Aspects of the Ecology of the Northern Pennines

Occasional Papers

No. 5

(Revised 1977)

Freshwater Biology

by

D.T. Crisp

"Aspects of the Ecology of the northern Pennines" is a series of informal review and discussion papers for the reader with a general interest in the subject. They are not official publications of the Nature Conservancy Council and do not necessarily reflect the Council's official views.

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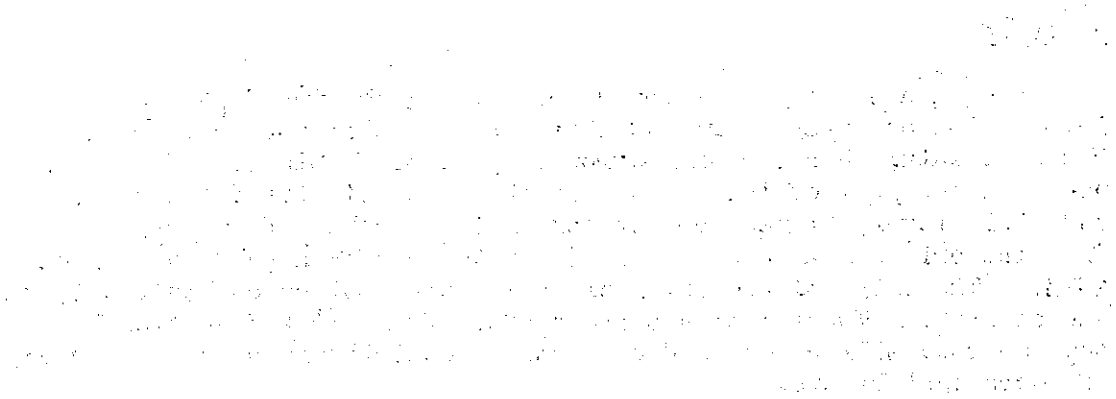
Foreword

Moor House Occasional Paper No. 5 (1973) reviewed published information on freshwaters and their fauna within the Moor House National Nature Reserve and surrounding area. This second edition up-dates the part of the account which dealt with the freshwaters and their invertebrate fauna by correcting errors and omissions from the original account and by adding information published since 1973. The original account included brief sections on aquatic flora and on fish. These subjects are omitted from the 2nd edition because they will be covered by separate contributions to the series of Occasional Papers.



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Description of freshwater habitats

1. Pools, tarns and reservoirs:
The standing water within and around the Reserve can be arbitrarily separated (Crisp 1962, Heal 1963) into 'pools' with surface areas generally less than 100m^2 and depths of up to 2m, and 'tarns and reservoirs', which range in size from 500m^2 upwards and may show considerable variation in depth and bottom material.

Two authors (Gorham 1956, Heal 1963) have distinguished between 'bog pools' and 'mine pools'. The bog pools are water-filled depressions in the bog surface with substrata either of bare peat or growing Sphagnum. The mine pools are man-made and associated with past mining activity. Their substrata often consist wholly or partially of inorganic material. A single tarn with a surface area of about 5,000m^2 is situated on the southern boundary of the Reserve at NY 736304 and three rather similar bodies of water lie beyond the southern boundary. The tarns are comparatively shallow (c. 1m) with bottoms of sand, overlain in many places by finely divided peat, and occasional stones.

There are numerous reservoirs in the area around the Nature Reserve. These are generally associated with past mining activity and have been constructed by building a wall across a valley or on a hillside so as to retain drainage water from the surrounding moorland. Thus all or part of the margin of each reservoir consists of a sandstone wall, sloping steeply into 0.5 to 4.0m depth of water. The bottoms of the reservoirs are generally fairly level and composed of sand or clay, often overlain by a depth of peat of a few cms. The areas of the reservoirs are generally within the range of 0.06 to 3.9 ha. (Crisp 1962). In 1970 a large (312 ha.) river regulating reservoir was completed on the Tees at Cow Green. General details are given by Armitage and Capper (1976) and Crisp (1977).

2. Flowing waters:
The streams on the south west edge of the Reserve are tributaries of the River Eden, and all have steep gradients in their upper reaches, e.g. Crowdundle and Swindale Becks have mean gradients of 1 in 10 to 1 in 5 throughout the first 3 or 4 km downstream from their sources (Davies and Smith 1958). They are torrential throughout most of their passage through the Reserve and have channel widths of 0.5 to 2.0m or more.

The River Tees rises on the slopes of Cross Fell and forms the northern and eastern boundary of the Reserve. The drainage water from most of the Reserve flows into the Tees, partly through fifteen small tributaries which flow directly into the main river and partly from Trout Beck, which is a major tributary entering the Tees about 1.5 km from Moor House. Trout Beck rises on the slopes of Great Dun Fell and Knock Fell where it receives water from about 9 small headwater streams. Throughout its course, its flow is augmented by water from numerous small streams and drainage channels, and finally, about 1 km. above its confluence with the Tees, it receives the combined discharges of Moss Burn, Nether Hearth Sike and Rough Sike. The headstreams of the Tees catchment within the Reserve generally rise from springs and/or lateral drainage and, during the first km. of their courses, their mean gradient rarely exceeds 1 in 15. Their substrata vary from place to place but consist chiefly of bedrock, large boulders, alluvial shingle and coarse gravel. Detailed information on the proportions of different types of substratum and stream margin and on the variations of mean depth, surface width and water velocity is given by (Crisp 1966) for a fairly typical small tributary of the Tees system.

