Murraya paniculata: what is the potential for this popular ornamental plant to become an environmental weed?

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Summary Murraya (*Murraya paniculata* cv. *exotica* (L.) Jack) is a popular hedge plant available from commercial nurseries in Australia. It produces fleshy, orange-red fruits from late winter to late spring. Concerns have been raised that recent large-scale plantings have increased the likelihood that murraya will become a bird-dispersed environmental weed in subtropical eastern Australia. We investigated these concerns by studying its seedling recruitment requirements, the role of birds in seed dispersal and the establishment of murraya in riparian rainforest corridors. In Brisbane, figbirds (*Sphecotheres viridis* Vieillot) fed on murraya fruits from June to November. Consumption peaked in August and September when murraya formed 12–14% of the non-*Ficus* proportion of their diet. Figbirds were effective dispersers of murraya with seed germinability rates after gut passage of 75%. These did not differ significantly from rates obtained for seeds from intact or manually depulped fruits. Germination under irrigated conditions was consistently high (70–80%), but varied under natural rainfall conditions from 60–70% for buried (1.5 cm) seed to 10–15% for surface-sown seed. Seedbank persistence was low, with <0.001% seed germinability at six months for seeds under a range of environmental conditions. Murraya plants were present in low densities (mean = 0.043 plants m^{-2}) in all suburban rainforest sites surveyed. Most were seedlings but mature plants (up to 170 cm in height) were also present.

This study demonstrates that murraya is effectively dispersed by birds around Brisbane and can recruit under environmental conditions typically found in this region. Therefore, we recommend that the nursery industry promote native hedging plants local to the area as an environmentally sound alternative for home gardeners.

Keywords Bird dispersal, frugivory, germination, gut passage, invasive species, seedling establishment.

INTRODUCTION

Murraya (*Murraya paniculata* cv. *exotica* (L.) Jack, Rutaceae) (also known as orange jessamine or mock orange) is a popular garden hedge plant currently available at commercial nurseries in Australia. Murraya shrubs grow to 3 m in height (Dodson and Gentry 1978) and produce orange-red fleshy fruits from late winter to late spring (and at other times after rain). Murraya, native to Southeast Asia (Dodson and Gentry 1978), is listed as a Category II invasive species in Florida (FLEPPC 2005) and has been identified as a potential bird-dispersed environmental weed in the Pacific Islands (PIER 2005) and subtropical eastern Australia (Groves *et al.* 2005). However, to date no research has been published on its invasive potential.

The aim of this study was to assess the invasive potential of murraya in southeast Queensland by investigating: i) germination rates and seed dormancy under a range of environmental conditions; ii) the importance of murraya fruit in the diet of a common native frugivore; and iii) the extent to which murraya has established in rainforest remnants in suburban Brisbane.

MATERIALS AND METHODS

Seed collection Seed was collected from plants at three Brisbane sites (Corinda, Seventeen Mile Rocks and Graceville) on September 18, 2003 and four sites (Corinda, Seventeen Mile Rocks, Graceville and Sherwood) on August 13, 2004. All seed studies commenced as soon as possible (<2 weeks) after collection.

Effect of photoperiod on germination Germination response to light environment was tested in growth cabinets, using a 12 h alternating temperature regime of 15/25°C. Ten replicates per treatment were used to test the effects of (1) a 12 h photoperiod and (2) continuous darkness. Each replicate consisted of a Petri dish containing ten manually depulped seeds placed on moistened filter paper. This study was initiated on September 3, 2004 with germination monitored fortnightly thereafter for ten weeks. Distilled water was added to Petri dishes daily to keep filter papers moist. Seed were classified as germinated once a radicle >3 mm in length was produced.

Effect of moisture conditions and burial on germination and seed bank longevity A completely randomised two-way factorial experiment investigated emergence responses to planting treatments (surface-sown and buried at 1.5 cm) at two levels of moisture availability (field rainfall conditions and non-limiting irrigated conditions in a polythene tunnel). Given that rainfall and resulting soil moisture conditions can vary widely between years this study was repeated over two consecutive years.

