BIOLOGICAL SURVEY OF THE RIVER WHARFE

II. REPORT ON THE INVERTEBRATE FAUNA.

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Observations and collections have been made over a period of one and a half years, commencing June 1926, at three chief stations, viz. Grassington Bridge, Pool Bridge and Ulleskelf. Subsidiary collections and observations have taken place at other stations, especially at Harewood Bridge and Collingham Bridge. At the three main stations, monthly visits were paid and material was taken from the various accessible parts of the bed. At Grassington and Pool the river bed is easy of access but at Ulleskelf collecting was limited owing to the nature of the banks and the depth of the water.

No attempt has been made to study the entire fauna and only invertebrates have been dealt with. Some groups have been omitted, e.g. Protozoa, Nematoda and Rotifera. The nature of the collecting apparatus used caused a loss of very many organisms since the usual net employed possessed a mesh of 0·5 mm. through which a large number of animals of various kinds passed.

The lists of species gathered at the various stations show a great similarity between the character of the fauna at Grassington, at Harewood Bridge and at Collingham: while the Ulleskelf fauna differs markedly from the others. The great majority of the species from all the stations require water well charged with oxygen, a point of interest bearing on the problem of pollution in this river.

Environmental conditions at the stations.

Grassington.

The water depth is liable to great fluctuations with sudden rises after heavy rains and, consequently, hêavy spates. At summer level, and in fine weather in winter, a very considerable portion of the bed is exposed for varying periods depending upon the duration of fine weather. The current has a variable speed both from time to time and at different places in the section of the stream. The deposit is generally coarse with almost no fragments below 0·5 mm. in diameter. The bulk of the fine material consists of stones of 2·5 cm. or thereabouts and beds of stones chiefly of 5–20 cm. in diameter occur in various places. Lying irregularly are large boulders, often mossy, which are immovable. Many of

these lie near the banks and form small pools between them giving shelter to a variety of organisms which would otherwise find a great difficulty in existing.

In the most rapid current the bed consists of smooth, rounded stones of 5–20 cm. diameter resting on fine material of about 1 cm. diameter with a small amount of about 5 mm. filling the interstices. Such beds are apparently liable to disturbance during heavy flooding. The dominant invertebrate here is *Rhithrogena semicolorata*. Laterally to these areas are others very similar but having, subjacently, more fine material down to 0·5 mm. The larger stones carry a flora of diatoms, blue-green algae and short *Cladophora*. Many of them are encrusted above with calcareous algae. The presence of such plant growth indicates that the beds are stable, not being disturbed during flooding. The quieter conditions allow of the deposition of the finer detritus and of the growth of plants on the upper side. This type of substratum is populated typically by Psychomyidae and Glossosomatinae. *Hexatoma* and *Ancylus fluviatilis* are also normally present, and *Ecdyurus venosus* largely takes the place of *Rhithrogena*, finally replacing it towards the bank.

Along the bank the large stones are populated further by *Halesus auricollis* and *Limnea peregra*. These two species are practically absent where there is no shelter.

Small gravel occurs along the bank in places where reinforcement by building stones has taken place. This gravel is the only medium in which *Ephemera danica* has been found here.

Pool Bridge.

Although the depth at this station is variable, there is no exposure of the stony bed during fine weather. The sides are more or less vertical and vary in depth from 2 to 6 feet. The bed consists chiefly of more or less flattened, water-worn stones set in a substratum of finer material varying in diameter from 5 cm. to 1 mm. and forming a stable floor to the stream. The flora on these stones consists largely of diatomaceous plants and *Cladophora*, but the right half of the bed above the bridge has a bed of *Potamogeton perfoliatus*, which extends up stream for a considerable distance. The depth of the water here is rarely less than 30 cm. Patches of *Ranunculus fluitans* are present. These hold up sand of 1 mm. to 0·5 mm. diameter in which many bivalve molluscs live. They appear to undergo much erosion during flooding and become re-formed when the current slackens. Patches of *Elodea* were seen by the left bank but they form an inconsiderable portion. A narrow strip of sand containing polluted organic matter runs along the left bank and is the only evidence of pollution found by us in this region.

Generally speaking, the area examined at Pool was remarkably uniform in character, due largely to the comparative uniformity in the flow of the current, which is governed by a slighter fall than exists at Grassington. The deposition of material below 0·3 mm. is very slight and is apparently compensated for by

erosion during flooding. On the whole the deposit includes much finer grades of material than occur at Grassington.

Harewood Bridge.

The portion studied is the concrete base of the bridge which carries thick growth of moss on the down-stream half, commencing about half-way through the arches. This vegetation becomes very dense during the summer but suffers sometimes from erosion during the winter flooding. In wet weather there is a strong flow which covers the whole surface, but in dry periods as much as half the moss may be exposed. This variation in water covering is reflected in the distribution of the fauna. (See Table, p. 295.)

The dominant organisms in this bed are *Nais elinguis*, Chironomidae and *Hydropsyche instabilis* (?).

Collingham Bridge.

The bed examined consists chiefly of boulders resting on a substratum of material varying from 0·5 mm. to 3 cm. There is very little below 0·5 mm. as the current is normally strong. The boulders vary very much in size from 8 cm. to 50 or 60 cm. The smaller boulders are ovoid, while the larger are more or less rectangular but water-worn. The indications here are that, although the current is fast, the bed is subjected to very little disturbance, since there is a marked development of vegetation consisting largely of diatomaceous growth with short and long *Cladophora*. Many of the larger boulders are covered with moss. The conditions at Collingham are a compound of those at the above-named stations.

Ulleskelf.

