NIWA

Taihoro Nukurangi

Riparian Vegetation Use by Adult Ephemeroptera, Plecoptera and Trichoptera Alongside some Central North Island Streams

June 1996

NIWA Science & Technology Series No. 34

Cataloguing-in-publication

Collier, Kevin J.
Riparian vegetation use by adult Ephemeroptera, Plecoptera, and Trichoptera alongside some Central North Island streams / Kevin J. Collier and Brian J. Smith. Hamilton, NZ : National Institute of Water and Atmospheric Research Ltd. 1996. (NIWA science and technology series ; 34)

ISSN 1173-0382
ISBN 0-478-08376-9

I, Title. II, Smith, Brian J. III, Series. IV, National Institute of Water and Atmospheric Research Ltd.

This report has been produced by NIWA for the New Zealand Department of Conservation, Science Investigation Number 1867.

The *NIWA Science and Technology Series* is published by NIWA (the National Institute of Water and Atmospheric Research Ltd.), New Zealand. It supersedes *NIWA Ecosystems Publications* (ISSN 1172-3726; published by NIWA Ecosystems, Hamilton), *New Zealand Freshwater Research Reports* (ISSN 1171-9842; published by NIWA Freshwater, Christchurch) and *Miscellaneous Publications, New Zealand Oceanographic Institute* (ISSN 0510-0054).

Available from:

Publications NIWA PO BOX 8602 Christchurch New Zealand Ph. 03 348 8987 Fax 03 348 5548	or:	Publications NIWA PO Box 11-115 Hamilton New Zealand Ph. 07 856 7026 Fax 07 856 0151	or:	Publications NIWA Private Bag 14-901 Kilbirnie, Wellington New Zealand Ph. 04 386 1189 Fax 04 386 2153

NIWA specialises in meeting information needs for the sustainable development of water and atmospheric resources. It was established on 1 July 1992.

Riparian Vegetation Use by Adult Ephemeroptera, Plecoptera and Trichoptera Alongside some Central North Island Streams

Kevin J. Collier
Brian J. Smith

prepared for
Department of Conservation

Information contained within this report should not be used without the prior consent of the client

NIWA
PO Box 11-115
Hamilton, New Zealand
Telephone +64-7-856 7026
Facsimile +64-7-856 0151

June 1996

NIWA Science & Technology Series No. 34

TABLE OF CONTENTS

Reviewed by: Approved for release by:

J.M. Quinn J.C. Rutherford

ABSTRACT

Sticky traps were deployed in 1993/94 alongside three second-order streams bordered by pines (*Pinus radiata*), willow (*Salix* sp.) or native forest (predominantly kanuka, *Kunzea ericoides*) near Whatawhata, Hamilton, to investigate the effect of land-use and riparian vegetation type on adult Ephemeroptera, Plecoptera and Trichoptera faunas (collectively termed EPT). Species richness and numbers of Ephemeroptera, Plecoptera and Trichoptera were highest at the willow site (31 species and 75% of total numbers), followed by the native site (17 species and 19% of numbers) and the pine site (14 species and 6% of numbers). At the pine site, Ephemeroptera (78%) were relatively more abundant than Plecoptera or Trichoptera. Ephemeroptera and Plecoptera were both relatively abundant at the native site (49% and 33%, respectively), while Ephemeroptera and Trichoptera were relatively abundant at the willow site (53% and 44%, respectively). These findings contrast with those of a survey of the benthic invertebrate fauna at 12 Whatawhata sites two years previously.

Sticky traps, Malaise traps and light traps were used in 1994/95 to investigate the distances travelled by adult aquatic insects into native forested riparian zones alongside three contrasting central North Island streams. The total number of insects caught declined sharply with distance from the channel edge such that few individuals (<20% of those caught at 0 m) were generally caught in native forest beyond 30 m from the stream edge. However, relatively high numbers of taxa (>30% of taxa numbers found at 0 m) were caught considerable distances inland (up to 200 m), indicating that a few individuals of several taxa dispersed widely from riparian zones. This study of native forested streams indicates that the main area of activity for adult EPT was within 20-30 m of the stream edge. The presence of a seepage stream in the riparian zone at one site was associated with increased relative abundance and taxonomic richness of adult aquatic insects suggesting that larger riparian zone widths may be desirable where other aquatic habitat types occur within riparian areas.

1. INTRODUCTION

Riparian zones have many ecologically important functions, including the provision of habitat for terrestrial species or phases of animals. The diversity of habitat types available reflects the physical complexity different vegetation types provide, and the degree of change (e.g., occasional flooding) and steepness of environmental gradients (e.g., microclimate, water table) that prevail. Because they support species associated with both terrestrial and aquatic environments, riparian zones tend to be areas of high biodiversity.

The winged adult stages of many aquatic insects live on riparian vegetation where they may actively select streamside trees as preferred sites to complete metamorphosis, to rest while awaiting proper swarming time, to feed in order to produce eggs, or to mate (Jackson & Resh 1989a,b, Sweeney 1993). The chloroperlid stonefly, *Suwallia pallidula*, for example, was found to mate preferentially on leaves of alder (*Alnus* spp.) alongside a creek in Colorado, USA. (Alexander and Stewart 1995), and another stonefly species, *Taenionema atlanticum*, required a diet of maple flowers to initiate mating and differentiation of the ovaries (Sweeney 1993).

Information on the distances travelled by adult aquatic insects is important for formulating recommendations on appropriate widths for riparian zone management, but little is known about this. Our investigation into riparian habitat use by adult aquatic insects was divided into two phases. The first phase was a pilot study to assess the utility of sticky traps alongside streams draining pasture, pine and native forest catchments near Whatawhata, Hamilton. The results of this phase are reported in Collier & Smith (1995). The second phase of the study (described in this report), investigated the distances away from the stream edge travelled by adult Ephemeroptera, Plecoptera and Trichoptera in native forested riparian zones.

Difficulties encountered during the pilot study necessitated some changes to the original contract proposal. Collier & Smith (1995) found that, although the sticky traps used can be a successful method for assessing the composition of the adult aquatic insect fauna where animals are abundant, these traps collected insufficient numbers for statistical analysis of faunas next to the small, forested Whatawhata streams. Furthermore, biomass measurements were not practical due to the difficulty in removing samples from the traps. In response to these problems, the second phase of the work incorporated larger streams outside the Whatawhata area, used additional trapping techniques to increase the catch, and focussed on taxonomic richness and relative abundance of Ephemeroptera, Plecoptera and Trichoptera as indicators of adult aquatic insect activity in riparian zones.

2. METHODS

2.1 Site descriptions

The three study sites are located along second (Whakakai Stream), third (Otahu Stream), and fifth (Tongariro River) order watercourses (70, 20, and 660 m, respectively, above sea level). General locations and map references for the three sites are:

- Whakakai Stream - Whatawhata, Waikato, NZMS260 S14 926785;
- Otahu Stream - Coromandel Peninsula, NZMS 260 T12 618343; and
- Tongariro River - central North Island, NZMS 260 533243.

Mean annual rainfall and air temperature in the regions encompassing the Whakakai and Otahu sites are between 1200 - 1600 mm and 12.5 - 15.0 °C, and in the Tongariro region are in the range 1600 - 2400 mm and 7.5 - 10.0 °C (Wards 1976).

Each study site comprises a section of forest extending 100 m along the channel edge and for 90 or 200 m away from the channel depending on the site characteristics. The Whakakai site extends for 90 m to the top of a steep (c. 40°) hillside, while the Otahu and Tongariro sites span comparatively low gradient slopes but with steeper sections next to the channel or floodplain edges. The Otahu site was extended from a width of 90 m on the initial sampling trip to 200 m away from the channel edge on all other trips. The Tongariro site is 90 m wide and ends near the base of a cliff face; a small stream draining a wetland runs through the riparian zone at about 50 m from the channel edge at this site. All other tributaries are at least 50 m from the boundaries of the three study areas.

The two smaller sites are vegetated predominantly by lowland podocarp-broadleaved forest. Tree ferns (*Dicksonia* and *Cyathea* spp.) and crown ferns (*Blechnum* spp.) form a dense understory beneath *Kunzea ericoides* for about 20 m next to the Whakakai Stream, before grading into a more open forest dominated by *Knightia excelsa*. The Otahu site is dominated for 50-60 m from the stream edge by *Carpodetus serratus*, *Leptospermum scoparium*, and tree ferns, before changing to plantation forest of introduced *Eucalyptus* trees with a groundcover of grass and low ferns. *Nothofagus* forest with an understory mainly of *Weinmannia racemosa* and *L. scoparium* dominates the Tongariro site. Tree canopy height in the study areas was estimated to be between 10 and 20 m except in the plantation forest at the Otahu site where the *Eualyptus* trees are around 30 m high.

2.2 Trap design and deployment

Three types of traps were used in this study: sticky traps, Malaise traps and ultraviolet light traps. Sweep netting was also tried at some sites but yielded few aquatic adults. Sticky traps followed the design of Collier & Smith (1995), and were deployed between November 1994 and February 1995 (Table 1). Sticky traps were attached to trees at a height of approximately 1.5 m along study sites at Otahu Stream and Tongariro River. At these sites, ten replicate traps were deployed at 10 m intervals at distances of 0, 5 and 20 m from the start of riparian forest (typically at the stream edge), except initially in November 1994 at Tongariro where eight traps were deployed at each distance. Additional traps were later put up in December to make ten replicates at each distance at this site. Acetate sheets on the sticky traps were changed on three occasions at intervals of 24-36 days (Table 1).

Malaise traps were deployed only at Whakakai where sticky traps had previously proven ineffective (Collier & Smith, 1995). Traps followed the design of Townes (1972) and Hutcheson (1991). They were constructed of curtain netting (approximately 0.5 mm mesh) and were 1.7 m long by 1.2 m wide. One end of the traps was lower (1.3 m from the ground) than the other (1.6 m) to encourage trapped insects to move towards the higher end where sampling jars were located. The traps had a partition down the middle of the long axis to intercept insects, and this enabled us to separate those moving towards from those moving away from the stream. The central partition and sides were painted black and the corners were attached to the ground using pegs while the upper part of the trap was tied to nearby trees. Three traps were set out at 0 m, 5 m and 20 m from the stream edge. Collecting jars were filled with ethylene glycol and were changed on three occasions at intervals of 24-36 days between November 1994 and February 1995 (Table 1).