Seeds were manually depulped, bulked, and sown in 12 cm pots containing commercial potting mix (30 seeds per pot). Nylon mesh was buried 1 cm below seeds to allow later recovery of ungerminated seeds. Each of the four treatment combinations (field × buried, field × surface, tunnel × buried and tunnel × surface) was replicated 12 times in 2005. In 2004 each 'field' treatment was replicated 24 times and each 'tunnel' treatment 18 times. Pots in the field were placed in the soil under wooden lattices covered with 50% shade cloth to simulate under-canopy microsite conditions. Pots in the tunnel were placed on benches and irrigated twice daily. Emerging seedlings were recorded and removed fortnightly for a year.

After six months, six replicates of each of the four treatments were used to assess germinability of seeds remaining in the soil. The remaining seeds were removed and those that were visibly decayed were counted and discarded. Any remaining seed were subjected to the germination test described above, with germination recorded weekly for eight weeks. In order to assess seedbank persistence after one year, this procedure was repeated for a further six replicates of each treatment at 12 months after initial planting in 2005.

Fruit consumption by figbirds Faecal material was collected from beneath a figbird roost in Sherwood Forest Park, Brisbane. Prior to collection a 1 × 3 m section of road was swept beneath three roost trees. Between two and five days later, faecal material was collected from swept areas. This was repeated monthly from October 2003 to February 2005. Seeds from samples were identified and counted. Fig (*Ficus* spp.) seeds were not counted, as we were unable to identify these to species or convert seed number to a fruit number estimate. The number of seeds and other identifiable fruit material in the samples were used to estimate the number of fruit consumed, using prior measures of seed number per fruit (Gosper *et al.* 2006).

Effect of gut passage on germination Owing to limited seed availability, this study was completed in two stages, the first initiated on September 3, 2004 and the second on October 16, 2004. Both datasets were combined prior to analysis. The number of replicates varied between the four treatments. Treatments were:

i) Figbird gut passage: These seeds were collected from faecal material under the figbird roost and had part or all of the pulp removed (17 replicates);
ii) Whole fruit: Whole fruits were collected from plants (sites described above); seed numbers were determined by lightly squeezing fruit. Only fruits containing one seed were used (12 replicates);
iii) Dropped fruit: Whole fruit with pulp attached were collected from under roosts, presumably dropped by figbirds. Seed numbers were determined by lightly squeezing fruit, and fruit were sown whole (ten replicates); and
iv) Manually depulped: Seeds from fruit collected from plants (sites described above) were depulped by hand (12 replicates).

Seeds were placed in commercial potting mix in 12 cm pots at a rate of 12 seeds per pot (each pot being a replicate) and kept in an irrigated polythene tunnel. Emerging seedlings were recorded and removed fortnightly for 28 weeks (no emergence was recorded in the final 6 weeks).

Establishment in riparian corridors Plant density was measured in four suburban riparian rainforest corridor sites in Brisbane: Enoggera Creek, The Gap; West Ithaca Creek, Bardon; Bulimba Creek, MacGregor; and Cabbage Tree Creek, Arana Hills. At each site, the number and height of murraya plants within randomly located 2 × 2 m quadrats were recorded. The number of quadrats varied between sites, depending on patch configuration: West Ithaca Creek and Bulimba Creek each had 30 quadrats, Cabbage Tree Creek had 16 and Enoggera Creek had 40.

Data analysis Germination data were not normally distributed, so non-parametric tests (Mann Whitney U and Kruskal-Wallis tests) were used for analyses, which were performed using Systat v. 11.0.

RESULTS

Effect of photoperiod on germination There was no significant difference in mean germination (79.50 ± 3.03) between seeds exposed to a 12 h photoperiod and those that received continuous darkness (U' = 56.50, df = 1, P = 0.61).

Effect of moisture conditions and burial on germination and seed bank longevity Germination varied significantly between treatments in both years (Kruskal-Wallis test; H = 62.69, df = 3, P <0.01, and H = 24.84, df = 3, P <0.01 for 2004 and 2005 respectively). The field × surface seeds exhibited significantly lower germination than other treatments in both years (Figure 1). In 2005 germination was similar between field × buried, tunnel × surface and tunnel × buried treatments, but in 2004 field × buried seeds showed significantly lower germination than either of the tunnel treatments.

