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THE EFFECT OF THE RELEASE OF AN ARTIFICIAL DISCHARGE OF WATER ON INVERTEBRATE DRIFT IN THE R. WYE, WALES.

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Abstract

An artificial discharge of water (3.0 m^3/sec), over a 48 h period, from an impoundment into the R. Wye did not substantially affect water temperature or concentrations of dissolved oxygen and suspended solids at a site 16 km below the impoundment. However, the load of suspended material on the second day of the release was about 10 times greater than the pre-release load. The total number of drifting macroinvertebrates on the first and second days of the release were about 7 and 3 times greater than the number on the day preceding the release. The initial increase in flow at 15.00 h resulted in an immediate increase in the number of drifting larvae of *Rheotanytarsus*, a tubicolous chironomid. Subsequently there was an enhanced night-time increase in the total number of drifting invertebrates, particularly the mayfly, *Ephemerella ignita* (Poda), and this also occurred on the second night of the release. Increases in the number of drifting *Rheotanytarsus* and *Ephemerella*, the most abundant invertebrates, resulted in increases in drift density.

Introduction

Some workers (Anderson & Lehmkuhl, 1968; Elliott, 1967; Minshall & Winger, 1968; Waters, 1962) have described certain of the effects of natural increases and decreases in flow on drift and Radford & Hartland-Rowe (1971) have compared invertebrate drift in an unregulated and regulated stream. With proposals to use impounded water to regulate natural river systems in the U.K. (Ministry of Agriculture Fisheries and Food and NWC, 1976) the potential use of artificial freshets or discharges for ecological benefit has been suggested (Banks, 1969; Fraser, 1972). This paper describes the effect of an artificial freshet on the drift of invertebrates in the R. Wye, Wales: the work froms part of a broader ecological study of the R. Wye to assess the consequences of the enlargement of the Craig Goch reservoir in its headwaters.

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Site of Study

The upper reaches of the R. Wye (length; 250 km: catchment; 4183 km^2) drain predominantly Ordovician and Silurian sediments, principally mudstones and shales. The catchments of the tributaries Elan and Claerwen are impounded (Fig. 1) and act as a direct water supply. At the time of the study the R. Elan downstream of Caban Coch (Fig. 1) received a compensation flow of 1.3 m^3/sec.

The two study sites, W3 and W5 (Fig. 1), are generally similar with substrata of cobbles and coarse gravels although the bed of W5 is more consolidated. The water at both sites and in the R. Elan is soft and contains low concentrations of inorganic ions (Table 1).

Artificial Release

The flow of water from Caban Coch Reservoir (Fig. 1) to the R. Elan was increased from 1.3 m^3/sec to 4.3 m^3/sec at 09.00 (B.S.T.) 31 May 1975. This flow was maintained until 09.00 2 June when it was reduced again to 1.3 m^3/sec.

