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FLOW PREFERENCES OF AQUATIC INVERTEBRATES IN THE TONGARIRO RIVER

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CONTENTS

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ABSTRACT

Aquatic invertebrates were collected from four sites along the Tongariro River in December 1990 to determine water depth and velocity preferences of the major invertebrate taxa, including five dominant Chironomidae (midge) taxa (three sites only). In addition, I investigated variations in flow preferences with size of nymphs of the mayfly genus *Deleatidium* spp. and of uncased caddisfly larvae belonging to the family Hydrobiosidae (most were *Hydrobiosis* and *Costachorema* species) at two sites to determine if flow preferences varied with larval size. Additional invertebrate sampling was carried out at a previously unsampled site in December 1992 to verify conclusions derived from the calculation of preference curves. It is intended that the resulting preference curves be linked with hydraulic surveys of the river and with information on the diet of blue duck and juvenile trout to determine the likely effects of different flow regimes on food supplies in the Tongariro River.

1. INTRODUCTION

The Tongariro River is the largest tributary of Lake Taupo. It receives drainage from the Kaimanawa Mountains in the east and volcanoes of Tongariro National Park in the west. The natural flow of the river has been substantially modified by a hydroelectric power scheme. Water is diverted from Moawhango River, Waihohonu Stream and upper tributaries of Whangaehu River into the Tongariro above Rangipo Dam. After passing through the turbines at Rangipo Power Station, the water re-enters the river above Poutu Intake which diverts much of it into Poutu Stream. Some of this water passes back into the Tongariro River via Poutu Stream (Fig. 1). Details of the power scheme, current flow management rules and fisheries issues are discussed in Stephens (1989).

The Tongariro River supports a nationally important trout fishery (Tierney 1988) and a population of the endangered blue duck (Cunningham 1991). Concern has been expressed about low juvenile trout production for several kilometres below Poutu Intake (Stephens 1989), and an apparent decline in the size of the blue duck population since the commissioning of the power scheme (Speedy and Keys 1992). These may be linked to decreased availability of food supplies brought about by a reduction in the area of suitable habitat for aquatic invertebrates, and/or a reduction in the quality of remaining habitat. As part of information gathering for the Tongariro