Light traps consisted of a 6 watt F6T5 blacklight flourescent tube laid over a white dish (38 x 27 x 6 cm) which was filled with water into which a few drops of detergent had been mixed to break the water surface tension. The lights were powered by 12 volt batteries run from a timing unit which enabled each light to be run on four occasions on each date. Traps were set to run for 0.5 or 1.0 hour intervals depending on the numbers of insects previously caught at a site from 2100, 2300, 0100 and 0300 h in November, December, January and February (see Table 1). The trays and lights were surrounded by a 0.5 m high cylinder of black polythene supported by plastic mesh to limit the lateral influence of the lights and thereby attract insects mostly from the vegetation canopy above. Ten traps were placed at random coordinates on a 10 x10 m grid alongside the streams, usually at 10 m intervals away from the stream edge and at least 20 m from any other trap. We estimated that the lights surrounded by the barriers could potentially attract from a 15 m radius at a tree canopy height of 20 m, so by placing traps at least 20 m apart we minimised the possibility of interference. Light trap distances from the stream edge at Otahu in December, January and February were changed to 0, 10, 20, 30, 40, 50, 70, 100, 150 and 200 m. Sticky traps and Malaise traps were not operating while the light traps were running.

Maximum-minimum thermometers were attached to trees at 0 m and 20 m at each site. Temperatures were recorded when sticky traps or Malaise traps were changed, and overnight minima were also recorded during light trapping (see Table 1).

Table 1 Data on trapping intervals and weather conditions at the three sites between November 1994 and February 1995.

Date trapping began	Site	Trapping method (interval[1])	Min.-max. air temperature (°C)[2]	Minimum over-night air temp-erature (°C)[3]	Overnight weather
11/11/94	Whakakai	L (0.5h)	ND	ND	Fine
10/11/94	Otahu	L (0.5h)	ND	ND	Fine
15/11/94	Tongariro	L (0.5h)	ND	ND	Rain
5/12/94	Whakakai	L (1.0h), M (24d)	4-21	10	Fine
7/12/94	Otahu	L (0.5h), S (27d)	3-24	9	Fine
12/12/94	Tongariro	L (0.5h), S (27d)	0-26	2	Fine
10/1/95	Whakakai	L (1.0h); M (36d)	3-23	10	Rain
12/1/95	Otahu	L (0.5h); S (36d)	6-28	13	Rain
16/1/95	Tongariro	L (1.0h); S (35d)	2-26	14	Cloudy
8/2/95	Whakakai	L (1.0h); M (29d)	9-23	16	Cloudy
7/2/95	Otahu	L (0.5h); S (26d)	12-24	12	Rain
9/2/95	Tongariro	L (1.0h); S (24d)	5-25	14	Rain

[1], light traps (L) were run for 0.5 or 1 hour intervals on four occasions throughout the night; Malaise (M) and sticky (S) traps were left out for 24-36 days.

[2], at stream edge; over period that sticky or Malaise traps were out

[3], at stream edge; relevant for light trapping only

3. RESULTS

3.1 Air temperatures and weather conditions

Maximum-minimum temperatures over the period that sticky traps or Malaise traps were deployed, and minimum temperatures and overnight weather conditions when light traps were deployed are given in Table 1. Temperature ranges were generally similar at all sites for the three months (range of maxima = 21-28°C), although minima tended to increase at equivalent sites from November to February and were always lower at the Tongariro. The weather during light trapping was generally fine or cloudy, although overnight rain is thought to have occurred at Tongariro in December, Whakakai and Otahu in January, and Otahu and Tongariro in February (Table 1).

3.2 Number of taxa caught and their conservation significance

A taxonomic list of the adult aquatic insect species caught at the different sites using sticky traps or light traps is given in Appendices 1 and 2. Five of the Trichoptera species were considered by Collier (1993) to be of potential conservation interest in surface waters of mainland New Zealand. The ecnomid Trichoptera *Ecnomina zelandica* was previously known from only two adult specimens (see Collier 1993, 1994); in this study specimens were collected in one light trap sample and six sticky trap samples up to 100 m away from the edge of Otahu Stream in December and January. The Trichoptera *Cryptobiosella hastata*, previously known from the Egmont Ecological Region (Collier 1993), and also more recently from the East Cape and Buller areas (I.M. Henderson, Massey University, pers. comm.), was collected from a single sticky trap 20 m from the edge of Otahu Stream in January. Another Trichoptera *Polyplectropus impulvii* which is relatively widespread but considered uncommon (Collier 1993), was collected from alongside Tongaririo River in February, and *Hydrobiosis falcis* was also collected at this site but work subsequent to Collier (1993) indicates that this species is relatively widespread. Finally, *Tiphobiosis plicosta*, a Trichoptera which has scattered records throughout the North Island and was considered uncommon by Collier (1993), was found up to 20 m away from Otahu Stream in December and January.

Two other species of Trichoptera in the genus *Tiphobiosis* were also recorded during our study, and although not included in Collier (1993), should also probably be considered of potential conservation interest. *T. veniflex* has been previously recorded from the central North Island (Henderson 1985), and in this study a single specimen was found alongside Tongariro River in December. *?Tiphobiosis* sp.q was collected in December 100 m away from Otahu Stream. It has previously been caught only in the Waitakere Ranges near Auckland; the taxonomic position of this species is uncertain and it may eventually be assigned to a new genus (J. Ward, Canterbury Museum, pers. comm.). An indeterminate species of *Paroxyethira* (*Paroxyethira* sp.d which may also belong to a new genus) was caught 50-90m from Otahu Stream and Tongariro River in January and February, whereas some unusual specimens of *Pycnocentrodes* (possibly a new species informally named *Pycnocentrodes* sp.a) were caught in light traps in November 90 m from Otahu Stream, and in January 20 m from Whakakai.

3.3 Changes in taxonomic richness

During the course of the study, 52 taxa were caught at Whakakai, 60 taxa at Otahu and 61 taxa at Tongariro (Table 2). Most taxa caught by light traps and sticky traps at all sites were Trichoptera (73-76% of total taxa). Similar numbers of taxa were caught in light traps and sticky traps at Otahu (Table 2). In contrast, around half of the number of taxa were caught on sticky traps compared with light traps at the Tongariro, and few taxa were caught in Malaise traps compared with light traps at Whakakai. More Trichoptera taxa were caught in light traps, whereas Malaise and sticky traps generally collected more Ephemeroptera and/or Plecoptera taxa than light traps.

Table 2 Numbers of Trichoptera, Ephemeroptera and Plecoptera taxa caught in different trap types at three sites.

Site/trap type	Trichoptera	Ephemeroptera	Plecoptera	Total
Whakakai light trap	40	6	1	47
Otahu light trap	39	2	0	41
Tongariro light trap	45	6	1	52
Whakakai Malaise trap	1	1	5	7
Otahu sticky trap	28	9	6	43
Tongariro sticky trap	15	7	6	28
Whakakai all traps	40	7	5	52
Otahu all traps	44	9	6	59
Tongariro all traps	46	9	6	61

Taxa richness (no. of taxa) of the Ephemeroptera, Plecoptera and Trichoptera (collectively termed EPT) fauna and the Trichoptera fauna alone on sticky traps declined markedly at 5 m on all sampling occasions (i.e., 95% confidence intervals of box plots at 5 m did not overlap with those at 0 m; Fig. 1). Taxa richness remained at similar low levels at 20 m on all dates except for December when a further significant drop in EPT (Otahu) or Trichoptera (Tongariro) richness between 5 and 20 m was indicated by the non-overlapping 95% confidence intervals (Fig. 1).

Trichoptera richness caught in light traps at three sites on four dates are shown in Figure 2. There was considerable variation in taxonomic richness between dates, but overall a general decline in richness was evident with distance from the channel. However, taxa richness was sometimes high considerable distances from the stream edge, notably in December within the eucalypt plantation forest (60-200 m from channel) at the Otahu site, and in January and February associated with the seepage stream (at 50 m) at the Tongariro site.

It is difficult to compare absolute values of taxonomic richness between dates and sites for each trap type because of the varying times that traps were run for on different occasions and variations in weather conditions (see Table 1). In order to factor out temporal variations, data were standardised by the taxa richness at 0 m on each date (means were used for sticky traps), yielding a value of 1.0 at 0 m. The means over all dates of these standardised values at each distance were then graphed to show generalised patterns in relative taxonomic richness with distance from the channel edge at each site.

This analysis indicated an exponential decline in EPT and Trichoptera taxa richness on sticky traps at both sites, with 30-40% of the taxa at 0 m caught at 5 m and 15-20% of taxa at 20 m (Fig. 3). Standardised light trap data at the three sites indicated a sharp decline overall in Trichoptera taxa richness over 10-40 m, after which relative taxonomic richness remained reasonably constant at Whakakai, or increased in association with the eucalypt plantation forest between 60 and 200 m at Otahu and the seepage stream at around 50 m at the Tongariro (Fig. 4). In light traps at Whakakai and Otahu, more than 30% of the taxa caught at the stream edge were recorded throughout the study area on average (distances of 90-200 m), while at Tongariro >30% of taxa were caught up to 70 m from the channel edge.

