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CONTENTS

AQUATIC INVERTEBRATES OF NGARURORO RIVER, HAWKE'S BAY

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ABSTRACT

Aquatic invertebrates were collected from pools, runs, riffles and margins at five sites on the lowland section of Ngaruroro River. The invertebrate fauna of runs ranged in density from 38 to 398 0.1 m^2 and was dominated by larvae of the mayfly *Deleatidium* spp. and the beetle Elmidae. This type of fauna is representative of braided rivers elsewhere in New Zealand. Only one exotic invertebrate species, the snail *Physa acuta*, was found; this was present at all sites. The upper three sites had the greatest number of "rare" taxa, and the site below Whanawhana had the most diverse invertebrate fauna. The section of river where the bed is wide, extensively braided and confined by cliffs has high conservation value in terms of the aquatic invertebrate fauna. The interstices between stones on the floodplain, a habitat not sampled here, is important for some aquatic invertebrates elsewhere. Pools and margins of Ngaruroro River may be refugia for invertebrates from floods and reservoirs for subsequent recolonisation. The integrity of these habitats should be maintained.

1 INTRODUCTION

In New Zealand, the largest braided rivers occur in Canterbury, but smaller examples are also found on the lowlands of Westland and Hawke's Bay. Considerable research has been carried out on the bird, fish and invertebrate faunas of the Canterbury rivers (Pierce 1979, Sagar 1983, Sagar and Eldon 1983, Glova and Duncan 1985, Pierce 1986, Sagar 1986, Scrimgeour *et al.* 1988, Scrimgeour 1991), but comparatively little is known about the faunas of braided rivers elsewhere in New Zealand.

In Hawke's Bay, lowland sections of the Waipawa and Ngaruroro Rivers are extensively braided, and the Ngaruroro is considered to be of "high" conservation value largely because of the diverse bird communities that use its bed as breeding and feeding habitat (Parrish 1988). The aquatic invertebrate faunas of the Hawke's Bay braided rivers are relatively unknown. Overseas this group of animals has proven useful in assessing conservation value (Jenkins *et al.* 1984, Foster *et al.* 1990).

The original aim of this study was to describe the aquatic invertebrate fauna of upland and lowland sections of Ngaruroro River. However, our sampling was curtailed because of bad weather, and we were able to collect samples from only the lowland section at five points.

Our approach was twofold. Firstly, we investigated community composition in different habitat types at several sites to determine the range of species present. Secondly, we measured invertebrate density in runs at each site to assess the abundance of food supplies for birds and fishes, and to compare our findings with other studies that had used similar sampling techniques. We discuss the application of these findings to the assessment of conservation value in terms of rarity, diversity, naturalness and representativeness (see Margules and Usher 1981 for definitions).

2 SITE DESCRIPTION

The Ngaruroro River (Fig. 1) originates at the junction of the Kaweka and Kaimanawa Ranges and flows for approximately 200 km before coalescing with the Clive and Tutaekuri Rivers and entering the sea. The river changes in character markedly as it moves towards the sea, and this first becomes obvious below Kuripapango where the channel progressively widens and the substrate becomes more active. Erosion scars around the Taruarau River confluence contribute large amounts of greywacke gravel to the river and this comprises the main riverbed substrate below this point. At Whanawhana, the river changes from a single thread to a wide (around 1 km) braided channel entrenched in a upland plain. From here and until Maraekakaho, where the river meets the Heretaunga Plains, the berms are sparsely vegetated, but then trees (mainly willows (*Salix* spp.) and also some poplars (*Populus* spp.)) become abundant. Below Fernhill there is a semi-single thread channel with minor braiding and fewer trees, and below Chesterhope Bridge the single, man-made channel is straight, and grasses predominate on the berms.

