Fruiting season and seed germination of coastal vine forest species from East Point Recreational Reserve, Northern Territory, Australia

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Abstract

Fires, storms, cyclones and human activities impact coastal vine forest communities around Darwin. To restore these communities after such disturbance, information on the fruiting season and seed germination of native species is important for collecting and propagating their seeds. We studied the seasonal occurrence of fruiting and the requirements for seed germination of 19 coastal vine forest species in Darwin's East Point Recreational Reserve. Fruiting and seeding were seasonal, nine species set fruit during the Wet season and 10 species set fruit during the Dry season. Seed fall lagged by two or three months behind fruiting. Thirteen of the species did not have any seed dormancy and five species were treated to break dormancy. With the application of the most effective germination treatment, two species started to germinate within two days, and all except two species commenced germinating within 14 days. Maximum germination of all species had occurred within 30 days. Because dispersal of mature seeds of most species occurs over only one or two months each year, fire impacts prior to dispersal could disrupt seed availability for at least one year.

Introduction

Coastal vine forest is a dry rainforest community established on a seasonally dry substrate with evergreen, deciduous and semi-deciduous species (Russell-Smith 1991). It is a unique community which supports a wide range of wildlife and native flora. Coastal vine forest in the Northern Territory is prone to disturbance, including cyclones and urban development. As it experiences an extended drought during the Dry season, it may also be impacted by fire.

One such iconic coastal vine forest community is at East Point Recreational Reserve in Darwin. This remnant forest was severely affected by disturbances prior to 1975 and has required active restoration (Franklin *et al*. 2010). One successful approach to restoring seasonally dry tropical rainforest such as this is to introduce a range of overstory and understory species to restore ecological function and structure (Blakesley *et al*. 2002). Native species are introduced by either direct seeding or by planting their seedlings in revegetation trials (Doust *et al.* 2006). These species then promote the recruitment of additional floral diversity over time.

Knowledge of the fruiting season, seed germination and seed dormancy are important to collect seeds, propagate seedlings, and for nursery planning for revegetation activities (Baskin & Baskin 2014; Thusithana *et al.* 2018). A Wet-Dry seasonal climate results in fluctuations in rainforest fruiting and seed maturation (Cortés-Flores *et al.* 2019). Dry fruits, which have a woody and drier pericarp with small, low-water-content seeds are produced in the Dry season. By contrast, in the Wet season, fleshy fruits are produced. They have a higher moisture content as well as nutritive and fleshy pericarps to attract birds and mammals to disperse their seeds (Griz & Machado 2001; Vieira & Scariot 2006). Fruiting phenology and seed fall periods for dry rainforest coastal vine forest species are crucial because fruiting/seed fall is strongly seasonal, can occur infrequently, and its timing can vary between dry rainforest patches (Bach 2002). Therefore, site specific monitoring is crucial to record the exact fruiting season of species for seed collection.

Other factors affecting propagation of rainforest species from seeds include seed maturity, seed germination and dormancy. There are few studies for coastal rainforest species in Australia and most such information is from Queensland. Seed maturity is when the seed or fruit disconnects from the parental plant. At this stage, the seed has gained maximum dry weight, vigour and potential to germinate (Baskin & Baskin 2014). At immature stages, the seeds may fail to germinate, or lack vigour, or may be more prone to disease (Hay & Smith 2003). It is vital to collect mature (ripe) seeds for germination or to store them for future use (Baskin & Baskin 2014). Therefore, it is essential for the collector to determine when the seed is mature and to time the harvest accordingly (Schmidt 2000). Seed maturation is also seasonal. Dry fruits have seeds that generally mature in the late Dry season to be dispersed by air, gravity or ballistic explosion (Griz & Marchado 2001). Greater wind circulation occurs in the open canopy during the Dry season and this favours long distance dispersal of seeds by wind (Griz & Marchado 2001). For seeds that are dispersed by ballistic methods, the Dry season air dehydrates the pericarp causing the fruit to eject the seeds into the air (Griz & Marchado 2001). In contrast, most fleshy fruited seeds mature during the Wet season. Such seeds have higher moisture; therefore, they time their maturation during the Wet season to germinate soon after detachment from the parental plant.

