

## 2.10 Waterchestnut

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*Trapa natans* L; floating-leaved plant in the Trapaceae (waterchestnut) family; originally placed in the Hydrocharitaceae (frog's-bit) family, but at the molecular level should be placed in the Lythraceae (purple loosestrife) family  
Derived from *calcitrapa* [Latin: a spiked iron ball (“caltrops”) used as an ancient weapon] and *natans* (Latin: swimming)

Introduced from Asia to Massachusetts and New York in the late 1870s to early 1880s

Present in the mid-Atlantic into the Northeast, south to northern Virginia, west to central Pennsylvania, east to New Hampshire, north to Quebec

### Introduction and spread

Botanists have subdivided the genus *Trapa* into at least 20 to 25 different species based upon small differences in the nutlets. Under the most recent taxonomic schemes, *Trapa natans* is subdivided into three varieties. The varieties *Trapa natans* var. *bispinosa* and *Trapa natans* var. *bicornis* are found primarily in northern India and southeastern Asia, where both are grown as agricultural crops, whereas the variety *Trapa natans* var. *natans*, commonly called waterchestnut, is a prized agricultural crop in India and China, a protected and disappearing plant in Europe and a highly aggressive



invader in the United States. Waterchestnut is often confused with the Chinese waterchestnut (*Eleocharis dulcis*), an edible tuber common in Chinese cuisine. Both species have been widely cultivated as a food source, but they are unrelated. Although “waterchestnut” is the most widely used common name for *Trapa natans* var. *natans*, the variety is also known by a number of other common names, with religious (“Jesuit’s nut”), evocative (“water caltrops”, “bull nut”) and sinister (“devils nut”, “death flower”) connotations.

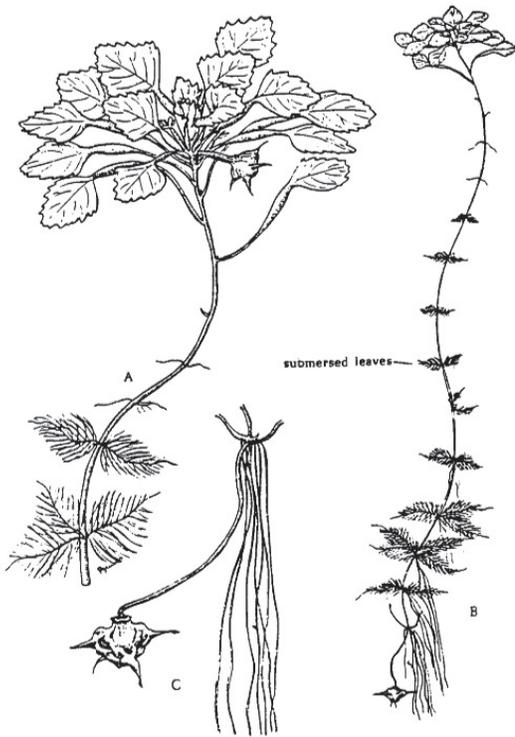
Waterchestnut is native to Eurasia and Africa and archaeologists have found evidence of waterchestnut in sediments dating back to at least 2800 BC. The first introduction of waterchestnut to the US is better documented than that of most other exotic plants, but there is some debate regarding the specific time and place of this introduction. The initial introduction to North America was well-described by Eric Kiviati in a Hudsonia newsletter. North American infestations can probably be traced to two distinct locations. Waterchestnut was first introduced from Europe to Middlesex County,

Massachusetts around 1874 and was cultivated as an ornamental in Asa Gray's botanical garden at Harvard University in 1877. Seeds were distributed by Harvard gardeners into nearby ponds over the next several years; as a result, waterchestnut migrated into the Concord and Sudbury Rivers by the mid-1880s, reached nuisance portions by the turn of the century and underwent explosive growth by the 1940s.