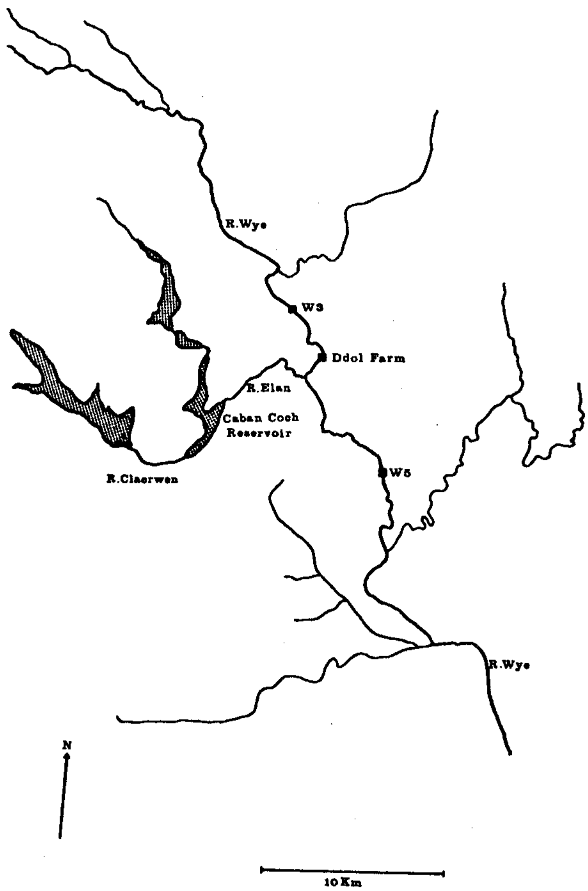

Fig. 1. Location map, R. Wye.

Methods

Samples of drifting invertebrates were collected from W3 and W5 over the period 09.00 30 May 1975-09.00 2 June 1975 using a modified plankton sampler (Elliott, 1970) with a net aperture of 440μ. Samplers were emptied at 3 h intervals when river depth and temperature were recorded. The water velocity, measured with a portable current meter in the exit tube of the sampler, was related to flow through the sampler from earlier calibration in an experimental flume. Average flow through the sampler between sampling intervals was calculated from velocity measurements at the beginning and end of the period assuming any changes in flow were linear with time. Drift density was expressed as no./100 m^3 and the total number of invertebrates drifting was calculated knowing the density and river flow.

Continuous records of dissolved oxygen concentration were obtained throughout the study at W5. Samples for suspended solids analysis were collected at W3 and W5 every 3 h.

Day 1, Day 2 and Day 3, the three days of the study, represent the 24 h periods beginning at 09.00 on each of the dates 30 May, 31 May and 1 June.

Table 1. Concentrations (mg/l) of some inorganic ions at W3, W5 and R. Elan (April 1975-July 1976).

	W3	W5	R. Elan
Calcium	4.10	3.39	1.77
Nitrate-nitrogen	0.50	0.41	0.28
Orthophosphate-phosphorus	0.02	0.02	0.02

Results

Over the period of the study natural flows in the R. Wye, measured continuously at Ddol Farm, upstream of the confluence with the R. Elan and near W3, averaged 0.73 m^3/sec (range 0.70-0.83). At W5 the pre-release flow was approximately 2.0 m^3/sec, increasing to 5.0 m^3/sec during the release. The increase in river level at W5 resulting from the release of water into the Wye system was recorded between 15.00 and 18.00 h on Day 2 with a maximum increase in stage height of 10 cm at 21.00 h (Fig. 2). Average water velocity through the drift sampler at W5 increased from 0.35 to 0.51 m/sec between 15.00 and 18.00 h but fell to 0.48 m/sec at 21.00 h.

Throughout the period of study temperatures ranged from 10-14 and 9-15°C at W3 and W5 respectively. The increase in flow did not substantially affect water temperatures at W5 (Fig. 2). The dissolved oxygen concentration at W5 ranged from 11.2-11.7 before and 11.0-11.1 mg/l during the release. Suspended solids concentrations at W3 and W5 were generally low, varying between 0.3 and 6.0 mg/l. However the estimated total load of suspended material at W5 increased from 103 kg/day on Day 1, before the artificial release, to 688 kg/d on Day 2 and 1080 kg/d on Day 3.

At W3 average and peak drift densities and the total number of drifting macroinvertebrates were generally similar on the three days of study (Table 2). Drifting was characterised by diel periodicity with highest numbers of invertebrates drifting at night (Fig. 3). The groups contributing to this periodicity were principally the Epheme-