For a seed to germinate, it must be viable, non-dormant and exposed to optimum environmental conditions such as light, moisture, temperature and oxygen (Baskin & Baskin 2014). Seed viability is the potential for a seed to germinate under those suitable environmental conditions. Many dry seasonal rainforest species lose viability due to desiccation during the Dry season drought (Khurana & Singh 2001). Viability is also affected by pre-dispersal predation of fruit, which causes physical damage to the seeds and affects the seed fill (Tiansawat *et al.* 2017). Viable seeds that fail to germinate in the presence of suitable moisture, temperature and light conditions are considered to be dormant (Baskin & Baskin 2014). Baskin & Baskin (2014) consider a seed lot is dormant if 50% or more of the viable seeds take more than one month to germinate. In a seasonally dry rainforest, a greater proportion of species produces dormant seeds when compared to an evergreen rainforest; Baskin & Baskin (2014) report that 66% of the 221 dry seasonal rainforest species have dormant seeds.

Dormancy is primarily found in species which disperse seeds in the Dry season. This prevents germination during the infrequent early Dry season rains, which are unfavourable for seedling establishment and survival (Khurana & Singh 2001). Seed coat dormancy and embryo dormancy are the two main types of dormancy possessed by rainforest species (Baskin & Baskin 2005). Seed coat dormancy may be due to an impermeable seed coat preventing water uptake or inhibitors present in the seed coat or fruit. Such seeds require either mechanical scarification, or hot water treatment, or chemical treatment to make the coat permeable. Embryo-related dormancy is due to the presence of inhibiting factors such as low levels of growth-promoting hormones in the embryo. This can be overcome by external application of gibberellic acid. Treating seeds to break dormancy leads to faster production time in the nursery, lowers nursery costs and gives greater control over seedling planting times. Information on the most suitable dormancy-breaking mechanisms for these coastal vine forest species are published in Thusithana *et al.* (2018), including the effects of individual dormancy-breaking treatments on cumulative germination and the days taken for the seeds to achieve the maximum germination after dormancy-breaking treatments are applied.

In this study, we investigated when fruiting and seed release occur in the coastal vine forest species present in the vine forest patch at East Point Recreational Reserve in Darwin. We also, for the first time, give an overall summary of germination characteristics of non-dormant seeds and of dormant seeds that have been treated with the best dormancy-breaking treatment, including the number of days until seeds started to germinate, and the number of days until germination ceased.

Materials and methods

Study site

The study site was the coastal vine forest at East Point Recreational Reserve, approximately 6 km north of Darwin, Northern Territory. This reserve is situated on a peninsula that is dominated by monsoonal coastal vine forest. The topography is a flat, lateritic plateau to a maximum altitude of 11.2 m above sea level, which is well-drained, but there is no permanent natural water (Franklin *et al.* 2010).

East Point Recreational Reserve was subjected to several anthropogenic activities and natural events which caused extensive vegetation clearance from 1932–1963 (Franklin *et al.* 2010). Revegetation of the area was started by the Northern Territory Government in 1974, then Darwin City Council took over the management of forest rehabilitation in 1984. Currently, the Reserve supports 14 ha of remnant forest and differently aged patches of rehabilitated forest, dating from 1964–1970, 1974, 1985–1991, 1992–2002 and 2003–2016. The history of the site is described in Franklin *et al.* (2010).

Fruiting phenology and morphology

Twelve plots, each 20 m by 10 m in size, were established in the coastal vine forest in the East Point Recreational Reserve in May 2015. Flowering and fruiting phenology of 19 species (Table 1) were assessed by monthly visits to the plots from May 2015 to April 2017. The months were categorised into seasons such as early Wet, late Wet, early Dry and late Dry based on the rainfall pattern as described in Thusithana (2020). Fruiting patterns were related to these seasons.

Table 1. Ecological attributes and the fruit type of the study species.

