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A method for estimating potential insect availability at the surface of rivers

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A method for estimating potential insect availability at the surface of rivers

by

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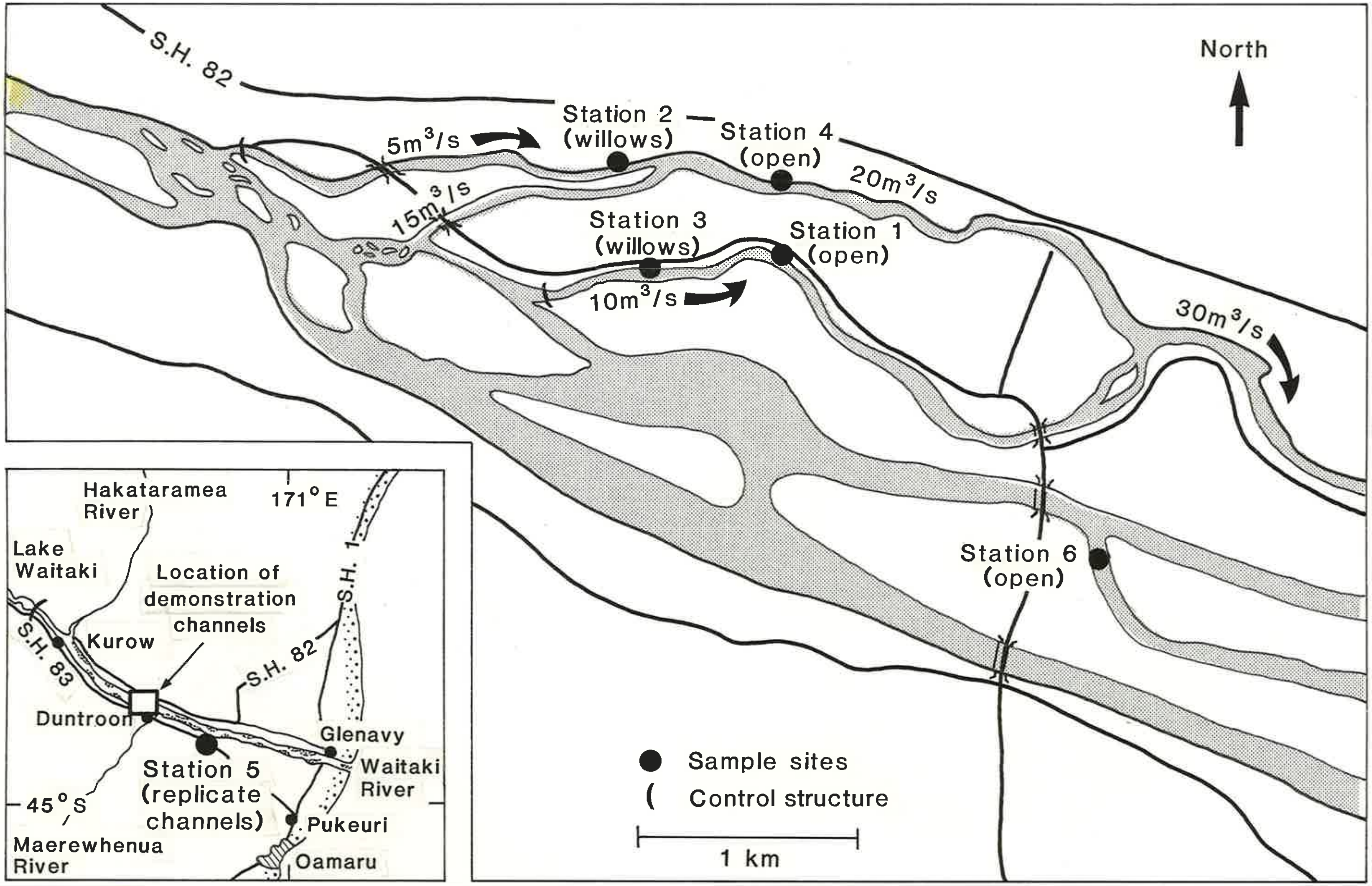

FIGURE 1. The lower Waitaki study area showing sampling sites in the demonstration channels and location of the replicate channels.

1. INTRODUCTION

The lower Waitaki River (the 65-km portion of the Waitaki downstream of Waitaki Power Station) has been proposed by the New Zealand Electricity Division (NZED) as the site for a 900-MW hydro-electric development. Various options for development have been presented and discussed by Ministry of Works and Development (1979) and McColl and Natusch (1982). One of these options provides for a residual river as a means of conserving the fishery, wildlife, and recreational values of the lower Waitaki. It is thought that this option holds the greatest potential for maintaining the qualities of the present river (Graynoth, Pierce, and Wing 1981).

