**Rapid Communication**

*Hydrocleys nymphoides* (Humb. & Bonpl. ex Willd.) Buchenau: first record of naturalisation in South Africa

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**Abstract**

*Hydrocleys nymphoides* (water poppy), an aquatic plant native to South America, has been recorded as invasive on several continents (Europe, Australia and Asia). Here we report on the first known naturalized population in South Africa, in a dam in the KwaZulu-Natal (KZN) Midlands region, near the town of Howick. This population, first detected and identified in 2009, had by the end of the 2013 summer season occupied 1.8ha (30% of the dam). Surveys of 34 surrounding water bodies during the period between 2012 and 2013 did not result in detection of any new populations. The only other population (0.1 ha) was recorded growing in cultivation at the Durban Botanic Gardens. This note reports on the history of *H. nymphoides* in South Africa, details its current and potential distribution, looks at the risk it poses, and outlines plans for nation-wide eradication.

**Key words:** water poppy, invasive alien aquatic plant, South Africa

**Introduction**

The negative impacts of invasive alien plants to natural resources are well documented (Richardson and van Wilgen 2004). Aquatic invaders are of particular concern in water-scarce countries such as South Africa and should be prioritized for management (van Wilgen and De Lange 2011).

*Hydrocleys nymphoides* (Humb. & Bonpl. ex Willd.) Buchenau (Limnocharitaceae), is a rooted aquatic plant native to South America (Brazil and Venezuela) that is regarded as a problematic invasive in parts of Australia and Europe (Williams 2008).

It is characterized by floating round to heart-shaped fleshy leaves that are supported by long petioles and cup-shaped flowers with three to six yellow petals and a reddish-brown centre (Figure 1A, B). (Aston and Jacobs 1980). In its introduced ranges, the plant reproduces solely vegetatively (Williams 2008). During vegetative reproduction, stolon fragments break away, at the end of the growing season rise to the surface, and are carried by water movements; these then root and form new plants (Emert and Clapp 1998). *Hydrocleys nymphoides* grows best in shallow waters (less than 2m), and nutrient-rich environments with sufficient light penetration (Sullivan and Hutchison 2010).

Due to its reproductive and growth characteristics, *H. nymphoides* poses an ecological threat to invaded water systems (Smith 1979). Broken plant fragments enable it to regenerate and out-compete indigenous vegetation. Long trailing petioles can cause physical obstruction which interferes with the behaviour of aquatic fauna, and also affect recreational activities such as fishing, swimming, and boating (Sullivan and Hutchison 2010). Dense infestations can trap silt and result in blockages of the water flow. Under favourable conditions, *H. nymphoides* can carpet the entire water surface preventing the penetration of light for photosynthetic process
and depleting oxygen, which changes the state of the water ecosystem, impacting negatively on indigenous flora and fauna (Gorham 2008).

In Australia, *H. nymphoides* was used as an ornamental as early as 1896 (Aston and Jacobs 1980), with the first naturalized populations reported in 1979 from Valencia Creek, Central Gippsland, Victoria. The species has now naturalised in slow-moving and high-nutrient waters of Queensland (Stephens and Dowling 2002), and is listed as a moderate high risk weed in the advisory list of environmental weeds of aquatic habitats of Victoria (Adair et al. 2008). Although adapted to tropical and subtropical habitats, literature suggests that *H. nymphoides* can also thrive in warm and cool temperate regions outside of the tropics (Williams 2008). It has also naturalised in New Zealand (Hosking et al. 2005) and became invasive in the warmer regions of England, USA, Japan, and in Fiji following the dumping of aquaria waste into water courses (Williams 2008).

The species is also recorded in two African countries: Zimbabwe (included in the GBIF records) and Kenya, where it is used as an ornamental plant in tropical water gardens and in constructed wetlands for waste water treatment (Howard and Chege 2007). However there is no evidence for naturalization or invasiveness in any of these cases.