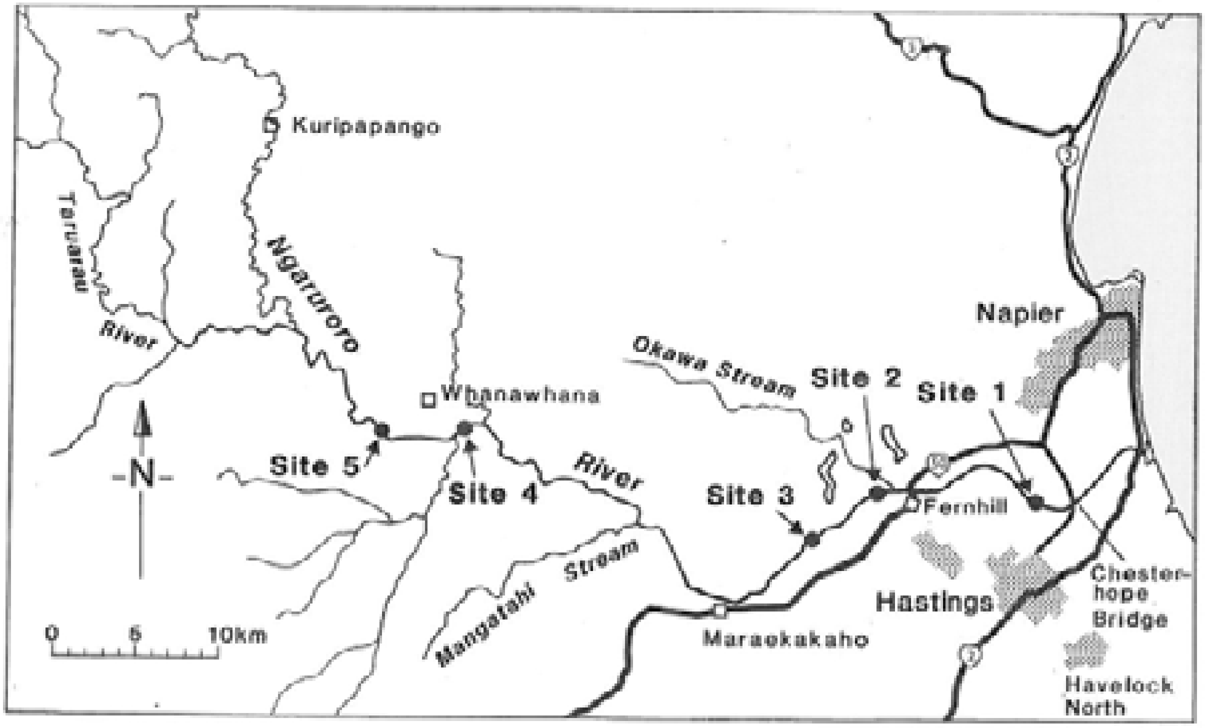

Figure 1 Location of the five sampling sites on Ngaruroro River.

Annual rainfall in the Hawke's Bay ranges from 700 to 1000 mm per annum, and most of this falls in winter. At this time, the river is prone to heavy flooding, and stopbanks have been built to protect the lower part of the catchment. During summer, flows can be very low and water temperatures high (up to 24°C). At the time of sampling in the present study, water temperatures were between 10.0 and 12.5°C, and conductivity ranged from 8.4 to 14.3 $mS.m^{-1}$ (Table 1; see also Methods). Landuse alongside the lowland section of Ngaruroro River is mainly horticulture with some sheep and cattle grazing in the foothills. Hawke's Bay has the largest number of irrigated hectares in the North Island; this along with vegetation encroachment, dam construction and channel modification, has been highlighted as a potential threat to the conservation value of the river (Parrish 1988).

Table 1 Grid references, altitude, conductivity and temperature of the five sampling sites.

Site No.	Grid ref. (NZMS 260)	Altitude (m a.s.l.)	Conductivity ($mS.m^{-1}$)	Temperature (°C)
1	V21 403718	10	14.3	11.5
2	V21 312725	30	12.4	12.0
3	V21 276703	50	13.3	12.5
4	U21 075776	150	11.1	11.5
5	U21 020774	180	8.4	10.0

The wide gravel beaches and associated riparian environments provide habitat for many birds, and 43 species have been reported to use various parts of Ngaruroro River (Parrish 1988). These include the only North Island breeding population of the South Island pied oystercatcher and a large population of threatened banded dotterels. In addition, 14 fish species have been recorded from the Ngaruroro catchment, and some lowland species such as smelt and black flounder have penetrated up to 100 km inland because of the absence of barriers to fish passage (Strickland 1990). Rainbow trout are present throughout the catchment, and the headwaters of Ngaruroro River have been identified as a nationally important wilderness trout fishery by Tierney *et al.* (1982).

3 METHODS

3.1 Sampling Locations

Samples were collected from four habitat types (runs, riffles, pools and margins) at five sites on Ngaruroro River between Whanawhana and the Okawa Stream confluence (Fig. 1) on 5 June 1990. Grid references and some physicochemical features of the sampling sites are given in Table 1.

Site 1 was located 2 km upstream of Chesterhope Bridge where the main channel was about 15 m wide and represented approximately 80% of the wetted area. Willows and grasses grew close to the edge of a secondary channel at this site and roots of these were included in the margin sample. Sites 2 and 3 were 2 km and 6 km, respectively, above the SH50 bridge. At the former site, the sampling braid was about 12 m wide (c. 50 % of wetted area) whereas at Site 3 the sampling channel was around 35 m wide and represented about 70% of the wetted area. Margins of the areas sampled at Sites 2 and 3 included some grasses, watercress (*Nasturtium* sp.) and growths of filamentous algae.

The remaining two sites (4 and 5) were at much higher altitudes (≥150 m a.s.l.) than Sites 1, 2 and 3 (≤50 m a.s.l.) (Table 1). At Site 4, width of the main sampling channel was about 20 m but this represented only a small proportion of the wetted area because of extensive braiding at this site (total bed width is c. 1 km here). In contrast, Site 5 was located above the braiding and consequently the main sampling channel (c. 30 m wide) comprised around 70% of the wetted area. The margin sample at the latter site did not incorporate terrestrial vegetation or macrophytes, although substantial amounts of filamentous algae were present. In contrast, the margin at Site 4 was invaded by overhanging blackberry and some grasses which were included in the sample.

3.2 Collection and Analysis of Samples

Samples were collected from the four habitat types at each site using a triangular framed 0.25 mm mesh hand net to determine the composition of benthic invertebrate communities (Table 2). Kick samples were taken by disturbing the substrate upstream of the net and brushing large stones with a stiff nylon brush. Sweep samples were taken by passing the net through submersed vegetation (margins only) and the water column where disturbed material from kick sampling was suspended. Sampling duration in all habitat types was 1 minute.

Table 2 Characteristics of the four habitat types and the collection methods used.

Habitat type	Sampling method	Characteristics
Riffle	kick	Shallow, fast flowing water; broken surface; erosional
Run	kick	Moderate-fast flowing water; smooth surface; erosional
Pool	kick/sweep	Still or very slow moving water; depositional
Margin	kick/sweep	Edges of channel including macrophytes and invading terrestrial vegetation where present; depositional

Surber samples (0.1 m^2 quadrat, 0.25 mm mesh net) were collected from three points at similar depths (30-43 cm) in runs to determine the density of benthic invertebrate communities in comparable habitats at different sites. The substrate within each quadrat was disturbed to a depth of up to 10 cm and large stones were cleaned in front of the net with a stiff nylon brush. All samples were preserved in 4% formalin.

