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The Effects of Electrofishing on the Invertebrates of a Lake District Stream

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Summary. The experiments were performed in Dale Park Beck, a stony stream in the English Lake District. Two operators electrofished the sampling area (length 20 m in April and July 1970, and 40 m in May 1971) three times (runs 1, 2, 3) in each experiment.

Electrofishing caused a marked increase in the number of invertebrates drifting out of the sampling area, and nearly all taxa taken in the bottom samples were also found in the drift samples. The fish shocker was chiefly responsible for the increased drifting of Plecoptera, Ephemeroptera and *Gammarus pulex*, and these taxa were dislodged from the substratum more easily than Trichoptera, Coleoptera, Diptera and *Polycelis felina*. The increased drifting of the latter taxa was chiefly due to the disturbance of the substratum by the two operators.

Most of the invertebrates drifting from the upstream end of the experimental section returned to the bottom within the sampling area. The invertebrate drift out of the sampling area came chiefly from the downstream end of the section, and was equivalent to a loss of only 5% from the total benthos in the sampling area (losses varied between < 1 and 13% for individual taxa).

Introduction

Samples of fish are frequently obtained from streams and rivers by means of an electrical shocker. In some work, the samples have to be taken from the same section of stream at regular intervals, e.g. monthly, and for total population estimation the multiple catch method (Seber and Le Cren, 1967) is often used. This sampling procedure could possibly affect the numbers of benthic invertebrates, and a marked reduction in potential food organisms would probably affect the numbers and spatial distribution of the fish in the sampling area. It is therefore important to determine the qualitative and quantitative effects of electrofishing on the invertebrates.

Description of Sampling Area

The experiments were all performed in the upper reaches of Dale Park Beck (SD 355935), a stony stream in the English Lake District. Physical conditions for each experiment are compared in Table 1. The

Table 1. *Physical conditions for experiments in April and July 1970 and May 1971*

	April	July	May
Water temperature (°C)	4.8	11.7	13.8
Modal depth (m)	0.19	0.25	0.14
Water velocity (m/sec)			
mean	0.42	0.96	0.15
range	0.11–0.83	0.31–2.62	0.07–0.34
Total discharge (m^3/sec)	0.24	0.72	0.06
Volume sampled by nets 1 and 2 (m^3/sec)	0.08	0.24	0.02

gradient is not very steep (fall about 3%), the width varies between 3 m and 3.5 m, and the bottom consists of large stones (width 7–30 cm) over smaller stones and gravel. Aquatic macrophytes are limited to sparse clumps of moss on the larger stones and exposed rock. The stream is moderately shaded by deciduous trees on the east bank, and leaf packets are found at the sides of the stream and between large stones in riffles.

Methods and Sampling Procedures

A pulsed D.C. shocker (Moore, 1968) was used to fish the sampling area which was 20 m long in April and July 1970, and was extended to 40 m in May 1971. One operator carried the anode electrode and slowly worked upstream until all the sampling area was covered. A second operator closely followed the first and caught stunned fish in a dip net. When both operators reached the upstream end of the sampling area, they returned to the downstream end and started a second run. This procedure was repeated for a third run, and the whole sampling procedure took about 30 minutes for the 20 m-section and about 60 minutes for the 40 m-section. The catches were trout *Salmo trutta* L., bullheads *Cottus gobio* L., and eels *Anguilla anguilla* L.

Drifting invertebrates were caught in surface nets (described by Elliott, 1967, 1970), which sampled to a depth of 10 cm from the water surface. Nets 1 and 2 were placed on either side of a large boulder at the downstream end of the sampling area, and sampled one third of the total stream discharge (Table 1). Net 3 was placed at the upstream end of the sampling area in April and July, and served as a control net. Each net sampled for the whole period of electrofishing, for 45 minutes before electrofishing started in April and July, and for 20 minutes before and between runs in May. Therefore comparisons were made between the normal level of invertebrate drift and the level of drift during electrofishing. The sampling area was divided into sections which were 5 m long. In July and May, nets 1 and 2 were emptied after each 5 m-section had been fished, and two drift samples were thus obtained from each section on each run. Electrofishing stopped for a few minutes when a section had been fished, and this time interval allowed drifting invertebrates to reach the nets. Therefore comparisons were made between the total drift catches for the three runs, and the total drift catches from each 5 m-section. A comparison was also made in May between drift catches with the shocker on or off. The first section (0–5 m) was fished from the bank with the shocker on and was then "fished" by two operators in the usual way but with the shocker off.

