

## PROVENANCE VARIATION IN FUCHSIA (*FUCHSIA EXCORTICATA*) IN RELATION TO PALATABILITY TO POSSUMS

**Summary:** Fuchsia (*Fuchsia excorticata*) has been heavily browsed and often killed by brushtail possums (*Trichosurus vulpecula*) in many New Zealand indigenous forests, but remains healthy at some sites despite long histories of possum occupation. To determine whether fuchsia varied genetically in its palatability to possums, material from six widely dispersed stands (provenances) was propagated, and leaf chemistry, leaf morphology, growth rate, and palatability to captive possums was compared. Leaf specific gravity, nitrogen, and phosphorous levels in field-collected foliage varied between palatable and apparently unpalatable provenances of fuchsia. However, these variables, and palatability to captive possums, were similar in propagated material from all provenances. To test the hypothesis that selective browsing had eliminated the more palatable or susceptible genotypes at sites where possums have been present for long periods, we tested the relationship between variation within provenances of measured variables and length of possum occupation at each site, but no significant relationships were found. These results suggest that phenotypic or situational differences rather than genetic variation between the six provenances may help explain observed regional differences in fuchsia health.

**Keywords:** Fuchsia; palatability; brushtail possums; provenance variation; feeding trials; foliar macro nutrients; leaf morphology.

### Introduction

Selective browsing by the introduced brushtail possum (*Trichosurus vulpecula* Kerr) in New Zealand indigenous forests can defoliate and kill possum-preferred trees, resulting in changes in forest composition or even total canopy collapse (Cowan, 1990). Fuchsia (*Fuchsia excorticata*<sup>1</sup>) is one of the most adversely affected species, suffering heavy browse, dieback, or local extinction in many areas (Batcheler, 1983; Campbell, 1984, 1990; Green, 1984; Coleman, Green and Polson, 1985; Rose *et al.*, 1993; Pekelharing, Parkes and Barker, 1998). However, healthy stands of fuchsia persist in other places, including many areas with long histories of possum occupation. A notable example is an apparently unpalatable red-coloured form of fuchsia common in many eastern areas (Batcheler, 1983), particularly on Banks Peninsula. Healthy fuchsia also frequently persists in the presence of possums on farmland (Brockie, 1992), along roadsides through forest, and occasionally as isolated stands in deep forest (*pers. obs.*).

There are several hypotheses that might explain the differential persistence of fuchsia between areas with equally long histories of possum occupation: (i) some stands comprise genotypes that are genetically unpalatable to possums or browse tolerant (are robust enough to survive possum browse), (ii) some stands comprise phenotypes that, although genetically similar to fuchsia in other regions, are either unpalatable or browse tolerant as a result of local site factors, or (iii) fuchsia in some areas is relatively less palatable because of the presence of other more palatable substitute foods. If some fuchsia are genetically less palatable or more browse tolerant than others, managers of forest ecosystems might then expect that the impact of possums on this species would diminish over time as unpalatable or browse tolerant forms increase in abundance and distribution, assuming that these genotypes can disperse to and colonise new areas. A corollary of that is that managers might not need to spend scarce resources on possum control to save fuchsia from possum browsing. If apparent unpalatability at some sites is solely due to phenotypic responses to local site factors or to the mix of alternative foods available, then we would not expect unpalatable or browse tolerant fuchsia to become more widely distributed in the future.

<sup>1</sup>Nomenclature follows Allan (1961)

In this study we aimed to determine whether fuchsia from different areas did differ widely in palatability, and, further, whether there was any evidence of a genetic basis for that difference. We did this by comparing the palatability of leaves of material collected from six widely distributed stands (= provenances) of fuchsia, but grown under identical conditions.

In addition to comparing palatability directly (using feeding trials with captive possums), we compared morphological and physiological variables that could potentially affect or relate to palatability (foliar macro nutrient content and leaf specific gravity, a crude measure of fibre content). Growth rate of propagated material was also measured because it might be linked to palatability. Many plant species exhibit alternative resource allocation strategies, either tending to maximise growth rates or to minimise palatability by diverting metabolic resources from growth to the production of herbivore deterring plant secondary compounds (Byrant, Chapin and Klein, 1983; Byrant *et al.*, 1991). Variation in leaf size (surface area) was also examined to provide an additional variable that might identify genetic differences between the six fuchsia provenances. Finally, we also compared the variation in these morphological and physiological variables within provenances with the estimated length of possum occupation at each site, to investigate whether there is any evidence to support the hypothesis that selective browsing by possums had eliminated the more palatable genotypes at sites where they have been present for long periods.