This station differs markedly from those described already. The water flow is uniform and the depth much greater, varying from 1 m. to 4 m. During very heavy flooding the depth may increase to about 30 ft. but the increased rate of flow does not unduly disturb the substratum. The channel is well marked with steep sides and the deposit is much finer than that higher up the river. It consists almost entirely of material less than 0·5 mm. and very much may be included in the "silt" category (particles less than 0·05 mm. and greater than 0·01 mm.).

The amount of deposition is not great, since at no time have we found it more than about 1 cm. thick in the middle portion of the bed. Laterally, sand is deposited.

Vegetation consists of phanerogams which occur in patches affording support, shelter and browsing areas for pulmonate gastropods, Chironomid larvae and worms, thus making possible the existence of a considerable number of organisms. The conditions here are reflected in the constitution of the fauna. All those species which are adapted to life in rapid waters being absent while there is a great increase in the number of bivalve molluscs and of gastropods

carrying relatively large shells, such as *Limnaea peregra* and *Neritella fluviatilis*.

No naturally placed stones were observed, but a few had been built into the bank.

This region does not offer such varied conditions for its fauna as the previously described stations, and to the difference may be ascribed the relatively small number of species collected. Many of the species present, however, are represented by enormous numbers of individuals, especially in the cases of the genera *Sphaerium*, *Pisidium*, *Limnaea*, *Gammarus* and *Hydra*.

FAUNISTIC NOTES.

Ephemeroptera.

The most abundant members of this order are *Ephemerella ignita*, *Baetis binoculatus*, *B. pumilus*, *B. rhodani*, *Rhithrogena semicolorata*, *Ecdyurus venosus* and *Caenis rivulorum*. These have been found in all the shallower and more rapidly flowing waters. From Pool to Boston Spa, *Heptagenia sulphurea* becomes more and more abundant, but does not appear to replace any particular species. *Rhithrogena* is found dominant in those regions, where there is a very rapid flow, with rounded smooth stones which have no visible vegetation and present evidence of movement during flooding. *Ecdyurus venosus* appears when the bed becomes more stable, and with increasing stability *Rhithrogena* disappears, while *Ecdyurus* increases. Further down, without any apparent change in conditions, *Heptagenia* contributes a considerable proportion of the Mayfly fauna. *Caenis rivulorum* is found more abundantly where *Cladophora* and loose mossy growths occur on stones. Here is usually a deposit of sand, and it is rarely that nymphs of this species are taken from places where there is no deposit of fine and coarse sand among the stones. *Ephemera danica* has not been taken to any appreciable extent. It is usually found in beds of sand consisting largely of material varying from 0·5 to 0·05 mm.[1] Since this type of deposit is not usual in the regions examined, the absence, generally, of nymphs is to be understood. Occasional specimens have been taken at Grassington along the edge of the stream, but the conditions were such as to suggest that only in very favourable circumstances are the eggs deposited there. This animal is to be regarded as not forming one of the characteristic species of the stations dealt with.

In the analysis it is seen that there is very little difference in the Ephemerid fauna of any two of the first four stations. The chief differences are seen in actual population density and in relative proportions, these varying with the nature of the bottom as determined by the effect of contour on water flows. *Baetis* spp. occur very abundantly in all the stony places, and tend to disappear

[1] **Percival** and **Whitehead.** "Observations on the Biology of the Mayfly, *Ephemera danica* Müll." *Proc. Leeds Phil. Soc.* (*Scientific Section*), **1**, Pt 3, pp. 136–48.

only where the conditions change to fine sand and finer material. They are the most widely spread and abundant of the Mayfly nymphs.

Plecoptera.

This order presents relatively and actually a smaller portion of the total fauna than does Ephemeroptera. No specimens have been taken from Ulleskelf, and the Stone-fly fauna from the other stations presents no striking differences *inter se*. The genera *Leuctra* and *Amphinemura* are the most abundant in individuals. *Perla* and *Perlodes*, although having a wide distribution are never abundant. All the species taken require a high degree of oxygen saturation, and this exists in the places examined.

Trichoptera.

In this order there are many species, the distribution of which extends as far down as Collingham, and any differences noted are seen in the numbers per unit area and in the proportion of the total fauna. It may be said that the species more characteristic of Grassington and of similar regions are *Agapetus fuscipes*, *Glossosoma vernale*, *Psychomyia pusilla*, *Tinodes waeneri*, *Cyrnus trimaculatus* and *Halesus auricollis*. They are almost all found further down the river in the more stony parts, but their actual numbers diminish. *Rhyacophila dorsalis* increases in number further down, and this applies to the remaining Trichoptera which are not included in the list above. The genus *Limnophilus* has not been found at Grassington, but it occurred relatively often at Pool, along the bank, under and among large stones and among *Potamogeton*. Generally speaking this genus is associated with quieter conditions than suit the species detailed above.

Leptocerus cinereus is widely distributed among stones with coarse sand. A species of *Leptocerus* was found under stones at Pool and at Boston Spa: at the latter place it is common.

Of the genus *Hydropsyche*, *H. instabilis* (?) is the most abundant and widely spread member. It has been taken in greatest numbers from thick carpets of moss.

Diptera.

The Chironomidae provide by far the largest numbers of insect larvae and reach their greatest development among thick mossy growths such as occur at Harewood Bridge, Pool Weir and on mossy stones at Grassington and similar places. *Tanytarsus* and Orthocladiariae form the bulk of this group of animals. They are also present in large numbers where the stony bed is not subjected to movement by the rush of water. The other genera recorded are insignificant in so far as numbers and proportion are concerned. *Hexatoma* is widely distributed in the stony and mossy regions and comes next to the Chironomidae in numbers and proportion.