Bottom samples were taken in April and July with a shovel sampler (Macan, 1958) which removes 0.05 m^2 of bottom. A stratified random sample of twenty sampling units (5 units from each 5 m-section) was taken from the sampling area before and after electrofishing. Comparisons were made between the densities of benthic invertebrates before and after electrofishing.

A small Ott current meter was used to measure water velocity at about 3 cm from the surface of the substratum. Five readings were taken across the stream in each 5 m-section and three readings were taken across the mouth of each net.

Results

Very few invertebrates were drifting into the sampling area (cf. catches of net 3), and the number of invertebrates drifting out of the sampling area (nets 1 and 2) was low before electrofishing but increased markedly during electrofishing (Table 2). More than 50 species were

Table 2. *Total numbers of stream invertebrates taken in drift samplers before and during electrofishing*

	April 1970		July 1970		May 1971
	Net 3	Nets 1 and 2	Net 3	Nets 1 and 2	Nets 1 and 2
Before electrofishing	17	35	9	26	15
During electrofishing	17	2457	9	2328	1552

taken in the drift and bottom samples, and Table 3 includes all taxa which contributed more than 1% to the total numbers in the bottom samples. The rarer taxa not listed in Table 3 included the following Plecoptera: *Brachyptera risi* Morton, *Protonemura meyeri* (Pictet), *Nemoura cambrica* (Stephens), *Leuctra hippopus* Kempny, *L. nigra* (Olivier), *Isoperla grammatica* (Poda), *Perla bipunctata* Pictet; Ephemeroptera: *Ecdyonurus torrentis* Kimmins, *Heptagenia lateralis* (Curtis), *Caenis rivulorum* Eaton; Trichoptera: *Rhyacophila dorsalis* (Curtis), *Plectrocnemia conspersa* (Curtis). There were some notable differences in the percentage composition of the drift and bottom samples. Percentages for Plecoptera, Ephemeroptera and *Gammarus pulex* were higher in the drift than in the bottom samples, whereas the converse was true for Trichoptera, Coleoptera, Diptera and *Polycelis felina* (Table 3). These discrepancies suggest that *Gammarus pulex* and nymphs of Ephemeroptera and Plecoptera were dislodged from the substratum more easily than other taxa.

Table 3. *Percentage composition of the drift samples during electrofishing and the bottom samples. The category "Other" includes taxa contributing <1% to the total numbers in the bottom samples*

	April 1970		July 1970		May 1971
	Drift	Benthos	Drift	Benthos	Drift
Amphinemura sulcicollis (Stephens)	20.0	6.8	—	—	8.7
Leuctra inermis Kempny	13.6	6.8	1.2	1.2	14.2
L. fusca (L.)	1.0	1.1	13.0	4.5	7.2
Chloroperla torrentium (Pictet)	0.7	1.3	0.1	0.3	0.6
C. tripunctata (Scopoli)	1.1	2.8	0.4	2.6	3.6
Other Plecoptera	7.8	2.9	1.3	1.4	1.6
Total Plecoptera	44.2	21.7	16.0	10.0	35.9
Ephemerella ignita (Poda)	—	—	8.2	5.1	—
Baëtis rhodani (Pictet)	13.2	9.7	11.2	8.8	18.8
Baëtis pumilus (Burmeister)	2.0	0.8	2.9	1.1	7.4
Baëtis scambus Eaton	—	—	3.3	1.4	—
Ecdyonurus venosus (Fabricius)	2.2	1.3	1.3	0.5	1.9
Rhithrogena semicolorata (Curtis)	14.5	9.4	0.4	0.4	9.2
Other Ephemeroptera	4.6	1.3	1.1	0.5	1.3
Total Ephemeroptera	36.5	22.5	28.4	17.8	38.6
Agapetus fuscipes Curtis	0.3	9.7	0.5	2.1	4.1
Glossosoma conformis Neboiss	0.6	4.3	—	—	0.8
Hydropsyche spp.	9.6	10.0	1.6	3.1	3.2
Wormaldia spp.	0.2	0.1	1.8	2.3	—
Sericostoma personatum (Spence)	—	1.6	—	0.9	—
Other Trichoptera	1.3	2.3	1.0	2.9	1.7
Total Trichoptera	12.0	28.0	4.9	11.3	9.8
Hydraena gracilis Germar	0.2	1.4	1.4	1.6	0.6
Elmis aenea Müller	0.4	1.7	0.9	1.3	1.3
Esolus parallelepipedus Müller	0.2	2.4	—	0.8	0.9
Other Coleoptera	0.3	0.1	0.5	—	0.4
Total Coleoptera	1.1	5.6	2.8	3.7	3.2
Simulium spp.	1.3	1.0	5.8	6.3	0.1
Chironomidae	0.4	9.3	23.9	32.4	5.9
Tipulidae	0.1	2.1	0.3	0.6	—
Other Diptera	—	—	0.5	1.7	0.4
Total Diptera	1.8	12.4	30.5	41.0	6.4
Gammarus pulex L.	3.6	1.7	13.9	8.9	4.8
Polycelis felina (Dalyell)	0.2	5.9	1.9	4.8	1.3
Other non-insecta	0.6	2.3	1.6	2.5	—
Total non-insecta	4.4	9.9	17.4	16.2	6.1