### Provenance site descriptions and possum histories

Cuttings were collected from three stands of putatively non-palatable fuchsia in areas with long histories of possum occupation (Banks Peninsula, Pigeon Flat, and Whitcombe Valley), from two areas where possums were heavily browsing fuchsia (Pureora Forest Park and Karamea Bluff), and one from an area where possums have yet to become established but fuchsia is thought to be palatable to possums (Moeraki Valley; Fig. 1). Published data on liberations sites and dates (Pracy, 1974) was the main information used to assess the likely length of time possums had been present at or near each study site, but in some instances other published or unpublished data was used. We used whatever data were available to subjectively classify present possum densities as low ( $<5 \text{ ha}^{-1}$ ), medium ( $5\text{--}10 \text{ ha}^{-1}$ ), and high ( $>10 \text{ ha}^{-1}$ ). Where this classification was based on bait-take or trap-catch data we relied on an unpublished correlation between these

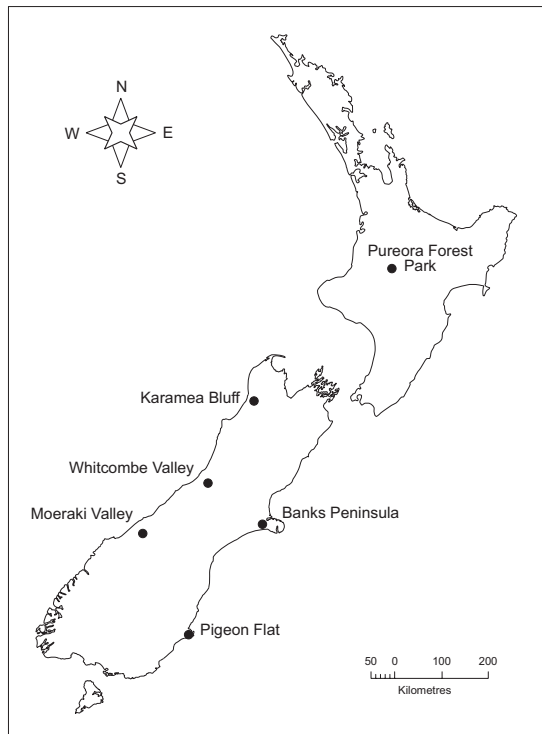


Figure 1: Locations at which fuchsia cuttings were collected.

parameters and possum density (B. Warburton, *unpubl. data*; Landcare Research, Lincoln)

### Banks Peninsula

Cuttings were collected at Ahuriri Summit Bush Reserve, on the Port Hills, Banks Peninsula ( $172^{\circ}37' \text{ E.}, 43^{\circ}40' \text{ S}, 450 \text{ m asl}$ ), which consists of *c.* 5 ha of mixed hardwood forest in which tree fuchsia is abundant (Burrows, 1994a, 1994b), and which is surrounded by exotic pasture. Soils are derived from a mixture of weathered tertiary basalt and loess (Suggate, 1973; Burrows, 1994b). Possums were liberated at Christchurch in 1865 (Cowan, 1990) and have, therefore, probably been present at Ahuriri for *c.* 100 years. Possum densities were low at the time of this study (15% trap-catch rate; *unpubl. data*) due to ongoing possum control by the Christchurch City Council. No possum browse was observed on fuchsia trees in this stand when cuttings were collected in January 1994, but some light possum browse was noted here, and in other stands on the Peninsula, in November 1995.

### **Pigeon Flat**

This site was a c. 13 ha patch of mixed hardwood forest, surrounded by exotic pasture, on pleistocene basalt (McKellar, 1975), c. 10 km north of Dunedin (45°, 48' S, 170°, 32' E; 250 m asl). Possums were liberated at Dunedin 100 years ago (Pracy, 1974), so we assume possums have been present at Pigeon Flat for c. 80 years. Possum densities were high (c. 16 ha<sup>-1</sup>; M. Efford, *pers. comm.*; Landcare Research, Dunedin) when fuchsia cuttings were collected in December 1993, but no possum browse on fuchsia trees was noted (K. Drew, *pers. comm.*; Landcare Research, Lincoln).