Depth and water velocity (at 0.4x the depth with a OSS PCI miniature meter) were measured above each Surber sample quadrat. These variables were used to calculate Froude and Reynolds numbers which describe the mean motion of water and have proven useful elsewhere is determining the distribution of benthic invertebrates within rivers (Statzner *et al.* 1988, Davis and Barmuta 1989). Slope of the water surface above each quadrat was also estimated by measuring the height from the water surface to the upstream and downstream ends of a level 3 m aluminium girder attached at each end to tripods (after Statzner *et al.* 1988). Substrate roughness was assessed using the visual technique described by Statzner *et al.* (1988). Analysis of these parameters showed that all Surber samples were collected from sites with "subcritical-turbulent" flow (*sensu* Davis and Barmuta 1989), similar bed roughness (1.8-2.8 "cm") and low slopes (<0.020) (see Appendix 1 for values).

In addition, water temperature and conductivity in runs at each site were measured using a YSI Model 33 S-C-T meter. Conductivity readings were converted to values at 25^{o}C using Table 3.1 in Golterman (1969), and generally decreased upstream. Water temperatures were similar at all sites (Table 1).

In the laboratory, invertebrate samples were passed through 1 mm and 0.2 mm mesh sieves, and material retained by the former sieve was picked through on a white tray. Material from the 0.2 mm mesh sieve was sorted at 10x magnification under a binocular microscope. Invertebrates were identified from Winterbourn and Gregson (1989). Taxonomic resolution did not extend below phylum for Nematoda, and class for Ostracoda, Copepoda and Oligochaeta. Chironomidae and small larvae of Hydrobiosidae, Conoesucidae and Gripopterygidae were not resolved below family.

4 RESULTS

4.1 Composition of the Invertebrate Fauna

Fifty-four benthic invertebrate taxa were recorded in kick, sweep and Surber samples from the five sites on Ngaruroro River (Appendix 2). Most taxa were collected at Site 4 (32) followed by Sites 5 and 3 (28 and 25, respectively), and Sites 2 and 1 (19 and 18, respectively). All taxa were native to New Zealand except for the snail *Physa acuta* which was present at all sites sampled on Ngaruroro River.

The leptophlebiid mayfly *Deleatidium* spp. was the most widespread taxon occurring at all 20 site/habitat combinations collected by kick/sweep sampling; Elmidae (19), and Chironomidae (17); then came *Pycnocentrodes* spp. and Oligochaeta (both 15). Along with these taxa, *P. acuta* and indeterminate Hydrobiosidae were found at all locations. Some taxa were collected in kick/sweep samples from only one location, and these were most frequent at Sites 4 and 5 which yielded 7-8 taxa that were not found at other sites (Table 3).

Table 3 Taxa found in kick/sweep samples at only one site. Number of habitat types where taxa were found is indicated in parentheses.

Site 1	Site 2	Site 3	Site 4	Site 5
	***Pycnocentria ev-ecta* (1)**	**Muscidae sp.A (1)**	***Neurochorema* sp. (2)**	***Austroperla cyrene* (1)**
	***Austroclima sepia* (1)**	***Hydrobiosis* sp.C (1)**	**Copepoda (1)**	**Muscidae sp.B (1)**
		***H.* aff. *umbripennis* (1)**	***Paralimnophila skusei* (1)**	***Archichauliodes diversus* (3)**
		***Paroxyethira hendersoni* (1)**	***Zelandoperla decorata* (1)**	***Plectronemia maclachlani* (1)**
		Gripopterygidae indet. (1)	***Hydrobiosis* aff. *frater* (1)**	***Hydrobiosis* sp.B (1)**
			***Anisops* sp. (1)**	**Tipulidae indet. (1)**
			***Polyplectropus puerilis* (1)**	***Beraeoptera roria* (2)**
				Platyhelminthes indet. (1)

Pools, margins and riffles supported similar numbers of invertebrate taxa (31-35), but only 23 taxa were recorded in kick samples from runs. Fifteen taxa were found in kick/sweep samples from all habitat types. These were the seven taxa that were also found at all sites (see above) and *Cura pinguis*, *Potamopyrgus antipodarum*, *Aoteapsyche colonica*, Eriopterini, *Zelandobius furcillatus*, *Olinga feredayi*, *Psilochorema* sp. and *Hudsonema amabilis*. Pools and margins had the highest number of taxa restricted to that habitat type, and most of these were found at only one site (Table 4).

Table 4 Taxa found in kick/sweep samples in only one habitat type. Number of sites where taxa were found is indicated in parentheses.

Riffle	Run	Pool	Margin
Platyhelminthes indet. (1)	***Zelandoperla decorata* (1)**	**Hydrophilidae (2)**	***Pycnocentria evecta* (1)**
***Paralimnophila skusei* (1)**	***Hydrobiosis* aff.*frater* (1)**	**Muscidae sp.A (1)**	***Sigara* sp. (2)**
Tipulidae sp.A (1)		**Muscidae sp.B (1)**	***Paroxyethira hender-soni* (1)**
***Hydrobiosis* aff. *umbripennis* (1)**		***Plectronemia maclachlani* (1)**	***Anisops* sp. (1)**
***Austroperla cyrene* (1)**		***Hydrobiosis* sp.B (1)**	***Polyplectropus puerilis* (1)**
		***H.* sp.C (1)**	**Copepoda (1)**
		Gripopterygidae indet. (1)	***Austroclima sepia* (1)**

4.2 Classification of Invertebrate Communities

Data from kick and sweep samples were analysed using two-way indicator species analysis (TWINSPAN, Hill 1979). This technique classifies samples and taxa into groups of similar composition, and identifies "indicators" diagnostic of each division. The initial division of sites at TWINSPAN Level 1 using presence/absence data clearly separated samples collected from Sites 1 and 3 which contained *Cura pinguis* and *Potamopyrgus antipodarum* from those taken from Sites 2, 4 and 5 which contained *Olinga feredayi* (Fig. 2).