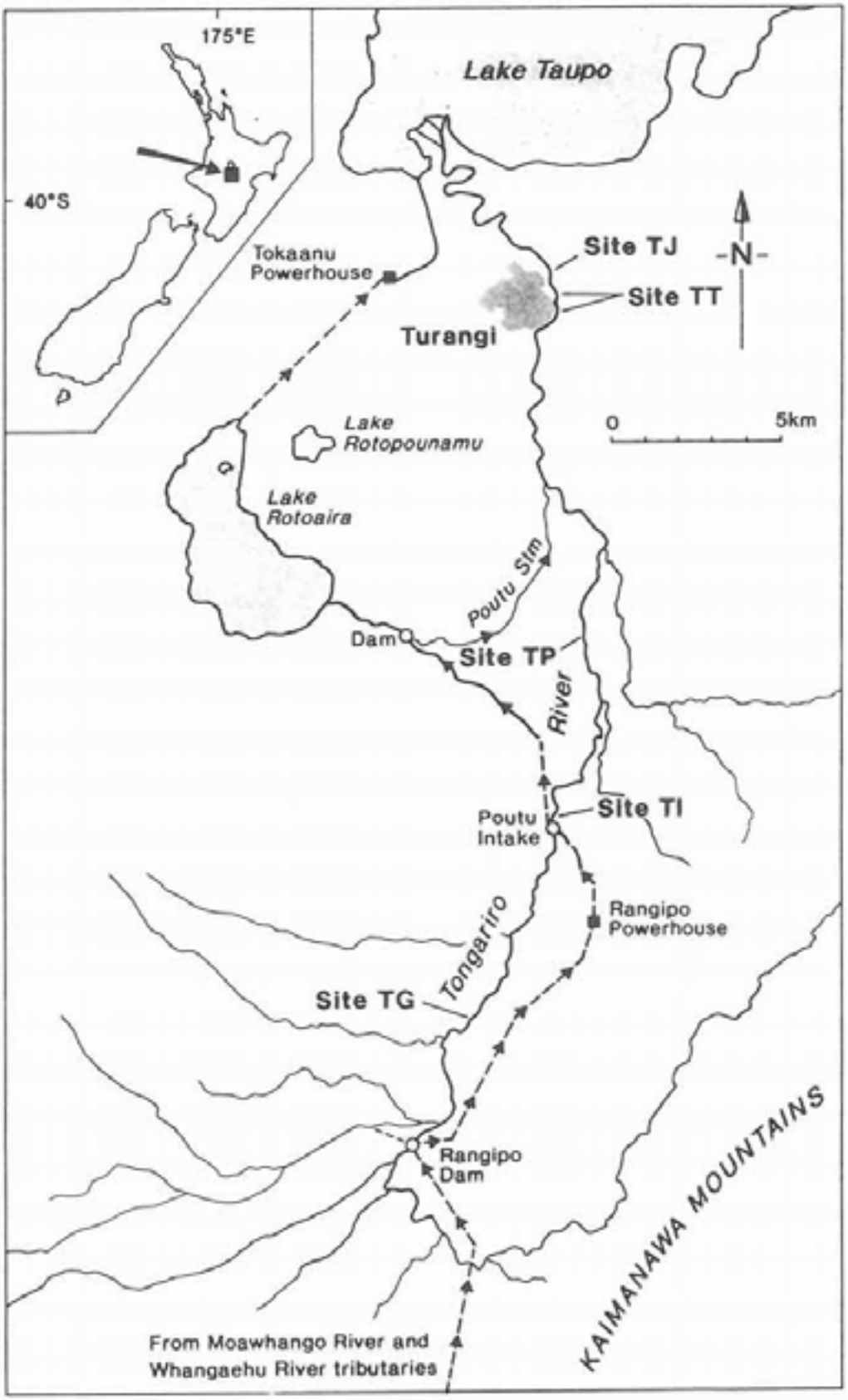

Figure 1. Location of sites on Tongariro River sampled in December 1990 and December 1992. See Table 1 for grid references of TG, TI, TP and TT. Grid reference of TJ is NZMS 260 T19 542 418.

Power Development water consents process, I studied the flow preferences in terms of water depth and velocity of benthic (bottom-dwelling) invertebrates in Tongariro River. Preference curves were developed for the dominant taxa, and variations in preferences with invertebrate size were investigated to enable more accurate preference curves to be defined. It is intended that these findings be linked with hydraulic surveys of the river and with information on the diet of blue duck and juvenile trout to determine the likely effects of different flow regimes on food supplies.

2. METHODS

2.1 Sampling Sites

Invertebrate samples were collected at four sites on Tongariro River (Fig. 1, see Table 1 for grid references) to obtain an overall picture of invertebrate micro-habitat preferences down the river. The uppermost site (TG) was approximately 500 m above Tree-trunk Gorge (Fig. 1). The section of river incorporating this site (i.e., between Rangipo Dam and Waikato Falls) provides the main habitat for blue duck on Tongariro River. A compensation flow of at least 0.6 $m^3.s^{-1}$ is maintained below Rangipo Dam. Tributaries entering Tongariro River progressively augment river flow down this section. The largest of these is Oturere Stream which enters the Tongariro approximately 2 km above Tree-trunk Gorge.

Site TI (Fig. 1) was immediately below Poutu Intake and approximately 13 km below Rangipo Dam. A discharge of 11.3 $m^3.s^{-1}$ is maintained below Poutu Intake and there can be rapid and extreme fluctuations in flow (Stephens 1989). Lake-run rainbow trout are found up the river as far as the intake; low numbers of resident trout occur above the intake. Site TP was about 20 km below Rangipo Dam (Fig. 1). Flow fluctuations are less extreme on this part of the river than below Poutu Intake. The lower most

Table 1 Grid references, distances below Rangipo Dam, ranges of physical factors assessed and the number of benthic samples collected at 4 smapling sites on the Tongariro River in December 1990

	TG	TI	TP	TT
Grid reference (NZMS 260 T19)	520 222	541 268	550 330	537 414 537 409
Distance (km)	6	13	20	30
Depth (m)	0.10-1.40	0.10-1.50	0.10-0.68	0.10-1.21
Velocity ($m.s^{-1}$)	0.08-1.53	0.08-1.53	0.08-1.58	0.11-1.78
Substrate index	4.2-5.9	3.9-5.9	4.1-5.5	4.6-5.8
Embeddedness index	1-4	1-4	1-4	3-4
Peripyhton index	2-5	2-4	2-4	2-4
No. of samples	23	26	13	21

sampling site, TT, was adjacent to Turangi township and covered parts of the river between Hydro Pool and Breakfast Pool. A constant baseflow of 27.7 $m^3.s^{-1}$ is maintained in the Tongariro River at Turangi, but short periods of high flow may occur following storms (Quinn and Vickers 1992).

2.2 Sample Collection

Eighty-four Surber samples were collected from the four sites between 11-14 December 1990. December was selected as the sampling month because, at this time, juvenile trout numbers and feeding activity are highest (Stephens 1989), and blue duck pairs usually have broods on the river (Cam Speedy, Department of Conservation, pers. comm.). Thus, early summer represents the time of year that there is likely to be the greatest demand on the invertebrate food resources provided by the river.