The low number of intact seeds retrieved after six months in both years, meant statistical analyses could not be performed. From a total of 1440 seeds initially sown (both years and all treatments pooled), 368 (26%) were recovered from the soil after a six-month period. Only 19 of these were intact, the remainder having decayed. Of the 19 intact seeds, only a single seed (<0.001% of the initial seeds planted) proved to be germinable. In the 12 month longevity study, none of the 23 intact seeds retrieved after 12 months were germinable.

Fruit consumption by figbirds The figbird population sampled in this study fed on murraya fruits from June to November. Consumption peaked in August and September when murraya formed 12–14% of the non-*Ficus* proportion of their diet (Figure 2).

Effect of gut passage on germination Germinability varied with fruit treatment (Kruskal-Wallis test; H = 8.17, df = 3, P = 0.04), with significantly lower mean germination for dropped seed (61.67 ± 4.51%) than for seed that had undergone gut passage (75.00 ± 4.85) (Kruskal-Wallis test; H = 40.50, df = 1, P = 0.02) and for manually depulped seed (78.06 ± 2.47) (Kruskal-Wallis test: H = 42.00, df = 1, P <0.01). Mean germination of seeds from intact fruit (74.86 ± 4.72) did not differ significantly from that of seeds from depulped fruit and seeds following gut passage (Kruskal-Wallis test; H = 0.01, df = 2, P = 0.10).

Establishment in riparian corridors Murraya plants were recorded in low densities at each of the four sites. Plants ranged in height from 4 to 170 cm, with the majority belonging to the smaller (<80 cm) height classes (Figure 3). Mean density was 0.04 ± 0.14 individuals m^{-2}.

DISCUSSION

This study provides evidence that murraya has no specific light requirements for germination and exhibits considerable germination of buried seeds in simulated natural field conditions (>60%), as well as for seed germinated in controlled irrigated conditions (>70%). The slightly higher germination recorded in 2005 for field × buried seed might be due to the higher rainfall recorded within the first two months of this trial compared with rainfall in 2004 (664 mm and 109 mm respectively).

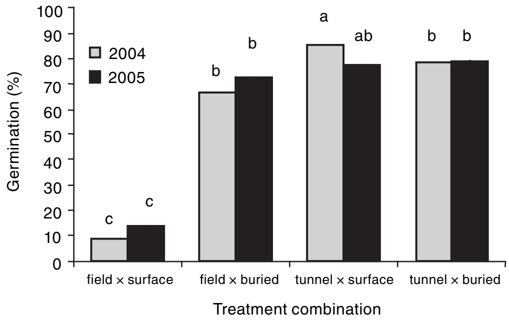

Figure 1. Mean percent germination for *Murraya paniculata* seeds for four treatment combinations. Columns surmounted by the same letter are not significantly different (P >0.05).

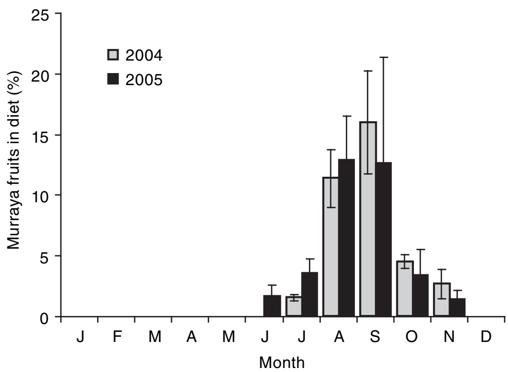

Figure 2. The percent of *Murraya paniculata* fruits in the non-*Ficus* spp. component of the diet of figbirds at Sherwood, Brisbane. Each column is the mean of three samples (standard error bars shown).