### **Whitcombe Valley**

Fuchsia trees are abundant in a small patch of seral forest surrounded by rata (*Metrosideros umbellata*)-kamahi (*Weinmannia racemosa*) forest near the head of the Whitcombe Valley in the central Southern Alps (43°, 10' S, 171° E; 600 m asl). There is considerable dieback (presumably possum induced) in rata, kamahi, and totara canopies in surrounding forest. Geology of the area comprises triassic to upper paleozoic greywacke (Warren, 1967). Possums were present at the study site 35 years ago (Cowan, 1990), and have probably been present for at least 60 years as they were liberated near the confluence of the Whitcombe and Hokitika Rivers, 15 km to the north of this study site, in 1905 (Pracy, 1974). At the time of sampling the fuchsia trees in January 1994, possum densities were high (30 possums killed from 60 cyanide bait nights), but possum browse on fuchsia was light (50% with no browse and 40% with less than 25% of foliage browsed).

### **Pureora Forest Park**

Small riparian stands of fuchsia are found at a few locations at c. 600 m asl along the Waitaia River, a tributary of the Waihaha River, in Pureora Forest Park, west of Lake Taupo in the central North Island (38°, 44' S, 175°, 36' E). Fuchsia was formerly more common in the area as evidenced by dead fuchsia found on the ground in many clearings in the surrounding podocarp-hardwood forest. Geology consists of quaternary ignimbrites (Grindley, 1960). Possums have been present in the area since at least 1960, as possum densities had peaked in the area by 1978 (Jane, 1979). Possum densities were low (21% trap-catch rate, *unpubl. data*), and when cuttings were collected in December 1993, all fuchsia trees were heavily browsed (more than 75% of foliage removed). However, when these stands were inspected again in March, 1994, all trees had fully recovered, and showed no evidence of current possum browse. This late summer-autumn reprieve from possum browse probably accounts for why

these clearly palatable fuchsia have survived at least 30 years of possum occupation.

### **Karamea Bluff**

Fuchsia occurs as individual trees and small stands in roadside seral vegetation, surrounded by mixed red beech (*Nothofagus fusca*)-silver beech (*N. menziesii*) forest, along State Highway 67 over the Karamea Bluff (41°, 30' S, 172°, 02' E, 400 m asl). Geology of the area is comprised of tertiary quartz sandstone and calcareous mudstone (Grindley, 1961). At the time of collection of cuttings (January 1994), possum densities were moderate (25% trap-catch, *unpubl. data*) and most fuchsia trees were heavily browsed by possums. Although there was little dieback of these trees when they were first visited, some had died and many had extensive dieback when they were revisited in November 1994. Possums were liberated at Karamea Bluff in 1926 (Pracy, 1974) and so have probably been present at this site for about 60 years.

### **Moeraki Valley**

Fuchsia is abundant on disturbed sites within silver beech forest throughout the upper Moeraki Valley in South Westland (43°, 50' S, 169°, 26' E; 400 m asl). Material was collected from stands growing on slip and debris fans derived from paleozoic schist (Mutch and McKellar, 1964). Possum densities are close to zero (no possums caught from 100 cyanide bait nights, *unpubl. data*) as the area is at the edge of an invasion front, and the Department of Conservation is conducting possum control to prevent the buildup of possum densities. At the time of collection of cuttings (December 1993 and November 1994) occasional trunk use (bite and scratch marks), and some browse on one tree, was observed on fuchsia. It is likely that fuchsia in the Moeraki Valley is palatable to possums because there has been widespread browsing and death of fuchsia in similar forests throughout South Westland where possums have become established (Rose *et al.*, 1993; Pekelharing *et al.*, 1998, Sweetapple and Fraser, *unpubl. data*). Data from Moeraki Valley is classed as palatable when statistical tests are used to compare palatable with unpalatable provenances.

A summary of possum densities and impacts on fuchsia at the six field sites is presented in Table 1.

