The name *bladderwort* refers to the bladder-like traps. The generic name *Utricularia* is similarly derived from the Latin *utriculus*, a word which has many related meanings but which most commonly means *wine flask* or *leather bottle*. The aquatic members of the genus have the largest and most obvious bladders, and these were initially thought to be flotation devices before their carnivorous nature was discovered.

Flowers and reproduction

Utricularia amethystina flower

Flowers are the only part of the plant clear of the underlying soil or water. They are usually produced at the end of thin, often vertical inflorescences. They can range in size from 2 mm to 10 cm wide, and have two asymmetric labiate (unequal, lip-like) petals, the lower usually significantly larger than the upper. They can be of any colour, or of many colours, and are similar in structure to the flowers of a related carnivorous genus, *Pinguicula*.

The flowers of aquatic varieties like *U. vulgaris* are often described as similar to small yellow snapdragons, and the Australian species *U. dichotoma* can produce the effect of a field full of violets on nodding stems. The epiphytic species of South America, however, are generally considered to have the showiest, as well as the largest, flowers. It is these species that are frequently compared with orchids.

Certain plants in particular seasons might produce closed, self-pollinating (*cleistogamous*) flowers; but the same plant or species might produce open, insect-pollinated flowers elsewhere or at a different time of year, and with no obvious pattern. Sometimes, individual plants have both types of flower at the same time: aquatic species such as *U. dimorphantha* and *U. geminiscapa*, for example, usually have open flowers riding clear of the water and one or more closed, self-pollinating flowers beneath the water. Seeds are numerous and small and for the majority of species are as small as 0.2 mm to 1 mm long.

Distribution and habitat

Utricularia aurea growing in a rice paddy in Thailand.

Utricularia can survive almost anywhere where there is fresh water for at least part of the year; only Antarctica and some oceanic islands have no native species. The greatest species diversity for the genus is seen in South America, with Australia coming a close second. In common with most carnivorous plants, they grow in moist soils which are poor in dissolved minerals, where their carnivorous nature gives them a competitive advantage; terrestrial varieties of *Utricularia* can frequently be found alongside representatives of the carnivorous genera–*Sarracenia*, *Drosera* and others–in very wet areas where continuously moving water removes most soluble minerals from the soil.

About 80% of the species are terrestrial, and most inhabit waterlogged or wet soils, where their tiny bladders can be permanently exposed to water in the substrate. Frequently they will be found in marshy areas where the water table is very close to the surface. Most of the terrestrial species are tropical, although they occur worldwide.

Approximately 20% of the species are aquatic. Most of these drift freely over the surface of ponds and other still, muddy-bottomed waters and only protrude above the surface when flowering, although a few species are lithophytic and adapted to rapidly moving streams or even waterfalls. The plants are usually found in acidic waters, but they are quite capable of growing in alkaline waters and would very likely do so were it not for the higher level of competition from other plants in such areas. *Utricularia vulgaris* is an aquatic species and grows into branching rafts with individual stolons up to one metre or longer in ponds and ditches throughout Eurasia.

Some South American tropical species are epiphytes, and can be found growing in wet moss and spongy bark on trees in rainforests, or even in the watery leaf-rosettes of other epiphytes such as various *Tillandsia* (a type of bromeliad) species. Rossette-forming epiphytes such as *U. nelumbifolia* put out runners, searching for other nearby bromeliads to colonise.

The plants are as highly adapted in their methods of surviving seasonally inclement conditions as they are in their structure and feeding habits. Temperate perennials can require a winter period in which they die back each year, and they will weaken in cultivation if they are not given it; tropical and warm-temperate species, on the other hand, require no dormancy. Floating bladderworts in cold temperate zones such as the UK and Siberia can produce winter buds called turions at the extremities of their stems: as the autumnal light fails and growth slows down, the main plant may rot away or be killed by freezing conditions, but the turions will separate and sink to the bottom of the pond to rest beneath the coming ice until the spring, when they will return to the surface and resume growth. Many Australian species will grow only during the wet season, reducing themselves to tubers only 10 mm long to wait out the dry season. Other species are annual, returning from seed each year.

Carnivory

Traps of *Utricularia aurea*

Trap of *Utricularia hamiltonii*

Physical description of the trap

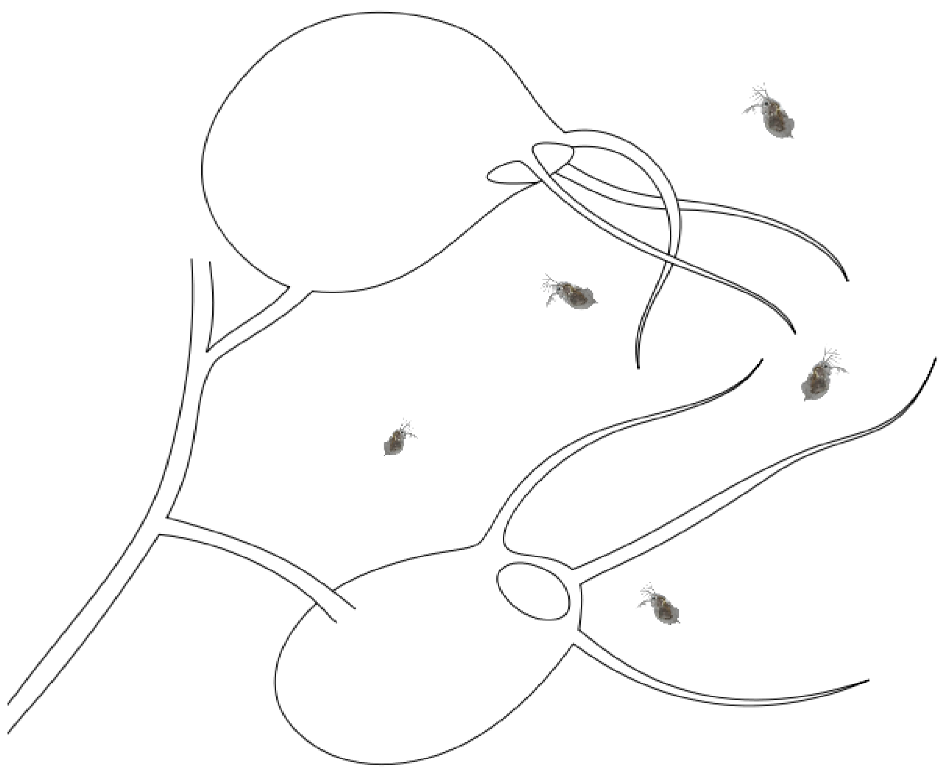
Authorities agree that the vacuum-driven bladders of *Utricularia* are the most sophisticated carnivorous trapping mechanism to be found anywhere in the plant kingdom. The bladders are usually shaped similarly to broad beans (though they come in various shapes) and are to be found attached to the submerged stolons by slender stalks.

The bladder walls are very thin and transparent, but are sufficiently inflexible to maintain the bladder's shape despite the vacuum created within. The entrance, or 'mouth', of the trap is a circular or oval flap whose upper half is joined to the body of the trap by very flexible, yielding cells which form an effective hinge. The door rests on a platform formed by the thickening of the bladder wall immediately underneath. A soft but substantial membrane called the *velum* stretches in a curve around the middle of this platform, and helps seal the door. A second band of springy cells cross the door just above its lower edge, and provide the flexibility for the bottom of the door to become a bendable 'lip' which can make a perfect seal with the velum.

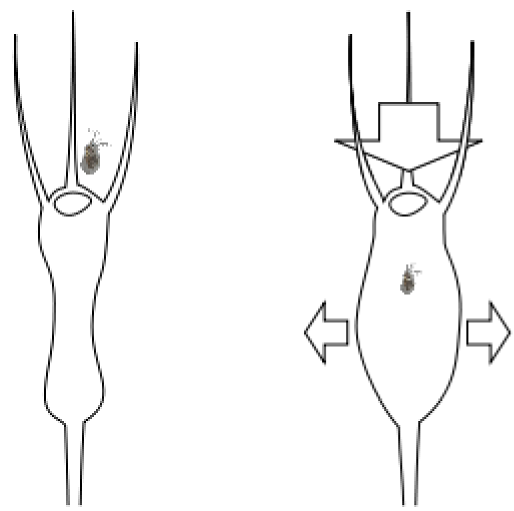
The outer cells of the whole trap excrete mucilage and under the door this is produced in greater quantities and contains sugars. The mucilage certainly contributes towards the seal, and the sugars may help to attract prey.

Terrestrial species generally have tiny traps (sometimes as small as 0.2 mm) with a broad beak-like structure extending and curving down over the entrance; this forms a passageway to the trapdoor and may help prevent the trapping and ingestion of inorganic particles. Aquatic species tend to have larger bladders (up to 1.2 cm), and the mouth of the trap is usually surrounded not by a beak but by branching antennae, which serve both to guide prey animals to the trap entrance and to fend the trap mouth away from larger bodies which might trigger the mechanism needlessly. Epiphytic species have unbranched antennae which curve in front of the mouth and probably serve the same purpose, although it has been observed that they are also capable of holding a pocket of water in front of the mouth by capillary action, and that this assists with the trapping action.

Trapping mechanism



Bladderwort traps: long, usually branching (but here simplified), antennae guide *Daphnia* to the trapdoors of an aquatic bladderwort.



Bladderwort trap mechanism: seen from below, a bladder squeezed by water excretion suddenly swells as its trapdoor is released by an errant *Daphnia*. The bladder sucks in the nearby water, including the unfortunate animal which triggered the trap.

The trapping mechanism of *Utricularia* is purely mechanical; no reaction from the plant (irritability) is required in the presence of prey, in contrast with the triggered mechanisms employed by Venus Flytraps (*Dionaea*), waterwheels (*Aldrovanda*), and many sundews (*Drosera*). The only active mechanism involved is the constant pumping out of water through the bladder walls by active transport.