In 1981 "demonstration channels" that made use of a series of interlinked side braids adjacent to the Waitaki River were established near Duntroon (Fig. 1) (Knowles and Pierce 1982). The channels are protected from flood waters and have flow rates controlled at from 5 to 30 m^3/s. Studies have been done in the channels to determine and evaluate habitat characteristics to be incorporated into a residual river. Many environmental parameters have to be measured to allow the application of various methods for assessing instream flow and habitat values in the demonstration channels. However, the usefulness of a few of the measurements, for example the amount of shade or cover provided by overhanging vegetation (particularly willow trees), is not clear. Although the trees are aesthetically appealing and help stabilise river banks, the assumption that they improve fish habitat is not supported by direct evidence.

Benefits of overhanging willows could include shade and cover for fish, in fallen branches or roots, and an increased supply of allochthonous material, such as catkins and leaf fall, to the stream. The willows may also influence the flight patterns of insects over the water and the rate at which terrestrial insects fall into the water.

This report describes a simple means of measuring insect contact with the water surface. Because insects which fall on to or are associated with the water surface may be consumed by fish, the method provides a measure of potential food for fish. No elaborate equipment is needed and results are suitable for making simultaneous comparisons between locations.

2. MATERIALS AND METHODS

The method is an application of the water trap, which catches insects in a container of dilute aqueous detergent. The detergent reduces the surface tension, so that the solution will not support an insect. Insects that come into contact with the surface are held there and drown.

Four experimental sampler arrangements were tried, of which the floating-platform sampler was the simplest and in one form or another the most recommendable. The other arrangements were used to test the functioning of the floating-platform sampler.

The floating-platform sampler (Fig. 2) consisted of four tin cans, each 10 cm in diameter and 5 cm deep, supported on a styrofoam platform 30 x 30 x 5 cm. The platform had a central hole through which a metal stake could pass freely. The platform was held in place by a metal stake driven into the streambed, but was free to rise and fall

FIGURE 2. The floating-platform sampler *in situ*.

with the water level. In windy conditions it would be better to double the thickness of the platform and to cut recesses in the float surface to hold the cans.

Hanging-can samplers consisted of the same tin cans suspended just above the water surface from a horizontal metal cross support held on a metal stake. Eight cans were suspended at 15- and 35-cm intervals along each of the four arms of the support. The supporting arms were welded to a central metal tube which fitted over the metal stake.

Tray samplers consisted of white plastic photographic trays 31 x 21 x 4 cm. These were held in pairs just above the water surface on an H-shaped horizontal metal support clamped to a central metal stake driven into the streambed.

Clear samplers used the same support as the tray samplers, but the white trays were replaced by clear acrylic shelves 34 x 13 x 0.5 cm. The detergent solution was held in four clear acrylic containers, each 11 cm in diameter and 6 cm deep.

Each container was half filled with dilute detergent and left exposed for 24 h. The detergent used was biodegradable Hurst lotion detergent. Diluted at about 1 part per 100 parts of water, the detergent had a faint straw colour and a barely detectable odour. Trapped insects were carefully removed from each can and placed in separate vials of 60% alcohol for identification and counting. In the analysis, counts were related to the sizes of trapped insects, which were either very small (less than 1.5 mm), small (1.5-3.0 mm), medium (3.0-6.0 mm), or large (greater than 6.0 mm).

A station in an open section of the 10-m^3/s channel (station 1) was the reference station and was used in every experiment. Simultaneous comparisons over 24 h were made between this station and stations 2, 3, and 4 (in the 5-, 10-, and 20-m^3/s channels respectively); station 5 in one of the replicate channels (0.25 m^3/s, located 15 km downstream on the south side of the Waitaki River); and station 6 (an open section of the Waitaki River at Duntroon) (Fig. 1). There were willows at stations 2 and 3, and station 4 was open. Another station (2a), in an open area in the 5 m^3/s channel and adjacent to station 2, was used only once. Additional comparisons were made between the floating-platform sampler and the other sampler arrangements operating simultaneously over 24 h at the same station. A sampling array usually consisted of 2-6 samplers (8-24 containers) or, when trays were used, 8 trays.

