Natural propagation of orange buddleia (*Buddleja madagascariensis* Lamarck) in eastern Australia

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Summary The exotic ornamental scrambling bramble orange buddleia, *Buddleja madagascariensis*, forms dense impenetrable thickets in various forest types in eastern Australia. The plant is widespread throughout the world and weedy in many locations. In Australia it is found growing in patches in the national parks of the Border Ranges between Queensland and New South Wales where it is of great concern for the damage it might do to the rainforest where it grows. *B. madagascariensis* is sterile in Australia and no seeds have been seen on the plant despite extensive searches of plants in eastern Australia nor reported in the literature. It is therefore curious that the plant is able to establish and grow in the midst of national parks apparently distant from any source of infestation. This study investigates the hypothesis that *B. madagascariensis* can be spread by stem sections that may be carried by birds, water, or perhaps people, and that simply casting them upon the ground is sufficient to allow them to root and grow. Stems of *B. madagascariensis* were placed on the ground in rainforest under various circumstances and it was found that a small proportion of stems can root and grow under a wide range of conditions.

Keywords *Buddleja madagascariensis*, orange buddleia, vegetative propagation, ornamental weed, rainforest weeds.

INTRODUCTION

There has been little research conducted on the ecology of orange buddleia *Buddleja madagascariensis* Lamarck (Scrophulariales: Buddlejaceae) in Australia or worldwide. Of the other six naturalised *Buddleja* species in Australia (Conn 1992) only *Buddleja davidii* has received some ecological attention, but only in New Zealand (Smale 1990, Zhang *et al*. 1993). Most of the previous research that has been conducted on *B. madagascariensis* has investigated the phytochemical aspects of the species (Baveja and Singla 1969, Debray *et al.* 1971, Kapoor *et al.* 1981, Gupta *et al.* 1982, Emam *et al.* 1997).

The species is considered a potentially invasive introduced plant in south-east Queensland and northern New South Wales (Humphries *et al.* 1991). In Springbrook National Park, *B. madagascariensis* can be seen ascending trees and smothering forest canopy in otherwise undisturbed subtropical rainforest. Given that it can grow very quickly and apparently out-compete other major environmental weeds in this region, *B. madagascariensis* may well become a serious problem in future.

As fruit and seed of *B. madagascariensis* has not been reported in Australia (Leeuwenberg 1979) nor found in our extensive searches, it is most likely that this species spreads via vegetative propagation. It is important to know how and under what circumstances (such as light, soil conditions etc.) vegetative propagation could occur.

The main aim of the this experiment was to study how *B. madagascariensis* stems might survive and grow in conditions similar to those they would encounter if scattered thorough the forest. The experiment involved placing *B. madagascariensis* stem segments on the ground, above or below leaf litter in varying light conditions in Springbrook rainforest.

The comparison was made between which particular plant portion grows best, under what light conditions and under what litter cover conditions. To gain an idea of the generalisability of there results through the seasons, the experiments were set up once in early autumn (March) and again in late winter (July). Measurements consisted of scoring each stem on its survival. Stem segments were judged to have survived if they had both roots extending into the ground below the stem and green leaves on them. If a stem section had either, but not both, roots and green leaves, it was not scored as having survived.

MATERIALS AND METHODS

Location The field site was located in rainforest regrowth at Springbrook in the MacPherson Ranges of southeast Queensland. The region is characterised by a moist tropical climate (mean annual temperature ~ 16°C, annual rainfall ~ 2600 mm). Peak rainfall is in late summer and early autumn and occasional severe dry spells may occur in spring. Annual temperatures are mild; frosts are rare and temperatures above 30°C uncommon.

Study sites The three sites were located on a private property at Springbrook, which contains a relatively undisturbed natural rainforest community. The sites were located within five meters of each other and were therefore subjected to approximately equal amounts of moisture, rainfall and also temperatures.

The light conditions were determined using the Canopy Gap Fraction (CGF) technique (Zancola *et al.* 2000). The three sites chosen have canopy gap fractions of: (i) 7% for the High Shade site (under a low branch of a mature tree, itself under heavy canopy); (ii) 14% for the Medium Shade site (more or less 'normal' canopy in this area); and (iii) 20% for the Low Shade site (a recent treefall site).

The stem segments chosen were: (i) the Soft Wood section (the section consisting of the first thirty centimetres of the growing shoot), (ii) the Intermediate Wood section (the section consisting of the first three nodes past where the stem is no longer green); and (iii) the Hard Wood section (the section consisting of the first three nodes past where the stem diameter reaches one centimetre). The ground conditions chosen were: (i) light covering with leaf litter (enough to just cover the stems); and (ii) not covered with leaf litter (stem placed on top of the leaf litter present). The seasons chosen were: (i) early autumn (March in this region); and (ii) late winter (July).

The stem segments were all collected from a roadside stand located near the study area. In each season, for each of the three sites, 180 stem segments were collected. This consisted of 10 pieces of each of the stem segment types, for each of the three light conditions for each of the two cover conditions. Therefore, in each of the three sites 60 stem segments were placed.

Each field site was divided up into six sections of equal area. Ten segments of one stem segment type were placed in each section. On one side of the site, all stem segments were placed under the leaf litter while on the other side the segments were placed on top of the leaf litter. Where further leaf litter collected on top of the stems during this experiment, it was left in place.