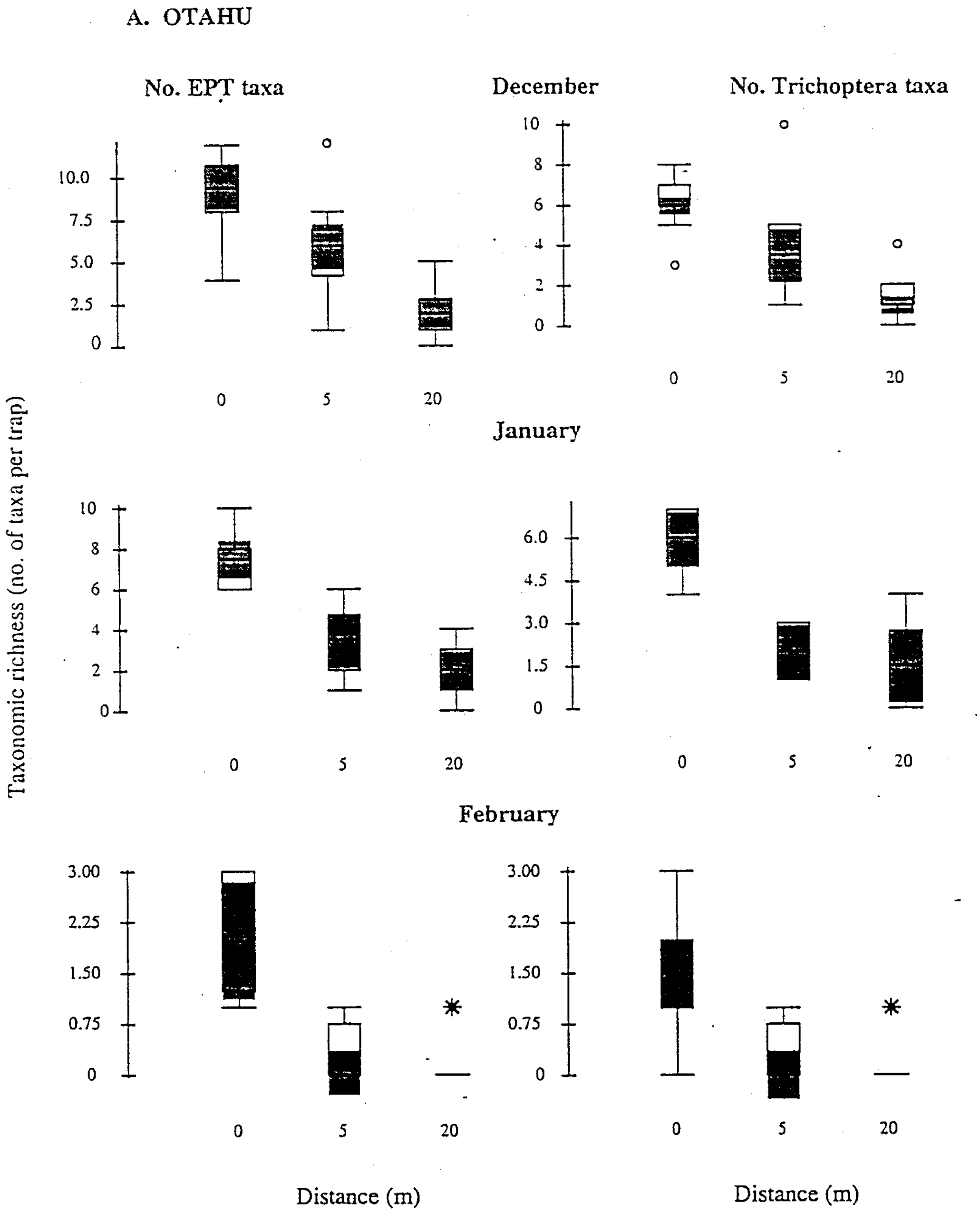
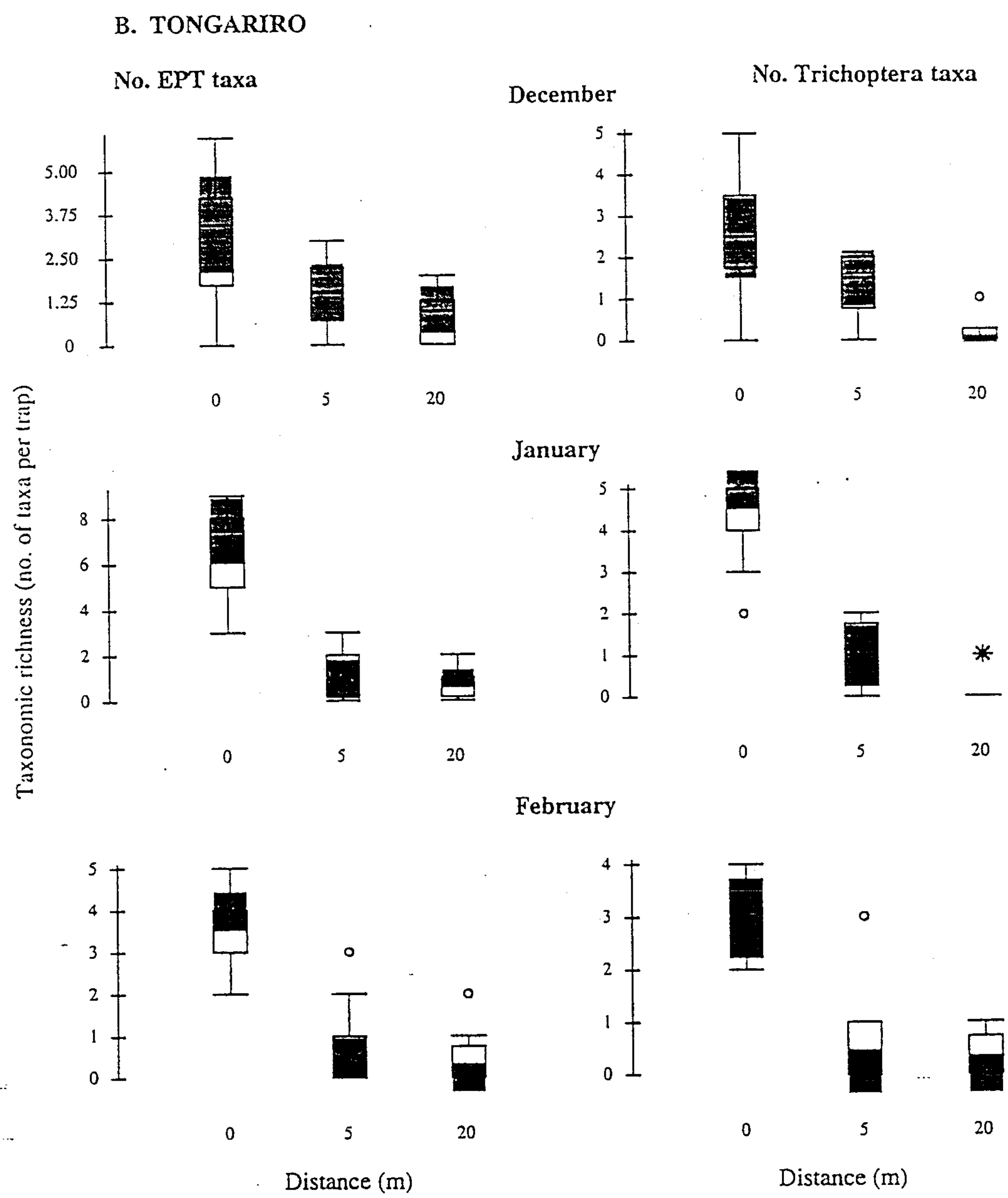


Fig. 1 Box plots of Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa richness or Trichoptera (Trichoptera) taxa richness alone on sticky traps at 0, 5 and 20 m from the channel edge at two sites on three dates (see Table 1). The upper and lower horizontal lines represent the upper and lower extremes of the "connected" data points, and the upper and lower edges of the "box" between the extremes represent the 75 and 25 %iles, respectively (i.e., 50% of the data points fall within this range). The horizontal line inside the box is the median. The hatched area superimposed upon this is the 95% confidence interval (i.e., there is a 95% chance that the median of a comparable dataset would lie in this range). The circles and asterisks denote outliers and extreme outliers, respectively.


B. TONGARIRO
No. EPT taxa
No. Trichoptera taxa
December
January
February
Taxonomic richness (no. of taxa per trap)
0
1.25
2.50
3.75
5.00
0
5
20
Distance (m)
Distance (m)

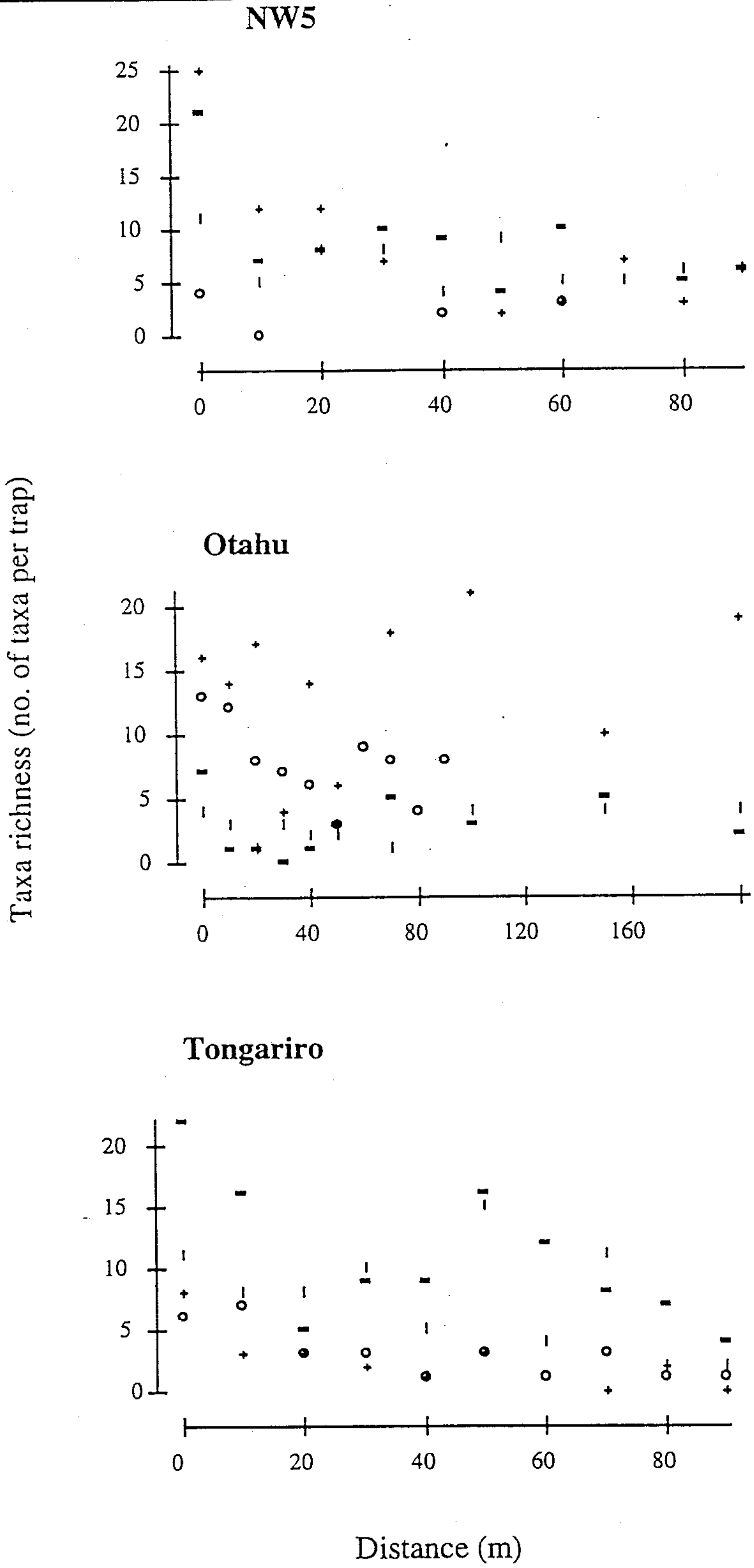


Fig. 2 Scatterplots of Trichoptera taxa richness in light traps at different distances from the stream edge at three sites on four dates (o=November, +=December, |=January, -=February).

