

# EFFECTS OF ELECTRIC FISHING ON THE INVERTEBRATE FAUNA OF A NEW ZEALAND STREAM

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## ABSTRACT

Electric fishing experiments were made in Woolly Creek, part of the Glenariffe system of tributaries to the Rakaia River, South Island, New Zealand, during December 1972. Two operators electric fished a 25-m length of stream from the banks, with three runs in both upstream and downstream directions.

Large increases in drift were caused by the electric fishing process, which had a marked effect on the Ephemeroptera and the oligochaete families Tubificidae and Lumbriculidae.

The invertebrate drift leaving the experimental reach came predominantly from the downstream 10 m section, and larger numbers were caught in drift samples when fishing proceeded in a downstream direction. This was probably because the electrode passed over invertebrates which had previously entered the drift 'higher' upstream and re-settled on the substrate lower in the reach.

Electric fishing caused a loss to the drift of 9.6% of the total benthos in the experimental area. This was slightly more than the 8% decrease in benthic numbers calculated from bottom samples.

## INTRODUCTION

Electric fishing surveys carried out by the Ministry of Agriculture and Fisheries in New Zealand showed that large numbers of stream invertebrates entered the drift, apparently in response to the effects of the electric shocking apparatus. A similar finding was made by Elliott & Bagenal (1972) who recorded large increases in drift in a stony stream in the English Lake District when using a fish stunner. In this study their experiments were repeated to examine the effects of the electric fishing apparatus on the benthic invertebrate fauna of a New Zealand stream.

## DESCRIPTION OF SAMPLING AREA

The experiments were performed over a 2-day period, 30 November–1 December 1972 at a site in Woolly Creek, a small tributary of the Upper Rakaia River, mid Canterbury, at grid reference NZMS 1

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TABLE 1—Physical conditions in the experimental reach of Woolly Creek, mid Canterbury, New Zealand, during the experiment on the effects of electric fishing on the invertebrate fauna, 30 November and 1 December 1972

|   | SECTION                |      |      |      |                      | DRIFT NETS |       |       |
|---|------------------------|------|------|------|----------------------|------------|-------|-------|
|   | A<br>(Down-<br>stream) | B    | C    | D    | E<br>(Up-<br>stream) | DL         | DR    | U     |
| Mean Depth (m)  | 0.26                   | 0.20 | 0.20 | 0.18 | 0.20                 | —          | —     | —     |
| Water velocity (m.s <sup>-1</sup> )                                       |                        |      |      |      |                      |            |       |       |
| Maximum ..  | 0.61                   | 0.62 | 0.77 | 0.66 | 0.75                 | 0.35       | 0.42  | 0.50  |
| Minimum ..  | 0.21                   | 0.38 | 0.50 | 0.41 | 0.33                 | 0.30       | 0.25  | 0.23  |
| Water Volume Sampled by Each Net During Runs (m <sup>3</sup> )            |                        |      |      |      |                      |            |       |       |
| Down Run ..   | ..                     | ..   | ..   | ..   | ..                   | 117.6      | 121.2 | 91.2  |
| Up Run ..   | ..                     | ..   | ..   | ..   | ..                   | 86.3       | 88.9  | 66.8  |
| Mean Flow Rate in Each Net During Runs (m <sup>3</sup> .s <sup>-1</sup> ) |                        |      |      |      |                      | 0.026      | 0.027 | 0.020 |

sheet S73 882833. Woolly Creek, a narrow open stream bordered by grass and tussock banks, rises from swampy ground nearly 100 m west of the Glenariffe Stream. The bottom consist of small stones and pebbles interspersed with a few larger stones. Little aquatic vegetation was present in the stream.

The experimental reach had a total length of 25 m divided into five uniform sections (A–E) of equal length (Fig. 1). Maximum water depth was 0.35 m (mean 0.20 m) and average stream width 1.5 m. Water velocity and stream depth in each section are shown in Table 1. Water temperature ranged from 9.0°C to 10.5°C over the 2-day period.