As the experimental design comprising a multi-way cross-tabulation with four dimensions (season, shade, stem type and cover) and the dependent variable is a +/- survival variable, the data are appropriate for analysis by log-linear analysis. It might be expected that all stem types might grow in autumn but only one type in winter, or that all of them will survive under cover in winter but only one type in autumn and so various interactions between the variables would be expected. A log-linear analysis enables these interactions to be examined.

Analysis In general, models for log linear analysis are built up hierarchically (StatSoft 1995). First a model with no relationships between factors is fitted and if that model has poor fit to the data the calculated Chi-square statistic will be significant. A model with all two-way interactions is then fitted. In this case the model with all two-way interactions was found to fit the data (the Chi-square was not significant). All two-way interactions that were not statistically significant were then eliminated one-by-one. The final resulting model was the one that included the least number of interactions necessary to fit the observed table. The important interactions were between Shade and Survival and Wood and Survival.

RESULTS

Survival *Buddleja madagascariensis* can survive being cast on the ground in rainforest conditions in south-east Queensland. The total number of stems that survived is summarised in Table 1. Out of 360 stems cast 22 survived. This indicates that approximately one in twenty stems will survive. The stem segments rooted mainly from only one end of the cutting, but a couple of stems had two rooting points towards one end of the stem.

Factors influencing survival Under low shade (higher light) levels, *B. madagascariensis* stems will grow best, with 18 of the 22 surviving stems occurring in this group (Table 1). Fifteen percent of the stems cast in the low shade survived (18 out of 120).

Furthermore, hard wood sections of *B. madagascariensis* will grow better than softer wood sections, with 17 of the 22 surviving stems occurring in this group (Table 1). Fourteen percent of the stems cast in the low shade survived (17 out of 120).

According to the log linear analysis, the effects of wood type and shading were independent (that is, there was no interaction between wood and shading).

It can be concluded from the final analysis of the raw data that the major factors associated with the survival of stem segments were the level of light and the type of stem segment. Neither season nor leaf litter cover seemed to be related to survival.

Table 1. Two-way table for survival by wood type and shade level.

	Hard wood	Intermediate wood	Soft wood	Total
High shade	4	0	0	4
Medium shade	0	0	0	0
Low shade	13	4	1	18
Total	17	4	1	22

DISCUSSION AND CONCLUSION

Stems of *B. madagascariensis* are able to root and survive in rainforest conditions. The factors that influence the survival of stem segments are (i) which particular stem segment is cast and (ii) the level of light in the area the segment is cast.

Many perennial weeds in common with *B. madagascariensis*, have been shown to regrow and spread via vegetative propagation derived from fragments of various plant parts, including root sections, leaves and stems (Radosevich *et al.* 1997). Within field infestations, *B. madagascariensis* is often observed to grow vegetatively from stems that have been damaged and are in contact with the ground. When stems of *B. madagascariensis* are placed on or in soil, with leaves intact, the plants may establish roots and commence growing even before those leaves can die.

Although only a small fraction (approximately 6%) of stems can survive when cast into the rainforest, it may take only a single survivor to establish a new infestation or derail the regeneration of disturbed sites. One single stem cast into the rainforest that does survive has the potential to further spread depending on the environmental conditions where it has been cast.

No birds were observed during this study carrying portions of *B. madagascariensis*, so it is not known if they contribute to the spread of this plant through the rainforest. It is expected, however, that watercourses could transport *B. madagascariensis* portions. A few specimens were found on a fallen log/mossy rock on a riverbank in Purlingbrook National Park and there is a small stand (practically inaccessible) further upstream. It is suggested that these specimens arrived here by being carried downstream by the watercourse or being dropped here by a bird.

The natural/vegetative propagation trait has been shown to be common in weeds with a perennial life cycle, but not restricted to this group. According to Radosevich *et al.* (1997) it is most effective for weeds that grow in disturbed but relatively stable environments. Rainforest ecosystems can be generally classified as relatively stable environments that have the ability to resist establishment of many exotic species.

An unexpected result was to find that leaf litter cover had no influence on the ability of stem segments to survive. A previous study by Facelli and Pickett (1991) found leaf litter had no significant effect on the biomass of woody seedlings, although it delayed the emergence of some seedlings. Other studies have shown that litter accumulation can cause rapid changes in the forest floor microenvironment and affect both the establishment and succession of plant communities, due to the release of secondary metabolites, shading or mechanical impedance (Carson and Peterson 1990, Facelli and Pickett 1991). It would appear from this study that litter does not affect the vegetative growth ability of *B. madagascariensis*.

It had been expected that the season of placement of the stems would influence the prospect they would survive. Considering that most plants grow better in warmer months than cooler months and indeed horticultural propagation by cuttings is done under heated conditions, it would be expected that the vegetative growth of *B. madagascariensis* and its establishment would be higher in the warmer months. It is curious that there is no effect of time of year in this particular study and the reason for this remains unexplained.

The accessibility of the sites where *B. madagascariensis* grows restricts the control of this species by both chemical and physical methods. Chemical control for B. *madagascariensis* in the rainforest would have to be specific enough to target only *B. madagascariensis* and not damage the native vegetation. Physical control methods must take into account that this plant can reproduce vegetatively via growing from broken portions so all physically removed plant material will have to be carefully removed from rainforest to ensure a new infestation does not occur and that the old infestation does not regrow.

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