The first naturalized population of this species in South Africa was discovered in 2009, when the South African National Biodiversity Institute’s Invasive Species Programme (SANBI ISP) was alerted to an aquatic plant naturalized at a dam in the Midlands area of the KwaZulu-Natal province. The SANBI ISP is mandated to target localized alien species of limited distribution which stand a chance of eradication (Wilson et al. 2013). A herbarium specimen (M Cheek, NH 0135792) was lodged at KwaZulu-Natal herbarium. The St. Joseph’s Dam (29.05194 S, 30.03222 E), located in Howick, is approximately 6 ha and occurs on private agricultural land belonging to

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**Figure 1.** *Hydrocleys nymphoides:* (A) leaf shape, (B) cup shaped yellow flower, (C) dense petiole fragments and (D) infestation at St. Joseph’s Dam. Photographs: M. M. Nxumalo.
First record of *Hydrocleys nymphoides* in South Africa

Figure 2. Extent of invasion of *Hydrocleys nymphoides* at St. Joseph’s Dam (A), relative position of the surrounding water bodies surveyed, indicating presence and absence data (B), and potential distribution of *H. nymphoides* generated by the bioclimatic models. Values represent the mean probability of the two fitted models (C).

In order to see if *H. nymphoides* is locally more widespread than the infestation recorded in St. Joseph’s Dam, upstream and downstream surveys were conducted and 34 water bodies (Figure 2B and Table S3) occurring within a 20km radius of the dam were surveyed.

Assessing the potential invasive risk

The Australian Weeds Risk Assessment model (Phelong et al. 1999) was used as a measure of the potential risk of this species in South Africa. Two different bioclimatic models (Bioclim and Domain), using presence-only data, were fitted to predict the potential future expansion in South Africa. Presence records of *H. nymphoides* and 19 climatic variables were gathered from internet sources (GBIF 2014; Hijmans et al. 2005). The climatic variables were merged in a principal component analysis (PCA) and keeping the first five orthogonal axes (cumulated explained variance 93%). The potential area was calculated as the averaged area predicted by two models.

Ecology of *H. nymphoides* at St. Joseph’s dam

The infestation was assessed to detect changes over time and to determine feasible control methods. Surface mapping was done, and the

Methods

Determining the current distribution of *H. nymphoides*

To determine if there are other populations in South Africa, the Southern African Plant Invaders Atlas (SAPIA) and three national South African herbaria were consulted; scientific literature searches conducted; and data from annual surveys of alien aquatic plants in approximately 200 South African freshwater systems (conducted by Rhodes University since 2008) were analysed. Pamphlets were also developed (Supplementary Figure S2) and distributed at several environmental fora and workshops to encourage people to report sightings, and two posters were presented at scientific conferences in KZN.

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Table 1. Hydrocleys nymphoides fresh weight biomass data from St Joseph’s Dam.

| Site number and GPS co-ordinates | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 | Site 7 | Site 8 |
|----------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| Site 1 (-29.5197, 30.2635)       | 73.6   | 59.6   | 13.96  | 49.05333 |
| Site 2 (-29.5186, 30.2631)       | 27.92  | 48.24  | 53.12  | 43.09333 |
| Site 3 (-29.5199, 30.2631)       | 43.56  | 44.92  | 33.56  | 40.68 |
| Site 4 (-29.5206, 30.2623)       | 32.4   | 18.44  | 20.68  | 23.84 |
| Site 5 (-29.5211, 30.2618)       | 17.12  | 23.88  | 17.64  | 19.54667 |
| Site 6 (-29.5225, 30.2609)       | 31.32  | 106.8  | 52.8   | 63.64 |
| Site 7 (-29.5209, 30.2609)       | 71.72  | 44.8   | 32.64  | 49.72 |
| Site 8 (-29.5204, 30.2609)       | 35.76  | 33.76  | 20.32  | 29.94667 |

Infestation was found to occur mostly along the edges of the system running from the wall to the catchment. The dam was then divided into four sections (40m apart). Within each section, eight sampling sites were randomly selected, and three 1m² quadrants were placed in each of these sampling sites for data collection, such as submerged aquatic macrophyte composition and density (fresh weight biomass). These were collected using a sampling rake (a metal leaf rake with eight 18 cm long teeth bending upward around the rake), which was thrown down into the water, lowered to the substrate, and twisted 180° as it was lifted vertically from the water to ensure that no plants were left behind. Plant samples were bagged, left to air dry for 5 to 7 minutes and weighed using a spring balance (kg). GPS coordinates and depth readings were recorded for every sampling site. Samples were transported to the laboratory for drying in order to get the dry weight biomass. Samples were air-dried for two weeks to remove as much moisture as possible from the plants and were then further dried using a 700 watt microwave oven (which was set to maximum heat) three times for 15 to 20 minutes. The dry mass was then recorded.