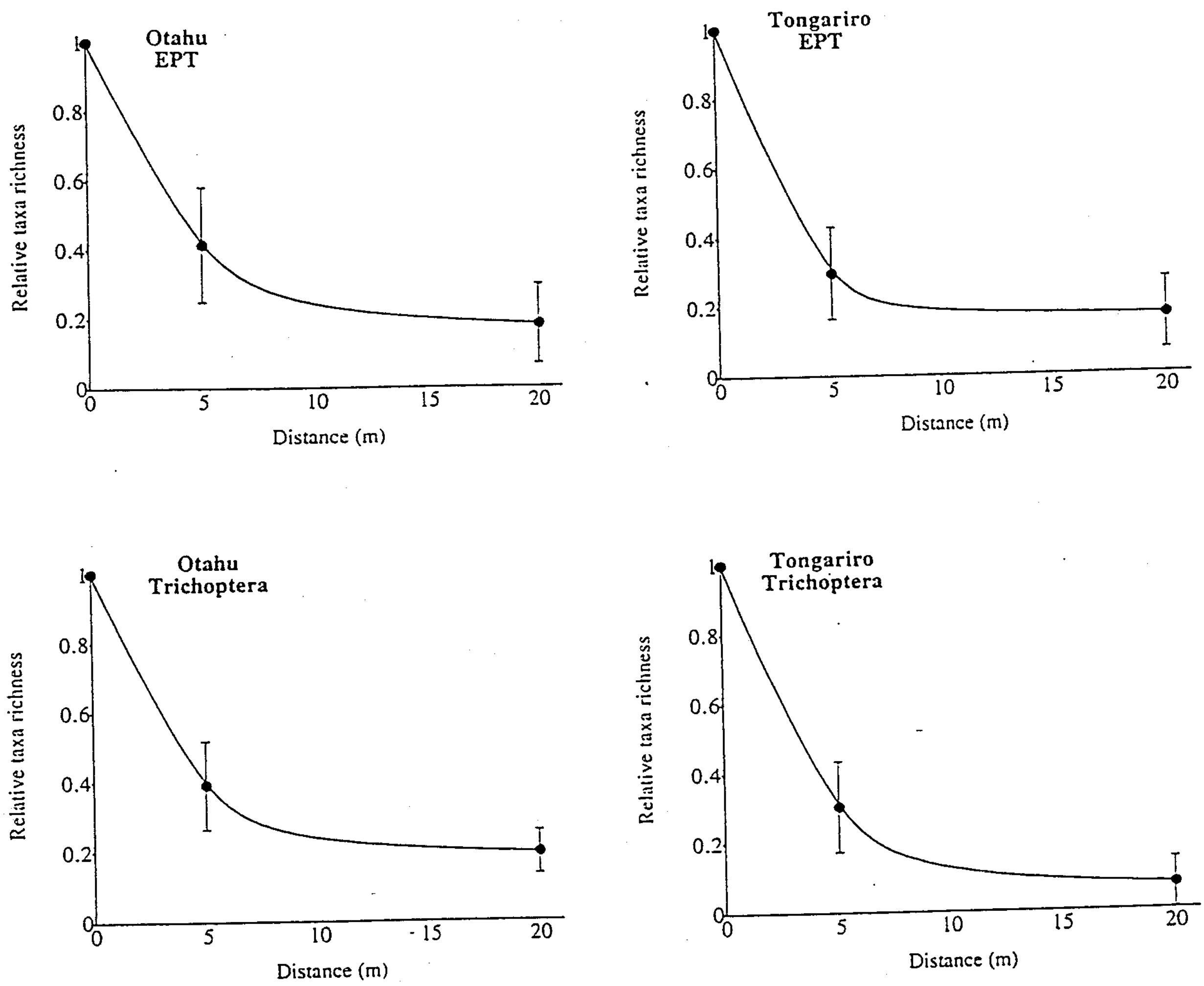


Fig. 3 Mean (± 1SE) EPT or Trichoptera taxa richness on sticky traps at three distances from the channel edge at two sites standardised by taxa richness at 0 m for December 1994 to February 1995.

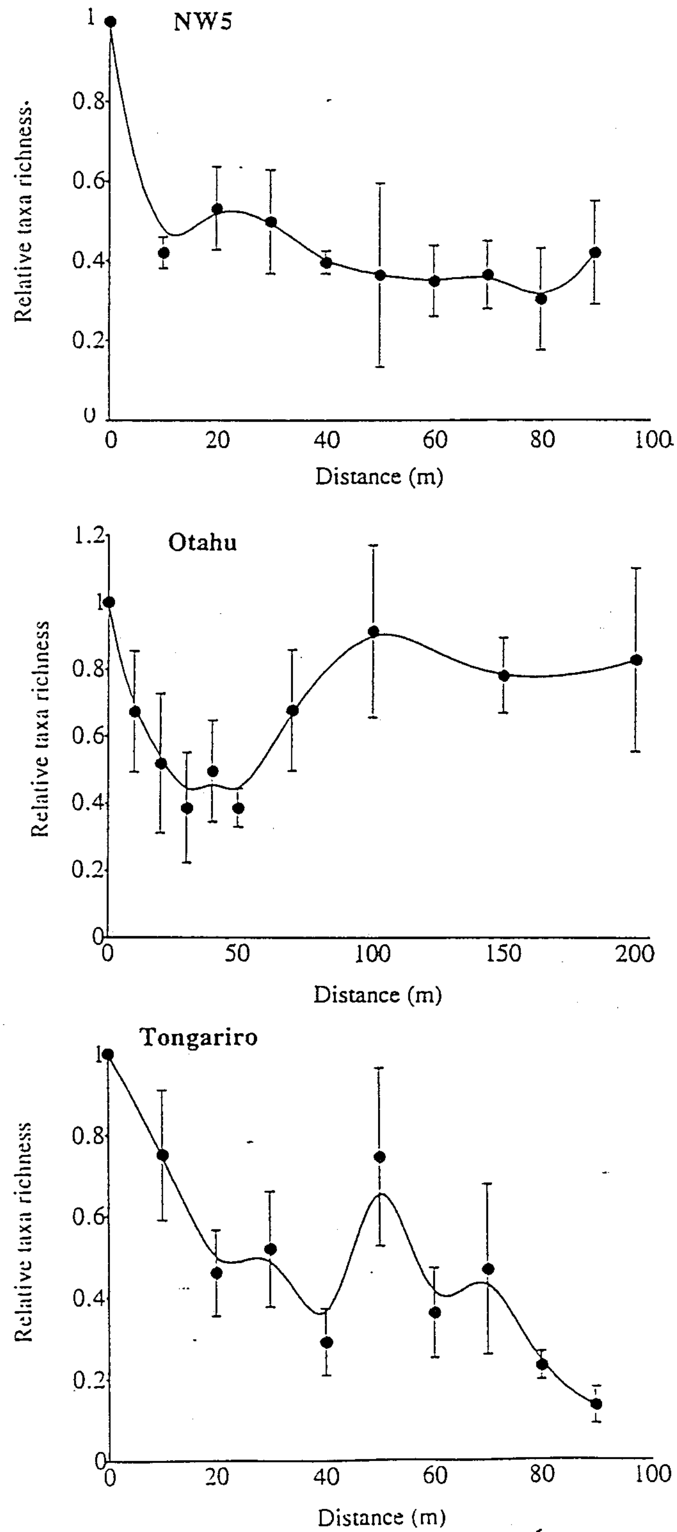


Fig. 4 Mean (± 1SE) EPT or Trichoptera taxa richness in light traps at ten distances from the channel edge at three sites standardised by taxa richness at 0 m for November 1994 to February 1995.

3.4 Changes in abundance

EPT faunas on sticky traps were dominated numerically by Trichoptera at Otahu (90% of numbers caught in all samples combined) and Tongariro (89% of numbers caught). Plecoptera made up 9% of numbers caught on sticky traps at the Tongariro, whereas Ephemeroptera and Plecoptera comprised <6% of numbers at Otahu.

As with taxonomic richness, total abundance (no. per trap) of EPT caught on sticky traps declined markedly at 5 m on all sampling occasions (95% confidence intervals of box plots at 5 m did not overlap with those at 0 m; Fig. 5), and remained at similar low levels at 20 m on all dates except at the Tongariro in December where Trichoptera abundance declined significantly between 5 and 20 m. Trichoptera abundance in light traps at three sites on four dates is shown in Figure 6. Despite the varying times that light traps were run for and variations in overnight weather conditions (see Table 1), few Trichoptera were consistently caught at Whakakai or Tongariro River further than 10 m from the channel edge. At Otahu Stream, Trichoptera abundance in November and December declined up to around 40 m from the channel edge, and in December increased again within the eucalypt plantation forest.

Data standardised by the number caught at 0 m on each date are shown in Figures 7 and 8. As with taxonomic richness, relative abundance of Trichoptera and EPT on sticky traps declined exponentially with distance from the channel edge at Otahu and Tongariro, although the rate of decline was sharper with <20% of numbers caught at 0 m being recorded 5 m from the edge. Standardised light trap data indicated an exponential decline in Trichoptera abundance over 0-40 m from the channel edge at all sites. The rate of decline varied between sites but, as with the sticky trap results, it was more rapid than for taxonomic richness. On average, less than 20% of numbers caught at 0 m were found at 10 m at Whakakai, 20 m at Otahu and 30 m at Tongariro, suggesting that there may be a relationship between stream size and distance travelled by the insects. Relative abundance remained low after 10 m at Whakakai, whereas at the Otahu it increased slightly in association with the eucalypt forest, and at the Tongariro mean relative abundance increased at the seepage stream (although the variation was large), before declining again.

