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A survey of the macro-fauna of the River Cynon, a polluted tributary of the River Taff (South Wales)

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Summary

(1) A survey of the macro-invertebrates and fish in the River Cynon, a trout stream in south-east Wales receiving industrial and domestic wastes, and nine of its tributaries, was carried out in the summer of 1970. Its principal purpose was to describe the structure of these communities before waste treatment facilities, in course of construction, reduce the degree of pollution.

(2) The macro-invertebrate communities changed dramatically at station C4, there being a very varied fauna upstream and one dominated by chironomids and oligochaetes downstream, principally *Nais barbata*, *Cricotopus bicinctus* and *Syncricotopus rufiventris*. It seems likely that coal particles, influencing the substrate, are largely responsible for this change. Further downstream, and below substantial organic discharges, tubificids and the enchytraeid, *Lumbricillus rivalis*, became increasingly abundant. The total density of macro-invertebrates increased from about 2000/m^2 in the headwaters to over 20,000/m^2 in the lower reaches.

(3) The fauna of the clean tributaries, Hir (C16) and Wenallt (C19) was similar to that of the unpolluted upper reaches of the Cynon (C1–C3) whereas that of tributaries affected by coal particles was similar to the fauna of the Cynon downstream of C4.

(4) Six species of fish were recorded (bullhead, eel, minnow, trout, stickleback and stoneloach) of which three (bullhead, eel and trout) were confined to reaches upstream (C8 and above) of industrial effluents at Abercwmboi. For 0·8 km downstream of these effluents the river was fishless and further downstream, to the confluence with the River Taff, fish density and biomass were reduced.

(5) In the upper Cynon and its tributaries the density and biomass of trout were within the range recorded elsewhere in the British Isles. The growth rate of trout in the catchment is low. Differences in growth rate and shape of trout in the main river and tributaries suggest that there is little interchange between these areas, except perhaps with very young fish. 0+* fish were only caught in abundance at two tributary

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* The convention of referring to fish in their first year as 0+, in their second year as 1+ and so on is adopted here.

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stations and their numbers, even if widely distributed, could not permanently support the current density of older fish throughout the upper catchment.

(6) Stone loach and minnow reached a very large size and individuals caught of the latter species approached the maximum recorded length for the British Isles.

Introduction

For a river system of its size and social and economic importance the River Taff has been neglected from the viewpoint of biological studies. In 1969 a general biological survey of the River Taff and its major tributaries, including the River Cynon, was conducted (Edwards *et al.*, 1972) and whilst this formed a basis for more detailed studies it suffered from several defects, the principal ones being the inadequacy of the taxonomy of certain groups, the comparatively few sampling stations in any component river, the absence of quantitative data on macro-invertebrate densities (sampling was standardized on a time basis), and the limited period of the year when samples were collected (July). The present study was undertaken to describe in more detail the animal communities within the River Cynon, attempting to overcome some of the deficiencies of the earlier general survey. Although most animals have been identified to species, more sampling stations have been included and densities of the more abundant species have been estimated, the authors are aware that too few samples were collected to give reasonable statistical limits of such densities and the collecting period, as in the earlier survey, was over a restricted period of the year (July–August). The River Cynon was chosen principally because a comprehensive scheme for the biological treatment of wastes currently discharged to this river has received planning consent and some form of 'base-line' was required to assess the influence of waste treatment on the biology of the river. Generally such assessments are based on comparisons of biological communities upstream and downstream of effluents (Hynes, 1960): these frequently suffer because of spatial differences in the physical nature of the stream bed, etc., not associated with pollution, which bring about changes in the structure of communities.

Description of the river

The River Cynon rises in moorland about 1 km south of Cader Fawr (SN 980120) in a region known as Fforest Fawr, some 390 m above sea level, and drops about 320 m to its confluence with the River Taff at Abercynon (ST 084949). The major superficial rock strata of the catchment along with the major areas of urban development are shown in Fig. 1.

The total catchment area is 108 km^2: flows range from $40 \times 10^3 m^3 d$ to $166 \times 10^5 m^3 d$ with a mean of $313 \times 10^3 m^3 d$.

Sewage and industrial discharges to the river

The river receives a number of sewage and industrial effluents, the known ones being shown in Fig. 1. Suspended solids of coal origin are discharged from coal washery plants and are also derived from coal-tips, particularly at times of heavy rain. Coal washery sites on the tributaries Dare and Aman ceased operation in 1969 although some run-off still occurs. Treated sewage is discharged above station C3 and further sewage enters the river via a tributary just above C4, below C8, and also just above C11. Known industrial effluents which contain cyanide, phenol and ammonia, enter

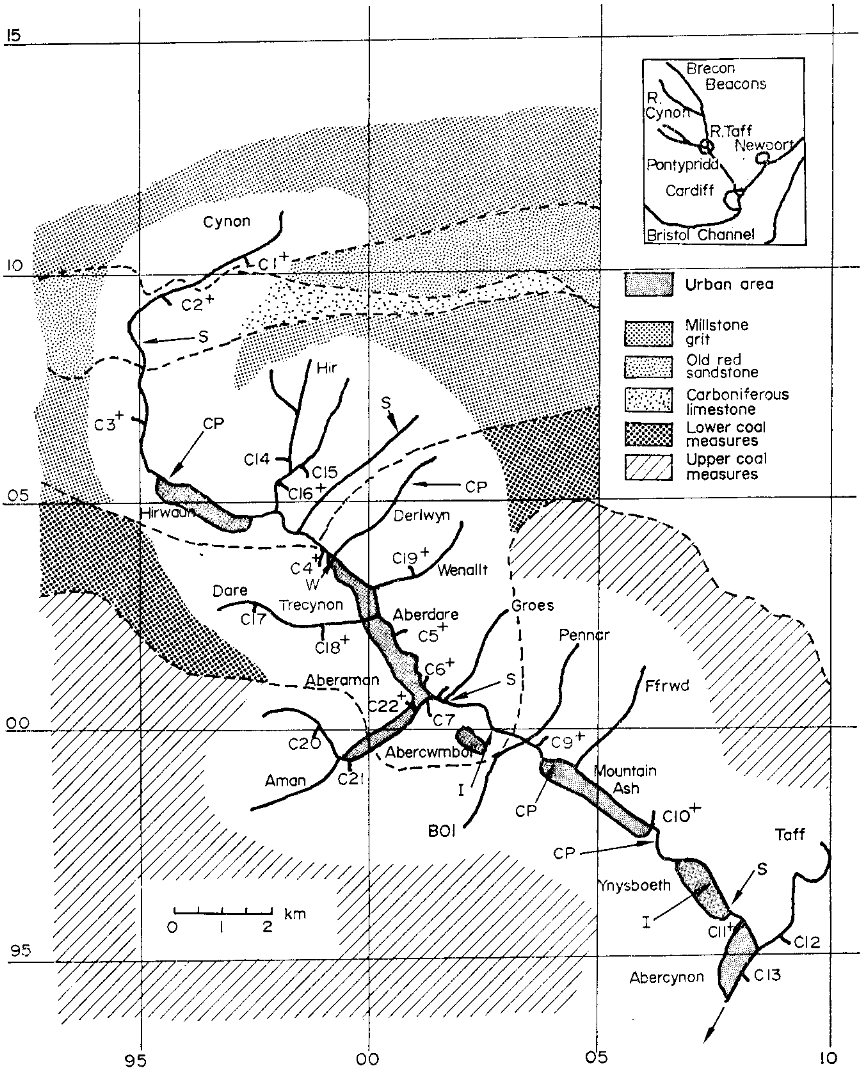


Fig. 1. Map of the River Cynon and its major tributaries showing sampling stations, sites of principal effluent discharges, major urban areas and geological features. + Indicates station sampled for macro-invertebrates as well as for fish. CP = Effluent containing coal particles. I = Industrial wastes. S = Sewage. W = Cooling water from creamery. Inset shows the River Cynon in relation to the Bristol Channel.

the river at Abercwmboi and others, from the Ynysboeth Trading Estate, contain cyanides.

All industrial and sewage effluents, except those from the coal washery plants, will shortly be fully treated at the Cwm Farm Sewage Disposal Works now under construction near Pontypridd, the effluent being discharged directly to the River Taff.