Coleoptera.

The important beetles in our collections are certain species of Helminae. These are clearly associated with the stony and mossy regions as exemplified at Grassington, Pool and Harewood Bridge. It is especially to be noticed that the mossy region, Harewood Bridge, has presented a much higher total, from fewer samples, than was found in the other places. Moss offers a very favourable environment for the growth of these small Coleoptera. *Brychius*, *Hydroporus*, and *Doronectes* are found usually in slowly flowing streams, and their almost entire absence from the collections from the upper and more quickly flowing parts of the river is to a certain extent comprehensible. It is noticeable that they are not present in any considerable number at Ulleskelf, although it presents apparently a more suitable habitat.

Analysis of distribution of 162 *adult Coleoptera taken in* 24 *samples from five Wharfe stations.*

	Grassington	Pool	Harewood Bridge	Collingham Bridge	Ulleskelf
Hydroporus rivalis ...	1	—	—	—	—
Brychius glabratus ...	1	—	—	—	1
Deronectes depressus	—	3	—	—	2
Cercyon sp.	—	1	—	—	—
Limnius tuberculatus	3	13	24	1	—
Esolus parallelepipedus	6	12	3	—	—
Riolus cupreus ...	14	—	—	—	—
Helmis aeneus ...	14	2	55	—	—
Latelmis volckmari ...	3	2	—	1	—
	42	33	82	2	3

Approximate percentage occurrence of 161 *adult Coleoptera taken in* 24 *samples from five Wharfe stations.*

	Percentage of total number	Percentage of total occurrence
Helmis aeneus ...	44·0	50·0
Limnius tuberculatus	24·0	46·0
Esolus parallelepipedus	13·0	37·5
Riolus cupreus ...	8·8	8·4
Latelmis volckmari ...	6·0	16·8
Deronectes depressus	3·2	12·5
Brychius glabratus ...	1·2	8·4
Hydroporus rivalis ...	0·5	4·0

The larvae of Helminae may be very abundant, as many as 1244 per square decimetre having been taken from moss at Harewood Bridge (9. vi. 26). Generally, among stones without moss, they occur to the extent of 10 to 15 per square decimetre, but the numbers vary very much with the nature of the finer deposit. If there is a strong current which prevents the laying down of material below 0·5 mm. there is usually an absence or a great scarcity of larvae, as, in such cases, the force of the water is felt strongly beneath the stones. The spiny flattened bodies and stout short legs with strong claws enable the larvae to move along and grip the moss or to hang on to stone surfaces.

It is to be noted that no pupae of Helminae were taken, although adults and larvae usually were found together.

Hydracarina.

Grassington, Pool and Harewood Bridge have a similar fauna. At the last place *Hydracarina* exist in very great numbers; the thick moss offers excellent shelter, and the dense fauna presents a suitable medium for feeding the parasitic nymphs. Grassington presents the most varied mite fauna, which may be correlated with the great diversity of conditions. Pool, with its less varied mite fauna, has somewhat more uniform conditions.

The distribution of the species of *Hydracarina* in our samples has not appeared to follow any definite rule: the various organisms occurring indiscriminately in the different substrata. The effect of environment has shown itself rather through the numbers of individuals. The species of *Hydracarina* collected are non-swimmers, and are provided with strong claws with stout bristles for assistance in climbing.

Gammarus pulex.

Although this species is widely distributed, it has never attained in our collections either a density or proportion at all comparable with that of the insects. Its greatest development appears to take place in the lower portion of the weir. At Ulleskelf it is one of the dominant species. At Grassington it is relatively scarce and not characteristic. The distribution in the Wharfe appears to be correlated with, to some extent, a slackened current.

Mollusca.

Pool has presented the largest number of species and Ulleskelf has almost the same molluscan fauna, except that *Ancylus fluviatilis* and *Neritella fluviatilis* were not taken at the latter locality. *Ancylus* belongs to the stony regions. The species of *Lamellibranchia* are practically identical at Pool and Ulleskelf, in spite of the fact that, at the former place, the bed is stony, and at the latter it consists of a thin layer of silt on a hard clay substratum. At Ulleskelf the number of bivalves was much greater and the situation clearly favoured them, there being a varying amount of suspended fine organic matter in the water.

Annelida.

Ulleskelf is characterised by the presence of a large number of Tubificidae and Lumbriculidae. The other stations showed a great abundance of *Nais elinguis*, and *Eiseniella tetraedra* was found on the stony places either under stones or in moss. From Boston Spa upwards the dominant Oligochaete in the stony regions is *Nais elinguis*. At Pool there were occasional groups of *Paranais naidina*, especially at the base of the *Potamogeton*. Among these plants Tubificidae replaced *Nais* and were present in abundance. In the polluted

sand along the left bank at this station, *Tubifex* sp., *Lumbriculus variegatus* and other unidentified Oligochaeta were found.

It is to be observed that the Leech fauna varies very little along the investigated length of the river. The absence of Leeches from Harewood Bridge and Collingham is explained by the fact that only moss was examined from the former place and from the latter were taken samples from sites particularly unsuited to Hirudinea.

There appears to be an association between *Glossosiphonia complanata*, *Helobdella stagnalis* and molluscs, while *Herpobdella atomaria* regularly occurs (apart from moss) with large numbers of Tubificidae and Chironomidae on which it feeds. These associations are very largely based upon food relations.[1]

Tricladida.

The greatest numbers were found at Ulleskelf which provides suitable conditions for flatworms. The number of species is small.

Hydrozoa.

