

Impacts of the weed *Tradescantia fluminensis* on insect communities in fragmented forests in New Zealand

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Abstract

The impact of the weed *Tradescantia fluminensis* on insect communities, as represented by Malaise-trapped beetles (Coleoptera) and fungus gnats (Diptera: Mycetophilidae s. l.), was studied in three forest fragments. Each fragment contained three plots with and without a dense weed cover. Data on vegetation and habitat variables were collected. Twinspan and Decorana analyses separated the plots by fragment for fungus gnat communities, and nearly so for the presence/absence of beetle species. The fungus gnat communities separated into plots with and without tradescantia at two sites, and there were fewer species of fungus gnats and beetles in tradescantia plots at the site with the simplest habitat structure. The richness of beetle and fungus gnat species was correlated with vascular plant richness. As tradescantia is known to prevent regeneration of many native plants, we predict a corresponding decline in invertebrate diversity and fragment complementarity where the weed is established. © 2001 Elsevier Science Ltd. All rights reserved.

Keywords: Weed impacts; *Tradescantia fluminensis*; Coleoptera; Mycetophilidae; Forest fragments

1. Introduction

Current evidence suggests that the conservation of biological diversity is important for the stability and functioning of ecosystems (Chapin et al., 2000; McCann, 2000). Adventive weeds threaten indigenous biodiversity in New Zealand at several trophic levels (Heywood, 1989; Timmins and Williams, 1991; Vitousek et al., 1997), and in several cases their impacts on native vegetation have been documented (e.g. Kelly and Skipworth, 1984; Smale, 1990; Rose et al., 1995; Heads and de Lange, 1999). One of the worst forest weeds in New Zealand is *Tradescantia fluminensis*, hereafter referred to by the common name “tradescantia”, a carpet-forming herb from Brazil (Healey and Edgar, 1980). *Tradescantia* attains high levels of infestation in forest remnants over much of the lowlands in the North Island, and medium levels in parts of the South Island (Timmins and Mackenzie, 1995). At light levels above 1% in canopy gaps and forest edges, it forms a thick sward that prevents other species from establishing

(Kelly and Skipworth, 1984). Very little is known, however, of its effects on the invertebrate fauna. Where native vegetation is largely replaced by an adventive species, the structure of the invertebrate community is altered and species richness can decline (e.g. Donnelly and Giliomere, 1985; Samways et al., 1996; Crisp et al., 1998; Harris and Burns, 2000). Beetles were chosen for our study of the effects of tradescantia because they represent a large component of the measurable biodiversity (Southwood, 1978), account for about 50% of New Zealand’s insect species (Watt, 1982; Kuschel, 1990), have representatives from all trophic groups, and have been shown to associate with habitats (Hutcheson, 1990, 1996). Fungus gnats (represented in New Zealand by the Ditomyiidae, Keroplatidae and Mycetophilidae s. s.) were also selected as a target group because they are a species-rich and abundant group of flies in temperate forest environments and have proved useful as indicators of disturbance and forest integrity (Okland, 1994, 1996). The research presented here describes species assemblages of beetles and fungus gnats in three contrasting forest fragments infested with tradescantia, and examines the impact of this weed on the forest insect community.

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2. Methods

2.1. Study sites

Three tradescantia-infested lowland podocarp-broad-leaf forest fragments in the southern part of the North Island were chosen for study (Fig. 1). Details of the sites are provided in Table 1.

All three sites have been modified by the activities of cattle and browsing by introduced brush-tailed possums (*Trichosurus vulpecula*) and rabbits (*Oryctolagus cuniculus*). Rangitawa Bush was subject to selective logging in the late nineteenth and early twentieth centuries and still retains canopy gaps, although the remaining forest tiers are relatively intact as the site has been fenced from stock for at least 20 years. Denton's Bush has a relatively intact canopy, but the sub-canopy and understorey layers are sparse as a result of stock grazing and

possum browsing before 1988. Kirkwell Bush No. 4 has regenerated in the last 100 years into a short-statured, even-aged, relatively intact *Podocarpus totara* canopy. Gaps in the sub-canopy and damage in the understorey are probably a consequence of stock grazing before 1984.

Tradescantia is the dominant ground cover (up to 60 cm) in parts of all three sites. It forms thick swards alongside a farm-track that bisects Rangitawa Bush and occurs sparsely in the forest interior. Dense swards of tradescantia occur around the perimeter of Kirkwell Bush and occasionally extend into the forest interior. Denton's Bush has thick swards of tradescantia in the northeast and southern corners, and here too forms less dense patches under the heavier canopy.

Within each site, three 20×20 m plots were placed non-randomly in the centres of thick tradescantia swards, and another three plots were placed in areas visually similar to the previous plots but without dense

