OIKOS 27: 307–310. Copenhagen 1976

Distribution of the benthos within the substratum of a Welsh mountain stream

H. B. N. Hynes

D. D. Williams

N. E. Williams

Department of Biology, University of Waterloo

Hynes, H. B. N., Williams, D. D. and Williams, N. E. 1976. Distribution of the benthos within the substratum of a Welsh mountain stream. – Oikos 27: 307–310.

Samples collected with a standpipe corer at depths of 10–15 and 15–25 cm below the gravel surface of the Afon Hirnant show that benthic invertebrates occur in considerable numbers down to at least 25 cm, which is only 5 cm above the bedrock. The numbers in these samples, together with estimates of the numbers in the top 5 cm as revealed by kick samples, indicate a faunal density of around a quarter of a million per square metre. This is a far greater number than is usually reported from stream beds, but it is shown to be in line with estimates made in very different streams by methods that collect specimens from deep in the substratum. Clearly the usual types of quantitative sample are quite inadequate.

H. B. N. Hynes, Dept of Biology, University of Waterloo, Waterloo, Ontario, Canada N2L 3G1. D. D. Williams and N. E. Williams, Pacific Biological Station, Nanaimo, BC, Canada V9R 5K6.

Пробы, собранные напорной трубой с глубины 10–15 и 15–25 см, показали, что бентосные беспозвоночные встречаются в значите льных количествах по крайней мере до 25 см глубины – лишь на 5 см выше коренной породы. Количества этих проб и измерения на глубине 5 см показали, что плотность животных составляет около 0,25 млн на кв.метр. Это – много больше, чем обычно находят на дне речного русла, но совпадает с измерениями, сделанными в очень различных реках методами, применяемыми для сбора животных с большой глубины донного субстрата. Ясно, что обычные типы количественных сборов здесь непригодны.

Accepted 13 January 1976

Introduction

In previous papers members of our laboratory have shown that rheophilic invertebrates occur far down into the gravel of streams where they form part of the hyporheos for at least some period in their lives (Coleman and Hynes 1970, Hynes 1974, Williams and Hynes 1974). These papers contain references to earlier studies made in Europe of hyporheic animals. However, our methods were questioned, so we developed new ones and hopefully overcame these criticisms (Williams and Hynes 1974, Hynes 1974). Later, although others have obtained similar results as far away as the Rocky Mountains (Radford and Hartland-Rowe 1971) and Malaya (Bishop 1973), and we ourselves on the Precambrian shield in Quebec (Williams and Hynes 1974), it has been asserted that the streams on which we have worked in southern Ontario must be peculiar because the region is covered with glacial and alluvial debris. It is alleged that such findings would not apply in genuine mountain trout streams.

So two of us (D.D.W. and N.E.W.) took advantage of a visit to Wales to collect samples of the hyporheos from the Afon Hirnant, a mountain trout stream of which the invertebrate fauna has been much studied (Hynes 1961, 1968). The site chosen was Station 3 of Hynes (280 m, National Grid map reference 952312), and the collections were made on 15 June 1974. The locality seems to have changed very little during the past 20 years, and has been dealt with in detail in the earlier papers.

Methods

Six samples were taken at each of 10 and 20 cm depth on a riffle and in a pool with the standpipe corer described by Williams and Hynes (1974). Each sample consisted of 25 ml of gravel and animals taken from within 5 cm of the mean depth of the sample, i.e. 5–15 and 15–25 cm. In both places the bedrock was apparently at about 30 cm below the gravel/water interface so deeper samples were not possible. In addition 3 kick samples covering about one square foot to a depth of about 5 cm (ca 4644 ml) were collected from both riffle and pool with a fine meshed net (130 μm). This is a fairly crude method, but it works well in conditions of low discharge such as were encountered on the sampling date. It was not considered necessary for our purpose to transport more sophisticated apparatus across the Atlantic, and, unfortunately, the standpipe corer does not collect good samples at the gravel surface.

The 30 samples were preserved in formaldehyde in the field and later floated off in a strong sugar solution. After transportation to our laboratory in Canada the animals were picked out and identified, using the counterstaining method of Williams and Williams (1974).

Larger quantities of gravel were collected with a shovel from two depths into the riffle in mid stream, and these, when dry, were shaken through a series of Wentworth sieves as recommended by Cummins (1962) and weighed. An estimate of the porosity of the gravel was also made by the method of Pollard (1953).