As water is pumped out, the bladder's walls are sucked inwards by the partial vacuum created, and any dissolved material inside the bladder will become more concentrated. The sides of the bladder bend inwards, storing potential energy like a spring. Eventually, no more water can be extracted, and the bladder trap is 'fully set' (technically, osmotic pressure rather than physical pressure is the limiting factor).

Extending outwards from the bottom of the trapdoor are several long bristle-stiff protuberances that are sometimes referred to as *trigger hairs* or *antennae* but which have no similarity to the sensitive triggers found in *Dionaea* and *Aldrovanda*. In fact, these bristles are simply levers. The suction force exerted by the primed bladder on the door is resisted by the adhesion of its flexible bottom against the soft-sealing velum. The equilibrium depends quite literally on a hair trigger, and the slightest touch to one of the lever hairs will deform the flexible door lip enough to create a tiny gap, breaking the seal.

Once the seal is disturbed, the bladder walls instantly spring back to a more rounded shape; the door flies open and a column of water is sucked into the bladder. The animal which touched the lever, if small enough, is inevitably drawn in, and as soon as the trap is filled, the door resumes its closed position—the whole operation being completed in as little as one-hundredth of a second.

Once inside, the prey will be dissolved by digestive secretions. This generally occurs within a few hours, although some protozoa appear to be highly resistant and have been observed to live for several days inside the trap. All the time, the trap walls continue to pump out water, and the bladder can be ready for its next capture in as little as 15 to 30 minutes.

Lloyd's experiments

In the 1940s Francis Ernest Lloyd conducted extensive experiments with carnivorous plants, including *Utricularia*, and settled many points which had previously been the subject of conjecture. He proved that the mechanism of the trap was purely mechanical by both killing the trigger hairs with iodine and subsequently showing that the response was unaffected, and by demonstrating that the trap could be made ready to spring a second (or third) time immediately after being set off if the bladder's excretion of water were helped by a gentle squeeze; in other words, the delay of at least fifteen minutes between trap springings is due solely to the time needed to excrete water, and the triggers need no time to recover irritability (unlike the reactive trigger hairs of Venus Flytraps, for example).

He tested the role of the velum by showing that the trap will never set if small cuts are made to it; and showed that the excretion of water can be continued under all conditions likely to be found in the natural environment, but can be prevented by driving the osmotic pressure in the trap beyond normal limits by the introduction of glycerine.

The ingestion of larger prey

Lloyd devoted several studies to the possibility, often recounted but never previously accounted for under scientific conditions, that *Utricularia* can consume larger prey such as young tadpoles and mosquito larvae by catching them by the tail, and ingesting them bit by bit.

Prior to Lloyd, several authors had reported this phenomenon and had attempted to explain it by positing that creatures caught by the tail repeatedly set off the trap as they thrash about in an attempt to escape—even as their tails are actively digested by the plant. Lloyd, however, demonstrated that the plant is quite capable of ingestion by stages without the need of multiple stimuli.

The flower stem of the aquatic *Utricularia inflata* is held aloft by a rosette of floats.

He produced suitable artificial "prey" for his experiments by stirring albumen (egg white) into hot water and selecting shreds of an appropriate length and thickness. When caught by one end, the strand would gradually be drawn in, sometimes in sudden jumps, and at other times by a slow and continuous motion. Strands of albumen would often be fully ingested in as little as twenty minutes.

Mosquito larvae, caught by the tail, would be engulfed bit by bit. A typical example given by Lloyd showed that a larva of a size at the upper limit of what the trap could manage would be ingested stage by stage over the course of about twenty-four hours; but that the head, being rigid, would often prove too large for the mouth of the trap and would remain outside, plugging the door. When this happened, the trap evidently formed an effective seal with the head of the larva as it could still excrete water and become flattened, but it would nevertheless die within about ten days "evidently due to overfeeding".

Softer-bodied prey of the same size such as small tadpoles could be ingested completely, because they have no rigid parts and the head, although capable of plugging the door for a time, will soften and yield and finally be drawn in.

Very thin strands of albumen could be soft and fine enough to allow the trapdoor to close completely; these would not be drawn in any further unless the trigger hairs were indeed stimulated again. On the other hand, a human hair, finer still but relatively hard and unyielding, could prevent a seal being formed; these would prevent the trap from resetting at all due to leakage of water.

Lloyd concluded that the sucking action produced by the excretion of water from the bladder was sufficient to draw larger soft-bodied prey into the trap without the need for a second or further touch to the trigger levers. An animal long enough not to be fully engulfed upon first springing the trap, but thin and soft enough to allow the door to return fully to its set position, would indeed be left partly outside the trap until it or another body triggered the mechanism once again. However, the capture of hard bodies not fully drawn into the trap would prevent its further operation.

Species

Utricularia is the largest genus of carnivorous plants. It is one of the three genera that make up the Bladderwort family (Lentibulariaceae), along with the butterworts *(Pinguicula)* and corkscrew plants *(Genlisea)*.

This genus was considered to have 250 species until Peter Taylor reduced the number to 214 in his exhaustive study *The Genus Utricularia: a taxonomic monograph*, published by HMSO (1989). Taylor's classification is now generally accepted with modifications based on phylogenetic studies.

The genus ***Polypompholyx***, the pink petticoats, contained just two species of carnivorous plant, *Polypompholyx tenella* and *Polypompholyx multifida*, previously distinguished from the otherwise similar genus *Utricularia* by their possession of four calyx lobes rather than two. The genus has now been subsumed into *Utricularia*.

The genus ***Biovularia*** contained the species *Biovularia olivacea* (also known as *B. brasiliensis* or *B. minima*) and *Biovularia cymbantha*. The genus has been subsumed into *Utricularia*.

Chapter- 7

Alternanthera Sessilis and Alisma Subcordatum

Alternanthera sessilis

Alternanthera sessilis	
	
Scientific classification	
Kingdom:	Plantae
Division:	Magnoliophyta
Class:	Magnoliopsida
Order:	Caryophyllales
Family:	Amaranthaceae
Subfamily:	Gomphrenoideae
Genus:	*Alternanthera*

Species: ***A. sessilis***

Binomial name
Alternanthera sessilis (L.) R.Br. ex DC.
Synonyms
Alternanthera glabra *Gomphrena sessilis*

Alternanthera sessilis is an aquatic plant known by several common names, including **sessile joyweed** and **dwarf copperleaf**. It is used as an aquarium plant.

The plant occurs around the world.

The leaves are used as a vegetable. Young shoots and leaves are eaten as a vegetable in Southeast Asia. Occasionally it is cultivated for food or for use in herbal medicines.

This species is classified as a weed in parts of the southern States of the USA. It is usually (but not always especially in areas of high humidity where it can even be a garden weed) found in wet or damp spots.

This is a perennial herb with prostrate stems, rarely ascending, often rooting at the nodes. Leaves obovate to broadly elliptic, occasionally linear-lanceolate, 1-15 cm long, 0.3-3 cm wide, glabrous to sparsely villous, petioles 1-5 mm long. Flowers in sessile spikes, bract and bracteoles shiny white, 0.7-1.5 mm long, glabrous; sepals equal, 2.5-3 mm long, outer ones 1-nerved or indistinctly 3-nerved toward base; stamens 5, 2 sterile. In the wild it flowers from December till March.

Aerva lanata is often mistaken for Alternanthera sessilis, which is also of the Amaranthecea family, and looks similar. On careful observation you will notice that flowers of Alternanthera sessilis are situated over the stem and their shape is round. As its flowers look like the eyes of a fish, Alternanthera sessilis is called Matsyakshi, fisheyed. Other Indian names of this plant are Koypa (Marathi), Honganne (Kannada). Leaves along with the flowers and tender stems are used as vegetable in Karnataka. It is diuretic, tonic and cooling. Juice of this plant, deemed beneficial to eyes, is an ingredient in the making of medicinal hairoils and Kajal (kohl). The red variety of this plant is a common garden hedging plant, which is also used as a culinary vegetable.

in Rangareddy district of Andhra Pradesh, India.

in Rangareddy district of Andhra Pradesh, India.

in Rangareddy district of Andhra Pradesh, India.

Alisma subcordatum

Alisma subcordatum	
	
Scientific classification	
Kingdom:	Plantae
(unranked):	Angiosperms
(unranked):	Monocots
Order:	Alismatales
Family:	Alismataceae
Genus:	*Alisma*
Species:	***A. subcordatum***
Binomial name	
Alisma subcordatum Raf.	
Synonyms	

- *Alisma plantago-aquatica* L. ssp. *subcordatum* (Raf.) Hultén
- *Alisma plantago-aquatica* L. var. *parviflorum* (Pursh) Torr.
- *Alisma parviflorum* Pursh

Alisma subcordatum (**American water plantain**) is a perennial aquatic plant in the Water-plantain family (Alismataceae). This plant grows to about 3 feet (1 meter) in height with lance to oval shaped leaves rising from bulbous corms with fibrous roots. Any leaves that form underwater a weak and quick to rot; they rarely remain on adult plants. A branched inflorescence with white to pink 3 petaled flowers blooms from June to September. The seeds are eaten by waterfowl and upland birds. The species name *subcordatum* means "almost heart-shaped".

American water plantain is native to North America from Massachusetts to Florida and east to Texas and Minnesota. It grows in the mud of still to slow moving water, seeps, and wetlands.

