Some aspects of the ecology of ephemeropteran larvae in the Rivers Deerness and Wear, Co Durham

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Ephemeropteran larvae

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Contents

Introduction

1. Introduction

Investigations of river fauna show Mayfly larvae to be a very important group in the rivers of N.E. England. They play a considerable part in the energy turnover and food webs found in fresh water, as they are known to be consumers of primary production (mainly in the form of algae) and of detritus (Jones, 1950 and Brown, 1961). In turn these animals as larvae and as adults provide a valuable source of food for carnivores. The relationships between feeding fish and the emergence of Mayflies has long been studied by those interested in fly fishing. Consequently local knowledge of adult Mayflies and their habits is often well documented but far less is known regarding the larval life in particular rivers.

The larvae take varying lengths of time to mature, undergo different numbers of ecdyses and grow to variable sizes (even within the same species) before emerging as adult flies. This variability is known to be partially if not wholly temperature dependent (Harris, 1956). Records of life histories of the same species show variability in different rivers of the British Isles. Harker, (1952) showed *Ecdyonurus torrentis* in one river to have three generations in two years, whilst Macan, (1957) has shown *E. torrentis* larvae, in another river, to have only one generation per year.

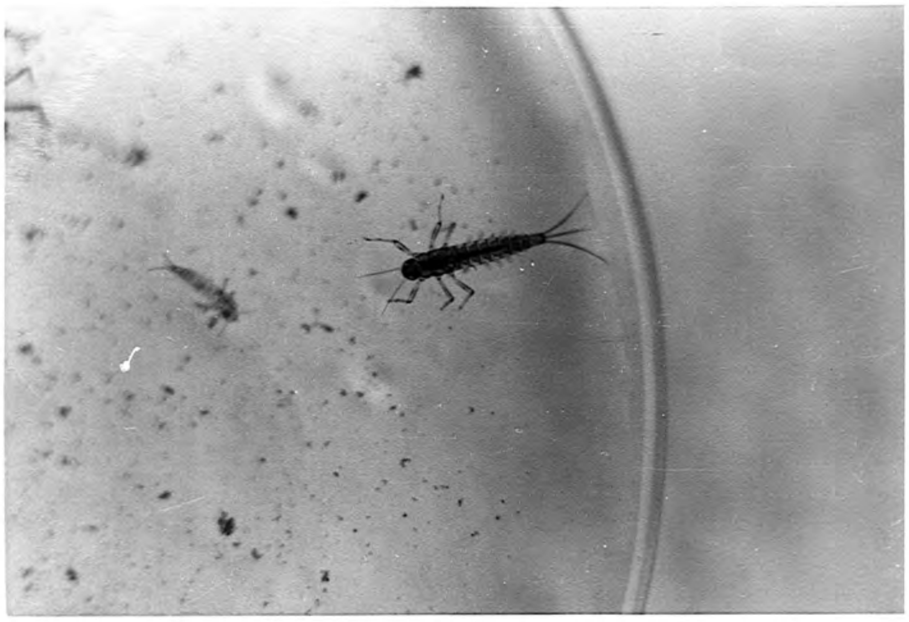
Three aspects of the ecology of Ephemeropheran larvae were examined closely in this study. Firstly by means of sequential sampling, the changes in the numbers and sizes of larvae were investigated to ascertain their growth pattern; secondly the change in biomass of certain species was investigated by dry weight measurements and thirdly an attempt was made to determine the food intake of the genus with the highest numbers of larvae present.

The study was made from spring to midsummer, (the time allocated on the course at Durham). This time restriction limited the full investigation of the problems encountered but the results obtained show the patterns of the life histories, and the growth of the animals in two different rivers.

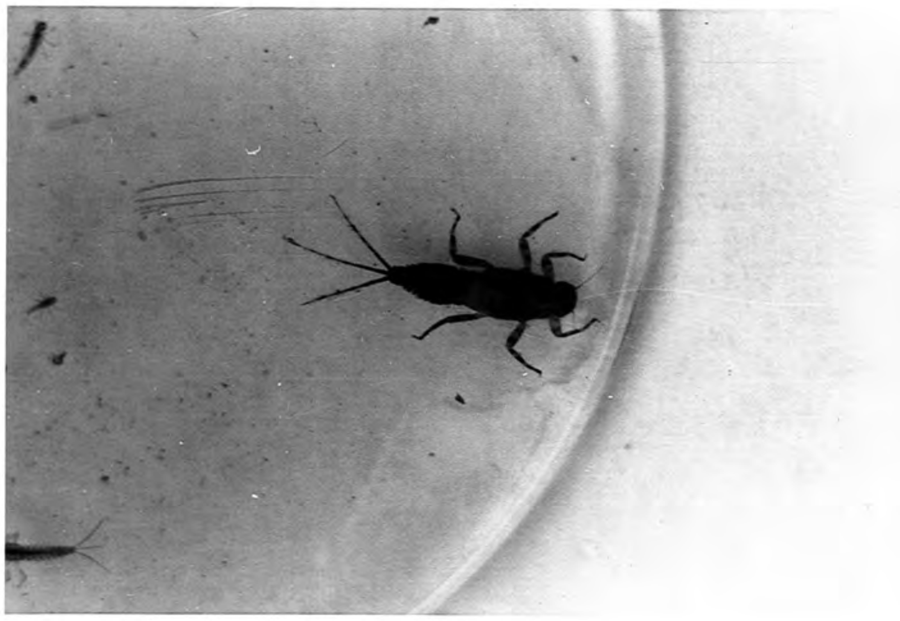
Two rivers, fairly typical of N.E. England, were chosen for the study - the large and often turbulent River Wear and the quieter River Deerness with its smaller volume of water.

Collection of material from the rivers for investigation into the numbers and lengths of animals, was fairly straightforward but certain sampling problems were experienced, due to the varying state of the water in the rivers. Difficulties were also experienced in keeping animals alive for laboratory experiments. Given more time, more of the initial problems would probably have been resolved and different techniques found for keeping specimens alive. Early ideas on feeding experiments had to be abandoned as the animals did not eat proffered food, so gut analysis was used in an attempt to determine quantities and types of food eaten by Baetis larvae. The results for B. rhodani were obtained after Dr. Macan (of the Freshwater Biological Association) informed me of the work of D.S. Brown, (1959) on the food of the larvae of B. rhodani. A comparison of results for feeding was then to some extent possible.

Previously, little work appears to have been carried out on Ephemeropteran larvae in the rivers of County Durham but this study enables some light to be thrown on the ecology of these animals in this area and also provides data upon which further work could be based.



1· Young *Baetis* larva x 3



2 *Ephemerella ignita* x 3

1.1. Species Studied

The animals studied in this project were only those mayfly larvae caught by lifting stones in fresh water rivers, consequently larvae living in other habitats such as in weed were not collected and hence were not recorded.

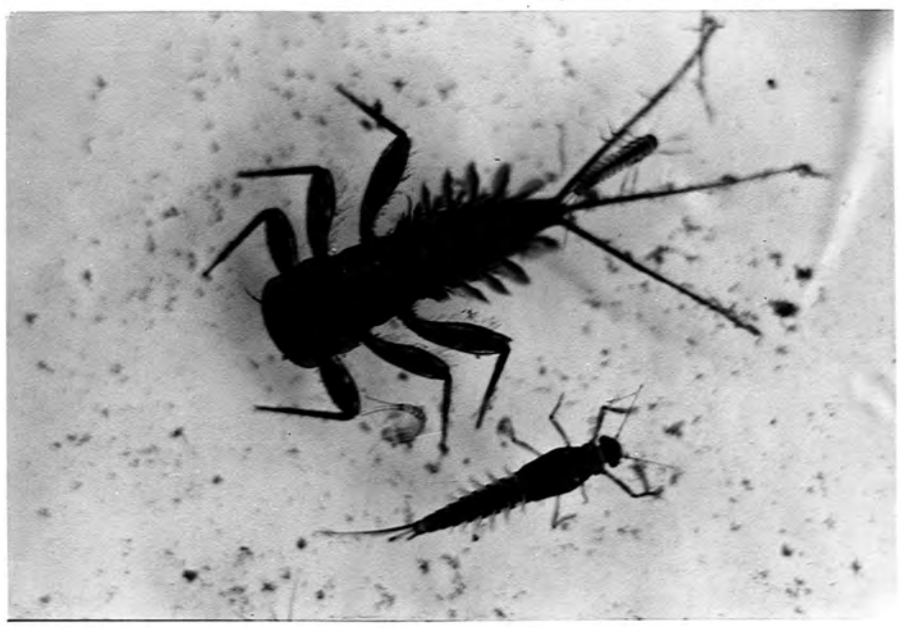
Baetis scambus. Etn. This species is referred to in the text as *Baetis A*., it is the most common species in the rivers particularly in early June. The larva is very similar to *B. fuscatus* (L) but identification at the adult stage (Table 12.) enables a definite verification to be made.

Baetis muticus (Linn.) and *Baetis rhodani* (Pict.) Small specimens of these two species were found difficult to distinguish and for most numerical purposes in this study the two species have been put together as *Baetis B*. In actual fact most were *B. rhodani* and in the latter part of the study during the gut analysis careful separation and identification of specimens was made before the larvae were used.

Ecdyonurus torrentis. Kimmins. Small larvae of Ecdyonurus are difficult to separate into species as the backward projections of the pronotum (used to separate the species) are not present on small larvae. Larger larvae collected were all found to be *E. torrentis*. The identification was verified at the F.B.A. Laboratory.

Ephemerella ignita. (Poda) This larval form is readily distinguished by its characteristic shape. It has a pinched 'waist' and the striped tails separate it from *E. notata* with uniformly pigmented tails. Only *E. ignita* was found in this study.

The adult of this species has three tails - all the other species found produced adults with two tails.



3. Ecdyonurus & emerging Baetis x 2-5

4. Baetis subimago - 30secs after emergence.

Rithrogena semi colorata. (Curt.) The larvae of this species have a flattened appearance and at first closely resemble those of Ecdyonurus but the pronotum has no backward projections and the first gill on each side is very large - meeting on the ventral side of the body.

Caenis rivulorum. Etn. Only a few specimens were found. The genus has a flap on each side of the body covering the gills - so that at first glance the animals appear to have two pairs of wing cases.

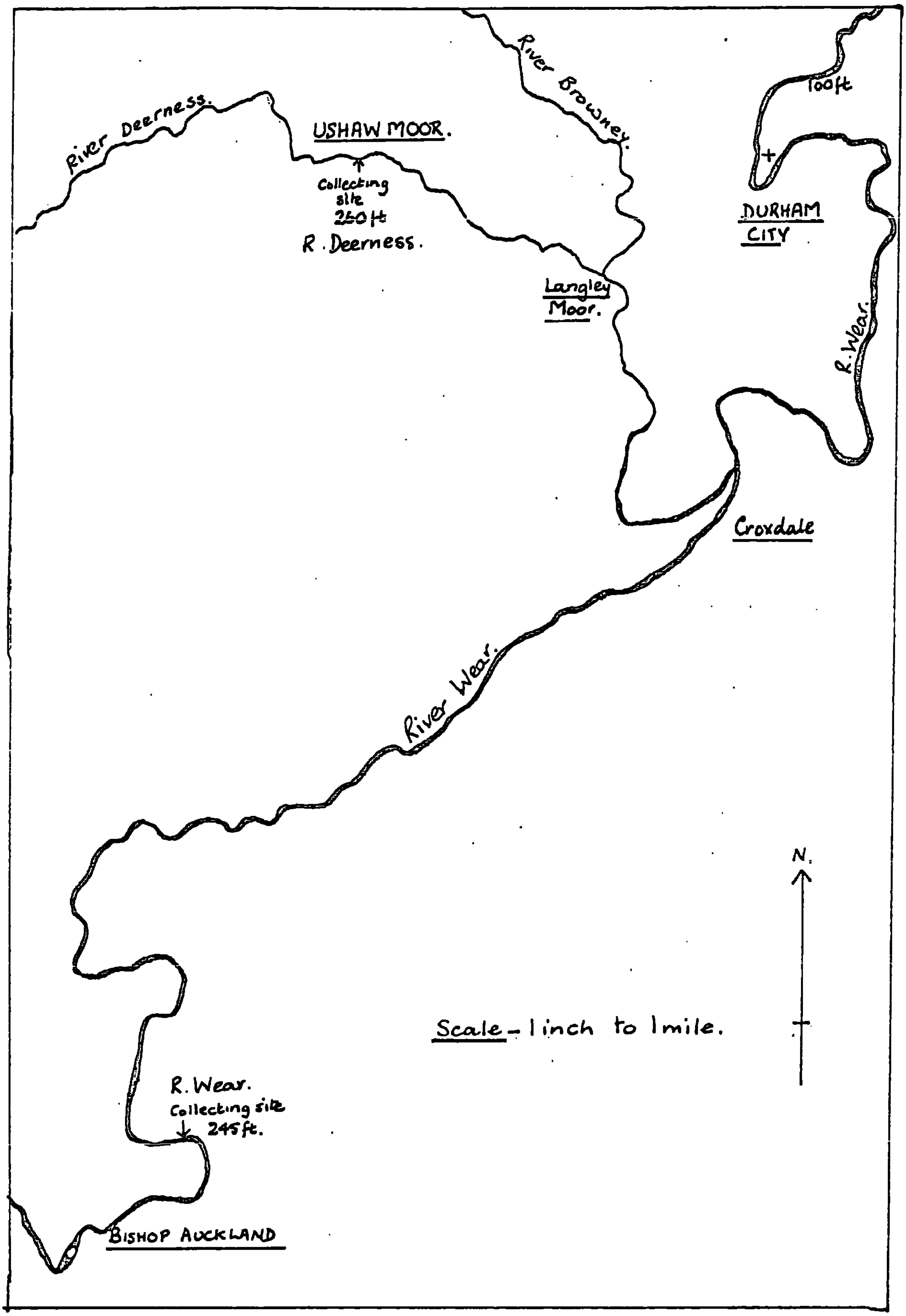
The photographs illustrate the main genera found and the phases through which the animals grow. At first the larvae have no external wing cases (as seen in photograph 1.), later they develop wing cases, (photographs 2 and 3); and then the wing cases become darkly pigmented just before the animal emerges - (Baetis larva on photograph 3). The change from larva to subimago is dramatic and in the case of the Baetis specimen in the photograph very fast. The back of the animal split open and the subimago emerged and flew all within three minutes.

