Buoyancy and germination of pond apple (*Annona glabra* L.) propagules in fresh and salt water

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Summary Pond apple (*Annona glabra* L) is an aggressive woody weed which has invaded many wetlands, drainage lines and riparian systems across the Wet Tropics bioregion of Far North Queensland. Its threat is so great to these ecosystems that it has been listed as one of 20 Weeds of National Significance (WoNS).

The majority of fruit and seed produced by the plant during the summer wet season fall directly into creeks, river banks, flood plains and swamps. Creeks and rivers can channel the seeds into the ocean where they can spread along the coastline. Dispersal by water, or hydrochory of the whole fruit, portions of the fruit or the individual seed is an important vector that requires study.

This paper reports that pond apple seeds can remain afloat for up to 12 months in either fresh or salt water, with approximately 38% of these seeds germinating in a soil medium once removed from the water tanks.

Keywords Seed dispersal, ecology, Wet Tropics weeds, hydrochory.

INTRODUCTION

Pond apple (*Annona glabra* L.) is a small semi-deciduous exotic tree from North, Central and South America which has invaded freshwater swamplands, creek banks, seasonally flooded areas and the upper edges of mangrove swamps along the Queensland coastline, Swarbrick and Skarratt (1994). Pond apple is considered a serious threat to Australia and is listed as a Weed of National Significance (WoNS), Thorp and Lynch (2000). It was also the highest ranked weed species in a Wet Tropics bioregion weed risk assessment (Werren 2003).

Since its introduction into Australia in 1886, Sugars *et al.* (2006), pond apple has invaded thousands of hectares of wetlands, riparian ecosystems and man made landscape structures such as agricultural and domestic drainage systems. A number of control programs now exist throughout northern Queensland.

Dispersal of pond apple fruit or seed by both fresh and salt water appears to be a key vector in aiding pond apple spread. Pond apple seed longevity is less than three years in soil, Setter *et al.* (2004), but its longevity in water before it is 'beached' is unknown. This study investigated the length of time seeds can remain viable in either a fresh or salt water system. Information derived from this study can also be incorporated into water movement studies to help predict the fate of seeds in an aquatic environment.

MATERIALS AND METHODS

The experiment was a 2 × 2 × 13 factorial replicated six times in a split-split-plot design. Factor A was the two water types (fresh and salt water) assigned to the main plots, factor B was the two fruiting parts (seed and fruit) assigned to the subplots, and factor C was the 13 monthly time periods (including the control at zero months) assigned to the sub-subplots.

Twenty-four glass tanks (46 × 25 × 25 cm deep) were set up with aerators in a laboratory at the Centre for Wet Tropics Agriculture, South Johnstone (17°36'S, 145°59'E). Aerators were positioned in each tank to provide water currents that allowed the movement of seed and fruit within the tank.

Twelve tanks were filled with fresh water collected from the headwaters of Liverpool Creek (17°46'S, 145°58'E) and 12 were filled with saline water from the ocean at Mourilyn Harbour (17°35'S, 146°07'E). The placement of fresh and saline tanks within the laboratory was randomized.

Fruit for the experiment was collected from several locations around Innisfail (17°32'S, 146°03'E) on 23 January 2006. From this pooled fruit 60 fruits were randomly selected and seed extracted. The extracted seeds were pooled and 600 seeds were randomly removed and placed on the water surface in each seed tank. Seven fruit (each containing approximately 1015 seeds), were also randomly selected and placed on the surface of each fruit tank.

Water in each tank was replaced every 14 days to minimize any possible effects from the leachate (discoloration from fruit decay). Water quality parameters measured were pH, specific gravity, temperature and water colouration. Fruit breakdown over time was

also recorded in the fruit tanks to provide propagule data size for a water current dispersal model (not reported in this study). The tanks were monitored fortnightly for the first two months and then monthly for water parameters, seed position, fruit breakdown and germination.

Seed germinability was tested monthly by removing 50 seeds from each tank, sowing them directly into a tray of loamy soil and placing the tray into an incubator maintained at a constant 33°C with no light. The trays were watered to field capacity with distilled water and maintained at this level for the duration of the germination period. Germination was monitored for three months from the date of sowing. Seeds that had germinated between sampling times while floating in the water tanks were added to the total germination count at the next sampling time. Any seed which had not germinated within the three month period was collectively classed as either being dormant or dead. No accurate viability test is currently available for pond apple seeds.