Chapter- 8

Azolla and Cryptocoryne

Azolla

Mosquito fern	
	
Azolla caroliniana	
Scientific classification	
Kingdom:	Plantae
Division:	Pteridophyta
Class:	Pteridopsida
Order:	Salviniales
Family:	**Azollaceae** Wettst.
Genus:	***Azolla*** Lam.
Type species	
A. filiculoides	
Species	

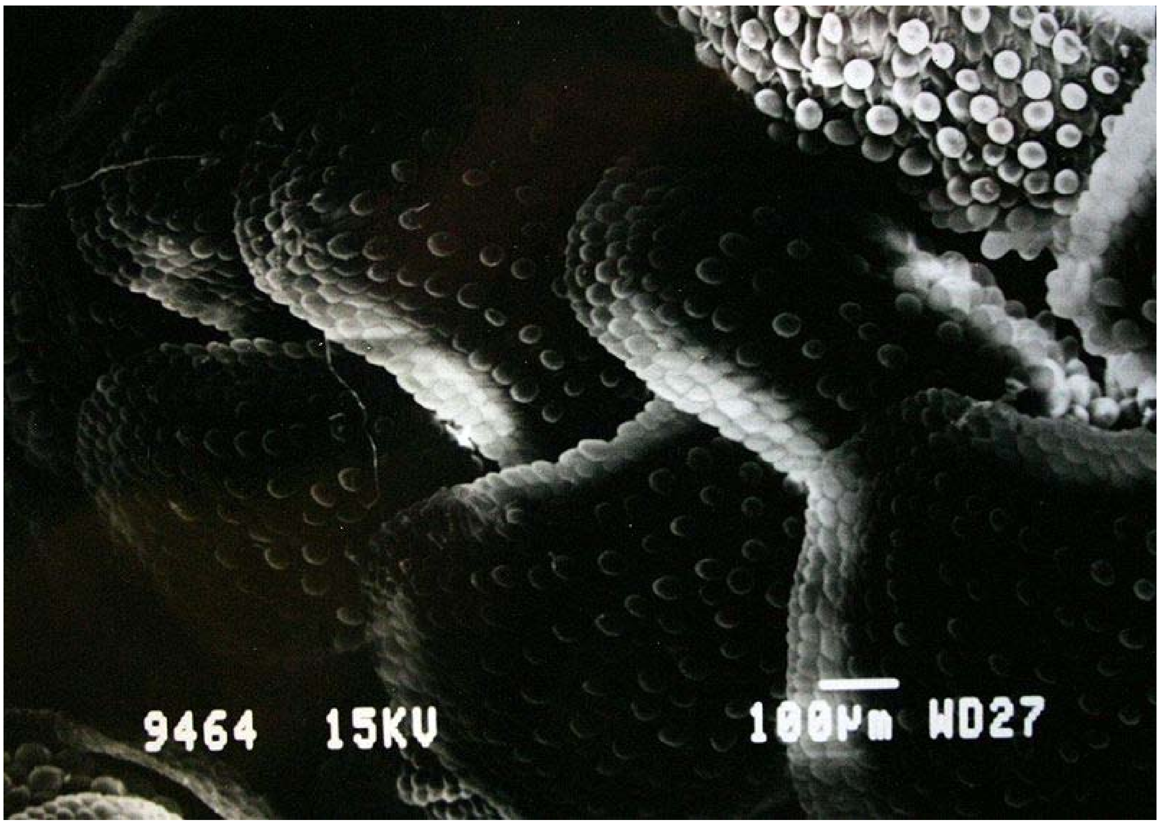
Azolla (**mosquito fern**, **duckweed fern**, **fairy moss**, **water fern**) is a genus of seven species of aquatic ferns, the only genus in the family **Azollaceae**. They are extremely reduced in form and specialized, looking nothing like conventional ferns but more resembling duckweed or some mosses.

Selected species

Azolla caroliniana Willd.
[Poss. synon. of *A. filiculoides*]
Azolla circinata Oltz & Hall
Azolla filiculoides Lam.
Azolla japonica Franch. & Sav.
[Poss. synon. of *A. filiculoides*]
Azolla mexicana C.Presl
Azolla microphylla Kaulf.
Azolla nilotica Decne. ex Mett.
Azolla pinnata R.Br.
Azolla rubra R.Br.
[Poss. synon. of *A. filiculoides*]

Ecology

Azolla floats on the surface of water by means of numerous, small, closely-overlapping scale-like leaves, with their roots hanging in the water. They form a symbiotic relationship with the cyanobacterium *Anabaena azollae*, which fixes atmospheric nitrogen, giving the plant access to the essential nutrient. This has led to the plant being dubbed a "super-plant", as it can readily colonise areas of freshwater, and grow at great speed - doubling its biomass every two to three days. The only known limiting factor on its growth is phosphorus, another essential mineral. An abundance of phosphorus, due for example to eutrophication or chemical runoff, often leads to *Azolla* blooms.



SEM image of Azolla surface

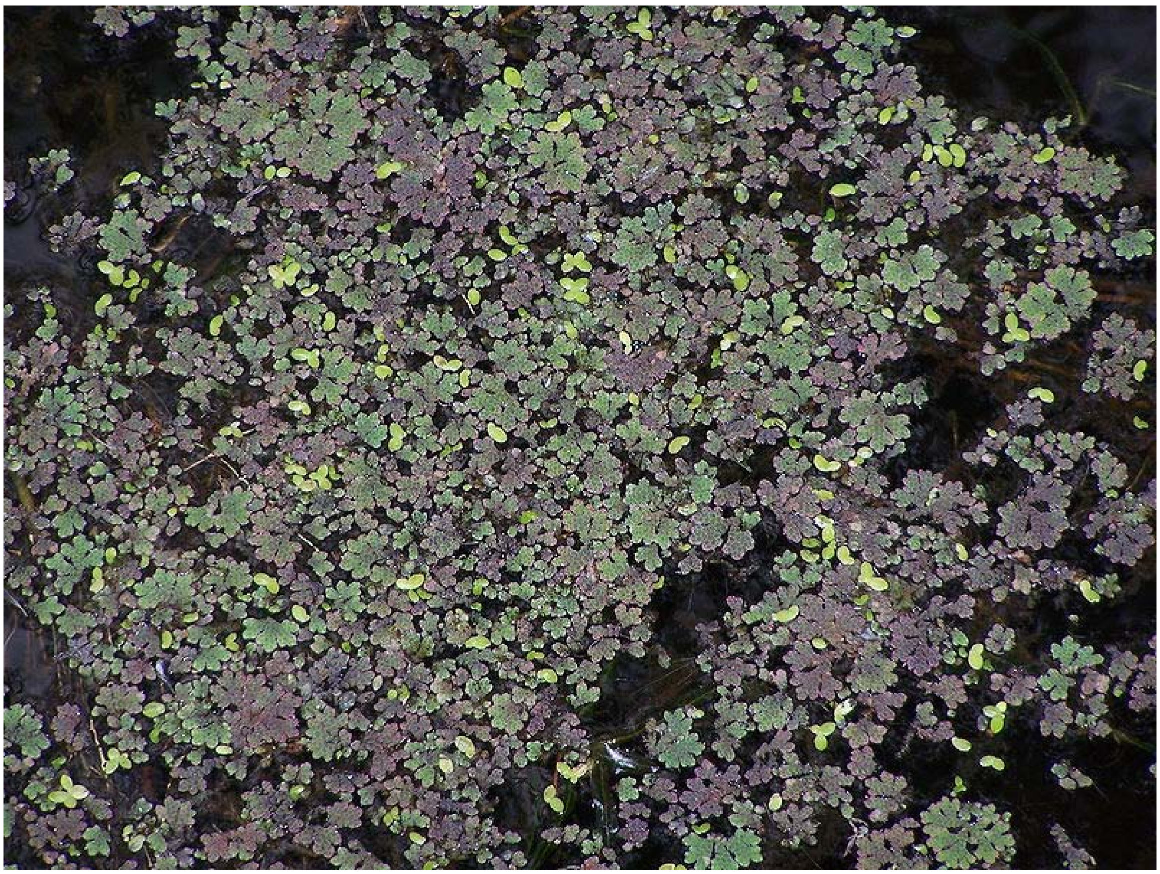
Their nitrogen-fixing capability of *Azolla* has led to it being widely used as a biofertiliser, especially in parts of southeast Asia. Indeed, the plant has been used to bolster agricultural productivity in China for over a thousand years. When rice paddies are flooded in the spring, they can be inoculated with *Azolla*, which then quickly multiplies to cover the water, suppressing weeds. The rotting plant material releases nitrogen to the rice plants, providing up to nine tonnes of protein per hectare per year.

Azolla are also serious weeds in many parts of the world, entirely covering some bodies of water. The myth that no mosquito can penetrate the coating of fern to lay its eggs in the water gives the plant its common name "mosquito fern".

Most of the species can produce large amounts of deoxyanthocyanins in response to various stresses, including bright sunlight and extremes of temperature,, causing the water surface to appear to be covered with an intensely red carpet. Herbivore feeding induces accumulation of deoxyanthocyanins and leads to a reduction in the proportion of polyunsaturated fatty acids in the fronds, thus lowering their palatability and nutritive value.

Azolla cannot survive winters with prolonged freezing, so is often grown as an ornamental plant at high latitudes where it cannot establish itself firmly enough to become a weed. It is not tolerant to salinity; normal plants can't survive in greater than 1-1.6‰, and even conditioned organisms die in over 5.5‰ salinity.

Reproduction



Azolla on the Canning River, Western Australia

Azolla reproduces sexually, and asexually by splitting.

Like all ferns, sexual reproduction leads to spore formation, but *Azolla* sets itself apart from other members of its group by producing two kinds. During the summer months, numerous spherical structures called sporocarps form on the undersides of the branches. The male sporocarp is greenish or reddish and looks like the egg mass of an insect or spider. It is two millimeters in diameter, and inside are numerous male sporangia. Male spores (microspores) are extremely small and are produced inside each microsporangium. Curiously, microspores tend to adhere in clumps called massulae.