At this stage the subimago is dull in colour (and known to fishermen as a dun). The ability to fly and the length of time before its final moult into the full imago varies with species. As can be seen from the results (Table 12) the final moult takes place usually within 24 hours. The final adult is more brightly coloured and of a shiny appearance - the wings also glisten - (photograph 5). Anglers refer to the fully adult fly as the 'spinner'.

It is at the time of the emergence of the larva as a sub imago that the greatest predation of mayflies by fish takes place. The eating of the subimago affects the next generation but the removal of spent spinners (after egg laying) by fish does not affect the population as these animals are already dying.

5. Imago of Ecdyonurus ×3/4.

Of the animals collected in this study, those not required for numerical and other data were kept in an aquarium for observation of their activity and behaviour. Emerging flies were trapped and kept as specimens - a list can be found in the appendix (Table 12). These specimens were used to confirm the species present particularly in the case of B. scambus.



Sketch map to show relative positions of collecting sites and their altitudes.

1·2 Description of Study sites on the Rivers Deerness and Wear

River Deerness

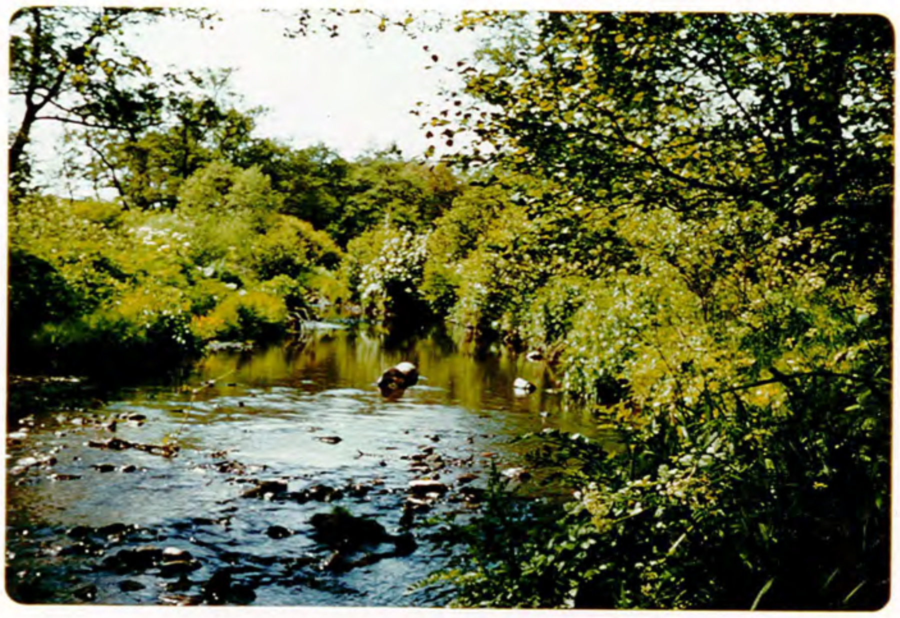
The sampling area on this river was 100 metre stretch (Grid ref. NZ.227423) near to a village - Ushaw Moor, where there have been extensive mine workings. Remains of colliery waste and the tip, produce a run off of water heavily polluted with metallic waste.

The river, narrow compared with the River Wear flows into the River Browney about 1 mile S.W. of Durham City. The River Browney flows into the River Wear near Croxdale, so the water from the Deerness finally flows into the Wear about 5 miles from the collecting site, (-see sketch map).

The water at all times (during the project) flowed with speed in the fast stretches but when the river was low the slow stretches dried up near the edges. Silting of the sluggish areas took place when the river was low, producing a muddy bottom but in fast stretches the stones were always free from silt.

Sampling was carried out at three points along the 100 metre stretch (altitude 260ft. above mean sea level) where the water showed definite differences in speed of flow. The changes in speed are partly due to the meandering nature of the river - the fast stretches wearing away the bank and being relatively narrow, whilst round the bend the river dramatically slowed its pace, this stretch can be seen in photograph 6. Vegetation on the banks was very thick and in places overhanging; casting varying amounts of shade over the three sites, (slow, medium and fast speeds of water).

These sites were visited each time that samples were obtained, care being taken to replace lifted stones in the same position after removal of



6 - The River Deerness.

7 - The River Wear.

animals. In this way variation in the habitat was not increased due to removal of the original stones by sampling.

Stones in sample squares of 50 x 50cm. were counted to show the average numbers of stones for each site. For the actual collection of animals only stones easily lifted by hand and approximately 10 x 10cm. or larger were used.

Animals for gut analysis and for comparative weight data were collected from the River Deerness - the site being near enough to the laboratory in Durham for quick processing.

River Wear

The sampling area on this river was 100 metre stretch (grid ref. NZ.201311) near to the town of Bishop Auckland. Another site on the river at Durham was initially sampled but here there was much interference, by young boys fishing the stretch and by a profuse growth of filamentous green algae. The Durham site was therefore abandoned and the Bishop Auckland site soley used for collection of River Wear animals.

At this site (altitude 245ft.) the river is comparatively wide, and free from overhanging vegetation (photograph 7). Projections have been built into the river, narrowing it and increasing the speed of the water flowing past at these points.

As with the Deerness the slowest edges of the Wear dried up and sampling was not always possible. At times of flooding, standing in the river was impossible and the height of the water prevented collection of samples.

Gut analysis was not carried out on any of the animals from this site (it being more than 20 mins. away by car from the laboratory). Analysis of stone size was carried out here as at the Deerness site, but the river flowed over large boulders and smaller stones were seen to be moved when the river was in spate. Results of 50 x 50cm. square sampling therefore only reflect the sample on the day on which it was made and cannot be considered accurate enough for analysis, (due to movement of stones). The results are given in the appendix (Tables **23**.).

The River Wear flows North from the Bishop Auckland site and about 10 miles along its course the water from the Deerness flows into it, via the Browney. Migration of animals from one site to the other is therefore quite possible. Macan (1957) shows that Ephemeropteran larvae migrate - so the populations at the two sites may not be discrete.

2. Methods used for collection and investigation of material

2. Methods used in the Study

2.1 River Data

As it was considered important to make measurements of factors which might influence the habitat of the animals, records were kept of the state of the rivers etc.

On each sample date

- temperature recordings were made of the river water.
- subjective assessments of the state of the river were made and noted.
- growth of vegetation and interference by humans was also noted.

On one occasion when the rivers were moderately high, measurements of rate of flow were made at each site, and the width at each site was measured. The results of these measurements and recordings can be found in Tables 9, 10 and 23 .

Investigation of stone size and number of animals per stone was made early in the project (Table 11) but there appeared to be no relationship. From observations made whilst collecting, it became apparent that texture, mineral content, colour and the number of crevices influence the numbers of animals found on a stone. Use of standardized stones of known properties would make an interesting line for further study.

2.2 Method used for collection and counting of animals for size and number analysis

Three sampling points were selected at each site where the water flowed at different speeds. These were slow, medium and fast. At times it was not possible to collect from certain of these sites owing to the state of the river. As far as possible the samples were taken at fortnightly intervals.

At each point samples were collected as follows. A stone was lifted and swiftly put into a bucket (which was held between the legs). The bucket was tipped to allow water in at the same time as the stone was placed in and any animals falling off were thus caught. Animals still adhering to the stone were carefully swilled off using a wash bottle. The stones were replaced on the river bed. Twenty stones at each point were sampled and the catches put into separately labelled pots. This provided sixty stone catches per river per visit. (On occasions only half this number were sampled.)

The pots containing the samples were brought back to the laboratory, excess river water was drained off and the animals killed and preserved using 70% alcohol. They were then sorted into genera and subsorted into sizes.

Measurement of the larvae was taken from the anterior end of the head to the posterior end of the abdomen (tails not included). They were sorted into size classes of 1mm. starting at 1.5mm. (Those smaller than 1.5mm were not counted.) The following size classes were measured and the animals recorded as follows:-

1.5 - 2.4mm	Animals recorded as 2mm
2.5 - 3.4mm	" " " 3mm
3.5 - 4.4mm	" " " 4mm
etc.	etc.

The largest size class was 15.5 - 16.4mm, reached by some *Ecdyonurus* larvae.

A binocular microscope was used for this measuring and a millimetre scale was fixed to the stage so that each animal could be placed on a glass slide and viewed directly above the scale. The animals were identified at the same time as their length was measured. Each species of animal (after it had been sorted and measured), was stored in a separate labelled tube for each sample.

2.3. Method used for collecting and keeping animals used for laboratory experiments

Special trips were made to the river when animals were required for laboratory experiments - they were collected by lifting stones and shaking off the animals carefully in water in a pie dish. They were then transferred to plastic topped jars and these were half filled to allow a good air space above the water. The animals were then transported as fast as possible back to the laboratory.

Animals to be kept in the aquarium were kept in their pots which were floated on the aquarium water until the temperatures had equalized - they were then allowed to swim out into the aquarium water. The aquariums had air pumped through the water constantly, but no method was used to control the temperature. A net was placed over the top and emerging subimagos were able to cling to this whilst changing into full adults.

Other animals that were needed for experimental work were kept in pots of aerated river water in the constant temperature room (at 15°C) until required.

2.4 Method used for determining the dry weights of larvae

A preliminary experiment was carried out to determine both wet and dry weights of captured animals. Due to adhesion of water to the animals, wet weights were found to vary whilst dry weights were constant.

Animals were then collected (from the Deerness) specifically for dry weighing; sorted into species and separated into size classes. Numbers of each size class 2, 4, 6 etc. mm. were then put into porcelain crucibles and heated to 105°C for 2 hours. They were then weighed, re-dried and re-weighed to constant weight. The weight of individual animals (Table 13.) was then obtained by dividing the actual weight by the number of animals weighed for each size class.

2.5 Diatom Counts

Preparation of gut contents and method of counting

Freshly caught nymphs were brought back to the laboratory - they were then measured and decapitated. (From catching to killing took approximately half an hour.)

The gut of each was removed under a binocular microscope and separately immersed in 5% sodium hydroxide in a Durham tube (the capacity of which had previously been measured). Tubes were then incubated at 100°C for 15 minutes. The resultant mixture was well mixed and the level again made up to the full capacity of the tube using distilled water and a small quantity of aqueous methylene blue.

Small quantities of well mixed gut sample were mounted onto a haemocytometer slide using a fresh micropipette tube for each specimen. Counts of diatoms lying within the grid of the haemocytometer slide were taken - five separate sample counts being made for each specimen.