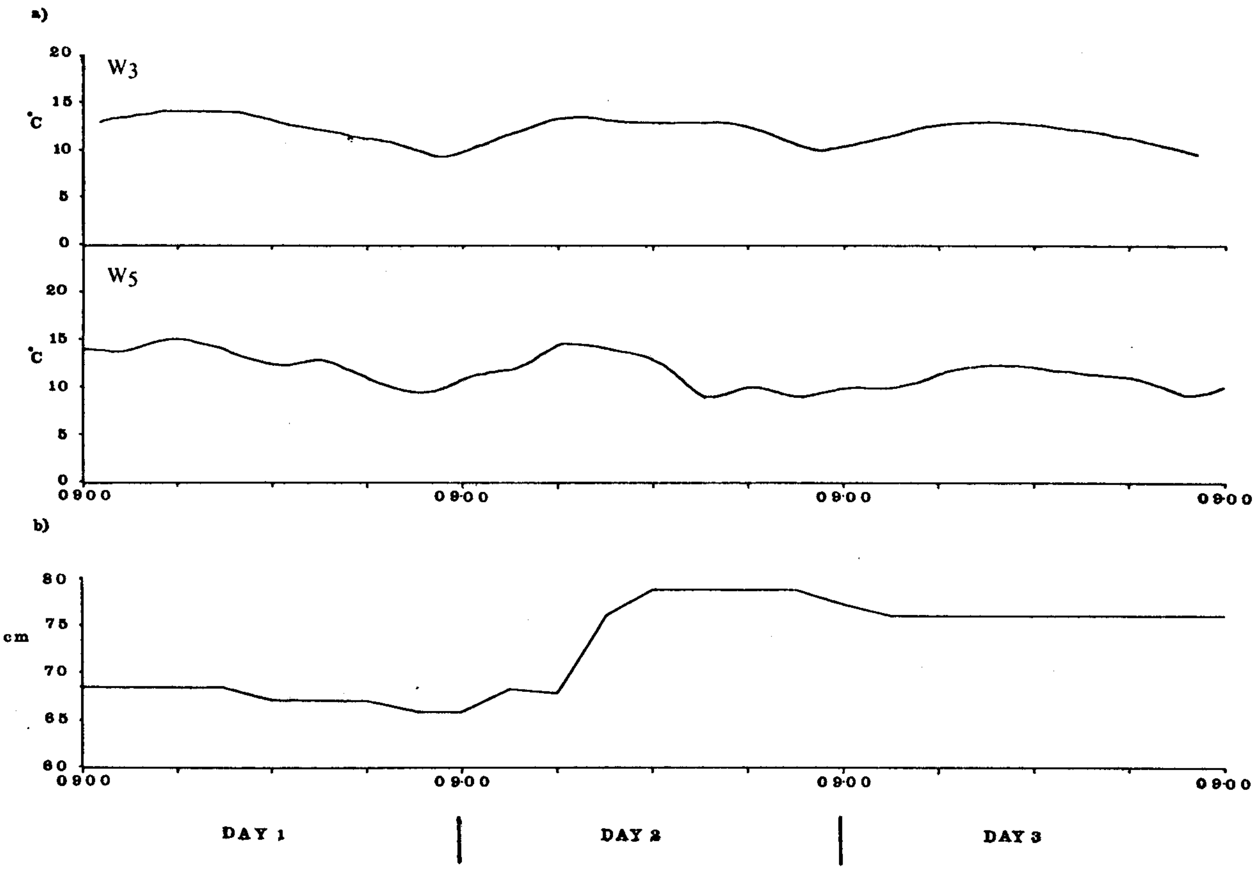

Fig. 2. Changes in a) temperature at W3 and W5 and b) stage height at W5.

Table 2. Densities and total numbers of drifting invertebrates in the R. Wye, 30 May-1 June 1975.

	Average density (No/100m^3)		Maximum density (No/100m^3)		Total number of drifting invertebrates (X 10^3/24h)		River Flow (m^3/sec)	
	W3	W5	W3	W5	W3	W5	W3	W5
Day 1	78	56	335	170	53	102	0.8	2.1
Day 2	86	180	335	523	52	698	0.7	5.0*
Day 3	72	82	304	186	44	354	0.7	5.0

*increased from 2.0 ⟶ 5.0 m^3/sec.