The Mann-Whitney U-test was used to compare the number (n) of insects trapped per container (counts) at a given station when different samplers were used simultaneously. Comparisons between containers of different sizes necessitated converting the numbers to a value per unit surface area equivalent to the 10-cm-diameter cans most frequently used. Simultaneous comparisons between two stations, and three stations when there were unequal numbers of containers, relied on the same statistical test. On 6-7 April when three stations had equal numbers of containers, the Kruskal-Wallis test followed by a nonparametric multiple comparison equivalent of the Newman-Keuls test was used. A chi-square (χ^2) analysis was used to test the hypothesis that the size-frequency distributions of insects trapped were independent of trapping location or type of sampler. Because in all counts the variances were far larger than the means, a log n or log n+1 transformation of the counts was used in regression analyses and in the calculation of the confidence intervals about the arithmetic means, as recommended by Elliott (1977).

3. RESULTS

An initial experiment at station 1 on 25-26 November 1982 was designed to test the operation of the floating-platform sampler and examine the hypothesis that catches differed along a gradient from shore to mid channel; that is, that there was a significant edge effect. Floating-platform samplers were placed on shore and at 2.5-m intervals to 12.5 m, which was the middle of the channel. The catch on shore was low, but traps over water showed little difference related to distance offshore. A Kruskal-Wallis test just failed to reject the hypothesis that catches were the same in all traps ($H_C = 10.729$, $\chi^2_{0.05,5} = 11.070$; $0.1 > p > 0.05$). The obvious discrepancy was the shore sampler, which caught only 15 insects in 4 cans as against 90-129 for the samplers over water. Mean number ($\bar{x}$) of insects per can over the water was 27.15 (variance (s^2) 102.55). Since s^2 is greater than $\bar{x}$, a contagious distribution of the insects trapped is implied.

A regression of log n against distance from shore gave a slope of 0.0116, which was clearly not significant ($F = 1.27_{1,18}$df). Therefore, it was concluded that the shore counts were different (lower) than the counts over water, but that the latter did not vary with distance from shore in a channel 25 m wide.

On 29-30 November 1982 the experiment was repeated at station 1, but samplers were added at 1.25 and 3.75 m from shore. A regression of log n against distance from shore was not significant ($F = 1.43_{1,26}$df), confirming the conclusion that the number of insects trapped did not vary with distance from shore.

There was the possibility the floating-platform sampler might act as a surface skimmer and the number of insects trapped might be inflated by those that crawled on to the samplers and fell into the cans. This was examined by comparing catches in hanging-can samplers with those taken by floating-platform samplers. On 7-8 December 1982, two floating-platform and one hanging-can samplers were compared at stations 1 and 6. In both locations there were no significant differences (Mann-Whitney $p > 0.05$) in the number of insects trapped. A χ^2 analysis of the size frequencies of insects trapped showed no difference between the two types of samplers at station 1 or the more exposed station 6. However, at station 6 the hanging-can traps caught no large insects, and so the "no difference" conclusion was unsatisfactory (and was probably the result of combining medium-sized and large-sized insects for the analysis). The hanging-can sampler had one obvious disadvantage; the cans swung in the wind and this may have repelled larger, more active insects.

The experiment was repeated at station 1 on 14-15 December 1982, when there was a warm, moderate NE breeze blowing. The result confirmed that there was no difference in numbers of insects trapped nor in their size-frequency distribution. The hanging-can sampler was not used again because of the wind problem and because it was more difficult to operate than the floating-platform sampler.

The apparently contagious distribution of the insects trapped prompted a comparison of catches in different sized containers. Trays with an area of 593 cm^2 (7.563 times larger than the cans) were used in an experiment at station 1 on 6-7 January 1983. This showed that the number of insects trapped per unit of surface area was not significantly different between the trays and the cans (Mann-Whitney $p > 0.05$), but the size distribution was different ($\chi^2 = 11.07$, 3 df, $p < 0.25$). The cans captured more large and fewer small insects than the trays. This result raised the possibility that the cans were acting as "islands" which might attract certain insects. This seemed particularly likely because many of the large insects captured were Diptera not normally associated with water. To investigate this possibility a transparent sampler was compared with the floating-platform sampler. The clear containers were slightly larger than the cans (95.0 cm^2 and 78.5 cm^2 respectively) therefore counts in the clear containers were multiplied by 0.826 to correct for area.