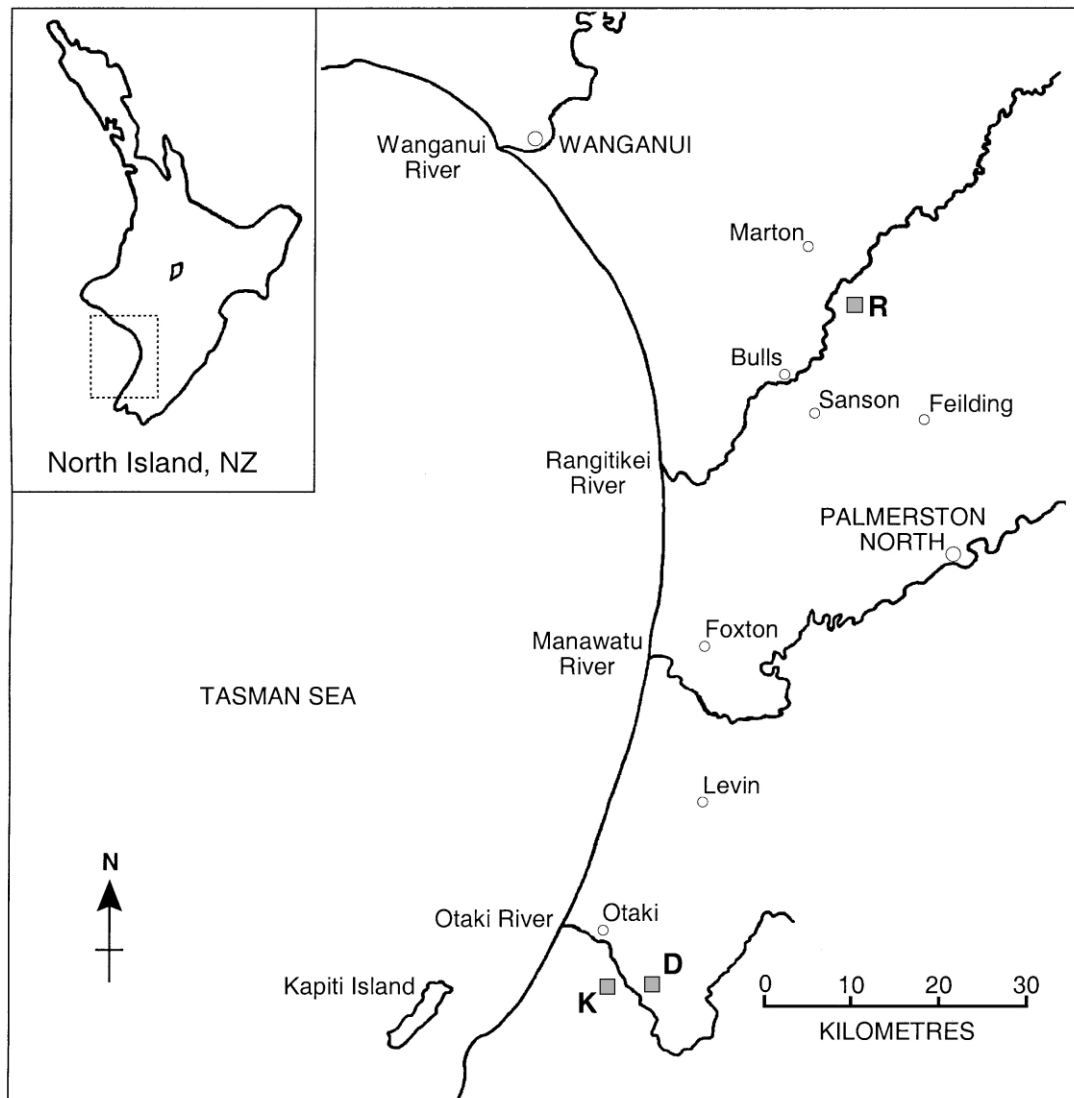


Fig. 1. Location of study sites: R, Rangitawa Bush; D, Denton's Bush; K, Kirkwell Bush No. 4.

tradescantia (although a few scattered tradescantia plants were usually present). The mean percentage cover of tradescantia in the tradescantia and non-tradescantia plots is provided in Table 1. The size of the plots is the standard used for the “recce” inventory method of assessing vegetation composition described below.

2.2. Vegetation and habitat variables within plots

The percentage cover of all vascular plant species in fixed height tiers (12+ m, 5–12 m, 2–5 m, <2 m), seedlings, and ground litter was visually estimated for each plot following the “recce” method of Allen (1992). The collecting bottle of the Malaise trap represented the centre of each plot.

Standing dead wood was estimated from the diameter of all dead stems over 10 cm d. b. h., converting the sum to m² ha⁻¹. The amount of dead wood on the ground was estimated by counting the number of stems greater than 10 cm diameter in three classes (1–2 m, 2–5 m, 5–10 m), multiplying the number by the class mid-points, and summing each plot. These two estimates were summed to gain a crude index of dead wood in each plot.

2.3. Malaise sampling

Invertebrates were collected using Malaise traps, which were cleared every 7 days from 1 to 29 December

1997. Traps were oriented with the collecting container facing north, and the base of each trap was pegged to the forest floor. Malaise traps are very efficient at sampling fungus gnats (Okland, 1994, 1996; Vockeroth, 1981), and this sampling period and methodology has been shown to provide samples that are representative of the underlying beetle communities (Hutcheson, 1990, 1996; Hutcheson and Kimberley, 1999; Hutcheson et al., 1999). The beetles were identified to recognisable taxonomic units (RTUs), in some cases to family level only, and were classified into functional groups (herbivores, detritivores, and predators) at family or subfamily level using the classifications of Hutcheson (1996), Klimaszewski and Watt (1997), and Didham et al. (1998). Fungus gnats were identified to species and RTUs. Specimens from both groups were compared with material in the New Zealand Arthropod Collection (NZAC).

2.4. Analyses

Sample affinities between all plots were assessed using polythetic diversive classification (TWINSPAN; Hill, 1979a) and detrended correspondence analysis (DECORANA; Hill, 1979b). The analyses of vegetation used the estimated percentage cover for each species summed over tiers (Allen, 1992). For analysis of beetles and fungus gnats, the four 7-day samples were combined for each plot.

Table 1

Site geography and main plant species (> 5% tier cover), listed in reducing order of tier cover%, for the six plots within each study site^a

| | Rangitawa Bush | Denton's Bush | Kirkwell Bush No. 4 |
|--|---|--|---|
| Latitude, longitude | 40°06' S, 175°28' E | 40°48' S, 175°11' E | 40°48' S, 175°10' E |
| Size (ha) | 12.4 | 2 | 14 |
| Altitude (m) | 120 | 40 | 40 |
| Mean annual temp (°C)/rain (mm) | 13/1050 | 13/1220 | 13/1220 |
| Canopy (12+ m) | <i>Alectryon excelsus</i> <i>Beilschmiedia tawa</i> <i>Kunzea ericoides</i> <i>Podocarpus totara</i> | <i>B. tawa</i> <i>Dysoxylum spectabile</i> <i>Laurelia novae-zelandiae</i> | <i>P. totara</i> |
| Sub-canopy (5–12 m) | <i>B. tawa</i> <i>A. excelsus</i> <i>K. ericoides</i> <i>Melicytus ramiflorus</i> | <i>D. spectabile</i> <i>M. ramiflorus</i> <i>B. tawa</i> <i>Hedycarya arborea</i> | <i>P. totara</i> <i>D. spectabile</i> <i>M. ramiflorus</i> |
| Understorey (2–5 m) | <i>Macropiper excelsum</i> <i>M. ramiflorus</i> <i>A. excelsus</i> <i>Coprosma arenaria</i> | <i>M. excelsum</i> <i>D. spectabile</i> | <i>P. totara</i> <i>M. ramiflorus</i> |
| Groundcover (< 2 m) | <i>Tradescantia fluminensis</i> <i>M. excelsum</i> <i>A. excelsus</i> <i>Arthropteris tenella</i> | <i>M. excelsum</i> <i>T. fluminensis</i> <i>Blechnum filiforme</i> <i>M. ramiflorus</i> | <i>T. fluminensis</i> <i>Microlaena avenacea</i> <i>P. totara</i> <i>Oplimenus hirtellus</i> |
| Tradescantia cover (mean%) Trad./Non-Trad. | 83.7/2.5 | 79.7/1.3 | 93.7/9.7 |

^a The mean percentage cover of tradescantia in the tradescantia-sward plots and the non-tradescantia plots in each site is provided. Meteorological data are estimated from the nearest climate stations operated by the National Institute of Water and Atmospheric Research, and that used for Denton's and Kirkwell Bush is the same.

The complementarity (distinctness, heterogeneity) of the sites was assessed in pairwise comparisons following Colwell and Coddington (1995). Species lists based on samples rather than complete inventories will tend to overestimate complementarity (Colwell and Coddington, 1995) due to the infrequent sampling of rare species. Therefore, a second estimate of complementarity was estimated using a dataset with rare species (arbitrarily set at ≤ 5 specimens) removed.

ANOVA was used to compare the species richness and abundance of beetles and fungus gnats, and the vascular plant richness, between plots stratified by site and by the presence/absence of dense tradescantia swards. Count data were square root transformed before analysis.

Pearson correlations were used to investigate the relationship between beetles and fungus gnats for both richness and abundance, and between both these groups and the richness of vegetation. To reduce the weighting given to plant species that occurred very rarely in any given plot, the richness of vegetation measure was restricted to a count of species recorded in the plot with a total cover greater than 1%. These specific correlation analyses were decided a priori, so the probabilities were not corrected for multiple tests (Wilkinson et al., 1996). We used multiple tests to search for correlations between the richness and abundance of the insect groups and the habitat variables, including the percentage cover of tradescantia, vegetation cover at four tier heights, dead wood index, and the percentage ground cover of litter and seedlings. The significance probabilities were adjusted by the Bonferroni multiple tests method. We then used stepwise multiple regression to explore the relative influence of the habitat variables to explain the species richness of beetles and fungus gnats. Litter was omitted from the stepwise regression procedure as the multiple tests showed a strong correlation with tradescantia cover.