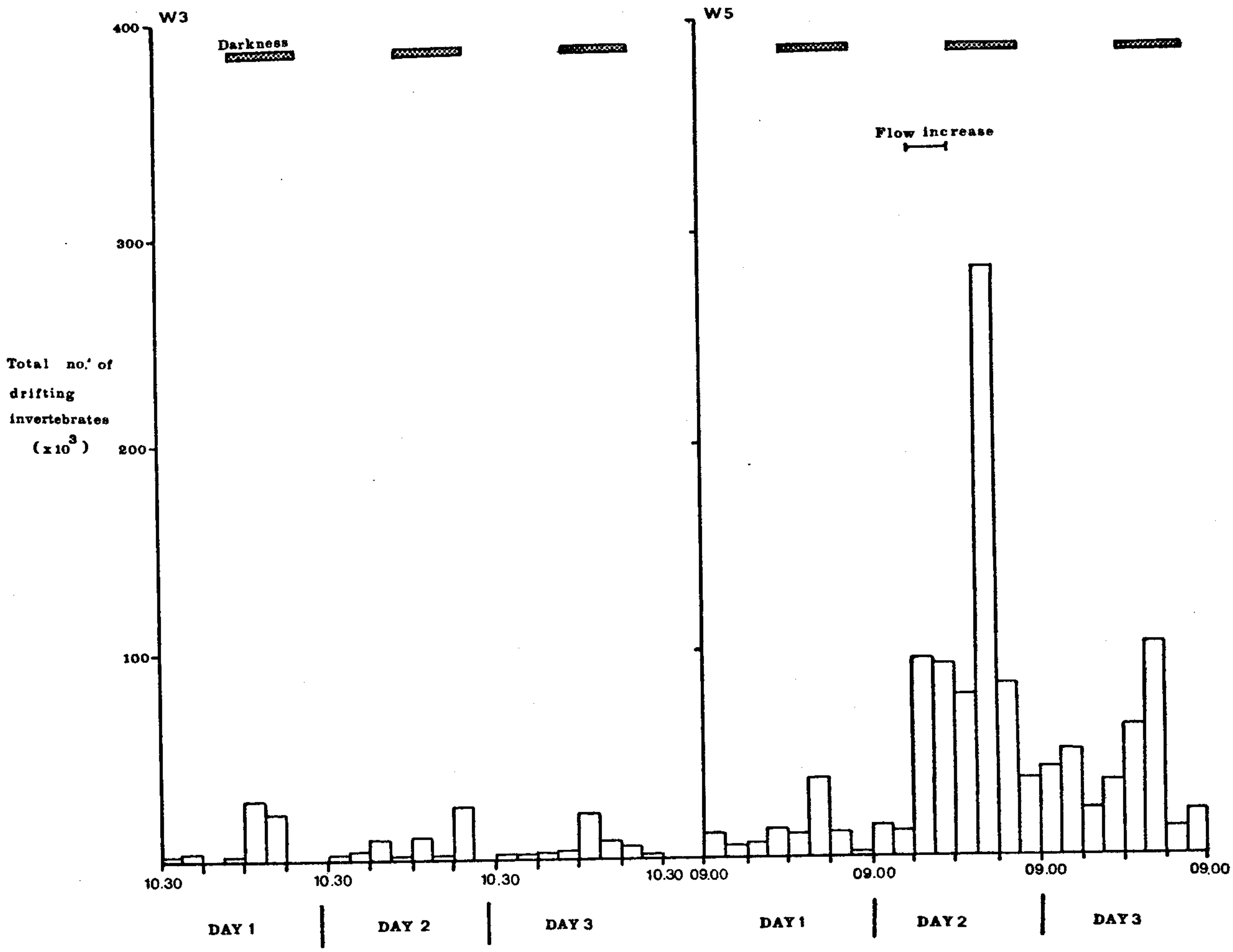

Fig. 3. Changes in the total number of drifting macroinvertebrates at W3 and W5.