Common name and species name	Family	Pioneer/climax, life form and stratum	Fruit type	No. seeds per fruit
Pioneer species				
Crab Eye Vine *Abrus precatorius*	Fabaceae	Pioneer Vine	Follicle	10–14
Red Ash *Alphitonia excelsa*	Rhamnaceae	Pioneer Canopy tree	Drupe	4–5
Gambrion *Breynia cernua*	Phyllanthaceae	Pioneer Midstory shrub	Berry	5–6
Kapok Tree *Bombax ceiba*	Malvaceae	Pioneer Canopy tree	Capsule	>40
Broad-winged Hop Bush *Dodonaea platyptera*	Sapindaceae	Pioneer Midstory shrub	Capsule	1
Coral Tree *Erythrina variegata*	Fabaceae	Pioneer Midstory shrub	Follicle	1–2
Cluster Fig *Ficus racemosa*	Moraceae	Pioneer Canopy tree	Syconium	>100
Lime Berry *Micromelum minutum*	Rutaceae	Pioneer Understory shrub	Berry	1
Cheese Fruit *Morinda citrifolia*	Rubiaceae	Pioneer Midstory tree	Composite fruit	>40
Opilia amentacea	Opiliacae	Pioneer Vine	Berry	1
Strychnine Tree *Strychnos lucida*	Loganiaceae	Pioneer Canopy/midstory tree	Berry	2–4
Peanut Tree *Sterculia quadrifida*	Sterculiaceae	Pioneer Canopy tree	Follicle	5–6
Dediteh *Wrightia pubescens*	Apocynaceae	Pioneer Midstory shrub	Follicle	>100
Climax species				
Archer Cherry *Aidia racemosa*	Rubiaceae	Climax Canopy tree	Berry	3–5
Ebony *Diospyros calycantha*	Ebenaceae	Climax Canopy /midstory tree	Berry	5–7
Australian Ebony *Diospyros compacta*	Ebenaceae	Climax Canopy/midstory tree	Berry	4–6
Ebony *Diospyros rugosula*	Ebenaceae	Climax Midstory shrub	Berry	4–6
Yellow Tulipwood *Drypetes deplanchei*	Putranjivaceae	Climax Canopy/midstory tree	Drupe	1
Pink-fruited Berry *Glycosmis trifoliata*	Rutaceae	Climax Shrub	Berry	1

Mature seeds/fruits of 19 native species were collected from at least 10 adult individuals per species randomly (Figures 1, 2) in May 2015. Fruit type and number of seeds per fruit were noted for each species. Seeds were collected when the fruits had reached dispersal maturity (Table 2). Dispersal maturity of the seeds was initially identified when fallen fruits were found around the maternal plants. Firmness of the fruit and colour of the pericarp were assessed. With maturity, the firmness of the fruit reduces with accumulation of more loosened pulp or dry mesocarp. The colour of the pericarp of many species turns from green to grey green, or brown, or into other bright colours when ripe (Schmidt 2007). Fruits were cut into halves to check the colour of the seed coat. With maturity, the colour of the seed coat typically turns from hyaline to brown and black. The seeds of dehiscent fruits were collected when the valves, scales and the margin of the pericarp started to break off.