3. Results

3.1. Vegetation

The number of plant species in plots varied between sites ($F=4.96$, d.f. = 2, $P=0.027$), with Rangitawa Bush plots having the greatest richness and Kirkwell Bush plots the lowest. Tradescantia plots had significantly fewer species than non-tradescantia plots ($F=5.04$, d.f. = 1, $P=0.044$).

The vegetation of the three fragments was very distinct, and both Twinspan and the ordination analysis clearly separated the plots by site (Figs. 2a and 3a). The distinction between tradescantia and non-tradescantia plots was less clear. Twinspan separated the vegetation at Denton's Bush and Kirkwell Bush into tradescantia and non-tradescantia plots, but not at Rangitawa Bush

(Fig. 2a). The principle ordination axes did not clearly separate out tradescantia plots within sites except for Kirkwell Bush (Fig. 3a). Similar groupings of sites to the Twinspan classification were evident for Kirkwell Bush and Rangitawa Bush, but not Denton's Bush. Rangitawa Bush and Denton's Bush had similar amounts of dead wood, but there was no dead wood in any of the plots at Kirkwell Bush. Plots with dense tradescantia had few seedlings and only small amounts of litter compared with the other plots.

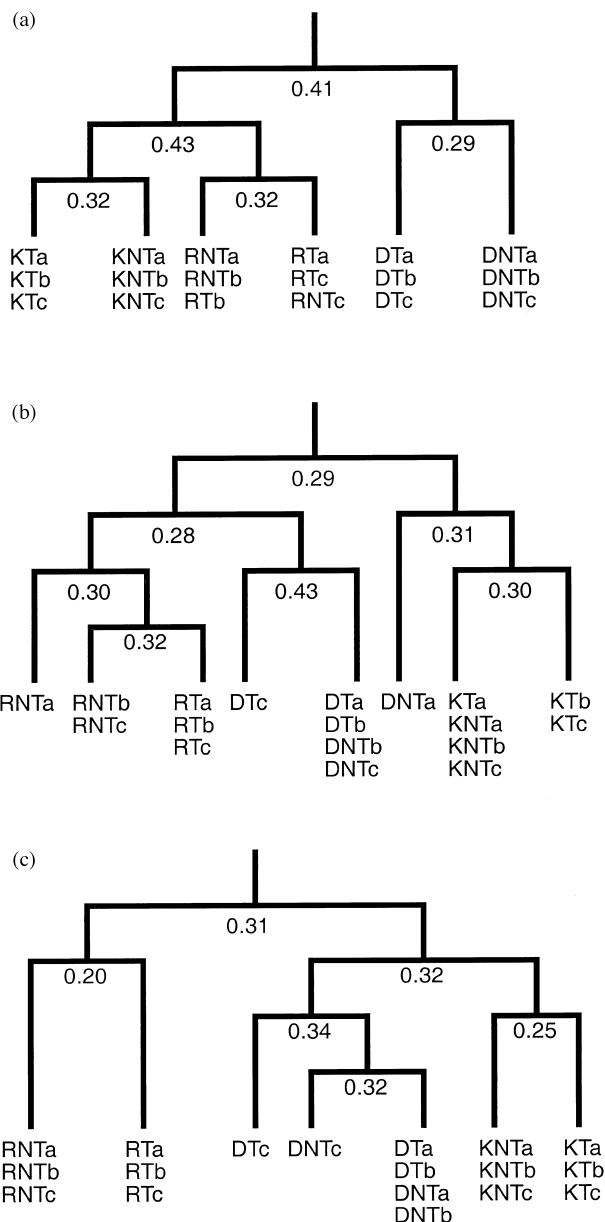


Fig. 2. Dendrograms of TWINSpan divisions of (a) vegetation in 20x20 m recce plots; (b) beetles sampled in Malaise traps in centre of plots during Dec 1997; (c) fungus gnats in same traps, with *Anomomyia guttata* excluded. The eigenvalues are a measure of the variance accounted for by each division. Plots labelled as follows: 3 Sites — R, Rangitawa Bush, D, Denton's Bush, K, Kirkwell Bush; plots with (T) and without (NT) tradescantia; 3 replicates = a, b, or c.

3.2. Beetles

A total of 7547 beetle specimens were collected, encompassing 44 families and 177 RTUs (Appendix A). The beetle assemblages from all three sites contained unique species, with Rangitawa Bush having the greatest number (Table 2). About 86% of the unique species were rare in the samples (≤ 5 specimens). Of the non-rare species (> 5 in data set), 52% were found at all three sites. Pairwise comparisons of complementarity indicate that the beetle assemblages at Rangitawa Bush and Denton's Bush were more similar to each other than to Kirkwell Bush, especially if the rarely caught species are excluded from analysis (Table 2).

The very large catch in one trap (DTc) in tradescantia at Denton's Bush was an outlier in the data set, so was removed from the ANOVA analyses in order to meet the required assumptions about the distribution of the data. There were significant site differences in both species richness ($F=15.88$, d.f.=2, $P=0.001$) and abundance ($F=15.84$, d.f.=2, $P=0.001$), with traps at Rangitawa Bush tending to catch the most beetles and have the greatest richness. Over all the sites, the abundance of beetles and the numbers of RTUs in tradescantia and non-tradescantia plots were similar. At Kirkwell Bush, however, there was a trend for species richness ($P=0.11$) and abundance ($P=0.06$) to be greater in non-tradescantia plots. Only 18% of the 716 weevils (Curculionidae) caught at Kirkwell Bush were from the tradescantia plots. The species most notably affected were *Andracalles ?vividus* (10 of 344 specimens in tradescantia plots) and *Microcryptorhynchus ?perpusillus* (one of 93 specimens). For the other two sites, the total number of weevils sampled was similar between tradescantia and non-tradescantia plots.

The beetle assemblages from Rangitawa Bush were clearly distinct from Kirkwell Bush, with Denton's Bush intermediate (Fig. 2b). Ordination of presence/absence data only (Fig. 3b) was better than ordination of abundance data at distinguishing between sites and highlighted plot DTc as an outlier. There was no evidence of assemblages differing between tradescantia and non-tradescantia plots.

3.3. Beetle guild differences

The species richness of detritivores ($F=18.5$, d.f.=2, $P<0.001$) and predators ($F=7.48$, d.f.=2, $p=0.008$) varied significantly between sites, but herbivores were similar ($P>0.05$) (Appendix A). However, for all three guilds, Rangitawa Bush plots had the greatest richness and Kirkwell Bush plots the lowest. Detritivores made up a much lower proportion of the assemblages in plots at Kirkwell Bush than the other two sites. There were no detectable differences in guild structure between plots with and without dense tradescantia.

Twinspan and ordination analysis clearly separated the plot assemblages by site for the herbivores. For the detritivores and predators, there was considerable overlap of plot assemblages from the three sites.