Hydra oligactis has been taken at all the three chief stations: few at Grassington but very many at Pool and Ulleskelf. At Pool it was taken chiefly from *Potamogeton* and at Ulleskelf, great numbers lived on the bed of the stream attached to the fine detritus on the substratum.

Porifera.

The only sponge taken was *Ephydatia fluviatilis*. At Grassington only very small patches were found; the current is too swift. At Pool the conditions were slightly more favourable, while at Ulleskelf, large areas of the bed were covered with massive growths.

THE SEASONS AND THE STREAM FAUNA.

Variations in the character of the stream fauna are very largely related to the length of the life cycle and the duration of the period during which mature adults are found: this applies particularly to the case of aquatic insects. Many of these latter are found in the adult condition from March to October, a period during which eggs are being produced. With a rise of temperature, the rate of incubation is increased and the speed of development is greater. In this way various stages of development in the same species are met with at the same time. The species of *Baetis*, *Ecdyurus*, *Rhithrogena*, *Agapetus*, *Glossosoma*, *Rhyacophila*, *Polycentropus*, *Leuctra*, *Protonemura*, *Amphinemura*, *Simulium* and Chironomidae present a variety of growth stages at any part of the year, all of them being found flying during several months. Species of *Baetis*, *Leuctra*, *Protonemura*, *Glossosoma* and Chironomidae have been taken in the

[1] **Percival** and **Whitehead.** *Journ. of Ecology*, **17**, 1929.

adult condition from early February until late October. *Ecdyurus venosus* emerges in April or May, depending on the weather, and persists well into November. In these cases there are two well-marked seasons, one during which reproduction takes place and the other, much shorter, when only actively growing forms are found. In the case of *Glossosoma vernale* newly pupated nymphs have been taken early in January.

Many other species mature at more or less definite portions of the year, e.g. *Ephemera danica*, *Caenis rivulorum*, *C. halterata*, *Perla* spp., *Nephelopteryx nebulosa*, *Hydropsyche* spp., *Halesus auricollis*, *Stenophylax* spp., *Lepidostoma hirtum* and in some of them the reproductive period is limited to five or six weeks. In those cases where the life cycle occupies one year there is a marked uniformity in the size of the young stages at a given time, but where the life cycle lasts over two or more years there are well-marked size differences after a given date. This particularly refers to *Perla* spp., *Perlodes* and *Ephemera*.

An examination of a large number of samples shows that October is the time when there is a maximum number of the above-named species in a juvenile condition, i.e. a size which enables them to be retained by a 0·5 mm. mesh and not exceeding 3 mm. in length. Juveniles are found especially during the winter months, but decrease in proportion as February approaches.

In the regions examined there are few species which appear to be temporarily absent. Such cases have a restricted period of emergence and have only one brood per annum, e.g. *Halesus auricollis*, *Stenophylax stellatus* (?) and *Heptagenia sulphurea*. In some places *Ephemerella ignita* cannot be found in December and early January, but usually a few large nymphs can be taken through the winter. Although the incubation period is long the life cycle is probably only one year.

Generally speaking there has not been noticed any marked seasonal change in the specific nature of the fauna, but further definite investigation on that point is needed.

The following table shows the analyses of six samples taken from moss on the concrete base of Harewood Bridge.

The sample consists of two series of three each taken from as nearly as possible the same place each time, and on the same dates. Except in the case of *Nais* (Series II) and *Rhyacophila*, it is difficult to see any definite indication of seasonal variation in numbers, since, during the year under consideration the weather conditions were extremely variable with prolonged and heavy flooding in the late winter 1926–7. The most striking part of the table is the continued falling off in Chironomidae, *Hydracarina* and Helminae, which must have been due, in part at any rate, to the continuous floods, and later, to the cold spring and early summer. The reproductive season of 1926 was very good until about the end of July, when practically all the insects named in the table would have considerably added to the potential population of the stream

in the vicinity. It is probable that a great washing out of larvae and nymphs took place during the winter.

	(I) Mid-stream below lower side of south arch, moss always submerged			(II) One metre from south side in shelter of masonry, moss uncovered during dry weather		
	9. vi. 26	16. ii. 27	30. vi. 27	9. vi. 26	16. ii. 27	30. vi. 27
Baetis	16	2	—	4	4	13
Ephemerella	196	—	188	36	juv. 7	23
Rhyacophila	16	46	2	2	16	11
Hydroptila	—	—	9	—	—	—
Ithytrichia	16	2	—	—	2	2
Philopotamus	28	—	1	—	—	—
Polycentropus	7	—	—	—	—	—
Hydropsyche	240	1031	45	4	194	—
Chironomidae	3,200	2080	—	1155	—	740
Hexatoma	—	13	7	—	4	—
Calliophrys	—	—	—	5	11	2
Hydracarina	1,244	65	83	21	3	—
Gammarus	28	16	14	11	9	—
Canthocamptus	20,090	5	—	—	5	—
Helminae, larvae	1,244	160	64	16	—	80
Helminae, adults	16	70	38	—	—	22
Nais	8,355	1422	464	3776	25	2280
Polycelis	37	18	—	—	22	—
Total number per sq. decimetre calculated from samples of 9 sq. in. ...	34,733	4930	915	5030	302	3173

Ephemerella presents quite definite indications of seasonal variation in numbers. During February the larvulae are either not hatched out or are too small to be retained by the 0·5 mm. sieve. With *Rhyacophila* there is a marked rise in February as compared with June. Pupation does not take place in moss but on and under stones, the larvae apparently becoming free from the moss and passing down stream. Thus, in the breeding and pupating seasons, there will be a stream of larvae passing from the moss and tending to reduce the number, while in the winter when pupation is in abeyance there is a maximum number of larvae in the moss.

