

Pond apple – are the endangered cassowary and feral pig helping this weed to invade Queensland’s Wet Tropics?

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Summary Pond apple (*Annona glabra*) is a woody weed invading wetlands and associated ecosystems in north Queensland. Pond apple seeds are spread predominantly by water, however animals also disperse them. This paper describes the role of the cassowary (*Casuarius casuarius*) and feral pig (*Sus scrofa*) in pond apple dispersal. Field observation and collections confirmed that both species consume pond apple fruit in the wild, and pass viable seed. Captive feeding results suggest that cassowaries could distribute seed up to a 1200 m from the ingestion site, and feral pigs up to 10 km. Amounts of seed passed intact or damaged were quantified; germination tests are still in progress on intact seeds from droppings. Animal dispersal of pond apple has implications for environmental management, particularly, methods of finding and destroying pond apple, and subsequent management of treated areas.

Keywords Pond apple, *Annona glabra*, cassowary, *Casuarius casuarius*, feral pig, *Sus scrofa*, seed dispersal, ecology, Wet Tropics.

INTRODUCTION

The World Heritage listed Wet Tropics bioregion of north Queensland is dominated by rugged rainforest-clad mountains, with low-lying coastal plains to the east and extensive plateau areas to the west (Goosem *et al.* 1999). It is an area of ‘extraordinary richness in flora and vegetation’ (Werren 2001), and also home to some 566 native terrestrial vertebrate species, including the endangered southern cassowary (*Casuarius casuarius*), and 20 introduced terrestrial vertebrates, including the feral pig (*Sus scrofa*) (Werren 2001).

The cassowary is one of the Wet Tropics most iconic species; it is endangered, protected by legislation and the focus of community group conservation activities. In contrast, the feral pig is generally regarded as the major vertebrate pest of the Wet Tropics. It is declared a pest under state legislation and is actively controlled. Both species are anecdotally implicated as dispersers of the exotic woody weed, pond apple (*Annona glabra* L.).

Introduced from Tropical America and West Africa as a rootstock for other *Annona* species, pond apple

is one of the Wet Tropics’ most serious environmental weeds. It has the capacity to spread into intact communities without the assistance of human disturbance (Werren 2001), and can form dense monocultures. It ‘competes strongly in native wetland ecosystems, reducing biodiversity, ecosystem function and conservation values’ (Agriculture and Resource Management Council of Australia and New Zealand 2000).

Pond apple infests wetlands, riparian zones, coastal foreshores, and other natural and artificial drainages in the Wet Tropics, and north to the tip of Cape York Peninsula. Although widespread, it still has great potential for further expansion (Agriculture and Resource Management Council of Australia and New Zealand 2000).

Many land managers are working to control pond apple. Effective control requires an understanding of how it is spread, and where it is most likely to appear. Knowledge of dispersal mechanisms is particularly important given that the plant has not yet reached its full distribution potential in Australia. This research intends to improve this understanding and verify the extent of pond apple dispersal by both feral pigs and cassowaries.

MATERIALS AND METHODS

Pond apple species description Pond apple is a small to medium tree (15 m) that can be multi-stemmed, and is sometimes buttressed at the roots. Fruit are similar in size and shape to small mangoes, and production generally peaks towards the end of the wet season (January–March). Each fruit contains 100 to 200 seeds. Both the seeds and fruits float, facilitating their dispersal by water. Fruits are also aromatic, brightly-coloured (yellow/orange) and palatable, characteristics likely to facilitate dispersal by frugivorous animals and birds. (observations by M.S.)

Cassowary species description The cassowary is a large flightless bird, up to 2 m tall and weighing 84 kg (observation by D.W). Cassowaries are frugivorous, but will also eat invertebrates and fungi (Marchant and Higgins 1990). They are known to consume and

disperse the seeds of approximately 230 plant species in the Wet Tropics rainforests (Westcott and Bradford in prep.) and are believed to be important dispersers for many large-seeded rainforest plants (Marchant and Higgins 1990).

Feral pig species description Feral pigs in the Wet Tropics range in weight from 30 to 150 kg (observations by J.M.). They are opportunistic omnivores, but essentially vegetarian, with seasonal fruits comprising a substantial part of their diet (observations by B.D., Pavlov and Edwards 1992).

Field observations and collections Field sites of substantial populations of both pond apple and the target disperser species were selected. Cassowary sites were near Innisfail, and feral pig sites were in the Daintree area, all in the Wet Tropics. Field dung samples from both species were collected, and the number of intact and damaged pond apple seeds was recorded. Germination tests on intact seed are in progress.

Captive feeding of cassowaries Two captive adult cassowaries were fed pond apple on two occasions. The birds were hand-fed fruit for a 15-minute period. The mid-point of the feeding period was designated as time zero. For the rest of the experiment, the cassowaries were fed other fruits. Each subsequent dropping was collected, and defecation time noted, until two consecutive droppings recorded no seed. Numbers of intact and damaged seed in each dropping were counted. Germination tests are in progress on intact seeds.