No significant differences were found between the drift catches for the three runs in July and runs 1 and 3 in May (Table 4). The low numbers in the drift samples from run 2 in May were chiefly due to low catches of

Table 4. *Comparison between drift catches for the three runs with the fish shocker*

	July 1970			May 1971		
	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3
Amphinemura sulcicollis	—	—	—	46	36	53
Leuctra inermis	8	8	11	88	39	94
L. fusca	108	87	107	38	50	24
Chloroperla torrentium	2	—	1	—	6	4
C. tripunctata	4	2	4	21	11	24
Other Plecoptera	11	12	7	8	8	7
Total Plecoptera	133	109	130	201	150	206
Ephemerella ignita	69	55	66	—	—	—
Baëtis rhodani	96	98	67	121	50	121
B. pumilus	15	25	27	62	21	32
Ecdyonurus venosus	19	6	5	9	11	10
Rhithrogena semicolorata	1	3	5	71	26	46
Other Ephemeroptera	41	33	29	3	4	12
Total Ephemeroptera	241	220	199	266	112	221
Agapetus fuscipes	3	3	5	25	18	20
Hydropsyche spp.	9	13	14	18	13	19
Other Trichoptera	22	23	22	10	11	18
Total Trichoptera	34	39	41	53	42	57
Total Coleoptera	27	20	18	13	18	18
Simulium spp.	39	54	43	—	—	2
Chironomidae	188	209	159	16	21	54
Other Diptera	16	2	1	1	3	3
Total Diptera	243	265	203	17	24	59
Gammarus pulex	131	101	91	33	17	25
Polycelis felina	11	16	17	7	3	10
Other non-Insecta	9	12	18	—	—	—
Total numbers	829	782	717	590	366	596

Leuctra inermis, *Baëtis* spp., and *Rhithrogena semicolorata*. There was no apparent explanation for these low catches. Therefore the number of invertebrates drifting out of the sampling area did not significantly decrease with each successive run. Comparisons were also made between the drift catches from each 5 m-section of stream (Table 5). As the distance from the nets increased, the size of the catch decreased and this decrease was more abrupt in May than in July. The possible reasons for the decrease in numbers will be discussed later. Therefore most of the

Table 5. *Comparison between drift catches from each section of stream covered by the fish shocker*

	Distance (m) from drift samplers											
	July 1970				May 1971							
	0–5	5–10	10–15	15–20	0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40
Amphinemura sulcicollis	—	—	—	—	122	5	2	3	1	2	—	—
Leuctra inermis	18	3	3	3	210	4	4	1	—	1	—	1
L. fusca	183	60	39	20	104	5	1	—	1	1	—	—
Chloroperla torrentium	2	—	—	1	8	2	—	—	—	—	—	—
C. tripunctata	4	5	—	1	52	3	—	-	—	—	1	—
Other Plecoptera	14	6	7	3	19	1	1	2	—	—	—	—
Total Plecoptera	221	74	49	28	515	20	8	6	2	4	1	1
Ephemerella ignita	114	44	22	10								
Baëtis rhodani	166	68	22	5	221	27	14	14	5	5	4	2 2
B. pumilus	36	20	8	3	109	4	1	1	—	—	—	—
Ecdyonurus venosus	15	11	1	3	25	2	3	—	—	—	—	—
Rhithrogena semicolorata	4	3	2	—	131	2	4	1	1	2	2	—
Other Ephemeroptera	65	25	11	2	12	4	2	—	1	—	—	—
Total Ephemeroptera	400	171	66	23	498	39	24	16	7	7	6	2
Agapetus fuscipes		5	1	5	25	15	3	10	5	2	3	—
Hydropsyche spp.	6	15	8	7	31	5	4	3	2	—	2	3
Other Trichoptera	25	23	9	10	22	5	2	3	2	2	2	1
Total Trichoptera	31	43	18	22	78	25	9	16	9	4	7	4
Total Coleoptera	30	16	12	7	26	7	7	2	—	4	—	3
Simulium spp.	69	26	22	19	—	1	—	1				
Chironomidae	171	194	105	86	41	13	9	8	5	6	7	2
Other Diptera	12	4	3	—	1	3	2	—	—	—	1	—
Total Diptera	252	224	130	105	42	17	11	9	5	6	8	2
Gammarus pulex	211	66	31	15	67	5	1	1	1	—	—	—
Polycelis felina	22	17	3	2	11	3	1	5	—	—	—	—
Other non-Insecta	14	11	10	4	—	—	—	—	—	—	—	—
Total numbers	1181	622	319	206	1237	116	61	55	24	25	22	12

