The environmental quality of a small urban water course, the Bourne Stream (Dorset), assessed with macroinvertebrate data,

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SUMMARY

The macroinvertebrate fauna of the Bourne stream was examined at four sites in three seasons. 128 taxa were recorded with species richness highest at site 2 below a pond. Despite a visually attractive appearance with abundance of apparently suitable habitat RIVPACS analysis showed that the fauna of all sites was lower than expected. The worst quality (D classification) was recorded below Coy Pond. Possible reasons for the reduced quality are discussed.

INTRODUCTION

Small urban streams are frequently overlooked in general surveys but they can provide much information on activities within their catchment areas. The macroinvertebrate faunal communities within these streams are the result of a variety of influences, both physical and chemical, and they can be regarded as integrating the effects of these influences over time (Armitage et al. 1995).

As part of a continuing series of reports on small watercourses in Dorset, the Bourne Stream was selected as a good example of a stream with a predominantly urban catchment. The objectives of the study were to survey the benthic macroinvertebrate fauna from top to bottom of the system and to use the data to assess the environmental quality.

STUDY AREA AND METHODS

The Bourne Stream arises at an altitude of 50m and flows for approx 6.3km before entering the sea near Bournemouth Pier. The geology of the catchment is mainly Eocene and the stream flows through tertiary deposits (Bagshot Beds) to the sea (Figure 1). The stream rises in coarse grassland about 1km south of the edge of Canford Heath and flows down a relatively steep gradient, through a built-up catchment with some extensive areas of grassland/heathland. Several ponds are located on the stream in the upper half of the Bourne. The bottom half of the stream flows through Bournemouth Gardens.

Four sites were sampled along the length of the system. Samples were collected in spring (April 6 1994), summer (August 8 1994) and autumn (October 7 1993) using a standard 3 minute kick/sweep technique (Wright et al. 1993) with a pond net of 900 um mesh. Samples were fixed in 5% formaldehyde solution and sorted into 70% alcohol. Identifications were made to species level wherever keys and life-history stage allowed.

Summary characteristics of the sites are presented in Table 1.

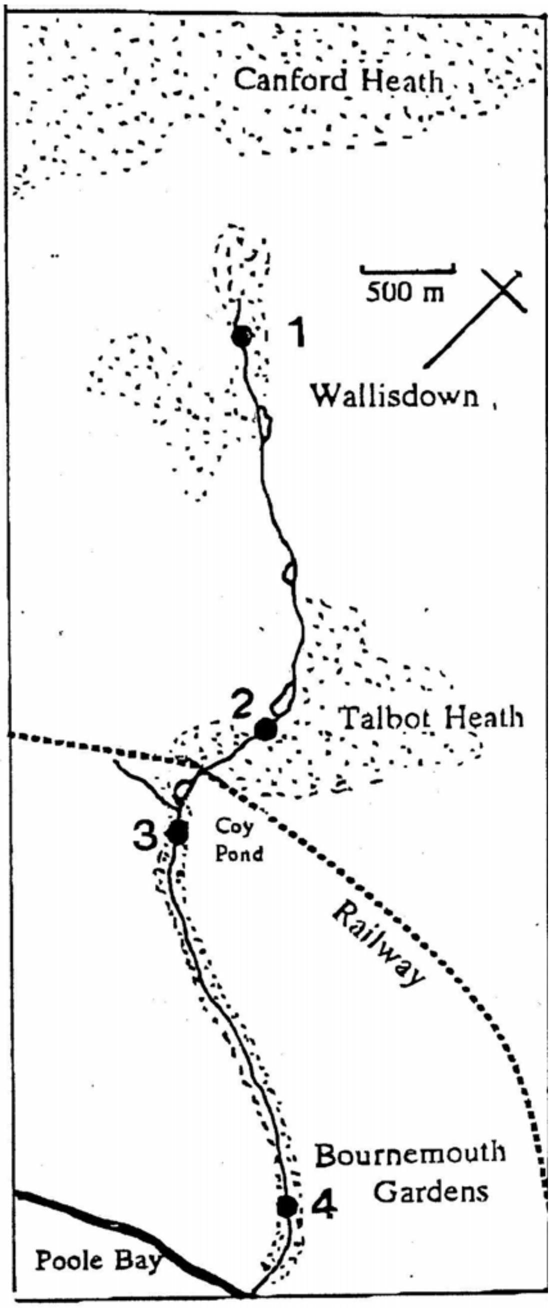

Figure 1. Sketch map of the Bourne stream showing the position of the 4 sites and location of non-urban areas (dotted) along its course

Site 1 was characterised by a predominantly coarse substrate with the largest components being bricks and concrete blocks. The stream was narrow and partially shaded with large herbs and small bushes. No instream macrophytes occurred at this site but trailing vegetation (*Epilobium*, Nettles) covered up to 5% of the area.