Description of stations

Twenty-two stations were selected along the length of the River Cynon and on four of its tributaries (Fig. 1). Thirteen of these were sampled for macro-invertebrates and fish, the remainder were sampled for fish alone (Fig. 1 and Table 1). The macro-

Table 1. Position of sampling stations at which macro-invertebrate and fish surveys were carried out, along with river width, average depth of water, average surface velocity and average stone diameter as measured on 28 July 1970

Station	National grid reference	River width (m)	Average depth of water (cm) (range)	Average surface velocity (m/s)	Average stone diameter (cm) (range)	Sampled for	
						Fish	Invertebrates
C1	SN 973107	1·9	21 (10–28)	0·2	10 (7–23)	×	×
C2	SN 951095	3·3	27 (18–35)	0·5	15 (5–34)	×	×
C3	SN 951068	4·0	37 (34–40)	1·7	15 (9–20)	×	×
C4	SN 991043	12·0	27 (0–50)	0·9	18 (8–34)	×	×
C5	SO 006025	12·0	33 (15–50)	0·8	16 (9–27)	×	×
C6	SO 015015	9·2	49 (11–69)	0·8	10 (6–17)	×	×
C7	SO 019013	7·0	—	—	13 (6–23)	×	
C8	SO 019013	10·9	—	—	12 (5–19)	×	
C9	ST 038998	13·0	53 (30–66)	0·5	<5	×	×
C10	ST 062978	15·0	50 (25–63)	0·6	16 (9–28)	×	×
C11	ST 082952	16·0	45 (23–56)	0·6	14 (9–22)	×	×
C12	ST 085950	14·0	—	—	20 (13–32)	×	
C13	ST 084949	26·0	—	—	22 (12–32)	×	
C14–C16 Hir	SN 979058	3·5	8 (2–15)	0·2	13 (6–25)	×	×
C17 Dare	SN 975028	2·0	—	—	9 (4–21)	×	

C18 Dare	SN 991026	5·0	14	0·4	16	×	×
			(6–21)		(5–30)		
C19 Wenallt	SO 008034	4·5	5	0·2	14	×	×
			(1–10)		(5–28)		
C20 Aman	SS 995998	2·6	—	—	11	×	
					(4–21)		
C21 Aman	ST 003994	4·3	—	—	18	×	
					(6–28)		
C22 Aman	SO 018011	5·0	15	0·2	13	×	×
			(5–20)		(6–21)		

Table 2. Water analysis (April 1967–April 1970)

Station	No. of samples	pH	Temp (°C)	Alkalinity (mg/l CaCO$_3$)	BOD (5 day at 20°C mg O$_2$ absorbed/l)	Ammonia (mg N/l)	Suspended solids (mg/l)	Electrical conductivity (micromhos at 20°C)	Dissolved oxygen (mg O$_2$/l)
Cynon C3	14	7·7	10·7	109	1·0	0·1	5·3	219	11·7
		(6·9–8·6)	(4·5–13·5)	(85–147)	(0·1–2·6)	(0·02–0·32)	(2–22)	(186–272)	(9·9–14·2)
C4	14	8·0	8·9	130	1·6	0·1	17	315	11·1
		(7·4–8·6)	(4·0–14·5)	(83–250)	(0·5–5·0)	(0·02–0·4)	(2–65)	(215–529)	(9·4–12·5)
C5	14	7·9	10·5	144	1·3	0·1	10	315	11·3
		(7·6–8·5)	(5·5–16·0)	(96–223)	(0·3–2·8)	(0·02–0·3)	(2–63)	(243–557)	(9·2–14·2)
C9	14	8·0	10·8	154	3·7	1·2	13	332	9·5
		(7·8–8·2)	(4·5–16·0)	(98–236)	(1·8–10·6)	(0·74–2·7)	(4–32)	(300–629)	(6·4–11·7)
C10	14	8·0	10·6	154	4·7	1·0	20	435	9·8
		(7·6–9·9)	(5·0–17·0)	(92–233)	(1·8–11·4)	(0·58–2·5)	(3–52)	(322–601)	(6·5–11·8)
C11	14	7·9	11·5	142	4·5	0·7	73	437	9·6
		(7·7–8·1)	(5·5–16·0)	(85–198)	(1·0–8·4)	(0·5–1·1)	(3–279)	(336–614)	(7·5–11·7)
Wenallt C19	1	8·3	—	67	0·6	0·7	3	—	10·6

Cyanide at 0·01 mgCN/l detected on one occasion at C9 and phenols 0·6 mg/l on one occasion at C11.

invertebrate stations on the Cynon were all sampled between 7 and 22 July 1970 and those on the tributaries on 11 August 1970. The fish stations were all sampled between 29 June and 10 July 1970. As far as possible care was taken to see that the stations selected were representative of the reaches of the river concerned but accessibility, flow and depth influenced the selection to some extent. Only one of the two major tributaries of the Aman was examined because the other was culverted over much of its length.

Table 1 gives some physical characteristics for each selected station. The average stone diameter was obtained by averaging the longest dimension of ten stones selected at random across the transect. The River Cynon throughout its length typically has an 'eroding' substratum (Hynes, 1960) and the bed is hard with the stones firmly embedded in it. However, at the upper stations C1 and C2 and at all the tributary stations apart from C22 the stones were loose. Station C9 had a bed noticeably different from that of the other stations with much smaller stones. From Trecynon C4 to the Cynon–Taff confluence the substrate was modified owing to the deposition of silt, largely coal dust. Of the tributaries both the Dare and Aman had beds affected by coal dust.

The water velocity at each station was measured just below the water surface at three points across the stream using a small Ott current meter.

There were few macrophytes at any station other than at C3 where *Ranunculus peltatus* (Schrank) occurred. Epilithic algae were noticeably abundant from Trecynon C4 to Aberaman C8 and fairly abundant at C3, and at the tributary stations C17, C20 and C22.

Water Quality

Table 2 gives a summary of water quality over the period April 1967 to April 1970, the data being supplied by the Glamorgan River Authority. Although the number of samples upon which the Table is based is small, certain generalizations can be made: (a) the water is alkaline, the pH throughout the system being generally about 8; (b) although dissolved oxygen concentrations are generally high, at C9 and C10 oxygen concentrations fall occasionally to about 6·5 mg/l; (c) the permanganate value, biochemical oxygen demand, and ammonia concentration all indicate increasing organic pollution in the lower reaches of the Cynon, from C9 to the confluence; and (d) there is also, with the exception of C4, a steady increase in average suspended solids downstream from about 5 mg/l at C3 to 73 mg/l at C11. Pulses of suspended solids as high as 279 mg/l have been recorded at this latter station. Substances, other than ammonia, known to be directly toxic to animals have been recorded on two occasions only, cyanide at a concentration of 0·01 mgCN/l at C9 and 0·5 mg phenol/l at C11 although it seems unlikely that these are the only discharges of such substances over the three years preceding this survey for which analytical data are available.

There are various schemes for classifying rivers on chemical data and in Table 3 representative stations on the River Cynon are classified in relation to four such schemes. It is apparent from Table 3 that according to these four schemes the average water quality in the upper Cynon (C3, C4 and C5) is clean to very clean (oligosaprobic) whilst in the lower Cynon (C9, C10 and C11) it is only fairly clean to doubtful (β-mesosaprobic). Both the Royal Commission and Schmitz schemes give poorer classes for stations C9–C11 than the other two and these two schemes alone take suspended solids into account, a factor likely to be of significance in the Cynon system.

Table 3. Water quality classification of stations based on averaged chemical data

	1 Royal Commission on Sewage Disposal	2 Fjerdingstad	3 Schmitz	4 Tümpling
Cynon C3	Class 1 (very clean)	Zone 8 (oligosaprobic)	Class 1	Class 1 (oligosaprobic)
C4	Class 2 (clean)	Zone 8 (oligosaprobic)	Class 1	Class 1 (oligosaprobic)
C5	Class 2 (clean)	Zone 8 (oligosaprobic)	Class 1	Class 1 (oligosaprobic)
C9	Class 3–4 (Fairly clean to doubtful)	Zone 7 (γ-mesosaprobic)	Class 3	Class 2 (β-mesosaprobic)
C10	Class 3–4 (fairly clean to doubtful)	Zone 6–7 (β-mesosaprobic to γ-mesosaprobic)	Class 4	Class 2 (β-mesosaprobic)
C11	Class 4 (doubtful)	Zone 6–7 (β-mesosaprobic to γ-mesosaprobic)	Class 4	Class 2 (β-mesosaprobic)
Wenallt C19	Class 1–2 (very clean)	Zone 8 (oligosaprobic)	Class 2	Class 1 (oligosaprobic)
No. of classes in scheme	5	9	5	4

1, Klein (1966); 2, Fjerdingstad (1964); 3, Schmitz (1971); 4, Tümpling (1969).