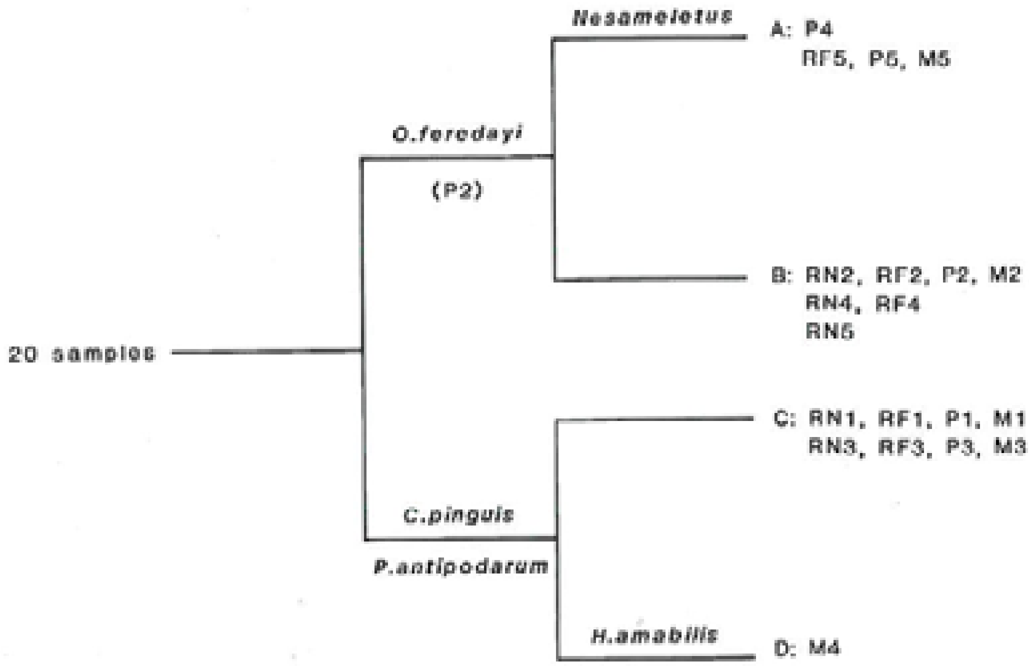

Figure 2 TWINSPAN classification using presence/absence data from the 20 kick and sweep samples collected from Ngaruroro River. Indicator taxa are shown for each division and borderline classifications are given in parentheses.

Four sample groupings (A-D) were distinguished at TWINSPAN Level 2. Group A was composed of samples from a mixture of habitats at Sites 4 and 5 which contained the fast-swimming mayfly *Nesameletus*. Group B included all samples collected from Site 2 and the other samples from Sites 4 and 5. All samples from Sites 1 and 3 were included in Group C and these did not separate out on the basis of site location at TWINSPAN Level 3. Finally, Group D was composed only of the sample collected from margins at Site 4 where riparian grasses and roots were present. This site was distinguished from Group C samples by the presence of *Hudsonema amabilis*.

TWINSPAN classified taxa into seven groups at Level 3 (Fig. 3). Group I was composed of taxa that occurred exclusively at Sites 2, 4 (excluding the margin sample) and 5, whereas Groups II-V included many taxa with little apparent sample group preference. Group VI was composed of taxa that occurred exclusively in the margin sample from Site 4 or predominantly in samples from Sites 1 and 3 (Fig. 3). Group VII consisted of 3 taxa found at a range of different habitat types and sites.

TWINSPAN taxa group	Taxa	A	B	C	D
		PMRP	RRRRPMR	PRRRPMRM	M
		F	FNFN N	FNF N	
		4555	2442225	33111133	4
I	*Nesameletus* sp.	1111	-------	--------	-
	Austroperla cyrene	--1-	-------	--------	-
	Beraeoptera roria	-1-1	-------	--------	-
	Muscidae sp.B	---1	-------	--------	-
	Archichauliodes diversus	-111	-------	--------	-
	Tipulidae indet.	--1-	-------	--------	-
	Plectronemia maclachlani	---1	-------	--------	-
	Hydrobiosis sp.B	---1	-------	--------	-
	Platyhelminthes indet.	--1-	-------	--------	-
	Neurochorema sp.	1---	--1----	--------	-
	Hydrobiosis sp.A	1--1	-11----	--------	-
	Olinga feredayi	1111	-11--11	--------	-
	Coloburiscus humeralis	-1--	-11----	--------	-
	Paralimnophila skusei	----	--1----	--------	-
	Austrosimulium sp.	----	111----	--------	-
	Zelandoperla decorata	----	-1-----	--------	-
	Hydrobiosis parumbripennis	----	-11--1-	--------	-
	Hydrobiosis aff frater	----	-1-----	--------	-
II	*Pycnocentria evecta*	----	-----1-	--------	-
	Austroclima sepia	----	-----1-	--------	-
	Zelandobius furcillatus	1111	11111-1	11-----1	-
	Psilochorema sp.	111-	1111--1	11------	-
	Hudsonema amabilis	11-1	-11----	--------	1
	Aoteapsyche colonica	-11-	1111111	--111---	-
III	Eripoterini	111-	1111-11	11----11	-
	Chironomidae	1111	1111111	1-1111-1	-
	Oligochaeta	1111	-111111	1-111---	1
	Hydrobiosidae indet.	-111	--1-1-1	1-11----	-
	Deleatidium spp.	1111	1111111	11111111	1
IV	*Pycnocentrodes* spp.	1111	1-1-111	11111--1	-
	Physa acuta	1-11	1-11---	--1-1-11	1
	Elmidae	1111	1111111	11111111	-
V	*Paratya curvirostris*	----	----11-	----11--	-
	Conoesucidae indet.	----	----1--	------1-	-
VI	*Anisops* sp.	----	-------	--------	1
	Polyplectropus puerilis	----	-------	--------	1
	Copepoda	----	-------	--------	1
	Sigara sp.	----	-------	-------1	1
	Ostrocoda	----	-------	----1---	1
	Potamopyrgus antipodarum	---1	--1----	11111111	1
	Gyraulus ?kahuica	----	-------	---111-1	1
	Aoteapsyche spp.	----	-------	1-11--1-	-
	Oxyethira albiceps	----	-----1-	1--111-1	-
	Cura pinguis	----	-------	11111111	-
	Paroxyethira hendersoni	----	-------	-------1	-
	Hydrobiosis affumbripennis	----	-------	-1------	-
	Aoteapsyche tepoka	----	-------	11---1--	-
	Hydrobiosis sp.C	----	-------	1-------	-
	Gripopterygidae indet.	----	-------	1-------	-
	Muscidae sp.A	----	-------	1-------	-
VII	Hydrophilidae	---1	-------	1-------	-
	Zelandobius confusus	-1--	-------	---1----	-
	Nematoda	---1	-------	--------	1