When gut contents were examined without sodium hydroxide treatment the diatoms were difficult to distinguish from the other organic particles present, and partially digested plant remains were not easily identifiable. After treatment with sodium hydroxide, the diatoms and resistant forms of filamentous algae were clearly visible in the liquid when viewed under high power.

Animals which were kept alive for sometime before gut analysis were found to have defaecated large quantities of their gut contents and some of this was undigested; - live diatoms were found in the discharge (Table No. 24). However, these organisms could have been adhering to the outside of the animal's body and not travelled through the gut. Analysis of faecal material was therefore discontinued due to possible large errors involved.

Nymphs were caught and kept for varying lengths of time in aerated distilled water without food. They were then decapitated and diatom counts of the gut contents were carried out after sodium hydroxide treatment.

3. Results and discussion

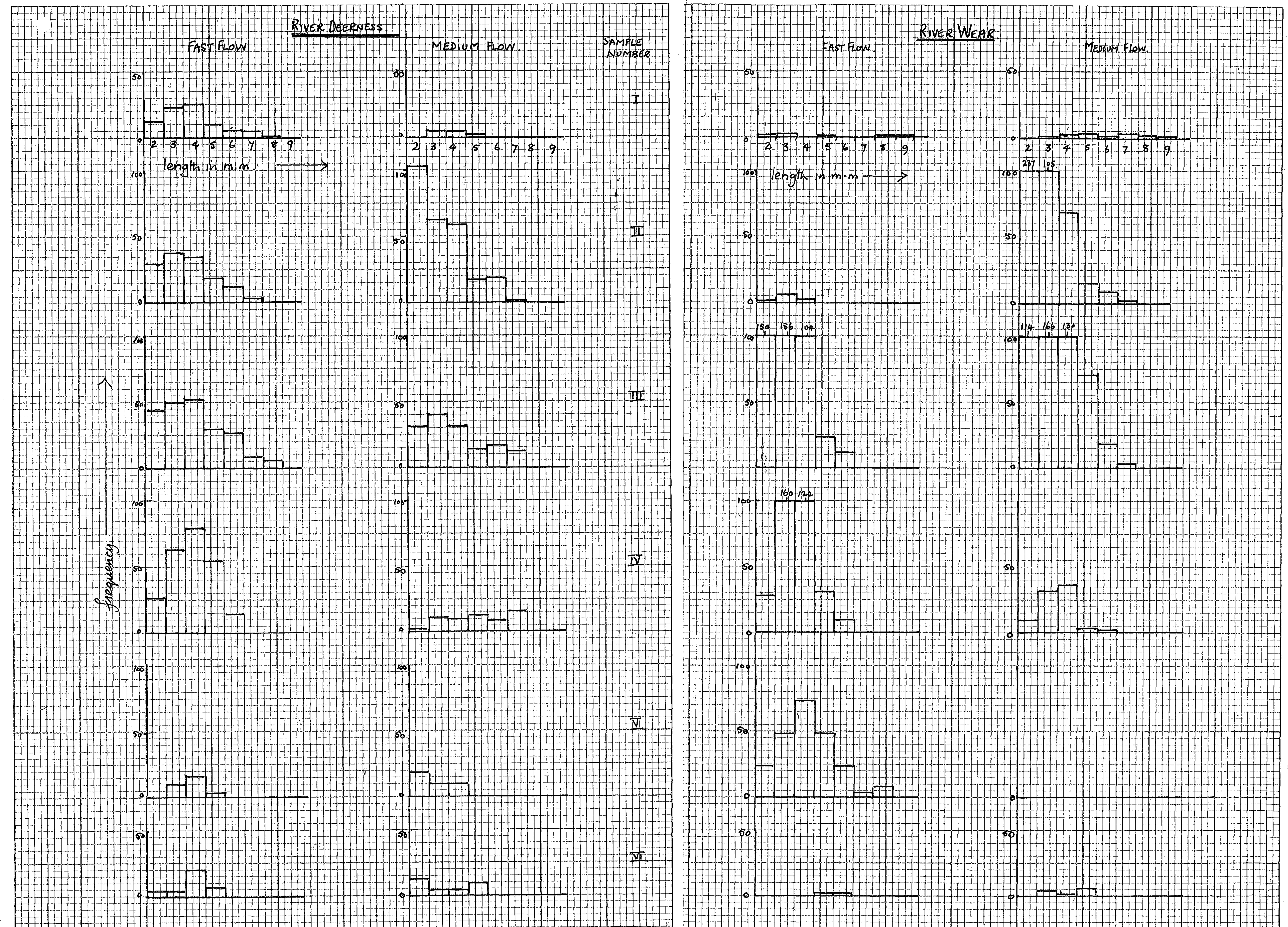


FIGURE 1A To show. Numbers and lengths of

3.1 Results of Sequential Sampling

The full results are tabulated in the appendix (Tables 1-3 for River Deerness and Tables 4-6 for the River Wear). Figures 1-3, show in histogram form, the results for the main genera found during sampling. Tables 7 and 8, give the separate figures for Baetis species for fast and medium water.

Baetis scambus (Baetis A) Figure 1A.

The larvae range in length from 2-9mm; the complete range of sizes being found in the May samples. The largest animals had black wing cases, were mature and ready to emerge. Numbers, particularly in the River Wear were low, but by Sample II a dramatic increase in the populations at both sites was found; 2mm larvae increasing from 0 to over 100 in the Deerness and from 0 to over 200 in the Wear (medium speed water). The numbers of larger larvae at this time were low but as the sampling proceeded the numbers showed a change to a higher proportion of larger animals in the samples - e.g. Sample IV, larger larvae with black wing cases being found again, with high numbers of 4 and 5mm larvae.

In both rivers the populations fluctuate enormously; the River Wear after flooding (Sample V) showing a strange lack of specimens in the medium speed water, whilst the fast water had many larvae of all sizes. At most other times more larvae were found in the medium speed water than in the fast.

A peak of hatching is shown in late May and early June with these animals maturing within two months. Hatching of small numbers continues through late June and into July. Probably two generations per year are to be found in these rivers with considerable overlap of development. Hynes, (1961) believes B. scambus to have only one generation in North Wales whilst Elliot, (1967) records two generations in Dartmoor streams.

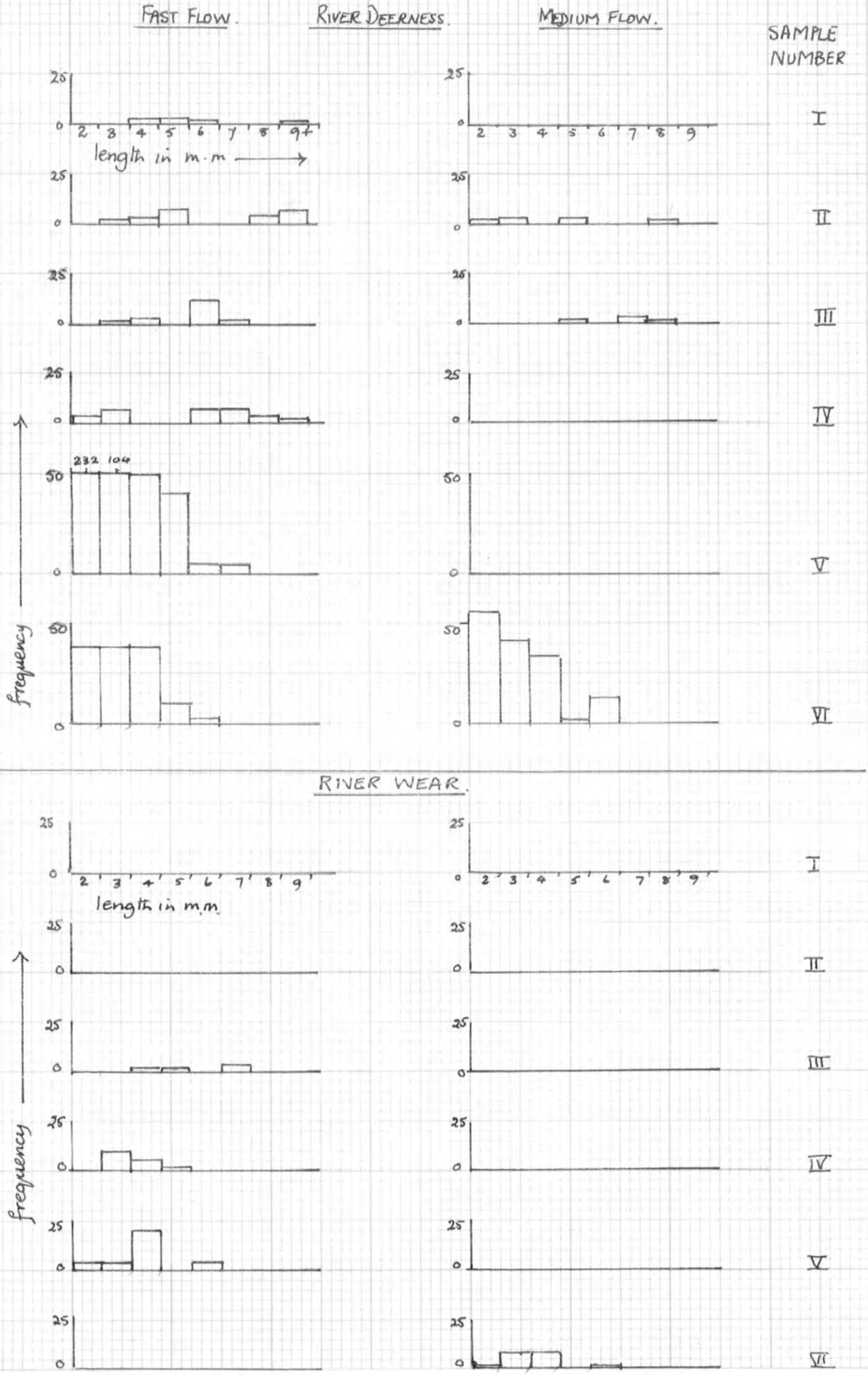


FIGURE I B To show numbers and lengths of BAETIS B

The latter would probably be true of rivers in Co. Durham but more detailed study would be required to confirm this supposition.

Baetis B. (Baetis rhodani and B. muticus) Figure IB.

Few large B. muticus were found in the samples but due to the fact that small specimens were difficult to distinguish from B. rhodani the two species were counted together.

Harker (1952) showed that B. rhodani were present throughout the year in the stream she was examining; also she found two sizes of penultimate instar larvae (7 and 10mm). Macan (1957) has shown B. rhodani which over winter produce big larvae, whilst the summer larvae mature at a smaller size - there being two generations. Two sizes of mature larvae were found in the Deerness samples (12mm Sample I and 9mm Sample II) (Table 26).

The eggs of B. rhodani are known to hatch over a long time and certainly hatching appeared to be continuing during June and July in the Deerness; whether this was from eggs laid by the adults in late May or delayed hatching of earlier eggs it would be difficult to say, from just the samples available.

Competition between B. scambus and Baetis B may influence the numbers of these animals, for the Deerness figures show a sudden rise in the numbers of Baetis B (Sample I) that is matched by a dramatic drop in the numbers of B. scambus.

The numbers of animals of the two species do fluctuate alternately as can be seen from Figures 1A 1B & 4, and this may point to interspecific competition between Baetis species in the rivers studied.