Female sporocarps are much smaller, containing one sporangium and one functional spore. Since an individual female spore is considerably larger than a male spore, it is termed a megaspore.

Azolla has microscopic male and female gametophytes that develop inside the male and female spores. The female gametophyte protrudes from the megaspore and bears a small number of archegonia, each containing a single egg. The microspore forms a male gametophyte with a single antheridium which produces eight swimming sperm. The barbed glochidia on the male spore clusters are assumed to cause them to cling to the female megaspores, thus facilitating fertilization.

Human Use

Food

In addition to its traditional cultivation as a bio-fertilizer for wetland paddy (due to its ability to fix Nitrogen into the soil), Azolla is finding increasing use for sustainable production of livestock feed. Azolla is rich in proteins, essential amino acids, vitamins and minerals. Studies describe feeding azolla to dairy cattle, pigs, ducks, and chickens, with reported increases in milk production, weight of broiler chickens and egg production of layers, as compared to conventional feed. One FAO study describes how azolla integrates into a tropical biomass agricultural system, reducing the need for inputs.

Companion plant

Azolla has been used, for at least one thousand years, in rice paddies as a companion plant, because of its ability to both fix nitrogen, and block out light to prevent any competition from other plants, aside from the rice, which is planted when tall enough to poke out of the water through the azolla layer.

Larvicide

As an additional benefit to its role as a paddy biofertilizer, *Azolla* spp. have been used to control mosquito larvae in rice fields. The plant grows in a thick mat on the surface of the water, reducing the rate at which oxygen dissolves into the water, effectively choking the larvae.

Climatic paleontology

Azolla covering the Canning River

A study of Arctic climatology reported that azolla may have had a significant role in reversing an increase in greenhouse effect that occurred 55 million years ago that caused the region around the north pole to turn into a hot tropical environment. This research conducted by the Institute of Environmental Biology at Utrecht University claims that large dense patches of *Azolla* growing around freshwater lakes formed by the climate change eventually consumed enough carbon dioxide for the greenhouse effect to reverse.

Cryptocoryne

Water trumpet	
Scientific classification	
Kingdom:	Plantae
(unranked):	Angiosperms

(unranked):	Monocotyledons
Order:	Alismatales
Family:	Araceae
Subfamily:	Aroideae
Tribe:	Cryptocoryneae
Genus:	***Cryptocoryne*** Fisch. ex Wydler

Cryptocoryne (**water trumpet**) is a genus of about 50-60 species of aquatic monocot plants from the family Araceae (arums). The genus is naturally distributed in tropical regions of Asia and New Guinea.

The typical habitats of *Cryptocoryne* are mostly streams and rivers with not too rapidly flowing water, in the lowland forest. They also live in seasonally inundated forest pools or on river banks submerged only at high water. Although the proper scientific name of the genus is *Cryptocoryne*, they are commonly referred to as **crypts**. The English name "water trumpet" refers to their inflorescence, a spadix enclosed by a spathe (typical for the whole family), which resembles a trumpet.

The first *Cryptocoryne* species was described in 1779 as *Arum spirale* by Retzius. The genus was described by Friedrich Ernst Ludwig von Fischer in 1828. However, the scientific classification of *Cryptocoryne* species is very complicated and there are different opinions about it. *Lagenandra* is another genus closely related to the genus *Cryptocoryne*. The two can be easily told apart since the leaves of *Cryptocorynes* exhibit convolute vernation whereas *Lagenandras* exhibit involute vernation.

The name *Cryptocoryne* is derived from the Latin *crypto*, meaning hidden, and the Greek *koryne*, meaning club. The common name (Watertrumpet) refers to the shape of its inflorescence, which is typical of the Arum family.

Selected species

Inflorescence of *C. pontederiifolia*

C. wendtii "Green", the most popular *Cryptocoryne*.

A form of *C. wendtii* produced by Tropica Aquarium Plants.

- *Cryptocoryne affinis*
- *Cryptocoryne aponogetifolia*
- *Cryptocoryne auriculata*
- *Cryptocoryne beckettii*
- *Cryptocoryne bogneri*
- *Cryptocoryne bullosa*
- *Cryptocoryne ciliata*
- *Cryptocoryne cognata*
- *Cryptocoryne cordata*
- *Cryptocoryne crispatula*
- *Cryptocoryne dewitii*
- *Cryptocoryne griffithii*
- *Cryptocoryne lingua*
- *Cryptocoryne longicauda*
- *Cryptocoryne mekongensis*
- *Cryptocoryne minima*
- *Cryptocoryne parva*
- *Cryptocoryne pontederiifolia*
- *Cryptocoryne purpurea*
- *Cryptocoryne retrospiralis*

- *Cryptocoryne spiralis*
- *Cryptocoryne thwaitesii*
- *Cryptocoryne undulata*
- *Cryptocoryne usteriana*
- *Cryptocoryne walkeri*
- *Cryptocoryne walkeri 'lutea'*
- *Cryptocoryne wendtii*
- *Cryptocoryne x willisii*

Cultivation and uses

Some water trumpets are popular commercially cultivated aquarium plants. Submersed plants reproduce vegetatively, emersed plants may flower and reproduce sexually. Many species are cultivated only by dedicated experts and are very hard to grow, or are not present in a culture at all. Some species are endangered because their natural habitats are disappearing. On the other hand, some water trumpets (eg. *Cryptocoryne beckettii*) are very hardy aquarium plants, easy to grow to the point that they have become an invasive species after being introduced in Florida in North America.

Some of the Cryptocorynes are generally the easier ones to keep (in fact, some species, such as *Cryptocorynes wendtii* are said to be among the most versatile of aquarium plants); they require low to moderate light (but can grow faster in more intense light), a temperature range of around 20 to 33 °C, and slightly acidic or neutral pH, though they can adapt to higher pH as well. In contrast to accepted aquarium wisdom, it thrives well in calcareous water. Many modern aquariums may be too well lit for crypts to thrive.

Plants of the genus *Cryptocoryne*, which range from India to New Guinea are found in very diverse conditions. Some are true acid loving plants such as *C. grabowski*, found in peat bogs in Borneo, while others such as *C. balansae* and *C. pontiderifolia* are found in streams with limestone beds - hard alkaline water. One species, *C. ciliata* is even found in semi brackish water in some areas. It is one of the few aquarium plants that tolerates salt concentrations that would almost certainly kill other aquarium plants.

There has been an extensive revision of the genus by Jacobsen and many names aquarists are familiar with have been changed. Crypts also have an annoying (to taxonomists!) tendency to hybridize freely in nature and there are a handful of "species" found in nature that are hybrids. Together with the fact that some species show a large variability (*C. wendtii*) and can only be properly identified by the flowering spathe, this makes it difficult to identify some species solely on leaf habit.

Cryptocoryne plants have been in cultivation in the aquarium hobby since the late 18th century, although it was not until the 1960 s that more than a handful of species were known and became more common in the hobby. New species still regularly crop up as interest in these plants widens and more collecting expeditions by private parties are carried out.

Crypts are of commercial importance in the pet trade and have escaped into the wild in America, Jamaica, and other places. Texas and Florida both have stands of well established populations and these are considered invasive weeds with no known methods of control.

Crypt melt

A phenomenon often encountered when planting new crypts in an aquarium is commonly called *Crypt melt*, whereby the plant loses all its leaves. There seem to be two possible causes for this.

Rapid environmental changes is thought to trigger this, as these plants don't seem to adapt well to transplantion, and may need thirty days or so to become established and for the leaves to regrow. Experienced growers report that it is better to plant crypts in aquariums that have been established for at least three months.

In the wild, Crypts can grow fully submerged underwater, but in Oriental nurseries they are often grown emersed and crypt melt could then be triggered by the change from emerse to submerse conditions.

There is lately a trend for such nurseries to send crypts as just a rootstock (ie. without the leaves to reduce shipping costs and because the leaves will be lost anyway once planted in an aquarium.

Other reports, eg.

- Howto cultivate Crypts

emphasise the need to change the aquarium water regularly to prevent the build up of nitrates which are thought to trigger this condition (often referred to as a *disease*)

- Cryptocoryne affinis leaf drop

Chapter- 9

Elodea and Elodea Canadensis

Elodea

Elodea	
	
Elodea canadensis	
Scientific classification	
Kingdom:	Plantae
(unranked):	Angiosperms
(unranked):	Monocots
Order:	Alismatales
Family:	Hydrocharitaceae
Genus:	***Elodea*** Michx.
Species	

- *E. callitrichoides*
- *E. canadensis*
- *E. nuttallii*

Synonyms

Anacharis Rich.

Elodea is a genus of aquatic plants often called the **waterweeds**. *Elodea* is native to North America and is also widely used as aquarium vegetation. The introduction of some species of *Elodea* into waterways in parts of Europe, Australia, Africa, Asia, and New Zealand has created a significant problem and it is now considered a noxious weed in these areas. An older name for this genus is *Anacharis*, which serves as a common name in North America.

Elodea canadensis, sometimes called American or Canadian water weed or pond weed, is widely known as the generic water weed. The use of these names causes it to be confused with similar-looking plants, like Brazilian elodea (*Egeria densa*) or hydrilla (*Hydrilla verticillata*). American water weed is an attractive aquarium plant and is a good substitute for Brazilian elodea. It can be used for science experiments in classrooms demonstrating how plants use carbon dioxide with the usage of bromothymol blue.

The American water weed lives entirely underwater with the exception of small white flowers which bloom at the surface and are attached to the plant by delicate stalks. It produces winter buds from the stem tips that overwinter on the lake bottom. It also often overwinters as an evergreen plant in mild climates. In the fall, leafy stalks will detach from the parent plant, float away, root, and start new plants. This is the American water weed's most important method of spreading, while seed production plays a relatively minor role.