Physical and Chemical Information

1. Chemical composition of water

Gorham (1956) analysed water samples from several pools and the results are summarized in Table 1. The results indicate the way in which the ionic concentrations vary in response to rainfall, while the dry weather data also show that the water of mine pools is chemically richer than that of the bog pools.

Table 2 summarizes present knowledge of the chemical composition of the Reserve's flowing waters. Analyses from a chemically rich chalk river in southern England (Crisp and Gledhill 1970) are given for comparison. Gorham's (1956) comparison of samples taken from Trout Beck during dry and wet weather suggest that the ionic concentrations may vary in response to changes in stream discharge and Crisp (1966) contains figures which illustrate the way in which the concentration of five elements varied with discharge in Rough Sike. The calcium concentration was 4.0 to 8.5 mgl^{-1} at discharges of less than 3 ls^{-1} but fell to 1.0 mgl^{-1} or less as the discharge approached 1,000 ls^{-1}. In contrast, the concentrations of K and P rose with increasing stream discharge.

Samples taken by Crisp et al (1975) from three tributaries of Trout Beck and from Great Dodgen Pot Sike show little difference in chemical composition between these four streams and the results from all of them agree well with the ranges given by Gorham (1956) and Crisp (1966). In contrast the data from Knock Ore Gill (Crisp & Cubby, in press) show that in this stream, as compared with the Trout Beck system, ionic concentrations (especially calcium) are relatively high and show little variation with weather conditions. A similar observation was made by Crisp, Mann & McCormack (1974) in the Cow Green Basin. The streams at Cow Green showed a range of dry weather calcium concentrations from 10.6 to 49.6 mg l^{-1} and the more calcareous streams were the least liable to have severe flash floods.

2. Stream water temperatures

Davies and Smith (1958) studied winter water temperatures in Swindale and Crowdundle Becks (tributaries of the Eden) by means of spot readings on mercury-in-glass thermometers and the records from two thermographs. In Swindale Beck, they found that between January and May, the thermal sum (degree-days above 0°C) was substantially greater at 150 m O.D. than at 400 m O.D., though the situation could be reversed in summer. The authors recorded some temperatures during the summer months in Moss Burn and Trout Beck at about 600 m O.D. Between mid May and the end of September 1953, the daily maximum exceeded 14.9°C on 30 out of 155 days.

Crisp and Le Cren (1970) give detailed analyses of water temperature records from Rough Sike (Moor House National Nature Reserve) at 565 m O.D. and two Lake District Becks at altitudes of 70 m and 245 m. The annual mean in Rough Sike was about 6°C whilst in the two Lakeland becks it was about 9°C. There were corresponding differences in annual degree-day totals. Although the highest and lowest temperatures recorded in the course of a year did not differ greatly between the three streams, the proportion of the total time in the year for which the temperature fell within each of a set of arbitrary temperature ranges differed markedly from stream to stream (Table 3).

Additional data on water temperature (Crisp et al. 1975) from Great Dodgen Pot Sike and the River Tees at Tees Bridge show the same general pattern as was observed at Rough Sike. Annual water temperature means in the Tees varied from 6.5°C in 1969 to 7.3°C in 1971, during the period 1969-1972 inclusive.

3. Water velocity and discharge

Butcher et al (1937) mention the great rapidity and amplitude of water level fluctuations which can occur in the River Tees, whilst Crisp (1963), Brown et al (1964) and Crisp (1966) refer to the 'flashy' nature of the Tees tributaries on the Moor House National Nature Reserve.

Phillipson (1967) recorded midstream water surface velocities of up to 1.25 ms^{-1} in Trout Beck and Brown et al (1964) measured velocities of up to 1.5 ms^{-1} during spates.

Records of discharge in Trout Beck have been kept by the Wear and Tees River Board (latterly the Northumbrian River Authority and the Northumbrian Water Authority) for many years and copies are kept at Moor House. Crisp (1966) gives details of one year's observations of the discharge in Rough Sike. In Table 4, these data are compared with data for a southern chalk river (Crisp & Gledhill, 1970). The southern river shows a reasonably smooth seasonal fluctuation, with high winter and low summer values, whilst the monthly discharges have an irregular pattern of fluctuation which reflects the month-by-month pattern of rainfall. The lowest monthly discharges in a Pennine stream may occur during one or more of the winter months when the catchment is frozen. This point is illustrated in Table 4. The greatest and smallest monthly totals in the chalk river were in the ratio 14:1, whilst the corresponding ratio for Rough Sike was 77:1. This difference would be greater if daily or instantaneous discharge values had been used.

4. Suspended solids

During spates the streams of Moor House National Nature Reserve become discoloured by suspended matter, chiefly peat. There is no evidence that this suspended peat has any effect upon the stream animals, but its possible harmful effects upon fish and its possible value as a source of food material for detritus consumers should be borne in mind.

During the normal spates in Rough Sike, Crisp (unpublished) recorded peat concentrations of 0.1 to 0.3 gl^{-1} and Crisp, Rawes and Welch (1965) observed concentrations of up to 2.0 gl^{-1} in the same stream during an exceptionally severe spate.

Aquatic Fauna

1. General

There are a number of unpublished species lists scattered amongst the Moor House Reserve Record Books and in other places. These lists are very patchy and, in some instances, the accuracy of the determinations has not been adequately established. For the purposes of the present review, they have, therefore, been ignored; attention is given only to those species and groups whose distribution or biology has been described in publications (with a single exception, mentioned below).

2. The Fauna of standing water

Table 5 is a list of species recorded. It includes records from the Cow Green basin (Armitage et al, 1974) and from Tarn Dub (Peters 1972).

