

## *Aquarius cordifolius* (L.) Christenh. & Byng (Alismataceae), an invasive alien species: its introduction, colonization and plausible threats in India

The exotic or non-native organisms that occur outside their natural adapted ranges and dispersal potential are called alien species. Human beings have been introducing animals and plants from one part of the world to another, for various purposes by different means since time immemorial. Some of the alien species become invasive when they are introduced deliberately or accidentally outside their natural habitats into new areas where they express the potential to establish, invade and out-compete native species<sup>1</sup>.

The water plantain family Alismataceae is one of the important aquatic families that comprises of about 100 species under 14 genera, and is distributed throughout the world<sup>2</sup>, growing mainly in freshwater marshes and ponds. In India, the family is represented by 13 species under six genera<sup>3</sup>. Recently, one of us (A.K.) observed a large colony of about hundreds of mature individuals and collected a few samples of the plant from a pond near Padmapukur water treatment plant, Howrah, West Bengal, India. After a critical study of the collected plant specimens coupled with scrutiny of the pertinent literature, it was identified as *Aquarius cordifolius* (L.) Christenh. & Byng. It was found growing in association with other weedy species such as *Sagittaria montevidensis* Cham. & Schlttdl., *Alternanthera philoxeroides* (Mart.) Griseb., *Pontederia crassipes* Mart. and *Cyperus alopecuroides* Rottb.

The genus *Aquarius* comprises of 26 species, and its native range is Central and southeastern USA to tropical and subtropical America<sup>2</sup>. Several species of genus *Aquarius* are among the economically most important aquarium plant groups<sup>4</sup>. *A. cordifolius* (L.) Christenh. & Byng allied to *A. grandiflorus* (Cham. & Schlttdl.) Christenh. & Byng, differs in arching to decumbent inflorescences and papillate veins on the sepals. It is considered as an obligate wetland indicator species. The native range of the species is central and southeastern USA to Caribbean, Eastern Mexico to Venezuela<sup>2</sup>. It is listed as invasive alien species in Europe<sup>5</sup> (Austria) and South Africa<sup>6</sup>.

We hereby report this as an invasive alien species in India, which is now naturalized in marshy ponds and forms a large colony in Howrah. Earlier it was spotted as an ornamental in Datya Village, near Parwanu, along Shimla road, Himachal Pradesh<sup>7</sup>. This species is fast invading the aquatic ecosystems and disturbing native vegetation. Species of *Aquarius* Christenh. & Byng invade easily because of their high plasticity and adaptability (they can grow partially out of the water and with low levels of light, and can reproduce easily)<sup>8</sup>. It can be propagated by means of rhizomes, seeds and young adventitious plantlets from the inflorescence.

Description and photographs are provided here for easy recognition in the field.

*Aquarius cordifolius* (L.) Christenh. & Byng, Global Fl. 4: 51. 2018. *Alisma cordifolia* L., Sp. Pl.: 343. 1753. *Echinodorus cordifolius* (L.) Griseb. in Abh. Königl. Ges. Wiss. Göttingen 7: 257. 1857 (Figure 1).

Rhizomatous perennial herb, up to 1.2 m high. Leaves emerged, erect, submerged leaves mostly absent; petioles triangular, 17.5–45 cm long, 5 or 6-ribbed, blades with translucent prominent veins, ovate to elliptic, 6.5–32 × 2.5–19 cm, truncate to cordate at base, entire along margins, obtuse with a short mucronate at apex (short acuminate in immature), chartaceous; veins 3–9 from base; secondary veins many, horizontally parallel in-between main veins. Racemes 3–9 in whorls, each 3–15-flowered, decumbent to arching, up to 1.5 m long, often proliferating; peduncles terete, 35–56 cm long; rachis triangular. Flowers showy, 9–11 at each node; bracts triangular-subulate, 10–20 mm long, tapering in acute apex, coarse; pedicels triangular, erect to ascending, 2–7.5 cm long, glabrous; sepals three, free, elliptic-ovate, 4–5 mm across, margins scarious, apex obtuse, spreading, 10–12-veined; veins papillate; petals three, white, free, suborbicular or broadly obovate, about 2 × 3 cm, entire; stamens 22, greenish-yellow; filaments linear, 2.5–3 mm long, glabrous; anthers versatile, about 1.5 mm

long; pistils 200–250, apocarpus, spirally arranged on receptacle; style short; stigma lateral, indistinct. Fruit an achene, ovoid, 2–3.5 × 0.9–1.5 mm, shortly beaked at apex, longitudinally three- or four-ribbed, with three or four rounded glands.