The great increase in the number of *Nais* in Series II is correlated with the fact that asexual reproduction takes place during the warmer months. No doubt a great many are washed down or die without replacement before February. In Series I the diminution in number could not be overcome by reproduction in the spring and early summer of 1927, probably owing to the unusually cold weather during that time and to the long continued heavy flow of water. At one date, early in January, the speed of the current at the surface was estimated at 16 miles per hour, the depth being about 1·25 m. At such a time the erosive effect must be very great. The remarkable variation in the numbers of *Canthocamptus* requires further investigation before an adequate explanation can be offered.

It is obvious that much more work, carried out at a few stations with regular intervals of time is needed before a great deal of light can be thrown on the problem of seasonal variation of the fauna in streams like the upper part

of the Wharfe. There is such a great variation in the nature of the bed, which directly affects the constitution and density of the fauna, that samples taken at adjacent places and at the same time are of no use for drawing more than the most general conclusions. Such conclusions are that the various types of stream bed can be approximately classified according to their structure and the fauna, and that the variation in numbers of organisms is due in part, at any rate, to the nature of the life cycle, to the effect of temperature and to the amount of rainfall both during the previous breeding season and at other times. The last factor determines the amount of flooding, of erosion and general disturbance of the river bed. That the bed is disturbed has been determined on several occasions at Grassington and Pool when *Baetis* nymphs, Helminae, Chironomidae, *Limnaea peregra*, *Paludestrina jenkinsi*, *Sericostoma personatum*, as well as terrestrial insects were taken in a coarse tow-net at the surface. At the rise of the stream there is a shifting of the less stable stones and a tearing off of moss, and consequently very many organisms, which normally find shelter, are thrown out and carried away to be deposited further down stream when the current slackens.

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Appendix A.

Faunistic list.

This list includes all stages in the life cycle.
+ indicates that specimens have been taken at that station.

	Grassington	Pool	Harewood Bridge	Collingham Bridge	Ulleskelf
Mollusca.					
Ancylus fluviatilis (O.F.M.) ...	+	+	.	+	.
Limnaea peregra (O.F.M.)	+	+	.	.	+
Physa fontinalis (L.)	.	+	.	.	+
Planorbis contortus (L.)	.	+	.	.	.
Valvata piscinalis (O.F.M.) ...	.	.	.	.	+
Paludestrina jenkinsi Smith ...	+	+	+	.	.
Neritella fluviatilis (L.)	.	+	.	+	.
Sphaerium corneum (L.)	.	+	.	.	+
Pisidium nitidum Jenyns	.	+	.	.	+
P. subtruncatum Malm.	.	+	.	.	+
P. amnicum (O.F.M.)	.	+	.	.	+
P. casertanum (Poli)	.	+	.	.	+
P. henslowianum (Sheppard) ...	.	+	.	.	+
Diptera.					
Chironomidae: Chironomus, Orthocladiariae, Tanytarsus, Tanypus	+	+	+	+	+
Chironomidae: Ceratopogon	+	.	+	.	.

	Grassington	Pool	Harewood Bridge	Collingham Bridge	Ulleskelf
DIPTERA (*continued*).					
Pericoma sp.	.	+	.	.	.
Dicranota sp.	+	+	+	.	.
Tipula sp.	.	+	.	.	.
Simulium latipes Mg.	+	.	.	.	.
S. reptans L.	+	.	.	+	.
S. equinum L.	.	+	.	.	.
Hexatoma sp.	+	+	+	+	.
Atherix sp.	.	.	.	+	.
Calliophrys riparia (Fall.)	.	+	.	.	.
Clinocera sp.	+	.	+	.	.
Hemerodromia sp.	+	.	+	.	.
COLEOPTERA.					
Brychius glabratus	+	.	.	.	+
Hydroporus rivalis Gyll.	+	.	.	.	.
Deronectes depressus F.	.	+	.	.	+
Cercyon sp.	.	+	.	.	.
Limnius tuberculatus Müll.	.	+	+	+	.
Esolus parallelepipedus Müll.	+	+	+	.	.
Latelmis volkmari Panz.	+	+	.	+	.
Helmis aeneus Müll.	+	+	+	.	.
Riolus cupreus Müll.	+	.	.	.	.
TRICHOPTERA.					
Rhyacophila dorsalis Curt.	+	+	+	+	.
Glossosoma vernale Pict.	+	+	+	+	.
Agapetus fuscipes Curt.	+	+	+	+	.
A. comatus Pict.	+	.	.	.	.
Hydroptila sp.	+	+	+	+	.
Ithytrichia lamellaris Eaton	+	+	+	.	.
Philopotamus montanus Donov.	.	.	+	.	.
Polycentropus flavomaculatus Pict.	+	+	+	+	.
Cyrnus trimaculatus Curt.	+	.	.	.	.
Tinodes waeneri L.	+	+	+	.	.
Psychomyia pusilla Fbr.	+	+	.	+	.
Hydropsyche lepida Pict. ? sp.	.	.	+	.	.
H. angustipennis Curt.	+	.	+	.	.
H. instabilis Curt. ? sp.	+	+	+	.	.
Leptocerus annulicornis Steph.	.	.	.	.	+
L. cinereus Curt.	+	+	+	+	.
Mystacides nigra L.	+	+	.	.	+
Limnophilus lunatus Curt.	.	+	.	.	.
L. rhombicus L.	.	+	.	.	.
L. fuscicornis Ramb.	.	+	.	.	.
Stenophylax stellatus Curt. ? sp.	.	+	.	.	.
Micropterna sequax Mc Lach.	+	.	.	.	.
Halesus digitatus Schrk.	.	+	.	.	.
H. auricollis Pict.	+	+	.	+	.
Ecclisopteryx guttulata Pict.	.	.	.	+	.
Goera pilosa Fbr.	+	+	.	+	.
Silo pallipes Fbr.	+	.	.	.	.
Lepidostoma hirtum Fab.	+	+	+	+	.
Sericostoma personatum Spence	+	.	.	.	.
PLANIPENNIA.					
Sialis flavilatera L. (lutaria Fbr.)	.	+	.	.	.
EPHEMEROPTERA.					
Ephemera danica Müll.	+	+	+	+	.
Leptophlebia cincta Retz	.	.	+	.	.
Ephemerella ignita Poda	+	+	+	+	+ 1 spm.
E. notata Etn.	+	+	+	+	.
Caenis rivulorum Etn.	+	+	+	+	.
Baetis binoculatus L.	+	+	+	+	.