Methods of sampling (macro-invertebrates)

The macro-invertebrate populations were sampled by means of a modified Surber-type sampler with a conical net of 400 μ diagonal pore aperture (24 mesh/cm) attached to a polythene pot. Four samples (each 0·1 m^2) were taken across the river at each station and these were preserved with formaldehyde for later examination.

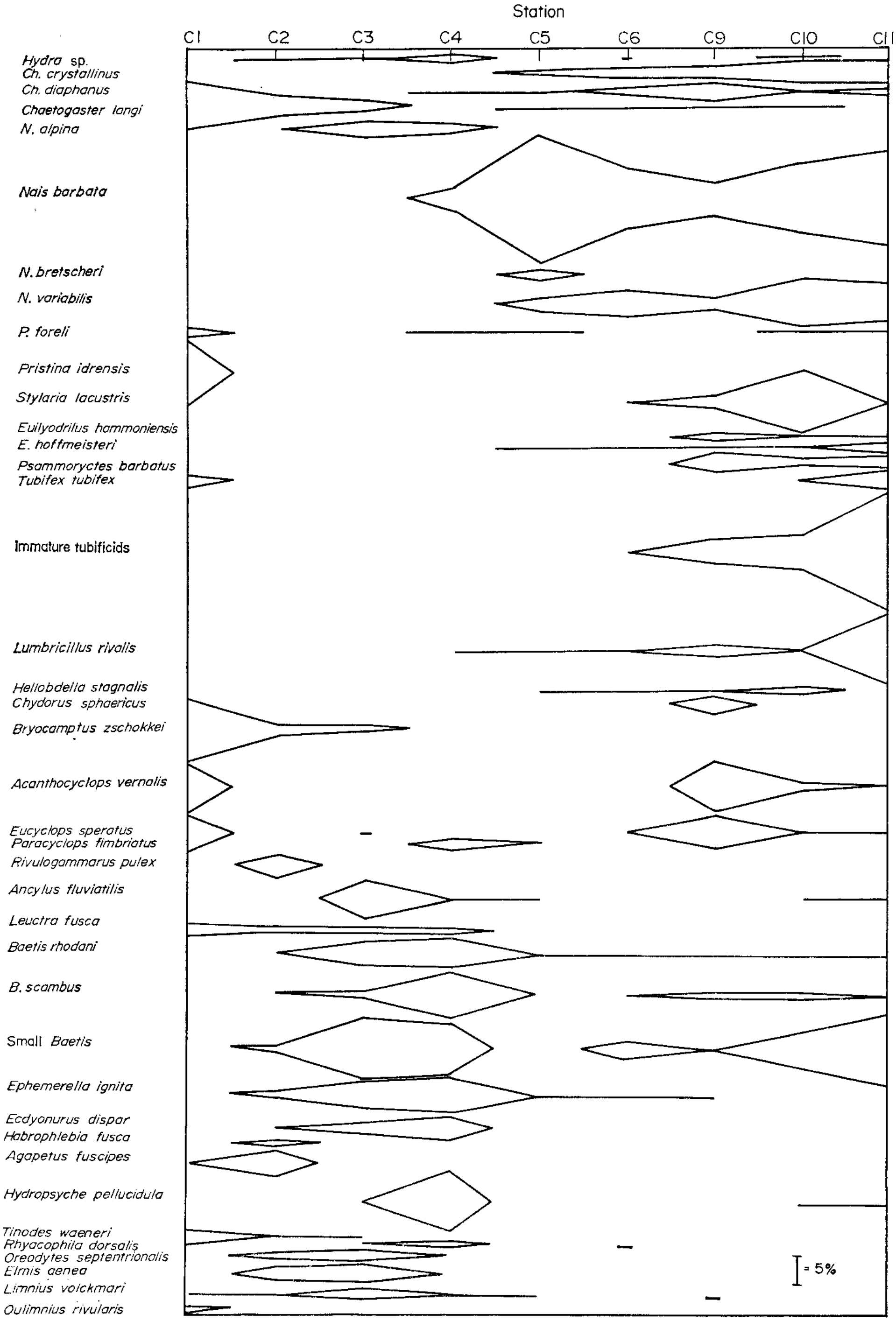
Although the larger animals were removed from whole samples, a standardized sub-sampling procedure was adopted for smaller animals. Microscopical examination was carried out using a Perspex counting tray based on the Fenwick pattern (Goodey, 1963).

To aid identification, adult midges were reared from larvae collected in additional samples brought back to the laboratory unpreserved. The chironomid larvae were reared in both static and flowing systems the temperatures of the two systems being 21 and 13–17°C respectively. Although mortalities were high (85%), practically all the chironomid species from the lower Cynon were reared; rearing of those groups characteristic of the upper Cynon was rather less successful.

Methods of sampling (fish)

Population estimates were made by isolating selected reaches with stop nets (1·3 cm knot to knot) followed by repeated electro-fishing moving upstream. The electro-fisher used was a pulsed d.c. unit based on the design of Moore (1967). Normally, reaches of about 50 m were selected but when only the smaller species were present, shorter reaches were electro-fished. Population estimates were based on the method of Zippin (1958).

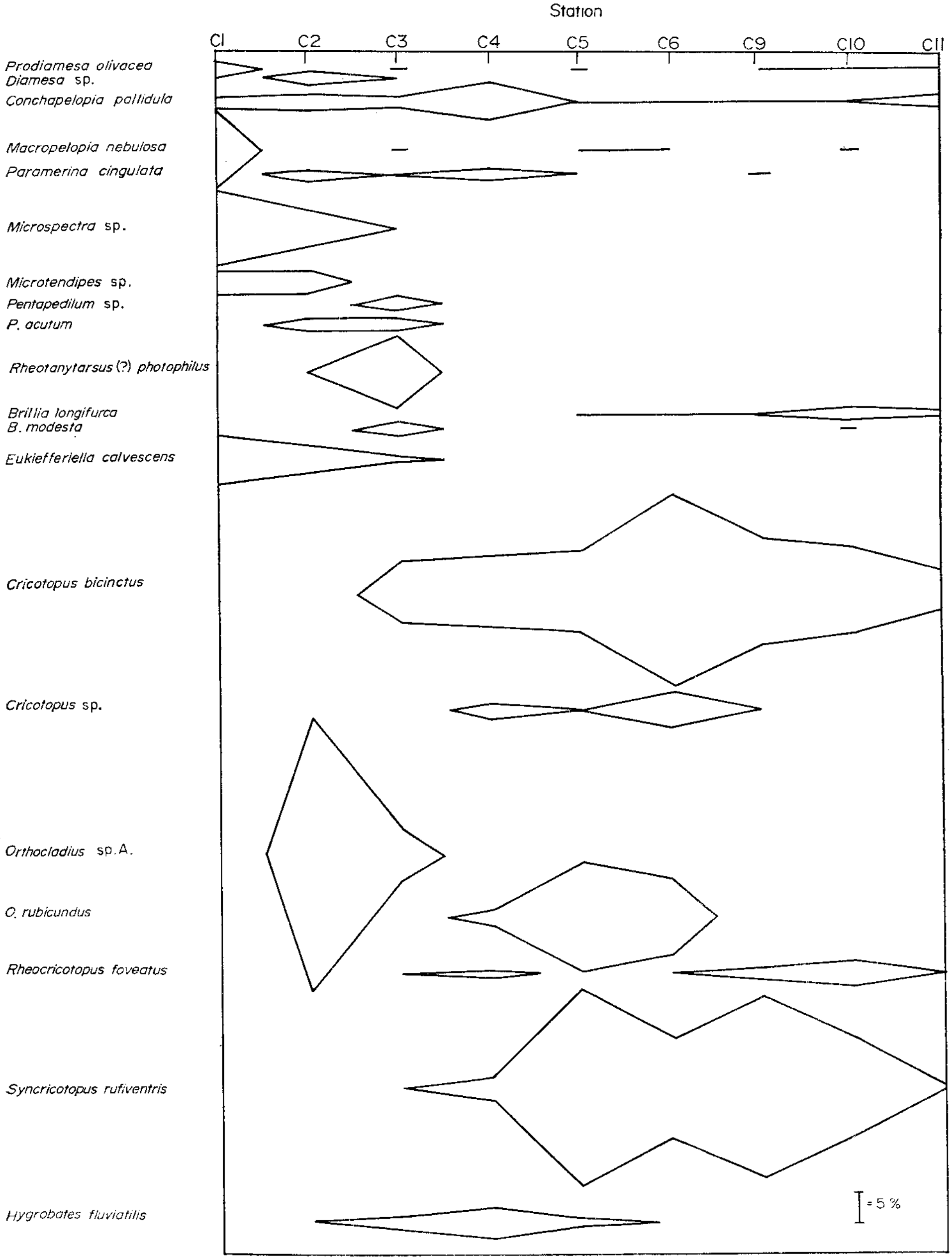
For ease of handling the fish were anaesthetized with MS222 at a dilution of 1 in



(a)

Fig. 2 (a) and (b). The proportional representation of species comprising 1 % or more of the macro-invertebrate community occurring at each station on the River Cynon.

