Rhamnus, rats and Rangitoto

A. Ian Popay[1], Trevor James[2] and Phil Brown[3]
[1] Department of Conservation, PO Box 112, Hamilton, New Zealand
[2] AgResearch, Ruakura Research Centre, Private Bag 3123, Hamilton, New Zealand
[3] Department of Conservation, Private Bag 68908, Newton Auckland, New Zealand

Summary *Rhamnus alaternus* L. (evergreen buckthorn or rhamnus) is a major threat to native vegetation on Rangitoto, an extinct volcanic island off the Auckland waterfront. Possums (*Trichosurus vulpecula*, Kerr, 1792) and wallabies (*Petrogale penicillata penicillata*, Gray, 1827) have been eradicated from the island, and eradication of rats (*Rattus* spp.) is being considered. This study was initiated to gain information that might help that decision and in the continuing control of rhamnus.

We measured the age of plants when they first bore fruit, the size of fruit and number and size of seeds in the fruit, and tested whether the seeds would pass unscathed through the digestive system of a Norway rat (*Rattus norvegicus*, Berkenhout, 1769).

The youngest plants to bear fruits were mostly three years old. The fruit were comparable in size to those found in Israel, but bigger than those in the Balearic Islands, although there is probably considerable variation in fruit size across the species natural range. Few rats ate a few seeds, but no entire seeds were found in the rats' faeces.

Keywords Invasive alien, eradication, fruit size, seed survival, evergreen buckthorn.

INTRODUCTION

Rhamnus alaternus is a small, fast-growing dioecious shrub or small tree able to establish under light canopy or in full sun, and capable of tolerating dry conditions. Its seeds are dispersed primarily by birds. Originally from the Mediterranean, the species was introduced to New Zealand presumably as a horticultural specimen, and became naturalised in the period 1900–1940 (Esler 1987). Esler (1987) described it as spreading slowly from low incidence in 1970. It now occurs in many places around Auckland and the Hauraki Gulf, especially in coastal areas, is common in parts of Hamilton, and occurs in scattered localities as far south as Canterbury in the South Island. Seen as a spreading threat to native bush, it has now been declared an unwanted organism and, as such, cannot legally be sold, propagated or displayed.

Rhamnus is of particular concern on Rangitoto Island in the Hauraki Gulf. This iconic island, clearly visible from the Auckland waterfront, is an extinct volcano that erupted about 600 years ago. It now supports 200 species of native plants, including 40 species of fern. Wotherspoon and Wotherspoon (2002) described the dominant tree canopy of the island as a hybrid swarm of *Metrosideros excelsa* (Sol. ex Gaertn., Pohutukawa) and *M. robusta* (A.Cunn., Northern rata) and also explained the determined efforts of early settlers to 'beautify' the island with exotic garden plants. The most serious threat to the native plant life is *R. alaternus*: other unwanted species are under sustained control. Possums and wallabies were also introduced to the Island but were declared eradicated in 2000. Their disappearance allowed some weed species to flourish. The island provides a home for rats (predominantly ship rats, *Rattus rattus*, Linnaeus, 1758 with possibly some Norway rats) and mice, *Mus musculus*, Linnaeus, 1758, (Miller and Miller 1995). Attempted eradication of the rat population is currently under consideration but anecdotal observations from other islands on which rats have been eradicated suggest that their eradication could allow rhamnus to proliferate.

We report here on observations on:

1. The age at which rhamnus first sets seed,
2. The size of New Zealand grown fruit,
3. The fate of seeds when fed to rats.

MATERIALS AND METHODS

Several observations were made on New Zealand-grown rhamnus. Our aim was to find out when plants first produce viable seed (important when planning control programs), collect information on fruit and seed size, and to examine some interactions between rats and rhamnus.

Age at first fruiting Plants of rhamnus growing on Rangitoto that had started producing fruit for the first time had transverse sections taken from their stems. Of these plants 13 had been growing in full sunlight, and 14 under the shade of other vegetation. Their ages were assessed by counts of annual rings by the Dendrology Laboratory at the University of Auckland.

Parameters of drupes and seeds Ripe fruits were collected from well-established bushes growing in a shelter belt on the Ruakura Research Centre,

Hamilton. Fresh drupes were measured and weighed, and the seeds extracted from each berry were counted, measured and weighed while fresh.

Feeding fruit to rats Our experimental aims were to:

- Establish whether rats eat rhamnus fruits and,
- If so, do they discard or ingest the seeds.
- Assess how passage through the digestive tract affects seed germination.

Each of ten individually caged Norway rats (five male and five female) were presented with 25 ripe, black drupes of rhamnus, still attached to plant branches, in each cage. These drupes had again been collected from the plants at the Ruakura Research Centre. Norway, and not ship, rats were used because the high level of biosecurity required for rhamnus fruit containment was only available in the confines of the small animal facility at Ruakura, in which only Norway rats are permitted.

Each rat had water but no food other than the rhamnus berries for first 36 hours, then food for next 60 hours. After 96 hours the rats were removed.

Wood-shavings containing faeces and dropped berries were removed from cages and separated. Berries were counted and the faeces moistened and passed through a 0.35 mm sieve to separate any intact seed. The germinability of any surviving seed was to have been tested.