Site 2 was situated just below the outfall from a large pond. The outfall itself was constructed of large stone boulders and samples were taken about 10m below, where the stream was more natural in appearance. The sample area included a shallow riffle and deeper slower-flowing section. Gravel dominated the substrate with sand co-dominant. Small patches of *Apium/Berula* occurred at the upstream end of the site with *Glyceria* sp. and *Juncus* at the stream edge. *Cladophora* occurred on the stones in the riffle area and on the boulders below the outfall. Total macrophyte cover ranged from 5 to 20% throughout the year. An extra non-standard (1 minute kick/sweep) sample was taken in the outfall from the pond in August. This sample is excluded from the main analysis.

Site 3 was situated about 50m below the outfall from the ornamental Coy Pond which supports a small group of ducks. The main stream is joined here by a tributary culverted further upstream. At the sample site the channel is shaded and straightened (but no reinforced) as it flows through Bournemouth Gardens. The substrate is mainly gravel with sand co-dominant with small patches of *Zannichellia palustris* and occasional *Apium/Berula*. These macrophytes can increase in late summer/autumn to cover up to about 20% of the area.

Site 4 is located in the centre of Bournemouth within the Town Gardens. Here the banks and channel are artificial stonework and the stream supports dense growths of macrophytes including *Potamogeton*, *Elodea*, and *Callitriche*. The substrate is mainly gravel with sand but with macrophyte cover making up 40% of the area on all sampling visits.

Water samples were taken for chemical analysis on every sampling occasion at sites 1, 3 and 4. The mean values are presented in Table 1.

Alkalinity and Calcium levels are surprisingly high considering the possible origin of the stream in the waters draining acid heathland. Phosphate is highest at the top site but falls to very low levels at site 3. An additional sample was taken in the tributary at site 3 in August. Values for all parameters tested were similar to those in the main stream (Calcium 52.8/ 56.2, Alkalinity 97.5/ 90.0, Nitrate 4.02/ 4.54 – tributary/ main stream) with the exception of Phosphate (not detectable/ 11.3).

