

2.9 Floatinghearts

Ian J. Markovich, Joseph W. Sigmon and Lyn A. Gettys: University of Florida FLREC, Davie FL; ijmarkovich@ufl.edu, jsigmon@ufl.edu and lgettys@ufl.edu

Floatinghearts (*Nymphoides* sp.) are rooted, floating-leaved plants in the Menyanthaceae (buckbean) family. Derived from *nymph* (Latin: water), *oides* (Greek: resembling, similar); “*Nymphaea-like*”

Introduction and spread

There are around 50 species of floatinghearts and seven have been found in North America. Two of these species (bananalily and little floatingheart) are native to North America, and three species (yellow floatingheart, snowflake lily and crested floatingheart) were introduced through the ornamental water garden market and have escaped cultivation.



The introduction pathways of the remaining two species (Gray’s floatingheart and Humboldt’s floatingheart) are unclear, but it is likely they are also water garden escapees or have spread due to “natural” range expansion, which was possibly facilitated by flood events or transportation by animals.

Although there are native species of *Nymphoides* in North America, some of the introduced species have had a significant impact on natural environments. For example, crested floatingheart has jeopardized south Florida’s flood control (canal) systems by obstructing water flow and choking out waterways while displacing native species. Resource managers in South Carolina also struggle to manage introduced floatinghearts in their reservoirs and lakes. In addition to these direct and immediate threats to the ecosystem, hybridization between native species (bananalily and little floatingheart) and between introduced and native species (crested floatingheart and bananalily) has been documented in South Carolina, which could change the native gene pool and impact management options.

Description of species

Nymphoides is a remarkably diverse genus, but member species share some similarities. All exhibit nymphaeid growth form, meaning they are rooted in the substrate and produce leaves and flowers that float on the surface of the water. These cosmopolitan species differ from one another in growth habitat, flower appearance, structure, and reproductive

strategy. Molecular work and ancestral reconstruction has shown that this genus has evolved independently at least twice through time. All of the seven species of floatingheart that have been reported in North American water bodies have multiple long petioles (leaf stalks) that each bear a single leaf. Most of the seven species reproduce through vegetative means, although some produce viable seeds as well.



Native floatinghearts

Bananalily (*N. aquatica*) and **little floatingheart** (*N. cordata*) are native to North America. Bananalily is found throughout the eastern and central United States. The leaves are oval to kidney-shaped, with a dark green upper surface and a purple corky underside that often has prominent veins. Flowers range from 1/3 to 3/4 inch wide and have five white, smooth petals with a papery margin and a yellow center. Little floatingheart is found throughout the eastern United States and Canada and has heart-shaped to oval leaves that are often variegated with a reddish-purple upper surface and an underside that is mostly smooth (like fine sandpaper). At only 1/5 to 2/5 inch wide, the flowers of little floatingheart are smaller than those of bananalily, but are otherwise similar in appearance. The primary reproduction method for both species is the

production of “ramets”, which are rhizome-like clusters that form at the base of the leaf. These ramets break off and float away to become a new plant.

Introduced floatinghearts

Crested floatingheart (*N. cristata*) is native to southeastern Asia. Leaves are up to 8 inches long, 6 inches wide and heart-shaped; the upper surface of the leaf is green, usually with a red margin, and the underside is smooth and reddish. This species produces white five-petaled flowers that are up to 1 inch across and have a membranous margin and a crest or ridge running down the center of each petal. Similar to the native floatinghearts, the primary method of reproduction for crested floatingheart is via spiky ramets, which float through the water column and eventually sink to the bottom where they can root and sprout to form new plants. A single founder plant can produce as many as 500 ramets over six months and 40% of these are likely to sprout, so ramets have the potential to start completely new infestations in a relatively short amount of time. Seed production by crested floatingheart is not well-understood but this species has reportedly hybridized with bananalily and therefore seems able to reproduce via seeds.

Due to its attractive appearance, crested floatingheart has long been grown as a water garden



ornamental. The species was first discovered in the wild in 1996, when it apparently escaped cultivation in southwest Florida, invaded the lake of a residential subdivision, and quickly spread throughout the drainage canals. By 2001, crested floatingheart had spread north to Sarasota and east to Palm Beach County and is now broadly distributed throughout the state, which spurred its addition to the Florida Noxious Weed List in 2014. The species was found in South Carolina's Santee Cooper system in 2006 and continues to be one of the most vexing problems for resource managers there. In addition to Florida and South Carolina, active invasions of crested floatingheart exist throughout the southeastern United States (eastern Texas, Louisiana, North Carolina and possibly Mississippi).