Sampling was stratified to encompass cells in a pre-defined matrix of depth and velocity points ranging, respectively, from 0.10 to 1.50 m and 0.08 to 1.78 $m.s^{-1}$ (Table 1). Water depth above each Surber sampling quadrat (0.1 m^2 and velocity at 0.6 x the depth from the water surface were measured using an OSS PC1 meter attached to a graduated rod (Hydrological Services Ltd.).

The percentage cover of different sized substrata in each quadrat was determined through a viewing box. The size classes used were (after Bovee and Milhous 1978): sand (0.06-2 mm), fine gravel (2-32 mm), coarse gravel (32-64 mm), cobbles (64–256 mm) and boulders (>256 mm). Proportional cover was converted into a substrate index as described by Jowett *et al.* (1991). Embeddedness of the substrate and periphyton cover within each Surber quadrat were assessed qualitatively as described in Table 2. Ranges of values measured at each site are given in Table 1. The index for periphyton cover has been shown to be positively correlated with chlorophyll *a* concentration and ash-free dry weight of periphyton in the Tongariro River (Quinn and Vickers 1992).

Table 2 Descriptors of embeddedness and periphyton indices used in this study

Score	Embeddedness index	Periphyton index
1	No packing evident, loose assortment easily moved	Clean substrate
2	Mostly a loose assortment with little overlap	Substrate slippery but periphyton growth not visible
3	Moderately packed with some overlap	Growth obvious with green/brown colour
4	Tightly packed and/or overlapping	Filamentous algae obvious, especially on downstream side
5	Bedrock	Filamentous algae covering >80% of upper surface and sides

Invertebrates colonising the substrate to a depth of about 10 cm in each Surber quadrat were brushed into a 0.25 mm mesh net. Where water depth exceeded about 0.8 m, samples were collected using SCUBA and a harness rope attached to upstream anchors to maintain position in fast water. All samples were preserved in 10% formalin.

23 Sample Analysis

In the laboratory, samples were passed through 1 mm and 0.2 mm mesh nested sieves. Material retained by the latter sieve was sorted at 10 X magnification in a Bogorov tray, and invertebrates caught on the 1 mm mesh sieve were picked out by eye. All identification and counting was done at 6-40 X magnification. Aquatic invertebrates were placed into one of eight taxonomic groups for subsequent analyses (see Table 7 for list of major taxa). A complete list of all invertebrate taxa collected in this study is given in Appendix 1.

The microdistributions of some taxa were examined in more detail to provide additional information on flow preferences at different life-history stages and amongst species within the broader taxonomic groupings. These analyses were carried out only at selected sites because of the intensity of labour involved. Larval head widths of the mayfly *Deleatidium* spp. and the net-spinning caddisfly *Aoteapsyche* spp., and pronotum widths of the caddisfly family Hydrobiosidae (excluding the genera *Psilochorema* and *Neurochorema;* see later) collected from TG and TI were measured with an eye-piece graticule. These two uncased caddisfly taxa can be important components of blue duck diet (Veltman *et al.* in prep.). For *Deleatidium* spp., which is relatively more abundant in the upper than in the lower river (Quinn and Vickers 1992), numbers of final instars (i.e., those with fully developed wing-pads) were also noted.

Chironomid (midge) larvae are dominant in the diet of juvenile trout in the Tongariro River during summer (Stephens 1989), and can also comprise a large proportion numerically of blue duck diet (Collier 1991, Wakelin in press). Other work in this river has shown that the chironomid fauna is comprised of up to six dominant species (Quinn and Vickers 1992). In the samples I collected from sites TI, TP and TT, chironomid larvae were sorted into one of 10 taxa (see Appendix 1). Only five of the taxa recognised were abundant and represented 83-99% of the total chironomid fauna (see Table 9 for list of major taxa). Where chironomids were particularly abundant (most samples from sites TP and TT), subsamples (162-882 individuals) were taken for identification using a Folsom splitter. Numbers of different taxa in each subsample were adjusted for the proportion of the total chironomid numbers they represented (range = 13-56 %) to give number per 0.1 m^2 of riverbed. After identification, the biomass of total chironomids collected in each Surber sample at TI, TP and TT was determined by drying larvae overnight at 60°C and weighing them to the nearest 1 mg on an Ohaus Galaxy 400D balance.

2.4 Analysis of Site Effects

Subsets of nine samples collected from the same combination of cells at all sites (depths 0.10-0.42 m, velocities 0.28-1.17 $m.s^{-1}$) were used to investigate gross site-related differences in invertebrate abundance. Samples sizes ranged from 36 (4 sites) for the main invertebrate groups and 27 (3 sites) for the different chironomid taxa.

Multiple pairwise comparisons between sites (log_e transformed data) for different invertebrate groups were made with the Bonferroni test in SYSTAT.