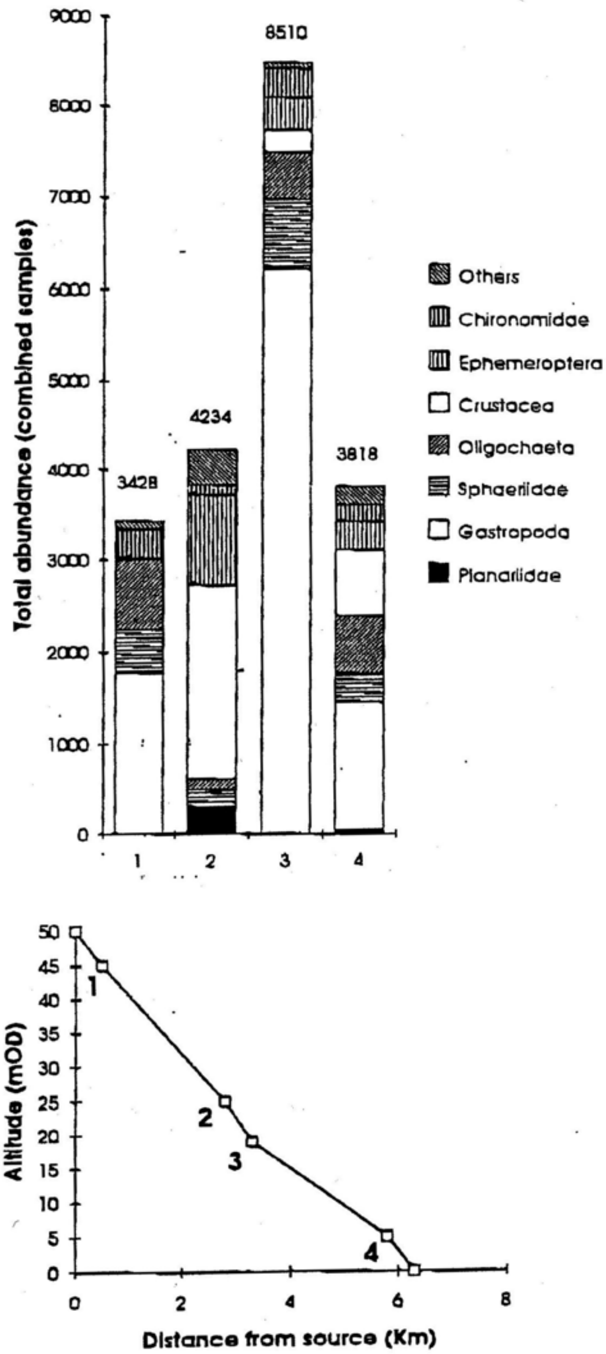

Figure 2. Faunal composition (relative numbers of major groups) at the 4 sites along the Bourne Stream, based on data collected in spring, summer and autumn. Also shown is a profile of the stream.

Micro-organics (herbicides and pesticides and other xenobiotics) and heavy metals were not analysed.

No discharge data are available for this stream and there is no information on the shape of the flood hydrograph. However in common with other urban streams run-off is apparently very rapid and the stream is liable to flood after heavy rain. Detritus was found trapped on bankside vegetation at sites 1 and 2.

Table 1. Physical and chemical characteristics of 4 sites on the Bourne Stream based on observations in spring, summer and autumn

Site	**1**	**2**	**3**	**4**
Grid Reference	**SZ052943**	**SZ069928**	**SZ067992**	**SZ087911**
Altitude (m O.D.)	45	25	19	5
Distance from source (km)	0.5	2.8	3.3	5.8
Slope (m/km)	10	10	8.33	6.25
Water Width (m)	0.9	3.8	2.5	3.5
Mean Depth (cm)	35.1	16.0	19.6	31.0
Surface Velocity (cm/s)	10-25	25-50	25-50	25-50
Substratum Cover %				
Boulders & Cobbles	25.0	3.7	5.0	10.0
Pebbles & Gravel	55.0	59.0	75.0	63.0
Sand	17.7	27.7	16.7	25.0
Silt & Clay	2.3	9.7	3.3	2.0
pH	7.7	-	7.4	7.4
Calcium (mg/l Ca)	81.1	-	59.1	54.1
Alkalinity (mg/l CaCO3)	158.0	-	101.5	76.8
Chloride (mg/l Cl)	29.1	-	29.6	33.6
Nitrate (mg/l N)	3.7	-	3.2	3.1
Phosphate (ug/l P)	75.7	-	9.6	9.7

RESULTS AND DISCUSSION

The fauna

A total of 128 taxa were found in the standard set of samples at the 4 sites in the three seasons (Table 2). The groups contributing most species/taxa were Coleoptera (22) and Chironomidae (22) with Oligochaeta, Hemiptera and Trichoptera contributing 16, 11 and 11 taxa, respectively. The distribution of taxa amongst major groups is shown in Table 3.

The composition in terms of major faunal groups and total abundance (based on the three seasons) is illustrated in Figure 2 which also shows the location of the sites along a profile of the stream.

Site 1 is dominated by Mollusca (Gastropoda and Bivalves) with high numbers of oligochaetes and Tanypodinae (Chironomidae). The coloeopteran *Cyphon* sp. (Helodidae) only occurred at this site and the ononate family Caenagriidae was most common here.

Site 2 was markedly different from all the others and its fauna was heavily influenced by the proximity of the pond upstream. The site is dominated numerically by Crustacea (*Asellus aquaticus* and *Crangonyx pseudogracilis*) with high abundances of Ephemoptera (Baetidae) and Planariidae. The extra samples taken at this site in the outfall revealed two species not found elsewhere in the Bourne Stream – the net-spinning caddis *Holocentropus picicornis* (Stephens) and the riffle beetle *Limnius volckmari* (Panzer). Coleoptera and Hemiptera although not very abundant were best represented at this site and eighteen of the 32 taxa records in these two groups in the whole survey occurred only at site 2.

