

Progress towards the eradication of *Limnocharis flava* from Australia

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Summary *Limnocharis flava* (Limnocharis) is an anchored aquatic weed preferring shallow silty tropical habitats. *Limnocharis flava* was discovered near Kuranda in north Queensland in 2001 and included in the nationally cost-shared National Tropical Weeds Eradication Program when it commenced in late 2003. Small and cultivated *L. flava* loci have been discovered between Cape Tribulation and Townsville, particularly around the greater Cairns area. In 2021, *L. flava* was discovered in the Northern Territory as well as in in southeast Queensland. The cultivation of this invasive plant as a garden ornamental or as a vegetable, increases the risk of populations established beyond the current known extent.

Keywords tropics, declaring eradication, aquatic weed, edible

INTRODUCTION

Limnocharis flava (L.) Buchenau. (Limnocharis) is an invasive anchored aquatic plant native to Central and South America. It has become naturalized in shallow water courses in tropical regions across Asia, where it is so widespread it is utilized as a local edible vegetable (Weber and Brooks 2013).

In Australia, *L. flava* is declared under state and federal legislation. The Biosecurity Act 2015 provides legislative measures to prevent the entry/reintroduction of *L. flava* into Australia. *Limnocharis flava* is declared under legislation in Queensland, New South Wales, Northern Territory and Western Australia. It is also Restricted Biosecurity Matter under the Queensland Biosecurity Act 2014, and it is illegal to distribute, move, keep and / or not report *L. flava*. Officers authorized under the Queensland Act can issue a Penalty Infringement Notice (PIN) or on the spot fines for keeping *L. flava*.

Limnocharis flava is a species targeted for eradication under the National Tropical Weed Eradication Program (NTWEP). The following information discusses changes to the NTWEP reporting procedures and to the national risk profile. There is also an update on overall progress towards

eradication of *L. flava*, last published by Brooks *et al.* (2008b).

ERADICATION DATA PROCESSING

The NTWEP reports eradication progress data from discrete locations (loci). These are categorised into either ‘contained water features’ (garden ponds, water features through which water doesn’t readily flow) and ‘uncontained habitat’ such as creeks, dams and drainage lines.

Field officers search areas which have previously recorded *L. flava* plants, including areas 200m downstream from loci within unconfined water systems. Active loci are revisited at monthly intervals throughout the year, which provides one or more opportunities to detect seedlings which take at least 46 days to produce immature fruit (Brooks *et al.* 2008a). Annual extended downstream surveys of 1km (or until salt water is reached) and 500m upstream are undertaken at loci within uncontained water systems.

Field records including, the date of discovery, precise location, number of plants and the reproductive status are stored in BORIS (Biosecurity Online Resources & Information Systems). This is the Biosecurity Queensland portal that houses all the NTWEP data records including compliance records. Presence or absence is derived from field records for every known unique site identification number (waypoint). Sites are added if plants are detected more than 30 m away from a known location.

From 2010, eradication progress reporting adopted a grid-based system of fixed one hectare ‘management areas’ (100m x 100m). Previously a system based on loci of a range of sizes was used (Brooks *et al.* 2008b). All data prior to 2010 was re-analysed using the ‘management area’ scale, which allows spatially consistent annual reporting.

Every six months, point records are summarized to allocate a ‘control phase’ status where plants are present, or ‘monitoring phase’ status where plants are absent for each management area. Management areas only enter a monitoring phase when absence data is recorded in the last 2 x 6-month periods; progression

is via evidence of absence. The time that management areas have been in the monitoring phase is categorised to an annual value of ‘years in monitoring phase’. If plants are recorded in a management area which is in the monitoring phase, it relapses to a control phase for at least a 12-month period. The number of years of monitoring (prior to a relapse) is tallied to determine ‘monitoring relapse’ frequency data. The allocation to control and years in monitoring status is updated every 6 months, with this dataset updated to the end December 2021.

The NTWEP also uses the ‘time since last reproduction’ as a measure of eradication progress (Brooks and Jeffery 2018). In cases where no seed production has been observed, the discovery date is used to calculate the time since last seed production. The time since last seed production (or discovery) accrues annually unless there is a seed production event (reproductive escape), causing the management area to suffer a ‘reproductive relapse’. The last reproduction data is determined at the end of each financial year from a single (discovery or reproductive relapse) date for each management area. The last detection and last reproduction or discovery data have the same sample size (Figures 1 and 2) but are calculated differently. The following information contains examples of data reported annually to cost-sharing partners.

ERADICATION PROGRESS

Discovery and delimitation There were 81 management areas as of December 2021. Twenty-one management areas are in (contained) domestic ponds or water features. The remaining 60 management areas are in dams, creeks and drainage channels through which water can flow.