RESULTS

Age at first fruiting Examination of the annual rings of the smallest rhamnus bushes that were flowering showed that those growing in the shade were slightly older on average than those growing in full sun, but the difference was not significant. Of the 27 bushes assessed, ages ranged between 2 and 7 years, with a mean of 3.81 ± 0.42 and a mode of three. Only visible annual rings were counted, so this may have given a slight underestimate of age.

Parameters of drupes and seeds Size and weight of drupes, number of seeds per drupe and seed weight are shown in Table 1.

Fruit and rats Most of the rats took no interest in the drupes. Only 14.4% (36 out of the total of 250) of the fruit presented were partly or wholly eaten, and only five of the rats touched the drupes.

Assuming three seeds to each drupe, about 80 seeds were eaten by the rats. No intact seeds were found in litter, nor in the rat faeces. Unfortunately seed fragments could not be distinguished from the grain fragments in the rats' regular diet.

DISCUSSION

Since rhamnus bushes seem capable of producing their first seeds when only three years old, control measures, especially if eradication or zero density is the aim, need to ensure that plants do not reach that age before being killed.

Table 2 shows the fruit size and seed content and size determined by other authors. There are few published measurements, and these results show considerable variation between Israel (Izhaki *et al*. 2002) and the Balearic Islands (Rodriguez-Perez *et al.* 2005).

Our fruit weight was closer to that recorded in Israel (Izhaki *et al*. 2002), and appreciably more than that in the Balearic Islands (Rodriguez-Perez *et al.* 2005). Other parameters of fruit and seed size were all larger than those of fruits from the Balearic Islands. There is almost certainly considerable variation in rhamnus morphology in different parts of its native environment, and New Zealand plants could have come from anywhere in the Mediterranean.

In its native habitat, rhamnus seed may be spread by birds, rodents, ants and lizards (Barnea *et al.* 1991, Gomez *et al.* 2003, Rodriguez-Perez *et al.* 2005). Passage of the seed through the gut of a blackbird (*Turdus merula* L.) or a bulbul (*Pycnonotus xanthopygos*, Ehrenberg 1833) enhanced subsequent germination of the seed (Barnea *et al.* 1991). Fromont (1995) showed that in New Zealand blackbirds and several other bird

Table 1. Size of fresh drupes and seeds.

Attribute	Mean ± SE	n
Individual drupe weight (mg)	222.74 ± 11.592	50
Individual seed weight (mg)	27.21 ± 1.555	100
Drupe length (mm)	8.80 ± 0.4500	10
Drupe diameter (mm)	7.03 ± 0.463	10
Seeds per drupe	2.66 ± 0.235	50
(mode)	3	

Table 2. Published data on fruit size, seeds per fruit, and seed weight.

Attribute	Published value (± SE)	n	Ref.
Mean fruit wt (mg)	238 ± 27.5	17	1
	129.2 ± 11.17	50	2
Mean seed wt (mg)	9.5 ± 0.32	50	2
Seeds per fruit	2.1 ± 0.029	50	2
Fruit length (mm)	6.3 ± 1.42	50	2
Fruit width (mm)	5.5 ± 0.17	50	2

References: 1) Izhaki *et al*. 2002, 2) Rodriguez-Perez *et al.* 2005.

species eat and distribute rhamnus seed. The possible role of rats in distributing rhamnus seed has not been explored before in New Zealand, although Williams *et al.* (2000) tested the ability of seeds of several species of plants with fleshy fruits to pass unharmed through a ship rats' digestive system. They concluded that ship rats could disperse seeds smaller than 1 mg: larger seeds were either discarded uneaten or eaten and failed to survive gut passage. On this count, rhamnus seeds are unlikely to be distributed by ship rats. In our experiment, Norway rats ate few seeds and passed no intact ones. This result goes some way to confirming Williams *et al*.'s (2000) conclusion.

Anecdotal evidence suggests that eradication of rats from islands leads to an increase in rhamnus. This suggests that rats are somehow keeping rhamnus in check by, perhaps, browsing on emerging seedlings, depleting its seed, or somehow affecting invertebrate populations that interact with the plant or its seed. Miller and Miller (1995) found that, on Rangitoto, plant matter was a minor constituent of the diet of both mice and ship rats. Campbell (1978) reviewed work on the effects of rats on vegetation and commented on complex interactions with herbivores, other bird predators and invertebrate populations. Season to season and year to year differences in the availability of food sources could also affect dietary preferences.

On Rangitoto, where an expanding population of rhamnus is competing with plants of *Metrosideros* spp., when rats browse on vegetation they are more likely to damage slow-growing *Metrosideros* spp. seedlings than the much faster-growing rhamnus seedlings: their eradication may thus enhance the relative performance of the native species. Rat and mouse exclusion cages are hard to set up on Rangitoto (K. Broome pers. comm.) because the lava surface has many fissures and tunnels. This makes direct prediction of the effect of rat eradication on the vegetation of the island very hard to achieve.

Other research currently under way is investigating the best control methods for rhamnus seedlings, larger trees and smaller bushes. The recruitment of rhamnus seedlings into the population is also being studied.

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