## **Methods**

### **Propagation of plant material**

Between November 1993 and January 1994 ten softwood cuttings (c. 10 cm long) were taken from

Table 1: *Forest type, possum population data, and possum impacts on fuchsia, at the time samples were collected at the six field sites.*

Area	Forest type	Length of possum occupation (years)	Possum density	Possum impacts on fuchsia (browse)
Banks Peninsula	mixed hardwood	100	low	light
Pigeon Flat	mixed hardwood	80	high	none
Whitcombe Valley	rata-kamahi	60	high	light
Pureora Forest Park	podocarp-hardwood	30	low	heavy
Karamea Bluff	mixed beech	60	moderate	heavy
Moeraki Valley	silver beech	<5	low	v. light

each of 20 trees at all six sites, wrapped in wet sphagnum moss, transported to Christchurch, potted in crushed pumice, and placed under mist in a glasshouse for *c.* 4 weeks. They were then transplanted into "BP1" containers containing a potting mix of sand, peat, and a slow release fertilizer, and placed in a shadehouse. Plants were potted up into "BP5" containers approximately three months later, and grown on for another 12 months before feeding trials were conducted in February and March 1995. Poor survival of plants from Karamea Bluff and Moeraki Valley over winter 1994 necessitated collection of more material from these sites in November 1994.

Following the feeding trials, all plants were cut back to *c.* 30 cm in height and held in the shadehouse over winter 1995. In September 1995, the plants were planted out in an open field at Lincoln, Canterbury, in six contiguous blocks, containing six rows of nine plants. Each row contained plants from one provenance, and the order of rows was randomly allocated in each block. Foliage samples for nutrient analysis were taken, and morphological measurements made in March 1996.

### Feeding trials

Shadehouse grown plants were fed to wild-caught captive possums in 3x3 m outdoor pens in two feeding trials. All possums had been acclimatised to captivity for several months before the trials. In the first trial, six plants, one from each provenance, were presented to a pair of possums (one male and one female) for one night. Plants were set out in random order in a line across the pen. We tried to ensure that each plant had similar amounts of foliar biomass by removing the foliage from the top and bottom 5 cm of each stem, and then removing additional leaves as required from particular individuals. The amount of foliage of each provenance eaten during the night by the pair of

possums was calculated from the number of whole and half leaves present on each plant at the beginning and end of the night, multiplied by the mean dry weight per leaf determined for plants from each parent tree before the trial. The trial was replicated six times during the same night (14/2/95), using different pairs of possums.

In the second feeding trial in early March 1995, only the three unpalatable provenances (Banks Peninsula, Pigeon Flat, and Whitcombe Valley) and one palatable provenance (Pureora Forest Park) were compared because there was insufficient Moeraki Valley and Karamea Bluff plant material available. In this trial six plants from a single provenance were fed to a group of three possums (one male and two females) each night for four nights with a different provenance being presented each night. This trial was replicated four times, using four different trios of possums. All replications were run concurrently. The order in which provenances were presented was determined using a 4 X 4 Latin Square, with possum pens as rows and nights as columns. The quantity of foliage consumed each night in each pen, was determined using the same method as for the first trial.

Possums used in the first trial were given some shadehouse grown fuchsia for two nights before the feeding trial to accustom them to the new food. In both trials possums had access to their normal diet of cereal pellets, apples, carrots, grass, and water, with more than enough of all items to meet their demands.

### Morphology and physiology measurements

When the original cuttings were first collected, an additional five current season's shoots at least 10 cm long were taken from near the top of all sampled trees. Ten leaves, two from the central portion of each shoot, were then selected from each tree for leaf size measurements. Subsequently, one to three

leaves were taken from the central portion of the longest current season shoot on each shadehouse and open-grown plant, so that morphology measurements could be made from a total of six leaves from each original tree for which propagated material survived. Leaf surface area, using a leaf area meter ( $\Delta T$  Devices, Cambridge, England) and dry weight, following drying at 70°C for 24 hrs, were measured for all sampled leaves. Leaf specific gravity was then calculated by dividing dry weight by surface area. For the shadehouse- and open-grown plants, maximum length of the current season's growth was also measured.

Remaining leaves from the shoots collected from trees in the field and from the longest current season's shoot from open grown plants were dried (70°C for 24 hrs) and ground, then analysed for nitrogen, phosphorous, potassium, calcium, and magnesium content, using the methods of Blackmore, Searle and Daley (1987). Total macro nutrient content was calculated by summing the values for these five individual macro nutrients.