2.5 Analysis of Preference Curves

Pearson correlation coefficients between measured physical variables (depth, velocity, substrate size index, substrate embeddedness and periphyton cover) were calculated to identify uncorrelated variables that could be used in multiple linear regression analyses with taxonomic richness (log_e transformed), density and chironomid biomass ($log_e(N+1)$ transformed). All variables were used in regression analyses except for substrate which was correlated with velocity and embeddedness (Table 3). Depth and velocity preference curves were subsequently calculated for those invertebrate groups which were significantly affected by depth or velocity in the regression analyses.

Preference curves were determined using two methods that have been found to be effective in determining flow preferences of aquatic invertebrates in other New Zealand studies (Jowett and Richardson 1990, Jowett *et al.* 1991). In the "Lowess" method, relative abundance was first calculated by dividing the abundance of each taxon in different samples by the maximum abundance of that taxon at each site. This produced "preference factors" ranging from 0 (no larvae collected) to 1 (maximum abundance at a site), and eliminated the tendency for data from one site with high abundances to obscure patterns at other sites with lower abundances (Jowett *et al.* 1991). The same procedure was also carried out on total numbers of invertebrates and the number of taxa, and on chironomid biomass at TI, TP and TT using maximum biomass at each of three sites as the denominator.

Locally weighted smooth ("Lowess") curves were then plotted through the data for each site using the Lowess smoothing routine with a tension of 0.5 in SYSTAT. This routine produces a smooth by running along the X axis and finding predicted values from a weighted average of nearby y values. Optima were considered to occur at the maximum value of the fitted curve. Where there appeared to be more than one maximum value on the curve, the value which corresponded most closely to the maximum of the fitted polynomial curve (see below) was chosen. Generalised Lowess-smoothed curves were derived by combining normalised data from each site.

Table 3 Pearson correlation coefficients between physical variables measured in Tongariro River (all sites combined).

	Velocity	Substrate	Embeddedness	Periphyton
Depth	0.01	-0.09	-0.05	-0.11
Velocity		0.37**	0.06	-0.06
Substrate			0.31**	0.15
Embeddedness				0.09

** = P<0.01. n = 83

The other method used for calculating preference curves involved deriving second order exponential polynomial regression equations for depth or velocity (Orth and Maughan 1983). For abundance and biomass data, these equations took the form:

(1) $\log^e(N+1) = a + bX + cX^2$

where N is density or biomass of invertebrates, X is depth or velocity and a, b and c are fitted coefficients obtained using the MGLH routine of SYSTAT. Log_e transformations were used to help normalise the data as confirmed by assessment of frequency distributions.

Polynomial preference curves for taxonomic richness were fitted in the same way using log_e transformed data. Maximum values of density or taxonomic richness were derived from the polynomial regression curves and preference factors ranging from 0 to 1 were determined by dividing the equation by the maximum value estimated by the function in the range of conditions sampled (Orth and Maughan 1983). Generalised exponential polynomial preference curves were derived by combining normalised data from each site.

2.6 Analysis of Larval Size Effects

Peaks in size-frequency distributions of taxa measured at sites TG and TI were used to identify classes for determination of the relationship between larval size and microhabitat preferences (Fig. 2). This analysis identified three *Aoteapsyche* spp., four Hydrobiosidae and eight *Deleatidium* spp. size classes (Table 4). Because of the limited size range of *Aoteapsyche* spp. larvae collected from the Tongariro River in December 1990, it was not possible to assess the effects of larval size on microhabitat preferences for this taxon, and these data were not considered further. Preference curves for different size classes of Hydrobiosidae and *Deleatidium* spp. at the two sites were calculated as described above. Larvae of the hydrobiosid genera *Psilochorema* and *Neurochorema,*

Table 4 Range of sizes (mm except for final instar (FI) *Deleatidium* spp. Which were recognised from fully developed wing pads) for head widths (*Deleatidium* and *Aoteapsyche* spp) and pronotum widths (hydrobiosidae) in different size classes differentiated from size frequency distributions (see Fig. 2). Number of larvae in each size class are given in parentheses.

Size class	I	II	III	IV	V	VI	VII	VIII
***Deleatidium* spp.**	<0.40 (216)	0.40-0.50 (373)	0.55-0.75 (536)	0.80-1.05 (557)	1.10-1.30 (341)	1.35-1.55 (265)	1.6-<F1 (255)	F1 (189)
Hydrobiosidae	<0.45 (317)	0.45-0.75 (138)	0.8-1.05 (63)	>1.05 (64)	-	-	-	-
***Aoteapsyche* spp.**	<0.65 (270)	0.65-0.95 (256)	>0.95 (2)	-	-	-	-	-

- not applicable
* not considered in subsequent analyses
Deleatidium spp. Groups I & II, III & IV, V & VI and VII & VIII were combined for log linear modelling (see text for explanation).