Silty sediments and water rich in nutrients favor the growth of American water weed in nutrient-rich lakes. However, the plants will grow in a wide range of conditions, from very shallow to deep water, and in many sediment types. It can even continue to grow unrooted, as floating fragments. It is found throughout temperate North America, where it is one of the most common aquatic plants.

American water weed is an important part of lake ecosystems. It provides good habitat for many aquatic invertebrates and cover for young fish and amphibians. Waterfowl, especially ducks, as well as beaver , muskrat and aquatic turtles eat this plant. It is also of economic importance as an attractive and easy to keep aquarium plant, although in the states of Oregon, South Carolina, and Washington it has been deemed an invasive species and is illegal to sell.

It is still unknown however to scientists worldwide who are trying to crack a very difficult problem which refers to all aquatic plants rather than just the **elodea**. That question is: How does the **elodea** still managed to obtain Carbon Dioxide (CO2) even when it doesn't have and stomata (plural. stoma)

Elodea canadensis

Elodea canadensis

Scientific classification

Kingdom:	Plantae
(unranked):	Angiosperms
(unranked):	Monocots
Order:	Alismatales
Family:	Hydrocharitaceae
Genus:	*Elodea*
Species:	***E. canadensis***

Binomial name

Elodea canadensis
Michx.

Synonyms

- *Anacharis alsinastrum* Bab.
  Babington, 1848
- *Anacharis canadensis* (Michaux)
  Planchon, 1848
- *Anacharis canadensis* (Michaux) Planchon, var. planchonii (Caspary)
  Victorin, 1931
- *Anacharis linearis* (Rydberg)
  Victorin, 1931
- *Anacharis planchonii* (Caspary)
  Rydberg, 1932
- *Elodea brandegeeae*
  St. John, 1962
- *Elodea iowensis*
  Wylie, 1910
- *Elodea latifolia*
  Caspary, 1857
- *Elodea linearis* (Rydberg)
  St. John, 1965
- *Elodea oblongifolia*
  Michaux ex Caspary, 1858
- *Elodea planchonii*
  Caspary, 1857
- *Philotria canadensis* (Michaux)
  Britton, 1895
- *Philotria iowensis* (Wylie)
  Wylie, 1911
- *Philotria linearis*
  Rydberg, 1908
- *Philotria planchonii*

(Caspary)
Rydberg, 1908

- *Serpicula canadensis* (Michaux) 1829
- *Udora canadensis* (Michaux) Nuttall, 1818

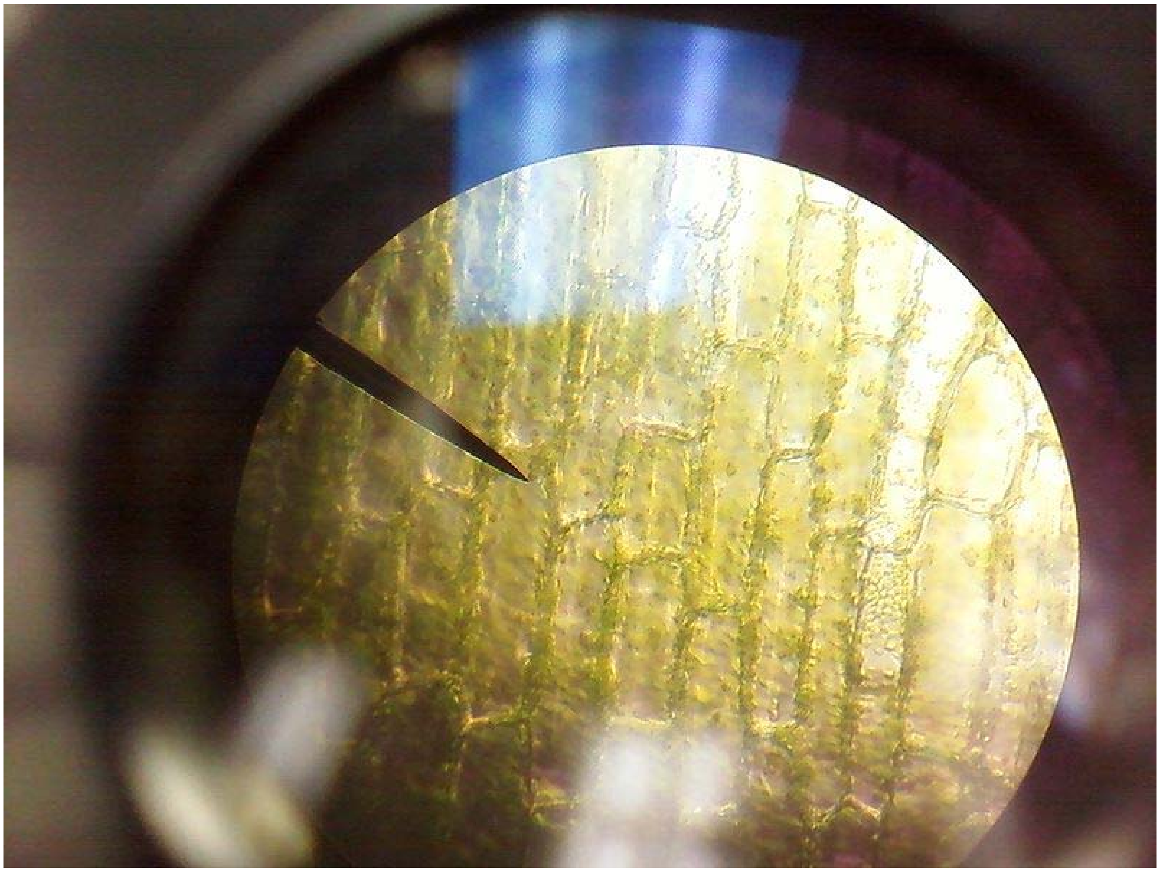
Elodea canadensis (**American** or **Canadian Waterweed** or **Pondweed**) is a perennial aquatic plant, or submergent macrophyte, native to most of North America. It was first recorded from the British Isles in about 1836.

Distribution

Native to most of North America. Widely naturalised in the British Isles (female plants only). In Ireland found at several sites along the Eglinton Canal, County Galway and Co. Down. and from the Lagan Canal near Lisburn, Ireland.

Description

Leaf detail



Elodea canadensis leaf cells at 450x magnification.

Young plants initially start with a seedling stem with roots growing in mud at the bottom of the water; further adventitious roots are produced at intervals along the stem, which may hang free in the water or anchor into the bottom. It grows indefinitely at the stem tips, and single specimens may reach lengths of 3 m or more.

The leaves are bright green, translucent, oblong, 6-17 mm long and 1-4 mm broad, borne in whorls of three (rarely two or four) round the stem. It lives entirely underwater, the only exception being the small white or pale purple flowers which float at the surface and are attached to the plant by delicate stalks.

It is dioecious, with male and female flowers on different plants. The flowers have three small white petals; male flowers have 4.5-5 mm petals and nine stamens, female flowers have 2-3 mm petals and three fused carpels. The fruit is an ovoid capsule, about 6 mm long containing several seeds that ripen underwater. The seeds are 4-5 mm long, fusiform, glabrous (round), and narrowly cylindrical. It flowers from May to October.

It grows rapidly in favorable conditions and can choke shallow ponds, canals, and the margins of some slow-flowing rivers. It requires summer water temperatures of 10-25 °C and moderate to bright lighting.

It is closely related to *Elodea nuttallii*, which generally has narrower leaves under 2 mm broad. It is usually fairly easy to distinguish from its relatives, like the Brazilian *Egeria densa* and *Hydrilla verticillata*. These all have leaves in whorls around the stem; however, *Elodea* usually has three leaves per whorl, whereas *Egeria* and *Hydrilla* usually have four or more leaves per whorl. *Egeria densa* is also a larger, bushier plant with longer leaves.

Cultivation and uses

It is frequently used as an aquarium plant. Propagation is by cuttings.

It is an invasive species in Europe, Asia, Africa, and Australia. It was introduced into County Down, Ireland in about 1836, and appeared in Great Britain in 1841, spreading through both countries in ponds, ditches and streams, which were often choked with its rank growth.

Other common names for this plant include Anacharis (an older name for the genus *Elodea*), water thyme, common elodea, and ditch moss.

Chapter- 10

Vallisneria and Stratiotes

Vallisneria

Vallisneria

Scientific classification

Kingdom:	Plantae
(unranked):	Angiosperms
(unranked):	Monocots
Order:	Alismatales
Family:	Hydrocharitaceae
Genus:	***Vallisneria***

Vallisneria is a genus of freshwater aquatic plant, commonly called **eelgrass**, **tape grass** or **vallis**. The genus has 6-10 species that are widely distributed, but do not grow in colder regions.

Vallisneria is a submersed plant that spreads by runners and sometimes forms tall underwater meadows. Leaves arise in clusters from their roots. The leaves have rounded tips, and definite raised veins. Single white female flowers grow to the water surface on very long stalks. Tape grass fruit is a banana-like capsule having many tiny seeds.

Sometimes it is confused with the superficially similar Sagittaria when grown submerged.

This plant should not be confused with *Zostera* species, marine seagrasses that are usually also given the common name "eelgrass".