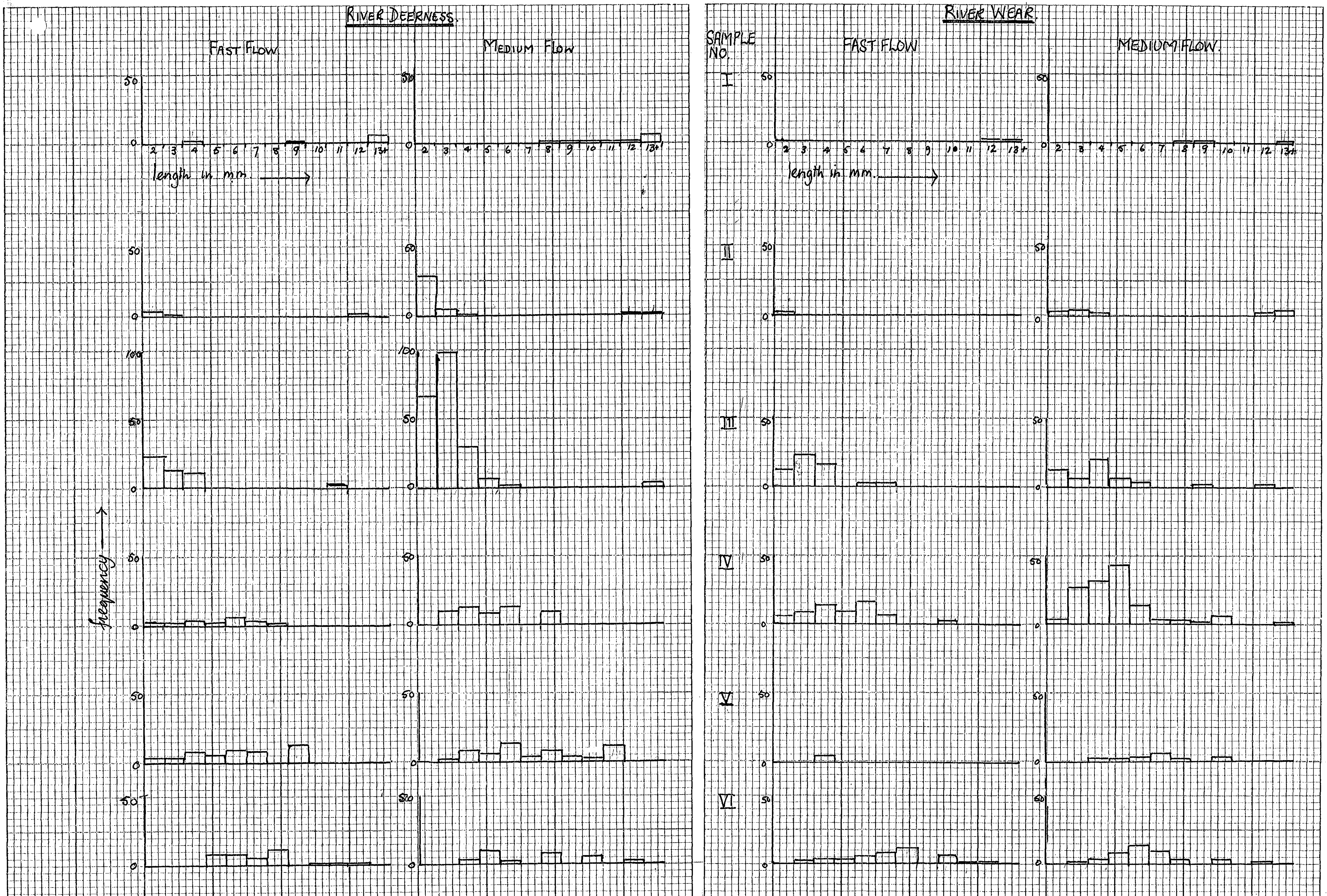


Figure 2. To show change in Numbers and Lengths of ECDYONURUS Larvae in sequential samples.

<u>Ecdyonurus torrentis</u> <u>Figure 2</u>.

The sequential sampling showed very clearly the change in composition and frequency of the population. In early May there were mainly large mature larvae, with only a very few smaller animals (4mm) in the Rivers. By 23rd May, however, both rivers had a population of newly hatched larvae. These formed the dominant size classes (2-3mm) during late May and early June. The last of the large larvae emerged during the last weeks of June. There appeared to be no further hatching of young <u>Ecdyonurus</u> after 20th June. The growth of these mayflies takes place very fast - the graphs show larvae on 20th June to be 8 and 9mm long which must have hatched after 16th May. As can be seen also in graph (3) the biomass increase for these animals shows a very rapid assimilation of food.

Figure 2 shows the growth of these animals (hatched about 16th May) through to a length of 12mm. From Table 26 , it can be seen that spring animals were ready to emerge at 13mm (or more) in length and presumably the larger animals would be emerging during August unless their growth stops.

<u>E. torrentis</u> has been shown to have a quick summer generation and to have three generations in four years (Harker, (1952)) in Walford Stream, Bolton, Lancashire, whilst Macan, (1957), has found in Ford Wood Beck, Cumbria, a simple single-generation-a-year life history.

Fluctuations of numbers of <u>E. torrentis</u> larvae have been shown to be typical of this species and it has also been shown (by Dr. Harker) to migrate upstream.

The results of this study would point to the probability of more than one generation per year of <u>E. torrentis</u>.

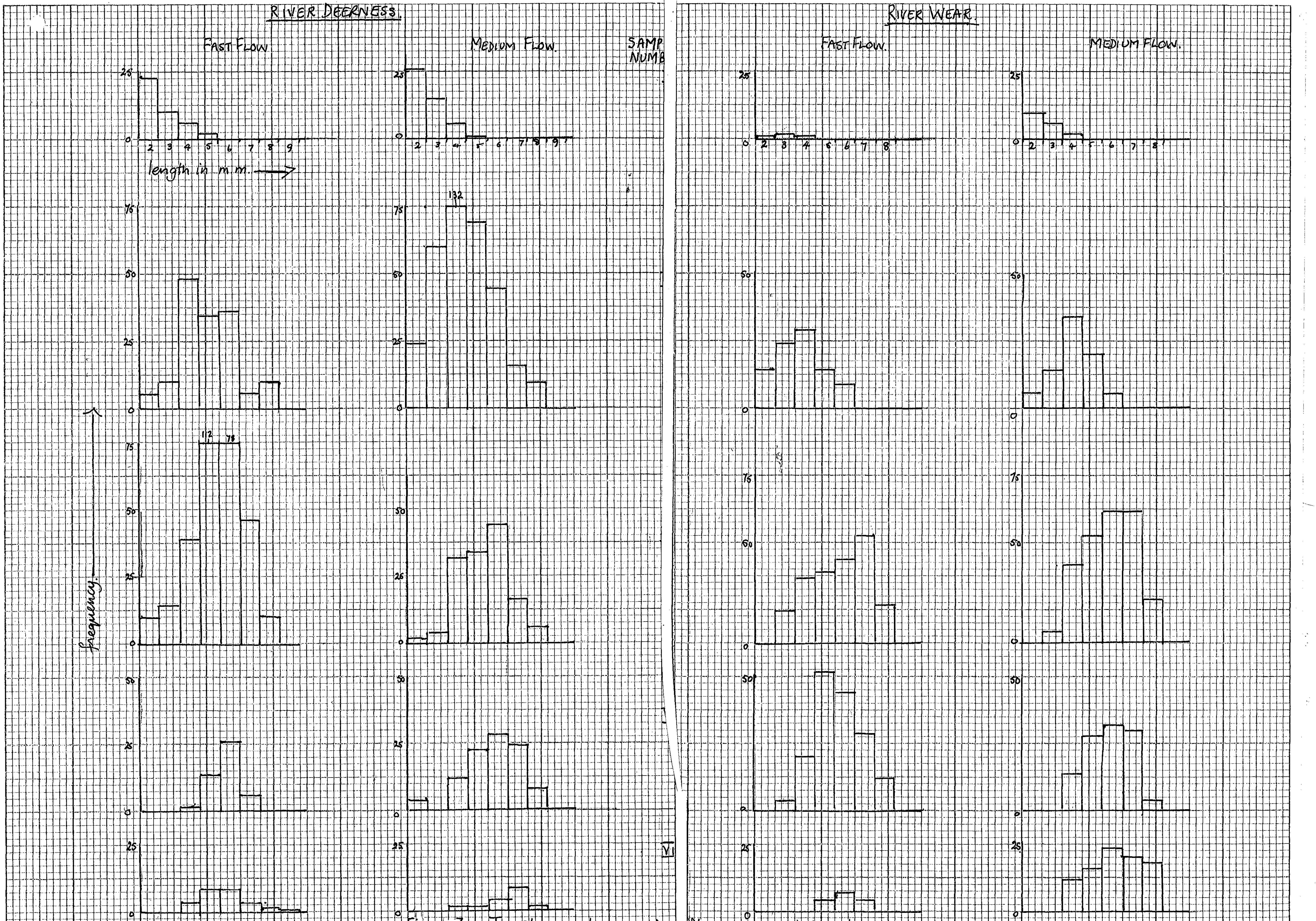


Figure 3. To show change in Numbers and lengths of EPHEMERELLA larvae in sequential samples.

Ephemerella ignita   Figure 3.

This species shows a clearly defined pattern of growth, unlike the two previous genera examined. This year the young larvae hatched between 16th and 23rd May in both rivers and their growth pattern, frequency of size class and time of first adults emerging, were similar at both sites. Numbers per sample were greater in the River Deerness but class sizes present and their changing representation in the histograms can be seen to be almost identical.

Ephemerella larvae grow fast. At the time of sample II (23.5.74) the class with highest frequency was size 2mm., whilst by sample III (a fortnight later) the class with the highest frequency is 4mm long, by 20th June high frequencies are found at 5, 6 and 7mm with high numbers of penultimate instar larvae present in all samples. This shows that some larvae hatching after 16th May were already mature enough to emerge by 20th June. The earliest captured Ephemerella to hatch in the laboratory, was that on 9th July and even this can only have spent about 8 weeks as a larva. (Table 12.)

Figure 3 shows very clearly the larval life history of Ephemerella ignita in both rivers. This species is able to complete its cycle in less than three months, and by the beginning of August only 8mm larvae are left in the river. (Observation made 5.8.74). Other workers have shown that Ephemerella ignita has a single generation per year and that the eggs do not hatch for 10 months. The results for the rivers studied here would appear to confirm these findings. The pattern of growth appears to be similar in both rivers for fast and medium water, although marginally larger numbers are to be found in the samples from the fast stretches.

Rithrogena semicolorata

The number of these animals found in the samples selected was very small. In the River Deerness they were found in fast water only, but in the River Wear they were found in all speeds of water. From the numbers available it is obvious that this animal is much more common in the bigger river, during May and June.

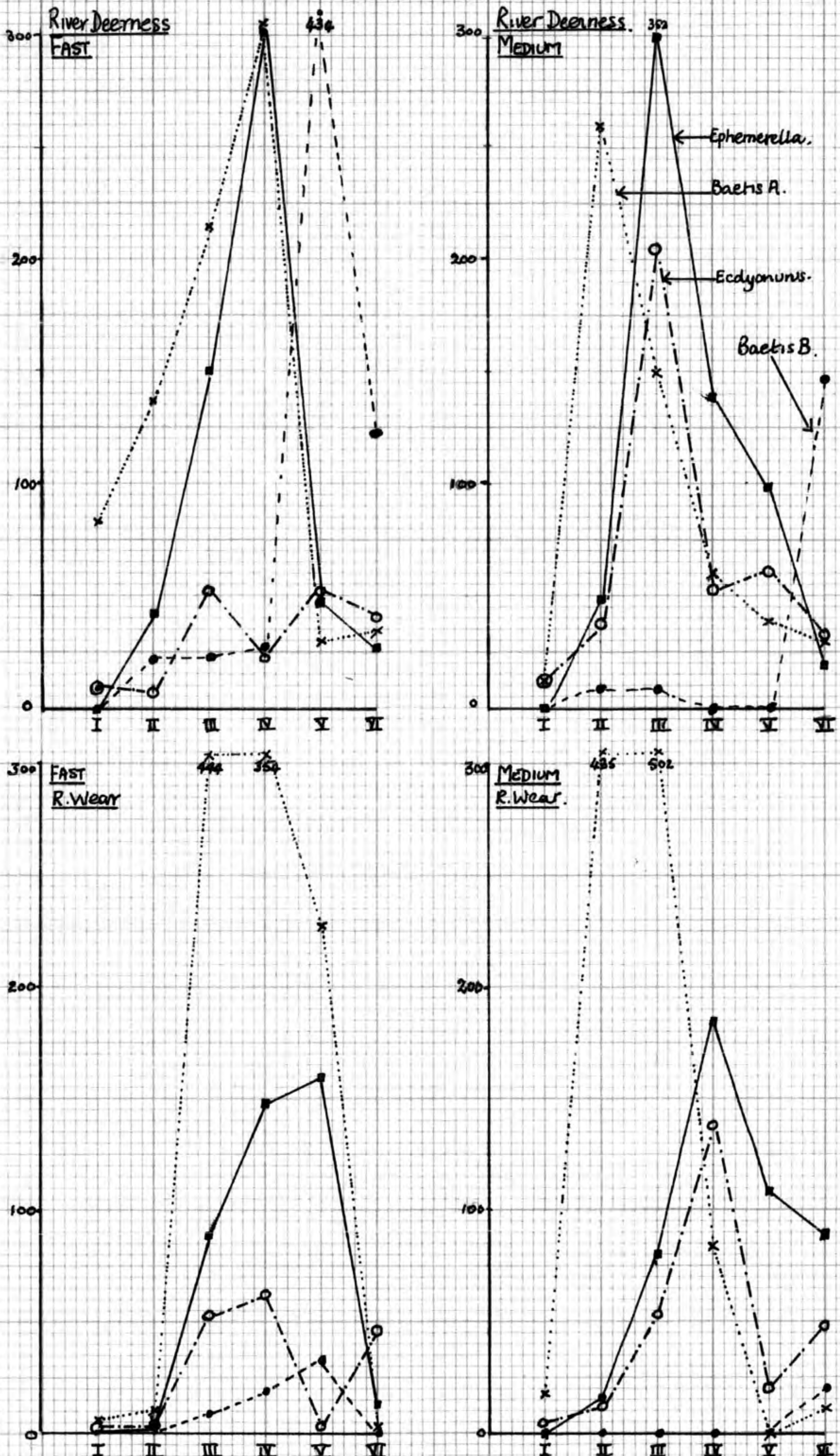
Young small animals were almost completely absent from samples during the study period - the smallest found being 5mm long. No young hatched during the period of study as can be seen by examining the tables of sequential sampling (1-6). The final size for the larvae appears to be 10mm and the majority appear to emerge during the latter half of May leaving the river devoid of Rithrogena larvae.