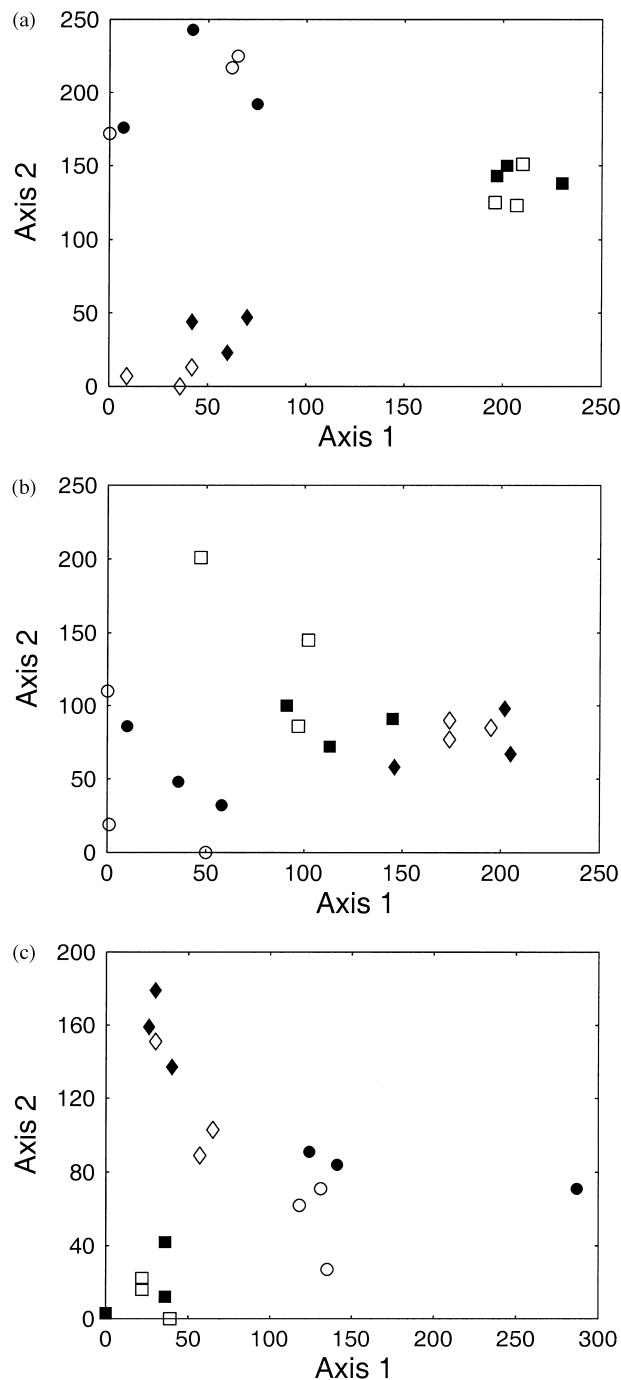


Fig. 3. DECORANA ordination diagrams of sites based on (a) vegetation in recce plots; (b) beetles sampled in Malaise traps (presence/absence data); (c) fungus gnats, with *Anomalomyia guttata* excluded. ●, Rangitawa; ■, Denton's; ◆, Kirkwell Bush; open symbols represent tradescantia plots and closed symbols non-tradescantia plots.

3.4. Fungus gnats

A total of 6772 individuals and 104 species of fungus gnats were collected (Appendix B). Of the three families represented, the Mycetophilidae were the best represented, with 5334 individuals and 77 species, followed by the Keroplatidae, with 1198 individuals and 14 species. The Ditomyiidae were the least common with 240 individuals and 13 species.

As with the beetles, all three sites had a number of unique fungus gnat species (Table 2), with 72% of uniques being rare (≤ 5 specimens). Of the abundant species (> 5 in data set), 51% were found at all three sites. Pairwise comparisons of complementarity revealed that heterogeneity amongst the three sites was similar (Table 2).

Between plots, the abundance of fungus gnats caught varied widely. One species, *Anomalomyia guttata* (Hutton), accounted for much variation in abundance. It was the most common fungus gnat with 2256 individuals (33.3% of the total fungus gnat catch), and its proportional representation in any single plot ranged from a minimum of < 5 –69% (a range of 5–524 individuals). Its abundance showed no relationship with either site or tradescantia cover.

The very large catch in one trap (DTc) was an outlier in the data set, so the ANOVA analyses were run without that trap in the data set. There was a significant between-site difference in both species richness ($F = 6.364$, d.f. = 2, $P = 0.015$) and abundance ($F = 12.82$, d.f. = 2, $P = 0.001$), with Rangitawa having more species and individuals than the other two sites.

There was no detectable difference over all sites in the fungus gnat richness or abundance between plots with or without tradescantia ($P > 0.05$). In Kirkwell Bush, the site with the simplest vegetational structure, plots without

tradescantia were significantly richer in fungus gnat species than those with tradescantia ($F = 84.5$, d.f. = 1, $P = 0.001$), but the number of individuals did not differ significantly due to large numbers of *A. guttata* in one of the tradescantia plots (more than 56% of trap catch).

Splitting the fungus gnats into their three families (Mycetophilidae, Keroplatidae, and Ditomyiidae) and performing ANOVAs for each family produced similar trends, with the abundance of all three families differing significantly by site. There were also significant differences in species richness between sites for the Keroplatidae ($F = 47.2$, d.f. = 2, $P < 0.001$) and Ditomyiidae ($F = 17.3$, d.f. = 2, $P < 0.001$), with Rangitawa Bush being the richest site and Kirkwell the poorest.

Over all sites, the only parameter to show a significant effect from tradescantia cover was the abundance of Keroplatidae ($F = 5.7$, d.f. = 1, $P = 0.036$), which were more abundant in the tradescantia plots. *Chiasmoneura fenestrata* (Edwards) was the most common keroplatid (518 individuals), and the only one to be caught at every plot. The catch of this species was strongly related to both site ($F = 11.5$, d.f. = 2, $P = 0.002$) and tradescantia cover ($F = 11.4$, d.f. = 1, $P = 0.006$). There were no significant interaction effects between site and tradescantia cover in any of the ANOVA performed.

For the Twinspan and ordination analyses, the overly influential *A. guttata* was removed from the data set. Twinspan split the three sites and separated tradescantia from non-tradescantia plots at Kirkwell and Rangitawa Bush, but not Denton's (Fig. 2c). Similarly, the ordination analysis separated the three sites and also went some way toward separating the tradescantia and non-tradescantia plots for both Kirkwell Bush and Rangitawa Bush (Fig. 3c). Analyses on presence/absence data alone separated the fungus gnat catch by site but not by tradescantia cover.

Table 2
Richness and complementarity percentage of beetle and fungus gnat communities sampled by Malaise traps in three forest patches^a

| | Beetle RTUs | | Fungus gnat species | |
|------------------------|-------------|-----------------------------------|---------------------|-----------------------------------|
| | Total | Excluding rare (> 5 specimens) | Total | Excluding rare (> 5 specimens) |
| Rangitawa richness | 134 | 72 | 65 | 51 |
| Denton's richness | 110 | 65 | 68 | 48 |
| Kirkwell richness | 71 | 50 | 57 | 45 |
| Rangitawa unique | 47 | 8 | 19 | 7 |
| Denton's unique | 30 | 2 | 21 | 4 |
| Kirkwell unique | 10 | 2 | 10 | 3 |
| <i>Complementarity</i> | | | | |
| Rangitawa + Denton's | 56 | 22 | 59 | 35 |
| Rangitawa + Kirkwell | 62 | 42 | 53 | 37 |
| Denton's + Kirkwell | 63 | 38 | 53 | 34 |

^a A complementarity percentage of 0 would indicate identical assemblages, 100 would indicate entirely distinct assemblages (Colwell and Codrington, 1995).

4. Community linkages

There was a correlation between the species richness of beetles and that of fungus gnats (Pearson $r=0.682$, $P=0.002$), and the abundance of beetles was strongly correlated with that of fungus gnats (Pearson $r=0.826$, $P<0.001$). The richness of vegetation was strongly correlated with the species richness of beetles (Pearson $r=0.806$, $P<0.001$) and less strongly with the richness of fungus gnats (Pearson $r=0.642$, $P=0.004$). There were no detectable relationships between the percentage cover of tradescantia and the species richness or abundance of either beetles or fungus gnats (in all cases, $P>0.05$). None of the other environmental variables were significantly correlated with the catch of beetles or fungus gnats.