Discoveries in 2021 include two new management areas in the Northern Territory (Table 1), these were cultivated specimens and are currently being treated as ‘contained’ loci. Viable seed has been found beside tubs at one location (S. Brooks, unpublished data) and it may be reclassified as unconfined if further plants are found. The Northern Territory government (Department of Environment, Parks and Water Security) is preparing their national response plan (N. Weston, pers comm 2022), but the two locations are included in this data set, until their response plan is endorsed.

Since 2016-17, six new loci have been in contained features, with some deliberately cultivated for sale as an edible vegetable. One of these discoveries was traced to south-east Queensland from a new locus in Townsville. Another was a cultivated plant at a residence near Cape Tribulation. Combined with the two new loci in the Northern Territory, these discoveries are beyond the extent of

the previous known locations, between Townsville and Port Douglas in north Queensland.

Table 1. Number and type of *Limnocharis flava* loci in Australia

Locus Type	QLD	NT	Total management areas
Contained (ponds or water features)	19	2	21
Unconfined habitat	22		60

The last new unconfined *L. flava* locus was discovered in May 2017. The unconfined loci occupy between one and eight management areas. They are small and discrete and appear limited by salty water or rocky substrates. To date, field surveys have revealed limited downstream spread, even after intense tropical rainfall events. However, further downstream dispersal is possible in shallow freshwater systems that are not under tidal influence. No new loci have been found by specific ground or water search activities.

Across both locus types, the establishment of new *L. flava* loci appears to be by the deliberate or accidental cultivation of plants. Using the categories of Brooks and Galway (2008), detection has resulted from awareness amongst weed allied professionals (43.2%), information from the public via engagement activities (40.9%) and tracing forward and backward information (15.9%). Whilst detection by tracing was more common at the start of the NTWEP, three of the last six confined loci were discovered using tracing information obtained from other occurrences.

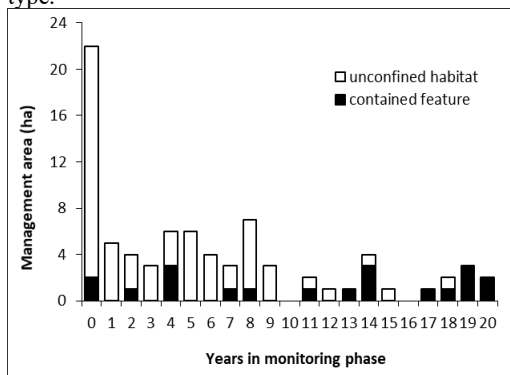
All the current unconfined loci are small and occur across a similar geographic extent. The detection of new contained loci over a much broader geographic area has been traced to the deliberate cultivation of this species as a vegetable in ethnic communities, which poses a significant risk to eradication of *L. flava* in Australia. Discoveries reflect the deliberate or unintentional cultivation of this plant, including being grown as a vegetable. This risk is managed principally through maintaining and expanding the surveillance and control efforts at current loci; advertising campaigns, including targeted social media; TV advertisements; community engagement activities and compliance.

Social media groups and websites were targeted by web scrapers to detect online domestic trade of *L. flava*, following methods described in Stringham *et al.* (2021). Over 380,000 online advertisements and social media posts were searched across four websites. Thirty-five search terms in three languages

were used to locate *L. flava*. This search found no evidence of *L. flava* being sold or traded through four e-commerce ‘surface’ websites. It appears that the greater risk is through ‘closed groups’ on the internet.

Plant absence and extirpation Of the 81 management areas, 73% had progressed to a monitoring stage (plant absence for more than a year) by December 2021 (Figure 1). Several of the confined habitats have been removed or permanently capped, which means they are not monitored regularly and are considered eradicated although they are still progressing along ‘years in monitoring axis’ in Figure 1. Most control phase management areas are either new contained features or six active loci along the wet tropical coast of north Queensland between Tully and Cairns. These loci include management areas that are still in the control phase despite more than 10 years after the last mature plant was controlled (Figure 2). The field crew data and ongoing field and glasshouse research (S. Brooks unpublished data) shows *L. flava* forms a persistent soil seed bank, particularly in constantly wet habitats. After 10 to 13 years, small numbers of seedlings continue to emerge in management areas that had high pre-discovery seed input. The *L. flava* seed bank is much more persistent than the evidence available to Brooks *et al.* (2008b) suggested.