Another introduction occurred in Scotia in eastern New York during the early 1880s. A Catholic priest planted waterchestnut seeds from Europe in Sanders Pond (now Collins Lake), which led to extensive colonization of the lake by 1884. Subsequent flooding of the neighboring Mohawk River (via locks and dams on the New York Barge Canal) further spread the plant and spawned widespread growth by the 1920s. Waterchestnut was reported in the Hudson River by 1930 and reached nuisance levels in the 1950s. The species likely then spread west through the Erie Barge Canal system and reached Oneida Lake and the Finger Lakes region by the turn of the 21st century. Waterchestnut also migrated north into Lake Champlain through the Hudson-Champlain Canal and most likely reached Quebec through the Richelieu River system during the late 1990s. Waterchestnut was first found in Maryland in the late 1910s and reached the Potomac River during the early 1920s; widespread populations were present by the 1940s. As of 2018, the waterchestnut range still appears to be limited to the northeastern United States, although populations may have been extirpated in Delaware and the District of Columbia.

### Description of the species

Waterchestnut is an ideal candidate for early detection programs because its appearance differs from all other plants found in North America and the species can often be identified early in its colonization cycle. Waterchestnut is an annual floating-leaved dicot that grows primarily in sluggish, shallow water. The habitat for this species includes lakes, ponds, reservoirs, sheltered margins of flowing water, freshwater wetlands and fresh to brackish estuaries. Waterchestnut usually grows in water less than 7 feet deep but has been found at depths of 12 to 15 feet. The species prefers thick, nutrient-rich organic sediments and an alkaline environment, but is tolerant of a wide pH range. Waterchestnut will not grow in salt water, although it can survive in brackish water with freshwater springs and groundwater input. The species grows aggressively and regularly produces as much as one pound of dry weight per square yard of surface area. Severe infestations can result in much greater biomass production; for example, waterchestnut populations growing in shallow impoundments in upstate New York have reportedly yielded almost 17,000 pounds of dry biomass per acre.



Submersed leaves of waterchestnut are pinnate (feather-like) and superficially resemble the finely dissected leaves of milfoils (*Myriophyllum* spp.). Submersed leaves are up to 4 inches long and are attached to the flexible stem in a whorl. Surface or floating leaves are palmate (divided like the fingers on a hand) and form a rosette that can be as broad as 1 foot in diameter. Leaf blades are 1 to 2 inches long and diamond shaped with a coarsely serrated (saw-toothed) margin. The upper sides of the leaves are bright green and the undersides are yellow-green with prominent veins. Rosettes form below the water surface and elongate to the surface by late spring – plants are buoyant due to inflated petioles or leafstalks (bladders) just below the rosette of leaves. Surface rosettes can form and may initially be hidden within beds of other plants that produce floating leaves [e.g., watershield (*Brasenia* spp.), spatterdock (*Nuphar* spp.) and white waterlilies (*Nymphaea* spp.)] and by smaller floating plants such as duckweed, watermeal (Section 2.14) and filamentous algae (Section 2.18). However, the prolific growth of waterchestnut will eventually create dense monocultures with as many as 50 rosettes per square yard and will crowd out desirable native plants. Waterchestnut beds can be so extensive that they may form up to three layers that completely cover the shallow zones of lakes and rivers and may obscure the margin between land and water.

Waterchestnut produces a single-seeded four-pronged nutlet with barbed spines. This structure is only produced by *Trapa natans* var. *natans* and allows for easy identification of the variety. The barbed spines are sharp enough to

penetrate a wet suit – a painful experience for anyone unfortunate enough to step on one of these nutlets – and are the basis for the imaginative common names given to this plant. In addition to wreaking havoc on divers and swimmers, these nutlets figure prominently in the spread and propagation of this invasive species.

### Reproduction

Many invasive species spread and reproduce from fragments, tubers, turions or underwater runners or stolons, but waterchestnut is an annual that reproduces solely from seeds. Small white flowers with yellow stamens are produced on the rosette after June, then drop into the water during summer and mature as nutlets between July and September. Each rosette produces 10 to 20 nutlets, which are capable of persisting for 10 to 15 years if kept moist in nutrient-rich sediment. Nutlets are around 1 inch wide, approximately 20% more dense than water and change from fleshy green to woody black by late summer. Mature nutlets drop from the plant and quickly sink into the sediment or wash to the shoreline, where the barbed spikes anchor the nutlet into the sediment. Parent plants disintegrate in the fall and seeds begin to germinate within a month after water temperatures warm to 50 °F or higher the following spring. A single



nutlet can produce multiple rosettes (up to 15 to 20 surface rosettes) because the rhizome can branch laterally to produce multiple upright stems.