Yellow floatingheart (*N. peltata*) is native to Central Europe and Asia Minor, where it occurs in temperate and subtropical climates. Leaves are oval to heart-shaped with a wavy or scalloped margin and are attached to the stems in an opposite manner. Leaf size and shape are dependent upon season; plants produce small leaves in winter, and spring to early summer brings small folded leaves that open more when temperature and daylight increase. The upper surface of the leaves is green to yellow-green and the underside may be maroon or purple. A bright yellow five-petaled flower that measures up to 2 inches across is produced at each leaf. The flower has a broad membranous margin that is wavy to ruffled, which creates an irregular "fringe". Yellow floatingheart does not seem to produce ramets, but instead produces stolons that grow through the water column and along the bottom of slow-moving water bodies. Stolon fragments produce adventitious roots and form young plants with a single leaf, but the primary mode of reproduction for yellow floatingheart appears to be seed production. Each flower produces a seed capsule that splits at the end of the growing season and releases many smooth seeds with winged margins. The seeds float until a disturbance causes them to break the water surface; they then sink, remain dormant through the winter and sprout in the spring.



Yellow floatingheart is cosmopolitan in distribution and is found throughout much of the world. The species may be spread via by escaping cultivation or by hitchhiking on birds or other aquatic animals. It is invasive in the United States (where it has been reported in 34 states) and New Zealand, but threatened in Japan. Yellow floatingheart was first documented in 1882 in New York City's Central Park, where it was grown in a terrace pond, and has been marketed as an ornamental in the water garden industry since 1891. By 1930, it was found out of cultivation in the Pacific Northwest and was reported in eastern Washington and Oregon. Similar to crested floatingheart, yellow floatingheart was added to the Florida Noxious Weeds List in 2014.



Water snowflake (*N. indica*) is native to tropical Asia and Africa. The thick, fleshy, round leaves measure up to 7 inches across and are bright green on the upper and lower surfaces. Each flower has six to twelve white densely fringed petals that are covered with hairs, and multiple flowers may be associated with a single leaf. Water snowflake reproduces mainly via seed but can also propagate very effectively through vegetative means such as stem fragments.

Water snowflake was introduced either intentionally or as an accidental escape from the water garden and aquarium industry. Water snowflake has been vouchered in several counties in Florida, although most of those specimens have now been identified as Humboldt's floatingheart (see below)

through molecular genetics. The only other report of non-cultivated water snowflake in the United States is from Hawaii, but the status of that infestation is unknown.

Floatinghearts of uncertain origin

Gray's floatingheart (*N. grayana*), native to Cuba and the Bahamas, was recently identified in Florida. The USDA classifies the species as non-native and Wunderlin et al. (2019) states the plant is probably a water garden escape in Florida, where the species has been reported in three counties. It is likely that the species has been in Florida for a number of years but was misidentified as a color variant of water snowflake. Gray's floatingheart has arrowhead- or heart-shaped leaves that are dull green on the upper surface and purplish on the underside with overlapping lobes. The flowers have bright yellow petals with densely fringed margins. Information regarding the reproductive ecology and true native range of Gray's floatingheart is uncertain due to lack of information about this species.



Humboldt's floatingheart (*N. humboldtiana*) has also been recently described in Florida. The species is native to the Caribbean and Mexico and is classified as introduced (non-native). Humboldt's floatingheart has oval to heart-shaped leaves that are bright green (or sometimes mottled) on the upper surface and underside with indistinct veins. The white flowers are very similar to those of water snowflake but usually have five petals. Humboldt's floatingheart reproduces via seeds that lack tubercles (small, wart-like projections). This characteristic can be useful to separate this species from water snowflake, which produces seeds that do have tubercles. Humboldt's floatingheart has been reported in two counties in Florida and one county in Texas. As with Gray's floatingheart, it is likely that Humboldt's floatingheart has been in Florida for a number of years but was misidentified as a variant of water snowflake.

Reproduction

Reproduction occurs via ramets in some species or through the production of seeds in others. As mentioned earlier, ramets are rhizome-like clusters that form at the base of the leaf and eventually break off and have the potential to form new plants. Several species of *Nymphoides* are also able to root from stem or leaf fragments, while a few utilize a combination of these strategies. Ramets may float away from the parent, which can increase population size, or may settle to the bottom of the water body, where they remain until they sprout. Seeds of some species of floatinghearts may have a dormancy period, while others may readily germinate almost as soon as they are shed by the parent plant. Plant fragments, ramets and seeds may be spread via currents, animals or via human activities by hitchhiking on recreational equipment.