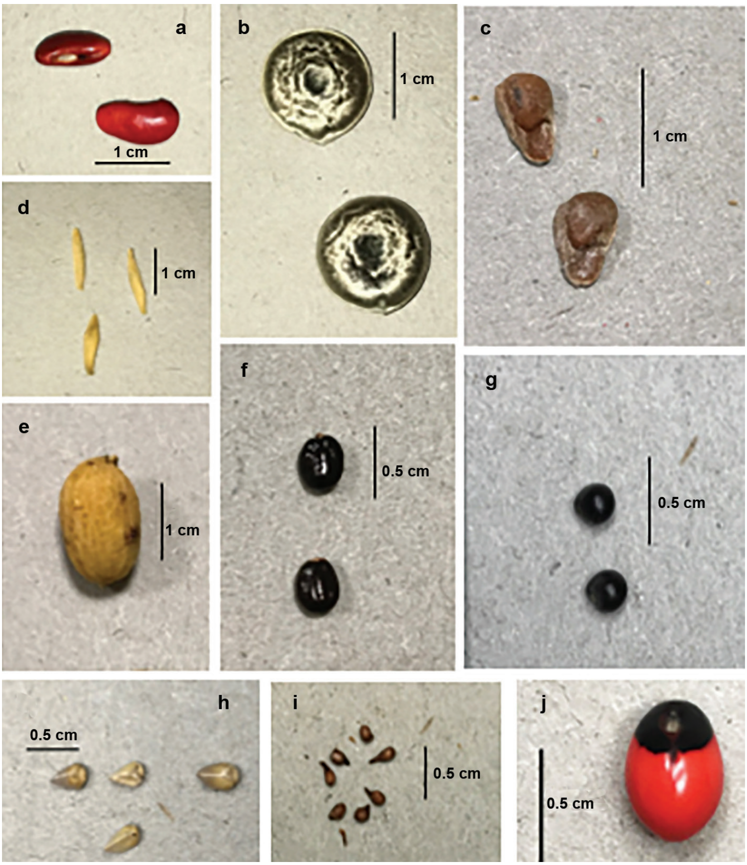

Figure 1. Seeds of pioneer species. **a.** *Erythrina variegata,* **b.** *Strychnos lucida*, **c.** *Morinda citrifolia*, **d.** *Wrightia pubescens*, **e.** *Opilia amentacea*. **f.** *Alphitonia excelsa*, **g.** *Dodonaea platyptera*, **h.** *Breynia cernua*, **i.** *Ficus racemosa*, **j.** *Abrus precatorius*.

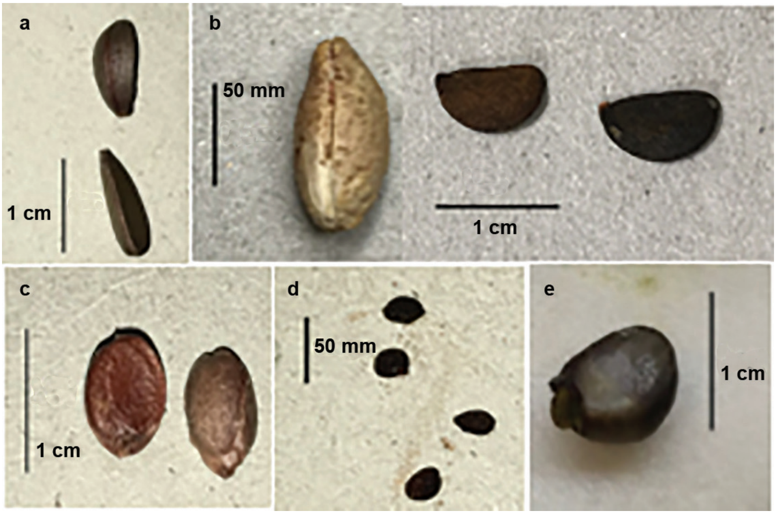

Figure 2. Seeds of climax species. **a.** *Diospyros calycantha,* **b.** *Drypetes deplanchei* (left)*, Diospyros rugosula* (right)*,* **c.** *Diospyros compacta,* **d.** *Aidia racemosa,* **e.** *Glycosmis trifoliata.*

During seed collection, either branches of small trees and shrubs were cut with secateurs or the fruits were hand-picked. For species that released seeds quickly, paper bags were tied around the branchlets before the branchlets were pruned. Seeds collected from different trees were bulked together for each species. Viability, germination, imbibition and the effectiveness of dormancy-breaking treatments were assessed within a week after seed collection (Thusithana *et al.* 2018).

Seed germination and seed dormancy

Germination assessments were carried out for four replicates of 25 seeds per species. Seeds were germinated on moist filter paper in 9 cm diameter Petri-dishes in an incubator maintained at 30 °C, as this temperature is the average Wet season temperature recorded in the habitat. The number of days to initial germination and to maximum germination, following the most effective seed dormancy treatment (Thusithana *et al.* 2018), were recorded. The mean number of days for untreated seeds to germinate (including untreated dormant seeds) is included for comparison from Thusithana *et al.* (2018).

Viability test

Three samples each with 25 seeds were subjected to the cut test. Seeds with milky, unfirm, mouldy, decayed, shrivelled or rancid-smelling embryos and seeds with a missing embryo were scored as inviable. Seeds with a white/green firm embryo were scored as viable.

Results

Fruiting was seasonal and varied between species and between years (Table 2). For a particular species, fruit production occurred either in the Dry or in the Wet season, but never both. Nine species fruited in the Wet season and 10 fruited in the Dry season. For most of the Dry season fruiting species, fruiting peaked between August to October (late Dry season) and the species fruiting in the Wet season peaked during December to February (early Wet season). Most species only dispersed mature seeds within a single month but *Micromelum minutum* dispersed its seeds over a four month period. Fruit fall lagged by one to two months after the fruits were first observed on the tree. The exceptions were *Strychnos lucida* and *Wrightia pubescens*, for which fruit fall occurred five to six months after the fruits were first observed on the tree.

Table 2. Fruiting and fruit fall phenology of study species (May–July: early Dry; August – October: late Dry; November–January: early Wet: February–April: late Wet). Open symbols indicate fruits were observed on the tree and solid symbols indicate mature fruit; dispersing in Year 1 (May 2015–April 2016) (△■) and Year 2 (May 2016–April 2017) (■□).