In contrast with Ecdyonurus this species appears to be part of the river fauna only during cooler months of the year in the rivers investigated. Other workers have found Rithrogena present in rivers in all months of the year (Harker, 1952) but Macan (1970) states that Rithrogena are unlike Ephemerella ignita and dislike warmer temperatures. (The warmer months are spent in the egg stage.) Harker concludes from her studies, that emergence may be spread over months and that the time of emergence depends on seasonal factors. The winter and spring in the N.E. of England 1973-74 was less severe than usual and this could be responsible for all the larvae emerging before the middle of June.

Another factor to be taken into account is the similarity in habit of Rithrogena and Ecdyonurus and the possible competition between these two species for the same niche. It is notable that with the decrease in numbers of Rithrogena there is a rapid increase in the numbers of Ecdyonurus. It would be useful to sample the same rivers later in the season to see if there is a change in balance between these two species and to ascertain if there is a correlation with temperature. It should be noted that the temperature of the River Wear (Table No. 10) during the early part of the study was sometimes lower (on the days samples were taken) than that of the River Deerness. It could be this factor which accounts for the different numbers found in the two sets of samples.

Caenis rivulorum

Only a few specimens of this species were found. They were not confined to any particular stretch of the river and appeared during the study in all the sampling areas. They did not appear to constitute a very important or variable factor in the fauna of the rivers.



Graph 1. To show changes in total Numbers of Mayfly Larvae.

Key. Baetis A ×·····× Baetis B •- - - -• Ecdyonurus O-·-·-O Ephemerella ■——■

3.2 Examination of total population changes

Total numbers of the four main species are given in Graph 1, Figure 4 and Table 25.

Sample I shows low numbers at all sites. B. scambus is the species showing the most dramatic rise and this takes place before the increase in numbers of the other species. Later a change in the balance occurs with higher numbers of all species in Sample III (6.6.74). A simultaneous rise in the numbers of Ephemerella and Ecdyonurus is found at both sites for fast and medium water. However, the rise for Ecdyonurus is less pronounced in fast water.

The spate of the Wear on July 4th probably accounts for the drop in numbers, in Sample V at Bishop Auckland on 8th July. The return to higher numbers is noticeable by the next sample date when the river was less turbulent. From the graphs it would appear that Ecdyonurus prefers calmer conditions and there is a rise in numbers to correspond (Sample VI).

The graphs demonstrate that B. scambus numbers drop at all places when Baetis B numbers rise, the rise of Baetis B also corresponds with a drop in numbers of Ecdyonurus and Ephemerella.

The histograms (Figure 4) show a drop in numbers of Rithrogena with a rise of Ecdyonurus. This could be due to competition (particularly for food and shelter). The change in stone pattern, shifting of stones by the current and change in the velocity of the water must cause changes in the populations even if other factors such as availability of food were to remain constant. It is known that changes in food (the algal population) fluctuate enormously over short periods of time (Patrick,1954) and this too will have a marked effect on the population and growth of Mayfly larvae.

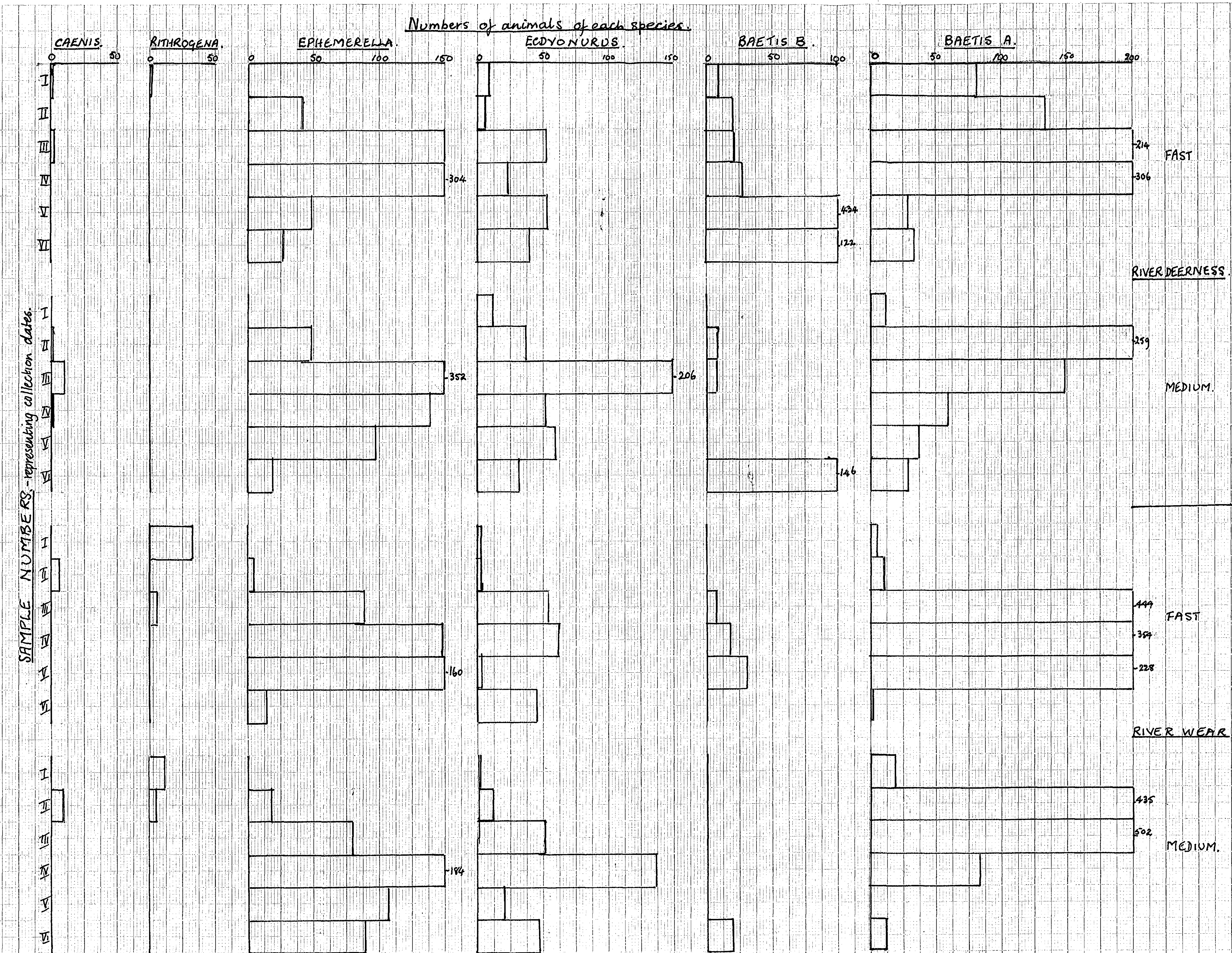


FIGURE 4. TO SHOW TOTAL NUMBERS OF EACH SPECIES EACH SAMPLING TIME FOR FAST & MEDIUM WATER.

The distribution of different sized larvae in the river can be examined using the data collected.

A chi squared test was applied to those samples having high enough numbers to test. The results are given below:

	Fast water		Medium water			
River Deerness	<4mm	>4mm	<4mm	>4mm	χ^2	p.
Baetis scambus						
Sample II	102	34	223	36	7.54	<0.01 *
III	146	68	106	42	0.48	>0.05
IV	170	136	24	36	4.87	<0.05 *
Baetis B						
Sample V	386	48	0	0	Obviously fast preferred	
VI	114	12	132	14	0.00	>0.99
River Wear						
B. scambus						
Sample III	410	34	410	92	23.23	<0.01 *
IV	312	42	78	6	1.55	>0.05
V	114	84	0	0	Obviously fast preferred	

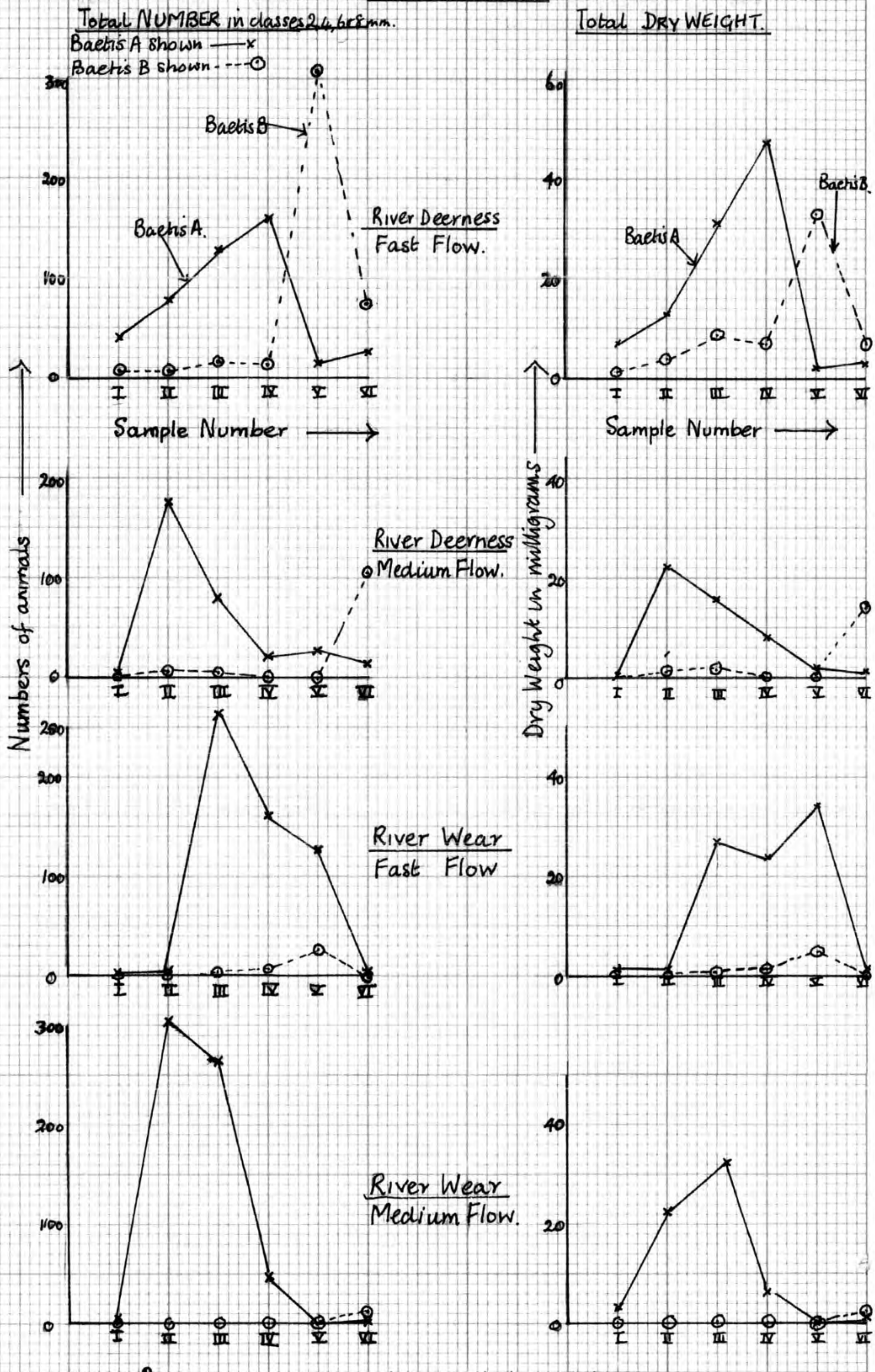
Using the Null Hypothesis that there is no significant difference in the numbers of animals below 4mm to those above 4mm in fast and medium water, it can be seen from the above figures that in only three sets of samples is there any significant difference for B. scambus and at the time of the most turbulent water (Sample V) Baetis spp. preferred the fast water exclusively.