Figure 3 Benthic invertebrate taxa found in kick and sweep samples from Ngaruroro River. TWINSPAN taxa groupings (I-VII) are shown on the left. 1 = present.

4.3 Invertebrate Density in Runs

Density of invertebrates in runs ranged from an average of 38 0.1 m^{-2} at Site 5 to 398 0.1 m^{-2} at Site 1 (Fig. 4). Larvae of the leptophlebiid mayfly genus *Deleatidium* spp. and of the beetle family Elmidae were the most abundant taxa in Surber samples (Fig. 4), and together comprised 84-92% of the total fauna. Mean numbers of taxa found in Surber samples at each site ranged from 4 to 10 (Fig. 4).

Statistically significant site differences (ANOVA, log transformed data, P<0.01) were detected for densities of total invertebrates, *Deleatidium* larvae, Elmidae and the number of invertebrate taxa collected in Surber samples (Table 5, Fig. 4). Site 1 had significantly (Student-Neuman-Keuls test, P<0.05) higher total invertebrate densities than Sites 2 and 5, and densities at Sites 3 and 4 were also significantly higher than at Site 5. Densities of *Deleatidium* larvae were significantly greater at Site 1 than at any other site (Fig. 4), whereas significant differences in Elmidae densities were apparent between all sites except for Sites 1 and 3 (Fig. 4). Significantly more taxa were collected in Surber samples from Sites 4 and 1 than Sites 2 or 5 (Fig. 4).

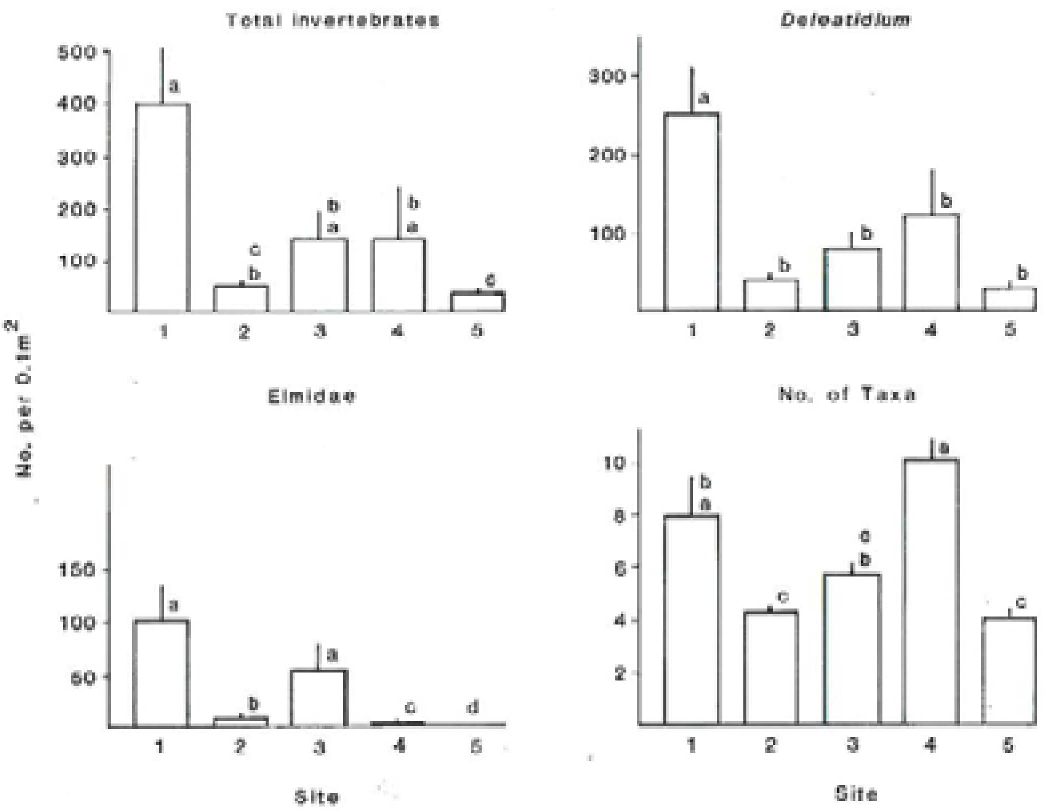

Figure 4 Mean (+1SE, n = 3) densities (no. per 0.1 m^2) of *Deleatidium* larvae, Elmidae and total invertebrates and number of taxa found in Surber samples at the five sites on Ngaruroro River. Sites with the same letter above bars are not significantly different (Student-Neuman-Keuls test, P>0.05).