roptera and Coleoptera. This general pattern was observed on Day 1 at W5 but was perturbed on Day 2 between 15.00 and 21.00 when the freshet reached W5, and the total numbers and density of drifting invertebrates increased dramatically during the day-time (Fig. 3). Subsequently, the usual night-time peak of drift density and total numbers were substantially enhanced. On Day 3, the second and final day of discharge, average and peak drift densities at W5 returned to pre-release levels but the total number of animals drifting was still elevated (Fig. 3, Table 2). The total number of invertebrates drifting at W5 during the first and second days of the release were respectively about 7 and 3 times greater than the number on the day before the release.

The chironomid *Rheotanytarsus (photophilus ?)* and the mayfly *Ephemerella ignita* illustrated two distinct responses to the freshet release at W5 (Fig. 4). The increase in flow at W5 between 15.00 and 18.00 h on Day 2 resulted in an immediate and dramatic increase in the number of drifting *Rheotanytarsus* larvae from 0.8 to 23.3 x 10^3/h, representing about 80% of total numbers of invertebrates drifting at this time. The number of drifting *Rheotanytarsus* at W3 at the same time did not exceed 0.3 x 10^3/h. Subsequently at W5 under conditions of constant flow the drift rate of *Rheotanytarsus* declined exponentially (Fig. 4a).

There was no immediate effect of the increase in discharge at W5 on the drift rate of *Ephemerella ignita*. However, there was considerable enhancement of the natural night-time increase in drifting numbers and density