Problems associated with *Nymphoides*

Introduced species of *Nymphoides* such as crested and yellow floatinghearts have the potential to interfere with navigation, recreation, flood control and other water-based activities by clogging the aquatic system with dense plant material. These invasive floatinghearts species cause ecological problems as well. Their accelerated reproduction and ability to create canopy-forming monocultures on the water surface allows these species to outcompete and displace native floatinghearts and other desirable indigenous species, thus reducing habitat quality. In addition to these immediate ecological effects, it appears that several species of this genus are able to hybridize; for



example, hybridization has occurred between two native species (little floatingheart and bananalily) and between native and invasive species (crested floatingheart and bananalily). These hybridization events could eventually cause significant contamination of the gene pool for native floatinghearts, which would imperil the integrity of these important plants.

Management options

It should be clear that the varied reproductive strategies (ramets, seeds and fragmentation) of introduced floatinghearts are problematic for resource managers and may limit the use of some management techniques. Similar to many introduced species, the best method to prevent these plants from causing ecological damage and interfering with human uses of an aquatic resource is to prevent the species from entering the water body. Some states do prohibit the sale and transport of some species of floatingheart, but existing populations still manage to slowly increase their range and colonize new bodies of water.

Physical (Section 3.4) or mechanical (Section 3.5) control measures such as hand removal or mechanical harvesters are not practical for managing crested and yellow floatinghearts because both species can reproduce via stem and leaf fragments and are thought to have the capacity to regrow from root crowns that remain in the soil after harvesting plant material in the water column. In addition, crested floatingheart produces many ramets and yellow floatingheart produces copious seeds, both of which are left behind after harvesting and can quickly sprout to repopulate the system. Cultural control methods (Section 3.4) such as dewatering or drawdowns may have some utility for crested floatingheart management, as ramet viability is significantly decreased after 24 hours of desiccation. However, the seeds of some floatingheart species are induced to germinate by drawdown, which can result in significant infestations once water levels are returned to their normal state. Ramets that are buried under as little as 4 cm of soil rarely sprout, so benthic barriers may reduce the number or density of populations that are derived from ramets. No floatingheart-specific biocontrol agents (Section 3.6) have been identified for these species, although the aquatic larvae of a native generalist moth reportedly consumes native floatinghearts.

The most effective tool in the toolbox for floatingheart management is chemical control (Section 3.7.1). Although both foliar and water-column treatments can be utilized to control large infestations, water-column treatments tend to have better efficacy. Contact herbicides such as diquat and endothall and systemic herbicides such as imazamox, imazapyr, and auxins (2,4-D, triclopyr and floryprauxifen-benzyl) have been used for management of floatinghearts with varying levels of success. As with other floating-leaved species, herbicide efficacy is influenced by environmental conditions such as currents and wave action.



Summary

The genus *Nymphoides* is quite diverse and the United States hosts both native and introduced species. Introduced species – especially crested and yellow floatinghearts – can have serious effects on the environment by outcompeting native floatinghearts and other desirable indigenous species and can interfere with human uses of invaded waters by clogging the water column and inhibiting flow. Early detection and rapid response is the least expensive and most effective means to prevent introduced floatinghearts from expanding into uninvaded aquatic systems. Aggressive management should be employed in areas where these introduced species already occur to avoid expansion of existing populations and reduce the likelihood of new introductions to connected waterways. The use of most control methods is limited due to the multiple reproductive strategies utilized by introduced floatinghearts, but several chemical control tools can be used to manage populations of invasive members of the genus *Nymphoides*.

Photo and illustration credits:

Page 59: Crested floatingheart in a canal in Naples, Florida; Lyn Gettys, University of Florida

Page 60 upper: Bananalily (inset: ramet); Lyn Gettys, University of Florida

Page 60 lower: Crested floatingheart (inset: ramet); Lyn Gettys, University of Florida

Page 61 upper: Yellow floatingheart (inset: seed capsules); Lyn Gettys, University of Florida

Page 61 lower: Water snowflake; Lyn Gettys, University of Florida

Page 62 upper: Gray's floatingheart; Lyn Gettys, University of Florida

Page 62 lower: Yellow floatingheart infestation in Ireland; Lyn Gettys, University of Florida

Page 63 upper: Adventitious roots on yellow floatingheart stems; Lyn Gettys, University of Florida

Page 63 lower: Humboldt's floatingheart mother plants and seedlings in a dry canal in Puerto Rico; Lyn Gettys, University of Florida