

Nymphaeales

Donald H Les, *University of Connecticut, Storrs, Connecticut, USA*

The Nymphaeales comprise an angiosperm order commonly known as 'water lilies'. All members of the order are aquatic plants that typically possess floating leaves.

Introduction

Some of the world's most beautiful and unusual plants are the water lilies, known botanically as the angiosperm order Nymphaeales Dumortier. These plants are not true lilies, but dicotyledons. All species are aquatic, typically inhabiting shallow waters along lake, pond and stream margins. The showy, colourful flowers and unusual floating leaves of water lilies make them the focal point of many water gardens (Figure 1).



Figure 1 Several hundred cultivars of *Nymphaea* (top) have been featured in water gardens worldwide. The giant leaves of the spectacular *Victoria amazonica* (bottom) can grow to 2 m in diameter.

Introductory article

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Families Included

The Nymphaeales are divided taxonomically into two families (Figure 2): Cabombaceae A. Richard (fanwort family) and Nymphaeaceae R. A. Salisbury (water lily family). Cabombaceae contain two genera (*Brasenia*, *Cabomba*) and six species. Nymphaeaceae are more diverse with six genera (*Barclaya*, *Euryale*, *Nuphar*, *Nymphaea*, *Ondinea*, *Victoria*) and approximately 75 species. Older literature included water lotus (Nelumbonaceae) within Nymphaeales; however, recent studies clearly show these families to be unrelated.

Economically Important Species

Shoots and leaves of *Brasenia schreberi* are eaten by Asians and Native Americans. Seeds, fruits and rhizomes of *Euryale ferox* provide food in Asia. The starchy rhizomes, tubers, flowers and seeds of *Nymphaea* and *Nuphar* were consumed by Native Americans. Seeds of *Nymphaea*

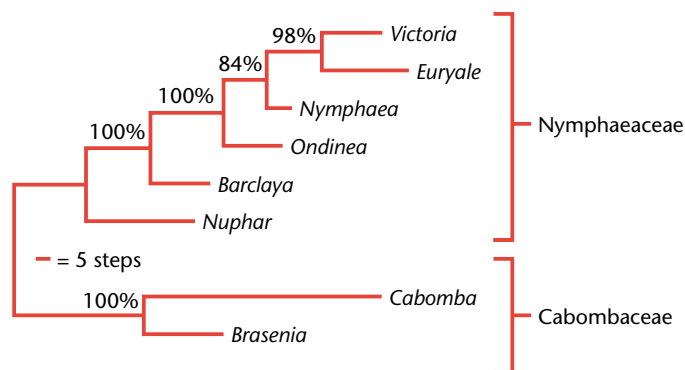


Figure 2 Diagram of relationships among Nymphaeales genera. This evolutionary 'tree' was constructed using a combination of morphological and molecular data. The different 'branch' lengths indicate relative differences separating the groups (scale shown). Two major groups or 'clades' are resolved which correspond to the families Nymphaeaceae and Cabombaceae. The high percentages above branches ('bootstrap' values) indicate that different sections of the tree are well supported.

nouchali are 'puffed' (by soaking and frying) and eaten (with rhizomes and pedicels) in Bangladesh. The edible corms of *Ondinea purpurea* are gathered by Australian Aborigines. Seeds of *Victoria amazonica* were made into flour by indigenous Brazilians.

The alkaloid-rich water lilies have been used medicinally since ancient times. Extracts from flowers and rhizomes of *Brasenia* and *Nymphaea* species have been used to treat cardiac problems, colic, diarrhoea, dyspepsia, dysentery, haemorrhage, leucorrhoea, menstrual disorders, phthisis, piles, skin irritations and sore throat. The narcotic effect of some *Nymphaea* flowers has been utilized in religious rituals.

Water lilies are religious symbols in many cultures and were prominent features of ancient Egyptian and Mayan art. They were popularized in the early twentieth century through the impressionist paintings of Claude Monet.

Nymphaea rhizomes are used for brewing and as a mordant for dyeing and tanning. Whole plants are used as green manure.

Cabomba caroliniana is an invasive weed in the north-eastern United States. Excessive growth of *Brasenia* is occasionally problematic.

Horticulturally Important Species

Water lilies dominate most water gardens and ornamental ponds. Horticulturally, the most important genus is *Nymphaea* (Figure 1), containing nearly 250 cultivars, whose fragrant, showy blossoms range from white to numerous shades of green, orange, red, blue and purple. Most cultivars are hardy. About 80 cultivars are tropical day-bloomers and 15 are tropical night-bloomers.