24,000 by volume. The fork lengths of trout (*Salmo trutta* L.) and minnow (*Phoxinus phoxinus* L.) were taken, while those fish which have no fork in their tails were measured to the tip of the tail. Eels (*Anguilla anguilla* L.) and trout of 1+ and over were weighed individually but 0+ trout, bullheads (*Cottus gobio* L.), minnows, sticklebacks (*Gasterosteus aculeatus* L.) and stoneloach (*Noemacheilus barbatulus* L.) were generally



(b)

weighed in groups. With the exception of a small number of 0+ trout retained for scale measurements, all fish were returned to the river on recovering from the anaesthetic. Trout were aged using the technique described by Mann (1971).

For the purpose of determining the species present, wide-ranging sweeps were made with the electro-fisher outside the quantitative sites. At sites C7, C8, C9, C10, C12 and C13 no quantitative work was attempted. In order to compare the species present in the lower Cynon with those in the Taff, sweeps with the electro-fisher were made up to 200 m above and below the entry of the Cynon into the Taff.

Results—Macro-invertebrates

Fig. 2 (a, b) shows the distribution of all species which contributed more than 1% to the total numbers at stations on the River Cynon. The Appendix gives a list of the species found at each station sampled together with their average densities. The classification used is that of the 'Limnofauna Europaea' (Illies, 1967).

Hydra sp., usually considered characteristic of lentic or slow-moving waters, was rare in the River Cynon, occurring at six of the thirteen stations sampled and reaching a maximum density of about $100/m^2$ (C10).

The distribution of triclads was limited to one species, *Dugesia lugubris*, at one station (C6). Triclads in general are intolerant of organic pollution (Hawkes, 1962) and this probably explains their absence in the lower reaches of the Cynon. It does not, however, explain their absence from the headwaters and unpolluted tributaries.

Of the oligochaetes, the naidids were well represented throughout the system, occurring at all stations and being especially abundant on the River Cynon downstream of C4, with average densities up to $8000/m^2$, and in the Aman, at a density in excess of $6000/m^2$. Thirteen species were found, an almost identical assemblage to that recorded by Besch, Hofman & Ellenberger (1967) in the River Kinzig, a 'polluted' trout stream in Germany. *Nais barbata* was the most abundant species, reaching an average density of about $6000/m^2$ at C5. It was not present in the River Cynon upstream of C4 or in certain tributaries (C16 and C19). According to Hynes (1960) the naidids are essentially inhabitants of soft substrata in the depositing regions of rivers and their abundance in the middle and lower Cynon (C5–C11) seems to be associated with the presence of fine solids of coal origin blocking the interstices between stones, and the increase in organic pollution. The importance of the substratum in relation to the distribution of naidids is also stressed by Besch *et al.* (1967) and the influence of organic pollution has been emphasized by Brinkhurst (1965) and Egglishaw & Mackay (1967). The distributions of *Pristina idrensis* and *Nais alpina* were rather different from those of other species, being restricted to the tributaries and the headwaters of the River Cynon. *P. idrensis* is certainly not sensitive to organic pollution, being frequently found in percolating filters of sewage-works (Learner, in preparation) but seems to be restricted to areas with low current velocities (Table 1). Little is known about the factors affecting the distribution of *N. alpina.*

Eleven species of tubificids were identified but most were restricted to the lower Cynon (see Appendix) where the group became numerically important with densities of $1000–6000/m^2$: *Euilodrilus bavaricus*, *E. hammoniensis*, *Limnodrilus hoffmeisteri*, *Psammoryctes barbatus* and *Tubifex tubifex* were the dominant species present in this region. Brinkhurst (1967) considers that the percentage occurrence of *Limnodrilus hoffmeisteri* in relation to all other oligochaetes may prove to be a useful indicator of organic pollution. In the River Cynon this percentage tends to increase downstream

(Table 4) and although this may be correlated with organic pollution, other factors could be involved. *Tubifex tubifex* was the most widely distributed tubificid in the system, occurring in three of the four tributaries (C16, C18 and C22) and at the upstream and downstream stations on the River Cynon (C1, C10 and C11). This discontinuous distribution of *T. tubifex*, where it occurs in both unproductive and highly productive waters but is often absent from mesotrophic waters, has been discussed by Brinkhurst (1969) who considers it a refuge species which does not do well in competition with other tubificids but is able to survive under more extreme conditions where competition is limited.

Table 4. *L. hoffmeisteri* numbers expressed as a percentage of all other oligochaetes in relation to the stations on the lower Cynon

C5	C6	C9	C10	C11
0·05	0·2	1·4	0·9	3·2

The enchytraeid *Lumbricillus rivalis* was widely distributed and seemed to respond to the same environmental conditions that promote the development of increasing densities of tubificids, the highest average density of about 3000/m^2 being recorded in the lower Cynon (C11). This species is known to be highly tolerant of organic pollution (Hawkes, 1962).

Apart from *Piscicola geometra* (L.) found on trout at C3, all species of leech were confined to the middle and lower Cynon (see Appendix) and their numbers were low, with the exception of *Helobdella stagnalis* which reached a density of 160/m^2 at C10.

The Crustacea were represented by eleven species of which five exceeded densities of 100/m^2. *Bryocamptus zschokkei* was restricted to the headwaters (C1–C3): the two cyclopids, *Acanthocyclops vernalis* and *Eucyclops speratus*, were widely distributed and reached densities of about 2400 and 1500/m^2 respectively at C9 where the substratum consisted largely of fine sand mixed with coal debris. *Rivulogammarus pulex* was present at three stations only (C2, C18 and C19). Although its sensitivity to suspended material (Hynes, 1960) may explain its absence in the lower Cynon, there are clearly other factors which restrict its distribution. Jones (1948) considered pH to be important, the lower limit for this species being about 7, but it is not likely to be a significant factor in the Cynon system where pHs generally exceeded 7 (Table 2). *Asellus aquaticus* occurred in low numbers at most stations on the lower Cynon: this species replaces *R. pulex* on eroding substrata where organic pollution occurs (Hawkes, 1962).

The Plecoptera were poorly represented, only two species, *Leuctra fusca* and *Perla bipunctata* having been found although this may be partly due to the time of sampling. Both were restricted to the tributaries and the upper reaches of the Cynon—areas having an unstable substratum with many loose stones. In the case of *L. fusca* this distribution is probably associated with its burrowing habit and inability to cling to stones in a swift current (Hynes, 1941).

Ten species of Ephemeroptera were recorded and although may-flies were present at all stations except the uppermost station (C1), most species were restricted to those stations of the main river (C2, C3 and C4) and tributaries where there was no continuous deposition of coal particles. The species composition at these stations was similar to that of stony rivers (Macan, 1957) and other species would be expected but for the time of sampling. The absence of may-flies from the uppermost station is in accordance with the findings of Arnold & Macan (1969) and Minshall & Kuehne (1969). The two most widely distributed species, *Baetis rhodani* and *Baetis scambus*, reached densities of over 2000/m^2 and their numerical distribution is in accordance with the conclusion of Macan (1957) that *B. scambus* is predominantly a species of stony rivers whereas *B. rhodani* is more prevalent in smaller streams. In the Cynon catchment, the former species was dominant in the main river downstream of C4, and the latter, elsewhere.

Although ten species of Trichoptera were found they were largely absent from the middle and lower Cynon and were in low numbers throughout the system, apart from *Agapetus fuscipes*, *Hydropsyche pellucidula* and *Rhyacophila dorsalis* which were locally abundant at densities exceeding 300/m^2. *H. pellucidula*, a net-spinner, was present in the lower Cynon despite the high concentrations of suspended solids of coal origin but only very small individuals were found and it seems likely that conditions at these stations either delayed or prevented full development.