invertebrates drifting out of the sampling area came from the downstream end of the experimental section.

The experiments with the fish shocker on or off provided similar results for the three runs over the 0–5 m section (Table 6). When the shocker was on, the live anode was operated from the bank and was therefore solely responsible for the high catches of Plecoptera, Ephemer-

Table 6. *Comparison between drift catches from section 0–5 m in May 1971, with fish shocker switched on or off*

	Run 1		Run 2		Run 3	
	Shocker on	Shocker off	Shocker on	Shocker off	Shocker on	Shocker off
Amphinemura sulcicollis	37	3	18	14	36	14
Leuctra inermis	71	16	32	4	74	13
L. fusca	33	1	43	5	17	5
Chloroperla tripunctata	20	—	11	—	17	4
Other Plecoptera	6	1	8	2	7	3
Baëtis rhodani	93	6	33	3	37	49
Baëtis pumilus	56	2	15	6	22	8
Ecdyonurus venosus	6	—	8	2	7	2
Rhithrogena semicolorata	63	2	19	3	43	1
Other Ephemeroptera				2	4	6
Agapetus fuscipes	3	11	2	2	3	4
Hydropsyche spp.	6	7	—	9	2	7
Other Trichoptera	6	1	—	5	5	5
Coleoptera	—	2	—	13	2	8
Chironomidae	2	4	3	6	4	22
Gammarus pulex	30		11	4	17	5
Polycelis felina	1		—	1	3	6
Total numbers	433	56	203	81	300	162
Detritus (g·dry weight)	0.39	7.91	0.38	5.69	0.48	10.30

optera (except *Baëtis rhodani* in run 3), and *Gammarus pulex*. The remaining taxa were less affected by the fish shocker and were taken in greatest numbers when the shocker was off. These invertebrates must have been dislodged by the two operators who disturbed the bottom when they "fished" the sampling area with the shocker off. The amount of detritus in the drift samples was also much higher when the shocker was off. Therefore the fish shocker caused the increased drifting of some taxa and the actions of the two operators were chiefly responsible for the dislodgment of other taxa during electrofishing.

As a preliminary analysis of the counts from the bottom samples revealed that the invertebrates were contagiously distributed on the bottom of the stream, a transformation of the counts was necessary before confidence limits could be calculated and *t*-tests applied to the means (see Chapter 3 in Elliott, 1971). A logarithmic transformation

Table 7. *Mean numbers (geometric means of a sample of 20 sampling units) of invertebrates in the bottom samples before and after electro-fishing. 95% confidence limits are given in parentheses. Significant differences between means are indicated by asterisks thus:* $^{*}P<0.05$, $^{**}P<0.01$. *NS = significant difference*