Species	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**January**	**February**	**March**	**April**
Pioneer species												
Abrus precatorius				△□	△■	▲						
Alphitonia excelsa				□	△▲■	▲■						
Bombax ceiba			△	△□	▲■							
Breynia cernua									△	△□	▲■	
Dodonaea platyptera		△□	△□	▲■								
Erythrina variegata				△	△□	▲■						
Ficus racemosa								△□	△□	▲■		
Micromelum minutum				△□	△□	△□	▲■	▲■	▲■	▲■		
Morinda citrifolia									△□	△□	▲■	
Opilia amentacea								△□	▲■	■		
Sterculia quadrifida				△□	△□	▲■						
Strychnos lucida	□	△□	△□	△□	▲■	▲■	■				△□	△
Wrightia pubescens	□	△□	△□	▲■	▲■	▲■					△□	△
Climax species												
Aidia racemosa								△	△□	△□	▲■	▲
Diospyros calycantha			△□	△□	▲□	▲■						
Diospyros compacta								△	▲■	▲■		
Diospyros rugosula	□	■	■	■						□	△□	△
Drypetes deplanchei								△□	▲■	▲■		
Glycosmis trifoliata						△□	▲■	■				

Species which set fruit in the Wet season commonly had a fleshy pericarp (berry type). Dry season fruiting species had fruits that were drupes, follicles or capsules (Table 1). The berry was the most common fruit type recorded among the 19 species. Six species had a single-seeded fruit while *Ficus racemosa*, *Wrightia pubescens* and *Morinda citrifolia* had more than 100 seeds per fruit. The number of seeds per fruit found in the remaining species varied between 5 and 25 (Table 2).

All of the studied species had 100% seed fill except for *Micromelum minutum* and *Diospyros rugosula*, which had 96% and 97% viability, respectively.

Table 3. Seed germination characteristics for coastal vine forest species following optimum germination and seed dormancy treatments identified in Thusithana *et al.* (2018). MGL, mean germination length of seeds to achieve the maximum germination % without any treatment for comparison to optimally treated seeds; G%, maximum cumulative germination % of non-treated and treated seeds; First G, days until first germination of non-treated and treated seeds; Max. G (days); days taken for seeds with optimal treatment to achieve the maximum cumulative germination %. ± is standard error mean. Viability (%): seeds that had a firm white embryo for cut test. HW = hot water; GA_3 = gibberellic acid. Max. G % information for all species, and MGL data, are from Thusithana *et al.* (2018).

Species name	MGL (days)	Viability (%)	Optimum treatment	G (%)	First G (days)	Max. G (days)
Abrus precatorius	14 ± 3	100.0 ± 0.0	HW 95°C for 5 min.	100.0 ± 0.0	3	26
Alphitonia excelsa	>30	100.0 ± 0.0	HW 88–92°C for 5 min.	93.6 ± 4.1	4	19
Bombax ceiba	12 ± 2	100.0 ± 0.0	Nil	92.0 ± 3.4	2	18
Breynia cernua	15 ± 0	100.0 ± 0.0	Nil	85.6 ± 5.2	12	20
Dodonaea platyptera	>30	100.0 ± 0.0	HW 88–92°C for 1 min.	93.7 ± 3.9	6	20
Erythrina variegata	13 ± 1	100.0 ± 0.0	Nil	94.4 ± 2.7	7	22
Ficus racemosa	12 ± 1	100.0 ± 0.0	Nil	81.6 ± 5.3	11	15
Micromelum minutum	6 ± 0	96.0 ± 2.3	Nil	100.0 ± 0.0	3	10
Morinda citrifolia	>30	100.0 ± 0.0	Scarification + 1000ppm GA_3	56.8 ± 4.2	21	28
Opilia amentacea	9 ± 1	100.0 ± 0.0	Nil	70.4 ± 3.7	5	20
Sterculia quadrifida	7 ± 0	100.0 ± 0.0	Nil	96.0 ± 1.3	5	11
Strychnos lucida	17 ± 0	100.0 ± 0.0	Nil	99.2 ± 0.2	12	20
Wrightia pubescens	8 ± 1	100.0 ± 0.0	Nil	94.4 ± 2.0	2	14
Diospyros calycantha	14 ± 1	100.0 ± 0.0	Nil	96.8 ± 3.2	9	28
Diospyros compacta	10 ± 1	100.0 ± 0.0	Nil	96.0 ± 3.1	6	16
Diospyros rugosula	20 ± 1	97.3 ± 2.7	Nil	55.2 ± 6.4	17	29
Drypetes deplanchei	>30	100.0 ± 0.0	Scarification + 1000 ppm GA_3	79.2 ± 4.6	7	20
Glycosmis trifoliata	3 ± 0	100.0 ± 0.0	Nil	92.0 ± 2.3	4	4