Step-wise regression analysis on factors relating to beetle species richness revealed that vegetation richness and percentage tradescantia cover were the two most powerful explanatory variables measured, together explaining about 74% of the variation. However, vegetation richness alone explained 65% of variation, while tradescantia cover alone explained just 0.2%. Richness of vegetation was also by far the best factor for explaining differences in the species richness of fungus gnats, with 50% of the variation explained. With the other environmental factors included, the explanatory power of the regression equation improved to just 57%.

5. Discussion

The impact of tradescantia on communities of beetles and fungus gnats was not clearly determined in this study. Over all sites, the proportion of tradescantia cover was a very poor predictor of species richness or abundance for either beetles or fungus gnats. Our analyses did identify differences in the communities of fungus gnats between plots with and without tradescantia at Kirkwell Bush and Rangitawa Bush, but we cannot conclude from this study whether those differences are necessarily an impact of tradescantia or a response to the environmental conditions that are favourable to tradescantia. Kirkwell Bush has the simplest vegetational structure, and would therefore be expected to have the lowest source of variance between plots. That was the only site where there were significantly fewer species of fungus gnats in the tradescantia plots than in the control plots, with a similar, nearly significant trend occurring with the beetles.

There is some evidence that particular taxa, such as some Keroplatidae and Curculionidae, are affected by the presence of tradescantia. *Chiasmoneura fenestrata* (Keroplatidae) were more abundant in the tradescantia plots. The biology of *Chiasmoneura* has not been recorded (L. Matile, pers. commun.), but it is possible that

tradescantia provides a favourable breeding habitat for this species. Adult keroplatids, and fungus gnats in general, have a tendency to stay in darkened, moist habitats during the day (Cole and Chandler, 1980; Hutson et al., 1980; Okland, 1996; Ostroverkhova, 1992), and tradescantia may provide such habitat. The main species of weevils to show negative responses to tradescantia at Kirkwell Bush, *Andracalles ?vividus* and *M. ?perpusillus*, are both found in leaf litter (Lyal, 1993). The amount of leaf litter was much reduced in the dense tradescantia plots.

As the Malaise traps sampled insects moving above the tradescantia, the measurements of the community directly associated with the weed plots will have been diluted by insects merely flying over. Underneath the weed itself, the invertebrate community may well be quite different from sites where tradescantia is absent. A study using pitfall traps to look at localised impacts within the plots indicates that some aspects of the invertebrate community living beneath tradescantia are different from sites where the weed is absent (R. Standish, pers. commun.).

One Malaise trap in a tradescantia plot at Denton's Bush was an outlier in the analyses, with much higher than expected abundance and richness of beetles, particularly detritivores, and fungus gnats. The main contributing factor was probably a large rotten stump within 2 m of the trap, as such material influences the number of detritivorous beetles (Hutcheson, 1996) and the composition of fungus gnat communities (Okland, 1994, 1996). Overall, the amount of dead wood and the species richness or abundance of beetles and fungus gnats were not significantly correlated, partly because of the scale at which the measurements were taken. One large stump within a few metres of the Malaise trap may have a much greater influence on the trap catch than the average amount of dead wood over the 400 m² area surveyed. The lack of dead wood at Kirkwell Bush may well be a major contributor to the low species richness at that site and the under-representation of detritivorous beetles.

Geographic proximity of the fragments appears to have little bearing on the complementarity of the insect species assemblages, although only three sites were used. In the case of beetles, Denton's had more in common with the distant Rangitawa than with the neighbouring Kirkwell Bush, whereas the fungus gnat assemblages at the sites were about equally distinct from each other. This is consistent with the Twinspan and ordination analyses, which were better able to differentiate between the three sites using fungus gnats than using beetles as a whole. Amongst the beetle guilds, herbivores were best for differentiating sites, which is to be expected considering the differences in vegetation composition.

The species richness of both beetles and fungus gnats was strongly correlated with the richness of the vegetation, with this factor alone explaining most of the

variation between plots. The link between plant species richness and that of beetles has also been shown in New Zealand by Crisp et al. (1998). *Tradescantia* prevents the regeneration of woody species (Kelly and Skipworth, 1984), which will probably reduce plant species richness over time. We might then expect a corresponding reduction in the richness of invertebrate species. In the case of beetles and fungus gnats at Kirkwell Bush, this trend may already be evident.

Other recent studies on the impact of invasive plants on invertebrate communities (Samways et al., 1996; French and Eardley, 1997) have also struggled to demonstrate an impact on species richness and diversity, and have found similar changes in the abundance of particular species. If *tradescantia* consistently favours regeneration of the same plant species at different sites, and consequently the same invertebrate species over others, then the community structure of isolated forest fragments will begin to converge and a gradual loss in complementarity will result. This has significant impli-

cations for the conservation of biological diversity in a landscape that has been largely deforested and where the continued existence of many species may depend on the integrity of forest fragments.

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Appendix A. Beetles collected from Malaise traps set in three forest fragments in the lower North Island over a 4-week sampling period in December^a

| Taxon | Guild | Location of plots | | |
|---|-------|-------------------|---------------|----------------|
| | | Denton's Bush | Kirkwell Bush | Rangitawa Bush |
| Suborder Adephaga | | | | |
| Superfamily Caraboidea | | | | |
| Carabidae | | | | |
| <i>Amarotypus edwardsi</i> Bates | P | – | – | 7 |
| Carabidae sp.1 | P | – | – | 2 |
| Suborder Polyphaga | | | | |
| Superfamily Hydrophiloidea | | | | |
| Hydrophilidae | P? | 1 | – | 2 |
| Superfamily Staphylinoidea | | | | |
| Ptiliidae | | | | |
| <i>Notoptenidium lawsoni</i> (Matthews) | D | 2 | 18 | 4 |
| Agyrtidae | | | | |
| " <i>Necrophilus</i> " <i>prolongatus</i> (Sharp) | D | 3 | – | – |
| Leiodidae | | 34 | 10 | 11 |
| Staphylinidae | | | | |
| <i>Atheta</i> sp. | P | – | 5 | 9 |
| <i>Botromana</i> sp.1 | P | 7 | 1 | 8 |
| <i>Carpelimus</i> sp. 1 | D | – | 1 | 1 |
| <i>Carpelimus</i> sp.2 | D | 2 | – | – |
| <i>Gyrophaena</i> sp.1 | P | 1 | – | 5 |
| ? <i>Gyrophaena</i> sp.2 | | – | – | 10 |