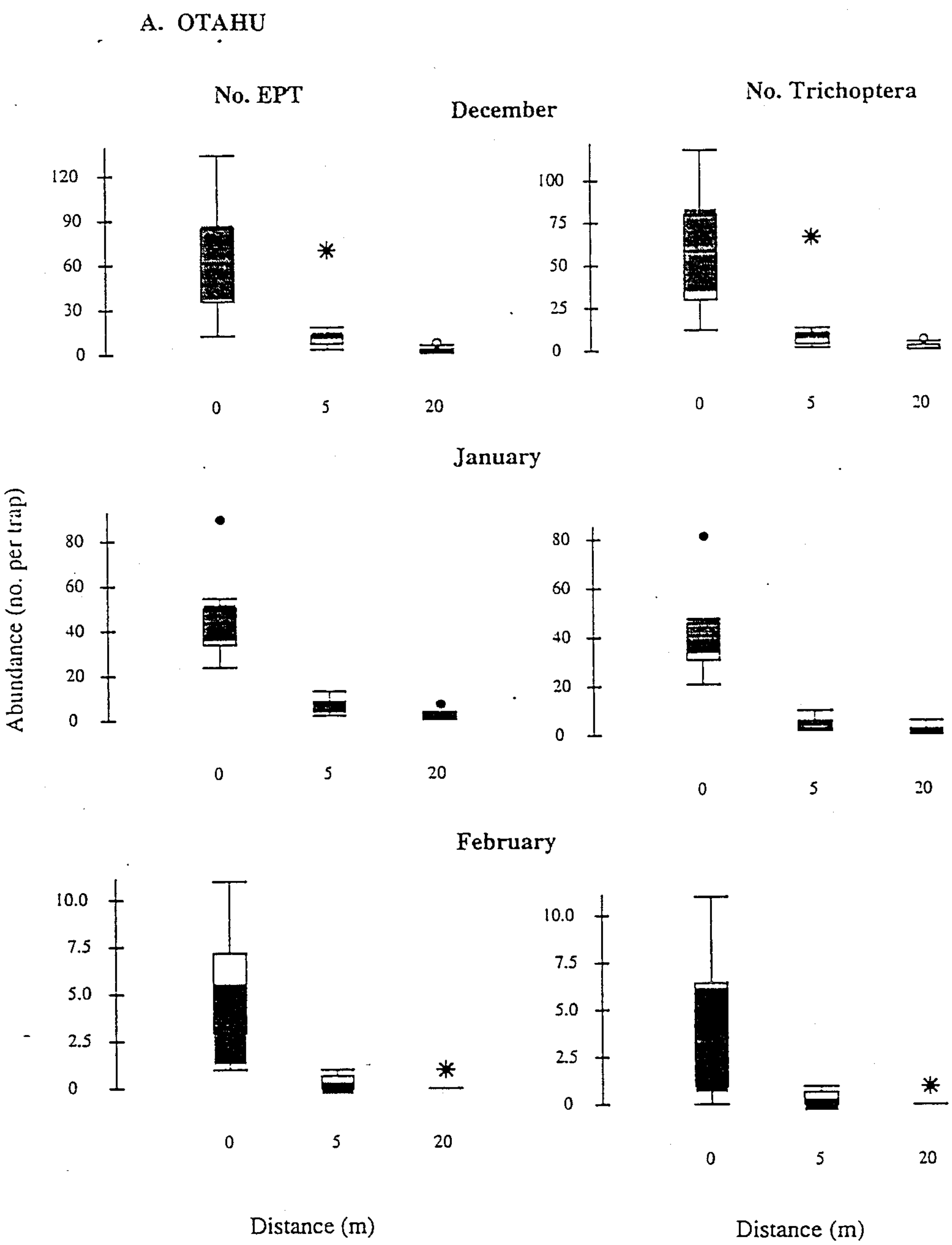
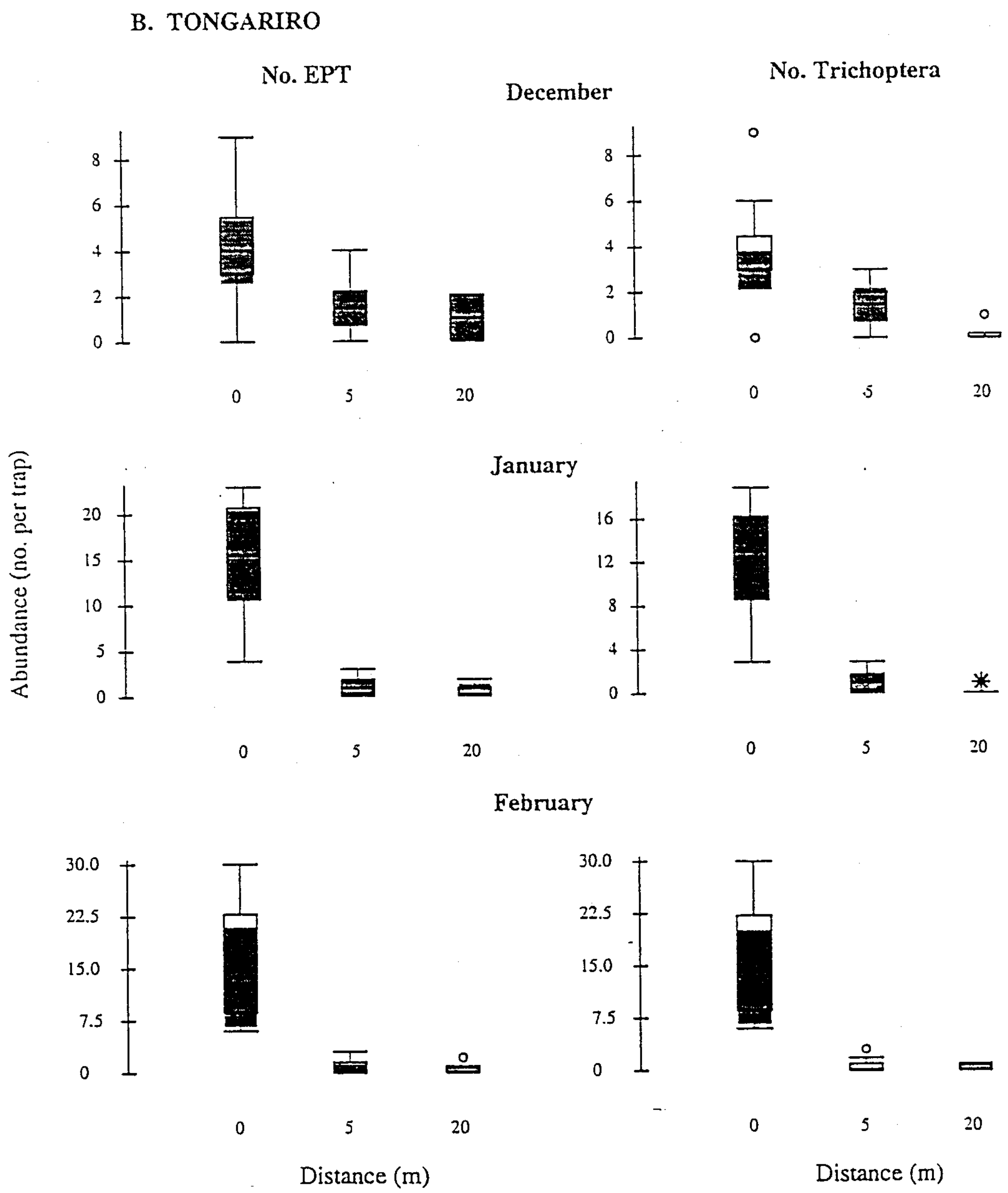


Fig. 5 Box plots of the abundance (no. per trap) of Ephemeroptera, Plecoptera and Trichoptera (EPT) or Trichoptera (Trichoptera) alone caught on sticky traps at 0, 5 and 20 m from the channel edge at two sites on three dates (see Table 1). See Fig. 1 for explanation of box plots.


B. TONGARIRO
No. EPT
No. Trichoptera
December
January
February
Abundance (no. per trap)
0
5
20
Distance (m)

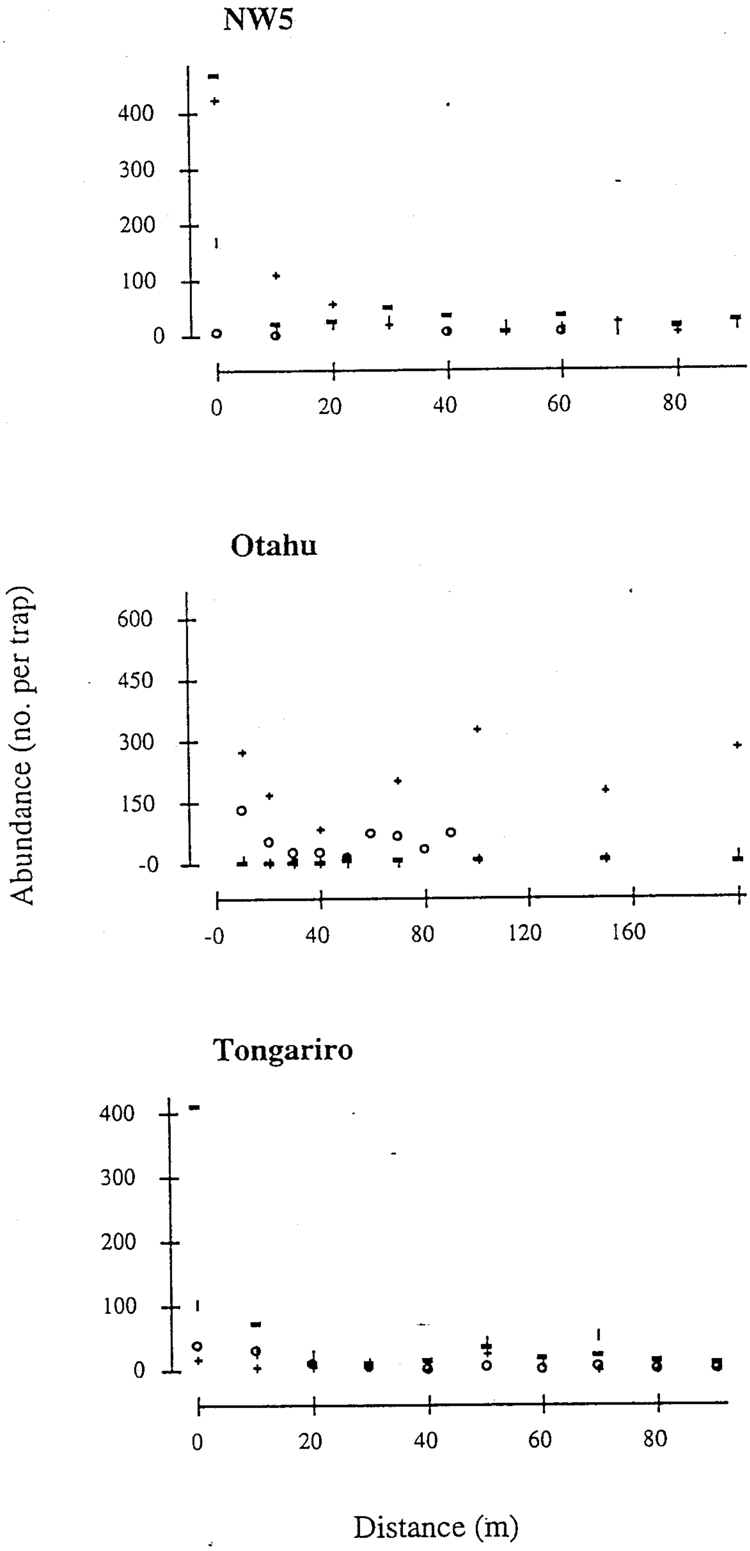


Fig. 6 Scatterplots of the abundance of Trichoptera caught in light traps at different distances from the stream edge at three sites on four dates (o=November, +=December, |=January, -=February).