Ecdyonurus samples were examined similarly but insufficient numbers were available for chi squared tests to be applied to different sizes of larvae. It is, however, clearly to be seen that *Ecdyonurus torrentis* in these two rivers prefer medium speed of water to both fast and slow.

Ephemerella ignita showed no significant preference when chi squared tests were applied (for either site).

The distribution of different sized larvae in different speeds of water has been demonstrated by other workers, e.g. Rawlinson (1939). Harris, (1956) says larger specimens are found in shallower water where there is less current but from the results obtained in this study no conclusive statement can be made regarding the distribution of larvae of different sizes.

BAETIS A + BAETIS B.



GRAPH 2. To show total numbers and dry weights of BAETIS A & BAETIS B in size classes 2,4,6&8 mm from sequential samples.

3.3 Biomass Results for Baetis spp. and Ecdyonurus

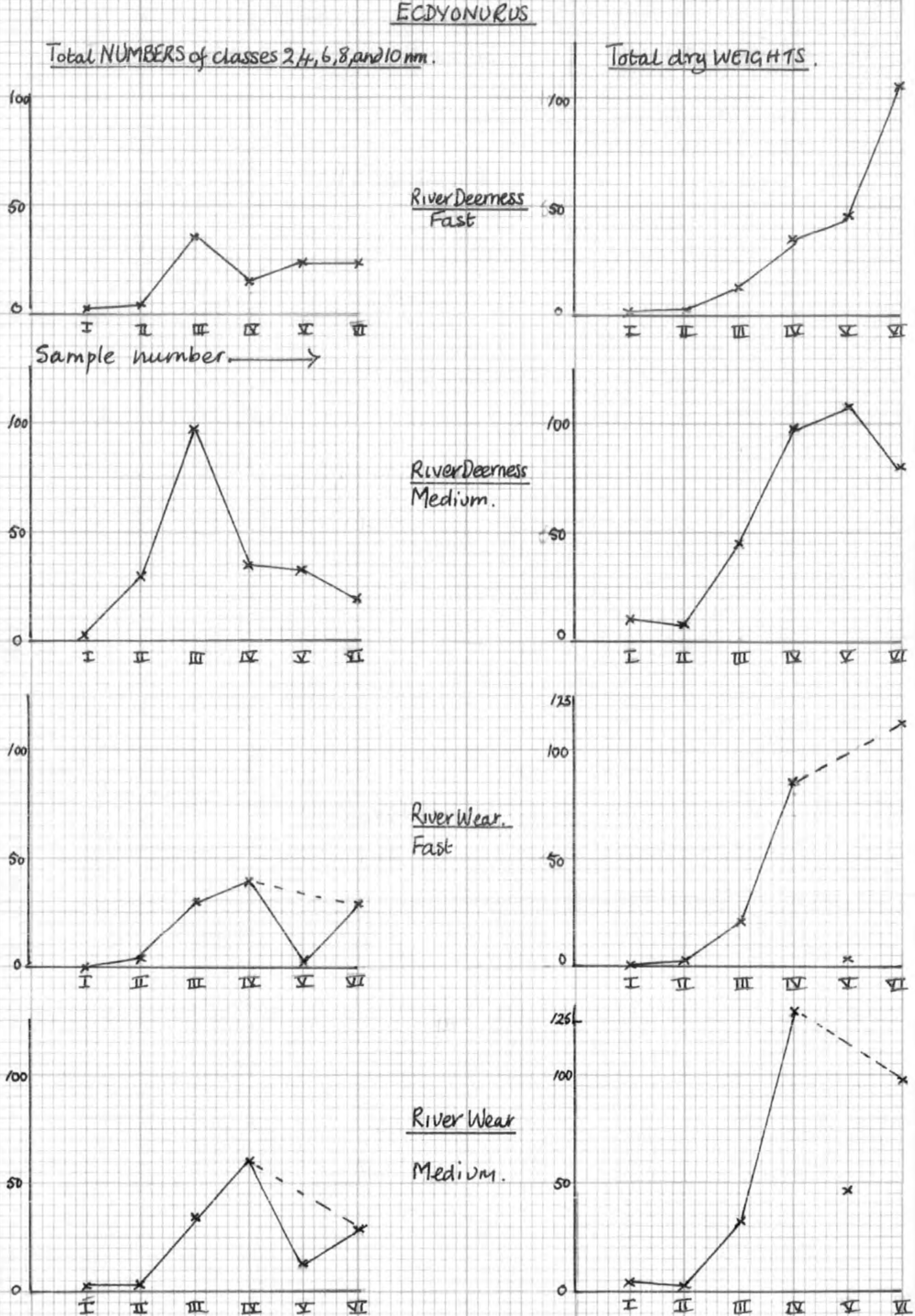
The numbers of animals in various size classes were totalled together with equivalent dry weights - results are given in Tables 14 and 15 and shown graphically (Graphs 2 and 3).

Biomass results are given for Baetis spp. and Ecdyonurus as sufficient numbers of these animals were available for weighing at the same time. Ephemerella, however, had such a speedy life cycle that all the small larvae had disappeared by the time weight measurements were made. Consequently only 8mm larvae of this species were weighed and no biomass calculations were made for this species.

The quick rise in numbers of B. scambus (Baetis A) early in the study period was followed by a later rise in weight and even though the animals were fewer in number the actual biomass was greater - contributing more to the food chain. During May and early June B. scambus contributed the bulk of the mayfly biomass.

The importance of size weight ratio is more clearly seen in the case of Ecdyonurus, the total numbers do not give any idea of the biomass - for example whilst the number of animals in the fast stretch of the River Deerness remained constant between Sample V and VI the biomass increased twofold - (Graph 3 top). (Numbers and consequently biomass in the River Wear were obviously affected by the spate (Sample V) with a later return to greater biomass (Sample VI) - Sample V numbers have been bypassed on the graph by the dotted line.)

The increase of biomass twofold in a fortnight has very important implications when the food chain of the river is considered - more primary production is converted per animal into food for others in the food chain, and each larva eaten will provide twice the food for predators such as trout.



GRAPH 3 To show total numbers and dry weights of Ecdyonurus in size classes 2, 4, 6, 8 & 10mm from sequential samples.

Both genera of mayflies show large fluctuations in biomass which must influence the growth and population of other members of the river fauna and flora. The effect on the food chain is also influenced by the type of primary production available for conversion to secondary production. Fluctuations in the primary production of the rivers are considerable and are often very speedy - a matter of a few days will be enough for the flora of the river to change, (Vollenweider, 1969). Brown, (1961) gives graphs of fluctuations in the food of B. rhodani and Patrick, (1954) gives a method to measure daily changes in the diatom population of rivers.

If it had been possible to determine accurately the total number of animals per unit area of river bed, determinations for total Ephemeropteran biomass could have been attempted, (with a possible comparison of species productivity). Owing to the variability of the river beds and shifting nature of the stones from which these animals were collected, it was not possible from the data obtained in this study to make predictions about total biomass. However, Graphs 2 and 3 give a relative picture of this level of secondary production, for the number of stones selected was constant and only stones of similar size were sampled.

3.4 Results of feeding experiments and gut analysis

At first it was hoped to grow algae colonies on microscope slides and to allow pre starved mayfly larvae to feed upon the cultured algae. Measurement of algal numbers before and after feeding were to be obtained. After much abortive effort this was abandoned for although it was found possible to culture the algae it was impossible to induce the animals to feed. They either refused to feed altogether and clung to the sides of the container, or died within a few hours after making little or no effort to feed. If a clean stone was introduced they clung to that and at no time did single specimens appear to eat with anything like the normal vigour observed under more natural conditions.

Animals kept in an aquarium tank with aerated river water, stones and a natural growth of plant material, appeared to thrive. Many grew and emerged as adults (Table 12.). They were always seen to be browsing on the walls of the tank and crawling over the stones both during day and night. The small nymphs were not alarmed by movement and shadows falling onto the tank - they would continue to feed even if the light was dramatically altered, whilst the larger nymphs ceased feeding and swam for cover when the light was altered.

After trying to get the animals to feed, an attempt was made to investigate the food they had eaten by examining the contents of their intestines immediately after collection from the river. Dissection showed all the species investigated (Baetis A and B, Ecdyonurus and Ephemerella) to have a mixture of brown mashed material of unidentifiable origin, mineral particles, a few cells of filamentous algae and many diatoms. The numbers of diatoms seemed to show a promising line of investigation for the larger animals appeared to contain larger numbers of diatoms - diatoms appeared to be the most consistent factor for all the animals. It was decided to investigate Baetis spp. for this genus showed the highest number of larvae in the samples collected.

The results of gut analysis and diatom counting showed great variability in the possible numbers of diatoms in the gut. This was particularly noticeable with results of animals collected 8.7.74. (Specimens 1B-11B Table No. 16). The animals with smaller numbers of diatoms in the gut were found to have other plant material - mainly Stigeoclonium present.

Brown, (1959) states that different species of Baetis have different diets and after consulting his papers it was decided to repeat gut analysis using distinct species of Baetis namely B. scambus and B. rhodani.

Results of B. scambus (Table 17) show relatively low numbers of diatoms, whilst B. rhodani show higher numbers, (Tables 18 and 19). Brown, states that the chief food of B. rhodani is detritus, but this was not found to be so in the specimens investigated. In specimens of B. rhodani bacteria as well as diatoms were present, particularly in 5mm specimens. Brown, (1961) states that local differences in food available may account for different diets found during his investigations. It would seem from the results of this present study that in the River Deerness when diatoms are plentiful the larvae of B. rhodani 5mm and larger actively feed on them and on other available plant material.

B. rhodani nymphs smaller than 5mm were not dissected in this study so no comparative results were obtained for animals 0-1mm and 4mm length. Brown, mainly worked on larvae of these two sizes, together with animals of 6mm. The larvae from his Red lodge site had large numbers of diatoms in their diet and these numbers fluctuated correspondingly with the fluctuations of the diatoms available in the river. He found evidence for selective feeding.

Evidence in this study would seem to bear out these findings and it is noticeable despite the variability of the results, that the larger 8mm larvae enjoy a diet with a higher number of diatoms. (The smaller animals have a lower number and more non diatomaceous material). The result was found to be significant showing the greater number of diatoms in the guts of 8mm B. rhodani. The statistical test used shows the difference in the number of diatoms to be significant.

To test the significance of the difference between the number of diatoms in the gut contents of 5mm *Baetis rhodani* with the number in 8mm *Baetis rhodani*.

$$\text{Variance} = \sum \frac{x^2}{N} - \bar{x}^2$$

where x is the diatom number
$\bar{x}$ is the mean of all diatom No.
N is No. of counts of x

5mm *B. rhodani* - (SAMPLE A) (Table No. 18) $\bar{x}_a = 1734$

$$\sqrt{\text{variance}} = \text{standard deviation} = \text{S.D.} = 104.2$$

$$\frac{\text{S.D.}}{\sqrt{N}} = \text{standard error} = 467.5 \text{ (a)}$$

8mm *B. rhodani* - (SAMPLE B) (Table No. 19) $\bar{x}_b = 4246$

$$\sqrt{\text{variance}} = \text{S.D.} = 2203$$

$$\frac{\text{S.D.}}{\sqrt{N}} = \text{S.E.} = 987.9 \text{ (b)}$$

$$\bar{x}_a - \bar{x}_b = 2512$$

$$\text{S.E. of difference} = \sqrt{a^2 + b^2} = 1093$$

$$t = \frac{\text{difference}}{\text{S.E. of difference}} = \frac{2512}{1093} = 2.30$$

$p > 0.05$ so difference is significant.

Results of gut analysis after several hours starvation

The results of starving the animals and examining the gut contents after differing lengths of time showed interesting features.

It has been stated that the usual time for passage of food through the gut is half an hour but that algae are retained a while longer, (Brown, 1961). From analysis of the results obtained in this study, all the animals examined retained gut contents for longer than half an hour (the time it took from collecting site to laboratory). Animals kept for six and twelve hours in distilled water before killing, were also found to have considerable numbers of diatoms remaining in the gut (see Tables 20, 21 and 22.) and that only after eighteen hours were the animals found to have finally removed all diatoms. (Specimen 2D, however, still had a few diatoms left).