Results from an experiment on 24-25 January 1983 at station 1 showed that the floating-platform samplers caught more insects than the clear samplers (Mann-Whitney $p < 0.02$). In addition, there was a highly significant ($p \ll 0.001$) difference in the proportions of different sized insects trapped. The floating-platform sampler had more large and small insects and fewer medium-sized insects than the clear sampler. The experiment was repeated during 24-25 February 1983 in cooler conditions. Catches were greatly reduced and the numbers of insects trapped by the two types of sampler were not significantly different. A third experiment on 25-27 February 1983 (and done over 48 h to increase numbers of insects trapped) confirmed this result. It appeared that the two types of samplers caught the same numbers of insects; though this result should be regarded with some reservation.

The results of χ^2 analyses of the size-frequency distribution of insects trapped were inconsistent. The experiment of 24-25 February 1983 produced almost identical proportions of small to medium and large insects in the two samplers, whereas that of 25-27 February 1983 showed the floating-platform sampler had an excess of large insects compared with the clear samplers. These large insects were either Diptera or Trichoptera and the proportions of each were identical in the two types of sampler.

All other experiments were carried out with the floating-platform samplers, because they were by far the easiest samplers to handle. The results are summarised in Table 1. For each location the mean number of insects trapped per square metre per day and 95% confidence intervals are given. The size distribution of insects captured, the number of cans used, and the probabilities of there being "no significant difference" between the various comparisons are also given.

Catches at station 1 varied significantly during the season (Fig. 3). The weather had a distinct influence on the catches, and the seasonal patterns suggested in Figure 3 may be affected by this. A note on the weather is provided in Table 1 to facilitate interpretation of the seasonal changes in numbers of insects trapped.

4. DISCUSSION

Tests on various types of samplers did not reveal distinct differences in their performance. The possibility that the floating-platform sampler might provide an inflated count by acting as a surface skimmer was not supported by results of comparisons with the hanging-can, tray, or clear samplers, which could not act in this way.

Tests to compare the clear sampler with the floating-platform sampler gave equivocal results. In two out of three experiments the numbers of insects trapped were not significantly different, but on these occasions catches were fairly low. In one experiment the floating-platform sampler caught more insects than the clear sampler, and the proportions of the size groups of insects trapped were markedly dissimilar. The biggest disparity in numbers of insects trapped was among the large Diptera, where 24 cans caught 58 and 12 clear plastic containers caught 13. Also, in one of the two experiments in which

TABLE 1. Results of floating-platform insect trap experiments, Waitaki River and demonstration channels, November 1982-April 1983.

Station	Date	Weather	Number of cans	Mean number of insects per m^2	95% confidence limits: Upper	95% confidence limits: Lower	Size distribution: Very small	Size distribution: Small	Size distribution: Medium	Size distribution: Large	Comparisons (between stations): Mann-Whitney Kruskal-Wallis	Comparisons (between stations): Chi-squared
1	25-26 Nov	Windy calm sunny	20	3 460	4 130	2 890	-	396	114	33	-	-
1	29-30 Nov	Cold rain warming	28	900	1 100	730	3	86	100	9	N.S.	N.S.
6			20	1 090	1 320	900	-	79	89	3		
1	7-8 Dec	Breezy	8	750	1 190	470	-	9	34	4	N.S.	p < .001
6			8	450	830	240	-	2	12	14		
1	14-15 Dec	Fine warm moderate	16	1 800	2 080	1 550	-	65	116	45	p = 0.05	p < .001
3		NE breeze	16	2 270	2 860	1 800	-	34	185	66		
1	15-16 Dec	Summer day	16	2 150	2 530	1 820	19	116	54	81	N.S.	p < .001
3			16	2 070	2 530	1 690	3	79	61	117		
1	6-7 Jan	Windy sunny	15	2 720	3 240	2 270	1	297	4	18	-	-
1	20-21 Jan	Cloudy showers	24	880	1 160	670	5	102	5	54	p < .001	p < .025
5		snow on hills at night	24	270	330	210	2	41	3	4		
1	24-25 Jan	Cloudy sun evening	24	2 100	2 610	1 690	2	294	23	77	p < .001	p < .001
5		cool	24	450	620	320	10	61	7	6		
1	24-25 Feb	Cool overcast rain	24	440	580	340	4	41	7	31	p < .001	N.S.
2a*		to clearing sunny	24	110	140	90	2	12	3	4		
1	25-27 Feb	Cloudy cool warming	24	460	570	380	3	107	25	40	p < .001	N.S.
2		to very warm sunny	21	120	150	90	1	23	7	9		
4	13-14 Mar	Windy at times	13	7 670	8 100	7 260	-	95	589	97	p < .001	p < .005
1			20	1 290	1 580	1 050	-	3	131	21	p < .001	p<< .001
2			20	550	760	400	-	13	6	65		
4	4-5 Apr	Period of strong wind	9	1 880	2 560	1 380	-	26	66	41	p = 0.05	p < .001
1		warm	16	1 270	1 590	1 010	4	28	112	15	N.S.	p<< .001
3			16	1 580	2 270	1 090	2	151	29	16		
4	6-7 Apr	Mild calm	16	9 030	16 710	4 880	1	77	1 005	52	p<< .001	p < .005
1			16	1 340	1 670	1 080	-	23	132	14	all	
3			16	510	660	390	1	20	37	6	individual	

