

DISPERSAL OF POND APPLE (*Annona glabra*) BY RODENTS, AGILE WALLABIES AND FLYING FOXES

S.D. Setter¹ and K.A. Patane

ABSTRACT

*Pond apple is primarily water-dispersed, but native and exotic animals are also potential dispersal agents. Previous studies confirmed cassowaries and feral pigs as vectors; this study investigated the dispersal role of other species, including rodents, wallabies and flying foxes. Infrared motion-detecting cameras recorded three native rodent species consuming seeds: giant white-tailed rats (*Uromys caudimaculatus*), cane field rats (*Rattus sordidus*) and pale field rats (*Rattus tunneyi*). All appeared to destructively consume large quantities of seeds without moving them from host plants. The cameras also recorded agile wallabies (*Macropus agilis*) consuming seeds. Intact seed was found in 66% of field dung samples; viability was confirmed by germination from dung. Dung containing seed was found up to 230 m from host plants, sometimes in areas where water dispersal was not possible. The dispersal role of these animals may be significant, given their wide northern Australian distribution. Flying foxes (*Pteropus conspicillatus*) were not recorded consuming pond apple seeds in this study; anecdotal evidence suggests they consume the flesh and carry fruit short distances from host plants. Other research shows that the seed is too big for this species to swallow and disperse via gut passage. Results showed that there are many different animal interactions with pond apple, some beneficial and some detrimental to its spread.*

Keywords: Pond apple, *Annona glabra*, animal dispersal, wallabies, flying foxes

INTRODUCTION

Pond apple (*Annona glabra* L.) is a highly invasive, small tree native to Central Americas. It is considered to be the weed of greatest concern to the Wet Tropics Bioregion and is a declared Class 2 Weed under the Land Protection (Stock Route and Land Management) Act 2002. Pond apple is listed as one of Australia's 20 Weeds of National Significance.

Since its introduction in 1912, pond apple has invaded 2000 ha of Wet Tropics and there is a high risk of further spread in this region and other suitable environments along Australia's eastern and northern coastline. Pond apple thrives in a wide range of habitats,

¹ Biosecurity Queensland, Department of Employment, Economic Development and Innovation, PO Box 20 South Johnstone, Queensland, 4859, Australia
Corresponding author's email: stephen.setter@deedi.qld.gov.au

particularly tidal or seasonally inundated coastal ecosystems such as melaleuca wetlands and mangrove communities. Pond apple plants form dense monocultures that exclude undergrowth and prevent regeneration of over-storey species.

Pond apple produces large amounts of fruit during wet season, when flood events allow large-scale seed dispersal by water, both in fresh water and out to sea and then via ocean currents (Mason and Hardy, 2007; Setter *et al.*, 2008). The fruit is also attractive to animals, which readily consume the flesh and seed and act as vectors for dispersal. For example, studies by Setter *et al.* (2002) and Westcott *et al.*, (2008) found cassowaries and feral pigs were capable of consuming and dispersing viable pond apple seed. It is suspected that other vertebrate species commonly found in pond apple infestations, including rodents, flying foxes and wallabies, may also consume pond apple fruit and seed. It is expected that different species will impact the seed differently: some may destroy seeds, and different gut retention and excretion rates will affect how and where other seeds are deposited.

This study aims to discover which vertebrate species consume pond apple, the impacts of their respective consumption of the seed and subsequent effects on dispersal. Animal dispersal may be significant, particularly in situations where they can disperse seed into areas where it is unlikely to be moved by water. This has obvious implications for surveillance programs.

MATERIALS AND METHODS

This experiment was conducted in a high density pond apple infestation along the riparian zone of the Russell River near Babinda (17° 15' 57" S, 145° 56' 3" E) in Far North Queensland. The first component of this study involved recording which vertebrate species ate pond apple and, where possible, to determine their effects on the seeds.

Photographic Documentation (Identifying Species)

Four infrared motion sensing cameras were placed within the pond apple infestation to record animal interactions with fruit on the trees and fallen on the ground. The cameras were positioned to focus on pond apple tree trunks or the ground during 2007 fruiting season. Cameras were kept in the field for two months, with memory cards downloaded and batteries replaced on a weekly basis.

Cameras were set up again after the fruiting season had finished and most of the freely available fruit and seed had been removed naturally. This would provide a concentrated source of food for the camera to focus on and an increased chance of photographing the more discreet and small animals such as rodents and bats. To

prevent consumption by larger animals (such as cassowaries and pigs), fruit and seed were placed in mesh baskets in pond apple trees or in cages on the ground at the base of pond apple trees. Fruit that was used in the cages and baskets had been collected during the fruiting season and frozen. Seeds in the cages and baskets were also inspected to see what impact that these animals had. Cameras were kept in the field for two months, with memory cards downloaded and batteries replaced on a weekly basis. Additional fruit and seed were also placed out each week.

Field Collected Wallaby Dung – Seed Counts and Dispersal Distances

As wallabies were the only species observed to consume whole seeds, studies were conducted to understand the impact of consumption on the seeds for this species.

Dung was collected in a grassy transitional zone between a monoculture of pond apple and the mountainous ranges commonly associated World Heritage-listed tropical rainforest.