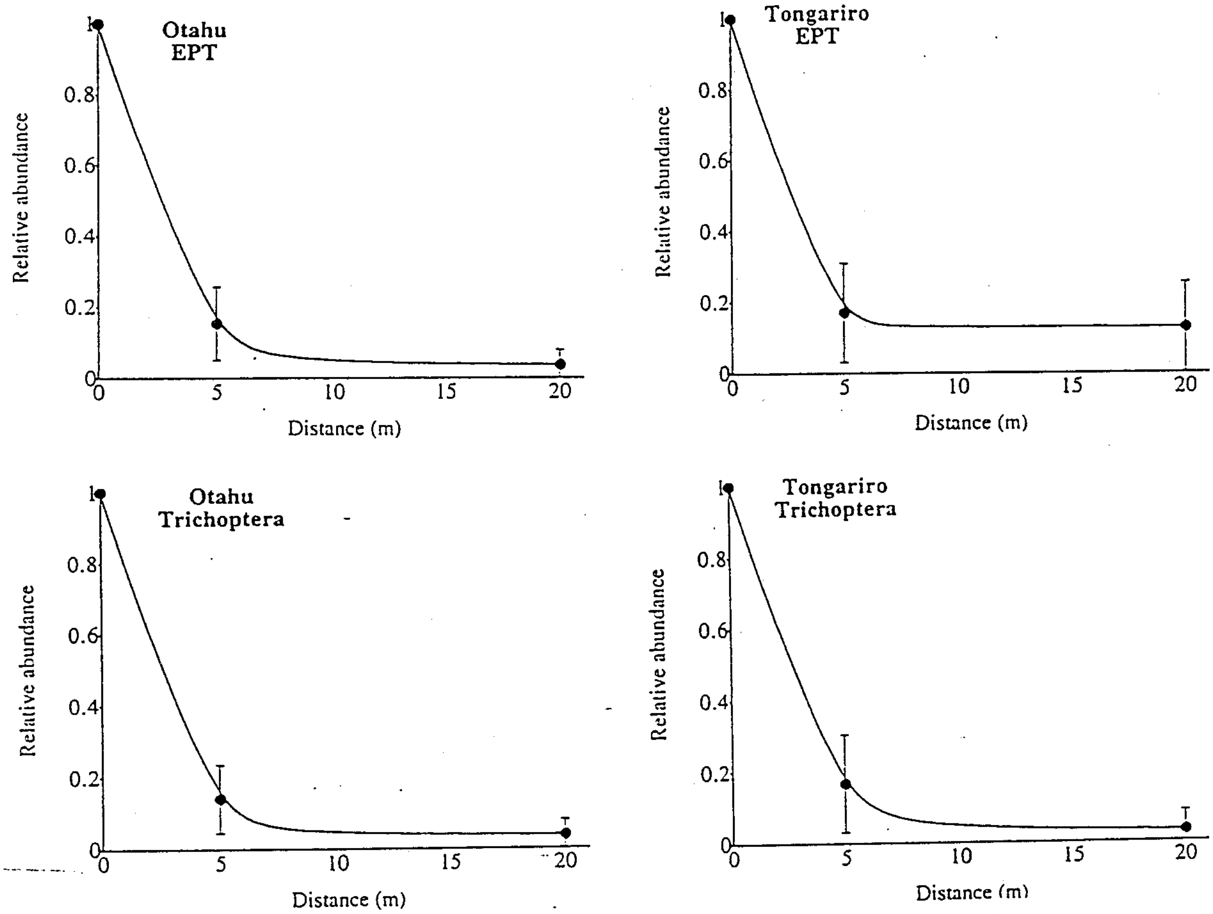


Fig. 7 Mean (± 1SE) abundance of EPT or Trichoptera caught on sticky traps at three distances from the channel edge at two sites standardised by the abundance at 0 m for December 1994 to February 1995.

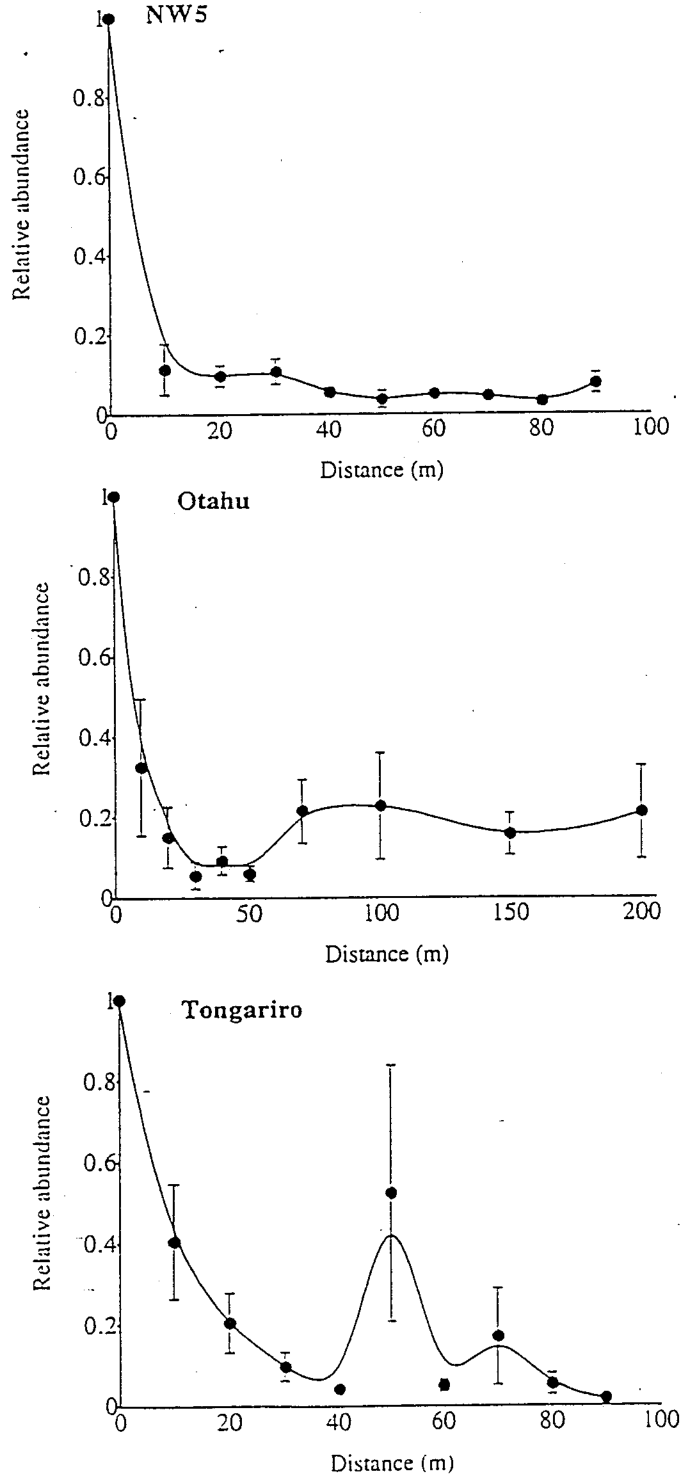


Fig. 8 Mean (± 1SE) abundance of EPT or Trichoptera caught in light traps at ten distances from the channel edge at three sites standardised by the abundance at 0 m for November 1994 to February 1995.

4. DISCUSSION

4.1 Effect of catchment type

During the course of the pilot study by Collier & Smith (1995), most species and highest numbers of Ephemeroptera, Plecoptera and Trichoptera were caught at the willow site (which had 50% of its headwaters in native forest), followed by the native site and then the pine site. The taxonomic composition of the adult EPT fauna also differed between sites. Ephemeroptera and Trichoptera were relatively common (both numerically and in terms of species richness) at the willow site, while Plecoptera and/or Ephemeroptera dominated numbers at the native and pine sites.

These findings contrast with those of a survey of the benthic invertebrate fauna at 12 Whatawhata sites two years previously. No comparable willow sites were sampled in that survey. In contrast to our findings for the adult insects, taxa numbers of the benthic faunas in 1992 were dominated by Ephemeroptera and Plecoptera (each 44% of total taxa) at the same pine site we sampled, and by Ephemeroptera at two native sites upstream of our site on the Whakakai (60-70% of total taxa). Ephemeroptera dominated the benthos numerically at the pine site (84% of individuals; predominantly *Deleatidium* sp., *Coloburiscus humeralis* and *Zephlebia dentata*) and the two upstream native sites (87-93%; mainly *Deleatidium* sp.). The Trichoptera *Orthopsyche fimbriata*, *O. thomasi*, *Psilochorema*, *Hydrobiosis parumbripennis*, *Pycnocentria evecta* and *Triplectides obsoleta*, the Plecoptera *Zelandobius furcillatus*, and the Ephemeroptera *Acanthophlebia cruentata* and *Ameletopsis perscitus* were recorded in the benthos in 1992 but were not recorded as adults on sticky traps in 1993/94 at the pine site. The Ephemeroptera *Mauiulus luma*, *Zephlebia borealis*, *Z. inconspicua*, *Z. planulata* and *Z. versicolor*, the Trichoptera *Helicopsyche zealandica* and *Zelandoptila moselyi* were recorded on sticky traps but not in benthic samples at this site.

Differences in benthic and adult insect faunas collected the two studies may partly reflect:

1. variations in the complement of species present at different sampling sites on the same stream or between different years;
2. the integration of a wider range of instream habitats when sampling adults compared to the benthic sampling of "runs" to obtain larvae;
3. selective sampling of the adult fauna by sticky traps which rely on intercepting flying insects (e.g., poor representation of Hydropsychidae on sticky traps may be because adults are stationary swarmers).
4. taxonomic difficulties with keying out larvae;
5. interception of species breeding in seepages or other water bodies close to the targeted area or dispersing from elsewhere along the stream.

In the study of Quinn *et al.* (1994), streams draining pasture catchments contained much lower densities of benthic Ephemeroptera, Plecoptera and Trichoptera compared with pine or native forest streams. None of the pasture streams sampled in that study were lined by riparian trees, and entire catchments were developed for farming. This contrasts with the situation in our study where the "willow" stream flowing through pasture was shaded and half of the catchment area upstream was in native forest. These factors probaably contributed to increased instream production of Ephemeroptera, Plecoptera and Trichoptera at the willow site, and consequently greater numbers and species richness of adults than at the pine or native sites.

Further adult insect work is required at a wider range of sites before the reasons for differences between benthic and adult insect data can be explained. Additional light trapping and collection of benthic samples was carried out at 3 pasture, 3 pine, 3 native forest sites at Whatawhata over the 1994/95 summer to help resolve this issue, and provide more conclusive data on the link between land use and the taxonomic composition and relative abundance of the adult Trichoptera fauna. The results of this work will be available shortly.