* An open station adjacent to station 2, see p.9.

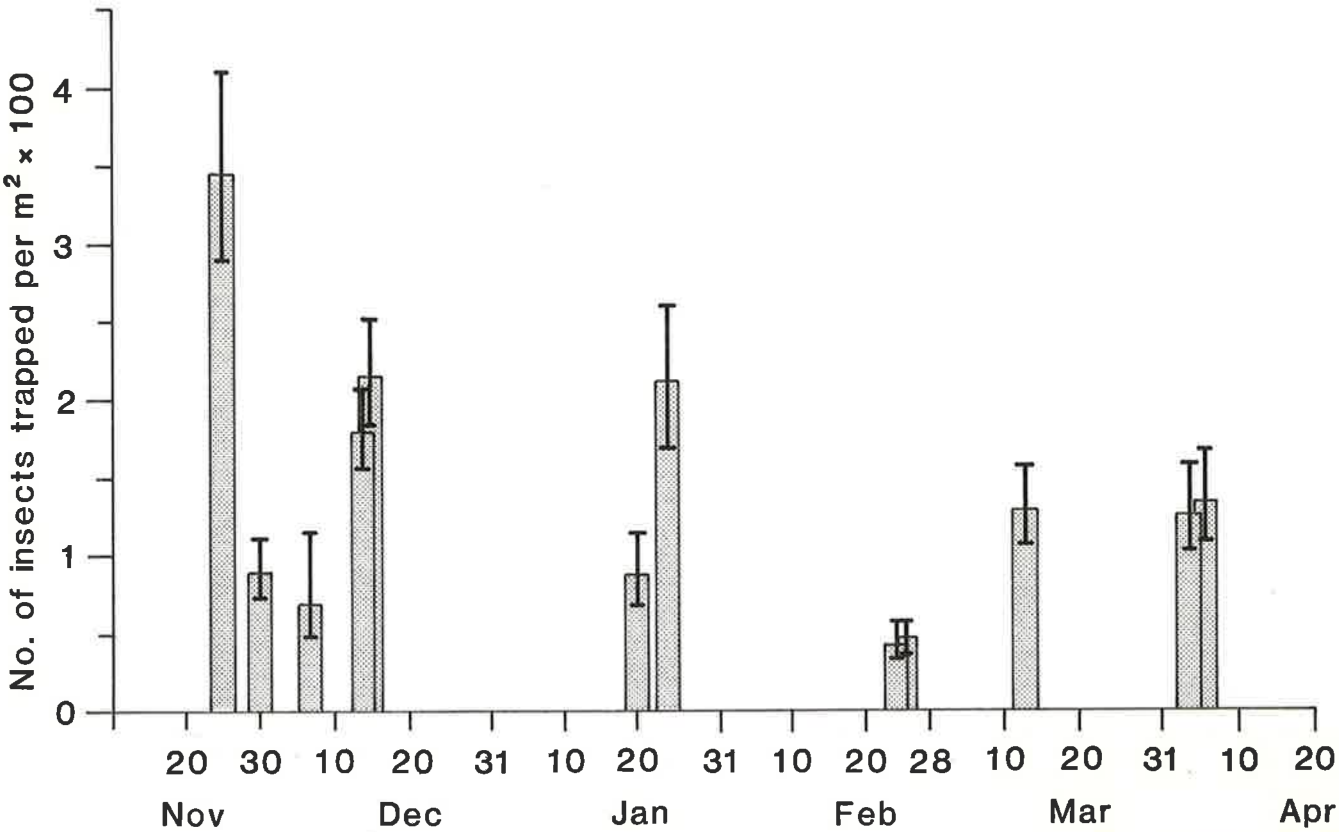

FIGURE 3. Seasonal changes in mean numbers of insects trapped per square metre (± 95% confidence interval) at station 1, November 1982-April 1983.

numbers of insects trapped did not differ, the cans caught more large insects (Diptera and Trichoptera) than the clear containers. This implied that the floating-platform samplers (with shiny metal cans) were attracting some of the larger insects. In terms of total numbers of insects trapped, any error caused by this is small, but it may have an influence on the size distribution of the catch. The performance of the floating-platform sampler was considered acceptable because of its ease of operation. However, if more detailed studies are to be done in future, the platform would be better made of clear plastic and the containers either made as part of the platform, or held on the platform in suitable recesses.