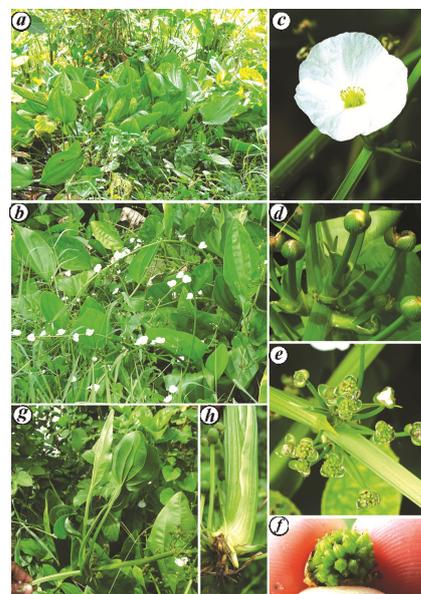
Distribution: India (West Bengal, Howrah district; grown as ornamental in Himachal Pradesh); North America (Mexico, USA (Florida, Illinois, Kansas, Texas, Virginia)), Europe (Austria and United Kingdom) and South Africa.

Flowering and fruiting: April–September.

Habitat: Grows in marshes, swamps or muddy ponds/ditches.

Specimen examined: India, West Bengal, Howrah district, in ponds near Padampukur water treatment plant, Danesh Shaikh Lane, 08.04.2019, *Anant Kumar* 53000 (CAL).

West Bengal is a state of lakes, ponds and rivers, having one of the important



**Figure 1.** *a*, Patch of a colony of *Aquarius cordifolius* (L.) Christenh. & Byng. *b*, Plants with arching inflorescence. *c*, Flower. *d*, Sepals showing papillate veins. *e*, Fruiting branchlet. *f*, Fruits. *g*, Young adventitious plantlet from inflorescence. *h*, Basal portion of young adventitious plantlet showing new emerging roots.

Ramsar wetland sites, viz. the East Kolkata Wetlands. A common hobby of People of West Bengal is maintenance of ornamental fish aquaria in which they grow *A. cordifolius*. Probably, this species from aquaria might have got introduced into the ponds/lakes. The aquarium plant and fish trade moves thousands of species around the globe, opening the door to unwanted organisms being released into fresh and marine waters, with subsequent adverse ecological and economic impacts. The aquarium plant and fish trade has only recently been recognized as a major pathway for fish and plant introductions<sup>9</sup>. So, the possible pathway of this species is trade in plant seeds, aquaculture and aquarium species. Therefore, the invasion pathways have been mostly attributed to humans.

Invasive alien plant species have gained global interest of ecologists, biological conservationists, forestry planners, natural resource managers and social development planners due to their negative impact on biodiversity and ecosystems. The invasion of alien species is the second major threat for biodiversity loss across the globe, next only to habitat destruction by human beings<sup>1,10</sup>. The wetland biome has been strongly invaded by invasive aquatic plant species in many parts of the world<sup>11</sup>. This is mainly because many of the invasive aquatic species possess broad environmental tolerance. In the Indian wetlands, the number of alien plants introduced both accidentally and intentionally such as *Pontederia crassipes* Mart., *Pistia stratiotes* L., *Salvinia adnata* Desv. and *Alternanthera philoxeroides* (Mart.) Griseb., have emerged as a major threat to aquatic diversity and pose a serious risk to regional and local economy such as

fisheries, agriculture (rice farming) and human health. Excessive increase in population of invasive aquatic plants has often increased habitats conducive to the development of vectors of human diseases<sup>12</sup>. Among wetland and littoral plants, large sums of money are spent annually to control non-indigenous aquatic plant species in the Western countries<sup>13</sup>. In 2001, economists estimated the costs of damages caused by invasive species to agriculture and forestry at about US\$ 91 billion a year in India alone<sup>14</sup>.

During field collection, we noticed that rhizomes of the species grow deep in the soil, making eradication by hands ineffective. It is suggested to survey all aquatic habitats in the country and control the further spread of this species from rigorously invading aquatic habitats. For effective management of invasive species, it is necessary to gather and consolidate historical details, including the pathways, morphology, phenology, reproductive biology, ecology and economic impacts of all alien species. This will help us to better scrutinize and control the population of such potential invasive alien species prior to their introduction.

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