(i) Micro-crustacea

Heal (1963) lists ten species or varieties of Cladocera found in 17 pools and 5 reservoirs and tarns on or near the Reserve, and mentions a further three species known to occur on the Reserve. He found that Chydorus sphaericus and C. sphaericus v coelatus were widely distributed, whilst Acantholeberis curvirostris and Scapholeberis mucronata occurred mainly in the larger pools. Rosmina coregoni v lilljeborgi was the main species in the open water of reservoirs tarns and the larger pools.

Chydorus sphaericus was more abundant in the summer and autumn than in spring, whereas Smyly (1952, 1957) observed that, in the Lake District, it was abundant in spring and sometimes in winter, but scarce or absent in the other seasons.

Specific identification of micro-crustacea and Hydra found in water flowing out of Cow Green reservoir was made by Armitage and Capper (1976) who added one species of Cladocera and three species of Copepoda to the list.

(ii) Order Hemiptera

An analysis of collections of Corixidae from the Pennines was published by Crisp (1962). This survey covered both the northern and southern Pennine areas. The list in Table 5 contains only those species found in the northern Pennines.

Corixa wollastoni was found in both pools and reservoirs and attained its greatest abundance in shallow water amongst vegetation. C. nigrolineata was found mainly in pools, generally in mine pools which had some inorganic matter in their substrata. C. carinata and Glaenocorisa propinqua were found only in reservoirs and tarns and these species (and C. germari) prefer large, deep bodies of water with steeply sloping margins and open water. Such water is often subject to severe wave action. C. germari, a common and often abundant species in south Pennine reservoirs was found in only two of the 14 samples from north Pennine tarns and reservoirs.

Two additional species of Corixidae are listed by Peters (1972) and two further species of Hemiptera by Nelson (1971).

(iii) Other taxa

The records for other groups are based on publications by Coulson (1959), Bray (1966), Nelson (1971), Peters (1972) and Armitage et al (1974).

3. The fauna of flowing water

A species list is given in Table 6.

(i) Order Diptera

Field and laboratory studies of the effect of speed of current upon Simulium monticola Fried. and S. variegatum Mg. were made by Phillipson (1967) in Trout Beck and Cross Gill. He showed that both species occurred in velocities of 0.5–2.5 ms^{-1} but aggregate in the velocity range 1.0–2.0 ms^{-1}.

On the basis of material collected from Crowdundle Beck, Davies (1957) described Prosimilium inflatum, a new British species. He also recorded this species from Knock Ore Gill and Swindale Beck on the Moor House National Nature Reserve and from two Lake District becks and nine Scottish localities. These records were followed (Davies & Smith 1958) by a study of the ecological relationship between P. inflatum and the taxonomically close P. hirtipes in Crowdundle and Swindale Becks. P. hirtipes larvae were normally found below 450 m O.D., and those of P. inflatum above 660 m O.D. P. hirtipes larvae grew more slowly at 400 m O.D. than at 180 m O.D., and under laboratory conditions they were harmed by even brief daily exposure to temperatures of 18–20°C. Restriction of the P. hirtipes larvae to lower altitudes may be because above a certain point, the winter thermal sum is insufficient for completion of larval development before mid-May, after which date water temperatures up to at least 400 m O.D. may rise to harmful levels. In contrast, the larvae of P. inflatum live under constantly cool conditions and complete development in 8 months (c.f. 4–5 months in P. hirtipes), although some individuals may take two years. The eggs of P. hirtipes appear to have some form of resting stage or diapause whilst those of P. inflatum do not. Additional records of Simuliidae are given by Armitage et al (1975) and Wotton (1976).

A list of Tipulid species is given by Coulson (1959) and those with larvae occurring in flowing water are listed in Table 6. Birkett (1976) listed species of Chironomidae found on the Nature Reserve.

Its inclusion under 'flowing waters' is partly a matter of convenience because the identifications are based on imagines whose occurrence does not necessarily give a precise indication of larval habitats. Certainly, the list includes some species hitherto associated with such diverse habitats as stagnant water (Paratrichocladius skirwithensis, P. obvius), pools (Cricotopus sylvestris, Chironomus lugubris, Micropsectra fuscus, M. praecox), woodland mud (Limnophyes prolongatus) terrestrial habitats (L. truncorum), sewage beds (L. minimus), lakes and tarns (Corynoneura scutellata) and sandy banks beside rivers and streams (Prodiamesa olivacea). The list includes two new British records (Cricotopus polaris, Eudactylocladius obtexens) and three species new to Cumbria (Diamesa insignipes, Cardiocladius capucinus, Cladotanytarsus van-der-wulpi), whilst Moor House is the northernmost recorded site in England for Cricotopus trifascia. Birkett concludes that, in general, the species recorded are characteristic of an oligotrophic and acidic biotope, though he notes that the catches contained a high proportion of Orthocladiinae and few Chironominae and this contrasts with the findings of Bryce (1965) in acid peat pools.

(ii) Order Plecoptera

Brown et al (1964) made a survey of Plecoptera within the Moor House National Nature Reserve. They recorded 25 of the 35 British species of Plecoptera and gave information on the nymphal habitats, altitudinal distribution and imaginal flight periods. The species list is included in Table 6, together with an additional species from Armitage et al (1975).

(iii) Order Ephemeroptera

Crisp and Nelson (1965) listed the species found during a survey of Ephemeroptera nymphs in twelve streams on the Reserve. Twelve species were found and information on the distribution and altitudinal ranges of the nymphs was obtained. Five additional species were recorded by Armitage et al (1975).