## METHODS

The experimental reach was fished from the stream banks with the pulsed d.c. apparatus described by Burnet (1967), by two operators each holding a positive electrode, one on each bank of the stream. The machine settings were 600 V at resistance setting 2. Three fishing runs were made working in a downstream direction, followed by three upstream runs. (Electric fishing surveys carried out in New Zealand by the Ministry of Agriculture and Fisheries are done in a downstream direction. Upstream runs were performed to provide data comparable with overseas work). Two Brundin nets, mesh 0.5 mm (Brundin 1966), were placed at the downstream end of the experimental reach, one on the left side of the stream (DL) and one on the right (DR), and one control net (U) was situated at the upstream end for collecting drift invertebrates. The electric fishing apparatus was switched off at the end of each 5-m section and one net (DL) was emptied after allowing sufficient time for all drift to reach the net. The other nets (DR and U) were emptied at the completion of each run. This enabled

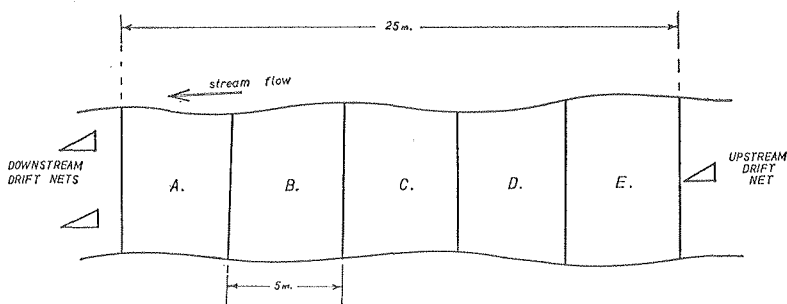


FIG. 1.—The experimental reach of Woolly Creek, mid Canterbury, New Zealand, showing the positioning of the drift nets.

comparisons to be made between total drift for the three runs in both upstream and downstream directions and drift from each of the five sections.

To evaluate the effects of electric fishing on the bottom fauna, 10 benthic samples (2 per section) were taken with a Surber Sampler of 0.5-mm mesh both before and after electric fishing the stream. All samples were sorted live soon after collection. Water velocities were recorded in each section A–E and at the mouth of each drift net with a Gurley No. 625 Pygmy current meter immediately above the substrate and just below the water surface. Temperatures were taken with a maximum-minimum thermometer placed in the stream over the experimental period. Conductivity measurements made in Woolly Creek during routine electric fishing indicated a range of conductivity from 75.5  $\mu\text{S}$  to 80.7  $\mu\text{S}$  for the period October 1972 to April 1973.

## RESULTS

A large increase in the number of drifting invertebrates occurred during electric fishing. Numbers increased from Run 1 to Run 3 (Table 2) and higher numbers of drifting invertebrates were caught during downstream runs than in upstream runs. Background drift (net U) was low at all times during the experimental period. The most abundant invertebrate, the cased trichopteran *Pycnocentodes aureola* formed a very small percentage of the drift (Table 3).

The large increases in drift occurred in the mayflies *Deleatidium* sp. (53% of the drift), *Zephlebia* sp., and *Coloburiscus humeralis*, and in the oligochaetes *Lumbriculus variegatus* and *Eiseniella tetraedra* and Tubificidae, all of which were proportionately more important constituents of the drift than of the benthos. Oligochaetes which were not easily sampled from beneath the stony substrate during benthic sampling, and blackfly larvae (*Austrosimulium* sp.) which were attached to the upper surfaces of the stones, were also an important component of the drift during electric fishing.