Results

Tab. 1 shows the composition of the gravel at the two depths in the riffle. It should, however, be noted that by its nature the sampler selects against larger stones. Its apertures are 100 × 10 mm, so spheres of over 10 mm diameter cannot enter, and this may result in some slight concentration of the fauna in the samples.

Tab. 2 shows the numbers of animals obtained in the samples, expressed as numbers per litre and thence as numbers per square metre for each of the three depth zones. The 95% confidence limits were calculated separately for each level, and the mean number per square metre is the sum of the means of each. Similarly the 95% confidence limits for this figure are the sums of the lowest and highest values for each level. It is apparent that the kick samples from the pool were the least uniform of the six sets.

The animals were identified as far as possible, and the species list differed little from that of Hynes (1961, 1968) apart from nomenclatorial changes and a much more thorough identification of the Chironomidae than previously. Considering organisms of which more than one specimen was collected, some occurred only on the riffle (Naididae, *Baetis tenax* Eaton, *B. scambus* Eaton, *Amphinemura sulcicollis* (Stephens), *Protonemura meyeri* (Pictet), *Leuctra inermis* Kempny, *L. hippopus* (Kempny)? (small), *Siphonoperla torrentium* (Pictet), *Potamophylax latipennis* (Curtis), *Corynoneura* sp., *Diamesa* sp., Limoniinae, *Simulium cryophilum* Rubtzov, *S. rheophilum* Knoz and *S. tuberosum* Lundstroem), and there was

Tab. 1. Percentage composition by weight, and porosity of the gravel in the riffle areas.

depth cm	5–15	15–25
sieve aperture mm	%	%
64	28.5	0
32	21.7	6.2
16	14.1	10.6
8	10.2	16.5
4	6.6	21.2
2	6.3	19.6
1	5.8	14.5
0.5	3.6	6.6
0.25	1.6	2.4
0.125	0.6	0.8
0.063	0.3	0.5
<0.063	0.6	1.0
porosity %	15	23

Tab. 2. Numbers of specimens per litre and per m², to a depth of 25 cm, as calculated, together with 95% confidence limits, from the kick and core samples.

depth cm	Riffle 0–5	5–15	15–25	Pool 0–5	5–15	15–25
no of samples	3	6	6	3	6	6
mean no. litre^{-1}	604	1620	1267	501	1933	1093
standard error %	5.2	30.5	18.6	39.2	22.2	16.6
no. m^{-2} 95%	37014	324000	187139	67397	303798	156060
confidence limits	23408	34967	66194	0	82868	62607
mean no. m^{-2}		318878			327731	
95% confidence		548153			527255	
limits		124569			145475	

none that was confined to the pool samples. There, however, certain taxa were markedly more abundant than on the riffle (*Cricotopus/Rheorthocladius* sp., *Prodiamesa olivacea* Meigen, *Pentaneura* sp.?, *Anatopynia* sp., *Micropsectra* sp. and *Polypedilum* sp.; all are Chironomidae). Markedly more common on the riffle than in the pool were *Bryocamptus zschokkei* (Schmeil) (Harpacticoidea), small *Baetis* probably *B. rhodani* (Pictet), *Ephemerella ignita* (Poda), *Heptagenia lateralis* (Curtis), *Thienemaniella/Eukiefferiella* sp., *Elmis aenea* (Müller) and Hydracarina. Probably this last list would have been longer if the samples had included more of the early emerging mayfly and stonefly species. Perhaps of greatest significance in this study is that many taxa occurred at the lowest depth in considerable numbers (Naididae, *Bryocamptus zschokkei*, *Cricotopus/Rheorthocladius*, *Thienemaniella/Eukiefferiella*, *Brillia modesta* Meigen, *Micropsectra* and *Polypedilum*) and that, usually several, specimens of many others were taken there (*Hydra*, Nematoda Ostracoda, *Baetis tenax*, *B. rhodani*? *Ephemerella ignita*, *Amphinemura sulcicollis*, *Leuctra moselyi* Morton, *Chloroperla tripunctata* (Scopoli), *Plectrocnemia conspersa* (Curtis), *Prodiamesa olivacea*, *Pentaneura*, *Anatopynia*, an unidentified member of the Tanypodinae, *Simulium cryophilum*, *S. rheophilum*, and Hydracarina). Others were found down to only the 5–15 cm level (*Leuctra fusca*, *L. hippopus*?, *Siphonoperla torrentium*, Empididae, *Elmis aenea* and Porohalacarida). Doubtless these lists would be increased by further study, but they are long when it is considered that they are based on a total of only 600 ml of gravel.