Use in aquaria

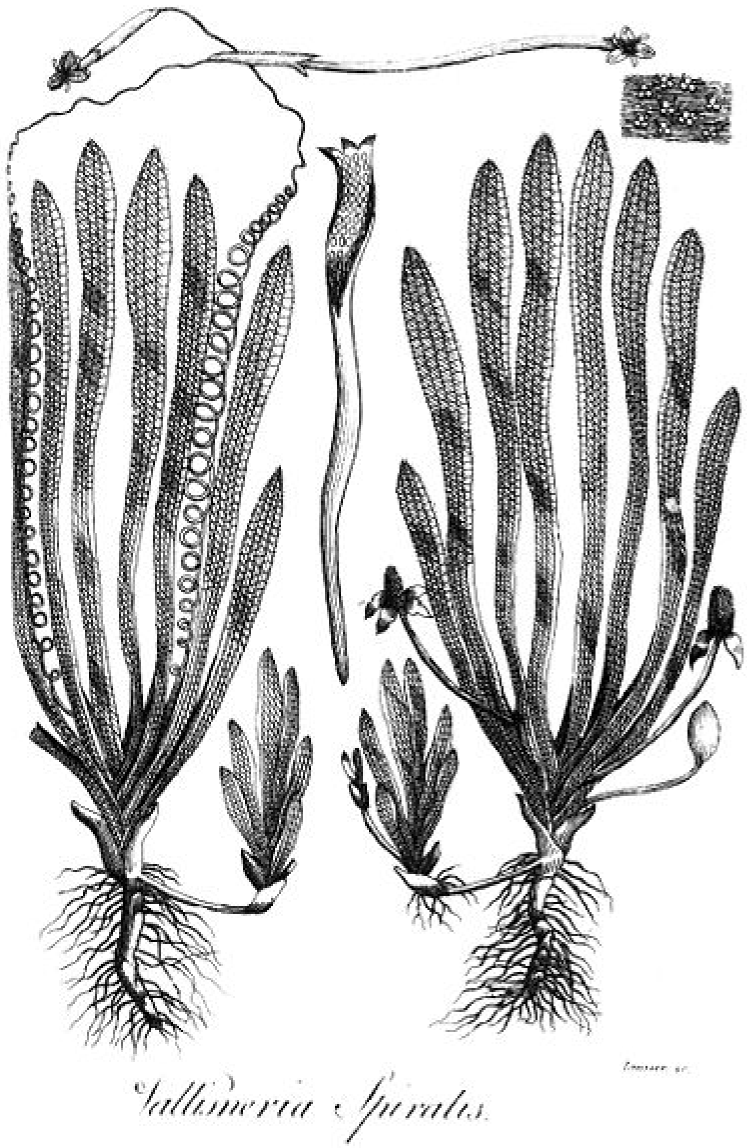
Various strains of *Vallisneria* are commonly kept in tropical and subtropical aquaria. These include dwarf forms such as *Vallisneria tortifolia*, a variety with leaves around 15 to 20 cm in length and characterised by having thin, tightly coiled leaves. A medium sized variety, *Vallisneria spiralis* is also very popular, typically having leaves 30 to 60 cm in length. The largest varieties are often called *Vallisneria gigantea* regardless of their actual taxonomic designation; in fact most of the plants sold as *Vallisneria gigantea* are actually *Vallisneria americana.* These giant varieties are only really suitable for very large tanks, having leaves that frequently exceed 1 m in length, but they are quite hardy and will do well in tanks with big fish that might uproot more delicate aquarium plants.

With few exceptions, the commonly traded *Vallisneria* are tolerant and adaptable. While they do best under bright illumination they will do well under moderate lighting as well, albeit with slower growth rates. They are not picky about the substrate, and will accept plain gravel provided an iron-rich fertiliser is added to the water periodically. Once settled in, they multiply readily through the production of daughter plants at the end of runners (as mentioned above). Once they have established their own roots, these daughter plants can be cut away and transplanted if necessary. *Vallisneria* will accept neutral to alkaline water conditions (they do not like very acidic conditions) and do not require carbon dioxide fertilization. They are also among the few commonly traded aquarium plants that tolerate brackish water, provided the specific gravity does not exceed 1.003 (around 10 percent the salinity of normal sea water).

Species

- *Vallisneria aethiopica*
- *Vallisneria americana*
- *Vallisneria alternifolia*
- *Vallisneria anhuiensis*
- *Vallisneria asiatica*
- *Vallisneria natans*
- *Vallisneria spiralis*

Vallisneria spiralis in a tropical fish tank (with freshwater halfbeaks, *Nomorhamphus liemi*)



Vallisneria spiralis from *The Botanic Garden* (1791) of Erasmus Darwin.

"Corkscrew vallis" Originally in Lake Biwa in Japan.
Also cultivated by farm in Southeast asia.

doubts

- what are the growth heights,optimum growth temperature,width,lighting rate and if Excel(plant product) cause's these plants to melt?

Stratiotes

Stratiotes	
	
Stratiotes aloides	
Scientific classification	
Kingdom:	Plantae
(unranked):	Angiosperms
(unranked):	Monocots
Order:	Alismatales
Family:	Hydrocharitaceae
Genus:	***Stratiotes***
Species	
Stratiotes acorides *Stratiotes alismoides* *Stratiotes aloides* *Stratiotes nymphoides*	

Stratiotes aloides flower

Stratiotes is a genus of submerged aquatic plant commonly known as water soldiers. A characteristic of the genus is the habit of the plants rising to the surface at flowering time.

Distribution

One species, *Stratiotes aloides*, is native to Europe and NW Asia.

Description

The leaves are serrate and very brittle, breaking easily when handled. Reproduction is generally by offsets, which may number 5 or more per plant. In the UK, male plants have rarely if ever been recorded, although some hermaphrodite flowers have been recorded from more southerly locations. Sexual reproduction is not known to occur.

Ecology

The plant appears to be associated with calcareous waters and there is a suggestion that changing levels of calcium carbonate on the leaves may explain the floating and submerging behaviour.

Stratiotes aloides plants

The rare dragonfly, the Norfolk hawker (*Aeshna isosceles*), relies on the presence of *Stratiotes aloides* as a food source for the smaller insects on which it feeds. they are very winter hardy

Uses

S. *aloides* is commonly used in cool water ponds and aquariums in Europe

Chapter- 11

Pontederia and Nymphaea Nouchali

Pontederia

Pontederia cordata

Pontederia	
	
Pontederia cordata	
Scientific classification	
Kingdom:	Plantae
(unranked):	Angiosperms
(unranked):	Monocots
(unranked):	Commelinids
Order:	Commelinales
Family:	Pontederiaceae
Genus:	***Pontederia*** L.

Pontederia cordata

Pontederia is a genus of tristylous aquatic plants, members of which are commonly known as **pickerel weeds**. *Pontederia* is endemic to the Americas, distributed from Canada to Argentina, where it is found in shallow water or on mud. The genus was named by Linnaeus in honour of the Italian botanist Giulio Pontedera.

Pontederia plants have large waxy leaves, succulent stems and a thick pad of fibrous roots. The roots give rise to rhizomes that allow rapid colonization by vegetative reproduction. Species are perennial, and produce a large spike of flowers in the summer. There is a species of bee (*Dufourea novae-angliae*) that exclusively visits *Pontederia cordata*; waterfowl also eat the fruit of the plant.

Pontederia cordata, and another member of the family, *Eichhornia crassipes*, have become invasive in many tropical and temperate parts of the globe, but are, on the other hand, efficient biological filters of polluted water in constructed wetlands.

Selected species

- *Pontederia cordata* L.
- *Pontederia parviflora* Alexander
- *Pontederia rotundifolia* L.f.
- *Pontederia sagittata* C.Presl

- *Pontederia subovata* (Seub.) Lowden
- *Pontederia triflora* (Endl. ex Seub.) G.Agostini, D.Velázquez & J.Velásquez

Nymphaea nouchali

Red and blue water lily

Scientific classification

Kingdom:	Plantae
(unranked):	Angiosperms
Order:	Nymphaeales
Family:	Nymphaeaceae
Genus:	*Nymphaea*
Species:	***N. nouchali***

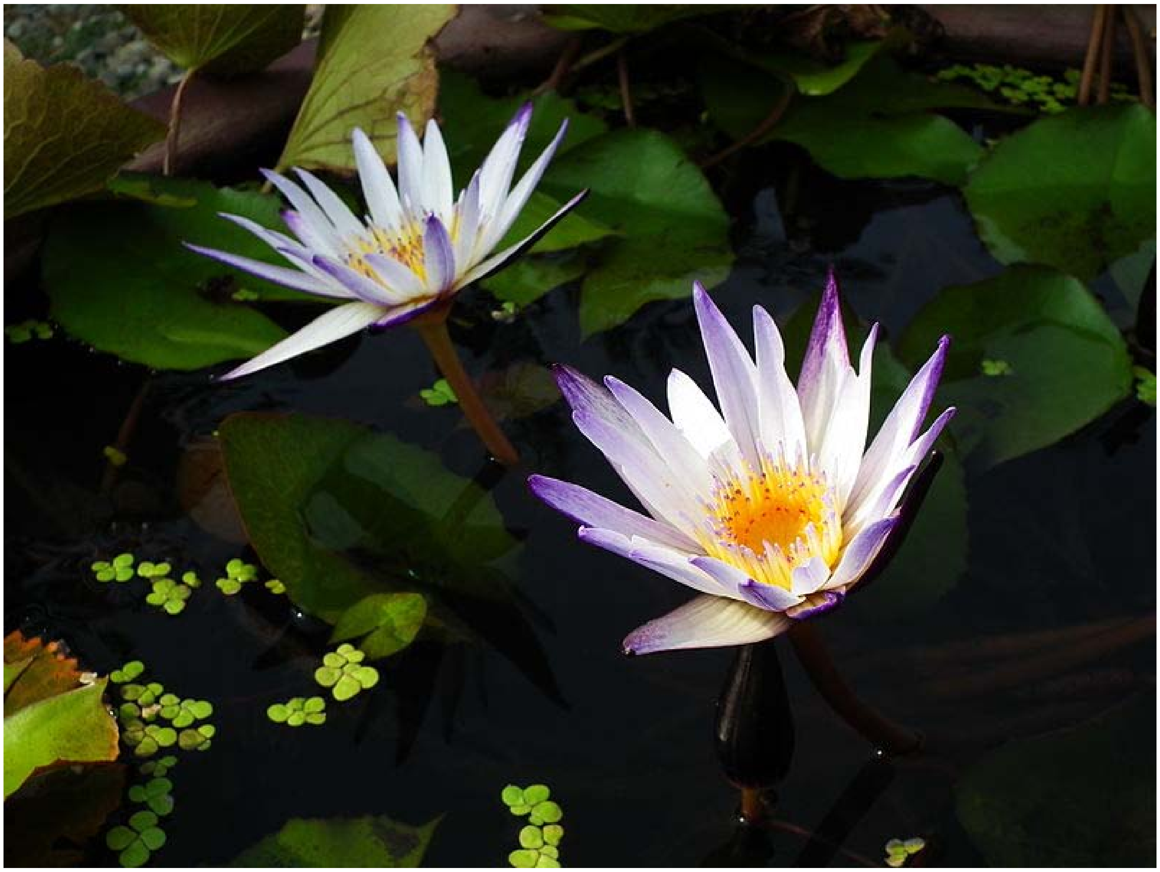
Binomial name

Nymphaea nouchali
Burm. f.