TABLE 2—Total numbers of stream invertebrates taken in drift samples during electric fishing in Woolly Creek, mid Canterbury, New Zealand, 30 November and 1 December 1972

| Run        | Direction | NETS                 |     |     |                       |     |     |                 |    |    |
|------------|-----------|----------------------|-----|-----|-----------------------|-----|-----|-----------------|----|----|
|            |           | Downstream Left (DL) |     |     | Downstream Right (DR) |     |     | Control Net (U) |    |    |
| ..         | ..        | 1                    | 2   | 3   | 1                     | 2   | 3   | 1               | 2  | 3  |
| Downstream | ..        | 432                  | 554 | 599 | 378                   | 464 | 440 | 16              | 15 | 18 |
| Upstream   | ..        | 349                  | 380 | 349 | 222                   | 251 | 247 | 13              | 10 | 9  |

TABLE 3—Total numbers and percentage composition of benthic samples before and after electric fishing, and drift samples during electric fishing in Woolly Creek, mid Canterbury, New Zealand, 30 November and 1 December 1972 (drift figures are the total of 6 runs; 'Other trichopters' includes *Pycnocentria*, spp. Oeconesini, *Olinga feredayi*, *Hudsonema aliena*, *Hydropsyche colonica*, *Polyplectropus puerilis*, *Hydrobiosis clavigera*, *H. harpidiosa*, *Psilochorema nemorale*, and *Oxyethira albiceps*)

| TAXON                                | BENTHOS |       |       |       | DRIFT |       |      |
|--------------------------------------|---------|-------|-------|-------|-------|-------|------|
|                                      | Before  |       | After |       | Nos   | %     |      |
|                                      | Nos     | %     | Nos   | %     |       |       |      |
| Platyhelminthes                      |         |       |       |       |       |       |      |
| <i>Dugesia montana</i> ..            | ..      | 64    | 1.6   | 12    | 0.3   | 10    | 0.2  |
| Oligochaeta                          |         |       |       |       |       |       |      |
| Tubificidae ..                       | ..      | 7     | 0.2   | 3     | 0.1   | 827   | 17.8 |
| <i>Lumbriculus variegatus</i> ..     | ..      | 42    | 1.1   | 5     | 0.1   | 0     | 0    |
| <i>Eiseniella tetraedra</i> ..       | ..      | 7     | 0.2   | 11    | 0.3   | 94    | 2.0  |
| Ephemeroptera                        |         |       |       |       |       |       |      |
| <i>Coloburiscus humeralis</i> ..     | ..      | 215   | 5.5   | 147   | 4.1   | 670   | 14.4 |
| <i>Zephlebia</i> sp. ..              | ..      | 13    | 0.3   | 12    | 0.3   | 347   | 7.5  |
| <i>Deleatidium</i> sp. ..            | ..      | 908   | 23.4  | 644   | 18.1  | 2 474 | 53.3 |
| Trichoptera                          |         |       |       |       |       |       |      |
| <i>Pycnocentroides aureola</i> ..    | ..      | 1 648 | 42.4  | 1 851 | 52.1  | 29    | 0.6  |
| <i>Beraeopters roria</i> ..          | ..      | 23    | 0.6   | 17    | 0.5   | 2     | 0    |
| <i>Hydrobiosis parumbripennis</i> .. | ..      | 10    | 0.3   | 10    | 0.3   | 14    | 0.3  |
| Other trichopters ..                 | ..      | 45    | 1.2   | 46    | 1.3   | 36    | 0.8  |
| Coleoptera                           |         |       |       |       |       |       |      |
| Elmintoidea ..                       | ..      | 292   | 7.5   | 455   | 12.8  | 23    | 0.5  |
| Diptera                              |         |       |       |       |       |       |      |
| <i>Austrosimulium</i> sp. ..         | ..      | 610   | 15.7  | 388   | 9.5   | 110   | 2.4  |
| Chironomidae ..                      | ..      | 5     | 0.1   | 1     | 0     | 8     | 0.2  |
| TOTALS ..                            | ..      | 3 889 | 100   | 3 552 | 100   | 4 744 | 100  |

Total numbers of drifting invertebrates collected during each of the three downstream and upstream runs are compared in Table 4. Generally, numbers increased from Run 1 through to Run 3. An exception was the final upstream run, in which lower numbers of Tubificidae, *Lumbriculus variegatus*, and *Deleatidium* sp. entered the drift. Total drift numbers were lower from the upstream runs. The three ephemeropteran species accounted for the decrease of close to 50%.