### Data analysis

Mean foliage consumption of each provenance by captive possums was compared by analysis of variance, using possum pen number, provenance (both feeding trials), and time (second feeding trial only) as independent factors. Mean morphological and physiological variables were compared between provenances by one way analysis of variance. Where these tests identified statistically significant differences, nested analysis of variance, with provenance nested within palatability groups (the three palatable provenances as one group and the three unpalatable provenances as a second group), were performed to determine whether differences lay between or within palatable and unpalatable groups. The strength of the linear relationship between coefficients of variation (standard deviation/mean) for a range of morphological and nutrient content

variables from open-grown plants and length of possum occupation at each provenance site was examined using coefficients of linear correlation.

## Results

### Feeding trials

In the first trial the proportion of foliage consumed from individual plants ranged from 0 to 100%, and averaged 76%. This range showed that at least some of the foliage was palatable, but also that sufficient quantities of foliage had been provided to enable possums to be selective, had they shown a marked preference for any of the six provenances. However, all provenances appeared to be equally palatable when grown in the shadehouse as similar proportions of foliage of all six fuchsia provenances were eaten by possums in the first feeding trial (Table 2). Observations during the first hour of feeding indicated that possums heavily browsed the first plant encountered regardless of provenance, before moving on to an adjacent plant, suggesting that all provenances were very palatable. Our analysis of this trial assumed that each plant was an independent observation. This was not strictly correct because a possum is less likely to feed on a second plant, regardless of palatability, once it has fed on a first plant (and partly or fully satiated its appetite for fuchsia). This means that our P value is likely to be smaller than it should be, but that will not have changed the outcome given the non-significant result.

Three individual plants in the first feeding trial were either unbrowsed or only lightly browsed (< 10% of foliage eaten), one each from two palatable provenances (Karamea Bluff and Moeraki Valley), and one from an unpalatable provenance (Whitcombe Valley). The total number of these plants from unpalatable provenances was not significantly different from the number from palatable provenances ( $\chi^2_1 = 0.37$ ,  $p > 0.05$ ).

Table 2: Mean percent consumption ( $\pm$  SEs) of fuchsia provenances by captive possums in feeding trials 1 and 2 (BP = Banks Peninsula, PF = Pigeon Flat, WV = Whitcombe Valley, PFP = Pureora Forest Park, MV = Moeraki Valley, KB = Karamea Bluff). Degrees of freedom (d.f.), F, and P values for the analysis of variance are given.

Trial	Provenance							ANOVA		
	BP	PF	WV	PFP	MV	KB	MO	d.f.	F	p
feeding trial 1	79.7 (5.4)	78.5 (8.8)	74.8 (12.9)	79.2 (9.5)	74.8 (12.9)	74.7 (13.8)	67.8 (12.8)	5, 25	0.68	0.64
feeding trial 2	71.4 (9.2)	76.2 (3.9)	79.2 (4.9)	68.4 (7.1)				3, 5	1.32	0.37