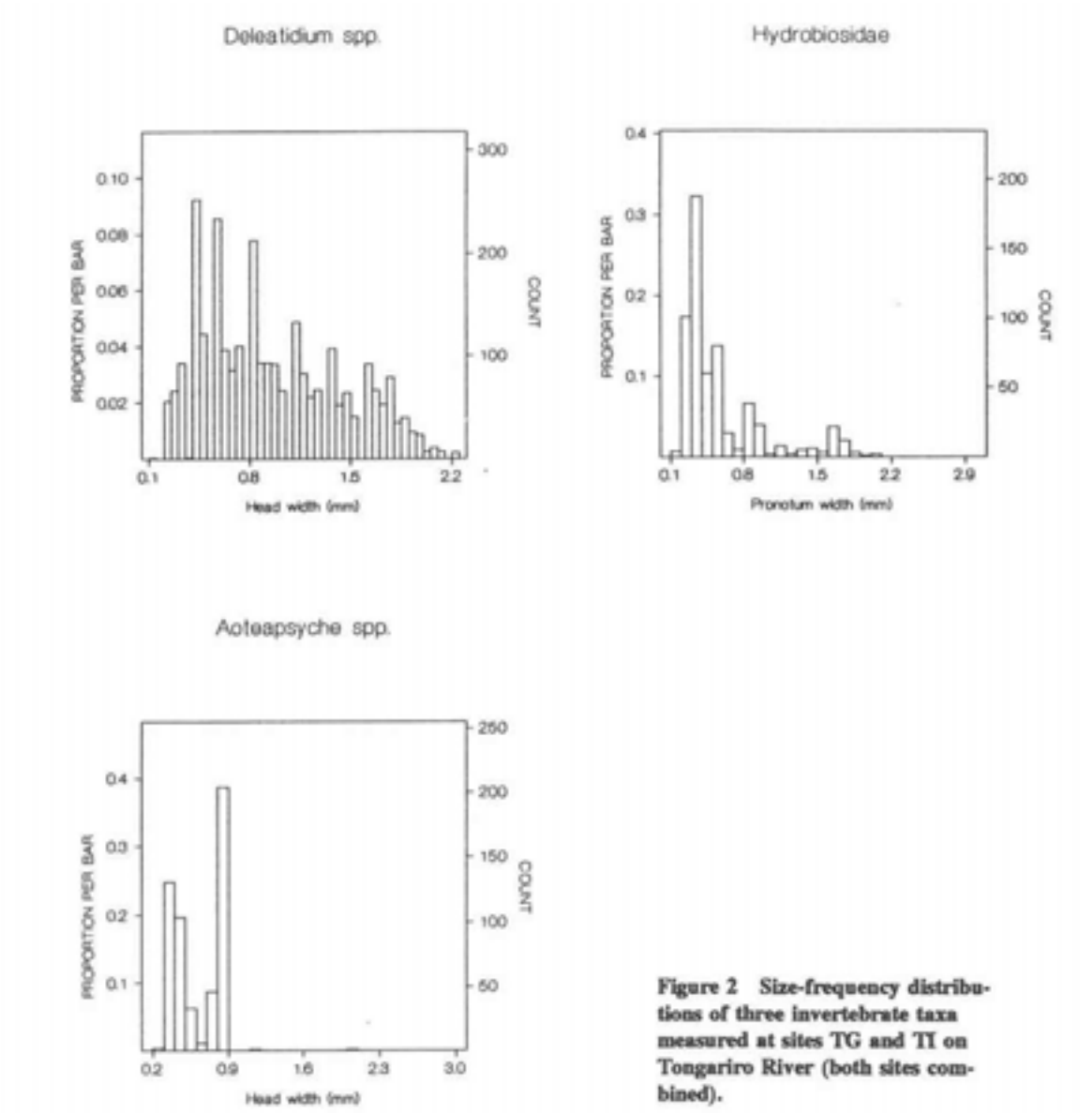

Figure 2 Size-frequency distributions of three invertebrate taxa measured at sites TG and TI on Tongariro River (both sites combined).

which could be distinguished as early instars, were omitted from the Hydrobiosidae group to make it as taxonomically homogenous as practical in order to minimise the effects of interspecific differences in flow preferences. Most larvae in the Hydrobiosidae group appeared to belong to the genera *Hydrobiosis* and *Costachorema. Psilochorema* and *Neurochorema* species made up only small proportions (3% and 6%, respectively) of the total Hydrobiosidae.

Because of the low numbers of larvae collected in some size classes, more detailed statistical analysis attaching significance levels to the effects of size was possible only for *Deleatidium* spp. nymphs. Interactions between sampling site, depth and velocity, and size of *Deleatidium* spp. nymphs were investigated using log-linear modelling in

SYSTAT. Log-linear modelling is a form of multi-dimensional contingency table analysis in which the log of frequencies is expressed as a function of main effect (categorical) and interaction parameters. Depth and velocity data were each separated into five groups for this analysis (Table 5). Some fast velocity sampling points did not fall into discrete groups and were omitted for the purposes of log linear modelling. To minimise the number of sparse cells (frequency <5), the size data were compressed into four size classes for analysis by combining classes I and II, III and IV, V and VI and VII and VIII. This reduced the proportion of sparse cells to 25%. This slightly exceeded the recommended 20% level for sparse cells, and so a higher than normal probability level ($P < 0.01$ instead of $P < 0.05$) was used to determine significance.