Site 3 was dominated by Mollusca with Lymnaeidae, Hydrobiidae and Physidae the most abundant families. Other abundant groups included the bivalves, *Pisidium* spp, oligochaetes, Crustacea (*Asellus aquaticus*) and Ephemeroptera (Baetidae). This site supported the greatest overall densities of macroinvertebrates,

The bottom site 4 in the Town Gardens had a similar structure to site 3 in terms of major groups but supported less than half of the total density of organisms recorded at site 3.

Table 2. The occurrence of macroinvertebrates at 4 sites on the Bourne Stream based on 3-minute kick/sweep samples taken in spring, summer and autumn

Table 2 The occurrence of macroinvertebrates at 4 sites on the Bourne Stream based on 3 minutes kick/sweep samples taken in spring, summer and autumn

TAXA\ SITES	1	2	3	4
TRICLADIDA				
Polycelis nigra group	0	1	1	1
Dugesia polychroa group	0	1	0	1
Dendrocoelum lacteum (Müller)	0	0	0	1
GASTROPODA				
Potamopyrgus jenkinsi (Smith)	1	1	1	1
Lymnaea stagnalis (L.)	0	1	1	0
Lymnaea peregra (Müller)	1	1	1	1
Physa sp.	1	1	1	1
Gyraulus albus (Müller)	0	1	1	1
Armiger crista (L.)	0	0	0	1
Hippeutis complanatus (L)	0	0	1	1
Ancylus fluviatilis Müller	0	0	1	1
Zonitoides nitidus (Müller)	0	1	0	0
BIVALVIA				
Pisidium casertanum (Poli)	1	1	1	1
Pisidium personatum Malm	1	0	1	0
Pisidium milium Held	0	0	0	1
Pisidium subtruncatum Malm	0	1	1	1
Pisidium nitidum Jenyns	0	0	1	0
OLIGOCHAETA				
Ophidonais serpentina (Müller)	0	0	1	1
Nais communis group	0	0	0	1
Nais elinguis Müller	1	0	0	0
Stylaria lacustris (L.)	0	0	0	1
Tubifex tubifex (Müller)	1	1	1	1
Limnodrilus claparedeianus Ratzel	1	0	0	1
Limnodrilus hoffmeisteri Claparede	1	1	1	1
Limnodrilus udekemianus Claparede	0	0	1	1
Rhyacodrilus coccineus (Vejdovsky)	0	0	0	1
Aulodrilus pluriseta (Piguet)	1	1	0	1
Enchytraeidae	0	0	1	1
Lumbriculus variegatus (Müller)	1	1	1	1
Stylodrilus sp.	1	0	1	1
Stylodrilus heringianus Claparede	1	0	1	1
Lumbricidae	1	1	0	1
Eiseniella tetraedra (Savigny)	1	1	1	1
HIRUDINEA				
Theromyzon tessulatum (Müller)	0	0	1	0
Glossiphonia heteroclita (L.)	0	0	1	1
Helobdella stagnalis (L.)	1	1	1	1
Erpobdella testacea (Savigny)	0	0	1	1
Erpobdella octoculata (L.)	0	1	1	1
Trocheta subviridis Dutrochet	1	0	0	1
Trocheta sp.	0	0	1	0
HYDRACARINA	0	0	0	1
CRUSTACEA				
Asellus aquaticus (L.)	0	1	1	1
Crangonyx pseudogracilis Bousfield	1	1	1	1
EPHEMEROPTERA				
Baetis rhodani (Pictet)	0	1	1	1
Cloeon dipterum (L.)	0	1	1	1
ODONATA				
Pyrrhosoma nymphula (Sulzer)	1	1	0	1
Enallagma cyathigerum (Charpentier)	0	1	0	0
Coenagrion puella group	0	1	0	0
Cordulegaster boltoni (Donovan)	1	1	0	0
HEMIPTERA				
Hydrometra stagnorum (L.)	1	0	0	0
Velia caprai Tamanini	0	0	1	0
Nepa cinerea L.	0	1	0	0