Aquatic coleopterans were fairly numerous in the upper reaches of the Cynon and in one of the tributaries (C19), with a maximum density of about 500/m^2 (C3). Only larvae of *Limnius volckmari* were found in the lower Cynon. This species, like other elminthid beetles, is generally considered intolerant of organic pollution or, more probably, the low dissolved oxygen concentrations generally associated with it. In the River Cynon organic pollution does not result in an appreciable decline in dissolved oxygen concentrations (Table 2).

Chironomids were the most abundant insects in the Cynon system, their larvae being found at all stations at densities ranging from 300/m^2 (C22) to 18,000/m^2 (C5) and at most stations they comprised, numerically, at least half of the macro-invertebrate fauna. Orthocladiines, particularly *Cricotopus bicinctus*, *Orthocladius rubicundus*, *Syncricotopus rufiventris* and *Rheocricotopus foveatus* were most abundant in the middle and lower Cynon (C4–C11) and in two of the tributaries (C16 and C18). This group seemed to be particularly numerous where the stones bore well-developed growths of filamentous algae, largely *Cladophora*, a feature also observed by Percival & Whitehead (1929). In the upper Cynon (C1 and C2) orthocladiines, with the exception of *Eukiefferiella calvescens*, were generally much less abundant and the four above-named species were absent. At these upper stations members of the Chironominae became much more important, especially *Micropsectra* sp., *Microtendipes* sp., *Polypedilum* spp. (largely *P. acutum*) and *Rheotanytarsus* sp. (probably *R. photophilus*). This latter species, which is a net-spinner, affixed to stones, became locally abundant at C3 (800/m^2) probably the first point sampled downstream having sufficient particles in suspension to support this density; further downstream the presence of coal particles in the suspension probably accounts for its disappearance.

The distribution of *Brillia modesta* and *B. longifurca* in the River Cynon is of interest. *B. modesta* is generally considered a stream species and *B. longifurca* an inhabitant of ponds and lakes (Thienemann, 1944) but in the Cynon, while *B. modesta* occurred in all the tributaries and at C3, *B. longifurca* was only present downstream, from C5 to the Taff confluence (C11). Besch & Hofman (1968) also found that *B. longifurca* largely replaced *B. modesta* downstream of organic pollution in the River Steinach (Germany).

The dominant tanypodine, *Conchapelopia pallidula*, was present at all stations. This species is generally found in the moss-zone of medium-sized mountain streams (Reiss, 1968) and the present investigation suggests that it is tolerant of a wide range of conditions since its densities in the upper and lower Cynon and in the tributaries were very similar, between about 50 and 400/m^2.

Prodiamesa olivacea, although widely distributed in the catchment, was only fairly abundant at C9 (about 100/m^2); the substratum at this station is different in having a high proportion of sand. Marks & Henderson (1970), from their studies in Lough Neagh, concluded that this species is particularly associated with a sandy substratum.

Only one species of simuliid, *Odagmia ornata*, was found at three stations (C3, C16 and C18). Its absence from lower stations in the Cynon is probably associated with the overloading of its filtration system by suspended coal particles and the adverse effect of settled silt on larval attachment (Fredeen, 1959). The present survey supports the observation by Maitland & Penney (1967) that comparatively few species have been recorded in rivers of South Wales.

Five species of water-mite (Hydracarina) were found and all are parasitic on chironomid midges (Jones, 1967). The most widely distributed and numerous species, *Hygrobates fluviatilis*, reached a density of about 300/m^2 at C5. Although adult hydracarines were recorded at eleven stations, larvae were much more restricted in their distribution being present at only five stations.

The gastropods were only abundant in the middle and lower Cynon and in one tributary (C22) with the exception of *Ancylus fluviatilis* which reached its maximum density of 400/m^2 at C3. *Physa fontinalis* and *Radix peregra* exceeded a density of 150/m^2 at C6 and *Potamopyrgus jenkinsi* one of 600/m^2 at C22. The density and diversity of snails at C9 was very low and seems to be associated with the sandy substratum at this station. Hynes (1960) comments that the presence of molluscs in streams is favoured by organic enrichment and cites *R. peregra* and *P. fontinalis* as characteristic examples. It would seem that these species, together with *A. fluviatilis*, are also tolerant of the high concentrations of fine coal particles present in the Cynon system.

Results—Fish

General distribution

The River Cynon contained six fish species—brown trout, bullhead, eel, minnow, stickleback and stoneloach, three of which were absent downstream of industrial discharges (above C9) at Abercwmboi (Fig. 1).

Fish density and biomass also declined downstream of these discharges (Table 5). The three species occurring in the lower Cynon (minnow, stickleback, stoneloach) were also found in the Rhondda, a river similarly affected by coal wastes and soluble poisons (Edwards *et al.*, 1972). Although, from distributional data, minnows appear to be the least sensitive of the fish present to pollution, this may reflect their mobility and ability to recolonize reaches rapidly after pollution incidents rather than any physiological tolerance to poisons.

The River Cynon also appeared to exert an influence on the fish distribution in the River Taff below the confluence of the two rivers (Fig. 3), trout, bullhead, stoneloach and eel being present above, but absent below, the confluence. Roach (*Rutilus rutilus* L.) and gudgeon (*Gobio gobio* L.) which were present in the Taff at the confluence did not penetrate the lower Cynon.

Table 5. Mid-summer biomasses and densities for the major fish species in the Cynon system, along with data for other British rivers.

	Trout		Bullhead		Stoneloach		Stickleback		Minnow	
Site	Density /m²	Biomass (g/m²)	Density /m²	Biomass (g/m²)	Density /m²	Biomass (g/m²)	Density /m²	Biomass (g/m²)	Density /m²	Biomass (g/m²)
Cynon										
C1	0·04	0·06	1·07	2·45	—	—	—	—	—	—
C2	0·18	3·13	1·29	4·82	—	—	—	—	—	—
C3	0·17	7·36	2·01	11·80	0·02†	0·30†	—	—	—	—
C4	0·10	6·02	1·60	8·44	0·04†	1·12†	—	—	—	—
C5	0·01	0·89	2·80	9·43	0·29	3·60	0·08†	0·08†	0·57	3·55
C6	0·03	3·54	1·70	5·79	1·57	11·97	—	—	0·68	6·06
C11	—	—	—	—	0·01†	0·14†	0·01†	0·02†	—	—
Tributaries										
C14	0·13	1·66	0·18†	0·78†	—	—	—	—	—	—
C15	0·08	3·29	0·01†	0·09†	—	—	—	—	—	—
C16	0·01	0·12	0·04†	0·18†	—	—	—	—	—	—
C17	0·30	0·30	—	—	—	—	—	—	—	—
C18	0·37	10·31	—	—	—	—	—	—	—	—
C19	2·29	13·09	—	—	—	—	—	—	—	—
C20	0·79	9·80	1·43	5·65	—	—	—	—	—	—
C21	0·33	0·88	0·01†	0·03†	—	—	—	—	—	—
C22	0·04	1·57	2·21	13·12	0·67	8·90	0·06†	0·53†	0·18†	2·20
Bere*	0·20	6·50	10·30	6·10	—	—	1·30	0·20	0·80	0·40
Gwyddon (Ebbw)**	0·15–1·57	19·20–25·80	0·06–2·05	0·92–4·53	—	—	—	—	—	—

* Le Cren (1969).

** Williams & Harcup (in preparation).

† Indicates that because of site difficulties the values are underestimates.

In a survey of the River Taff (Edwards *et al.*, 1972) it was suggested that the distribution of bullheads is particularly restricted by high concentrations of suspended solids. As the average concentration of suspended solids in the Cynon was very similar at C4 and C5, where the species was common, to that recorded at C9 and C10, where the species was absent, it seems that other factors, particularly soluble poisons, are also involved.

Trout

The population densities and weights of trout in the upper Cynon and its tributaries are similar to those recorded elsewhere in British rivers (Table 5), being generally between 0·1 and 2/m² and 0·8 and 15 g/m² respectively. In the tributaries which contained trout, average densities and weights were higher than in the main river but fish populations in such tributaries contained few other fish. The lower densities of trout in the middle reaches of the Cynon (C5 and C6) are likely to reflect the heavy fishing pressures of this area.