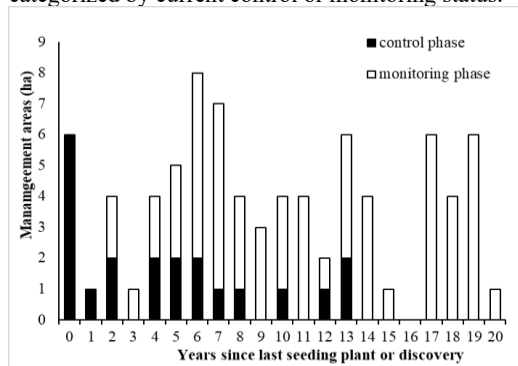
Figure 1. Years in monitoring phase of *Limnocharis flava* management areas (n=81), categorized by locus type.



Fifty-eight of 81 management areas are in 1 to 20 years of monitoring (Figure 1). There have been 42 monitoring to control phase relapse events recorded, and some management areas have relapsed 2 or 3 times. Most of these events (39 of 42) have been after 4 years or less in monitoring phase. The remaining 3 events occurred between 7 and 8.5 years, with two of these at a contained loci in central Cairns. Multiple eradication criteria, including an absence of 9 to 10

years will be developed to cover all field situations. Given the spread of management areas in Figure 1 and with 92% of relapses from 1 to 4 years of monitoring, the provisionally eradicated category could be the fifth or sixth year of the monitoring phase for *L. flava*.

Figure 2. Years since last reproduction or discovery of *Limnocharis flava* management areas (n=81), categorized by current control or monitoring status.



The information presented in Figure 2 is primarily driven by the discovery data, as plants are likely to have produced seed prior to discovery and the rate of reproductive relapses is low. There has never been a reproductive relapse recorded in a contained locus and the overall occurrence of reproductive relapses at unconfined loci is low (0, 1 or 2 events a year since 2003-2004). Many of these events involve the production of intact fruit which may not have spilt seed from the follicles (Weber and Brooks 2008). Throughout the year, monthly survey and control activities are preventing all but an occasional potential seed production event in known management areas. Whilst the seed is persistent, the ongoing recruitment at more active loci reflects seed production prior to discovery more-so than reproductive relapses.

As an example of possible eradication criteria, there are 17 management areas currently in 11+ years monitoring (Figure 1) which largely overlap with the 17 management areas with 16+ years since last reproduction or discovery (Figure 2). Where these data points overlap, all management areas form part of the same locus and if they have a consistent coverage of visits over time and space, then proposed eradication criteria could be met. Ultimately decisions about declaring loci eradicated are not seen as solely a combination of data points, but also involve local field manager input as to how confident they are to reduce the visit frequency to zero.

OPPORTUNITIES AND CHALLENGES

The net progression of management areas transitioning to a monitoring phase is outpacing the discovery of new areas, ensuring that progress towards eradication accrues gradually. The longevity of the soil seed bank and detection of all small loci and cultivated specimens are the main issues confronting the eradication program.

The overall progress towards the eradication of this serious tropical aquatic weed is prompting discussion about the application of program resources to areas with a continuous history of plant absence. Although management areas within loci show different stages of last reproduction and years in monitoring, the loci are small and discrete. These decisions will be informed by using a range of criteria including time since last mature plant, years in monitoring, status of neighbouring management areas and local field manager confidence as to the frequency, duration, and extent of loci management. Although, the field activities targeting *L. flava* consume approximately 4% of the total recorded field effort. So, a lower frequency of contained loci visits or declaring loci eradicated, will have a small impact on the NTWEP budget. Even with new discoveries, the Queensland-based resource use was approximately 120 field workdays a year over the last decade.

Continuing the theme of constant improvement (Jeffery and Brooks 2016), the NTWEP is encouraging photographic evidence of all reproductive plants and herbarium specimens from all new loci. The Program is also investigating the capacity to deliver quick DNA results for confirmation of identification in the cases where desiccated or juvenile specimens are found at new loci. The program may explore environmental DNA samples from adjacent water bodies, to assist with determining proof of freedom as an additional criterion to declaring eradication.

The NTWEP is addressing the challenge of detecting all *L. flava* plants being cultivated in Australia through a) the utilization of web scraping technology, b) encouraging the reporting of suspected plants through policy and legislation (illegal not to report), c) extension and education through targeted social media campaigns and compliance activities. The NTWEP recognizes increased risk apparent in the sourcing of *L. flava* online across state and potentially international borders, and the potential for cultivation within and beyond areas currently considered suitable habitat. Each jurisdiction should be aware of the trade of this plant as a vegetable amongst ethnic communities to avert further cultivation and potential naturalization events.

ACKNOWLEDGMENTS

We thank Christopher Collins, Louis Elliott and Nigel Weston from the Department of Environment, Parks and Water Security Northern Territory Government for additional site information in the Northern Territory. We are grateful to all Biosecurity Officers, and Local Government Pest Management Officers for undertaking inspections and the reporting of suspected *L. flava* loci.

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