Ilyocoris cimicoides (L.)	0	1	0	0
Notonecta glauca L.	0	1	0	0
Notonecta maculata Fabricius	0	1	0	0
Notonecta marmorea viridis Delcourt	0	1	0	0
Cymatia coleoptrata (Fabricius)	0	1	0	0
Callicorixa praeusta (Fieber)	0	1	0	0
Hesperocorixa sahlbergi (Fieber)	0	1	0	0
Sigara (Sigara) sp.	0	1	0	0
COLEOPTERA				
Haliplus lineatocollis (Marsham)	1	1	0	0
Haliplus immaculatus Gerhardt	0	1	0	1
Hygrobia hermanni (Fabricius)	0	1	0	0
Laccophilus minutus (L.)	0	1	0	0
Laccophilus hyalinus (Degeer)	0	1	0	0
Stictotarsus duodecimpustulatus (Fabricius)	0	0	1	0
Hydroporus planus (Fabricius)	1	0	0	0
Agabus didymus (Olivier)	0	1	1	0
Agabus sturmii (Gyllenhal)	0	1	0	0
Agabus bipustulatus (L.)	1	0	0	0
Agabus sp.	0	0	0	1
Ilybius quadriguttatus (Lacordaire & Boisduval)	0	1	0	0
Ilybius fenestratus (Fabricius)	0	1	0	0
Rhantus exsoletus (Forster)	0	1	0	0
Colymbetes fuscus (L.)	0	1	0	0
Gyrinus substriatus Stephens	0	1	0	0
Hydrophilidae indet	0	0	0	1
Helophorus brevipalpis Bedel	1	0	0	0
Anacaena globulus (Paykull)	1	0	0	0
Cyphon sp.	1	0	0	0
Limnius volckmari (Panzer)	0	0	0	0
Oulimnius sp.	0	0	0	1
MEGALOPTERA				
Sialis lutaria (L.)	0	1	0	0
TRICHOPTERA				
Plectrocnemia conspersa (Curtis)	0	1	0	0
Tinodes waeneri (L.)	0	1	0	1
Lype sp.	1	0	0	0
Hydropsyche pellucidula (Curtis)	0	0	1	0
Hydropsyche angustipennis (Curtis)	0	1	0	0
Limnephilus rhombicus (L.)	0	1	0	0
Limnephilus marmoratus Curtis	0	1	0	0
Limnephilus lunatus group	1	1	0	1
Micropterna lateralis (Stephens)	1	0	0	0
Goera pilosa (Fabricius)	0	1	0	0
LEPIDOPTERA				
Non-gilled Pyralidae	0	1	0	0
TIPULIDAE				
Tipula montium group	0	1	1	0
Tipula paludosa Meigen	0	1	0	1
CHIRONOMIDAE				
Brillia longifurca Kieffer	1	0	1	1
Brillia modesta (Meigen)	1	0	1	0
Chironomus sp.	0	1	1	0
Cricotopus (Isocladius) sp.	0	1	0	0
Cricotopus group	0	1	0	1
Cricotopus sp.	0	0	1	1
Cricotopus trifascia Edwards	0	1	0	0
Demicryptochironomus vulneratus (Zetterstedt)	0	1	0	1
Eukiefferiella claripennis (Lundbeck)	0	0	1	1
Gymnometriocnemus sp.	0	1	0	0
Macropelopia sp.	1	0	1	1
Micropsectra sp.	0	1	0	0
Phaenopsectra sp.	0	1	0	0
Polypedilum sp.	0	0	1	1

(continued over)

TAXA\ SITES	1	2	3	4
Procladius sp.	1	0	0	0
Prodiamesa olivacea (Meigen)	1	1	1	1
Psectrocladius sp.	1	0	0	0
Psectrotanypus varius (Fabricius)	1	0	0	0
Stenochironomus sp.	1	0	0	0
Tanytarsus sp.	0	1	0	0
Thienemannimyia group	1	1	1	1
Trissopelopia longimana (Staeger)	1	0	0	0
SIMULIIDAE				
Simulium (Eusimulium) aureum group	0	1	1	0
Simulium (Simulium) noelleri Friederichs	0	0	1	0
Simulium (Simulium) ornatum group	0	0	1	1
OTHER DIPTERA				
Psychoda sp.	0	0	0	1
Culex (Culex) sp.	0	0	0	1
Stratiomyidae	1	0	1	1
Dolichopodidae	0	0	0	1
Ephydridae	1	1	0	1
Limnophora sp.	0	1	1	0
TOTAL	42	72	50	61