Age-frequency distributions revealed, with the exception of C19 and C20, an apparent scarcity of 0+ trout in the Cynon system, few being recorded in the head-waters and none downstream of C3. The scarcity of young fish was noted early in the

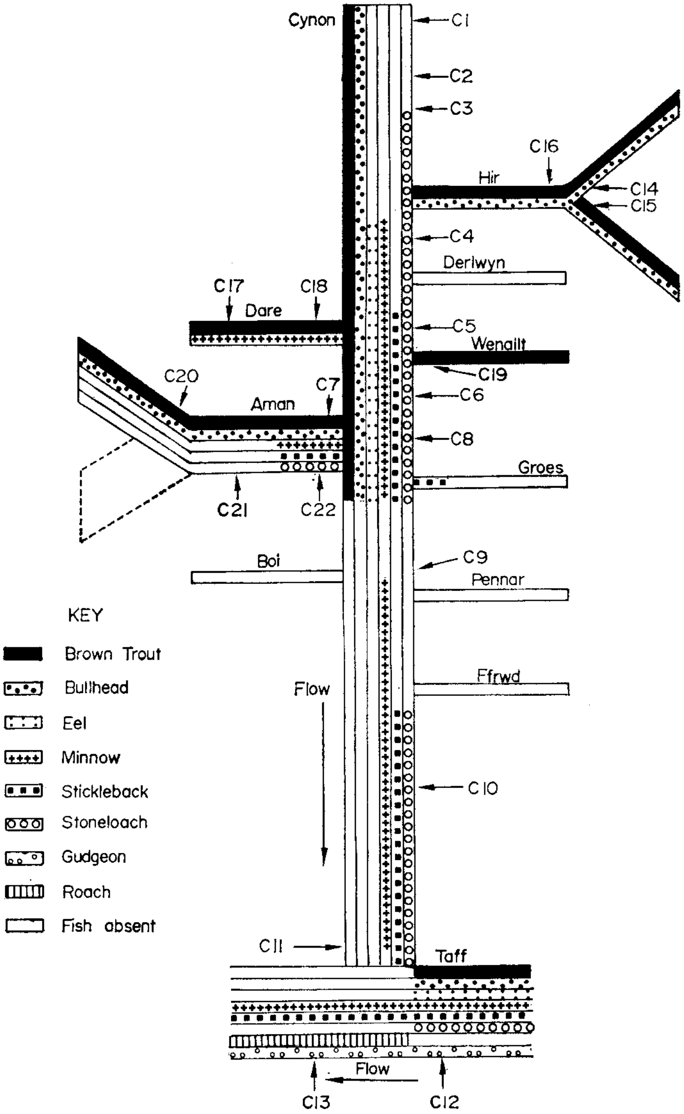


Fig. 3. Fish distribution in the Cynon system.

survey but wide-ranging searches failed to reveal any areas, apart from those previously mentioned, with age-frequency distributions typical of breeding streams.

There seems to be little movement of trout between the tributary streams and the main river except perhaps at the fry stage (Le Cren, 1962), for the growth and shape of trout in the tributaries are different from those in the main river. Table 6 shows the values of a and b relating length in cm (L) and weight in g (W) in the equation $W = a.L^b$. The value of b for tributary fish is significantly different from that of fish from the main river ($P<0{\cdot}01$). The size of trout in tributary streams (Table 7) is significantly different from that in the main river for 0+ fish ($P<0{\cdot}05$), and 1+ fish

Table 6. Log length to log weight relationships for brown trout for stations on the Cynon system

Site	No. of trout in sample	Range in length (cm)	Range in weight (g)	Coefficient *a*	Coefficient *b*	Confidence limits (95%) of *b*	Correlation coefficient (r)	Probability (*P*)
Cynon								
C2	37	4·7–116·3	4·5–22·2	−0·63	1·83	0·37	0·86	0·001
C3	35	3·4–23·4	2·5–141·0	−1·03	2·25	0·38	0·89	0·001
C4	32	9·5–30·4	15·8–304·8	−1·28	2·53	0·19	0·98	0·001
Tributaries								
C14, 15, 16	33	8·6–20·2	8·0–86·3	−1·65	2·77	0·058	0·99	0·001
C18	66	7·3–32·2	5·3–295·1	−1·52	2·66	0·094	1·00	0·001
C20	74	5·0–17·0	4·3–59·1	−1·75	2·83	0·130	0·98	0·001

Table 7. Comparison between main river and tributaries for brown trout log length to log weight relationship

Site	No. of trout in sample	Coefficient *a*	Coefficient *b*	Confidence limits (95%) of *b*
Main River (C2, C3, C4)	104	−1·73	2·35	0·09
Tributaries (C14, C15, C16, C18, C19, C20)	206	−1·11	2·84	0·13

($P < 0{\cdot}01$) but not for 2+ fish ($P = 0{\cdot}2$) and according to the classification of Cuinat & Vibert (1963) growth would be described as 'very slow', i.e. a length of less than 17 cm in three years. The growth of fish in two other Welsh rivers is shown for comparison. Specific growth rates (Table 8) were obtained from corrected back-calculated lengths determined by a graphical method (Frost & Brown, 1967). These growth rates are broadly similar to those recorded from other British rivers for the first year of life, but are generally lower in the second and successive years (Frost & Brown, 1967). Logarithmic plots of scale length against fish length (Table 9) gave coefficients for *b* for fish of 1+ and over which were not significantly different from 1 (isometric growth) in the three sites on the tributaries but were significantly different from 1 for the three sites on the main river (allometric growth).

0+ trout were caught at only a few stations in the Cynon system and in large numbers only at two stations (C19 and C20), despite the apparent suitability of the substratum for spawning and development over a much wider area. The reasons for this restriction are not yet clear although it seems to be a widespread feature of trout

Table 8. Specific growth rates of brown trout, estimated from back calculated lengths, for stations on the Cynon system along with figures for other British rivers; length when fry start feeding taken as 2·4 cm

Site	No. of fish in sample	Age			
		0–1	1–2	2–3	3–4
Cynon					
C2	27	107·2	50·2	—	—
C3	31	124·2	56·5	14·3	—
C4	24	117·2	52·3	—	—
Tributaries					
C18	53	104·7	55·9	17·2	—
C19	26	89·7	69·5	26·7	—
C20	62	77·0	66·2	18·5	10·3
River Rhydwen*	—	97·0	50·0	22·0	16·0
River Teify*	—	112·0	81·0	26·0	19·0
River Test* (Slow growers)	—	133·0	86·0	43·0	25·0

*Frost & Brown (1967).

Table 9. Scale length to fish length relationships for brown trout at various stations; regression coefficients from equation: log length = $a+b$ log scale length

Site	No. of trout in sample	Range in length (cm)	Coefficient b	95% confidence limits for b	Correlation coefficient r	Probability P
Cynon						
C2	28	8·7–22·2	0·688	0·198	0·805	0·001
C3	31	9·8–22·1	0·628	0·136	0·862	0·01
C4	29	9·5–22·5	0·662	0·208	0·776	0·001
Tributaries						
C18	8	4·2–5·60	0·365	0·358	0·705	0·1
C18	58	7·3–32·2	0·869	0·214	0·735	0·001
C19	8	3·3–4·40	0·350	0·604	0·500	NS to 0·1
C19	29	8·1–18·7	1·359	0·516	0·712	0·001
C20	16	3·6–4·40	0·150	0·150	0·488	0·1
C20	65	6·7–17·0	0·911	0·230	0·913	0·001

populations in industrial catchments in South Wales (Edwards *et al.*, 1972; Williams & Harcup, in preparation). Furthermore, the numbers of 0+ trout caught were too few to maintain, permanently, the populations of older fish, the percentages of each year class in the combined samples being 42 (0+), 37 (1+), 13 (2+), 5 (3+), 3 (4+ and older). If one assumes that the reaches sampled adequately represent the trout reaches in the catchment and that extensive stocking is not carried out, one can only conclude that there is a considerable variation in annual recruitment, the populations are declining, or the sampling methods employed are not adequate for small fish. The latter cannot be discounted for low recoveries have been reported elsewhere (Mann, 1971). Egglishaw (1970) in his study of Shelligan Burn, considered that the probability of capture of 0+ fish was only about 50% but much lower capture efficiencies must be postulated to explain the age distribution of trout in the Cynon catchment. Although stocking does occur over a limited reach of the River Cynon (C5) the numbers of fish are so small (about 500 per year) that their overall effect on population density and structure can probably be ignored.