	April			July		
	Before	After		Before	After	
Amphinemura sulcicollis	8.9 (6.6–12.1)	6.4 (4.6– 9.1)	NS	—	—	—
Leuctra inermis	8.6 (6.1–12.4)	7.4 (5.6–10.0)	NS	1.0 (0.5– 1.6)	0.8 (0.5– 1.2)	NS
L. fusca	1.1 (0.6– 1.7)	1.2 (0.6– 2.1)	NS	5.9 (3.9– 8.7)	4.2 (3.0– 5.9)	NS
Chloroperla tripunctata	2.9 (2.0– 4.1)	1.0 (0.4– 1.8)	$^{**}P<0.01$	2.5 (1.7– 3.6)	0.6 (0.2– 1.1)	$^{**}P<0.01$
Total Plecoptera	24.3 (18.5–31.9)	18.8 (13.2–27.2)	NS	10.2 (7.6–13.6)	6.9 (5.6–10.1)	NS
Ephemerella ignita				4.9 (3.2– 7.3)	3.6 (2.3– 5.4)	NS
Baëtis rhodani	10.4 (7.1–15.0)	4.3 (2.5– 7.0)	$^{**}P<0.01$	8.6 (6.4–11.5)	5.5 (3.6– 8.1)	NS
Ecdyonurus venosus	2.2 (1.2– 3.9)	1.2 (0.7– 1.9)	NS			
Rhithrogena semicolorata	9.8 (6.7–14.1)	7.2 (4.5–11.3)	NS			
Total Ephemeroptera	26.6 (20.2–34.9)	17.3 (13.1–22.8)	$^{*}P<0.05$	18.8 (14.2–24.7)	12.7 (8.8–18.2)	NS
Agapetus fuscipes	7.7 (4.4–12.9)	4.8 (3.1– 7.1)	NS	1.7 (0.9– 2.8)	0.9 (0.4–1.7)	NS
Glossosoma conformis	4.5 (2.9– 6.7)	3.3 (2.1– 5.0)	NS			
Hydropsyche spp.	9.1 (6.2–13.1)	7.5 (4.3–12.6)	NS	2.3 (1.2– 4.0)	1.6 (0.6–3.2)	NS
Sericostoma personatum	1.3 (0.5– 2.5)	1.2 (0.6– 2.1)	NS			
Total Trichoptera	30.1 (21.2–42.5)	20.8 (13.5–31.7)	NS	8.6 (5.0–14.4)	5.4 (3.3–8.6)	NS
Total Coleoptera	6.5 (4.4–9.5)	4.7 (2.8–7.6)	NS	3.3 (2.1–5.0)	2.2 (1.3–3.5)	NS
Simulium spp.				5.7 (3.8– 8.4)	4.7 (3.1– 7.0)	NS
Chironomidae	8.1 (5.1–12.7)	4.1 (2.4–6.7)	$^{*}P<0.05$	35.6 (27.2–46.6)	23.8 (16.7–33.7)	$^{*}P<0.05$
Total Diptera	11.1 (7.1–17.2)	5.6 (3.7–8.2)	$^{*}P<0.05$	43.2 (33.0–56.5)	30.8 (25.5–37.2)	$^{*}P<0.05$
Gammarus pulex	3.9 (2.2–6.4)	3.1 (1.7–5.2)	NS	8.9 (6.1–12.9)	7.6 (5.6–10.2)	NS
Polycelis felina	4.7 (2.8–7.6)	3.6 (2.1–5.9)	NS	3.1 (1.6– 5.6)	3.0 (1.7– 5.0)	NS
Total numbers	118.0 (90.8–153.4)	78.6 (56.1–110.0)	$^{*}P<0.05$	109.8 (91.3–132.0)	76.6 (63.7–91.1)	$^{*}P<0.05$

Table 8. *Estimates of total numbers in the sampling area and total numbers drifting out of the sampling area during electrofishing. The numbers in the drift are also expressed as percentages of the numbers in the benthos (% loss)*

	April			July		
	Benthos	Drift	% loss	Benthos	Drift	% loss
Amphinemura sulcicollis	10680	1473	13	—	—	—
Leuctra inermis	10320	1002	10	1200	81	7
L. fusca	1320	72	6	7080	906	13
Chloroperla tripunctata	3480	84	2	3000	30	1
Total Plecoptera	29160	3261	11	12240	1116	9
Ephemerella ignita				5880	570	10
Baëtis rhodani	12480	969	8	10320	783	8
Ecdyonurus venosus	2640	160	6			
Rhithrogena semicolorata	11760	1067	9			
Total Ephemeroptera	31920	2688	8	22560	1980	9
Agapetus fuscipes	9240	24	<1	2040	33	2
Glossosoma conformis	5400	45	1			
Hydropsyche spp.	10920	705	7	2760	108	4
Sericostoma personatum	1560	0				
Total Trichoptera	36120	885	2	10320	342	3
Total Coleoptera	7800	78	1	3960	195	5
Simulium spp.				6840	408	6
Chironomidae	9720	27	<1	42720	1503	4
Total Diptera	13320	135	1	51840	2133	4
Gammarus pulex	4680	264	6	10680	969	9
Polycelis felina	5640	18	<1	3720	132	4
Total numbers	141600	7371	5	131760	6984	5