TABLE 4—Comparison of drift samples collected during three upstream and three downstream electric fishing runs in Woolly Creek, mid Canterbury, New Zealand, 30 November and 1 December 1972 ('Other non-Insecta' includes *Dugesia montana*, unidentified Ostracoda, Cyclopoidea, and Amphipoda)

| TAXON   | RUN        |       |       |       | RUN      |     |     |       |
|---|------------|-------|-------|-------|----------|-----|-----|-------|
|   | Downstream |       |       | Total | Upstream |     |     | Total |
|   | 1          | 2     | 3     |       | 1        | 2   | 3   |       |
| Tubificidae and<br><i>Lumbriculus</i><br><i>variegatus</i> .. | 113        | 158   | 135   | 406   | 87       | 184 | 150 | 421   |
| <i>Eiseniella tetraedra</i> ..                                | 14         | 19    | 12    | 45    | 15       | 15  | 19  | 49    |
| Other non-Insecta ..  | 4          | 2     | 7     | 13    | 7        | 3   | 8   | 18    |
| Total non-Insecta ..  | 131        | 179   | 154   | 464   | 109      | 202 | 177 | 488   |
| <i>Coloburiscus humeralis</i>                                 | 147        | 179   | 183   | 509   | 55       | 48  | 58  | 161   |
| <i>Zephlebia</i> sp. ..                                       | 88         | 84    | 83    | 255   | 33       | 31  | 28  | 92    |
| <i>Deleatidium</i> sp. ..                                     | 406        | 538   | 582   | 1 526 | 336      | 309 | 303 | 948   |
| Total Ephemeroptera ..  | 641        | 801   | 848   | 2 290 | 424      | 388 | 389 | 1 201 |
| <i>Pycnocentroides</i><br><i>aureola</i> ..                   | 5          | 2     | 4     | 11    | 9        | 5   | 4   | 18    |
| Other Trichoptera ..  | 8          | 10    | 4     | 22    | 11       | 7   | 12  | 30    |
| Total Trichoptera ..  | 13         | 12    | 8     | 33    | 20       | 12  | 16  | 48    |
| Total Coleoptera<br>(=Elminthidae) ..                         | 6          | 4     | 5     | 15    | 3        | 4   | 1   | 8     |
| <i>Austrosimulium</i> sp.                                     | 17         | 20    | 24    | 61    | 13       | 23  | 13  | 49    |
| Chironomidae ..   | 2          | 2     | 0     | 4     | 2        | 2   | —   | 4     |
| Total Diptera ..  | 19         | 22    | 24    | 65    | 15       | 25  | 13  | 53    |
| TOTALS ..   | 810        | 1 018 | 1 039 | 2 867 | 571      | 631 | 596 | 1 798 |

A comparison of the numbers of animals collected in drift nets from each of the five 5-m sections of the stream (Table 5) indicated that more than 70% of the total drift entered the drift from the benthos within 10 m of the sampling nets, and almost 40% originated within 5 m of the sampling nets.

All the major invertebrate groups except the Tubificidae and Lumbricidae conformed to this pattern, decreasing in numbers as distance from the drift net increased. In contrast, most oligochaetes caught came from 10–20 m upstream of the nets. Unfortunately, it was not possible to determine whether greater numbers of worms were present deep in the substrate of these sections.

To compare numbers of benthic invertebrates before and after electric fishing, a procedure similar to that used by Elliott & Bagenal (1972) was followed. As preliminary analysis indicated that the benthos was contagiously distributed (Elliott 1971b), a logarithmic transformation was applied to the raw data, yielding geometric mean densities (and their 95% confidence levels) of the benthic invertebrates (Table 6). The mean densities before and after electric fishing were compared using *t* tests. Mean numbers of most invertebrates decreased, but statistically significant decreases were only found in certain of the Ephemeroptera and non-insects (Table 6). The overall change in total benthic numbers was not significant.