Discussion

This brief study has confirmed that even in a typical mountain stream the ordinary stream fauna extends deeply into the substratum, a fact that had already been suggested to account for the recovery of the populations at the same site in the Afon Hirnant after a spate (Hynes 1968). It also shows that the number of individuals per unit area of stream bed is enormously greater than is usually recorded. Hynes (1968) gives figures from which one may calculate that he found 8830 m^{-2} (95% confidence limits 4436–13223) with his fine-meshed sampler at the same station in June 1960. This is considerably fewer than was found by the kick samples in 1974 (Tab. 2), but it was after a time of great faunal loss, and perhaps the sampler used in 1960 was less efficient than was believed. One may therefore conclude that the figures used here from the kick samples are not unreasonable, and this seems probable in view of the fact that they were collected under ideal conditions. In any event, they are more likely to be an underestimate than an overestimate of the population down to 5 cm.

The totals given in Tab. 2 may thus be compared with those from our other studies. Our early figures for the Speed River, Ontario, average 227530 m^{-2} down to 30 cm (Coleman and Hynes 1970), and later figures obtained with the apparatus used in this study range from 184760–797960, down to the point where the animals cease to occur, in the same stream (Williams and Hynes 1974). The actual figures among the latter as calculated for May, June and July are 268664, 280683 and 212723, which are quite close to those given for the riffle in the Afon Hirnant in June (Tab. 2). It would seem then that around a quarter of a million animals per square metre may be an approximate figure for many streams with a porous substratum, as these two streams are near the opposite ends of several ecological scales.

The Afon Hirnant is a cool softwater mountain trout stream while the Speed River is a summer warm, rich, hardwater lowland stream which is only very marginally available to trout. Also the climate regimes are quite different, as are the rocks. The Speed River flows in midcontinent over glacial alluvium and the porosity of its sediments is from 20 to 35% (Stocker and Williams 1972). The Afon Hirnant flows near a sea coast with an onshore wind, on slate, and the real porosity of its bed undoubtedly far exceeds values shown in Tab. 1 because the flat pieces of slate tend to lie horizontally.

The last point possibly explains why, most unusually in our studies, we found 8 larvae of *Simulium cryophilum* and *S. rheophilum* in the bottom layer of the riffle. Our previous findings have indicated that Simuliidae usually remain near the surface (Coleman and Hynes 1970) which could be an important consideration in their control with insecticides.

Acknowledgements – This work was supported by a National Research Council of Canada operating grant to H. B. N. Hynes for which we express our thanks. We are also very grateful to Dr. L. Davies of the University of Durham for identifying the Simuliidae, Mrs D. Pisarczyk for sorting the samples, and to Prof. T. B. Reynoldson for providing laboratory space at the University College of North Wales, Bangor, when the preliminary work on the samples was done.

References

Bishop, J. E. 1973. Observations on the vertical distribution of the benthos in a Malaysian stream. – Freshwat. Biol. 3: 147–156.

Coleman, M. J. and Hynes, H. B. N. 1970. The vertical distribution of the invertebrate fauna in the bed of a stream. – Limnol. Oceanogr. 15: 31–40.

Cummins, K. W. 1962. An evaluation of some techniques for the collection and analysis of benthic samples with special emphasis on lotic waters. – Amer. Midl. Nat. 67: 474–504.

Hynes, H. B. N. 1961. The invertebrate fauna of a Welsh mountain stream. – Arch. Hydrobiol. 57: 344–388.

– 1968. Further studies on the invertebrate fauna of a Welsh mountain stream. – Arch. Hydrobiol. 65: 360–379.

– 1974. Further studies on the distribution of stream animals within the substratum. – Limnol. Oceanogr. 19: 92–99.

Pollard, R. A. 1955. Measuring seepage through salmon spawning gravel. – J. Fish. Res. Bd Can. 17: 706–741.

Radford, D. S. and Hartland-Rowe, R. 1971. Subsurface and surface sampling of benthic invertebrates in two streams. – Limnol. Oceanogr. 16: 114–117.

Stocker, Z. S. J. and Williams, D. D. 1972. A freezing core method for describing the vertical distribution of sediments in a streambed. – Limnol. Oceanogr. 17: 136–138.

Williams, D. D. and Hynes, H. B. N. 1974. The occurrence of benthos deep in the substratum of a stream. – Freshwat. Biol. 4: 233–256.

– and Williams, N. E. 1974. A counterstaining technique for use in sorting benthic samples. – Limnol. Oceanogr. 19: 152–154.