Table 5 Delimiters of depth (m) and velocity ($m.s^{-1}$) groups used for log- linear modelling at 2 sites on Tongariro River

Depth Groups	Velocity Groups
0.10	0.08-0.13
0.19-0.22	0.28-0.36
0.39-0.48	0.56-0.74
0.58-0.60	0.92-1.18
1.0-1.20	1.32-1.53

A nested hierarchy of main factors (site, depth group, velocity group and size class) and relevant second and third order interactions was established for log-linear modelling, as recommended by Fienberg (1970). Effects of interactions on numbers of nymphs in Surber quadrats were determined by testing the significance of the sum of likelihood ratio chi-square test statistics and degrees of freedom at subsequent stages of the hierarchy. Four cells were sampled at TI but not at TG and these were regarded as structural zeros during log-linear modelling (i.e., they were not included in the analysis).

2.7 Validation Sampling

Five replicate Surber samples (0.1 m^2, 0.25 mm mesh net) were collected from "slow", "medium" and "fast" water habitats (see Table 6) near Judges Pool (Site TJ on Fig. 1), a site not previously sampled in the Tongariro, on 3 December 1992 to validate velocity preferences indicated by the earlier sampling. Water depth and velocity above each Surber quadrat were measured before benthic sampling as described in Section 2.2, using a Scientific Instruments Model 1205 mini meter with a Stewart Stream Gauging counter. Samples were analysed as in Section 2.3, except that material retained by the 0.2 mm mesh sieve was subsampled by half using a Folsom splitter. Differences in densities of different invertebrate groups and size classes of *Deleatidium* spp. and Hydrobiosidae in the three habitat types (slow, medium and fast) were tested using multiple Bonferroni pairwise comparisons following $\log_e N + 1$ transformation in SYSTAT. Raw data used in these analyses are presented in Appendix 2.

Table 6 Depth (m) and velocity ($m.s^{-1}$) conditions for 5 Surber samples collected from "slow", "medium" and "fast" flowing water at Site TJ (see Fig. 1) on Tongariro River in December 1992.

Sample	"Slow"		"Medium"		"Fast"	
	Depth	Vel.	Depth	Vel.	Depth	Vel.
1	0.28	0.25	0.31	0.57	0.23	1.17
2	0.25	0.28	0.30	0.60	0.22	0.99
3	0.29	0.13	0.24	0.54	0.19	1.11
4	0.18	0.22	0.25	0.63	0.25	1.23
5	0.13	0.25	0.36	0.60	0.28	1.23
$\bar{x}$ (± SE)	0.23 (0.03)	0.23 (0.03)	0.29 (0.02)	0.59 (0.01)	0.23 (0.01)	1.15 (0.10)

3. FLOW PREFERENCES OF MAJOR INVERTEBRATE GROUPS

3.1 Site-related Differences

Significantly higher densities of total invertebrates, chironomids (midges) and oligochaetes (worms) were found at sites TP and/or TT than at the upper two sites on the Tongariro River (Fig. 3). Chironomid biomass was also considerably higher at the two lower sites than at Site TI (Fig. 4). Fewer larvae of the crane-fly *Aphrophila neozelandica* were found at Site TG whereas densities of the mayfly *Deleatidium* spp. were significantly lower at TT than at any other site (Fig. 3). Numbers of the stonefly *Zelandobius furcillatus* and the net-spinning caddisfly *Aoteapsyche* spp. were higher at the lower two sites, but these differences were not statistically significant. On average, similar numbers of taxa were found at all sites in the subset of samples used in this analysis.

3.2 Factors Affecting Distribution

The uncorrelated variables depth, velocity, substrate embeddedness and periphyton cover (see Table 3 for correlation coefficients) accounted for 20% of the variation in taxonomic richness at all sites combined, and for between 10% (elmid beetles) and 68% *(Aoteapsyche* spp.) of variation in abundances of the other invertebrate groups (Table 7). Depth or velocity were significant factors in the model for taxonomic richness, chironomid biomass and abundances of all major taxa and total invertebrates except for Elmidae. Embeddedness was also a significant factor affecting density of total invertebrates, *Deleatidium* spp., *Aoteapsyche* spp., *A. neozelandica,* and Oligochaeta, and numbers and biomass of Chironomidae (Table 7). Relative periphyton abundance was significant only for *Deleatidium* spp. and *Aoteapsyche* spp. Depth and velocity preference curves were calculated for all of the invertebrate groups in Table 7 except for Elmidae.