Table 5 F and probability values for analyses of variance of invertebrate densities (total, *Deleatidium* and Elmidae) and numbers of taxa at the five sites on Ngaruroro River (log or log*x*+1 transformed data).

Variable	F value	Probability
Deleatidium	6.8	0.007
Elmidae	39.5	<0.001
Total	10.9	0.002
No. of taxa	7.9	0.004

5 DISCUSSION

5.1 Importance of Different Habitat Types

Jenkins *et al.* (1984) emphasised the importance of sampling a range of habitat types when using aquatic invertebrates to assess conservation value, and tentatively concluded that an adequate assessment could be achieved by sampling an eroding area (e.g., run or riffle), a depositional area (e.g., pool or backwater), and marginal roots or macrophytes. The importance of sampling pools and margins is emphasised in our study by the fact that they had the greatest number of taxa found only in that habitat type and substantially more taxa than runs.

Plectronemia maclachlani, *Pycnocentria evecta*, *Anisops* and *Sigara* were found only in pools and margins and are typical inhabitants of slower flowing habitats (Pendergrast and Cowley 1966, Cowley 1978, Winterbourn and Gregson 1989). However, some of the other taxa that we found only in pools and margins have been found in runs and riffles elsewhere in New Zealand. *Austroclima sepia* has been found where water courses form small waterfalls and cascades (Towns and Peters 1979), and *Polyplectropus puerilis* usually lives in faster currents (Cowley 1978). These species may have occurred in pools and margins of Ngaruroro River because these habitats can provide refugia for recolonisation of runs and riffles following floods (Scrimgeour *et al.* 1988). These refugia are thought to be particularly important for recolonisation by the mayfly *Deleatidium* which made up to 42% and 88% of the invertebrate fauna in pools and margins, respectively, and was numerically dominant in runs and riffles.

In our study, densities of invertebrates were determined only in runs which provide feeding habitat for dotterels, stilts, gulls and some waterfowl (Parrish 1988). For those species that feed on aquatic invertebrates, food supplies were most abundant per m^2 of bed at Site 1 followed Sites 3 and 4. However, at Site 4 the river channel was extensively braided and this site seems most likely most to have the greatest amount of feeding habitat available.

One potentially important habitat type not sampled in our study is the hyporheic zone, the area outside the channel (streambed or floodplain) where water seeps between the interstices of stones. In the United States, the hyporheis has been found to be particularly important in braided, gravel-bed rivers (which the Ngaruroro also is) where extensive floodplain aquifers are connected to river channels (Stanford and Ward 1988). These authors suggested that the biomass of invertebrates in the hyporheic zone could exceed that found in the benthos of gravel-bed rivers.

5.2 Naturalness of the Invertebrate Fauna

This criterion reflects the level of human induced disturbance to a system (Margules and Usher 1981). We used the number of exotic species present as in indication of naturalness of the aquatic invertebrate fauna in Ngaruroro River. The planorbid snail *Physa acuta* was the only exotic invertebrate found and it was present at all sites sampled. This species is widespread throughout the country and is particularly abundant in agricultural and urban areas where it is thought to have displaced the native species *Physastra variabilis* (Winterbourn 1973, Forsyth and Lewis 1987). In Ngaruroro River, *P. acuta* was relatively most abundant in margins at Sites 3 and 4 (49 and 45% of the total fauna, respectively), and in pools at Site 5 (16%). It comprised <2% of the fauna in runs or riffles.

5.3 Rarity and Diversity

Assessments of rarity and diversity between rivers are difficult to make; different workers use different sampling techniques and intensities, and habitats such as margins and pools have not been adequately sampled in the past (Jenkins *et al.* 1984). This problem is compounded in New Zealand by poor taxonomic knowledge of many invertebrate groups and inadequate information on the distribution of described species. Several unidentified species were found in our sampling of Ngaruroro River but most were small larvae making identification difficult. Reasonable numbers and sizes (possibly 3rd instar) of an undescribed species of *Neurochorema* were found at Site 4; this species is also known from other rivers in the North Island (I. Henderson, Massey University, pers. comm.). The planorbid mollusc *Gyraulus kahuica* has a restricted distribution and is known only from the Gisborne-Hawke's Bay area and Kaikoura, although the validity of this species is doubtful (Winterbourn 1973).

Cowie (1980) defined rare species **within** a river system as ones which represent <0.1% of the fauna at any site, although this was not done in a conservation assessment context. Nevertheless, this operational definition does allow some assessment of within river rarity, and on this basis, most "rare" taxa at the points we sampled in Ngaruroro River were found at Sites 3 and 4 (7 and 6 taxa, respectively, c.f. 0-3 taxa at the other sites). Sites 4 and 5 had the greatest number of taxa found only at that site (Table 3).

Diversity is best assessed using the number of taxa recorded at different sites (Margules and Usher 1981), and we used this attribute to compare diversity of invertebrate faunas at the five sites on Ngaruroro River. This indicated that Site 4 had the most diverse invertebrate fauna followed by Sites 5 and 3. Diversity of community types at different sites within Ngaruroro River can also be assessed by examining the distribution of sites amongst the TWINSPAN sample groups (see Fig. 2). On this basis, Site 4 also had the greatest community diversity as it was represented in 3 of the 4 groups at Level 2.