	Grassington	Pool	Harewood Bridge	Collingham Bridge	Ulleskelf
EPHEMEROPTERA (*continued*).					
Baetis pumilus Burm.	+	+	+	+	.
B. rhodani Pict.	+	+	+	+	.
Centroptilum luteolum Müll. ...	+	+	.	.	.
Cloeon rufulum Müll.	.	.	+	+	.
Rhithrogena semicolorata Curt. ...	+	+	+	+	.
Heptagenia sulphurea Müll. ...	.	+	+	+	.
Ecdyurus venosus Fab.	+	+	+	+	.
PLECOPTERA.					
Perlodes mortoni Klp.	+	+	+	+	.
Perla cephalotes Curt.	+	+	.	+	.
P. carlukiana Klp.	+	+	.	+	.
Chloroperla grammatica Scop. ...	+	+	+	+	.
Isopteryx torrentium Pict. ...	+	+	+	+	.
I. tripunctata Scop.	+	+	+	+	.
Taeniopteryx risi Mort.	.	+	.	.	.
Nephelopteryx nebulosa L. ...	+	+	.	.	.
Leuctra geniculata Steph.	+	+	+	+	.
L. klapaleki Kmpny.	+	+	+	+	.
L. hippopus Kmpny.	+	+	+	+	.
L. inermis Kmpny.	.	+	.	.	.
Amphinemura cinerea Oliv. ...	+	+	.	.	.
Protonemura meyeri Pict.	+	.	.	.	.
HYDRACARINA.					
Protzia eximia (Protz.)	+	.	.	.	.
Sperchon brevirostris Koen. ...	+	+	.	.	.
S. tenuabilis Koen.	+	+	+	+	.
S. denticulatus Koen.	.	+	.	.	.
S. clupeifer Piers.	+	+	.	.	.
Aturus scaber Kram.	+	+	+	.	.
Pseudosperchon verrucosus (Protz.)	+	.	+	+	.
Midea orbiculata (O.F.M.)	+	.	.	.	.
Lebertia celtica Sig. Thor.	+	.	.	.	.
L. porosa Sig. Thor.	+	+	+	.	+
L. stigmatifera Sig. Thor.	.	.	+	.	.
Atractides anomalus C. L. Koch ...	+	+	+	+	.
Hygrobates longipalpis (Herm.) ...	+	+	.	.	+
H. naicus (Johnst.)	+	+	.	.	.
H. nigromaculatus Lebert	+	+	+	.	.
H. calliger Piers.	+	.	.	.	.
Megapus spinipes (C. L. Koch) ...	+	+	.	.	.
M. octoporus Piers.	.	.	+	.	.
Notaspis lacustris	+	.	.	.	.
CRUSTACEA.					
Gammarus pulex (L.)	+	+	+	+	+
Daphnia longispina O.F.M. ...	+	.	+	.	.
Bosmina longirostris (O.F.M.) ...	.	.	+	.	.
Canthocamptus zschokkei Schmeil.	+	.	+	.	.
HIRUDINEA.					
Piscicola geometra L.	.	+	.	.	.
Glossosiphonia complanata L. ...	+	+	.	.	+
Helobdella stagnalis L.	+	+	.	.	+
Herpobdella atomaria Carena ...	+	+	.	.	+
OLIGOCHAETA.					
Eiseniella tetraedra Sav.	+	+	+	+	.
Lumbriculus variegatus	.	+	.	.	+
Rhynchelmis sp.	.	+	.	.	.
Tubifex? albicola Mchlsn.	+	.	.	.	.
T. barbatus Grube	.	+	.	.	.
T. tubifex Müll.	.	.	.	.	+
Paranais naidina Bretscher ...	.	+	.	.	.
Nais elinguis	+	+	+	+	.
Chaetogaster diaphanus Gruith. ...	.	+	.	.	+

	Grassington	Pool	Harewood Bridge	Collingham Bridge	Ulleskelf
TRICLADIDA.					
Dendrocoelum lacteum (Müll.) ...	.	+	.	.	.
Planaria polychroa O. Schm.	.	.	.	.	+
Polycelis cornuta (Johnson) ...	.	+	+	.	+
HYDROZOA.					
Hydra oligactis Pall.	+	+	.	.	+
PORIFERA.					
Ephydatia fluviatilis (L.)	.	+	.	+	+

APPENDIX B.

Table showing the stages in the life cycle of the commoner forms taken during various months of the year.