| | | | | |
|--|----|----|---|-----|
| <i>Ischnoderus tectus</i> (Broun) | P | 1 | 1 | 1 |
| <i>Ocalea</i> sp.1 | P | 1 | 3 | 1 |
| <i>Oligota setigera</i> Williams | P | – | – | 2 |
| <i>Sagola</i> sp.1 | P | 2 | – | – |
| <i>Sagola</i> sp.2 | P | 2 | – | – |
| <i>Sepedophilus acerbus</i> (Broun) | P | 1 | – | – |
| <i>Stenomaliium ?sulcithorax</i> (Broun) | P | 1 | 4 | 2 |
| <i>Sytus</i> sp.1 | P | 1 | – | – |
| <i>Tachyporus nitidulus</i> (F.) | P | – | 1 | – |
| Staphylinidae sp.1 | P | – | – | 1 |
| Staphylinidae sp.2 | P | 1 | – | 1 |
| Staphylinidae sp.3 | P | – | – | 2 |
| Staphylinidae sp.4 | P | – | 1 | 1 |
| Staphylinidae sp.5 | P | 1 | – | – |
| Staphylinidae sp.6 | P | 1 | – | 1 |
| Staphylinidae sp.7 | P | – | – | 2 |
| Staphylinidae sp.8 | P | 6 | – | – |
| Staphylinidae sp.9 | P | – | – | 1 |
| Staphylinidae sp.10 | P | – | 1 | 11 |
| Staphylinidae sp.11 | P | – | 1 | 2 |
| Staphylinidae sp.12 | P | 1 | – | – |
| Staphylinidae sp.13 | P | – | – | 1 |
| Staphylinidae sp.14 | P | 3 | 2 | 1 |
| Staphylinidae sp.15 | P | – | – | 1 |
| Superfamily Scarabaeoidea | | | | |
| Scarabaeidae | | | | |
| <i>Costelytra zealandica</i> (White) | H | 1 | 2 | 1 |
| <i>Odontria</i> sp.1 | H | – | – | 6 |
| <i>Stethaspis longicornis</i> (Arrow) | H | 1 | – | 15 |
| Superfamily Scirtoidea | | | | |
| Scirtidae | D | 29 | – | 114 |
| Eucinetidae | | | | |
| <i>Eucinetus stewarti</i> (Broun) | D | – | – | 3 |
| Clambidae | D | – | – | 3 |
| Superfamily Buprestoidea | | | | |
| Buprestidae | D? | – | – | 1 |
| Superfamily Elateroidea | | | | |
| Elateridae | | | | |
| <i>Panspoeus guttatus</i> Sharp | H | 1 | 1 | 13 |
| <i>Protelater ?elongatus</i> Sharp | H | – | – | 2 |
| Elateridae sp.a | H | – | – | – |
| Elateridae sp.d | H | 1 | – | 1 |
| Elateridae sp.f | H | 2 | – | 3 |
| Elateridae sp.g | H | 13 | 7 | – |
| Elateridae sp.j | H | 5 | 4 | – |
| Elateridae sp.m | H | 1 | – | – |
| Elateridae sp.n | H | 2 | 5 | – |
| Elateridae sp.q | H | – | – | 1 |
| Elateridae sp.r | H | – | – | 2 |
| Elateridae sp.s | H | – | – | 1 |
| Cantharidae | | | | |
| Cantharidae sp.1 | ? | 7 | 0 | 19 |

| | | | | |
|--|----|-----|-----|-----|
| Superfamily Bostrichoidea | | | | |
| Dermestidae | | 1 | – | – |
| Anobiidae | | | | |
| <i>Ptinus maorianus</i> Brooks | D | – | 1 | 3 |
| <i>Ptinus speciosus</i> Broun | D | 4 | – | 8 |
| Ptininae sp.1 | D | 10 | 78 | 1 |
| Superfamily Cleroidea | | | | |
| Trogoxipidae | | | | |
| <i>Australiodes</i> sp.1 | P | 12 | 2 | 5 |
| <i>Grynoma</i> sp.1 | P | 1 | – | – |
| Rentoniinae new genus new sp.2 | P | – | 1 | – |
| Cleridae | P | 16 | 1 | 46 |
| Melyridae | P | 1 | 6 | 7 |
| Superfamily Cucujoidea | | | | |
| Nitidulidae | H | 5 | 1 | 24 |
| Silvanidae | | | | |
| <i>Dendrophagus</i> sp.1 | D | 1 | – | – |
| Cryptophagidae | D | 842 | 325 | 718 |
| Languriidae | | | | |
| <i>Cathartocryptus maculosus</i> Broun | D? | – | – | 2 |
| Endomychidae | | | | |
| <i>Holoparamecus</i> sp.1 | D | 1 | – | 1 |
| Coccinellidae | | | | |
| <i>Coccinella undecimpunctata</i> L. | P | – | – | 1 |
| <i>Rhyzobius</i> spp. | P | 63 | 41 | 32 |
| <i>Stethorus</i> spp. | P | 29 | 4 | – |
| Coccinellidae sp.1 | P | 1 | – | – |
| Coccinellidae sp.2 | P | 1 | – | – |
| Coccinellidae sp.3 | P | 1 | – | – |
| Corylophidae | | | | |
| <i>Anisomeristes</i> spp. | D | 8 | 1 | 20 |
| <i>Holopsis</i> spp. | D | 61 | 66 | 32 |
| new genus new sp.1 | D | 1 | – | – |
| <i>Sacina oblonga</i> Broun | D | 335 | 135 | 450 |
| Corylophidae sp.1 | D | 1 | – | – |
| Corylophidae sp.2 | D | 19 | – | 4 |
| Latridiidae | | | | |
| <i>Aridius nodifer</i> (Westwood) | D | 11 | 19 | 18 |
| <i>Bicava illustrus</i> (Reitter) | D | 24 | 13 | 29 |
| <i>Bicava ?variegata</i> (Broun) | D | – | – | 3 |
| <i>Enicmus foveatus</i> Belon | D | 7 | 1 | 23 |
| Latridiidae spp. | D | 300 | 75 | 572 |
| Superfamily Tenebrionoidea | | | | |
| Mycetophagidae | | | | |
| <i>Triphyllus hispidellus</i> (Broun) | D | 3 | – | – |
| Ciidae | D | – | – | 2 |
| Melandryidae | D | 5 | – | 5 |
| Mordellidae | D | 1 | – | 7 |
| Zopheridae | | | | |
| Colydiinae | D | 8 | – | 42 |
| Tenebrionidae | D | 2 | – | 6 |
| Oedemeridae | D | – | – | 9 |