Whilst it may be true of smaller Baetis larvae that the usual time for passage of food through the gut is approximately half an hour the above results clearly demonstrate that in many cases for specimens of Baetis the time is considerably longer.

It is also suggested that the results of gut analysis in this study show diatoms to be an important element in the diet of larger larvae, even if this has not been shown for smaller animals (Brown, 1959).

The main types of diatoms found in this investigation are listed (Table 28.) in the appendix.

4. General Discussion

Ephemeropteran larvae live only in fresh water. Those studied in this project were found in fast running rivers with stony beds and a high oxygen content in the water. Species normally found in still water such as Clöeon dipterum (studied by Brown, 1959) were not investigated. The morphology and life histories of most species have been well investigated by other workers, e.g. Elliot, Harker, Kimmins, Macan and Needham - The list of references refers to some of their works.

The activity patterns of larvae and the effect of temperature on their distribution have also been investigated (Elliot, 1968 and Ide, 1935) but much of the other literature available is of a general nature. Little detailed investigation appears to have been carried out on the place of Ephemeropteran larvae in food chains and the inter-specific relationships within a common habitat. To attempt a detailed investigation and to answer questions satisfactorily regarding the ecology of mayflies requires carefully controlled experiments of long duration - such is the work of Macan (1957) at Ford Wood Beck.

The present study was only of a limited extent, and as it proceeded, more questions arose as a result of the information collected than could be investigated in one early summer season.

Changes in the rivers studied were such that controls in experimental methods were not feasible, e.g. a spate in the river changed the speed of water to different speeds in different places, and drought led to some collecting sites drying up completely.

The sampling technique employed has some disadvantages but it does allow for comparative sampling (Macan, 1958 b) and many of the sampling errors incurred are common to all the samples.

The results brought out some interesting comparisons between rivers - the temperature of the water in the larger river being usually less than that in the smaller river - but not subject to such variation over short periods of time. The largest animals caught per sample were nearly always from the Deerness (Graphs 4-7 in appendix) the only exceptions being Sample I _Baetis_ and Sample IV _Ecdyonurus_.

The population of larvae was also higher at Ushaw Moor (Deerness) than at Bishop Auckland (Wear) except in the case of _Baetis A_ (Figures 1A and 4) where the reverse was true. The Deerness therefore appears to be a more favourable habitat for larvae of _Ephemerella_, _Ecdyonurus_ and _Baetis B_.

The changes in populations from May to July show many parallels in the two rivers and the growth pattern shows a slower development of most species in the Wear. As growth and maturity is said to be temperature dependent (Harris, 1956) this could account for slower growth in the Wear.

Population changes in biomass as well as numbers, could well be examined further but weighings of the animals should have been made from the start of the project so that _Rithrogena_, _Caenis_ and _Ephemerella_ could all have been estimated whilst they were available. The speed at which some species of larvae mature (e.g. _Ephemerella_) and the fact that only one generation was to be seen during the course of the project was not appreciated until too late, and the animals had flown. This meant that comparable valid results could not be obtained during this season except in the case of _Baetis_ and _Ecdyonurus_.

Comparison of fluctuating diatom and larval numbers could well provide interesting future study - the diatom results from the gut analysis show great fluctuations and this may be due to availability. Animals in samples were collected all at once (dates are given on the Tables) but sampling was spread over a period of weeks. The vast numbers of larvae all feeding in June must make a great demand on available food and if this is not met, starvation could result in migration, slower growth or death. Variation in numbers of diatoms in larvae may be due to feeding preferences but it may also reflect availability, (Brown, 1961).

With the observations made during the investigation it would now be possible to redesign some of the methods and construct new experiments to try to answer some of the problems arising out of the study. Variations in river habitats are difficult to measure accurately and investigation over several seasons would be necessary in order to balance the fluctuations of factors such as flooding, drought, early and late seasons and changes in available food - all of which must affect the life of Ephemeropteran larvae.

5. Summary

1. By examination of sequential samples the growth and changing populations of Ephemeropteran larvae (in the Rivers Deerness and Wear) have been demonstrated.

2. The relative biomass of Baetis and Ecdyonurus have been calculated for numbers collected in the samples.

3. The diets of Baetis spp. have been investigated (using gut analysis) and are shown to have diatoms as an important component.

All these results lead to the conclusion that the influence of Ephemeropteran larvae as members of the river fauna have a profound effect on the ecology of a river. These animals obviously have a marked effect on the primary production of the river, by eating considerable quantities of plant material and they in turn provide a substantial food source for other animals. The vast numbers of larvae and the available biomass and food source they represent indicates the importance of these animals in the ecology of fresh water and the food chains found in rivers.

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8. Appendix

TABLE NO. 1.

RIVER DEERNESS. USHAW MOOR - FAST RUNNING WATER

SIZE AND NUMBER OF ANIMALS - 20 stones

	Length in mm.	I 16.5.74	II 23.5.74	III 6.6.74	IV 20.6.74	V 8.7.74	VI 18.7.74
BAETIS	2	12	30	44	30	232	38
	3	23	38	52	72	104	42
	4	28	38	56	80	66	58
	5	13	25	28	68	40	16
	6	8	12	38	60	22	2
	7	5	4	10	20	4	0
	8	1	4	8	4	4	0
	9	0	0	0	2	0	0
	10	0	3	0	0	0	0
	11	0	3	0	0	0	0
	12	1	0	0	0	0	0
ECDYONURUS	2	0	4	24	2	4	0
	3	0	1	14	2	4	0
	4	1	0	12	4	8	0
	5	0	0	0	2	6	8
	6	0	0	0	6	10	8
	7	0	0	0	4	8	6
	8	0	0	0	2	0	12
	9	1	0	0	0	12	0
	10	0	0	0	0	0	2
	11	0	0	2	0	0	2
	12	0	1	0	0	0	2
	13	1	0	0	0	0	0
	14	2	0	0	0	0	0
	15	1	0	0	0	0	0
	16	2	0	0	0	0	0
EPHEMERELLA	2	0	23	6	10	0	0
	3	0	10	10	14	0	0
	4	0	6	48	38	2	4
	5	0	2	34	112	14	8
	6	0	0	36	78	26	8
	7	0	0	6	42	6	4
	8	0	0	10	10	0	2
	9	0	0	0	0	0	1
RITHROGENA	6	1	0	0	0	0	0
CAENIS	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	1	0	2	0	0	0
	5	0	0	0	0	0	0

TABLE NO. 2.

RIVER DEERNESS. USHAW MOOR - MEDIUM SPEED WATER

SIZE AND NUMBER OF ANIMALS - 20 stones

		I	II	III	IV	V	VI
	Length in mm.	16.5.74	23.5.74	6.6.74	20.6.74	8.7.74	18.7.74
BAETIS	2	0	105	32	2	18	68
	3	5	66	42	12	10	46
	4	5	57	32	10	10	38
	5	2	20	16	12	0	10
	6	0	18	16	8	0	12
	7	0	1	16	16	0	0
	8	0	1	2	0	0	0
ECDYONURUS	2	0	29	66	0	0	0
	3	0	5	98	10	2	0
	4	0	1	30	12	8	4
	5	0	0	6	8	6	10
	6	0	0	2	12	14	2
	7	0	0	0	0	4	0
	8	1	0	0	10	8	8
	9	1	0	0	0	4	0
	10	1	0	0	0	2	6
	11	1	0	0	0	12	0
	12	1	1	0	0	0	2
	13	2	0	0	0	0	0
	14	2	0	0	0	0	0
	15	2	0	4	0	0	0
	16	1	1	0	0	0	0
EPHEMERELLA	2	0	26	24	2	4	0
	3	0	15	60	4	0	0
	4	0	6	132	32	12	2
	5	0	1	68	34	22	2
	6	0	0	44	44	28	4
	7	0	0	16	16	24	8
	8	0	0	8	6	8	2
CAENIS	3	0	0	6	0	0	0
	4	0	0	2	0	0	0
	5	0	1	2	2	0	0

NO RITHROGENA

TABLE NO. 3.

RIVER DEERNESS. USHAW MOOR - SLOW RUNNING WATER

SIZE AND NUMBER OF ANIMALS - 20 stones

	Length in mm.	I 16.5.74	II 23.5.74	III 6.6.74	IV 20.6.74	V 8.7.74	VI 18.7.74
BAETIS	2	1				2	8
	3	9	NO	SAMPLES	TAKEN	0	10
	4	6		↓		0	4
	5	3				5	4
	6	0				0	0
	7	0				0	0
	8	0				0	0
	9	0				0	0
	10	0				0	0
	11	1				0	0
ECDYONURUS	2	0				0	0
	3	0				0	0
	4	0				2	4
	5	0				4	8
	6	0				2	0
	7	0				0	4
	8	0				0	6
	9	1				0	2
	10	1				2	8
	11	1				2	2
	12	4				2	12
	13	0				0	0
	14	1				0	0
	15	4				0	0
EPHEMERELLA	2	0				0	0
	3	0				4	0
	4	0				2	2
	5	0				2	2
	6	0				6	8
	7	0				12	20
	8	0				3	2
	2	0				0	0
	3	0				0	0
	4	0				0	0
	5	0				0	4
	6	0				0	2
	7	0				0	0
	8	0				0	2

NO RITHROGENA

TABLE NO. 4.

RIVER WEAR. BISHOP AUCKLAND - FAST FLOWING WATER

SIZE AND NUMBER OF ANIMALS - 20 stones

	Length in mm.	I 9.5.74	II 23.5.74	III 6.6.74	IV 20.6.74	V 8.7.74	VI 18.7.74
BAETIS	2	1	1	150	28	28	0
	3	2	6	156	170	52	0
	4	0	3	106	130	92	0
	5	1	0	24	34	48	2
	6	0	0	12	10	28	2
	7	0	0	4	0	4	0
	8	1	0	0	0	8	0
	9	1	0	0	0	0	0
ECDYONURUS	2	0	2	12	6	0	0
	3	0	0	22	8	0	2
	4	0	0	16	14	4	4
	5	0	0	0	10	0	4
	6	0	0	2	16	0	6
	7	0	0	2	6	0	8
	8	0	0	0	0	0	12
	9	0	0	0	0	0	0
	10	0	0	0	2	0	6
	11	0	0	0	0	0	2
	12	1	0	0	0	0	2
	13	0	0	0	0	0	0
	14	1	0	0	0	0	0
EPHEMERELLA	2	0	1	14	0	0	0
	3	0	2	24	12	4	0
	4	0	1	28	24	20	0
	5	0	0	14	26	52	4
	6	0	0	8	32	44	6
	7	0	0	0	40	28	4
	8	0	0	0	14	12	0
RITHROGENA	5	1	0	0	0	0	0
	6	2	0	0	0	0	0
	7	3	0	2	0	0	0
	8	11	0	4	0	0	0
	9	7	0	0	0	0	0
	10	6	0	0	0	0	0
	11	3	0	0	0	0	0
CAENIS	3	0	2	0	0	0	0
	4	0	4	0	0	0	0
	5	0	1	0	0	0	0

TABLE NO. 5.

RIVER WEAR. BISHOP AUCKLAND - MEDIUM SPEED WATER

SIZE AND NUMBER OF ANIMALS - 20 stones

		I	II	III	IV	V	VI
	Length in mm.	9.5.74	23.5.74	6.6.74	20.6.74	8.7.74	18.7.74
BAETIS	2	0	237	114	10	0	0
	3	1	105	166	32	0	2
	4	3	68	130	36	0	12
	5	4	15	70	4	0	10
	6	1	8	15	2	0	6
	7	4	2	4	0	0	2
	8	2	0	0	0	0	0
ECDYONURUS	2	0	3	12	4	0	0
	3	0	4	6	26	0	2
	4	0	1	20	32	2	4
	5	0	0	6	44	2	8
	6	0	0	4	14	4	14
	7	0	0	0	4	6	10
	8	1	0	0	4	2	4
	9	1	0	2	2	0	0
	10	0	0	0	6	4	4
	11	0	0	0	0	0	0
	12	0	1	2	0	0	2
	13	1	0	0	2	0	0
	14	0	1	0	0	0	0
	15	0	1	0	0	0	0
	16	0	1	0	0	0	0
EPHEMERELLA	2	0	9	6	0	0	0
	3	0	6	14	4	0	0
	4	0	2	34	28	14	12
	5	0	0	20	40	28	16
	6	0	0	6	48	32	24
	7	0	0	0	48	30	20
	8	0	0	0	16	4	18
RITHROGENA	6	1	1	0	0	0	0
	7	0	0	0	0	0	0
	8	0	2	0	0	0	0
	9	3	1	0	0	0	0
	10	7	1	0	0	0	0
CAENIS	2	0	1	0	0	0	0
	3	0	3	0	0	0	0
	4	0	5	0	0	0	0

TABLE NO. 6.