None of the species found was particularly rare and the main features of interest centre around the location of the ponds. At site 2 the large number of species of Coleoptera and Hemiptera were apparently directly related to the pond immediately upstream. The following species are typical of standing waters, Ilyocoris cimicoides, Notonecta maculata, Cymatia coleoptrata, Hygrobia hermanni, Laccophilus minutes, Ilybius quadriguttatus, Ilybius fenestratus, Rhantus exsoletus, Colymbetes fuscus and were all recorded below the pond at site 2 whence they may have been washed out. In addition juvenile newts were found at this site and returned to the stream.

Coy Pond in contrast had little direct effect and the numbers of species in these groups was low. The occurrence of the leech Theromyzon tessulatum (an ectoparasite of water fowl) at site 3 is probably directly related to the presence of ducks in the pond.

Table 3. The distribution of species/taxa per major groups and total number of taxa per group at the 4 sites on the Bourne Stream

MAJOR GROUPS\SITES	**1**	**2**	**3**	**4**	**Total**
TRICLADIDA	0	2	1	3	3
GASTROPODA	3	6	7	7	9
BIVALVIA	2	2	4	3	5
OLIGOCHAETA	10	6	9	15	16
HIRUDINAE	2	2	6	5	7
HYDRACARINA	0	0	0	1	1
CRUSTACEA	1	2	2	2	2
EPHEMEROPTERA	0	2	2	2	2
ODONATA	2	4	0	1	4
HEMIPTERA	1	9	1	0	11
COLEOPTERA	6	12	2	4	22
MEGALOPTERA	0	1	0	0	1
TRICHOPTERA	3	7	1	2	11
LEPIDOPTERA	0	1	0	0	1
TIPULIDAE	0	2	1	1	2
CHIRONOMIDAE	10	11	9	9	22
SIMULIIDAE	0	1	3	1	3
OTHER DIPTERA	2	2	2	5	6
	42	72	50	61	128

The difference in the impact of the two ponds is probably due to two main factors. The pond above site 2 is located in an open area receptive to a large number of colonizers. Its sides are of earth and stone, this combined with a high macrophyte cover including emergent species offers a wide diversity of habitats and the stream downstream also shows a range of flow conditions with the outflow itself forming a distinct habitat of its own. In contrast Coy Pond is an ornamental stone pond without macrophytes situated in an urban area drained by a pipe which enters the Bourne Stream above the sample site which itself is characterised by a rather homogeneous flow pattern.

Two other features of interest are firstly the absence of Gammarus pulex – the usual crustacean found in small streams – which in this case was replaced by Crangonyx pseudogracilis. This species inhabits both standing and running waters and is tolerant to pollution. This North American species was first discovered in the London area in the 1930's and is now widespread in the British Isles (Gledhill et al. 1993). Its predominance in the Bourne Stream may be attributable to a combination of pollution from unknown sources which kills the more sensitive G. pulex and the presence of the ponds which may offer a stable habitat for the build up of large populations of this species.

Secondly one of the most common molluscs at sites 3 and 4 was Physa sp. This species was not identifiable and was sent to the British Museum of Natural History. The species is an alien and not the native fontinalis. Idnetification is a problem due to the number and identity of species introduced into Britain. The shells are of 'acuta type' (supposedly southern European) rather than of 'heterostropha type' (supposedly North American) (M.P. Kerney pers. comm.).

Environmental Assessment

RIVPACS (River Invertebrate Prediction And Classification System) a software program developed by the Institute of Freshwater Ecology at their Dorset River Laboratory for the classification and prediction of macroinvertebrate communities in running water (Wright et al. 1993) was used to assess the environmental quality of the sites. Details of the system are presented in Armitage et al. (1995) and need not be repeated here.