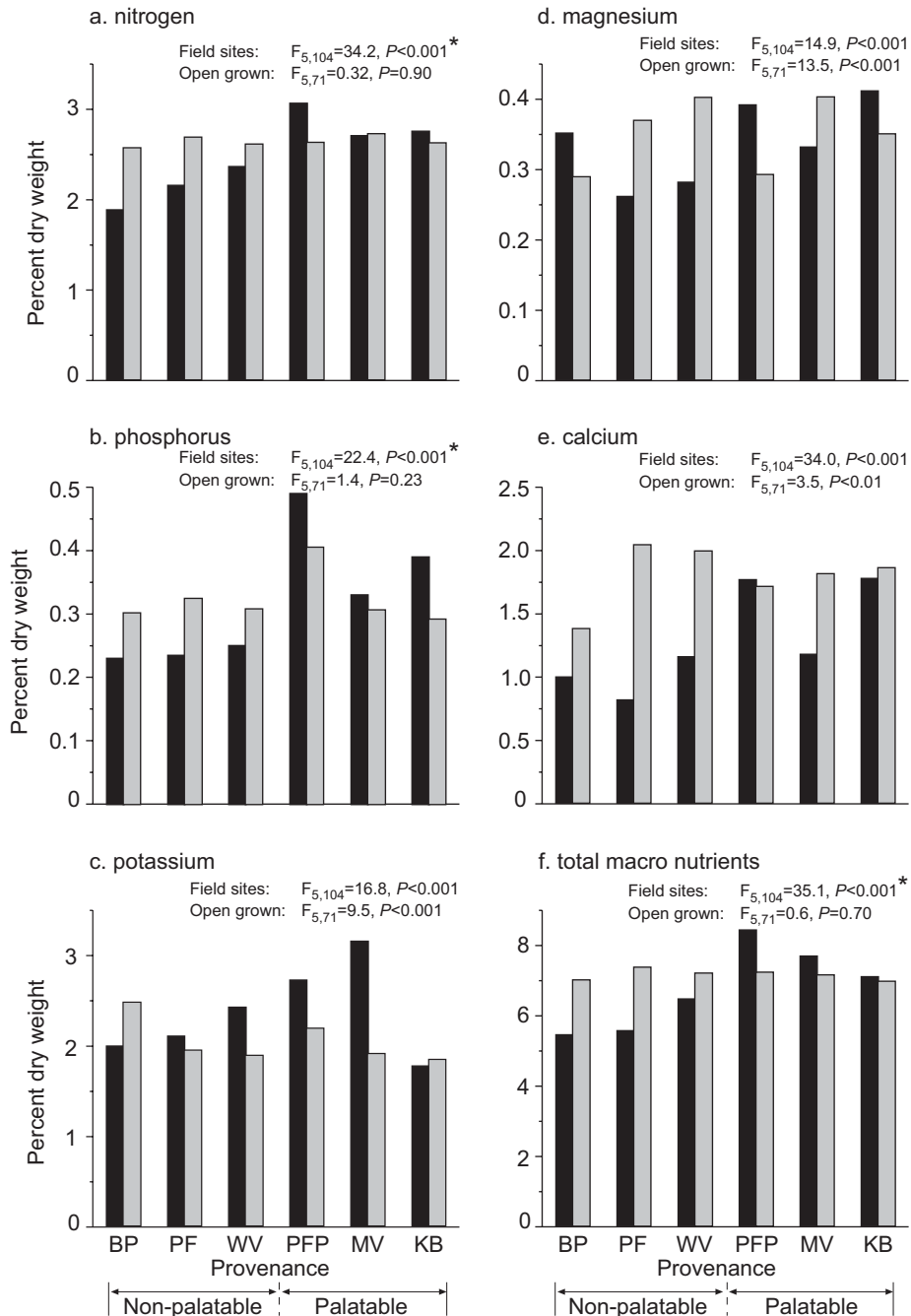


Figure 2: Macro nutrient content of foliage collected from field sites (black bars) and propagated plants grown in the open (shaded bars). BP = Banks Peninsula, PF = Pigeon Flat, WV = Whitcombe Valley, PFP = Pureora Forest Park, MV = Moeraki Valley, and KB = Karamaea Bluff. F and P values from analyses of variance are shown. \* indicates significant differences between palatable and non-palatable provenances.

In the second feeding trial there was again no difference in the quantity of foliage eaten between the four provenances tested (Table 2). Again, about three-quarters of the foliage presented in each pen was consumed during the trial (mean: 75%; range: 50-88%).

### Foliar macro nutrients

For foliage collected in the field, there were significant differences between sites for all five macro nutrients measured, with nitrogen, phosphorous, and total macro nutrients levels significantly higher in the palatable provenances than in the non-palatable provenances (Fig. 2). In contrast, only potassium, magnesium, and calcium content differed between provenances for plants grown in the open, and these differences occurred within, and not between palatability groups (Fig. 2). Therefore, differences between palatability groups in foliar-nutrient content observed in the field disappeared in plants grown in the same soil, suggesting that these differences were phenotypic rather than genotypic.

### Foliar morphology and growth rate

For foliage collected in the field, there were highly significant differences between provenances in leaf specific gravity, with the unpalatable provenances having significantly 'tougher' leaves than palatable provenances (Fig. 3a). However, there were no differences between provenances in leaf specific gravity for the shadehouse or open-grown plants, indicating that the field site differences in specific gravity were largely phenotypic. Leaf size differed significantly between provenances for both field-collected and shadehouse-grown foliage but was not significantly related to provenance palatability (Fig 3b). There was also no correlation between field and shadehouse leaf size ( $r = 0.08$ ,  $P = 0.88$ ).