Most species with non-dormant seeds had their seeds start to germinate within a week of incubation (Table 3). The exceptions were *Strychnos lucida*, *Breynia cernua* and *Diospyros rugosula*, which took 12–19 days for the first seed to germinate. Most species were not dormant, and all species completed germination within 29 days if treated appropriately.

Discussion

Fruiting phenology and fruit or seed collection

Fruiting of individual species was limited to a particular season and was often only for a short duration. Such seasonality in fruiting was also reported in the seasonally dry rainforest patch at Gunn Point, Shoal Bay, Northern Territory, by Bach (2002) and Franklin & Bach (2005). Similarly, in seasonally dry rainforest in Panama, Sautu *et al.* (2006) reported that seeds of 32, 29, and 33 species were dispersed during the Dry (January–March), early rainy (April–July), and late rainy (August–December) seasons, respectively. However, that study reported that most species fruited over more than two months, with some species fruiting for seven months, and one species for 11 months. In our study four of the six climax species dispersed seeds in the Wet season, whereas eight of the 13 pioneer species dispersed seeds in the Dry season. The pioneer tree species tended to disperse seeds at the end of the Dry season but the timing was variable for shrubs. As reported by Franklin and Bach (2005), although individual species had short intervals of seed and fruit dispersal, across all the species there was some seed dispersal in every month (except for May in our study).

Fires can have a substantial impact on fruit production, and a fire impacting a remnant forest is likely to affect fruits of some species no matter what time of the year it occurs. For each species there is a brief period each year when fruits are shed. This means that a fire impact would likely affect the availability of mature fruit for at least 12 months. While there are direct impacts on fruit if a fire occurs when they are maturing, early season fires can impact ovule success through affecting pollination and by damaging developing flowers, even if destruction of foliage and branches does not occur (Setterfield 1997).

Phenological data on fruiting and seed shed are important when planning for revegetation of disturbed dry rainforest communities. The phenological data can be used to produce monthly prognoses for species and help to plan seed collection, plan seedling stock production and evaluate the availability of seedlings before the revegetation trials. This will assist in ensuring that species are not absent from plantings due to lack of seeds.

Different types of fruit were observed in the study species. Dry season fruiting species produced follicles, pods and capsules, while the fruits of Wet season fruiting species were berries and drupes. Information on the type of fruit is crucial for efficiently collecting seeds. Species which bear capsules, pods, follicles and cones open or split on maturity, allowing the seeds to be shed by wind or gravity. The exact time of seed release is hard to predict. Bagging the seed heads with a breathable lightweight fabric (Murphy & Dalton 1996) will capture the seeds as soon as they are shed. One difficulty is that most local rainforest species are zoochorous (i.e. they have spores or seeds dispersed by animals) (Bach & Price 2005; Franklin & Bach 2006) and their fleshy and bright coloured fruits are likely to be eaten by birds, insects or other animals at the time of maturity. This results in physical damage to, and loss of, seeds while attached to the parental plant. Therefore, having nets around the branches before the fruits reach maturity assists in conserving fruits and viable seeds for collection.