Captive feeding of feral pigs Captive feral pigs (ranging in size from 25–45 kg) were fed pond apple on three occasions. Four pigs were fed a single whole fruit, and four were fed 140 naked seeds (the average number of seeds contained in a single fruit). Pigs were also fed a daily supplement (0.5–1 kg) of commercial pig food pellets. The fruit/seeds were left in the feed trays for 24 h, after which any uneaten portion or spillage was removed and counted. Droppings were collected daily. Numbers of intact and damaged seed in each day's dung was counted. Germination tests are in progress on intact seeds.

RESULTS

Field observations Two cassowaries were observed at the field site, during two collections and on two additional trips. One cassowary was observed swallowing a whole pond apple fruit. No feral pigs were observed but signs of recent pig activity were found at three sites where dung was found containing pond

apple seed. All references made hereafter to seed or seeds refer to pond apple seeds only.

Field collection of cassowary droppings Cassowary droppings containing seeds were found at three field sites. At one site, 13 droppings were collected, and all contained some seeds. The average number of seeds per dung sample was 199 ± 66 , range 3–842. Only one damaged seed was found from more than 2500 seeds collected. Germination tests results are pending, however indications are that most of the seed is viable.

Field collection of feral pig droppings Forty-six feral pig droppings were collected from three field sites. Twenty-four of these contained seeds. Most of the samples containing seeds were found in one 50×50 m area, along a well-used pig pad, within 100 m of mature pond apple trees. The total number of seeds found was 738, average number of seeds per dung sample was 15 ± 7 , ranging from 0–288 ($n = 46$). Less than 10% of seeds found in the droppings were damaged. Germination test results are pending however seedlings were found in several of the droppings.

Captive feeding of cassowaries Cassowaries retained seed in their digestive system for up to 28 h, most passed within 2–5 h of ingestion. No damaged seed was found from over 1000 seeds retrieved.

Captive feeding of feral pigs Feeding pigs whole fruit or naked seed did not significantly alter gut retention times. The majority of seed was passed within three days of ingestion; some were retained for up to eight days. The pigs that were fed naked seed ingested an average of 20% of the seeds presented to them. Approximately 48% of seeds found in the droppings of pigs fed naked seeds were damaged, compared to 23% in the droppings of pigs fed whole fruit.

DISCUSSION

Field collections of dung containing seeds verified that both cassowaries and feral pigs consume pond apple and pass viable seed in the wild. The geographic spread of collection sites indicates fruit consumption is widespread in wild populations.

Captive feeding of cassowaries allowed quantification of gut retention times of pond apple seeds. By combining this data with cassowary movement data (Westcott and Bradford in prep.), it is estimated the majority of seeds (passed within 2–5 h of ingestion) are deposited within 350 m of the ingestion site. The maximum gut retention time of 28 h equates to a dispersal distance of approximately 1200 m from the

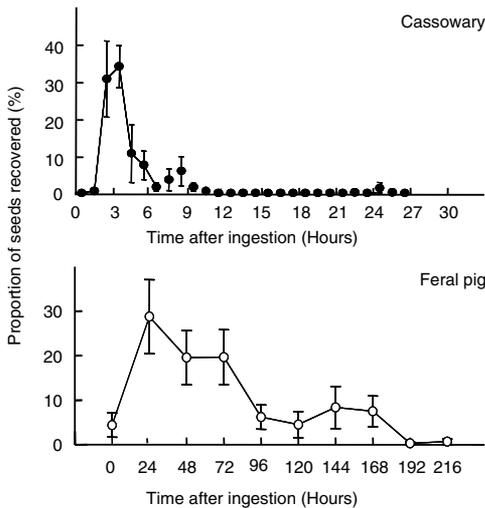


Figure 1. Gut retention time of pond apple seeds in cassowaries and feral pigs fed in captivity. Vertical bars represent standard errors of the mean (note different scales on x axes).

ingestion location. The cassowary is known to have a gentle digestive system (Stocker and Irvine 1983), which explains why less than 0.1% of seed recovered from the droppings of wild and captive birds was physically damaged.

Recent research by Mitchell (in prep.) shows that feral pigs generally stay within a defined home range that varies in size depending on seasonal conditions. The average home range size for a pig in the wet tropics is 5.5 km². The majority of ingested seed, passed within three days, could be deposited anywhere within this area. The overlap of home ranges coupled with nomadic movements of some adult boars means that feral pigs have the potential to spread pond apple seeds considerable distances compared to cassowaries, possibly up to 10 km or more. The small fraction of seed remaining in the gut for up to eight days is more likely to be transported a longer distance from the source, but germination test results (pending) are needed to see if seed is still viable after this period of time in the gut.