Synonyms

Castalia acutiloba (DC.) Hand.-Mazz.
Castalia stellaris Salisb.
Castalia stellata (Willd.) Blume
Leuconymphaea stellata (Willd.) Kuntze
Nymphaea acutiloba DC.
Nymphaea cahlara Donn, nom. inval.
Nymphaea cyanea Roxb.
Nymphaea edgeworthii Lehm.
Nymphaea henkeliana

Rehnelt
Nymphaea hookeriana Lehm.
Nymphaea malabarica Poir.
Nymphaea membranacea Wall. ex Casp., nom. inval.
Nymphaea minima F.M.Bailey nom. illeg.
Nymphaea punctata Edgew.
Nymphaea rhodantha Lehm.
Nymphaea stellata Willd.
Nymphaea stellata var. *albiflora* F. Henkel & al.
Nymphaea stellata var. *cyanea* (Roxb.) Hook. f. & Thomson
Nymphaea stellata var. *parviflora* Hook. f. & Thomson
Nymphaea stellata var. *versicolor* (Sims) Hook. f. & Thomson
Nymphaea tetragona var. *acutiloba* (DC.) F. Henkel & al.
Nymphaea versicolor Sims
Nymphaea voalefoka Lat.-Marl. ex W. Watson, nom. nud.



Nymphaea nouchali, commonly known as the **Red and blue water lily**, **Blue star water lily**, **Star lotus**, or by its synonym ***Nymphaea stellata***, is a water lily of genus *Nymphaea*.

Distribution and habitat

This aquatic plant is native to the Indian Subcontinent area. It was spread to other countries already in ancient times and has been long valued as a garden flower in Thailand and Myanmar to decorate ponds and gardens.

In its natural state the Red and blue water-lily is found in static or slow-flowing aquatic habitats of little to moderate depth.

Description

Nymphaea nouchali; pale-colored variety in Cambodia.

Nymphaea nouchali is a day blooming nonviviparous plant with submerged roots and stems. Part of the leaves are submerged, while others rise slightly above the surface. The leaves are round and green on top; they usually have a darker underside. The floating leaves have undulating edges that give them a crenellate appearance. Their size is about 20–23 cm and their spread is 0.9 to 1.8 m

This water-lily has a beautiful flower which is usually violet blue in color with reddish edges. Some varieties have white, purple, mauve or fuchsia-colored flowers. The flower has 4-5 sepals and 13-15 petals that have an angular appearance making the flower look star-shaped from above. The cup-like calyx has a diameter of 11–14 cm.

Symbolism

Sigiriya frescoes, Anuradhapura period, Central Ceylon. The lady on the left is holding a *Nil Mānel*.

Nymphaea nouchali is the National flower of Sri Lanka where it is known as *Nil Mānel*. Since *"Nil"* means 'blue' in Sinhala, the Sinhalese name of this plant is often rendered as "blue lotus" in English.

In Sri Lanka this plant usually grows in buffalo ponds and natural wetlands. Its beautiful aquatic flower has been mentioned in Sanskrit, Pali and Sinhala literary works since ancient times under the names *"Kuvalaya"*, *"Indhīwara"*, *"Niluppala"*, *"Nilothpala"* and *"Nilupul"* as a symbol of virtue, discipline and purity. Buddhist lore in Sri Lanka claims that this flower was one of the 108 auspicious signs found on Prince Siddhartha's footprint.It is said that when Buddha died, lotus flowers blossomed everywhere he had walked in his lifetime.

The star lotus might have been one of the plants eaten by the Lotophagi of Homer's Odyssey.

Uses

Fuchsia-colored *Nymphaea nouchali* in Hyderabad, Andhra Pradesh.

The Red and blue water-lily is used as an ornamental plant because of its spectacular flowers. It is also popular as an aquarium plant under the name "Dwarf Lily" or "Dwarf Red Lily". Sometimes it is grown for its flowers, while other aquarists prefer to trim the lily pads, and just have the underwater foliage.

Nymphaea nouchali is considered a medicinal plant in Indian Ayurvedic medicine under the name *Ambal*; it was mainly used to treat indigestion. Recent experiments have confirmed that it has medicinal qualities as an antihepatotoxic and antidiabetic. Like all waterlilies or lotuses, its tubers and rhizomes can be used as food items; they are eaten usually boiled or roasted. In the case of the Red and blue water-lily, its tender leaves and flower peduncles are also valued as food.

The dried plant is collected from ponds, tanks and marshes during the dry season and used in India as animal forage.

Chapter- 12

Nymphaea and Nuphar

Nymphaea

Nymphaea	
	
Nymphaea 'Peach Glow'	
Scientific classification	
Kingdom:	Plantae
(unranked):	Angiosperms
Order:	Nymphaeales
Family:	Nymphaeaceae
Genus:	***Nymphaea*** L.
Species	
About 50 species, including: *Nymphaea alba* - European White Water-lily *Nymphaea amazonum* *Nymphaea ampla*	

Nymphaea blanda
Nymphaea caerulea - Egyptian Blue Water-lily
Nymphaea calliantha
Nymphaea candida
Nymphaea capensis - Cape Blue Water-lily
Nymphaea citrina
Nymphaea colorata
Nymphaea elegans
Nymphaea fennica
Nymphaea flavovirens
Nymphaea gardneriana
Nymphaea gigantea - Australian Water-lily
Nymphaea heudelotii
Nymphaea jamesoniana
Nymphaea leibergii - Dwarf Water-lily
Nymphaea lotus - Egyptian White Water-lily
Nymphaea lotus var. termalis
Nymphaea macrosperma - Native to Australia's Top End
Nymphaea mexicana - Yellow Water-lily
Nymphaea micrantha
Nymphaea nouchali - Red and blue water lily (National flower of Sri Lanka)
Nymphaea odorata - Fragrant Water-lily
Nymphaea pubescens - Hairy water lily (National flower of Bangladesh)
Nymphaea rubra - India Red Water-lily
Nymphaea rudgeana
Nymphaea stuhlmannii
Nymphaea sulfurea
Nymphaea tetragona - Pygmy Water-lily
Nymphaea thermarum

Nymphaea is a genus of aquatic plants in the family Nymphaeaceae. There are about 50 species in the genus, which has a cosmopolitan distribution.

Name

The common name, shared with some other genera in the same family, is Water Lily.

The name *Nymphaea* comes from the Greek term "Νυμφαία", possibly related to "Νύμφη" meaning "nymph". The nymphs in Greek mythology were supernatural feminine beings associated with springs, so the application of the name to delicately flowered aquatic plants is understandable.

Description

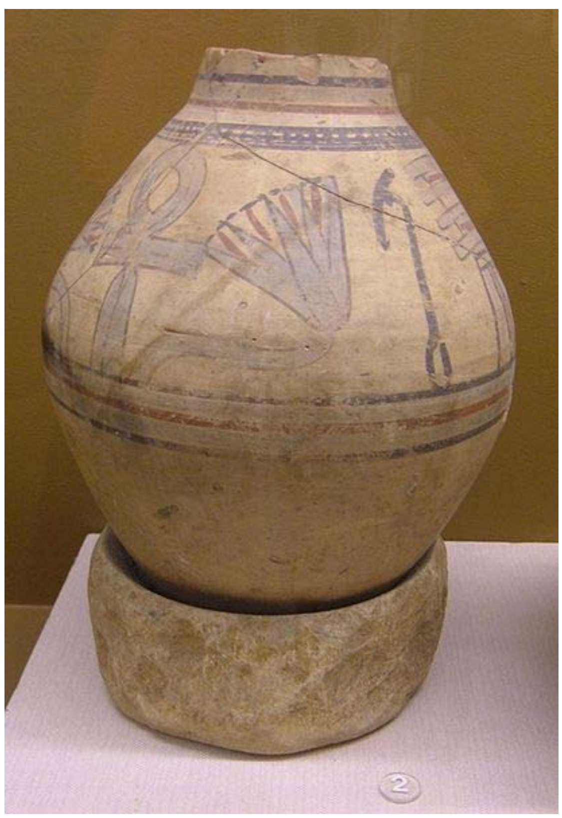
Nymphaea leaves have a radial notch from the circumference to the petiole (leaf stem) in the center.

Classification

Despite their name, water-lilies are not related to the true lilies (family Liliaceae). The name "lily" is applied to a number of plants that are not at all closely related, such as day lilies, spider lilies and arum lilies, in addition to the water lilies. *Nymphaea* (Egyptian lotuses) are also not related to the Chinese and Indian lotus of genus *Nelumbo*, which are used in Asian cooking and sacred to Hinduism and Buddhism.