(iv) Order Trichoptera

The presence of Rhyacophila obliterata larvae in Moss Burn is mentioned by Mackereth (1954). Nelson (1971) identified adults collected from waterside vegetation, in light traps, under streamside stones and in general sweeps of vegetation. Armitage et al (1975) list four additional species.

(v) Other taxa

Most of the work on stream invertebrates within the Reserve before 1970 was confined to studies of selected taxa. The result was that reasonably comprehensive species lists were available for certain groups, but little or nothing was known about the representation of other groups within the Reserve. To some extent these gaps have been filled by the general invertebrate survey of Nelson (1971) and detailed studies of the whole invertebrate fauna of four selected stream reaches by Armitage et al (1975). These two papers have made a substantial contribution to the lists of the previously neglected groups and valuable additions to the lists of some groups which had already been studied in some detail.

T. Gledhill (F.B.A. River Laboratory) has identified water mite species collected from streams in the study area by other workers and has also made his own collections from streams and other phreatic waters in the district. Mr. Gledhill expects to publish his data, together with details of localities and habitats, in due course. Meantime his record of the crustacean Bathynella stammeri has been included in Table 6 and records of water mites additional to those in Tables 5 and 6 are given in Table 7.

(vi) Discussion

The list of Armitage et al (1975) represents the first attempt, within the Reserve, to identify all elements of the aquatic fauna, as far as possible, to the species level. As such, it adds considerably to our knowledge of the Reserve's freshwater fauna. There is, however, scope for further additions especially within the following areas:

(1) Some groups, notably within the Diptera, are difficult or impossible to identify as larvae. Consequently, such groups as the Chironomidae have not been subdivided. Further, several types of other dipterous larvae have been accorded generic names (Pedicia, Pericoma, Nemotelus, Clinocera and Hemerodroma) as an indication of general facies rather than as an accurate identification.

(2) The kick sampling method employed in this study causes severe damage to delicate organisms such as Platyhelminthes and Oligochaetes. Additional species of these two groups would probably be found if a special search was made.

(3) The four sampling sites all lie between 540 and 570 m O.D. on tributaries of the River Tees whereas most of the streams of the Reserve rise at 700 m or more. Consequently there is a need for more detailed examination of the headwaters and also of the streams situated on the western side of the Reserve which are tributaries of the River Eden.

Armitage et al (1975) note that a larger number of taxa were recorded than in similar studies elsewhere by Hynes (1961), Egglishaw and Mackay (1967), Minshall and Keuhne (1969) and Arnold and Macan (1969). They suggest that the possible reasons for this are the presence at Moor House of a wide range of flow conditions, high inorganic ion concentrations and high content of organic detritus, relative to the streams studied by the other workers. To this must be added the presence of the River Tees, which is a relatively large river at a comparatively high altitude and could provide habitat for some species more typical of rivers than of small streams.

Table 8 lists species found in the Tees and its tributaries at Cow Green (Armitage et al 1974) but not, so far, within the Moor House N.N.R. It should be noted that the genus Limnodrilus was recorded for Moor House by Armitage et al (1975) but that no specific identification was made. The authors draw attention to the fact that Riolus subviolaceus and R. cupreus are typical of calcareous conditions (Holland 1972) and were only found in the more calcareous of the Cow Green streams (15–50 mg l^{-1} Ca).

In contrast the highest Ca concentration so far recorded in the four streams studied at Moor House was a dry weather value of 19.2 mg l^{-1} in Trout Beck (Gorham 1956). A similar association with the calcareous streams at Cow Green was observed, and might be expected, for the molluscs Zonitoides nitidus and Lymnaea palustris and the leech Glossiphonia complanata. In contrast two of the species found only at Cow Green appear to reflect the occurrence there of specialised habitat requirements. The larvae of Wormaldia occipitalis occupy thin sheets of water flowing over rocks and were found in appreciable numbers in such a habitat in Weelhead Sike. The nymphs of Ephemera danica burrow in the sand or gravel of lake and river beds (Macan 1961) and the lower reaches of Dubby Sike, where the species was found, formed one of relatively few local sites where fine gravels occurred within a relatively stable stream bed. However, it is not possible to give any satisfactory explanation, in terms of specific environmental variables, for the fact that some species occur at Cow Green but not, apparently, at Moor House. It is possible to describe several likely correlations between species distribution and environmental variables. The two most obvious variables are altitude and calcium ion concentration. Armitage et al (1975) note that their Cow Green sampling stations were generally 40 m lower than the Moor House stations. An altitudinal difference of this size could conceivably have some effect through climate and/or exposure effects. Several species occur only in the more calcareous streams and this could be a physiological effect of calcium concentration, pH or bicarbonate concentration. These three factors can probably be correlated with one another but, in the Cow Green context, they can also be correlated with stream gradient and liability to severe spates. It is unlikely that all species will be influenced by the same elements of this complex of interrelated variables.