Bullhead

The population densities were low in tributary streams except the Aman where densities were similar to those in the main river, exceeding 1/m^2. A survey of the River Ebbw catchment in Monmouthshire (Williams & Harcup, in preparation) has shown mid-summer densities of 0·06–2·05/m^2 very similar to those in the River Cynon. Densities up to 45·2/m^2 have been recorded in certain chalk streams (Le Cren, 1969).

At several stations in the Cynon system, bullheads constituted the major component of fish biomass (Table 5) and at two stations exceeded 10 g/m^2. As with population density, much higher biomasses (20 g/m^2) have been found in chalk streams (Le Cren, 1969).

Stone Loach

Stone loach were absent from the upstream stations of the River Cynon (C1 and C2) and the upstream tributaries. Their density increased downstream of C3 to a maximum of about 1·6/m^2 at C6 where they constituted about 30% of the total fish population. They were also numerous in the River Aman near its junction with the middle reaches of the River Cynon. Few fish were present downstream of industrial discharges, their maximum density immediately above the confluence with the Taff being less than 0·01/m².

A feature of this species in the Cynon and elsewhere in the Taff System is the large size attained, the largest specimen caught measuring 13·6 cm at C22.

Minnow

This species was absent from the upper catchment and achieved its maximum density and biomass at C6 (Table 5) immediately upstream of industrial discharges. Downstream of these discharges densities remained very low. As with the stone loach, the minnow reached a very large size in this catchment, the largest specimen caught (12·8 cm fork length) exceeding the specimen (10·2 cm fork length) recorded by Mann (1971) in Devil's Brook, and suggested as being one of the largest recorded from the British Isles.

Stickleback

Although widely distributed throughout the catchment this species was never abundant, the highest density being only about 0·1/m² (C5).

Discussion

It is clear from Fig. 2(a, b) that in the River Cynon there is a dramatic difference in the macro-invertebrate communities upstream and downstream of C4, with increasing numbers of naidid and gastropod species and a change in the chironomid species, and an increase in their densities, downstream of this station. It is perhaps significant that a coal washery lies between C3 and C4 (Fig. 1) and further effluents containing coal particles are discharged between C4 and C5. The tributaries, Dare (C18) and Aman (C22), both of which were affected by deposition of coal dust, had communities very similar to those on the River Cynon at C5 and C6 whilst clean tributaries, Hir (C16) and Wenallt (C19) had communities resembling those upstream of C4 (see Appendix).

Organic enrichment by sewage upstream of C5, probably from storm overflows, affects the number of animals present and although there is a decline in the number of invertebrate families downstream of this discharge, the species composition of the community remains comparatively stable downstream to the confluence with the Taff. The principal effects of organic enrichment in the middle and lower Cynon seem to be the increased proportion of *Limnodrilus hoffmeisteri* to other oligochaetes (Table 4), the increasing representation of tubificids and the enchytraeid, *Lumbricillus rivalis*, and a decline in chironomid numbers and diversity. Although the lower Cynon (C9–C11) has been subject to occasional discharges of cyanides and phenols there is no evidence that macro-invertebrate communities have been affected.

The most outstanding feature in relation to fish distribution in the River Cynon is the marked change below C8 where industrial effluents are discharged. Not only does the number of species decline, but the density and biomass too. It seems that such effluents are directly, but intermittently, toxic to fish. Invertebrates are not similarly affected and it is unlikely that food is limiting. Although avoidance reactions by fish to poisons have been recorded, one of the important poisons in these effluents, phenol, is not detected at sub-lethal concentrations, at least by some salmonids (Sprague & Drury, 1969).

Table 10. Back calculated lengths of brown trout in relation to age for stations on the Cynon system along with those from other Welsh rivers

Site	Age (years)	No of fish	Average calculated lengths (cm) at the end of each winter 1	2	3	4
Cynon						
C2	1+	22	6·9	—	—	—
	2+	5	7·9	11·9	—	—
C3	1+	22	7·7	—	—	—
	2+	5	8·3	13·9	—	—
	3+	2	9·3	14·8	18·2	—
	4+	2	8·2	16·8	18·2	20·3
C4	1+	9	7·6	—	—	—
	2+	15	8·0	13·5	—	—
Tributaries						
C18	1+	46	6·5	—	—	—
	2+	4	6·8	12·5	—	—
	3+	3	7·3	12·4	14·7	—
C19	1+	16	5·8	—	—	—
	2+	8	6·3	11·5	—	—
	3+	2	5·7	10·6	13·8	—
C20	1+	47	5·0	—	—	—
	2+	6	4·7	10·2	—	—
	3+	4	5·9	10·3	12·2	—
	4+	5	5·3	10·3	12·5	13·9
River Teify*	All fish	—	7·4	16·5	21·3	25·9
River Rhydwen**	All fish	—	6·3	10·4	12·9	15·2

* Thomas (1962).
** Ball & Jones (1960).

Upstream of such discharges the growth of trout is poor, and even poorer in the tributaries (Table 10). In contrast, the size achieved by minnows and stone loaches suggests that conditions are quite favourable for these species. Campbell (1971) reviews the factors influencing trout growth and it seems likely that in the Cynon catchment the size of streams is critical; the difference in the rates of growth of trout in biologically and chemically similar reaches of the main river and its tributaries would support this. The altitude and associated lower temperatures in the upper catchment could also have some significance. There is no evidence that the trout are over-crowded, densities being similar to those recorded elsewhere in the British Isles (Table 5).

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Appendix

The distribution and abundance (nos/m²) of macro-invertebrate families and species in the Cynon System

													Station
Species	C1	C2	C3	C4	C5	C6	C9	C10	C11	C16	C18	C19	C22
Coelenterata													
Hydra sp./spp.		34	34	69		34		103				69	
Platyhelminthes													
Dugesia lugubris (O. Schm.)						4							
Annelida (Oligochaeta)													
Aelosomatidae													
Aelosoma (?) *headleyi* Bedd.													34
Naididae	342	346	274	376	7765	3740	3895	5308	6555	141	2514	651	6624
Chaetogaster crystallinus Vej.					274	377	641	545	825		34		216
Chaetogaster diaphanus (Gruit)				34	103	216	699	113	223				69
Chaetogaster langi Bret.	137	342	103		137	34	34	103			34	69	
Nais alpina Sperb.		4	171	69						4	278	171	2109
Nais barbata Mull.				171	5946	2166	1445	1712	3439		520		1270
Nais bretscheri Mich.					445				206		206		
Nais communis Pig.							69	4		103	890		1264
Nais elinguis Mull.				34			103	110			69		503
Nais pardalis Pig.				34							243		274
Nais variabilis Pig.					620	906	425	1161	1657				62
Pristina foreli (Pig.)	34			34	240			106	34			137	103
Pristina idrensis Sperb.	171									34	240	274	754
Stylaria lacustris (L.)						41	479	1454	171				
Tubificidae	48			7	90	41	2634	1099	6330	17	38		206
Aulodrilus pluriseta (Pig.)	10						4	4					
Euilyodrilus bavaricus (Osch.)							116						
Euilyodrilus hammoniensis (Mich.)							349	10	4				
Euilyodrilus moldaviensis (Vej. et Mr.)							4	10	10				
Euilyodrilus (?) *vejdovskyi* (Hrabe)							4						

Appendix (*cont.*)

	Station												
Species	C1	C2	C3	C4	C5	C6	C9	C10	C11	C16	C18	C19	C22
Annelida (Oligochaeta) *continued*													
Tubificidae *continued*													
Limnodrilus hoffmeisteri Clap.					4	7	99	58	500				
Limnodrilus udekemianus Clap.								7					
Psammoryctes barbatus (Grube)							719	144	472				
Rhyacodrilus coccineus (Vej.)				7	86								
Tubifex ignotus (Stolc.)							4		4				
Tubifex tubifex (Mull.)	38							79	684	17	4		31
Small immatures						34	1335	787	4656		34		175
Lumbriculidae			10	21	17					4			41
Stylodrilus heringianus (Clap.)				21	17					4			
Trichodrilus sp.			10										41
Enchytraeidae		7	137	4	226	41	552	89	2883	4	34	34	343
Lumbricillus rivalis Levin.				4	226	41	552	89	2883		34	34	343
Species A		7	137							4			
Lumbricidae													
Eiseniella tetraedra (Savigny)	4				4						14		
Annelida (Hirudinea)													
Glossiphoniidae					7	31	14	161					
Helobdella stagnalis (L.)					7	17	14	161					
Glossiphonia complanata (L.)						14							
Erpobdellidae						72		4	99				
Erpobdella octoculata (L.)								4	99				
Trocheta subviridis Dut.						72							
Arthropoda (Crustacea)													
Chydoridae			34				788						
Alona affinis (Leydig)			34										
Chydorus sphaericus (O.F.M.)							788						
Ameiridae													
Nitocra hibernica (Brady)													34