was applied, and therefore geometric means with 95% confidence limits were used in all comparisons between the densities of benthic invertebrates before and after electrofishing. The mean numbers of most taxa decreased after electrofishing (Table 7). Although few of these decreases were significant, the cumulative effect produced a significant decrease in total numbers. Estimates were made of the total numbers in the sampling area and drift (Table 8). The total drift was equivalent to a loss of only 5% from the total benthos in the sampling area, and losses varied between <1 and 13% for individual taxa. Therefore only a small percentage of the total benthos drifted out of the sampling area during electrofishing. These losses through drifting did not explain the relatively large decrease in mean numbers in the bottom samples after electrofishing. The decrease was about 30% for total numbers and the 5% loss due to drifting leaves a discrepancy of 25%. Therefore the efficiency of the bottom sampling must have decreased after electrofishing, and the possible reasons for this decrease will be discussed later.

Discussion

The marked increase in invertebrate drift during electrofishing was due both to the direct effect of the fish shocker and to the disturbance of the substratum by the two operators. Small numbers of most taxa were dislodged by the operators, but only *Gammarus pulex*, Plecoptera and Ephemeroptera were dislodged in large numbers by the shocker. The discrepancies between the percentage composition of the drift and bottom samples also showed that these taxa were dislodged from the substratum more easily than Trichoptera, Coleoptera, Diptera and *Polycelis felina*. It is possible that these taxa were hardly affected by the fish shocker, but this is an unlikely hypothesis. It is more probable that they were rarely dislodged from the substratum because of their behaviour or position in the substratum. The marked effect of the shocker on *Gammarus pulex*, *Baëtis rhodani*, *Ecdyonurus venosus* and *Rhithrogena semicolorata* may be due to the position of these invertebrates which usually occur on or under large stones. A similar explanation would not account for the increased drifting of *Leuctra* spp., *Chloroperla* spp. and *Baëtis pumilus* which all live in the substratum and usually dive deeper into the substratum when they are alarmed. Therefore the effects of electrofishing were not the same for different species, but these differences cannot be successfully explained.

The invertebrates drifting out of the sampling area during electrofishing came chiefly from the downstream end of the experimental section. Therefore most of the invertebrates dislodged from the upstream end of the section must have returned to the bottom within the sampling area. This conclusion is strongly supported by the results of a previous study which demonstrated that the distances travelled by drifting invertebrates are surprisingly short and that many taxa are capable of a rapid return to the bottom (Elliott, 1971). Drifting invertebrates vary considerably in their ability to return to the bottom and the drift distance is positively correlated with water velocity. Mean drift distances for the electrofishing experiments were predicted from the results of the previous study, and ranged from 2–5 m for the May experiments and from 9–33 m for the July experiments. The smallest value in each month is for taxa capable of a rapid return to the bottom e.g. *Baëtis rhodani* and *Gammarus pulex*, and the largest value is for taxa incapable of a rapid return, e.g. Chironomidae. From a comparison of the ranges for the two months, it is obvious why the decrease in drift catches from each 5 m-section was more abrupt in May than in July.

Although only 5% of the total benthos drifted out of the sampling area during electrofishing, the number of invertebrates in the bottom samples decreased by about 30% after electrofishing. This paradox cannot be successfully explained, but the following hypotheses are suggested. It is possible that the dislodgment and return to the bottom of invertebrates led to a marked change in the spatial distribution of the invertebrates in the sampling area, and that this change reduced the probability of an animal being taken in a bottom sample. Many drifting invertebrates return to the bottom when they land in a zone of comparatively low water velocity, e.g. near the banks, within leaf packets, between and at the rear of large stones (Elliott, 1971). As only 20 sampling units were taken in each bottom sample, the clumps of invertebrates in zones of low water velocity could have been easily missed by the shovel sampler after electrofishing. It is also possible that the electrofishing alarmed many invertebrates which responded by burrowing deeper into the substratum. As the shovel sampler only removes the stones near the surface of the substratum, invertebrates at greater depths are missed by the sampler and an apparent decrease in numbers could occur after electrofishing. Therefore more information is clearly needed on the behaviour and dispersion of stream invertebrates before the paradox is successfully explained. It is clear, however, that although electrofishing leads to a spatial re-arrangement of the bottom fauna, it only produces a small loss from the total benthos.

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