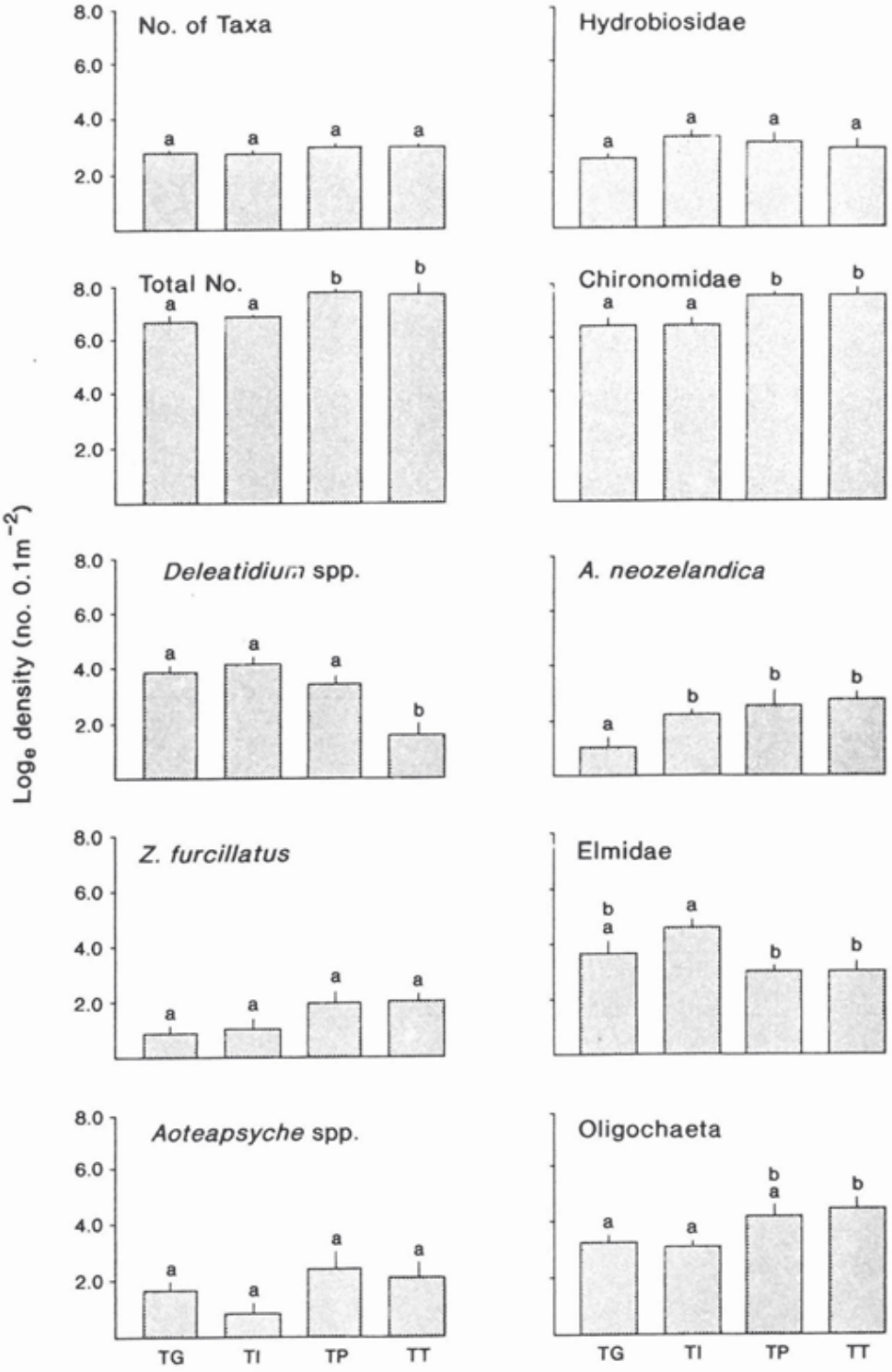

Figure 3 Abundances (log$_e$ N or N+1, x ± 1SE) of the major invertebrate groups in subsets of nine samples (see Section 2.4 for explanation) from four sites down Tongariro River in December 1990. Bars with different letters above are significantly (P <0.05) different.

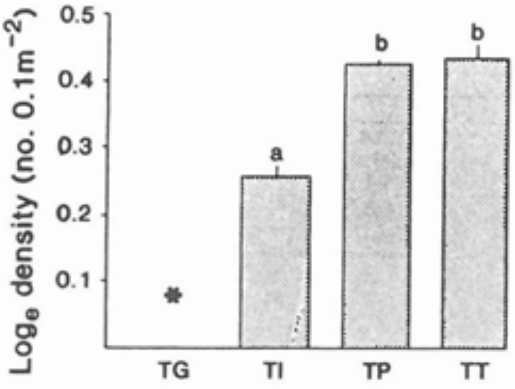

Figure 4 Biomass (log$_e$ N+1, x ± 1SE) of total chironomids in subsets of nine samples (see Section 2.4 for explanation) from three sites down Tongariro River in December 1990. Bars with different letters above are significantly (P <0.05) different. * = no data.