5.4 Comparisons with Other Rivers

Most studies of New Zealand rivers have focused on invertebrate faunas colonising only fast-flowing erosional habitats such as runs and riffles, and data from these habitats provide the best information for assessing representativeness. Because other data sets were collected using different techniques and sampling intensities to those we adopted, we have restricted ourselves to comparisons of community composition and mean density where similar sampling equipment was used.

The benthic fauna of Ngaruroro River was dominated numerically by larvae of the mayfly *Deleatidium* and elmid beetles. Together, these taxa were dominant in runs and riffles (84-98% and 68-99% of the benthos, respectively) except at Site 4 where they made up only 2% of the fauna found in riffles (oligochaetes comprised 86%). In terms of community dominance, the section of Ngaruroro River that we sampled appears to be representative of lowland riverine sites with low gradients, and fine substrates or a recent history of major flooding (i.e., Class II of Quinn and Hickey 1990).

Runs and riffles of braided rivers elsewhere in New Zealand are also dominated by *Deleatidium* larvae (31-97% of the fauna) with Elmidae and chironomid larvae the next most important (Pierce 1986, Sagar 1986, Scrimgeour *et al.* 1988, Scrimgeour and Winterbourn 1989). As with other braided rivers, proportions of cased caddisfly larvae were low in runs and riffles of Ngaruroro River (usually < 2% of the total fauna), and this is thought to reflect their vulnerability to damage by moving substrates (e.g., Sagar 1986, Scrimgeour and Winterbourn 1989).

Invertebrate densities in Ngaruroro River (38-398 0.1 m^{-2}) were within the range of most (62%) Class II sites sampled in summer by Quinn and Hickey (1990), and of the Ashley, a Canterbury braided river, (33-1100 0.1 m^{-2}) sampled by Scrimgeour and Winterbourn (1989); both pairs of workers also used 0.25 mm mesh Surber samplers. Densities of invertebrates in braided rivers tend to be highly variable over time, and this has been related to the frequency of flooding and subsequent bed load movement (Pierce 1986, Sagar 1986, Scrimgeour *et al.* 1988). Indeed, frequency of flooding is thought to be a major reason for the invertebrate fauna of braided rivers being so heavily dominated by *Deleatidium* larvae which have rapid recolonisation abilities, and flexible habitat requirements and life histories (Scrimgeour 1991).

5.5 Management Recommendations

Pools and margins provide important habitat for aquatic invertebrates in Ngaruroro River. They can serve as refugia from floods for normally running-water species and act as reservoirs of invertebrates for downriver recolonisation following disturbance. In addition, pools and margins provide habitat for species not normally found in fast-running water and thereby increase the diversity of the aquatic invertebrate fauna.

Management should ensure that the integrity of pools and margins is maintained, and that their connections with running water habitats remain intact.

5.6 Conservation Recommendations

The section of river characterised by Site 4 (extensively braided, wide floodplain) has the highest conservation value based on a combined assessment of the rarity, diversity, naturalness and representativeness of the aquatic invertebrate fauna (Table 6). This site could be representative of the river between Whanawhana and the Mangatahi Stream confluence where cliffs confine the river naturally. Along this section, the river effectively manages itself due to the presence of these cliffs. The virtual absence of exotic weeds from the shingle beds and the low density of exotic trees along the berms add to the conservation value of this section. In addition, a lowland fish community extends into this section of the river; the continued existence of this community is dependent on the maintenance of downstream and upstream passage for migratory species.

The section of Ngaruroro River between Whanawhana and the Mangatahi Stream confluence has high conservation value.

Table 6 Assessment of the conservation value of 5 sites on Ngaruroro River using different attributes of the aquatic invertebrate fauna. X=low, XX=medium, XXX=high.

Site	Naturalness	Rarity	Diversity	Representiveness
1	XX	X	X	XXX
2	XX	XX	X	XXX
3	XX	XXX	XX	XXX
4	XX	XXX	XXX	XXX
5	XX	X	XX	XXX

5.7 Future Work

This study is not extensive enough to recommend areas for protection under Water Conservation Orders, and further work is required to provide information for catchment management plans. The hyporheic zone (where interstitial running water occurs) may provide important habitat for aquatic invertebrates on the Ngaruroro River floodplain, and sampling is required to assess this. More extensive river sampling also needs to be carried out to determine whether Site 4 is truly representative of the extensively braided section of river below Whanawhana. Parts of the river that are likely to form ox-bow lakes in the future also need to be identified and considered for protection where appropriate as these lakes are an endangered habitat type on lowland areas.

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APPENDIX 1 Hydraulic and benthic invertebrate data ciollected during Surber sampling of runs in Nga ruroro River. See below for units. -, no data.

Site/ sample	Depth	Velocity	Slope	Roughness	Froude no.	Reynolds no.$x10^{-3}$	*Deleatidium* no.	Elmidae no.	Total no.	No. taxa
1	0.43	0.610	0.017	2.2	0.30	2623	326	122	503	9
1	0.38	0.508	0.005	2.2	0.26	1930	301	147	506	10
1	0.35	0.941	0.008	2.2	0.51	3294	143	35	184	5
2	0.33	0.865	0.013	1.8	0.48	2855	52	6	64	5
2	0.37	0.890	0.008	1.8	0.47	3293	37	10	50	4
2	0.36	0.890	0.013	1.8	0.47	3204	29	10	41	4
3	0.36	0.967	0.017	2.2	0.51	3481	80	35	120	5
3	0.30	0.890	0.013	2.2	0.52	2670	116	109	235	5
3	0.32	1.068	0.020	2.8	0.60	3418	43	23	75	7
4	0.33	0.755	0.008	2.2	0.42	2492	238	2	254	12
4	0.36	0.814	0.007	2.2	0.43	2930	44	1	85	9
4	0.37	1.119	0.003	2.2	0.59	4140	67	2	85	9
5	0.41	0.636	0.008	1.8	0.32	2608	25	0	29	3
5	0.42	0.636	0.007	1.8	0.31	2671	41	0	46	4
5	0.37	0.483	-	2.4	0.25	1787	36	0	40	5