Feral pigs target certain seasonal food sources, and will often totally exhaust a supply before moving on (observation by B.D.). The most significant movement of seeds by pigs is therefore likely towards the end of the fruiting cycle, when pigs seek new food sources, carrying the last of the season's seeds in their guts.

Considerable variation occurred in the number of damaged seeds found in feral pig droppings collected from the field (less than 10%), from the captive pigs fed naked seeds (48%) and captive pigs fed whole fruit

(23%). Variation in captive feeding and field results could be due to a number of reasons, e.g. different feeding behaviour in wild and captive animals, different mastication processes for whole fruit and naked seed, varying hunger levels, or age differences. The variation noted suggests that captive feeding (particularly of naked seeds) of feral pigs may not be indicative of field seed predation, and that caution is needed when drawing conclusions about seed fate from this type of experiment

Ecological implications Both cassowaries and feral pigs may assist pond apple's dispersal in two ways. Firstly, these animals start new infestations by dispersing seeds considerable distances into uninfested areas. Significantly, this could be upstream, or between catchments, providing pond apple with a dispersal service that would otherwise be unavailable. Secondly, they accelerate the increase in density and gradual spread of an existing infestation – by moving it short distances away from parent trees. Feral pigs help pond apple to proliferate in areas where it already exists, by destroying existing vegetation and creating an ideal microhabitat for germination through soil disturbance. Cassowaries and feral pigs assist germination by providing warm, moist conditions and fertiliser through the dung surrounding the passed seeds. In droppings with many seeds, there may be an elevated level of competition between the seedlings. Results of the germination tests on passed seed (in progress) will indicate whether gut passage affects germination times and percentages.

In captivity, feral pigs ate less fruit per animal per day, and passed a smaller percentage of intact seed than did cassowaries. However pigs are more widespread in the Wet Tropics, and frequent a larger range of ecosystem types, so they may spread pond apple into new areas more readily than cassowaries. Feral pigs have a more diverse habitat range than cassowaries so are less likely to be affected by replacement of native habitat with pond apple communities.

Management implications The information from this study should be combined with other knowledge, such as information on water currents, locations of existing infestations, and habitat preference to determine areas of high-risk. The information could also be used to determine if 'buffer zones' can be used in pond apple control, and how big these need to be. For example, as the main seed spread north along Queensland's east coast is considered to be through ocean currents, it might be logical to start a control program at the southern-most end of the infestation and work north. The results of this research may allow

us to work out how much 'backflow' of reinfestation could occur through animal dispersal, and factor this into control programs.

The situation of an endangered species, the cassowary, helping to spread a noxious weed poses a complex management problem. Some members of the community perceive pond apple as an important cassowary food. The characteristics and abundance of the fruit do make them a favoured item in the cassowary diet. However, the benefits hide some disadvantages. While pond apple provides a plentiful resource, it forms single species dominated stands at the cost of a diverse native flora. Natural diversity provides a number of benefits over pond apple. First, a diverse diet is more likely to be nutritionally complete than one dominated by a single food. Second, a diverse flora is better buffered against bad seasons as a greater range of environmental tolerances are represented. Thus cassowaries feeding in a diverse vegetation type are less likely to face a starvation year than they are in a monospecific dominated stand. Third, pond apple fruits in the season of greatest food abundance but provides nothing for the rest of the year. More diverse vegetation communities are less seasonal in fruit production, with some fruit present at all times. Without a nutritionally complete, seasonally and annually reliable resource base, viable cassowary populations cannot be maintained.

However, due to the restricted and fragmented nature of cassowary habitat in coastal areas of the Wet Tropics, complete pond apple removal may be (at least temporarily) detrimental to some cassowary populations. Control programs should include revegetation with appropriate cassowary food plants, and perhaps staggering of control efforts over time. Community education is needed to ensure awareness of the threat that pond apple poses to the biodiversity of the Wet Tropics, to discourage retention of pond apple as a cassowary food source, and to publicise efforts made to ensure minimisation of any detrimental effects to cassowaries through pond apple control programs. The role of the feral pig in pond apple dispersal is less likely to cause controversy than the cassowary – the community is less likely to be concerned about feral pigs losing a food source than cassowaries. Feral pigs involvement in pond apple dispersal may provide further incentive for their control.

In summary, pigs and cassowaries can and do disperse pond apple, augmenting its chief dispersal method of water. Most significantly, they can disperse it into areas where water would not carry it. Although pond apple is a food source for the endangered cassowary, its retention for this purpose is not advocated due to long-term environmental degradation. We cannot control cassowary movement, and despite the

efforts of control programs in many areas, pigs are still potentially important dispersers. Therefore the role of both species in dispersal must be taken into consideration when managing pond apple, particularly in regard to how we locate and control infestations, and what follow-up management regimes are used after control.

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