| | | | | |
|---|---|----|----|-----|
| Pyrochroidae | | | | |
| <i>Techmessodes</i> sp.1 | D | – | – | 1 |
| Salpingidae | | | | |
| <i>Salpingus bilunatus</i> Pascoe | P | 12 | 4 | 1 |
| <i>Salpingus</i> sp.1 | P | 3 | 1 | 26 |
| Inopeplinae sp. 1 | P | 7 | 5 | 15 |
| Salpingidae spp. | P | 6 | 2 | 11 |
| Anthicidae | | | | |
| Anthicidae sp.1 | D | – | 1 | – |
| Aderidae | | | | |
| “ <i>Xylophilus</i> ” spp. | D | 5 | 13 | 37 |
| Scraptiidae | D | 20 | 32 | 68 |
| Superfamily Chrysomeloidea | | | | |
| Cerambycidae | | | | |
| ? <i>Astetholea</i> sp.1 | D | – | – | 1 |
| <i>Calliprason sinclairi</i> White | D | 4 | – | 2 |
| <i>Eburida sublineata</i> White | D | 5 | 2 | 6 |
| <i>Hydolasius viridescens</i> Bates | D | 1 | 1 | 3 |
| ? <i>Hydolasius</i> sp.1 | D | – | – | 2 |
| <i>Navomorpha sulcata</i> (F.) | D | – | 2 | 1 |
| <i>Oemona hirta</i> (F.) | D | 8 | 5 | 11 |
| <i>Polyacanthia ?flavipes</i> (White) | D | – | – | 2 |
| <i>Psilocnaeia</i> sp.1 | D | – | – | 1 |
| <i>Somatidia antarctica</i> (White) | D | 2 | 3 | – |
| <i>Spilotrogia</i> sp.1 | D | 3 | – | 1 |
| <i>Xylotoles</i> spp. | D | 4 | 2 | 5 |
| <i>Zorion minutum</i> (F.) | D | 2 | 1 | 18 |
| Chrysomelidae | | | | |
| <i>Adoxia vulgaris</i> (Broun) | H | – | – | 15 |
| <i>Eucolaspis</i> spp. | H | – | 25 | 657 |
| <i>Longitarsus</i> spp. | H | – | – | 2 |
| Chrysomelidae sp.1 | H | 1 | – | – |
| Chrysomelidae sp.2 | H | – | – | 1 |
| Superfamily Curculionoidea | | | | |
| Nemonychidae | | | | |
| <i>Rhinorhynchus rufulus</i> (Broun) | H | – | 3 | 1 |
| Anthribidae | | | | |
| <i>Androporus discedens</i> (Sharp) | D | 1 | – | 7 |
| <i>Cacephatus ?huttoni</i> (Sharp) | D | 4 | – | – |
| <i>Cacephatus inertus</i> (White) | D | 1 | – | – |
| <i>Cacephatus ?vates</i> (Sharp) | D | – | – | 1 |
| <i>Dysnocryptus rugosus</i> (Sharp) | D | – | 1 | 4 |
| <i>Hoplorhaphus spinifer</i> (Sharp) | D | 1 | – | 3 |
| <i>Lawsonia variabilis</i> Sharp | D | 1 | – | 8 |
| <i>Lophus rudis</i> (Sharp) | D | – | – | 1 |
| <i>Notochoragus crassus</i> (Sharp) | D | 5 | – | 7 |
| <i>Phymatus hetaera</i> (Sharp) | D | 38 | 8 | 65 |
| <i>Phymatus phymatodes</i> (Redtenbacher) | D | – | – | 3 |
| <i>Pleosporius bullatus</i> (Sharp) | D | 3 | – | 10 |
| <i>Sharpius brouni</i> (Sharp) | D | 5 | 2 | 4 |
| Brentidae | | | | |
| Brentidae sp.1 | H | – | 2 | – |
| Curculionidae | | | | |
| <i>Agastegnus ?simulans</i> (Sharp) | H | 2 | 1 | 1 |

| | | | | |
|--|---|----|-----|----|
| <i>Andracalles horridus</i> (Broun) | H | 23 | 94 | 65 |
| <i>Andracalles ?vividus</i> (Broun) | H | 15 | 344 | 49 |
| <i>Andracalles</i> sp.2 | H | – | 17 | – |
| <i>Dendrotrupes</i> sp.1 | H | – | – | 3 |
| <i>Didymus intutus</i> (Pascoe) | H | 7 | 22 | 18 |
| <i>Hoplocneme ?hookeri</i> (White) | H | – | 4 | 1 |
| <i>Hypocryphalus</i> sp.1 | H | – | – | 2 |
| <i>Listronotus bonariensis</i> (Kuschel) | H | – | – | 1 |
| <i>Microcryptorhynchus ?perpusillus</i> (Pascoe) | H | – | 93 | – |
| <i>Microcryptorhynchus</i> sp.1 | H | 9 | 107 | 8 |
| <i>Notacalles</i> spp. | H | 9 | 1 | 2 |
| <i>Omoecalles crisioides</i> (Broun) | H | 36 | 11 | 7 |
| <i>Pachyops ?dubius</i> (Wollaston) | H | – | – | 6 |
| <i>Pactola ?demissa</i> Pascoe | H | 1 | – | 7 |
| ? <i>Pactola</i> sp.1 | H | – | – | 1 |
| ? <i>Pentarthrum</i> sp.1 | H | 28 | 1 | 5 |
| <i>Phloeophagosoma dilutum</i> Wollaston | H | 15 | – | 17 |
| ? <i>Phloeophagosoma</i> sp.1 | H | 7 | – | – |
| <i>Praoelepra infusca</i> Broun | H | – | 1 | – |
| <i>Psepholax coronatus</i> (White) | H | 3 | – | – |
| <i>Rhopalomerus tenuirostris</i> Blanchard | H | 2 | – | 7 |
| <i>Scalopterus aequus</i> Broun | H | 1 | – | 17 |
| <i>Scolopterus</i> sp.1 | H | 1 | – | 1 |
| <i>Scolopterus</i> sp.2 | H | – | – | 14 |
| <i>Strongylopterus ?hylobiodes</i> (White) | H | – | 2 | – |
| <i>Synacalles hystriculus</i> (Pascoe) | H | 1 | – | 1 |
| <i>Zenoteratus macrocephalus</i> (Broun) | H | 9 | 3 | 5 |
| Cossoninae sp.1 | H | – | 11 | 1 |
| Cossoninae sp.2 | H | – | – | 1 |
| Cossoninae sp.3 | H | 3 | – | 2 |
| Cossoninae sp. 4 | H | 5 | – | – |
| Cossoninae sp.5 | H | 1 | – | – |
| Platypodinae sp.1 | H | – | – | 1 |
| Curculionidae sp.1 | H | – | – | 5 |
| Curculionidae sp.2 | H | 1 | – | – |
| Curculionidae sp.3 | H | 15 | 4 | 29 |
| Curculionidae sp.4 | H | – | – | 4 |
| Curculionidae sp.5 | H | 2 | – | – |
| Curculionidae sp.6 | H | – | – | 1 |

^a P, predator; D, detritivore; H, herbivore. The arrangement of families follows Lawrence and Newton (1995).

Appendix B. Fungus gnats collected from Malaise traps set in three forest fragments in the lower North Island over a 4-week sampling period in December^a

| Taxon | Location of plots | | |
|---------------------------------------|-------------------|---------------|----------------|
| | Denton's Bush | Kirkwell Bush | Rangitawa Bush |
| Family Ditomyiidae | | | |
| <i>Nervijuncta bicolor</i> Edwards | – | – | 2 |
| <i>Nervijuncta hexachaeta</i> Edwards | – | – | 6 |
| <i>Nervijuncta hudsoni</i> (Marshall) | – | – | 1 |
| <i>Nervijuncta marshalli</i> Edwards | 11 | 3 | 7 |