Depth (m); Velocity ($m.s^{-1}$); Slope, Froude no. and Reynolds no. (dimensionless); Roughness ("cm"); *Deleatidium*, Elmidae, total and taxa numbers ($0.1m^2$)

APPENDIX 2 Taxonomic list of aquatic invertebrates found at five sites on Ngaruroro River on June 5 1990. For sample codes, RF = riffle, RN = run, P = pool, M = margin, 1-5 = site numbers (see Fig.1). All samples were collected by the kick and/or sweep methods, but in runs Surber samplers were also taken (indicated in parenthese; K = kick, S = Surber).

Taxon	Samples
ARTHROPODA	
INSECTA	
Order Ephemeroptera (mayflies)	
Deleatidium spp.	All samples
Austroclima sepia	M2
Nesameletus sp.	P4, RF5, P5, M5
Coloburiscus humeralis	RF4, RN4(K), M5
Plecoptera (stoneflies)	
Zelandobius confusus	RF1, M5
Zelandobius furcillatus	RF2, RN2(K), P2, RF3, P3, M3, RF4, RN4(K,S), P4, RF5, RN5(K), P5, M5
Zelandoperla decorata	RN4(K)
Austroperla cyrene	RF5
Gripopterygidae indet.	P3
Trichoptera (caddisflies)	
Hudsonema amabilis	RF4, RN4(K), P4, M4, P5, M5
Pycnocentria evecta	M2
Pycnocentria funerea	RN4(S)
Olinga feredayi	M2, RF4, RN4(K), P4, RF5, RN5(K), P5, M5
Beraeoptera roria	P5, M5
Pycnocentrodes spp.	RF1, RN1(K,S), P1, RF2, RN2(S), P2, M2, RF3, RN3(S), P3, M3, RF4, RN4(S), P4, RF5, RN5(K,S), P5, M5
Conoesucidae gen. et sp. indet.	P2, RN3(K)
Oxyethira albiceps	RF1, RN1(S), P1, M1, M2, P3, M3
Paroxyethira hendersoni	M3
Aoteapsyche colonica	RF1, RN1(K,S), P1, RF2, RN2(K), P2, M2, RN3(S), RF4, RN4(K), RF5, RN5(K,S), M5
Aoteapsyche tepoka	M1, RF3, P3
Aoteapsyche spp.	RF1, RN1(K), RN3(K), P3, RN4(S)
Hydrobiosis parumbripennis	M2, RF4, RN4(K,S)
Hydrobiosis aff *umbripennis*	RF3
Hydrobiosis aff *frater*	RN4(K)
Hydrobiosis sp. A	RF4, RN4(K), P4, P5
Hydrobiosis sp. B	P5
Hydrobiosis sp. C	P3
Neurochorema sp.	RF4, P4
Psilochorema sp.	RN1(S), RF2, RN2(K,S), RF3, P3, RF4, RN4(K,S), P4, RF5, RN5(K,S), M5
Hydrobiosidae indet.	RF1, RN1(K,S), RN2(S), P2, P3, RF4, RN4(S), RF5, RN5(K), P5, M5
Polyplectropus puerilis	M4
Plectronemia maclachlani	P5
Coleoptera (beetles)	
Elmidae	RF1, RN1(K,S), P1, M1, RF2, RN2(K,S), P2, M2, RF3, RN3(K,S), P3, M3, RF4, RN4(K,S), P4, RF5, RN5(K), P5, M5
Hydrophilidae	P3, P5
Hemiptera (bugs)	
Sigara sp.	M3, M4
Anisops sp.	M4
Megaloptera (dobsonflies)	
Archichauliodes diversus	RF5, P5, M5

Diptera (true flies)	
Chironomidae	RF1, RN1(K,S), P1, M1, RF2, RN2(K,S), P2, M2, RN3(S), P3, M3, RF4, RN4(K,S), P4, RF5, RN5(K), P5, M5
Austrosimulium sp.	RF2, RF4, RN4(K,S)
Paralimnophila skusei	RF4
Eriopterini	RF2, RN2(K,S), M2, RF3, RN3(K,S), P3, M3, RF4, RN4(K,S), P4, RF5, RN5(K,S), M5
Muscidae sp.A	P3
Muscidae sp.B	P5
Tipulidae indet.	RF5
CRUSTACEA	
Paratya curvirostris	P1, M1, P2, M2
Ostracoda	P1, M4
Copepoda	M4
MOLLUSCA	
Potamopyrgus antipodarum	RF1, RN1(K,S), P1, M1, RF3, RN3(K), P3, M3, RF4, M4, P5
Gyraulus ?kahuica	RF1, P1, M1, M3, M4
Physa acuta	RN1(K), P1, RF2, RN2(K), RN3(K,S), M3, RF4, RN4(S), P4, M4, RF5, P5
PLATYHELMINTHES	
Cura pinguis	RF1, RN1(K,S), P1, M1, RF3, RN3(K), P3, M3
indet.	RF5
ANNELIDA	
OLIGOCHAETA	RF1, RN1(K,S), P1, RN2(K,S), P2, M2, RN3(S), P3, RF4, RN4(K,S), P4, M4, RF5, RN5(K), P5, M5
NEMATODA	M4, P5