RESULTS

Germinability ranged from 12 to 60% (average 38%) after 12 months afloat in either fresh or salt water irrespective of whether they initially entered the water system as isolated seeds or seeds within fruit. During the course of the experiment less than 1% of the seeds sank to the bottom of the tanks. A significantly ($P = 0.005$) higher number of pond apple seeds (irrespective of initial status) were found germinable in salt water (31.3%) compared to fresh water (24.4%). Germinability of seed in fruit (34.1%) was also found to be significantly higher ($P < 0.0005$) than seeds (21.4%) that had been introduced by themselves irrespective of water type. Seed germinability during the 12 months was significant ($P < 0.0005$) ranging from 0 to 88%, with germinations fluctuating on a month to month basis. A significant interaction ($P = 0.018$) was observed for water type by fruiting part by time (Figure 1.)

The pH of all water treatments fluctuated between 5 and 8 for the duration of the experiment. The salinity in the saltwater and freshwater tanks was 30 parts per thousand and 0 ppt, respectively, with water temperatures ranging from 18 to 26°C (averaging 22.5°C) over the entire experimental period.

DISCUSSION

In aquatic systems, the two most important intrinsic factors influencing the spread of fruit and seed and plant establishment are the length of time seeds remain viable and the length of time they remain floating, Edwards *et al*. (1994). The findings from this study indicate that pond apple seed and fruit can remain afloat for greater than 12 months in water with germinability fluctuating monthly (28 ± 30%). Germinability was

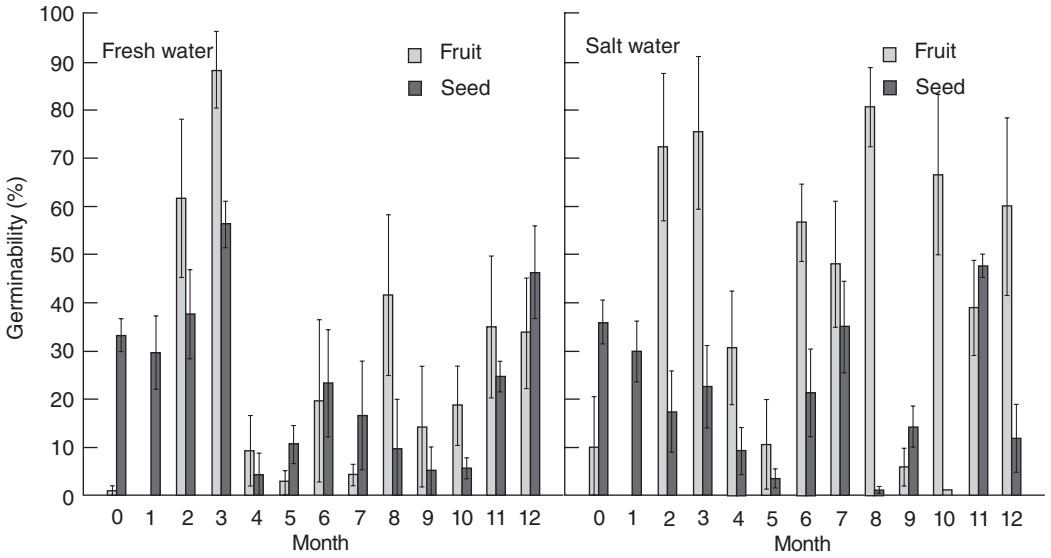

Figure 1. Germinability of pond apple seeds following floatation (fruit and seed) in either fresh or salt water over time. (Error bars indicate one SE from the mean.)

greater in seeds that had been in saltwater (31.3%) than those in freshwater (24.4%), however all of the seeds which had germinated in the fresh water tanks were capable of surviving for up to one month in the water medium. No seeds germinated while still floating in the saltwater medium. Intact fruit disintegrated within two weeks in the water tanks with the majority (99%) of the shed seeds remaining afloat for greater than 12 months. Based on this study pond apple appears to be readily adapted to water dispersal therefore the establishment of plants along freshwater tributaries and coastlines will need to be targeted for control in order to reduce the spread of this species.

Pond apple seeds were able to remain floating and germinable after extensive periods in both fresh and salt water. Although the average germinability is less than 38% at 12 months there is still a significant amount of recruitment potential given the large amounts of seed produced by pond apple, up to 3.7 million seeds ha^{-1}.(Setter unpublished data 2007). The results of this study suggest that the removal of reproductive trees from areas adjacent to creeks and rivers will have an immediate impact on potential spread of pond apple by limiting seed input into flowing water bodies.

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