Species	Station												
	C1	C2	C3	C4	C5	C6	C9	C10	C11	C16	C18	C19	C22
Arthropoda (Crustacea) *continued*													
Canthocamptidae													
Bryocamptus zschokkei (Schmeil)	171	137	69										
Cyclopidae	240		34	69	103	34	3876	240	171	69	137	205	137
Acanthocyclops vernalis (Fisch.)	137						2404	137	34			34	
Diacyclops bisetosus (Rehbg.)													103
Eucylops speratus (Lillj.)	103		34			34	1472	103	137	69	137	171	
Paracyclops fimbriatus (Fisch.) *f. typica*				69	69								
Paracyclops fimbriatus—form with short furcal rami					34								34
Cyprididae													
(?) *Potamocypris* sp.												206	
Asellidae													
Asellus aquaticus L.						7		7	103				
Gammaridae													
Rivulogammarus pulex (L.)		301									27	10	
Arthropoda (Insecta)													
Leuctridae	41	110	65	38						226	124	158	
Leuctra fusca (L.)	7	110	65	38						123	21	55	
Leuctra—very small	34									103	103	103	
Perlidae													
Perla bipunctata Pict.			4							7			
Baetidae		130	1030	898	158	876	582	989	2767	51	2293	391	499
Baetis rhodani (Pict.)		10	243	219	55	72	72	31	58	27	1239	69	260
Baetis scambus Etn.		17	65	336	103	154	270	133	117	24	130	48	68
Baetis—very small		103	722	343		650	240	825	2592		924	274	171
Caenidae													
Caenis horaria (L.)				14		4							
Ephemerellidae													
Ephemerella ignita (Poda)		99	343	222	7	10	21		4	41	4	17	14

Appendix (*cont.*)

Species	Station												
	C1	C2	C3	C4	C5	C6	C9	C10	C11	C16	C18	C19	C22
Arthropoda (Insecta) *continued*													
Ephemeridae													
Ephemera danica Mull.		10											
Heptageniidae		58	144	168						62		10	
Ecdyonurus dispar (Curt.)		58	140	168						58		10	
Ecdyonurus lateralis (Curt.)										4			
Ecdyonurus torrentis Kimm.			4										
Leptophlebiidae		96										4	
Habrophlebia fusca (Curt.)		96											
Paraleptophlebia submarginata (St.)												4	
Corixidae		4					4						
Nymph indet.							4						
Micronecta poweri (Doug. et Sc.)		4											
Veliidae													
Velia caprai Tam.	4												
Osmylidae													
Osmylus fulvicephalus (Sc.)			4										
Sialidae													
Sialis lutaria L.										4			
Glossosomatidae													
Agapetus fuscipes Curt.	4	380									127		
Hydropsychidae													
Hydropsyche pellucidula (Curt.)			4	452				82	103		110		
Limnephilidae		8											
Melampophylax mucoreus (Hag.)		4											
Stenophylax permistus McL.		4											
Polycentropodidae	4			7						11		14	
Plectrocnemia conspersa (Curt.)												10	
Polycentropus flavomaculatus (Pict.)				7						4			
Polycentropus kingi McL.	4									7		4	

	Station												
Species	C1	C2	C3	C4	C5	C6	C9	C10	C11	C16	C18	C19	C22
Arthropoda (Insecta) *continued*													
Psychomyiidae													
Tinodes waeneri (L.)	34	17	4										
Rhyacophilidae													
Rhyacophila dorsalis (Curt.)			7	41		137					349	7	
Sericostomatidae													
Pupa indet.			4										
Dytiscidae													
Oreodytes septentrionalis Gyll.		75	130	4								38	
Elminthidae	21	206	375	8	4		7				4	110	
Elmis aenea P. Mull. (=maugei Bed.)		175	216	4								4	
Limnius volckmari Panz.	4	31	159	4	4		7				4	72	
Oulimnius (?) *rivularis* Rosenh. (=variabilis Steph.)	17											34	
Hydraenidae													
Hydraena gracilis Germ.			4	4									
Hydrophilidae													
Helophorus brevipalpis Bed.				14	4								
Limoniidae													
Larva indet.			14										
Chironomidae	686	5369	2992	1245	18071	13341	13426	5480	2740	807	6130	2816	306
Prodiamesa olivacea (Mg.)	38		10		10		89	31	7			10	7
Diamesa sp. A					4	4					27		41
Diamesa sp. B		134	28										
Diamesa sp. C											10		
Conchapelopia pallidula (Mg.)	38	253	154	227	219	103	151	96	418	48	247	462	38
Macropelopia nebulosa (Mg.)	195		48		14	10		4		4		62	14
Trissopelopia longimana (Staeg.)		79	45	69	10		4			4	4	48	24
Procladius sagittalis K.				4									
Cryptochironomus sp.—'defectus' gp.					14								

Appendix (*cont.*)

	Station												
Species	C1	C2	C3	C4	C5	C6	C9	C10	C11	C16	C18	C19	C22
Arthropoda (Insecta) *continued*													
Chironomidae *continued*													
Micropsectra sp.	206	534	4									1588	
Microtentipes sp.	72	291											
Pentapedilum sp.			195									75	4
Polypedilum (?) *acutum* K.		137	133		7		7	21	7		10		
Polypedilum sp.			4										
Rheotanytarsus (?) *photophilus* G.		21	794										
Brillia longifurca K.					7	10	68	288	267				
Brillia modesta (Mg.)			175					62		151	4	51	72
Corynoneura sp.		69								4			
Cricotopus bicinctus (Mg).			719	459	3902	6285	4688	2116	1654		716	69	
Cricotopus triannulatus (Magqu.)						4	21		34				
Cricotopus sp.				120	4	1106	65				3917	4	
Eukiefferiella calvescens Edw.	137	377	79							48		147	
Metriocnemus sp.												151	
Orthocladius rubicundus (Mg.)				127	4947	2434					110	4	
Orthocladius sp. A		3474	596							359	671	4	
Orthocladius sp. B.										34	17		
Rheocricotopus foveatus (Edw.)			4	41		86	486	507	55	117	380	141	
Syncricotopus rufiventris (Mg.)			4	164	8933	3299	7847	2355	298	48	17		106
Synorthocladius semivirens (K)?			34										
Ceratopogonidae													
Species A (*Bezzia–Palpomyia* gp.)		34		10	17	4						38	4
Simuliidae													
Odagmia ornata (Mg.)			52							7	54		
Tabanidae													
Species A		4		4									
Empididae		114	113	34	10	4	10		7		175	144	128
Chelifera sp.		4	34										21

													Station
Species	C1	C2	C3	C4	C5	C6	C9	C10	C11	C16	C18	C19	C22
Arthropoda (Insecta) *continued*													
Empididae *continued*													
Hemerodromia sp.			45								72	106	93
Wiedemannia sp.		110	34	34	10	4	10		7		103	38	14
Dolichopodidae													
Species A											4		
Anthomyiidae													
Species A					7						4		
Arthropoda (Arachnida)													
Hygrobatidae													
Hygrobates fluviatilis (Strom.)		4	154	202	305	178	21	4	72		45		171
Lebertiidae		4		10	4	17	55	7				34	34
Lebertia fimbriata Thor.												34	
Lebertia porosa Thor.		4		10	4	17	55	7					34
Sperchonidae			10		10						69	34	
Sperchon brevirostris Koen			10										
Sperchon glandulosus Koen					10						69	34	
Hydracarina larvae			34		76	240	171				34		
Mollusca													
Ancylidae													
Ancylus fluviatilis Mull.	4		459	24	21			120	109		28		55
Hydrobiidae													
Potamopyrgus jenkinsi (Smith)				17	4	195	10	46	7		7		626
Lymnaeidae													
Radix peregra (Mull.)		10		10	24	178		4	10				
Physidae													
Physa fontinalis (L.)					4	147	10	7					
Valvatidae													
Valvata cristata Mull.											4		
Total	1603	7557	6538	3972	26938	19335	25905	13750	21960	1451	12295	4960	9256