Growth rate also varied significantly between provenances grown in the shadehouse and in the open, but, like leaf size, was not significantly related to provenance palatability (Fig. 3c). Growth rates in the shadehouse plants did not appear to be related to growth rates of open-grown plants ( $r = 0.1$ ,  $P = 0.85$ ).

### Variation within provenances

There were no significant correlations between length of possum occupation at field sites and the variability in leaf size, specific gravity, growth rate, or for any of the five foliar macro nutrients ( $P > 0.05$ ).

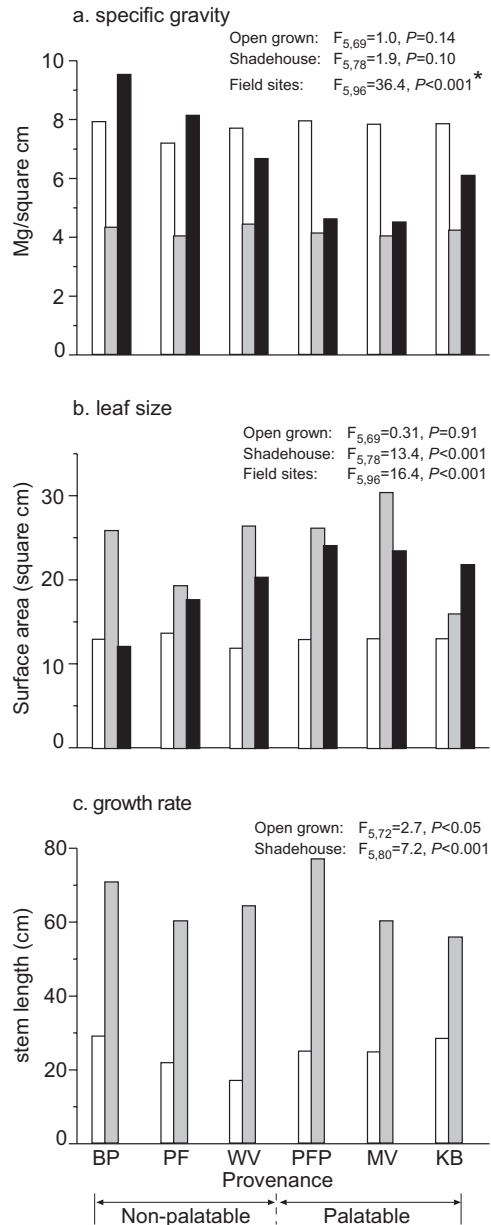


Figure 3: Mean values for leaf specific gravity, leaf size, and growth rates (maximum stem length) for propagated plants grown in the open (open bars), plants grown in the shadehouse (shaded bars), and foliage collected at field sites (black bars). BP = Banks Peninsula, PF = Pigeon Flat, WV = Whitcombe Valley, PFP = Pureora Forest Park, MV = Moeraki Valley, and KB = Karamea Bluff. F and P values for analyses of variance are shown. \* indicates significant differences between palatable and non-palatable provenances.

## Discussion

The feeding trials show conclusively that all six provenances are palatable to possums. Further, there was no apparent difference in the palatability to captive possums of shadehouse-grown material from each of the provenances. Possible explanations of these results are either that the provenances do not differ genetically in ways that affect their palatability to possums, or that palatability does differ between genotypes but the difference is not expressed in shadehouse material. Alternatively, captive possums may be less selective than wild possums or the preferences of captive and wild possums somehow differ.

The latter explanation seems highly unlikely. Captive possums do display strong preferences: Morgan (1990) reports they selectively ate flavoured rather than unflavoured barley in a bait development trial, and feeding trials with captive possums have been used to produce a repeatable palatability ranking among 20 poplar (*Populus* spp.) hybrids (Edwards, 1974). In addition, the lures used to attract possums to baits that were most favoured by captive possums have subsequently been found to be the most effective lures in field trials (Morgan *et al.*, 1995), indicating that the feeding preferences of captive and wild possums are likely to be similar.

If genetic differences in palatability are only expressed in open-grown foliage then we would expect sub-canopy foliage to be palatable regardless of provenance, yet when possum browse occurs on fuchsia it is usually on sunlit foliage in the outermost canopy, regardless of whether the browse is occurring on palatable or relatively unpalatable provenances (field observations).