An expected increase in the number of insects trapped closer to the river edge was not found. Most insects trapped had aquatic larval stages and appeared to be evenly distributed over the water surface in an open channel. The numbers trapped in samplers placed only 30 cm from the water's edge were less than in samplers further away from the edge, and the catches in samplers close to the edge included more terrestrial forms such as Hemiptera and also Collembola. No experiments were conducted in wide channels, and it is possible that in wide areas of the river there may be less insect activity over the water in the centre of the channel. There was no obvious edge effect, and the idea that young fish near the margin of the channel are at an advantage because they have more opportunity to prey on surface insects or those of terrestrial origin was not supported by these observations.

Results from simultaneous comparisons between locations were not predictable (Table 1). Two comparisons (29-30 November and 7-8 December) between station 6 (which was very open and exposed with little vegetation on the marginal islands) and station 1 showed a difference in the size distribution of the catch on the second occasion. The availability of surface insects on the Waitaki River appeared to be as great as the much more protected, open, reference location (station 1) in the channel with a controlled flow of 10 m^3/s. This result is hard to understand and should be tested with additional observations.

Four comparisons between station 1 and station 3 (under a marginal willow canopy) gave inconsistent results (Table 1). In one comparison, the traps at station 1 caught more insects than those at station 3, in two comparisons there were no differences in numbers trapped at the stations, and in the fourth the traps at station 3 caught the most insects. The experiment in which more insects were trapped under the willows was done in summer, whereas the experiment in which more insects were trapped at station 1 was in autumn.

In two experiments, floating-platform samplers at station 2 (which was heavily shaded by a canopy of willows) caught fewer insects than those at station 1. These experiments were done in late summer and autumn.

In most of the above comparisons between open and tree-shaded sites, there were highly significant differences in the size distribution of the insects trapped. There tended to be fewer small insects in December samples and fewer medium insects (for example, *Oxyethira*) in the April samples under the willow canopy. The trees did not appear to provide any special benefit which would increase insect activity, nor did they appear to provide shelter to smaller insects. If anything, there appeared to be more insect activity over the open channel.

The greatest differences between locations occurred on 13-14 March 1983 and 6-7 April 1983, when floating-platform samplers at station 4 caught 6 and 1.5 times as many insects as at station 1. These big differences were caused by large numbers of recently emerged *Oxyethira* which were caught in station 4 traps.

Data from the experimental sites ranked in increasing numbers of insects trapped suggested that wider channels were more productive than narrower ones. However, more data on variations within channels and between sites are needed to test this.

An expanded sampling programme is needed to test the above results. Simultaneous comparisons of several matched habitats within each channel would reduce errors caused by possible local abundances of specific insects. If channel widths rather than habitats were important, samplers placed randomly along the lengths of channels would be a reasonable sampling strategy. Catches at any one site may be influenced by the mixture of habitats in the vicinity, both upstream and downstream of the site.

Within the demonstration channels there could be complicating factors due to the layout of the channels, and the evolution of habitats under a controlled flow regime could be investigated. If controlled flow channels change in time because stable substrates and sedimentation allow the establishment of algal and macrophyte communities, these changes will be reflected in water quality, benthos, and fish communities. The three feeder channels (5, 10, and 15 m^3/s) all receive Waitaki River water at their intakes, and this water is subject to all the perturbations due to impoundment, floods, and other conditions as it flows down the Waitaki River. During its passage down the channels it will be modified by physical and biotic conditions, so that water entering the 20- and 30-m^3/s channels is not the same as that entering the smaller channels. It should be possible to measure such changes by comparing locations where physical factors are similar, at different distances along the length of controlled flow channels. Turbidity measurements and quantities and particle sizes of suspended material might be the easiest measurements to make to detect change. Channels of different width, flow rates, and tree cover may not evolve at the same rate. Some of the differences detected in the insect trapping experiments may be a reflection of the complex situation prevailing in the demonstration channels.

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