Results

Distribution and ecology

The only other herbarium record of the species in South Africa was from a cultivated specimen collected in 1951 from the Durban Botanic Gardens in South Africa (ER Thorp, NH 40848). As a result of this study, the Durban Botanic Gardens management was alerted to the plant, and the population was manually removed in 2013. Since then, no plants were recorded in the pond.

The history behind its current occurrence in St. Joseph’s dam (~65km away from the Durban Botanic Gardens) is not clear. Management staff at the St Joseph’s Theological Institute and neighboring agricultural college (CEDARA) were approached, but they could not provide details of how the population originated.

Surveys conducted by Rhodes University in water bodies in South Africa revealed no other infestations (Supplementary Figure S1 and Table S1). Surveys of water bodies surrounding St. Joseph’s dam also showed no signs of spread or establishment of H. nymphoides. Hence, the population detected at St. Joseph’s dam is the only known naturalized population in South Africa (Figure 2B).

Invasive potential and risk

Hydrocleys nymphoides obtained a score of 22 for South Africa, based on the Australian Weeds Risk Assessment Protocol (Table S2). However, in New Zealand where it has also naturalized, H. nymphoides obtained an even higher score of 45 (Champion et al. 2014). Other studies have also suggested that H. nymphoides requires attention as a potential invader of wetlands when conditions are favourable (Williams 2008; Aston and Jacobs 1979; Smith 1979). In the US, despite being been present for over a century and currently a minor invader of water systems, Gordon et al. (2012)
iterated the importance in implementing management efforts at this stage, to avoid probable future impacts. In addition, the bioclimatic modelling map has shown the eastern region of South Africa to be climatically suitable for *H. nymphoides*. This includes the Eastern Cape, KZN, Mpumalanga and Limpopo provinces (Figure 2C).

**Discussion**

Since the discovery of *H. nymphoides* in South Africa, the SANBI ISP has taken steps to assess the distribution and threat of this species. Results indicate that *H. nymphoides* is limited to only one locality at the St. Joseph’s Dam in KZN.

According to Aston and Jacobs (1980), *H. nymphoides* grows best in warm nutrient rich environments, but dies back in winter. The Midlands region of KZN in which the St. Joseph’s Dam is located experiences very low temperatures and endures frost in winter. This, together with the inability of *H. nymphoides* to produce seeds, may also be a limiting factor towards establishment and spread to nearby water bodies or downstream. *Hydrocleys nymphoides* grows in an artificial dam that is connected to the stream that runs down into another dam (Albert Falls Dam). From our in-field observations, should the system experience floods or any disturbance that leads to the movement of plants, there is a high probability that plants and fragments could escape downstream and start invading lower parts of the stream.

Freshwater aquatic plant species have demonstrated a high rate of becoming invasive and pose higher risks of invasion when grown or released in new habitats (Gordon and Gantz 2011). Due to its demonstrated invasiveness in other countries with a similar climate and taking into account the assessment of the results from both the AWRA and the bioclimatic model, it is concluded that *H. nymphoides* poses a risk of invasion to waterbodies in South Africa, particularly in the eastern parts of the country.

At this early stage of invasion in South Africa *H. nymphoides* stands a good chance of eradication and management efforts should aim to remove the current infestation and prevent spread to other water bodies. As such we support the categorisation of *H. nymphoides* as an eradication target under South African regulations (*i.e.* Category 1a species on the NEM: BA regulations (DEA 2014). The ISP has already started controlling the population at St Joseph’s Dam, and we also suggest targeting surrounding water bodies that are *directly* linked to St. Joseph’s Dam for future surveys, due to this species’ preference for vegetative propagation. Awareness-raising initiatives should also extend to other climatically suitable areas of the country, as indicated from results of the bioclimatic model (*e.g.* in the northern provinces).

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Supplementary material

The following supplementary material is available for this article:

Table S1. Details of surveys conducted by Rhodes University in water bodies in South Africa.
Table S2. Australian Weed Risk Assessment used for H. nymphoides in South Africa.
Table S3. Details of water bodies surveyed surrounding St Joseph’s dam within a radius of 20 kms.
Figure S1. Sites surveyed at a national scale annually by Rhodes University in South Africa to assess water weeds invasion.
Figure S2. Awareness raising pamphlet on H. nymphoides.

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