TABLE 5—Comparison of drift catches from each 5-m section of all downstream and upstream electric fishing runs in Woolly Creek, mid Canterbury, New Zealand, 30 November and 1 December 1972

| TAXON                              | DISTANCE (m) FROM SAMPLING NETS |      |       |       |       |               |      |       |       |       |
|------------------------------------|---------------------------------|------|-------|-------|-------|---------------|------|-------|-------|-------|
|                                    | Downstream Runs                 |      |       |       |       | Upstream Runs |      |       |       |       |
|                                    | 0-5                             | 5-10 | 10-15 | 15-20 | 20-25 | 0-5           | 5-10 | 10-15 | 15-20 | 20-25 |
| Tubificidae and <i>Lumbriculus</i> |                                 |      |       |       |       |               |      |       |       |       |
| <i>variegatus</i>                  | 6                               | 13   | 78    | 68    | 14    | 19            | 31   | 83    | 72    | 42    |
| <i>Eiseniella tetraedra</i>        | 12                              | 8    | 1     | 0     | 2     | 8             | 10   | 3     | 1     | 1     |
| Other non-Insecta                  | 1                               | 4    | 1     | 1     | 1     | 0             | 3    | 4     | 3     | 3     |
| Total non-Insecta                  | 19                              | 25   | 80    | 69    | 17    | 27            | 44   | 90    | 76    | 46    |
| <i>Coloburiscus humeralis</i>      | 112                             | 92   | 40    | 8     | 8     | 51            | 32   | 12    | 5     | 6     |
| <i>Zephlebia</i> sp.               | 56                              | 60   | 13    | 9     | 10    | 14            | 28   | 5     | 2     | 2     |
| <i>Deleatidium</i> sp.             | 411                             | 291  | 114   | 53    | 29    | 253           | 189  | 84    | 33    | 19    |
| Total Ephemeroptera                | 579                             | 443  | 167   | 70    | 47    | 318           | 249  | 101   | 40    | 27    |
| <i>Pycnocentroides aureola</i>     | 1                               | 1    | 0     | 1     | 4     | 1             | 1    | 1     | 2     | 1     |
| Other Trichoptera                  | 3                               | 5    | 1     | 1     | 3     | 4             | 2    | 3     | 3     | 2     |
| Total Trichoptera                  | 4                               | 6    | 1     | 2     | 7     | 5             | 3    | 4     | 5     | 3     |
| Total Coleoptera (= Elminthidae)   | 1                               | 3    | 1     | 3     | 2     | 1             | 2    | 1     | 0     | 0     |
| <i>Austrosimulium</i> sp.          | 16                              | 12   | 4     | 3     | 1     | 8             | 13   | 4     | 5     | 4     |
| Chironomidae                       | 0                               | 0    | 0     | 1     | 1     | 1             | 1    | 1     | 0     | 0     |
| Total Diptera                      | 16                              | 12   | 4     | 4     | 2     | 9             | 14   | 5     | 5     | 4     |
| TOTALS                             | 1 218                           | 950  | 425   | 225   | 131   | 692           | 578  | 311   | 176   | 114   |
| PERCENTAGES                        | 41.3                            | 32.2 | 14.4  | 7.6   | 4.4   | 37.0          | 30.9 | 16.6  | 9.4   | 6.1   |

TABLE 6—Mean numbers (geometric means from 10 samples; 95% confidence limits shown in parentheses) of benthic invertebrates in bottom samples before and after electric fishing in Woolly Creek, mid Canterbury, New Zealand, 30 November and 1 December 1972 (N.S. = not significant,  $P > 0.05$ )