Victoria, with floating leaves reaching 2 m in diameter, is a spectacular specimen (Figure 1). Historical photographs show animals, children and even adults standing upon its leaves. *Victoria* has two species (both cultivated): the larger, tropical *V. amazonica* and the somewhat smaller and hardier *V. cruziana*. The similar but smaller *Euryale ferox* is often displayed with *Victoria*. *Brasenia* and *Nuphar* are cultivated infrequently. *Barclaya longifolia* and *Cabomba* are popular aquarium plants.

Morphology

Nymphaeales stems are variously modified perennial organs. The slender rhizomes of Cabombaceae elongate into erect, leafy stems. Nymphaeaceae leaves originate from thin, creeping rhizomes (*Barclaya*), highly thickened rhizomes (*Nymphaea*, *Nuphar*), or thick caudices (*Euryale*, *Nymphaea*, *Ondinea*, *Victoria*). Some (*Nymphaea*, *Ondinea*) are tuberous.

All genera possess floating leaves with stomata (for gas exchange) on their upper surface, and extensive internal air spaces (lacunae) that enhance flotation. Most leaves are circular, with the petiole attached near the centre in a deep sinus (e.g. *Nymphaea*), or peltate with the petiole surrounded by leaf tissue (e.g. *Brasenia*, *Cabomba*, *Euryale*, *Victoria*). Leaf blades are ovoid in *Brasenia* and elongate in *Barclaya longifolia*, *Nuphar sagittifolia* and *Ondinea purpurea*. The small floating leaves of *Cabomba* range from circular to sagittate. Leaf margins of *Victoria* (Figure 1) are upturned, forming a nearly continuous rim around the leaves (for support), with two small notches (drains) to prevent flooding of the leaf surface. Numerous pores (stomatodes) facilitate drainage of standing water from *Victoria* leaf surfaces. *Euryale* and *Victoria* have prickly foliage. Sturdy veins support the leaf undersides in *Euryale*, *Victoria* and some *Nymphaea* species. Shoots of *Brasenia* and *Cabomba* are often coated by mucilage. Submersed leaves occur in *Barclaya*, *Cabomba*, *Nuphar* and *Ondinea*. They are opposite and palmate-dichotomously dissected in *Cabomba*, but broad, translucent and undivided in the other genera. Leaves of *Nuphar advena* and *Barclaya rotundifolia* are emergent.

The pleiomerous (many-parted) flowers of Nymphaeaceae were once thought to be primitive, but recent studies demonstrate that increased floral organ numbers are derived in the family. Cabombaceae flowers are small, trimerous, with 6-parted perianths, 4–18 carpels and 18–36 stamens. Nymphaeaceae flowers are large, showy (up to 35 cm in *Victoria*) with 4–14 sepals, 4–70 petals, 3–40 carpels and 14–750 stamens. Fruits are dry (achene-like or follicle-like) in Cabombaceae and fleshy (berries) in Nymphaeaceae.

Ecology

Nymphaeales provide habitat for fish and aquatic invertebrates. *Brasenia* is an important waterfowl food. Most water lilies require calm, shallow (< 2 m) water, full sunlight and neutral to slightly alkaline pH. Pollination occurs by beetles (*Victoria*, *Nuphar*, *Nymphaea*), bees (*Nymphaea*, *Ondinea*) flies (*Cabomba*) or wind (*Brasenia*). *Euryale* and *Barclaya* are autogamous. Seeds are dispersed by animals or water. Floating leaves are damaged by beetles, burrowing flies, caterpillars, fungi and snails.

Biogeography

Barclaya occurs in southeast Asia. *Brasenia* is widespread (Africa, Australia, eastern Asia, Central America, North America) but extirpated from Europe. *Cabomba* is restricted to the New World. *Euryale* ranges from India to China and Japan. *Nuphar* occurs in temperate Old and

New World habitats. *Nymphaea* is virtually cosmopolitan. *Ondinea* is confined to northwestern Australia. *Victoria* is restricted to South America.

Fossil history

The Nymphaeales are an ancient flowering plant lineage. The oldest known fossils (early Cretaceous) are 125–115 million-year-old preserved flowers resembling *Cabomba*. Other fossils extend from the Cenomanian Cretaceous to the Tertiary and Quaternary systems where most taxa are well represented. Fossilized seeds extend back to the Maastrichtian Cretaceous, and indicate greater species diversity in the past.

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