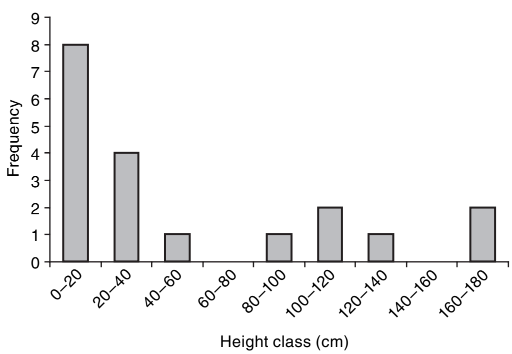

Figure 3. Frequency of *Murraya paniculata* plants of different height classes established in four Brisbane riparian rainforest corridors.

Surface-sown seed under natural rainfall conditions exhibited significantly lower germination than buried seed, presumably due to desiccation. High levels of predation are unlikely since most seeds that failed to germinate were later retrieved in a decayed state from the soil. This suggests that murraya might benefit from a moderate level of soil disturbance promoting incorporation of the seeds into the soil profile.

Owing to murraya's high germinability and low persistence in the seedbank, *in situ* seedbanks in natural areas are likely to be transient. Continual input of seed either from external sources or reproductive plants within a patch will be necessary for the expansion of the population in a bushland area. Short-lived seed is a trait that has been demonstrated in several major bird-dispersed weed species in southeast Queensland (e.g. Panetta 2001, Gosper *et al.* 2006). This is a potential weakness in the lifecycle that could be exploited if control is required.

From August to October, murraya fruit formed an important part of the diet of the figbird population sampled and germination of seed after gut passage was high. Despite the slightly lower germination recorded for seeds from dropped fruit, considerable germination from these was also observed.

Although the frugivores sampled deposited seeds to an area largely unsuitable for seedling establishment, our field surveys confirm that murraya is also being dispersed to bushland sites. Plants have established in rainforest corridors and growth to maturity under the rainforest canopy is possible. The low and variable density of plants recorded may represent the early stages of an invasion and do not necessarily reflect the long-term invasive potential of this species. Since this study was conducted outside of the reproductive season, no flowers or fruit were recorded. However, given the ability of plants as small as 0.5 m in height to reproduce in a heavily shaded garden environment (E. White pers. obs.), it is likely that the larger plants recorded at our sites are capable of reproducing. The presence of reproductive plants in rainforest patches may result in accelerated rates of recruitment due to seedfall around the parent plant in addition to bird-dispersal.

Given the proximity of many suburban rainforest patches to gardens containing murraya, the ability of local frugivores to disperse the seed, and murraya's potential to germinate under a range of conditions, further establishment of murraya in rainforest sites is likely as long as it remains a popular garden plant. A cutting-grown variety of murraya, described by the nursery industry as 'non-fruiting' is commercially available (M. Gleeson pers. comm.). Controlled studies are required to verify sterility of the variety. Until then, we recommend the use of local native hedging plants and promotion of these environmentally sound alternatives by the nursery industry.

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REFERENCES

Dodson, C.G. and Gentry, A.H. (1978). Flora of the Rio Palenque Science Centre. *Selbyana* 4, 1-623.

FLEPPC (Florida Exotic Pest Plant Council) (2005). List of Florida's invasive species. Florida Exotic Pest Plant Council. Available from: http://www.fleppc.org/list/05list.htm. Accessed 7 March 2006.

Gosper, C.R., Vivian-Smith, G. and Hoad, K. (2006). Reproductive ecology of invasive *Ochna serrulata* (Ochnaceae) in south-eastern Queensland. *Australian Journal of Botany* 54, 43-52.

Groves, R.H., Boden, R. and Lonsdale, W.M. (2005). 'Jumping the garden fence. Invasive garden plants in Australia and their environmental and agricultural impacts'. (WWF Australia, Sydney).

Hoppes, W.G. (1988). Seedfall patterns of several species of bird-dispersed plants in an Illinois woodland. *Ecology* 69, 320-29.

Panetta, F.D. (2001). Seedling emergence and seed longevity of the tree weeds *Celtis sinensis* and *Cinnamomum camphora. Weed Research* 41, 83-95.

PIER (Pacific Island Ecosystems at Risk) (2005). Plant threats to Pacific ecosystems. USDA Forestry Service. Available from: http://www.hear.org/pier/index.html. Accessed 7 March 2006.