	Coefficients				
Group	**Depth**	**Velocity**	**Embeddedness**	**Periphyton**	**r^2**
Taxa no.	-0.29 **	0.14 *	0.01	0.04	0.20
Total no.	-0.84 ***	-0.14 *	0.31 ***	-0.05	0.34
Deleatidium spp. no.	0.19	1.11 ***	-0.55 ***	0.30 *	0.31
Z. furcillatus no.	-0.56 *	-1.13 ***	0.07	-0.10	0.31
Aoteapsyche spp. no.	-0.86 **	2.71 ***	0.36 **	0.25 *	0.68
Hydrobiosidae spp. no.	-1.24 ***	0.58 *	0.06	0.20	0.29
Chironomidae spp. no.	-0.79 ***	-0.20	0.38 ***	-0.08	0.32
A. neozelandica no.	-0.60 *	0.92 ***	0.46 ***	-0.23	0.35
Elmidae no.	-0.66	-0.26	-0.17	0.18	0.10
Oligochaeta no.	-1.59 ***	-0.93 ***	0.20 *	0.04	0.44
Chironomidae biomass	-1.29 **	0.25	0.43 **	-0.07	0.39

Astericks indicate probability levels for t statistics associated with the coefficients
* = P<0.05; ** = P<0.01; *** = P<0.001.

3.3 Flow Preferences of Invertebrate Groups

Preference curves for water depth and velocity are presented in Appendices 3A and B. Similar generalised optima (all sites combined), as indicated by the maximum value of a curve, were obtained for most invertebrate groups using both the Lowess and exponential polynomial curve calculation techniques (see Table 8). Notable exceptions were optimum depths for *Deleatidium* spp. (0.1 m, cf. 1.5 m), and optimum velocities for taxonomic richness, *Deleatidium* spp. and *A. neozelandica* which differed by at least 0.5m.s^{-1}. The Lowess technique is more sensitive to outliers than the exponential polynomial method, and this may account for some of the differences observed between the two curve calculation techniques.

Ranges of optima for most invertebrate groups generally differed between sites, although some taxa exhibited reasonably narrow depth and velocity preferences at all

Table 8 Optimum water depths (m) and velocities (m.s^{-1}) over the range of conditions sampled for 11 aquatic invertebrate groups at 3 (chronomid biomass) or 4 (all other groups) sites on the Tongariro River. Optima were derived from maxima of locally weighted smooth curves (Lowess) and exponential polynomial curves (Polynomial) (see Appendix 3). Optima are for generalised curves (data from all sites combined: no parentheses) and for curves from each site (range given in parentheses).

	Depth		Velocity	
	Lowess	**Polynomial**	**Lowess**	**Polynomial**
Taxa no.	0.4 (0.1-0.4)	0.1 (0.1-0.4)	1.8 (0.6-1.8)	1.3 (0.1-1.5)
Total no.	0.1 (0.1-0.2)	0.1 (0.1-1.2)	0.3 (0.3-.7)	0.1 (0.1-1.5)
***Deleatidium* spp. no**	0.1 (0.1-0.9)	1.5 (0.1-1.2)	1.8 (0.6-1.8)	1.1 (0.9-1.4)
***Z. furcillatus* no.**	0.1 (0.1-0.6)	0.1 (0.1-1.5)	0.3 (0.1-0.7)	0.1 (0.1-0.6)
***Aoteapsyche* spp. no.**	0.6 (0.2-0.6)	0.4 (0.1-0.7)	1.8 (1.3-1.8)	1.8 (1.5-1.8)
Hydrobiosidae no.	0.1 (0.1-0.4)	0.1 (0.1-0.5)	0.3 (0.3-07)	1.0 (0.7-1.8)
Chironomidae no.	0.2 (0.1-0.2)	0.1 (0.1-1.5)	0.3 (0.3-0.7)	0.1 (0.1-1.5)
***A. neozelandica* no.**	0.2 (0.1-0.6)	0.4 (0.1-1.3)	0.6 (0.3-1.8)	1.2 (0.4-1.4)
Elmidae no.	0.2 (0.1-0.7)	0.1 (0.1-0.7)	0.1 (0.1-0.7)	0.1 (0.1)
Oligochaeta no.	0.1 (0.1-0.3)	0.1 (0.1-0.3)	0.1 (0.1-0.7)	0.1 (0.1)
Chironomidae biomass	0.2 (0.1-0.2)	0.2 (0.1-0.2)	1.8 (0.6-1.8)	1.8 (0.5-1.8)

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