A. = Adult. B. = With buds. E = Eggs. G. = Gemmules. J. = Juveniles (retained by 0·5 mm. sieve and not exceeding 3 mm. in length). L. = Larva. M. = Imago. N. = Nymph. P. = Pupa.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Ancylus	—	—	—	—	—	—	J.	—	—	—	—	—
Limnaea	J.	—	J.	—	—	E.J.	J.	E.	—	J.	—	—
Physa	—	—	—	—	—	—	—	—	—	E.J.	—	—
Neritella	—	—	—	—	—	—	—	—	—	E.J.	—	—
Chironomidae... ...	—	P.	L.P.	J.L.P.	—	E.J.L.P.	E.J.L.P.	—	—	J.L.P.	J.L.	L.
Simulium	—	L.	—	—	L.P.	L.P.	L.P.	—	—	J.	—	—
Hexatoma	L.	L.	—	L.	—	L.P.	L.P.	—	—	J.L.	—	L.
Calliophrys	—	L.	—	—	—	—	—	—	—	—	L.	—
Clinocera	—	—	—	—	—	L.	—	—	L.	—	—	—
Hemerodromia ...	—	—	—	—	—	L.P.	—	—	L.P.	—	—	—
Rhyacophila	J.	J.	—	—	L.P.	J.L.	L.	—	—	J.	—	J.
Glossosoma	P.	—	L.P.	—	—	—	L.P.	—	—	J.L.P.	J.	L.
Agapetus	—	—	L.	L.P.	L.P.	J.L.P.	L.P.	—	—	J.	J.	L.
Polycentropus ...	J.L.	J.L.	L.	—	—	L.	L.	—	—	J.	J.L.	L.
Tinodes	—	—	—	L.	—	—	—	—	—	J.L.	—	L.
Psychomyia	—	J.	—	L.	L.	J.L.	—	—	—	J.L.	—	—
Hydropsyche instabilis (?)	—	J.	—	—	L.	L.P.	L.	—	—	J.	—	L.
Leptocerus cinereus ...	J.	J.	—	L.	L.	J.	J.L.P.	—	—	J.	J.	—
Lepidostoma	J.	J.	—	L.	—	—	L.P.	—	—	J.	J.	L.
Ephemera danica ...	J.N.	N.	N.	N.	N.M.	N.M.	N.	—	—	J.	J.	J.
Ephemerella ignita ...	—	J.	J.N.	—	N.	J.	N.	—	—	J.N.	—	—
Caenis rivulorum ...	J.	J.	N.	—	—	M.	N.M.	—	N.	J.	—	—
Baetis	J.N.	J.N.	J.N.	—	—	J.N.M.	N.	—	—	J.N.	J.	—
Rhithrogena	—	—	N.	—	N.	—	—	—	—	J.	—	—
Heptagenia	—	—	N.	—	N.	—	—	—	—	—	—	—
Ecdyurus	N.	—	N.	—	N.	—	—	—	—	J.	—	—
Gammarus	—	—	—	—	—	J.A.	—	—	—	J.A.	—	—
Perla	—	—	N.	—	N.	—	E.J.	J.	—	J.	—	—
Chloroperla	—	—	N.	—	—	N.M.	—	—	—	J.	—	—
Leuctra	J.	J.N.	J.N.	N.	N.	N.	N.	N.	N.	J.M.	J.	J.
Amphinemura ...	—	—	N.	—	—	—	J.	—	—	J.	J.	—
Glossosiphonia ...	—	—	—	—	E.J.	J.	—	—	—	—	—	—
Herpobdella	—	—	—	—	—	E.J.	—	—	—	—	—	—
Eiseniella	E.	—	—	—	—	E.	—	—	—	—	—	—
Nais	—	—	—	—	J.	J.	J.	J.	—	—	—	—
Hydra...	—	—	—	—	B.	B.	B.	B.	B.	B.	—	—
Ephydatia	G.	G.	G.	G.A.	A.	A.	A.	A.	A.	G.	G.	G.

Appendix C.

(i) *Analysis of typical sample from region of loose stones.*

Grassington, 17. iii. 27. Midstream, egg-size stones, no moss. Depth of water 13 in. Rate of flow at surface 12·3 ft. per sec. Area sampled 8 sq. dcm.

	No. of specimens taken in 8 sq. dcm.		No. of specimens per sq. dcm.		Percentages	
Diptera	15		1·86		21·97	
Chironomidae		14		1·75		20·5
Dicranota		1		0·11		1·47
Coleoptera	10		1·22		14·67	
Undetermined		10		1·22		14·67
Trichoptera	26		3·22		38·3	
Glossosoma vernale ...		4		0·5		5·9
Agapetus fuscipes ...		17		2·1		25·0
Lepidostoma hirtum ...		5		0·62		7·4
Ephemeroptera	12		1·5		17·6	
Baetis sp.		6		0·75		8·8
Rhithrogena semicolorata		6		0·75		8·8
Plecoptera	2		0·25		2·95	
Leuctra sp.		2		0·25		2·95
Hydracarina	3		0·37		4·4	
Undetermined		3		0·37		4·4
		68		8·42		99·89

(ii) *Analysis of typical sample from region of cemented stones.*

Grassington, 18. viii. 26. Immovable large stones, some sand. Area sampled 4 sq. dcm.