4.2 Distance travelled from the stream edge

The study of dispersal distances at three contrasting central North Island sites bordered by native forest described in this report indicated that taxonomic richness and relative abundance of the adult aquatic insect fauna declined exponentially with distance from the channel edge. Most insects were collected between 0 and 30 m depending on the site and the type of trap. Sticky traps tended to collect fewer insects than light traps, probably due to the smaller trapping area and passive mode of collection of sticky traps (cf the UV light traps which could potentially attract Trichoptera from a large area above the barriers). Despite these differences, both trap types indicated a more rapid decline in abundance compared to taxonomic richness with distance away from the channel edge, suggesting that a few individuals of several taxa do travel widely within riparian zones.

There was also some indication that stream size affected the rate of decline with distance from the stream edge, at least of the Trichoptera fauna in light traps. Thus, relative abundance and taxa richness declined less sharply with distance from the stream edge in the order of increasing channel size: Whakakai-Otahu-Tongariro (see Figs. 4 and 8). This suggests that the widths of native forested riparian zones required to accomodate adult Trichoptera at least may increase with stream size. However, more work at a wider range of sites and down stream continua is necessary before this can be verified.

Increases in the relative abundance and taxonomic richness of adult Trichoptera faunas in light traps were observed in association with the eucalypt plantation forest at Otahu and the riparian seepage stream at the Tongariro. The apparent effect of forest type may be an artifact of forest architecture with the light traps being more efficient in the more open eucalypt forest. However, the increase associated with the seepage stream, which was surrounded by native forest, is more likely to be due to the emergence or association of several Trichoptera species with this riparian habitat type. This suggests that widths of riparian management zones may need to be wider where other aquatic habitat types occur within riparian zones.

5. CONCLUSIONS AND RECOMMENDATIONS

- Taxonomic richness and abundance of adult aquatic insects declined sharply with distance from the channel edge in native forested riparian zones, althought a few individuals of several taxa penetrated relatively long distances from the stream edges (up to 200 m). The ecological significance of these "good dispersers" is worthy of investigation.

- Adult insects were mostly active within 20-30 m of the edge of the streams studied, suggesting that native forested riparian management zone widths of this size range should provide habitat for most adult aquatic insects.

- Biodiversity and relative abundance of adult aquatic insects may be influenced by the presence of seepage streams in the riparian zone. Larger management zone widths may be required where other aquatic habitats occur within riparian areas.

- Further work is required to determine the relationship between stream size and distance from the channel edge travelled by adult aquatic insects. Additional work is planned in the near future to quantify the riparian habitat requirements of some common adult insect species in terms of microclimate and plant species.

6. ACKNOWLEDGEMENTS

Thanks to the Tongariro/Taupo and Waikato Conservancies of the Department of Conservation for giving permission to sample at the study sites. Geoff Latimer and Norm Wood assisted with development of the light trapping equipment. Taxonomic advice was provided by Dave Towns, Ian McLellan and, in particular, John Ward. Brenda Baillee assisted with field work. The study was funded by the Department of Conservation and the Foundation for Research, Science and Technology. Comments on a draft report were kindly made by John Quinn, Kit Rutherford, Rob McColl and an anonymous referee. Kath MacLeod and Leanne Moyes assisted with report preparation.

7. REFERENCES

Alexander, K.D. and K.W. Stewart. 1995. Description of mate searching and other adult behaviours of *Suwallia pallidula* (Plecoptera: Chloroperlidae) from Quartz Creek, Colorado (Abstract). Bulletin of the North American Benthological Society 12 (1):92.

Collier, K. J. 1993. Freshwater macroinvertebrates of potential conservation interest. Scienc and Research Series no. 50. Department of Conservation, Wellington.

Collier, K. J. 1994. Review of the status, distribution, and conservation of freshwater invertebrates in New Zealand. *New Zealand Journal of Marine and Freshwater Research 27*: 339-356.

Collier, K.J.; Smith, B.J. 1995. Sticky trapping of adult Ephemeroptera, Plecoptera and Trichoptera alongside three contrasting streams near Hamilton, New Zealand. *New Zealand Natural Sciences 22:* 1-9.

Henderson, I.M. 1985. Systematic studies of New Zealand Trichoptera and critical analysis of systematic methods. Unpubl. Ph.D. thesis, Victoria University of Wellington.

Hutcheson, J 1991. Malaise trap collection jar: a cheap simple modification. *New Zealand Entomologist 14*: 48-49.

Jackson, J.K. and V.H. Resh. 1989a. Activities and ecological role of adult aquatic insects in the riparian zone of streams. USDA Forest Service Gen. Tech. Rep. PSW-110. pp 342-345.

Jackson, J.K.; Resh, V.H. 1989b. Distribution and abundance of adult aquatic insects in the forest adjacent to a northern Californian stream. *Environmental Entomology 18*: 278-283.

Quinn, J.M., Cooper, A.B., Davies-Colley, R.J., Rutherford, J.C. & Williamson, B. 1994. Land-use effects on New Zealand hill country streams and implications for riparian management. Proceedings of the International Workshop on the Ecology and Management of Aquatic-Terrestrial Ecotones, University of Washington, Seattle, February 14-19, 1994.

Sweeney, B.W. 1993. Effects of streamside vegetation on macroinvertebrate communities of White Clay Creek in eastern North America. Proceedings of The Academy of Natural Sciences of Philadelphia 144:291-340.

Townes, H. 1972. A light-weight Malaise trap. *Entomological News 83*: 239-247.

Wards, I. (ed.) 1976: New Zealand atlas. A. Shearer, Government printer, Wellington.

Appendix 1 Taxonomic list of Trichoptera, Plecoptera and Ephemeroptera caught on sticky traps at 0, 5 and 20 m from the channel edge over three months (D=November-December, J=December-January, F=January-February). Total number of samples (traps) = 88 for Otahu and 84 for Tongariro.

Otahu Stream:

Species	Months	Distances	No. of samples
TRICHOPTERA			
Hydropsychidae			
Aoteapsyche colonica (McLachlan)	D, J, F	0, 5, 20	27
A. raruraru (McFarlane)	D	5	2
Hydroptilidae			
Oxyethira albiceps (McLachlan)	D, J	0, 5	8
Ecnomidae			
Ecnomina zealandica Wise	D, J	0, 5, 20	6
Psychomyiidae			
Zelandoptila moselyi Tillyard	J	0	1
Hydrobiosidae			
Hydrobiosis gollanis Mosely	J	0	2
H. parumbripennis McFarlane	D	5	1
Neurochorema armstrongi McFarlane	D	5	1
N. confusum (McLachlan)	D, J	0, 5	5
Psilochorema mimicum McLachlan	J	0	2
T. plicosta McFarlane	D, J	0, 20	4
Philopotamidae			
Cryptobiosella hastata Henderson	J	20	1
Hydrobiosella mixta Cowley	D, J	5, 20	3
Helicopsychidae			
Helicopsyche albescens Tillyard	D, J	0, 5, 20	19
H. zealandica Hudson	J	20	1
Oeconesidae			
Oeconesus maori McLachlan	D, J	0, 20	3
Pseudoeconesus sp.a	D, J, F	0, 5, 20	13
Leptoceridae			
Hudsonema amabilis (McLachlan)	D	0	1
Oecetis unicolor (McLachlan)	J	0	1
Tiplectides dolichos McFarlane	D, J	0, 20	2
T. obsoleta McLachlan	D	0, 5	2
Helicophidae			
Zelolessica cheira McFarlane	D	5	1
Conoesucidae			

Species	Months	Distances	No. of samples
Baeroptera roria Mosely	D, J	0, 5	24
Confluens hamiltoni (Tillyard)	D	0	1
Olinga feredayi (McLachlan)	D, F	0, 5	4
Pycnocentria evecta McLachlan	D. J	0	3
Pycnocentrodes aeris Wise	D, J, F	0, 5	29
P. aureola (McLachlan)	D, J, F	0, 5, 20	57
PLECOPTERA			
Gripopterygidae			
Acroperla trivacuata (Tillyard)	J	5	1
Nesoperla fulvescens (Hare)	D	0	2
Zelandobius confusus (Hare)	F	0	1
Z. furcillatus Tillyard	D, J	0, 5, 20	23
Zelandoperla decorata Tillyard	D	0	1
Notonemouridae			
Spaniocerca zelandica Tillyard	D, J	5, 20	2
EPHEMEROPTERA			
Leptophlebiidae			
Austroclima sp.	J	20	1
Deleatidium spp.	D, F	0, 20	6
Neozephlebia scita (Walker)	D	0, 5, 20	3
Zephlebia borealis (Phillips)	J	20	1
Z. dentata (Eaton)	D, J	0, 5	4
Z. spectabilis Towns	D, J, F	0, 5, 20	10
Z. versicolor (Eaton)	J	0	1
Oligoneuriidae			
Coloburiscus humeralis (Walker)	D, J	0, 5, 20	27
Siphlonuridae			
Rallidens mcfarlanei Penniket	F	0	2

Tongariro River:

Species	Months	Distances	No. of samples
TRICHOPTERA			
Hydropsychidae			
Aoteapsyche colonica (McLachlan)	D, J, F	0, 5, 20	26
A. tepoka (Mosely)	D, J	0, 5	12
Hydroptilidae			
Oxyethira albiceps (McLachlan)	D	0, 5	3
Hydrobiosidae			
Costachorema xanthoptera McFarlane	D, J	0	5
Edpercivalia thomasoni (McFarlane)	F	5	1
Hydrobiosis parumbripennis McFarlane	D, J	0, 5, 20	8
Neurochorema armstrongi McFarlane	D, J, F	0, 5, 20	26
Polycentropiidae			
Plectrocnemia maclachlani Mosely	F	0, 5	2
Polyplectropus altera McFarlane	D	0	1
Helicophidae			
Zelolessica cheira McFarlane	D, J, F	0	13
Conoesucidae			
Baeroptera roria Mosely	D, J, F	0, 5	19
Olinga feredayi (McLachlan)	F	0, 20	2
Pycnocentria funerea McLachlan	J	0	1
Pycnocentrodes aeris Wise	J	0	1
P. aureola (McLachlan)	F	0	1
EPHEMEROPTERA			
Leptophlbiidae			
Austroclima jollyae Towns & Peters	J	0	1
Deleatidium spp.	D, J	0, 20	4
Mauiulus luma Towns & Peters	J	0	1
Neozephlebia scita (Walker)	D, J, F	5, 20	8
Zephlebia dentata (Eaton)	J	0	1
Z. spectabilis Towns	F	0	1
Oligoneuriidae			
Coloburiscus humeralis (Walker)	F	0, 5, 20	3
PLECOPTERA			
Austroperlidae			
Austroperla cyrene (Newman)	J	5, 20	2
Gripopterygidae			
Acroperla spiniger Tillyard	J	0	1

Species	Months	Distances	No. of samples
A. trivacuata (Tillyard)	D, J	0, 5	9
Zelandobius furcillatus Tillyard	D, J, F	0, 5, 20	12
Zelandoperla agnetis McLellan	D, J	0	3
Notonemouridae			
Spaniocerca zelandica Tillyard	J	20	1

Appendix 2 Taxonomic list of Trichoptera, Plecoptera and Ephemeroptera caught on sticky traps at 0, 5 and 20 m from the channel edge over three months (D=November-December, J=December-January, F=January-February). Total number of samples (traps) = 32 for Whakakai, 40 for Otahu and 39 for Tongariro.