Armitage et al (1975) used an index of similarity to compare the faunal composition in their four sampling sites on the Moor House Reserve. This indicated closer similarities between the fauna of Moss Burn, Nether Hearth Sike and Trout Beck than between these three and Great Dodgen Pot Sike. The most obvious differences were that Trichoptera, Diptera, and Coleoptera were relatively more numerous and Ephemeroptera were relatively less numerous in Great Dodgen Pot Sike than in the other streams. Armitage et al (1975) showed that in dry weather (November 1973) Gt. Dodgen Pot Sike was the only one of the four sites with a pH value on the acid side of neutrality, though Crisp et al (1975) found a calcium concentration of 10.8 mg l^{-1} in Great Dodgen Pot Sike (April 1972) whilst roughly comparable analyses for Moss Burn, Nether Hearth Sike and Trout Beck gave 8.1, 5.3 and 7.3 mg l^{-1} respectively, under conditions of relatively low flow. The differences in calcium concentration and pH do not give a very convincing explanation of the observed faunal differences within a given stream, especially as they may both fluctuate considerably with discharge, and these fluctuations within a stream can be at least as large as the observed dry weather differences between streams. We can therefore conclude that the analyses for common ions do not reveal any unusual feature in Great Dodgen Pot Sike. Nevertheless, it appears to be a rather unusual stream and its unusual features, whatever they may be, are strikingly reflected in the composition of its invertebrate fauna and in a number of aspects of the growth and reproduction of its trout population.

The data suggest that the fish are subject to some form of environmental stress, possibly the presence of a sub-lethal concentration of some pollutant, though detailed chemical studies would be required before this possibility could be critically assessed.

(vii) General conclusions

The first edition of this paper concluded that the study of the freshwater biology was still at the descriptive stage. This is still true insofar as there are doubtless numerous aquatic invertebrate species present on the Reserve which have so far not been recorded. However, work published by the F.B.A. Cow Green team and others since 1973 has added considerably to the species lists. In addition we are now in a position where, on a somewhat speculative level at least, it is possible to discuss possible reasons for the relative species-richness of the Moor House aquatic invertebrate fauna. Given the resources, this could lead to a more detailed and perhaps, more experimental approach to the ecology of this fauna.

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	Bog Pools		Mine Pools
	Dry Weather	Wet Weather	Dry Weather
pH (glass electrode)	3.62 - 4.20	4.16 - 4.24	7.20 - 8.10
Na	3.3 - 5.3	1.6 - 1.9	3.1 - 3.3
K	0.1 - 1.0	0.1 - 0.2	0.6 - 0.7
Mg	0.4 - 1.1	0.2	0.4 - 1.5
Ca	0.7 - 3.8	0.3	15.4 - 30.5
HCO_3	nil	nil	24.4 - 87.8
Cl	5.4 - 5.5	3.0 - 3.4	4.1 - 4.4
SO_4	8.0 - 19.9	3.6 - 4.3	10.5 - 19.4
NO_3-N	<0.05		-
PO_4-P	<0.004	c. 0.4	<0.004
SiO_2	0.5 - 0.6		<0.5

Table 1 Chemical composition of the water in some pools on the Moor House National Nature Reserve, from Gorham (1956). The dry weather data for bog pools are the range of values from seven pools, the wet weather values are for three pools and the ranges for mine pools refer to two pools in dry weather only. Concentrations are in mgl^{-1}.

Publication	Gorham (1956) Single samples from Trout Beck in (a) dry weather (b) wet weather		Crisp (1966) Weekly samples from Rough Sike from May 1962 to Oct. 1963	Crisp & Cubby (in press) Single samples from Knock Ore Gill in (a) dry weather (b) wet weather		Crisp, Mann & McCormack (1975) Single samples, moderate flow.				Crisp & Gledhill (1970) Means of 50 to 80 analyses from a mill stream in Dorset
Material	(a)	(b)		(a)	(b)	Moss Burn	Nether Hearth Sike	Trout Beck	Gt. Dodgen Pot Sike	
pH glass electrode	7.8	6.2	-	-	-	-	-	-	-	8.06
Na	3.3	1.6	2.0 – 3.2	3.65	3.20	2.3	2.2	2.4	2.3	13.2
K	0.7	0.3	0.2 – 1.0	0.67	0.49	0.1	0.1	0.2	0.1	1.9
Mg	0.6	0.5	-	0.71	2.87	0.68	0.68	0.75	1.02	2.5
Ca	19.2	3.4	0.9 – 8.5	37.9	31.6	8.1	5.3	7.3	10.8	84.0
HCO_3	49.0	6.6	-	-	-	-	-	-	-	-
Cl	4.8	2.2	-	4.93	5.20	5.4	4.8	5.3	4.7	13.8
SO_4	12.0	5.6	-	15.7	14.0	5.6	5.8	6.4	6.6	30.5
NO_3-N	0.05	-	0.08 – 0.25	-	-	n.d.	n.d.	n.d.	0.006	-
P	-	-	0.01 – 0.04	-	-	-	-	-	-	-

Table 2 Chemical composition of flowing water from the Moor House National Nature Reserve. All concentrations are in mg l^{-1}. The data in the last column refer to a chalk stream in southern England and are given for comparison.

n.d. = Not detectable.

Range (°C)	Black Brows Beck (Lake District, 70 m O.D.)	Langden Well Beck (Lake District, 245 m O.D.)	Rough Sike (Moor House, 565 m O.D.)
0 – 4.9	16.6	9.0	45.3
5.0 – 9.9	37.7	56.8	37.4
10.0 – 14.9	37.7	29.0	14.2
15.0 – 19.9	7.7	4.7	2.9
20.0 – 24.9	0.3	0.5	0.2
> 24.9	0	0	0

Table 3 Percentage of the total time in a year when the water temperature was within each of a series of 5°C temperature ranges, from Crisp and Le Cren (1970)

	Rough Sike (Moor House National Nature Reserve)		East Stoke Mill Stream (Dorset)		
	1962	1963	1964	1965	1966
January	–	13	–	2852	4415
February	–	4	–	1761	5817
March	–	307	–	1927	4028
April	–	128	–	1373	3061
May	–	106	–	1267	2260
June	–	78	–	440	631
July	–	78	–	448	326
August	–	156	–	592	364
September	–	104	–	683	–
October	–	116	387	455	–
November	87	–	396	1408	–
December	142	–	1206	4343	–
Annual Totals		1368	–	17549	–

Table 4 Monthly discharges (thousands of m3) in Rough Sike, a small tributary of the Tees and in East Stoke Mill Stream, Dorset. From Crisp and Gledhill (1970).