	No. of specimens taken in 4 sq. dcm.		No. of specimens per sq. dcm.		Percentages	
Mollusca	14		3·5		6·05	
Ancylus fluviatilis		13		3·25		5·62
Limnaea peregra		1		0·25		0·43
Diptera	13		3·25		5·62	
Chironomidae...		11		2·75		4·76
Hexatoma		2		0·5		0·86
Coleoptera	15		3·75		6·48	
Undetermined		15		3·75		6·48
Trichoptera	157		39·2		67·88	
Rhyacophila dorsalis... ...		1		0·25		0·43
Agapetus fuscipes		109		27·2		47·2
Hydroptila femoralis... ...		2		0·5		0·86
Ithytrichia lamellaris ...		1		0·25		0·43
Polycentropus flavomaculatus		12		3		5·16
Psychomyia pusilla		20		5		8·6
Leptocerus cinereus		3		0·75		1·3
Lepidostoma hirtum ...		7		1·75		3·04
Sericostoma personatum ...		2		0·5		0·86
Ephemeroptera	17		4·25		7·35	
Ephemerella ignita		8		2		3·46
Baetis sp.		1		0·25		0·43
Ecdyurus venosus		8		2		3·46
Plecoptera	3		0·75		1·3	
Leuctra		3		0·75		1·3
Hydracarina	4		1		1·72	
Undetermined		4		1		1·72
Crustacea	6		1·5		2·6	
Daphnia longispina		6		1·5		2·6
Oligochaeta	2		0·5		0·86	
Eiseniella tetraedra		1		0·25		0·43
Undetermined		1		0·25		0·43
	231		57·7		99·86	

(iii) *Analysis of typical sample from region of stones covered with* Cladophora.

Pool Bridge, 23. vi. 26. Handful of *Cladophora* on stone. Similar types of river bed around. Coarse and fine sand present.

	No. of specimens		Percentages	
MOLLUSCA	1021		41·02	
Prosobranchs ...		6		0·24
Limnaea peregra Ad.		13		40·7
Many small		1000		
Sphaerium sp. ...		2		0·08
DIPTERA	1131		45·54	
Chironomidae ...		1130		45·5
Tipulid larva ...		1		0·04
COLEOPTERA	5		0·22	
Larvae and adults ...		5		0·22
TRICHOPTERA	7		0·28	
Hydroptila sp. ...		2		0·08
Leptocerus cinereus...		2		0·08
Limnophilus lunatus		1		0·04
Lepidostoma hirtum		2		0·08
EPHEMEROPTERA ...	61		2·49	
Ephemerella ignita ...		60		2·45
Caenis rivulorum ...		1		0·04
HYDRACARINA	5		0·22	
Undetermined ...		5		0·22
CRUSTACEA	15		0·66	
Gammarus pulex ...		15		0·66
HIRUDINEA	5		0·22	
Herpobdella atomaria		5		0·22
OLIGOCHAETA	221		9·04	
Tubificidae		1		0·04
Nais spp.		170		6·8
Chaetogaster (about)		50		2·2
TRICLADIDA	5		0·22	
Polycelis cornuta ...		5		0·22
		2476		99·91

(iv) *Analysis of typical sample from region of loose moss.*

Grassington 21. vii. 26. From two mossy boulders with some sand.

	No. of specimens		Percentages	
MOLLUSCA	14		7·0	
Ancylus fluviatilis		12		6·0
Limnaea peregra and egg masses		2		1·0
DIPTERA	73		36·6	
Chironomidae...		73		36·6
COLEOPTERA	13		6·5	
Larvae and pupae		13		6·5
TRICHOPTERA	41		20·5	
Agapetus fuscipes		3		1·5
Polycentropus flavomaculatus		9		4·5
Psychomyia pusilla		4		2·0
Leptocerus cinerus, pupae ...		2		1·0
Lepidostoma hirtum (l. and p.)		23		11·5
EPHEMEROPTERA	31		15·5	
Ephemerella ignita		25		12·5
Baetis sp.		5		2·5
Ecdyurus venosus		1		0·5
PLECOPTERA	3		1·5	
Leuctra sp.		3		1·5
HYDRACARINA	9		4·5	
Undetermined		9		4·5
SPIDER	1	1	0·5	0·5
CRUSTACEA	14		7·0	
Ostracoda		14		7·0
OLIGOCHAETA	—		—	
Nais, traces		—		—
		199		99·6

(v) *Analysis of typical sample from region of thick moss.*

Harewood Bridge 9. vi. 26. Middle of south arch, downstream side. Moss chiefly *Eurhynchium rusciforme*. Area covered by sample 9 sq. in.

	No. of specimens taken in 9 sq. in.		No. of specimens per sq. dcm.		Percentages
DIPTERA	1800		3200		21·84
Chironomidae, l. and p. ...		1800		3200	21·84
COLEOPTERA	709		1260		8·61
Elmis (larvae)		700		1244	8·5
Adults (undetermined) ...		9		16	0·11
TRICHOPTERA	173		307·3		2·09
Rhyacophila dorsalis... ...		9		16	0·11
Ithytrichia lamellaris ...		9		16	0·11
Philopotamus montanus ...		16		28·4	0·2
Polycentropus flavomaculatus		4		7·1	0·04
Hydropsyche lepida (?) ...		1		1·8	0·01
H. instabilis (?)		134		238	1·62
EPHEMEROPTERA	119		212		1·44
Ephemerella ignita		110		196	1·33
Baetis sp.		9		16	0·11
PLECOPTERA	1		1·8		0·01
Leuctra sp.		1		1·8	0·01
HYDRACARINA	700		1244		8·5
Undetermined		700		1244	8·5
CRUSTACEA	15		26·7		0·18
Gammarus pulex		15		26·7	0·18
Large no. of Harpactids and Cladocera not included (over 11,000)					
OLIGOCHAETA	4702		8358·6		57·02
Eiseniella tetraedra		2		3·6	0·02
Nais spp.		4700		8355	57
TRICLADIDA	21		37·3		0·25
Polycelis cornuta		21		37·3	0·25
		8240		14,647·7	99·94