A collection of wallaby dung was taken on 14 February 2007 during the fruiting season. On this occasion a field search was conducted and any dung encountered was collected. An area of approximately 4.5 ha was searched and 50 dung samples were collected. Collections started close to the infestation and worked out from it until it was obvious that dung no longer contained pond apple seeds. This distance was recorded as the maximum dispersal distance. The 50 dung samples were returned to the laboratory, where each dung sample was broken apart and seeds were counted, removed and recorded.

Viability of Pond Apple Seeds in Dung

A second field search for wallaby dung was conducted in the above location during fruiting season of 2011. Twenty-five fresh dung samples were collected and transported to shade house facilities at Centre for Wet Tropics Agriculture near South Johnstone for germination and viability testing. To keep conditions as natural as possible, dung was not pulled apart to count seeds prior to germination testing. Dung samples were placed individually on the surface of a commercial loamy soil mixture in 220 mm pots. Pots were watered twice daily to field capacity and monitored weekly for germination over a period of 4 months. Seeds were considered germinated if the radicle extended at least 0.5 cm beyond the seed coat. After this time the pots were taken from the shade house to the lab, where the remaining dung was dissected and seed counts and viability tests were conducted on ungerminated seeds. Viability tests involved squeezing seed to see if there was any resistance to pressure – those that felt firm were considered as potentially viable.

RESULTS

Photographic Documentation

Species that were photographed by the motion sensing cameras were *Macropus agilis* (agile wallaby), *Uromys causimaculatus* (giant white-tailed rat), *Rattus sordidus* (cane field rat) and *Rattus tunneyi* (pale field rat). One species of macropod and three species of rodent were documented eating pond apple seeds. The rodents consumed large amounts of seed, and visual inspection of seed after rodent consumption showed all seeds to be destroyed, with embryos fatally damaged. Wallabies consumed seeds without visible ill-effects on the embryo, i.e. the seed found in wallaby dung was intact.

Flying foxes have often been anecdotally linked with pond apple infestations. We were unable to make any direct observations of flying fox-pond apple interactions using the cameras but the establishment of colonies within infestations has been observed.

Field Collected Wallaby Dung – Seed Counts and Dispersal Distances

Whole pond apple seeds were found in 66% of the wallaby dung sampled. The mean number of pond apple seeds per dung was 6 (range 0-42, n = 50). No dung containing pond apple seeds was found at greater than 230 m.

Viability of Pond Apple Seeds in Dung

Approximately 73% of seed in dung samples germinated over a period of four months. There was no notable difference between the germination, viability, or time to germination of the seeds in the wallaby dung when compared to unconsumed seed from other studies. For example, Setter *et al.* (2004) found 71% of seeds germinated after three months on the surface of the soil in pots in similar conditions.

DISCUSSION

How animals consume and potentially disperse pond apple seed is important information, as it assists in the management of this weed. Consumption by animals in this study had both negative and positive impacts on pond apple seed.

Rodents destructively consumed large quantities of seed by damaging the embryo. Rodents are commonly known to consume hard seeds by gnawing through them, as they are not capable of consuming them whole. Destructive consumption of seeds by rodents will reduce the number of seed entering the seed bank, but it is considered that this will have a minimal impact on the overall seed bank. It has been suggested that rodents may cache seed; we did not find any evidence in this regard. However, it is likely that if caching did occur, seed would not be taken very far from the parent tree.

Agile wallabies were able to consume and excrete viable seed, which should assist in dispersal of pond apple. Although only a

relatively short dispersal distance was observed in this experiment, macropods are recorded to have a mean gut retention time of 48 hours. Warner (1981) and Stirrat (2003) estimates that agile wallabies in Northern Territory have a maximum home range of 24.6 ha. This suggests that they could potentially transport viable seed considerably further than recorded in this study. It is possible that other species of wallaby may also consume and transport seeds, and given that wallabies are far more abundant than cassowaries and may be present in a wider range of habitats, they may play a role in pond apple dispersal across a larger range of pond apple sites (Setter *et al.*, 2008).

As the large size of pond apple seeds precludes the ability for flying foxes to swallow them any movement would occur locally. However, other means by which flying foxes could potentially spread seeds is by carrying off fruit in their mouths. They tend to do this with fruit that are large and often with fruit they have stolen from a tree that is patrolled by an already resident flying fox. The distance they would travel would be minimal as their intentions are to find the nearest tree to eat the fruit (Fox, S pers. Comm, 2007).

Dispersal of pond apple seed by any animal imposes the risk of moving it where water would not – such as upstream, uphill and possibly between catchments. For example, the wallaby that had dispersed seed furthest from infestation (230 m) in this observation had gone through two barbed wire fences, across a bitumen road and uphill into the rainforest margin. This unpredictability of dispersal direction and distance by animals directly impacts on search pattern and search area for detecting new infestations. One factor leading to a reduction in the effect of animal dispersal over water dispersal is that some animal dispersal will, by its more random nature, disperse seed to places unsuitable for germination and survival, while water dispersal will largely be moving seed to suitable pond apple habitat. Improved knowledge of plant-animal interactions will generally assist weed management by enabling improvements to management strategies and protocols.

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