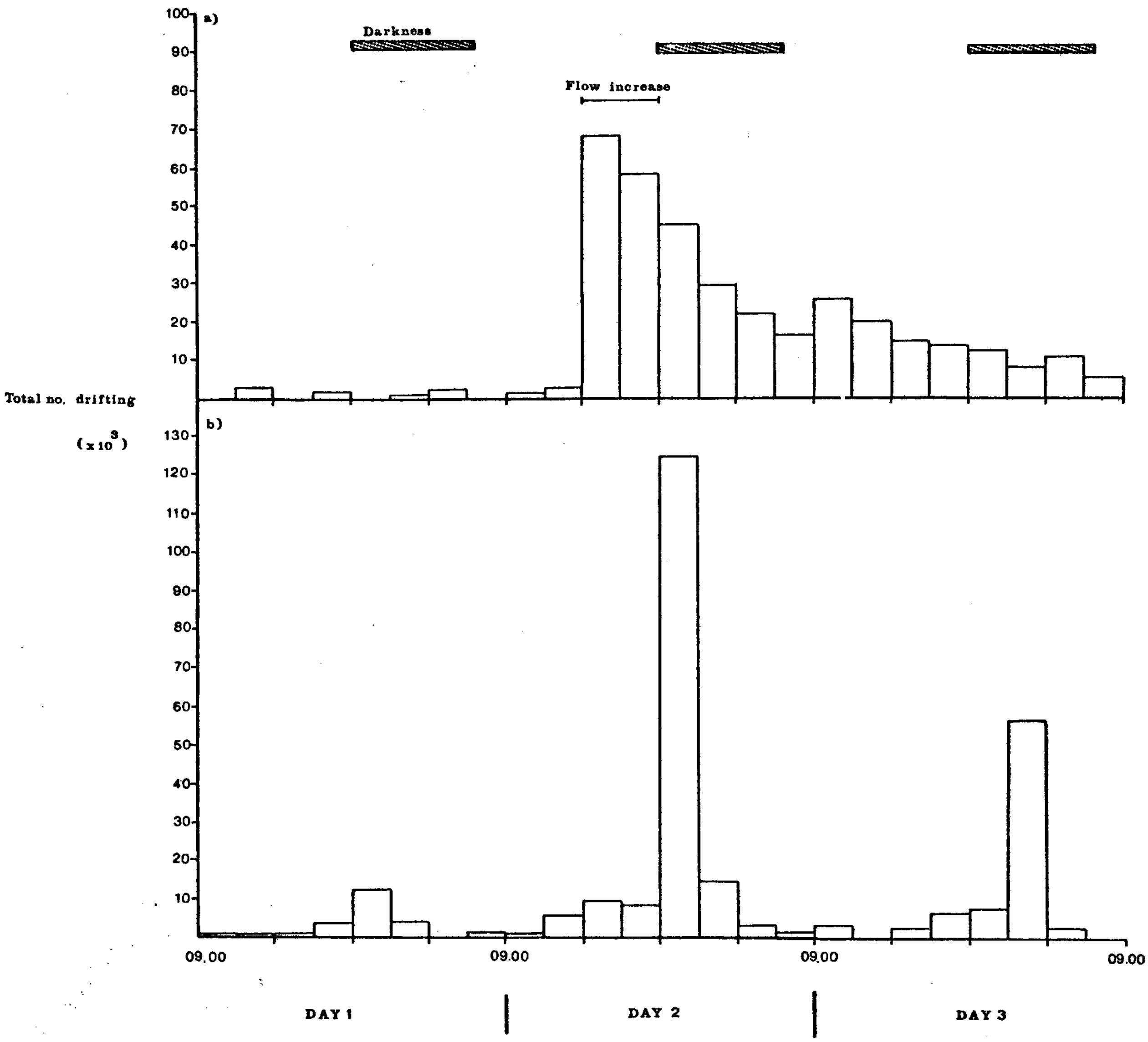

Fig. 4. Changes in the total number of a) *Rheotanytarsus* (*photophilus*?) and b) *Ephemerella ignita* drifting at W5.

during the period 24.00-03.00 h, Day 2 (Fig. 4). The highest number of drifting *Ephemerella* at W5 on Day 2 was 41.8 x 10^3/h which represented 44% of the total drift at this time, and was over 10 times as great as the peak drift rate on Day 1. On Day 3 the highest number drifting had fallen to 18.7 x 10^3/h. On both Day 2 and Day 3 the increased drift rate of *Ephemerella* was associated with increased drift density.

Results from other, less abundant taxa, generally confirm that substantial increases in the number of drifting invertebrates at W5 resulted from the freshet (Table 3).

Comparison of the number of macroinvertebrates taxa collected at the two study sites indicated that on the three days of the study 20, 26 and 30 taxa were taken at W3 compared with 28, 44 and 38 at W5 (Table 3).

Discussion

Controlled reservoir releases have been used for the removal of sediment from stream beds (Eustis & Hillen, 1954) and the release of water from Caban Coch Reser-

Table 3. Total numbers ($X 10^3/d$) of drifting macroinvertebrates at W3 and W5, R. Wye, 30 May-2 June 1975.