Table 5 Part 1.

Lists of species recorded from standing water on or near the Moor House National Nature Reserve, taken from publications by Coulson (1959), Heal (1963), Crisp (1962), Bray, (1966), Nelson (1971), Peters (1972), Armitage, MacHale & Crisp (1974), and Armitage & Capper (1976).

Class Crustacea:

Scapholeberis mucronata	(O.F. Müller)
Bosmina coregoni v lilljeborgi	(Sars)
Acantholeberis curvirostris	(O.F. Müller)
Acroperus harpae	Baird
Alona quadrangularis	(O.F. Müller)
Alona affinis	Scott
Alonella excisa	(Fischer)
Alonella nana	(Baird)
Alonopsis elongata	(Sars)
Chydorus sphaericus	(O.F. Müller)
Chydorus sphaericus v coelatus	Schoedler
Ceriodaphnia quadrangular	(O.F. Müller)
Simocephalus vettulus	(O.F. Müller)
Daphnia hyalina v lacustris	Sars
Cyclops agilis	(Koch, Sars)
Cyclops viridis	(Jurine)
Canthocamptus staphylinus	(Jurine)
Gammarus pulex	(L.)

Order Hemiptera:

Corixa wollastoni	(D. & S.)
C. nigrolineata	(Fieb.)
C. germari	(Fieb.)
C. carinata	(C. Sahlb.)
C. sahlbergi	(Fieb.)
C. lateralis	(Leach)
C. punctata	(Illig.)
C. venusta	(D. & S.)
C. praeusta	(Fieb.)
C. dorsalis	Leach
C. scotti	(D. & S.)

Table 5 (2)

C. distincta	(Fieb.)
C. semistriata	(Fieb.)
C. fossarum	(Leach)
C. castanea	(Thoms.)
C. concinna	(Fieb.)
Glaenocorisa propinqua	(Fieb.)
Velia caprai	Tamanini
Gerris costai	(H. & S.)

Order Odonata:

Pyrrhosoma nymphula	(Sulzer)
Aeshna juncea	(Linnaeus)
Aeshna cyanea	(Müller)
Aeshna grandis	(Linnaeus)

Order Megaloptera:

Sialis fuliginosa	(Pictet)
Sialis lutaria	(Linnaeus)

Order Diptera:

Tipula melanoceros	Schummel
Phalacrocera replicata	L.
Erioptera fuscipennis	Meigen
Trichoptera immaculata	Meigen
Chaoborus crystallinus	Degeer
Culicoides impunctatus	Goetghebuer
Hydromia fontinalis	(Haliday)

Order Coleoptera:

Agabus congener	(Thunberg)
Agabus bipustulatus	(Linnaeus)
Dytiscus marginalis	(Linnaeus)
Acilius sulcatus	(Linnaeus)
Cyrinus natator	(Linnaeus)
Anacaena globulus	(Payk)
Agabus arcticus	(Thoms.)
Agabus chalconatus	(Panz.)
Agabus labiatus	(Br.)

Table 5 (3)

Agabus sturmii	(Gyll)
Hydroporus umbrosus	(Ghyll.)
Hydroporus gyllenhalii	Schiödte
Hydroporus palustris	(L.)
Hydroporus pubescens	Gyll.
Hydroporus obscurus	Strm.
Haliplus ruficollis	Deg.
Haliplus fulvus	F.
Helophorus brevipalpis	Bedel
Helophorus aequalis	Thoms.
Helophorus minutus	F.
Helophorus walkeri	Sharp
Limnebius truncatellus	Thunb.
Oreodytes rivalis	Gyll.
Rhantus bistriatus	Berg.

Order Plecoptera:

Nemoura cinerea	(Retz)

Order Ephemeroptera:

Centroptilum luteolum	(Müll.)

Order Trichoptera:

Oligotrichia ruficrus	(Scopoli)
Phryganea obsoleta	Hager
Phryganea grandis	(Linn.)
Limnephilus vittatus	(For.)
Limnephilus centralis	(Curt.)
Limnephilus incisus	Curt.
Limnephilus luridus	(Curt.)
Limnephilus sparsus	Curt.

Phylum Mollusca:

Lymnaea truncatula	(Müller)
Lymnaea glabra	(Müll.)
Lymnaea stagnalis	(Linn.)
Gyraulus laevis	(Alder)
Planorbis spirorbis	(Linn.)

Table 5 (4)

Phylum Annelida:

Lumbriculus variegatus	(Müll.)
Tubifex tubifex	(Müll.)
Eiseniella tetraedra	(Savigny)
Erpobdella octoculata	(L.)
Helobdella stagnalis	(L.)

Phylum Coelenterata:

Hydra oligactis	Pallas
Hydra vulgaris	Pallas

Class Arachnida:

Arrenurus buccinator	(Müll.)
Arrenurus membranator	Thor.
Limnesia koenikei	Piers
Limnesia undulata	(Müll.)
Lebertia porosa	Thor
Oxus nodigerus	Koen.
Piona coccinea	(Koch)
Pionopsis lutescens	(Herm.)
Pionacercus leukartii	(Piers.)