| TAXON  | BEFORE              | AFTER               | SIGNIFICANCE |
|--|---------------------|---------------------|--------------|
| <i>Dugesia montana</i>                                     | 5.7 (3.8–8.4)       | 0.7 (0–1.9)         | $P < 0.01$   |
| Tubificidae and<br><i>Lumbriculus</i><br><i>variegatus</i> | 4.0 (2.3–6.7)       | 0.5 (0–1.3)         | $P < 0.01$   |
| <i>Eiseniella tetraedra</i>                                | 0.6 (0.2–1.1)       | 0.6 (0–1.7)         | N.S.         |
| Total non-Insecta  | 11.7 (8.4–16.0)     | 2.3 (0.8–5.2)       | $P < 0.01$   |
| <i>Coloburiscus humeralis</i>                              | 13.5 (5.0–34.4)     | 11.7 (7.1–18.9)     | N.S.         |
| <i>Deleatidium</i> sp.                                     | 88.5 (73.9–106.1)   | 59.9 (43.7–82.0)    | $P < 0.05$   |
| Total Ephemeroptera  | 111.9 (97.1–128.9)  | 77.7 (63.8–94.6)    | $P < 0.05$   |
| <i>Pycnocentroides aureola</i>                             | 162.4 (142.2–185.5) | 173.2 (132.7–226.0) | N.S.         |
| Total Trichoptera  | 169.7 (147.6–195.1) | 181.1 (140.8–233.1) | N.S.         |
| Total Coleoptera<br>(=Elminthidae)                         | 27.3 (20.1–37.3)    | 44.3 (36.3–53.6)    | N.S.         |
| <i>Austrosimulium</i> sp.                                  | 23.6 (5.5–92.9)     | 22.4 (10.1–48.2)    | N.S.         |
| Total Diptera  | 24.2 (5.4–97.4)     | 22.9 (10.1–50.7)    | N.S.         |
| TOTALS   | 380.0 (319.2–452.5) | 348.5 (261.0–465.2) | N.S.         |

Total induced drift during the experiment represented 9.6% of the benthic fauna (Table 7), 3.7% in the upstream and 5.9% in the downstream runs. Unrealistically high proportions of Oligochaeta were found in the drift, emphasising the difficulty in sampling them in the benthos. The high drift compared with the low benthic numbers of *Zephlebia* sp. is difficult to explain. Mean numbers of benthic animals decreased by a little over 8% during the experimental period (although this was statistically insignificant, Table 6), a value close to that obtained for drift (9.6%). (Had benthic sampling of the oligochaetes been more adequate, then a significant difference might have been obtained.)

## DISCUSSION

Invertebrate drift increased considerably as a direct result of electric fishing in Woolly Creek. Some invertebrates, particularly Ephemeroptera and oligochaetes of the families Lumbriculidae and Tubificidae, were affected by the electric fishing more than others, e.g., species of Trichoptera. Changes in total numbers of benthic invertebrates over the electric fishing period were not statistically significant for most species or for the total fauna, although numbers of *Deleatidium* sp., and of ephemeropterans generally, were significantly reduced.

A high proportion (71%) of the invertebrates which drifted out of the experimental section came from within 10 m of the downstream sampling nets. This agrees with Elliott & Bagenal's (1972) results and

TABLE 7—Estimates of total numbers of animals in the benthos in the 25-m experimental section and of total numbers drifting out of it during electric fishing in Woolly Creek, mid Canterbury, New Zealand, 30 November and 1 December 1972 (benthic totals calculated for total area of the experimental reach; drift calculated from the total flow out of the experimental reach; total drift is the sum of the drift from six electric fishing runs)