Mammalian folivores prefer trees with high foliar macro nutrient levels, particularly nitrogen (Braithwaite, Dudzinski and Turner, 1983; Landsberg, 1987; Kavanagh and Lambert, 1990; Cork, 1992; Braithwaite, 1996), and low leaf fibre content (Waterman *et al.*, 1988; Cork and Sanson, 1991). Consistent with this, foliage collected from the provenances that were clearly palatable to possums at the time of collection (Karamea Bluff and Pureora Forest Park) or were thought to be palatable (Moeraki Valley), did have higher total macro nutrient, nitrogen, and phosphorus concentrations and lower leaf specific gravity than the remaining provenances that were either unbrowsed or only lightly browsed at the time of sample collection (Fig. 2abf; 3a). This suggests that these four foliar parameters are somehow linked to observed palatability in the field. However, they are unlikely to provide a complete explanation for the

apparent low palatability of some provenances because field material from all six provenances had higher macro nutrient concentrations than reported for some other possum-preferred tree species (Fitzgerald, 1978; Lee, 1988; Braithwaite, 1996) and lower specific gravities (field observations). The differences between provenances for these four parameters all disappeared when grown under identical condition (Fig. 2abf; 3a). This in turn suggests these differences were largely phenotypic.

In contrast, potassium, calcium, and magnesium concentrations varied between provenances not only in field samples but in material that had been grown under identical conditions, although there was no obvious correlation between the two sets of concentrations (Fig. 2cde). Similarly, leaf size varied between provenances in both field and shade-house grown samples (Fig. 3b). These differences suggest that the provenances do differ genetically. However, none of these four parameters are linked with apparent field palatability. The lack of correlation between field and identical-condition measurements and (for growth rate) between shadehouse- and open-grown plants, indicates that the observed phenotype reflects a complex interaction between genotype and site factors.

Selective browsing and killing of palatable genotypes by possums, creating browse resistant plant populations at sites with lengthy possum histories, has been suggested to have occurred in New Zealand forests (Freeland and Winter, 1975). Under this scenario we might expect the variation within populations of palatable species, particularly for variables that relate directly to palatability (e.g., foliar macro nutrient content and specific gravity), to be lower at sites with long possum histories than at recently colonised sites. However, within-provenance variability of fuchsia was not correlated with the length of time possums had been present at each of our field sites. Therefore, we found no evidence that long histories of possum occupation had modified the genetic character of fuchsia populations at these sites.

Two of the three palatable provenances tested came from within beech forests while all three of the unpalatable provenances came from within non-beech forests, which might indicate that there is a link between possum impacts on fuchsia and forest type. However, apparently unpalatable populations of fuchsia are not restricted to non-beech forests. Numerous healthy stands of fuchsia within beech forests with long histories of possum occupation are known to the authors, including stands in parts of the Tararua Range (lower North Island), Cobb Valley (north-western South Island), and numerous roadside stands in central and northern South Island. The



observed trend within our six provenances is just as likely to be an artefact of the non-random selection of these sites, than evidence of a relationship between health of fuchsia and forest type.

The persistence of fuchsia in some areas and not in others logically reflects differential browse tolerance or differential browsing pressure that, in turn, must reflect some differences in either the absolute or the relative attractiveness of fuchsia to possums. We have shown that it cannot be attributed to absolute unpalatability of some strains of fuchsia. Further, we consider it unlikely (but not impossible) that the difference is genetically based. If so, the remaining possibilities are that the difference is either largely phenotypic (i.e., fuchsia differs in palatability or browse tolerance between areas as a consequence of variation in site factors) or due to differences in relative palatability (i.e., fuchsia does not actually differ in palatability or browse tolerance between sites, but differs in its palatability ranking and/or use relative to the other foods present at each site), or some mixture of the two. The relative-palatability explanation might arise, for example, where fuchsia provides a key nutrient or energy source at some times of year that is also provided by an alternative more palatable species at some sites but not at others. It is noteworthy that another fast growing soft leaved native species, pohuehue (*Muehlenbeckia australis*), is common in the diet of possums on Banks Peninsula (O'Cain, 1997) and Pigeon Flat (R. Allen, *unpubl. data*). Variable absolute palatability might arise by populations on lower nutrient status soils diverting scarce metabolic resources from growth to the production of herbivore-deterrent plant secondary compounds, as has been described for many plant species (Byrant, Chapin and Klein, 1983; Byrant *et al.*, 1991).

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