Table 6

List of species recorded from within and around Moor House National Nature Reserve in flowing water taken from publications by Coulson (1959), Phillipson (1967), Davies (1957, 1958, 1966), Brown, Cragg & Crisp (1964), Crisp & Nelson (1965), Nelson (1971), Armitage, MacHale & Crisp (1975), Birkett (1976) and Wotton (1976).

Note:- (i) The records of Chironomidae from Birkett (1976) have been subdivided into:-

a. species recorded from the catches on sticky traps in Rough Sike in 1962

and

b. additional species noted by Dr. Birkett during visits to Rough Sike in 1972.

(ii) There is no known morphological distinction between the nymphs of B. tenax and B. vernus or between the nymphs of B. scambus and B. bioculatus. From what is known of the ecology of these species the Moor House specimens are most likely to be B. tenax and B. scambus.

Phylum Platyhelminthes:

Crenobia alpina (Dana)

Polycelis felina (Mull)

Phylum Annelida:

Nais alpina Sperber

Nais pardalis Piguet

Nais elinguis Müll

Peloscolex ferox (Eisen)

Tubifex ignotus (Štolc.)

Tubifex tubifex (Müll.)

Rhyacodrilus coccineus (Vejd.)

Stylodrilus heringianus Clap.

Lumbriculus variegatus (Müll.)

Eiseniella tetraedra (Savigny)

Class Crustacea:

Gammarus pulex (L.)

Bathynella stammeri Jakobi

Table 6 (2)

Order Plecoptera:

Perlodes microcephala (Pictet)
Diura bicaudata (Linne)
Dinocras cephalotes (Curtis)
Perla bipunctata (Pictet)
Isoperla grammatica (Poda)
Chloroperla torrentium (Pictet)
C. tripunctata (Scopoli)
Taeniopteryx nebulosa (Linne)
Brachyptera risi (Morton)
Capnia vidua Klapalek
Leuctra nigra (Olivier)
L. inermis Kempny
L. fusca (Linne)
L. hippopus (Kempny)
L. moselyi Morton
Protonemura meyeri (Pictet)
P. praecox (Morton)
P. montana Kimmins
Amphinemura sulcicollis (Stephens)
A. standifussi Ris.
Nemoura erratica Claassen
N. cambrica (Stephens)
N. cinerea (Retzius)
N. avicularis Morton
Nemurella picteti Klapalek
Capnia bifrons (Newman)

Order Ephemeroptera:

Ameletus inopinatus Etn.
Rhithrogena semicolorata (Curt.)
Heptagenia lateralis (Curt.)
Ecdyonurus venosus (Fabr.)
E. torrentis Kimmins
Baetis rhodani (Pict.)
B. pumilus (Burn.)
B. tenax Etn./B. vernus Curt.
B. scambus Etn./B. bioculatus (L.)

Table 6 (3)

Siphlonurus lacustris Etn.
Caenis rivulorum Etn.
Ephemerella ignita Poda
Ecdyonurus dispar. (Curt)
Paraleptophlebia submarginata (Steph.)
Paraleptophlebia cincta (Retz.)
Leptophlebia marginata (L.)
Centroptilum pennulatum Eaton

Order Trichoptera:

Rhyacophila dorsalis (Curtis)
R. obliterata McLachlan
Glossosoma boltoni (Curtis)
Agepetus delicatulus McLachlan
Hydroptila tineoides Dalman
H. forcipata Eaton
Oxythira falcata Morton
Plectrocnemia conspersa (Curtis)
Polycentropus flavomaculatus (Pict)
Tinodes waeneri (Linne)
Oligotricha ruficrus (Scopoli)
Phryganea obsoleta McLachlan
Drusus annulatus Stephens
Ecclisopteryx guttulata (Pictet)
Limnephilus centralis Curtis
L. coenosus Curtis
L. incisus Curtis
L. luridus Curtis
L. rhombicus (Linne)
L. sparsus Curtis
Anabolia nervosa (Curtis)
Potamophylax cingulatus (Stephens)
P. latipennis (Curtis)
Halesus radiatus (Curtis)
Stenophylax permistus McLachlan
S. lateralis (Stephens)

Table 6 (4)

Allogamus auricollis (Pictet)
Chaetopteryx villosa (Fabricius)
Mystacides azurea (Linne)
Sericostoma personatum Curtis
Brachycentrus subnubilis Curtis
Lepidostoma hirtum (Fabr.)
Plectrocnemia geniculata (McLachlan)
Cyrnus trimaculatus (Curt.)

Order Coleoptera:

Hydroporus melanarius (Sturm.)
Hydraena gracilis Germ.
Oreodytes rivalis Gyllenhal
Oreodytes borealis davisi Curt.
Elmis aenea (Müll.)
Limnius volckmari Panz.
Esolus parallelepipedus (Müll.)
Oulimnius tuberculatus (Müll.)
Helodes marginata (F.)