Seed viability varies considerably between rainforest species and is commonly affected by pathogen attack/disease, predation, environmental variability, and by genetics (Khurana & Singh 2001). Seedling production is most efficient if seeds are of high viability as lower viability seed lots require collecting and sowing of more fruits and seeds to get sufficient seedlings. Seed viability can be assessed by determining the seed fill and by tetrazolium tests. Assessing seed fill is an important first indication of seed quality (Bellairs & Caswell 2016), and seed fill can be tested during the time of seed collection by pressing the seeds or cutting open the seed and checking for the presence of an embryo. If plants at a particular site have poor seed fill then the collection can be shifted to another site where seed fill is high. However, seeds can be filled with an intact embryo but not be viable. Tetrazolium testing detects whether filled seeds are metabolically active by staining living tissue red. As it requires at least two days, laboratory facilities and expertise, it is generally only carried out in commercial seed test laboratories. For these particular seed lots in this study, seed fill was greater than 96% (Thusithana *et al.* 2018), except for *Aidia racemosa*, which had 0% seed fill. Viability as assessed with tetrazolium and reported in Thusithana *et al.* (2018) was lower, but they found that most species had greater than 77% viability when assessed with tetrazolium, except *Diospyros rugosula* (52.0 ± 0.1%) and *Aidia racemosa* (0.0 ± 0.0%). Therefore testing seed fill by observation in the field would give a reasonable indication of the proportion of viable seeds for these species.

Seed treatment and germination

Some tropical seasonally dry rainforest species produce dormant seeds and Thusithana *et al.* (2018) determined that five of the species they studied had less than 10% germination if untreated, due to seed dormancy. The seeds of non-dormant species, and also of dormant species if the seeds were treated, commenced germination within two weeks (except *Morinda citrifolia*). Rapidly germinating seeds are more likely to escape seed death than slowly germinating seeds upon sowing because they escape seed predation by developing into saplings quickly (Kindt *et al.* 2006; Beckstead *et al.* 2007). We would agree with Farley *et al.* (2013) in not recommending the treatment of all dormant seeds, as retaining some dormant seeds gives a chance of success in the long term if adverse environmental conditions occur after the seeds are sown.

Most species in our trials did not require seed pre-treatment but if the five species with dormant seeds had the seeds treated, then germination was completed within 29 days. A hot water treatment improved the germination of *Abrus precatorius*, *Alphitonia excelsa* and *Dodonaea platyptera* (Thusithana *et al.*. 2018). Other studies also have shown that germination of *Alphitonia petrei* and of *Dodonaea petiolaris* was improved after hot water treatment (Turner *et al.* 2005, Turner *et al.* 2009, respectively). Seeds of *Abrus precatorius* have a thicker seed coat and require a higher temperature (95°C) to break dormancy. Two other species had dormant seeds that required treatment. *Morinda citrifolia* and *Drypetes deplanchei* had the seeds manually scarified and incubated in 1000 ppm gibberellic acid. Either mechanical scarification alone or together with gibberellic acid treatment is effective for *Drypetes deplanchei* and *Morinda citrifolia* but the combination of scarification with gibberellic acid gives highest germination (Thusithana *et al.* 2018). This is a typical response for species with physiological dormancy. Scarification abrades the seed coat, improving oxygen uptake into the seed, enhancing development of the embryo, and thus permitting the embryo to protrude from the seed coat (Côme & Tissaoui 1973). Although scarification improves the germination of seeds, it has drawbacks in large scale application. Intense tumbling of seeds within an abrasive medium can damage the embryo. Therefore, protocols need to balance sufficient scarification to promote germination without causing loss of seed viability due to damage. Application of gibberellic acid improves cell elongation in the embryo and enables the embryo to protrude from the seed coat (Baskin & Baskin 2014).

These species with dormant seeds that have germination promoted by hot water and scarification treatments, could also have germination enhanced by mild fires. Fire-stimulated species, such as Black Wattle (*Acacia auriculiformis*) and White Siris (*Albizia lebbeck*), are even more abundant in the standing vegetation and seed rain of revegetation patches at East Point than in the remnant forest (Thusithana 2020). Fire could stimulate germination of these species, increase their seedling recruitment and tend to cause divergence in the species composition from that of the remnant forest.

Conclusion

Introducing native dry rainforest species into suitable degraded habitat contributes considerably to local biodiversity and maintains the structural integrity of degraded/degrading patches. When small patches are impacted by fire, regional disturbance and urban development might limit natural dispersal of fruits and seeds. Therefore, seeds need to be actively sought to aid revegetation. However, a challenge for seed collection is that mature seeds are only dispersed during particular, often short, periods of the year. Current rehabilitation activities are often limited by seed availability. To maximise the likelihood of seed collection of a diverse range of species, it is necessary to understand the variation in fruiting phenology of the species and to be prepared to collect the seeds or fruits in the short window when they are available. To broaden the range of native species that are able to be introduced in the revegetation works, it is vital to understand their fruiting phenology, treat seeds appropriately, and be able to time germination to suit seedling propagation activities.

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