Nutlets migrate between bodies of water by a variety of means. The most conspicuous vector for many years was humans, who intentionally introduced the waterchestnut as an ornamental. *Trapa natans* is listed as a federal “species of concern”, but there are currently no explicit federal transport restrictions. Fortunately, a new appreciation of the environmental and economic problems that accompany establishment of this species and a network of state laws (including laws in New York, Vermont, New

Hampshire, Illinois, Michigan, Florida, Minnesota, Wisconsin and Maine) that prohibit its transport have greatly reduced intentional introduction of waterchestnut. However, nutlets continue to move on currents between connected waterways, on the feathers, talons and webbed feet of numerous waterfowl and furred mammals, and especially on boat propellers, trailers and even foam bumpers on canoes.

### Problems associated with waterchestnut

Infestations of waterchestnut cause problems similar to those of other invasive aquatic plants. Waterchestnut provides little wildlife value and can form dense surface canopies that reduce sunlight penetration into the water column by 95% and crowd out other submersed and floating-leaved native plants and the fauna that rely on these plants for food and shelter. There is strong evidence that water celery (*Vallisneria americana*), a highly valued native plant, has been eliminated from many parts of the Hudson River after colonization by waterchestnut. This is due to the reduction in habitat available to water celery and to depletion of dissolved oxygen under large waterchestnut canopies, which also has a negative effect on small invertebrates. Large populations of waterchestnut create hostile environments for many desirable species such as banded killifish and spottail shiner and are often inhabited by fauna that are more tolerant of adverse conditions, including rough fish species such as the common carp. There is some evidence that waterchestnut inhibits the growth of phytoplankton due to production of allelopathic substances. Dense beds of waterchestnut can also entrap predatory birds seeking food within and underneath the surface canopy. Although waterchestnut canopies could potentially create significant pockets of still water to support mosquitoes, this has not been well documented in North American populations of waterchestnut.

Waterchestnut often grows under eutrophic conditions (Section 1.1), in part because eutrophic bodies of water often create the thick organic sediments preferred by this plant and in part because waterchestnut grows in shallow waters where poor water clarity does not limit plant growth. Thick masses of leaves and stems generated by waterchestnut degrade and settle into the bottom sediments, which increases the organic content (and depth) of the sediment and contributes to greater turbidity and a cycle of increasing eutrophication. Bacterial degradation of this plant material can reduce dissolved oxygen, particularly at the end of the daily respiration cycle and when plants rapidly degrade in response to active management, such as herbicide treatment. Plant tissues also accumulate some heavy metals; this may occur with other highly abundant aquatic plants as well and may ultimately be a net benefit since these metals are removed from sediments or the water column.



Dense surface canopies of waterchestnut reduce water flow and impede boating and other forms of non-contact recreation, a particularly vexing problem since this plant often dominates navigable rivers and slow-moving water around marinas. Unlike submersed invasive plants and most floating-leaved plants, waterchestnut creates canopies that are impenetrable by even canoes and kayaks – the rosettes swallow paddles and significantly retard the momentum of the paddler. The same shallow waters frequented by canoers and kayakers are sometimes used for swimming, although the soft, thick organic sediments usually needed to support waterchestnut plants do not provide the ideal habitat for waders and swimmers. Waders willing to slog through dense populations of waterchestnut must carefully navigate through the nutlets commonly found along the shoreline and in the upper layer of near-shore sediments since stepping on the sharp barbs can cause deep puncture wounds. Dense mats create an additional safety concern – entanglement in waterchestnut beds may have contributed to drowning deaths in the Hudson River in 2001.

The most significant impact of waterchestnut infestations on humans may well be a reduction in aesthetics. Dense waterchestnut beds can completely cover the surface of shallow bodies of water and small ponds and will often carpet the near-shore areas of popular navigable rivers. The description grudgingly applied to waterhyacinth (Section 2.11) – “chokes out a water surface” – applies to waterchestnut as well.

### Management options

During the past 100 years, many techniques have been used to manage waterchestnut. Unlike most invasive aquatic plants, waterchestnut has been effectively controlled and perhaps even eradicated in some bodies of water, but only after persistent effort. Similar to other invasive plants, best management of waterchestnut results from a vigilant prevention program. Weed watcher programs are particularly effective in controlling waterchestnut since the species is easily identified and early intervention greatly improve opportunities for eradication.