Order Diptera:

Tipula montium Egger
T. coerulescens Lackschewitz
Dicranota robusta Lundstroem
D. subtilis Loew
D. brevitarsis Bergroth
D. bimaculata Schummel
D. guerini Zetterstedt
D. exclusa Walker
Hexatoma bicolor Meigen
Limnophila mundata Loew
Erioptera lutea Meigen
E. fuscipennis Meigen
E. trivialis Meigen
Prosimulium hirtipes Fries
P. inflatum Davies

Table 6 (5)

Simulium monticola Friedrichs
S. variegatum Meigen
S. dunfellense Davies
S. naturale Davies
S. aureum Fries
S. brevicaule Dorier & Granier
S. latipes Meigen
S. nitidifrons Edwards
S. vernum Macquart
S. angustitarse Lundstroem
Culicoides impunctatus Goetghebuer
Hydromia stagnalis (Haliday)
Hydromia fontinalis (Haliday)
H. wesmaelii Macquart
Weidemannia bistigma (Curtis)
W. rhynchops insularis Collin
Acanthocnema glaucescens (Loew)
Diamesa tonsa (Walker) a
D. insignipes Kieffer a
Cardiocladius capucinus (Zetterstedt) a
Cricotopus sylvestris (F.) a
C. pulchripes Verrall a
C. trifascia Edwards a
C. polaris Kieffer a
Acricotopus lucens (Zetterstedt) a
Paratrichocladius skirwithensis Edwards a
P. rufiventris (Meigen) a
Psectrocladius (Allopsectrocladius) obvius (Walker) a
Chaetocladius perennis (Meigen) a
C. excerptus (Walker)
Orthocladius (Eudactylocladius) obtexens Brundin a
Orthocladius (Euorthocladius) thienemanni Kieffer a
O. (E.) frigidus (Zetterstedt) a
Synorthocladius semivirens (Kieffer) a
Eukiefferiella minor (Edwards) a
E. claripennis (Lundbeck) a
E. brevicalcar (Kieffer) a
E. calvescens (Edwards) a

Table 6 (6)

Paralimnophyes hydrophilus (Goetghebuer) a
Limnophyes minimus (Meigen) a
L. prolongatus (Kieffer) a
L. truncorum (Goetghebuer) a
Parakiefferiella bathophila (Kieffer) a
Smittia leucopogon (Meigen) a
Thienemanniella clavicornis (Kieffer) a
Corynoneura lobata (Edwards) a
C. scutellata Winnertz a
Cladotanytarsus mancus (Walker) a
C. van-der-wulpi Edwards a
Prodiamesa olivacea (Meigen) b
Metriocnemus fuscipes (Meigen) b
Bryophaenocladius subvernalis (Edwards) b
Chaetocladius dentiforceps (Edwards) b
Pseudorthocladius filiformis (Kieffer) b
Eukiefferiella claripennis (Lundbeck) b
Limnophyes gurgicola (Edwards) b
Pseudosmittia recta (Edwards) b
Corynoneura lacustris Edwards b
Chironomus lugubris Zetterstedt b
Micropsectra fusca (Meigen) b
M. praecox (Meigen) b
M. recurvata Goetghebuer b
Tanytarsus debilis (Meigen) b

Phylum Mollusca:

Pisidium casertanum (Poli.)
P. hibernicum Westerlund
P. personatum Malm
P. obtusale (Lamarck)
Ancylus fluviatilis Muller
Lymnaea peregra (Muller)

Class Arachnida:

Sperchon brevirostris Koenike
S. glandulosus Koenike
Hygrobates foreli (Lebert)
Lebertia porosa Thor.

Hydrachnellae

Panisus michaeli Koenike
Sperchonopsis verrucosa verrucosa (Protz.)
Sperchon clupeifer Piersig
Teutonia (Teutonia) cometes (Koch)
Bandakia concreta concreta Thor
Torrenticola (Torrenticola) anomala (Koch)
Hygrobates (Hygrobates) nigromaculatus Lebert
Atractides (Atractides) gibberipalpis Piersig
Feltria (Feltria) minuta Koenike
Feltria (Feltria) rouxi Walter (= Feltria romijni Besseling)
Feltria (Feltria) subterranea Viets
Atractides (Atractides) latipalpis latipalpis (Motas & Tanasachi)
Ljania bipapillata bipapillata Thor
Lexathona (Lexathona) cavifrons Szalay
Aturus brachypus Viet
Aturus scaber scaber Kramer
Kongsbergia (Kongsbergia) clypeata Szalay

Limnohalacaridae:

Lobohalacarus weberi weberi (Romijn & Viets)
Soldanellonyx chappuisi Walter
Soldanellonyx monardi Walter
Porolohmannella violacea (Kramer)

Table 7 List of water mites recorded from the Moor House and Upper Teesdale area and from the South Tyne at Garrigill by Mr. T. Gledhill. Species already listed in tables 5 and 6 have been omitted. All species determined by T. Gledhill.

GROUP AND SPECIES

Order Ephemeroptera:

Centroptilum luteolum (Müll.)
Habrophlebia fusca (Curt)
Ephemera danica Müll

Order Coleoptera:

Riolus subviolaceus (Müll)
R. cupreus (Müll)

Order Trichoptera:

Wormaldia occipitalis (Pict.)
Neureclepsis bimaculata (l.)
Oxyethira simplex Ris
Goera pilosa Fabr.

Phylum Mollusca:

Zonitoides nitidus (Müll)
Lymnaea palustris (Müll)

Class Arachnida:

Hygrobates fluviatilis (Strom)
Atractides nodipalpis (Thor)
A. [illegible]ener (Thor)

Phylum Annelida:

Limnodrilus hoffmeisteri Clap
Glossiphonia complanata (L.)

Order Plecoptera:

Leuctra geniculata (Stephens)

Order Diptera:

Simulium reptans L.
*S. nitidifrons Edwards

Table 8 Species found in flowing waters at Cow Green by Armitage et al (1974) and Wotton (1976)* but not recorded from the Moor House NNR.