| | | | |
|--|-----|-----|------|
| <i>Nervijuncta nigrescens</i> Marshall | – | – | 24 |
| <i>Nervijuncta nigricornis</i> Tonnoir | – | – | 2 |
| <i>Nervijuncta parvicauda</i> Edwards | – | – | 70 |
| <i>Nervijuncta pulchella</i> Edwards | – | – | 22 |
| <i>Nervijuncta ruficeps</i> Edwards | 20 | 4 | 4 |
| <i>Nervijuncta tridens</i> Hutton | 4 | 6 | 45 |
| <i>Nervijuncta wakefieldi wakefieldi</i> Edwards | – | 1 | 1 |
| <i>Nervijuncta</i> sp.1 | – | – | 3 |
| <i>Nervijuncta</i> sp.2 | 4 | – | – |
| Family Keroplatidae | | | |
| Subfamily Macrocerinae | | | |
| <i>Chiasmoneura (Prochiasmoneura)</i> <i>fenestrata</i> (Edwards) | 176 | 80 | 262 |
| <i>Chiasmoneura (Prochiasmoneura)</i> <i>milligani</i> (Tonnoir) | 5 | 1 | 2 |
| <i>Macrocera scoparia</i> Marshall | 4 | – | – |
| <i>Paramacrocera brevicornis</i> Edwards | 3 | – | – |
| Subfamily Keroplatinae | | | |
| <i>Cerotelion</i> sp.1 | – | – | 2 |
| <i>Isoneuromyia harrisi</i> (Tonnoir) | – | 3 | 4 |
| <i>Neoplatyura lamellata</i> (Tonnoir) | – | – | 6 |
| <i>Neoplatyura marshalli</i> (Tonnoir) | 7 | 2 | 55 |
| <i>Orfelia nemoralis</i> (Meigen) | 1 | 2 | 11 |
| <i>Pyrtaula ohakunensis</i> (Edwards) | 197 | 2 | 127 |
| <i>Pyrtaula rufipectus</i> (Tonnoir) | 176 | – | – |
| <i>Pyrtaula</i> sp.1 | 1 | 2 | 22 |
| <i>Pyrtaula</i> sp.2 | 1 | – | – |
| <i>Rypatula</i> sp. 1 | 2 | 2 | – |
| Family Mycetophilidae | | | |
| Subfamily Sciophilinae | | | |
| <i>Allocotocera dilatata</i> Tonnoir | 152 | 13 | 52 |
| <i>Aneura filiformis</i> Tonnoir | 18 | – | – |
| <i>Aneura fusca</i> Tonnoir | – | 2 | 11 |
| <i>Aneura nitida</i> Tonnoir | 8 | – | – |
| <i>Neoaphelomera forcipata</i> (Edwards) | – | 4 | – |
| <i>Neoaphelomera skusei</i> (Marshall) | 2 | 6 | – |
| <i>Neoaphelomera</i> sp. 1 | – | 7 | – |
| <i>Neoaphelomera</i> sp. 2 | – | – | 2 |
| <i>Parvicellula apicalis</i> Tonnoir | – | – | 1 |
| <i>Parvicellula fascipennis</i> Edwards | 4 | – | – |
| <i>Parvicellula ruficoxa</i> Tonnoir | 98 | 68 | – |
| <i>Phthinia longiventris</i> Tonnoir | 1 | – | 6 |
| <i>Phthinia</i> sp.1 | 9 | 8 | 2 |
| <i>Taxicnemis flava</i> Edwards | 2 | – | – |
| Subfamily Leiinae | | | |
| <i>Anomalomyia guttata</i> (Hutton) | 340 | 296 | 1620 |
| <i>Cycloneura aberrans</i> Tonnoir | 2 | – | – |
| <i>Cycloneura flava</i> Marshall | – | 54 | – |
| <i>Tetragoneura</i> nr. <i>fusca</i> Tonnoir | 44 | 1 | – |
| <i>Tetragoneura obliqua</i> Edwards | 1 | 12 | – |
| <i>Tetragoneura spinipes</i> Edwards | 1 | – | – |
| <i>Tetragoneura ultima</i> Tonnoir | – | – | 5 |

| | | | |
|---|-----|-----|-----|
| <i>Tetragoneura</i> sp.1 | 5 | – | – |
| <i>Tetragoneura</i> sp.2 | 5 | 29 | 40 |
| <i>Tetragoneura</i> sp.3 | 5 | – | 3 |
| <i>Tetragoneura</i> sp.4 | 1 | – | – |
| <i>Tetragoneura</i> sp.5 | – | 1 | – |
| <i>Tetragoneura</i> sp.6 | 2 | – | – |
| <i>Tetragoneura</i> sp.7 | – | – | 3 |
| <i>Tetragoneura</i> sp.8 | 11 | – | 4 |
| <i>Trichoterga monticola</i> Tonnoir | 5 | 2 | 12 |
| Subfamily Manotinae | | | |
| <i>Manota maorica</i> Edwards | 117 | 98 | 104 |
| Subfamily Mycetophilinae | | | |
| <i>Brevicornu maculatum</i> (Tonnoir) | 4 | – | 2 |
| <i>Brevicornu quadriseta</i> (Edwards) | 8 | 23 | 36 |
| <i>Brevicornu</i> sp.1 | – | 8 | – |
| <i>Exechia biseta</i> Edwards | – | 1 | – |
| <i>Exechia filata</i> Edwards | 6 | 2 | 3 |
| <i>Exechia hiemalis</i> (Marshall) | 16 | 15 | 18 |
| <i>Exechia</i> sp.1 | – | – | 2 |
| <i>Mycetophila clara</i> Tonnoir | 1 | – | 5 |
| <i>Mycetophila colorata</i> Tonnoir | 70 | 7 | 44 |
| <i>Mycetophila crassitarsis</i> Edwards | 33 | 20 | 4 |
| <i>Mycetophila dilatata</i> Tonnoir | – | 2 | 81 |
| <i>Mycetophila fagi</i> Marshall | 176 | 108 | 183 |
| <i>Mycetophila filicornis</i> Tonnoir | 80 | 97 | 73 |
| <i>Mycetophila grandis</i> Tonnoir | – | – | 4 |
| <i>Mycetophila</i> nr. <i>harrisi</i> Edwards | 7 | – | – |
| <i>Mycetophila latifascia</i> Edwards | 2 | 2 | 5 |
| <i>Mycetophila marginepunctata</i> Tonnoir | 11 | 1 | 10 |
| <i>Mycetophila marshalli</i> Enderlein | – | 3 | – |
| <i>Mycetophila</i> nr. <i>minima</i> Edwards | – | 1 | 151 |
| <i>Mycetophila nitens</i> Tonnoir | – | 1 | – |
| <i>Mycetophila phyllura</i> Edwards | 1 | 3 | 3 |
| <i>Mycetophila pseudommarshalli</i> Tonnoir | 4 | 1 | 5 |
| <i>Mycetophila solitaria</i> Tonnoir | – | 16 | 12 |
| <i>Mycetophila subspinigera</i> Tonnoir | 200 | 93 | 104 |
| <i>Mycetophila sylvatica</i> Marshall | 1 | – | – |
| <i>Mycetophila trispinosa</i> Tonnoir | 1 | – | – |
| <i>Mycetophila unispinosa</i> Tonnoir | – | – | 6 |
| <i>Mycetophila vulgaris</i> Tonnoir | 2 | 9 | – |
| <i>Mycetophila</i> sp.1 | 9 | 6 | 1 |
| <i>Mycetophila</i> sp.2 | 1 | 2 | – |
| <i>Mycetophila</i> sp.3 | – | 1 | – |
| <i>Platurocypta immaculata</i> (Tonnoir) | 13 | 6 | 5 |
| <i>Zygomia bifasciola</i> Matile | 9 | – | 6 |
| <i>Zygomia costata</i> Tonnoir | 2 | – | – |
| <i>Zygomia</i> nr. <i>fusca</i> Marshall | 12 | 12 | 9 |
| <i>Zygomia penicillata</i> Edwards | 1 | 1 | – |
| <i>Zygomia ruficollis</i> Tonnoir | – | 1 | – |
| <i>Zygomia</i> nr. <i>similis</i> Tonnoir | 1 | – | – |
| <i>Zygomia</i> sp.1 | 15 | 19 | 3 |
| <i>Zygomia</i> sp.2 | 3 | 20 | 8 |
| <i>Zygomia</i> sp.3 | 8 | – | 2 |
| <i>Zygomia</i> sp.4 | – | 1 | 3 |

| | | | |
|---------------------|---|---|---|
| <i>Zygomya</i> sp.5 | 1 | – | – |
| <i>Zygomya</i> sp.6 | 5 | – | – |
| <i>Zygomya</i> sp.7 | – | 1 | – |
| <i>Zygomya</i> sp.8 | – | – | 1 |

^a The classification follows Matile (1990).

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