However, the genus *Nymphaea* is closely related to *Nuphar*, another genus commonly called "lotus". In *Nymphaea*, the flower petals are much larger than the sepals, whereas in *Nuphar* the petals are much smaller than its sepals. The fruit maturation also differs, with *Nymphaea* fruit sinking below the water level immediately after the flower closes, whereas *Nuphar* fruit are held above water level to maturity. Both genera share leaves with a radial notch from the circumference to the petiole (leaf stem) in the center.

Cultural significance



Blue lotus symbol (*Nymphaea caerulea*) among other ancient Egyptian symbols on an 18th Dynasty jar. Found at Amarna in the 19th century.

The ancient Egyptians revered the Nile water-lilies, or **lotuses** as they were also called. The lotus motif is a frequent feature of temple column architecture.

The Egyptian Blue Water-lily, *N. caerulea*, opens its flowers in the morning and then sinks beneath the water at dusk, while the Egyptian White Water-lily, *N. lotus*, flowers at night and closes in the morning. This symbolizes the Egyptian separation of deities and is a motif associated with Egyptian beliefs concerning death and the afterlife. The recent discovery of psychedelic properties of the blue lotus may also have been known to the Egyptians and explain its ceremonial role. Remains of both flowers have been found in the burial tomb of Ramesses II.

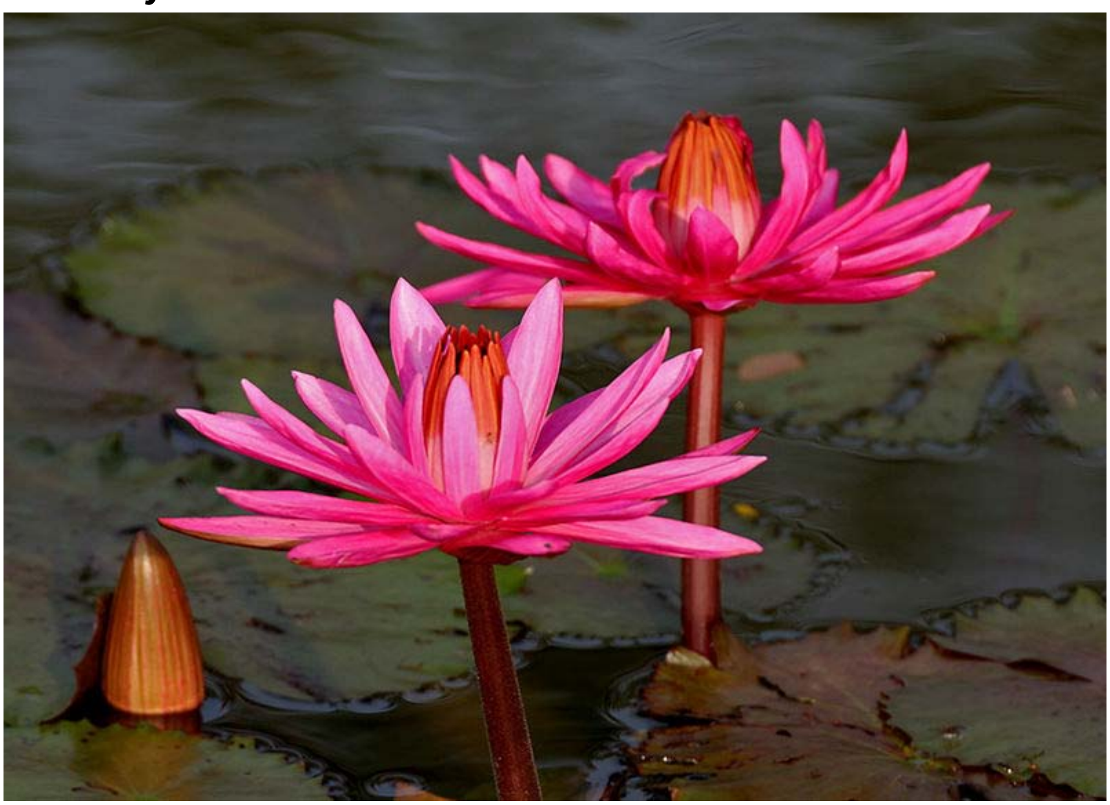
A syrian terra-cotta plaque from the 14th-13th century B.C.E. shows the goddess Asherah holding two lotus blossoms. An ivory panel from the 9th-8th century B.C.E. shows the god Horus seated on a lotus blossom, flanked by two Cherubs.

The French painter Claude Monet is famous for his paintings of water lilies.

Cultivation

Many of the water-lilies familiar in water gardening are hybrids.

Taxonomy



Nymphaea pubescens in Hyderabad, India.

Subdivisions of genus Nymphaea:

- Subgenus:
- Anecphya
- Brachyceras
- Hydrocallis
- Lotos
- Nymphaea:
- Nymphaea Chamaenymphaea
- Nymphaea Nymphaea
- Nymphaea Xanthantha

Nymphaea alba

Nymphaea ampla

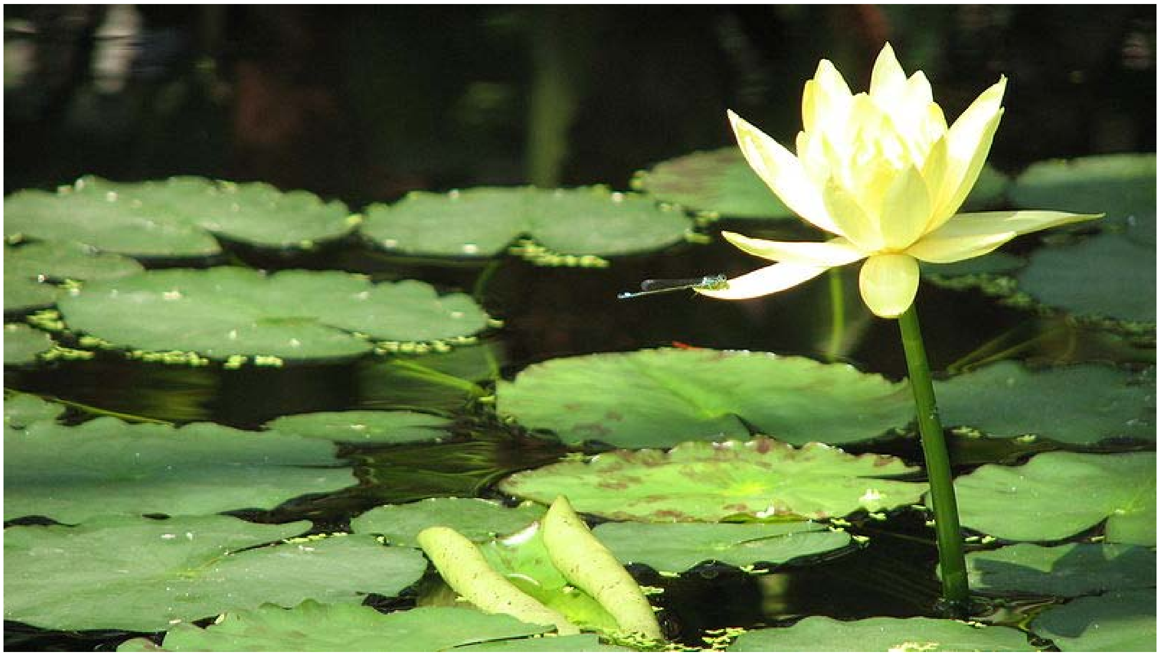
Nymphaea capensis

Nymphaea colorata

Nymphaea × daubenyana

Nymphaea gigantea

Nymphaea lotus



Nymphaea mexicana

Nymphaea nouchali

Nymphaea pygmaea

Nuphar

Nuphar	
	
Nuphar lutea	
Scientific classification	
Kingdom:	Plantae
(unranked):	Angiosperms
Order:	Nymphaeales
Family:	Nymphaeaceae
Genus:	***Nuphar*** Sibth. & Sm.
Species	
About 10-15 species, including: *Nuphar advena* *Nuphar lutea* *Nuphar pumila* *Nuphar variegata*	

Nuphar is genus of aquatic plants in the family Nymphaeaceae, with a temperate Northern Hemisphere distribution. The common name, shared with some other genera in the same family, is **water lily** or **waterlily**.

There are from 1 to 25 species in the genus. Some botanists treat the genus as just a single variable species (for which the European name *N. lutea* has priority), but 10-12 species are typically accepted by most authorities. Recent molecular work has shown that there is some difference between the European and American species.

Nuphar pumila

The genus is closely related to *Nymphaea*. *Nuphar* differs in having its petals being much smaller than its 4-6 bright yellow-coloured sepals, whereas in *Nymphaea*, the petals are much larger than the sepals. The fruit maturation also differs, with *Nuphar* fruit being held above water level to maturity, whereas *Nymphaea* fruit sink below the water level immediately after the flower closes. Both genera share leaves with a radial notch from the circumference to the petiole (leaf stem) in the center.

The etymology of the word is: medieval Latin *nuphar*, from medieval Latin *nenuphar*, thence from Arabic *nīnūfar*, thence from Persian *nīlūfar*, thence from Sanskrit *nīlōtpala* = blue lotus flower.

Selected species

- *Nuphar advena* (Aiton) W.T.Aiton
- *Nuphar japonica* DC.
- *Nuphar kalmiana*
- *Nuphar lutea* (L.) Sm. – Yellow Water-lily
- *Nuphar microphylla* (Pers.) Fernald
- *Nuphar orbiculata*
- *Nuphar polysepala*
- *Nuphar pumila* – Least Water-lily

- *Nuphar rubrodisca*
- *Nuphar saggitifolia*
- *Nuphar shimadae*
- *Nuphar ulvacea*
- *Nuphar variegata*