Whakakai:

Species	Months	Range of distances	No. of samples
TRICHOPTERA			
Hydropsychidae			
Aoteapsyche sp.x	D	0	1
A. colonica (McLachlan)	D, J, F	0-90	6
A. raruraru (McFarlane)	D, J	0-50	3
Orthopsyche fimbriata (McLachlan)	D, J, F	0	3
Hydroptilidae			
Oxyethira albiceps (McLachlan)	N, D, J, F	0-90	22
Paroxyethira hendersoni Mosely	D, J, F	10-90	8
Psychomyiidae			
Zelandoptila moselyi Tillyard	D	0	1
Hydrobiosidae			
Costachorema hecton McFarlane	D	10	1
C. xanthoptera McFarlane	J	20-30	2
Hydrobiosis sp.c	D, F	20-40	2
H. budgei McFarlane	D	0	1
H. gollanis Mosely	D, F	0-10	3
H. parumbripennis McFarlane	N, D, J, F	0-90	17
H. soror Mosely	D, J, F	0-90	7
H. styracine McFarlane	D, F	0-50	3
H. umbripennis McLachlan	D, J, F	0-70	6
Neurochorema confusum (McLachlan)	D, F	0-50	4
Psilochorema donaldsoni McFarlane	D	0-30	2
P. leptoharpax McFarlane	J	0	1
P. mimicum McLachlan	D	0	1
Philopotamidae			
Hydrobiosella mixta Cowley	J, F	20-80	3
Polycentropiidae			
Plectrocnemia maclachlani Mosely	F	0	1
Polyplectropus altera McFarlane	N, D, J, F	0-90	15
P. aurifusca McFarlane	N, D, F	0-60	5
Helicopsychidae			
Helicopsyche albescens Tillyard	D	0	1
H. zealandica Hudson	D, J, F	0-90	9
Oeconesidae			
Oeconesus maori McLachlan	D	70	1
Pseudoeconesus sp.a	J	40	1
Leptoceridae			
Hudsonema amabilis (McLachlan)	D, F	0	2
Oecetis unicolor (McLachlan)	J, F	0-20	2
Triplectides dolichos McFarlane	N, D, J, F	0-80	7
T. obsoleta (McLachlan)	J	30	1

Species	Months	Range of distances	No. of samples
Conoesucidae			
Baeroptera roria Mosely	D	0-20	2
Confluens hamiltoni (Tillyard)	D, J, F	0-80	8
Olinga feredayi (McLachlan)	D, J, F	0-90	22
Pycnocentria evecta McLachlan	D, J	0-90	5
P. gunni (McFarlane)	J	30	1
Pycnocentrodes sp.a	J	20	1
P. aeris Wise	D, J, F	0-90	7
P. aureola (McLachlan)	N, D, J, F	0-90	21
EPHEMEROPTERA			
Ephemeridae			
Ichthybotus hudsoni (McLachlan)	J	0	1
Leptophlebiidae			
Acanthophlebia cruentata (Hudson)	F	0	1
Deleatidium spp.	F	0	1
Zephlebia borealis (Phillips)	N	0	1
Z. dentata (Eaton)	D	0	1
Oligoneuriidae			
Coloburiscus humeralis (Walker)	J, F	0	2
PLECOPTERA			
Eustheniidae			
Stenoperla prasina (Newman)	N	0	1

Otahu Stream:

Species	Months	Range of distances	No. of samples
TRICHOPTERA			
Hydropsychidae			
Aoteapsyche colonica (McLachlan)	N, D, J, F	0-200	15
A. raruraru (McFarlane)	N	0	1
O. fimbriata (McLachlan)	D	200	1
O. thomasi (Wise)	D	0-20	2
Hydroptilidae			
Oxyethira albiceps (McLachlan)	N, D, J, F	0-200	25
Paroxyethira sp.d	J	50	1
P. hendersoni Mosely	D	40-200	3
Ecnomidae			
Ecnomina zealandica Wise	D	100	1
Hydrobiosidae			
Costachorema xthanoptera (McFarlane)	N, D, F	0-200	5
Edpercivalia thomasoni (McFarlane)	N	40	1
H. budgei McFarlane	D	70	1
H. copis McFarlane	D, F	100-200	3
H. gollanis Mosely	D, J	0-100	3
H. parumbripennis McFarlane	N, D, J, F	0-200	16
H. umbripennis McLachlan	D	200	1
Neurochorema confusum (McLachlan)	N, D, J	0-200	15
Psilochorema donaldsoni McFarlane	D	20-200	2
P. macroharpax McFarlane	D	200	1
P. mimicum McLachlan	D	10-200	2
Tiphobiosis sp.q	D	100	1
T. plicosta McFarlane	N, D	50-80	1
Polycentropiidae			
Plectrocnemia maclachlani Mosely	D	0-10	2
Polyplectropus altera McFarlane	N, D, J	10-200	9
P. aurifusca McFarlane	D	40-200	5
Philopotamidae			
Hydrobiosella mixta Cowley	N	30	1
Helicopsychidae			
Helicopsyche albescens Tillyard	N, D	0-70	8
H. zealandica Hudson	N, D, J	10-200	12
Oeconesidae			
Oeconesus sp.	D, J	20-30	2
O. maori McLachlan	N, D, F	0-150	9
Pseudoeconesus sp.a	N, D, J	10-100	5
Leptoceridae			
Hudsonema amabilis (McLachlan)	N, D	0-200	12
Oecetis unicolor (McLachlan)	D	0-100	4
Triplectides obsoleta McLachlan	N, D, F	0-200	13
Conoesucidae			
Baeroptera roria Mosely	N, D, F	0-200	9
Olinga feredayi (McLachlan)	N, D, J, F	0-200	16
Pycnocentria evecta McLachlan	N, D	0-70	8
Pycnocentrodes sp.a	N	90	1
P. aeris Wise	N, D, J, F	0-200	22
P. aureola (McLachlan)	N, D, J, F	0-200	33

Species	Months	Range of distances	No. of samples
EPHEMEROPTERA			
Leptophlebiidae			
Zephlebia dentata (Eaton)	J	200	1
Oligoneuriidae			
Coloburiscus humeralis (Walker)	N, D	0-100	3

Tongariro River:

Species	Months	Range of distances	No. of samples
TRICHOPTERA			
Hydropsychidae			
Aoteapsyche catherinae (McFarlane)	J, F	0	2
A. colonica (McLachlan)	J, F	0-80	10
A. tepoka (Mosely)	D, J, F	0-50	5
Orthopsyche fimbriata (McLachlan)	D, J, F	0-60	5
Hydroptilidae			
Oxyethira albiceps (McLachlan)	N, D, J, F	0-70	20
Paroxyethira sp.d	J, F	50-90	3
P. hendersoni Mosely	F	0-40	2
Hydrobiosidae			
Costachorema callistum McFarlane	D, J, F	0-70	7
C. xanthoptera McFarlane	N, D, J, F	0-50	6
Edpercivalia thomasoni (McFarlane)	N, D, J, F	10-90	13
Hydrobiosis clavigera McFarlane	F	0	1
H. falcis Wise	F	0	1
H. gollanis Mosely	N, J	10-70	2
H. parumbripennis McFarlane	N, D, J, F	0-70	14
H. soror Mosely	N, J	0-30	2
H. spatulata McFarlane	F	50-90	3
Hydrochorema crassicaudatum Tillyard	D	80	1
Neurochorema armstrongi McFarlane	N, D, F	0-20	5
Psilochorema donaldsoni McFarlane	J	50	1
P. leptoharpax McFarlane	N, F	0-80	7
P. mimicum McLachlan	F	50	1
Synchorema tillyardi McFarlane	J, F	0-20	2
Tiphobiosis veniflex McFarlane	D	0	1
Philopotamidae			
Hydrobiosella mixta Cowley	J, F	20-90	8
Polycentropiidae			
Plectrocnemia maclachlani Mosely	J, F	0-10	3
Polyplectropus altera McFarlane	N, D, J, F	0-80	16
P. aurifusca McFarlane	F	10-60	2
P. impluvii Wise	F	10	1
Helicopsychidae			
Helicopsyche albescens Tillyard	J, F	0-10	3
Oeconesidae			
Oeconesus maori McLachlan	N, D, J, F	0-90	21
Pseudoeconesus mimus McLachlan	N	70	1
Pseudoeconesus sp.a	N	80	1
Leptoceridae			
Hudsonema amabilis (McLachlan)	J, F	0-70	3
Triplectides cephalotes (Walker)	J	60	1
T. dolichos McFarlane	D, J, F	10-80	9
T. moselyi (Tillyard)	J, F	30-80	7
Philorheithridae			
Philorheithrus aliciae n.sp.	J, F	50-80	3
Helicophidae			

Species	Months	Range of distances	No. of samples
Zelolessica cheira McFarlane	J	30	1
Conoesucidae			
Baeroptera roria Mosely	J, F	10-80	10
Confluens hamiltoni (Tillyard)	J, F	0-40	6
Olinga feredayi (McLachlan)	J, F	10-70	6
Pycnocentria evecta McLachlan	J, F	10-50	3
P. gunni (McFarlane)	F	10	1
P. aeris Wise	J, F	0-20	3
P. aureola (McLachlan)	J, F	10-80	9
EPHEMEROPTERA			
Leptophlebiidae			
Deleatidium spp.	F	10-80	3
Neozephlebia scita (Walker)	N	50	1
Zephlebia borealis (Phillips)	D	50	1
Z. dentata (Eaton)	D	90	1
Z. spectabilis Towns	F	0	1
Oligoneuriidae			
Coloburiscus humeralis (Walker)	F	0	1
PLECOPTERA			
Notonemouridae			
Spaniocerca zelandica Tillyard	N	50	1