	W3			W5		
	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3
Amphinemura sulcicollis (Stephens)	-	-	0.1	2.2	8.9	3.2
Chloroperla torrentium (Picket)	1.0	1.4	1.9	2.5	9.6	14.5
C. tripunctata (Scopoli)	-	-	-	-	12.3	1.2
Isoperla grammatica (Poda)	0.7	0.6	0.7	-	3.0	0.6
Leuctra geniculata (Stephens)	-	-	-	-	0.7	-
L. hippopus (Kempny)	-	-	-	-	-	1.9
L. moselyi Morton	0.7	0.1	0.1	-	0.7	-
Protonemura meyeri (Picket)	-	-	0.1	-	-	-
Baetis muticus (L.)	-	0.1	-	0.3	1.2	1.1
B. niger (L.)	-	-	0.1	-	-	-
B. rhodani (Pict.)	2.2	0.1	0.1	-	3.0	1.3
B. scambus Etn.	1.8	9.5	5.8	6.7	14.4	9.0
B. vernus Curt.	-	-	-	-	-	1.3
Caenis moesta Bengtss	-	-	-	0.5	2.3	1.8
Ecdyonurus dispar (Curt.)	0.1	0.4	-	-	-	-
Ephemerella ignita (Poda)	3.2	2.2	3.9	19.7	159.3	67.7
Heptagenia sulphurea (Mull.)	0.1	-	-	1.2	1.2	-
Paraleptophlebia (cincta ?)	-	-	0.1	-	-	-
Rhithrogena semicolorata (Curt.)	1.8	1.9	3.9	1.8	12.5	5.6
Holocentropus sp.	-	-	-	-	1.2	-
Hydropsyche siltalai (Dohler)	5.9	5.4	6.7	1.0	4.8	1.8
Lepidostoma hirtum (Pict.)	-	0.1	0.1	0.5	26.5	7.3
Limnephilidae	-	-	-	-	0.5	-
Polycentropus flavomaculatus (Pict.)	-	-	0.1	0.7	2.8	0.6
Rhyacophila dorsalis (Curtis)	-	0.2	0.1	-	1.2	1.8
Dytiscidae larvae	0.6	0.8	1.1	-	2.0	-
Elmis aenea (Mull)	2.7	2.3	1.3	-	2.6	6.3
Esolus parallelepipedus	25.7	12.3	9.7	13.0	22.3	10.0
Helophorus brevipalpis (Bedel)	0.1	-	-	-	-	-
Hydraena gracilis (Germar)	-	0.1	0.1	-	2.0	-
Limnius volkmari (Mull)	0.8	0.2	0.1	-	-	0.6
Oulimnius tuberculatus (Mull)	1.8	1.2	2.0	1.5	4.1	5.0

Table 3 (Contd.)

Enchytraeidae	-	-	-	-	1.3	-
Nais alpina Sperber	-	-	-	2.0	2.8	1.2
Oligochaeta indet.	-	-	-	8.5	5.9	5.6
Simulium aureum gp.	-	0.1	-	-	-	-
S. ornatum Meigen	-	0.1	-	-	-	-
S. reptans (L.)	0.2	-	0.1	-	1.2	-
Brillia modesta Meigen	-	-	0.2	-	-	-
Cricotopus bicinctus Meigen	-	-	-	-	-	2.6
C. (trifascia ?)	-	-	-	14.3	75.6	41.8
Cricotopus sp 1	-	-	-	1.0	5.9	0.6
Cricotopus sp 3	-	-	-	2.0	2.8	-
Diamesa (insignipes ?)	-	0.3	-	-	-	2.6
Eukiefferiella (bavarica ?)	-	0.1	1.3	1.0	7.6	7.8
E. (calvescens ?)	-	-	0.2	0.8	1.2	3.5
E. (clypeata ?)	-	-	-	1.3	-	-
'*Lauterbornia*' sp.	-	-	-	-	-	5.9
Orthocladius sp 3	-	0.4	-	1.0	3.7	0.5
Orthocladius sp 5	-	-	-	1.3	5.1	8.9
Pentaneurini sp 1	-	-	-	-	4.8	-
Pentaneurini sp 3	-	-	-	-	1.6	-
Polypedilum 'nubeculosum' gp	-	-	-	1.5	3.2	1.1
Potthastia (longimana ?)	-	-	0.3	-	2.7	-
Rheotanytarsus (photophilus ?)	0.1	1.0	0.5	7.9	247.1	113.0
Synorthocladius semivirens (Kieff)	-	-	-	0.8	1.9	0.7
Thienemanniella sp.	1.5	8.5	4.4	2.4	2.9	1.3
Chironomidae indet.	-	-	0.2	2.8	14.2	2.9
Hydracarina spp.	0.7	1.2	0.3	-	7.1	9.4
Mermithidae	-	-	-	-	-	0.7

– = not recorded

voir substantially increased the load of suspended material at W5, 16 km from the reservoir. The suspended solids concentration, however, remained low (less than 6 mg/l).