The technique has been adopted by the National Rivers Authority in their surveys of river quality. The output from the program includes predictions of numbers of taxa, BMWP biotic score and Average Score Per Taxon (ASPT) (Armitage et al. 1983). Predicted target values for BMWP score, number of scoring taxa and ASPT were obtained for each site based on data from the three seasons. These results are compared with observed values based on combined seasons data to give an observed/predicted index (Table 4). In addition, the banding system developed by Wright et al. (1993) in conjunction with biologists in the water industry was applied to the results. Four biological classes A,B,C,D are recognized where A is indicative of a high quality site and D represents a poor quality site. Class values for all three faunal parameters are considered in the assignment of the final classification for the site.

Table 4. Indices of faunal quality at 4 sites on the Bourne Stream based on three faunal parameters (BMWP score, number of scoring taxa, and the average score per taxon) where P is the value of the faunal parameter predicted from RIVPACS (see text), lcl and ucl are the 95% confidence limits associated with that prediction, and O is the observed value. The index I (O/P) is banded in one of four quality categories A (good) – D (bad).

Parameter	Site	P	lcl	ucl	O	I	Band
SCORE	1	151.7	111.64	191.8	87	0.57	B
	2	201.3	160.27	242.41	153	0.76	A
	3	207.6	165.5	249.73	68	0.33	C
	4	207.6	165.8	249.47	108	0.52	B
TAXA	1	26.3	20.69	3.02	18	0.68	B
	2	33.6	27.83	39.3	31	0.92	A
	3	33.8	28.0	39.69	18	0.53	C
	4	34.0	28.25	39.78	24	0.71	B
ASPT	1	5.7	5.16	6.33	4.83	0.85	B
	2	6.0	5.51	6.47	4.94	0.82	B
	3	6.1	5.67	6.59	3.78	0.62	D
	4	6.1	5.63	6.57	5	0.82	B

In the Bourne Stream the overall quality class of the sites 1-4 is respectively B, B, D and B. The B classification for site 2 despite A for score and taxa is due to the B classification for ASPT which takes precedence. Similarly at site 3 the D classification for ASPT means the overall quality is D. If we use the lower confidence limit of the predicted values to compare with observed values the classification of the 4 sites 1-4 is B, A, C and B. Whatever version we choose it is clear that the quality of all sites is lower than expected and that the stream is most impacted at site 3 below Coy Pond.

It is hard to attribute a specific cause for this low quality. The habitat conditions are generally good with unsedimented clean substrate and luch macrophyte growth at some sites. The low diversity of mesohabitats in heavily managed systems and in sandy-bottomed streams which is frequently a cause of reduced faunal richness in streams was no apparent here. However the artificial nature of the channel at site 4 may have contributed to the lower than expected quota of species. Some species require access to an earth bank to complete their development (e.g. Elmidae and some Tipulidae) and the ansence of emergent macrophytes may account for the low number of odonates.

It seems more likely that there is some untested-for pollution which is having an effect on the faunal community as a whole. It is very likely that the upper part of the Bourne Stream receives storm water run-off from roads and roofs and it is highly probable that road drains enter the stream at other points down the system. Urban storm drainage is a well know source of polluting chemicals which can enter aquatic systems (Maršálek and Torno 1994). Ponds with vegetated areas may act as sinks for some of these pollutants which may include a whole range of micro-organics and heavy metal compounds. The better environmental quality at site 2 may in part be due to this natural cleaning. The Coy pond was drained in April 1994 during our visit to the sample site. Sediment from the bottom of the pond was entrained and flowed downstream. Events such as this may contribute to the low quality of the stream by resuspending toxic micro-organics.

CONCLUSION

This survey has indicated that despite the abundance of apparently suitable habitat the faunal richness is poorer than expected. A programme of work should be instigated to investigate three aspects of the survey which were treated in insufficient detail or omitted completely.

First this has been a one-off survey and it would be necessary to establish the degree of annual variation associated with the stream faunal communities in order to determine if this standard of water quality was the norm. Secondly any chemical analysis should consider micro-organics and heavy metals in addition to main ion chemistry. Thirdly it would be necessary to establish the drainage pattern of the stream to identify any inputs which may occur in culverted sections. This approach will help to identify what the likely specific causes of reduced quality are and identify their sources. The construction of more ponds above Coy Pond will help dampen the flood peaks and may reduce the impacts of stormwater run-off but it would still be advisable to identify the sources of pollution.

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