Once present in a body of water, waterchestnut can be controlled by physical and chemical techniques and may ultimately be managed by biological agents. Initial infestations, particularly when only a single rosette is found, can be pulled by hand (Section 3.4). The best window for removal of waterchestnut is from mid-June to mid-August – earlier efforts may result in regrowth or incomplete removal of nutlets, whereas later attempts might miss some nutlets or cause loosely attached seeds to dislodge. Plants should be flipped upside down immediately after removal to prevent dropping of seeds. Kayaks or canoes can be used for hand removal of waterchestnut; kayaks are more easily maneuvered through dense beds of waterchestnuts, but canoes carry more chestnut cargo. Hand removal programs led by cooperative extension offices, community groups, Boy Scout troops and volunteers have effectively controlled waterchestnut in Oneida Lake in central NY and in many other smaller bodies of water throughout the Northeast.

Mechanical harvesting (Section 3.5) can effectively control large infestations of waterchestnut since the species does not reproduce by fragmentation, although cutting just the leaves (rosettes) from plants will likely leave nutlets in the system. Mechanical harvesting of plants after seeds have formed but before they mature can effectively break the reproductive cycle of the plant; however, the longevity and quantity of seeds in the sediment’s seed bank may make it



necessary to repeat the operation for at least 5 to 10 years to eradicate the species. A variety of state and federal agencies have used large mechanical harvesters to greatly reduce waterchestnut populations in Lake Champlain in Vermont and New York and in the Mohawk and Potomac Rivers. However, populations rapidly rebounded and returned to pre-harvesting densities if harvesting is suspended before a population is extirpated.

Herbicides have also been used to control large-scale infestations of waterchestnut (Section 3.7.1). The herbicide used most often for control of this aquatic weed is 2,4-D, which is usually applied in early summer when plants are just reaching the water surface. Recently, triclopyr has also been used to control waterchestnut. Research is underway to determine whether glyphosate provides control of waterchestnut when applied directly to the rosette of surface leaves. Some formulations of imazamox has also been used to control waterchestnut.

Grass carp (Section 3.6.2) have been used as biocontrol agents to manage waterchestnut in some bodies of water. However, grass carp are relatively indiscriminate feeders that find waterchestnut to be unpalatable, so few plants are consumed. Insect-based biocontrol (Section 3.6.1) may be a more promising alternative; researchers continue evaluating a native leaf beetle (*Galerucella birmanica*) which has shown promise. However, this native beetle is a generalist feeder that consumes plants other than waterchestnut. Because successful biocontrol agents must be species-specific and feed only on a particular host plant (Section 3.6), this native beetle may not be a viable biocontrol option for waterchestnut, although some biocontrol work on waterchestnut has been funded by New York state. Some research has also evaluated the use of ultrasonic waves at 20 kHz to break down plant tissues, but this work has not translated to large scale control efforts.

### Summary

Waterchestnut is one of the most invasive aquatic plants in the northeastern United States and has spread from its introduced range into neighboring states over the last 125 to 150 years. This species creates significant ecological damage, restricts human use of waterways and can be very difficult to control without consistent and persistent effort. However, waterchestnut is unique among invasive aquatic plants because it is easily detectable through citizen watch programs and can be controlled or even eradicated if caught early in its colonization. The species is an annual and can be managed by preventing seed production. Once established, waterchestnut requires significant resources to manage and vigilant use of mechanical or chemical control methods for 10 to 15 years to exhaust the reservoir of dormant seeds harbored in sediments.

### Photo and illustration credits:

Page 65: Volunteers with the Buffalo Niagara Riverkeepers removing waterchestnut from Ellicott Creek Park in Western New York; Mike Goehle, USFWS

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Page 67: Waterchestnut nutlets; TheDarkCurrent, distributed under a CC BY-SA 3.0 license.

Page 68: Waterchestnut plant; Hilary Smith, The Nature Conservancy

Page 69: Mechanical harvesting waterchestnut from Tonawanda Creek in Western New York; Mike Goehle, USFWS