The diel periodicity of drifting displayed by some aquatic organisms has been described by many workers (Elliott & Minshall, 1968; Elliott, 1969; Waters, 1962) and results from this study confirm the occurrence of night-time increases in drift rate and density in the R. Wye, particularly Ephemeroptera and Coleoptera.

The effects of the artificial increase in flow in the R. Wye on invertebrate drift are similar to those of natural flow increases. Anderson & Lehmkuhl (1968) and Elliott (1967) recorded increases in the number of drifting invertebrates resulting from natural freshets but, in contrast to the present study, found no effect on drift density: in the R. Wye there was a general increase in drift density associated with increased flow. It has been well established that salmonid fish utilise drift as a food source (Mundie, 1971; Elliott, 1973) and Mundie (1974) regarded the artificial enhancement of drift density during daylight periods as a method of increasing fish food supply. Such potential is available with freshet releases if turbidity remains low and the fish are not disturbed by the release itself.

During a natural spate Elliott (1976) collected taxa which had not been recorded in the drift previously. In this study there was an increase in the number of taxa collected at W5 during the freshet release although increases were also recorded at W3 which was not affected by the release of water.

The immediate response of *Rheotanytarsus,* a tubicolous chironomid, which showed no diel periodicity of drifting, to the freshet release confirmed the report of Anderson & Lehmkuhl (1968) who found that the drift of Diptera (90% Chironomidae) was influenced by rainfall and associated changes in river flow. The same workers also reported that Ephemeroptera and Plecoptera retained their behavioural day-night periodicity during natural spate conditions and this explains the delay in the response of the Coleoptera and Ephemeroptera, particularly *Ephemerella,* to the artificial freshet in the R. Wye. Peak numbers of these organisms were recorded 6 h after the increase in flow, during the period of darkness.

The increase in the number of drifting invertebrates on Day 2 and Day 3 resulting from the artificial release suggests a substantial increase in the loss of invertebrates downstream. However, comparison of the drift densities at W5 with the probable benthic density over the period of study indicates that before the release only 0.006% of the benthos was in the drift at any one time. During the first and second days of the release, the size of which was small in comparison with natural spates, 0.013 and 0.010% respectively of the benthos was drifting. Despite the relative increase in the proportion of the benthos in the drift the absolute maximum porportion remained low compared with the results of other workers (Radford & Hartland-Rowe, 1971).

Results from this and other studies indicate that rapid changes in flow resulting from natural or artificial causes substantially modify the drift of invertebrates in rivers. However, proposals to regulate natural river systems in the U.K. (Ministry of Agriculture Fisheries and Food and NWC, 1976) are likely to place greater emphasis on the effects of long-term changes in flow regime on drifting invertebrates and the implications of these effects on benthic invertebrate populations. Such effects can only be assessed by long-term studies.

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Summary

1. Observations were made on the effects of an artificial discharge of water, from an impoundment over a period of 48 h, on the macroinvertebrate drift and some aspects of water quality of the R. Wye, Wales.

2. An increase in discharge, from 2.0-5.0 m^3/sec, at a site 16 km below the impoundment did not substantially effect water temperature, dissolved oxygen or suspended solids concentrations. However, on the second day of the release the load of suspended material was about 10 times greater than the pre-release period.

3. The total numbers of drifting invertebrates on the first and second days of the release were respectively about 7 and 3 times greater than the numbers on the day preceding the release.

4. The increase in flow resulted in an immediate daytime increase in the total number and density of the larvae of *Rheotanytarsus* (Chironomidae).

5. Those organisms which displayed periodicity of drift, e.g. *Ephemerella ignita* (Poda), retained this behaviour during the release and night-time drift numbers were substantially greater during the release than during the pre-release period.

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