| TAXON   | Benthos | Drift During<br>Downstream<br>Runs | Drift During<br>Upstream<br>Runs | Total Drift<br>as Percentage<br>of Benthos |
|---|---------|------------------------------------|----------------------------------|--|
| <i>Dugesia montana</i>                            | 2 384   | 6                                  | 24                               | 1.3  |
| Tubificidae and <i>Lumbriculus<br/>variegatus</i> | 1 825   | 1 222                              | 1 267                            | 136.4                                      |
| <i>Eiseniella tetraedra</i>                       | 261     | 135                                | 147                              | 108.0                                      |
| Other non-Insecta                                 | 261     | 33                                 | 30                               | 24.1                                       |
| Total non-Insecta                                 | 4 731   | 1 396                              | 1 468                            | 60.5                                       |
| <i>Coloburiscus humeralis</i>                     | 8 009   | 1 532                              | 485                              | 25.2                                       |
| <i>Zephlebia</i> sp. . .                          | 484     | 768                                | 277                              | 215.9                                      |
| <i>Deleatidium</i> sp.                            | 33 823  | 4 593                              | 2 853                            | 22.0                                       |
| Total Ephemeroptera                               | 42 316  | 6 893                              | 3 615                            | 24.8                                       |
| <i>Pycnocentroides aureola</i>                    | 61 388  | 33                                 | 54                               | 0.1  |
| Other Trichoptera                                 | 2 906   | 66                                 | 90                               | 5.4  |
| Total Trichoptera                                 | 64 294  | 99                                 | 144                              | 0.4  |
| Elminthidae                                       | 10 877  | 39                                 | 24                               | 0.6  |
| Other Coleoptera                                  | —       | 6                                  | —                                | —  |
| Total Coleoptera                                  | 10 877  | 45                                 | 24                               | 0.6  |
| <i>Austrosimulium</i> sp.                         | 22 760  | 184                                | 147                              | 1.4  |
| Chironomidae                                      | 1 863   | 12                                 | 12                               | 1.3  |
| Other Diptera                                     | 149     | —                                  | —                                | —  |
| Total Diptera                                     | 24 772  | 196                                | 159                              | 1.4  |
| TOTALS  | 146 990 | 8 629                              | 5 410                            | 9.6  |

is probably explained by the short distances required for many drift invertebrates to return to the stream bed (McLay 1970, Elliott 1971a). The mean distance travelled by all members of the total benthic invertebrate fauna of another New Zealand stream, Silverstream, was 10.7 m (McLay 1970). This was much less than the total length of the experimental area (25 m) used in the present study. The mean distance (total distance travelled divided by the number of organisms) given by McLay (1970) for *Deleatidium* sp. to return to the benthos in the Silverstream was 8.0 m and in this study more than 75% of *Deleatidium* taken in the drift nets came from within 10 m of the sampling nets.

The ability of drifting invertebrates to return to the benthos within relatively short distances probably accounted for the larger drift numbers recorded in the three downstream runs (5.9%) as opposed to the upstream runs (3.7%). As the electrodes were moved downstream in 5-m sections, much of the induced drift would be able to return to the substrate "ahead" of the electrode. (A gradual build-up of benthic numbers, which can contribute to the drift again, probably occurs all the way along the 25 m reach ahead of the sampling nets).

In the present study the total reduction of the benthic fauna by drift was close to 10% following six runs of the electric fishing apparatus. In comparison, Elliott & Bagenal (1972) found a 5% loss as drift during three electric fishing runs in their experiment, and similarly found that the ephemeropterans were most susceptible to the effects of the electric current. They found, however, that benthic numbers were reduced by 30% in that time compared with only a little over 8% in the present study, all of which can be accounted for as drift.

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#### LITERATURE CITED

- BRUNDIN, L. 1966: Transantarctic relationships and their significance, as evidenced by chironomid midges. *Kungliga Svenska Vetenskapsakademiens Handlingar* 11. 472 pp.
- BURNETT, A. M. R. 1967: Electric fishing equipment design notes. *N.Z. Marine Department Fisheries Technical Report* 19. 48 pp.
- ELLIOTT, J. M. 1971a: The distances travelled by drifting invertebrates in a Lake District stream. *Oecologia (Berl.)* 6: 350-79.
- 1971b: Some methods for the statistical analysis of samples of benthic invertebrates. *Scientific Publication of the Freshwater Biological Association* 25. 144 pp.
- ELLIOTT, J. M. & BAGENAL, T. B. 1972: The effects of electro-fishing on the invertebrates of a Lake District stream. *Oecologia (Berl.)* 9: 1-11.
- MCLAY, C. L. 1970: A theory concerning the distance travelled by animals entering the drift of a stream. *Journal of the Fisheries Research Board of Canada* 27: 359-70.