RIVER WEAR. BISHOP AUCKLAND - SLOW RUNNING WATER

SIZE AND NUMBERS OF ANIMALS - 20 stones

		I	II	III	IV	V	VI
	Length in mm.	9.5.74	23.5.74	6.6.74	20.6.74	8.7.74	18.7.74
BAETIS	2	1	NO	SAMPLES	TAKEN	0	0
	3	0				0	0
	4	1				0	0
ECDYONURUS	2	0				0	0
	3	0				0	0
	4	1				2	2
	5	0				2	4
	6	0				0	4
	7	0				0	4
	8	3				2	2
	9	0				0	0
	10	0				2	8
	11	1				0	0
	12	2				0	0
	13	1				0	0
	14	2				0	0
	15	1				0	0
EPHEMERELLA	3	0				0	0
	4	0				4	2
	5	0				12	2
	6	0				8	8
	7	0				4	20
	8	0				0	2
RITHROGENA	9	1				0	0
CAENIS	2	0				0	0
	3	2				0	0
	4	0				0	0
	5	1				0	0

TABLE NO. 7.

Number of animals per size class. Baetis A / Baetis B.

Baetis A = B.scambus and B. = B.rhodani + B. muticus

River Deerness

Length in mm.	I		II		III		IV		V		VI	
	A	B	A	B	A	B	A	B	A	B	A	B
FAST												
2	12	0	30	0	44	0	26	4	0	232	4	34
3	23	0	37	1	50	2	64	6	10	104	4	38
4	25	3	35	3	52	4	80	0	16	50	20	38
5	10	3	18	7	28	0	68	0	2	40	6	10
6	6	2	12	0	26	12	54	6	0	4	0	2
7	5	0	4	0	8	2	14	6	0	4	0	0
8	1	0	0	4	6	2	0	4	0	0	0	0
9	0	0	0	0	0	0	0	1	0	0	0	0
10	0	0	0	3	0	0	0	0	0	0	0	0
11	0	0	0	3	0	0	0	0	0	0	0	0
12	0	1	0	0	0	0	0	0	0	0	0	0
MEDIUM												
2	0	0	103	2	32	0	2	0	18	0	12	56
3	5	0	63	3	42	0	12	0	10	0	4	42
4	5	0	57	0	32	0	10	0	10	0	4	34
5	2	0	17	3	14	2	12	0	0	0	8	2
6	0	0	18	0	16	0	8	0	0	0	0	12
7	0	0	1	0	12	4	16	0	0	0	0	0
8	0	0	0	1	0	2	0	0	0	0	0	0

TABLE NO. 8.

Number of animals per size class. Baetis A / Baetis B.

Baetis A = B.scambus and B. = B.rhodani + B. muticus

River Wear

Length in mm.	I		II		III		IV		V		VI	
	A	B	A	B	A	B	A	B	A	B	A	B
FAST												
2	1	0	1	0	150	0	28	0	24	4	0	0
3	2	0	6	0	156	0	160	10	48	4	0	0
4	0	0	3	0	104	2	124	6	72	20	0	0
5	1	0	0	0	22	2	32	2	48	0	2	0
6	0	0	0	0	12	0	10	0	24	4	2	0
7	0	0	0	0	0	4	0	0	4	0	0	0
8	1	0	0	0	0	0	0	0	8	0	0	0
9	1	0	0	0	0	0	0	0	0	0	0	0
MEDIUM												
2	0	0	237	0	114	0	10	0	0	0	0	2
3	1	0	105	0	166	0	32	0	0	0	4	8
4	3	0	68	0	130	0	36	0	0	0	2	8
5	4	0	15	0	70	0	4	0	0	0	6	0
6	1	0	8	0	18	0	2	0	0	0	0	2
7	4	0	2	0	4	0	0	0	0	0	0	0
8	3	0	0	0	0	0	0	0	0	0	0	0
9	2	0	0	0	0	0	0	0	0	0	0	0

TABLE NO. 9.

Sample numbers used in tables and on graphs with corresponding dates at different sampling points

River Deerness	Date	River Wear	Date
I	16.5.74	I	9.5.74
II	23.5.74	II	23.5.74
III	6.6.74	III	6.6.74
IV	20.6.74	IV	20.6.74
V	8.7.74	V	8.7.74
VI	18.7.74	VI	18.7.74

Grid references for sampling points

River Deerness	River Wear
NZ. 227423	NZ. 201311

Average speed of water

River Deerness		River Wear	
FAST	43.8 metres/minute	FAST	75 m/min
MEDIUM	25.8 m/min	MEDIUM	34 m/min
SLOW	12.0 m/min	SLOW	4.4 m/min

TABLE NO. 10.

State of Rivers on Sampling Days

River Wear at Bishop Auckland

Date	State of river	Temperature of water
9.5.74	Slow flowing part - 20cm deep	$8^{o}C$
23.5.74	River v. high - no slow samples taken	$9^{o}C$
6.6.74	River low - no slow sampling possible	$8^{o}C$
20.6.74	River low - no slow sampling possible	$11^{o}C$
4th, 5th, 6th & 7th	River in spate - no sampling possible	
8.7.74	River fast - moderately high	$14^{o}C$
18.7.74	River moderately fast	$13^{o}C$
River Wear at Durham Sands		
9.5.74	Slow part covered by water - 10cm. Some filamentous algal growth	$8^{o}C$
23.5.74	River high - no slow samples taken. Filamentous algal growth in slow part very pronounced	$9^{o}C$
6.6.74	Algal growth inhibited further sampling	
River Deerness at Ushaw Moor		
16.5.74	Slow part covered by water	$5^{o}C$
23.5.74	River v. high	$11^{o}C$
6.6.74	River v. low - no slow sampling possible	$9^{o}C$
20.6.74	River v. low - no slow sampling possible	$12^{o}C$
4th, 5th 6th & 7th	River in spate - no sampling possible	
8.7.74	River high - slow, medium and fast samples taken	$13^{o}C$
18.7.74	River moderately high	$15^{o}C$

TABLE NO. 11.

9.5.74 MEASUREMENT OF STONES AND No. OF ANIMALS CAUGHT per stone

	Area of base of stone	No. of animals		Area of base of stone	No. of animals
BISHOP AUCKLAND	sq.cm.		DURHAM SANDS	sq.cm.	
10 stones from:-	132	1		150	1
	117	1		110	3
	72	5		126	1
slow running water	54	1	slow	224	3
	150	2		54	0
	88	2		99	0
	160	1		144	1
	187	0 *		240	0
	100	2		117	7
	143	2		45	0
	96	9		98	1
	140	1		180	2
	108	3		242	1
medium	80	5	medium	63	3
	160	2		187	0
	105	7		99	2
	49	0 *		88	2
	80	3		70	2
	72	1		56	0
	130	1		72	0
	165	4 *		88	0
	88	5		154	0
	64	10 *		56	1
fast	77	3	fast	99	1
	80	2		72	0
	96	1		72	0
	120	1		56	2
	80	2		88	1
	126	4		195	1
	56	6		90	0

* There appears to be no correlation between size of stone and number of animals caught.

TABLE NO. 12.

Larvae emerged in Laboratory

	Date of emergence		
	subimago	fullimago	Species
1.	23.5.74	24.5.74	Ecdyonurus torrentis
2.	25.5.74	25.5.74	E. torrentis
3.	27.5.74	28.5.74	Baetis scambus
4.	17.6.74	18.6.74	B. muticus
5.	28.6.74	29.6.74	Baetis sp. ?
6.	1.7.74	1.7.74	B. muticus
7.	9.7.74	11.7.74	Ephemerella ignita
8.	14.7.74	15.7.74	Baetis rhodani
9.	17.7.74	19.7.74	B. rhodani
10.	20.7.74	21.7.74	B. rhodani
11.	21.7.74	21.7.74	Ephemerella ignita
12.	21.7.74	21.7.74	E. ignita
13.	13.8.74	13.8.74	E. ignita
14.	14.8.74		B. muticus flew away as subimago

TABLE NO. 13.

Weights of larvae after drying (given in milligrams)

Several animals a class size were dried at 102°C and weighed, re dried and re weighed to constant weight.

Final results (after division of weight for single animal weights) were as below.

	Length in mm.	Dry wt. of single larva
BAETIS	2	0.035 mg
	4	0.13
	6	0.67
	8	0.96
ECDYONURUS	2	0.26
	4	0.68
	6	3.91
	8	4.42
	10	5.81
EPHEMERELLA	8	2.45

TABLE NO. 14.

Relative weights in milligrams of samples of Baetis A and Baetis B.

BAETIS A = B.scambus and BAETIS B = B.rhodani + B.muticus

River Deerness

SAMPLE		I		II		III		IV		V		VI	
	Length in mm.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
FAST													
BAETIS A	2	12	0.42	30	1.05	44	1.54	26	0.91	0	0	4	0.14
	4	25	3.25	35	4.55	52	6.76	80	10.4	16	2.08	20	2.6
	6	6	4.0	12	8.0	26	17.4	54	36.2	0	0	0	0
	8	1	0.96	0	0	6	5,76	0	0	0	0	0	0
BAETIS B	2	0	0	0	0	0	0	4	0.14	232	8.12	34	1.19
	4	3	0.39	3	0.39	4	0.52	0	0	50	6.5	38	4.94
	6	2	1.34	0	0	12	8.0	6	4.0	22	14.7	2	1.34
	8	0	0	4	3.8	2	1.9	4	3.8	4	3.8	0	0
MEDIUM													
BAETIS A	2	0	0	103	3.6	32	1.12	2	0.07	18	0.63	12	0.42
	4	5	0.65	57	7.4	32	4.16	10	1.3	10	1.3	4	0.52
	6	0	0	18	12.1	16	10.7	8	5.4	0	0	0	0
	8	0	0	0	0	0	0	0	0	0	0	0	0
BAETIS B	2	0	0	2	0.07	0	0	0	0	0	0	56	1.96
	4	0	0	0	0	0	0	0	0	0	0	34	4.42
	6	0	0	0	0	0	0	0	0	0	0	12	8.0
	8	0	0	1	0.96	2	1.9	0	0	0	0	0	0

TABLE NO. 14. (cont.)

Relative weights in milligrams of samples of Baetis A and Baetis B.

River Wear

	SAMPLE	I		II		III		IV		V		VI	
	Length in mm.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
FAST													
BAETIS A	2	1	0.035	1	0.035	150	5.25	28	0.98	24	0.84	0	0
	4	0	0	3	0.39	104	13.5	124	16.1	72	9.36	0	0
	6	0	0	0	0	12	8.04	10	6.7	24	16.1	2	1.34
	8	1	0.96	0	0	0	0	0	0	8	7.7	0	0
BAETIS B	2	0	0	0	0	0	0	0	0	4	0.14	0	0
	4	0	0	0	0	2	0.26	6	0.78	20	2.6	0	0
	6	0	0	0	0	0	0	0	0	4	2.68	0	0
	8	0	0	0	0	0	0	0	0	0	0	0	0
MEDIUM													
BAETIS A	2	0	0	237	8.29	114	3.99	10	0.35	0	0	0	0
	4	3	0.39	68	8.84	130	16.9	36	4.68	0	0	2	0.26
	6	1	0.67	8	5.36	18	12.1	2	1.34	0	0	0	0
	8	3	2.88	0	0	0	0	0	0	0	0	0	0
BAETIS B	2	0	0	0	0	0	0	0	0	0	0	2	0.07
	4	0	0	0	0	0	0	0	0	0	0	8	1.04
	6	0	0	0	0	0	0	0	0	0	0	2	1.34
	8	0	0	0	0	0	0	0	0	0	0	0	0

TABLE NO. 14. (cont.)

Total Baetis weights (in milligrams) of size classes 2, 4, 6 and 8mm added together

Baetis A - B. scambus

Baetis B - B. muticus and B. rhodani

River Deerness

	I		II		III		IV		V		VI	
FAST	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Baetis A	44	8.63	77	12.6	128	31.46	160	47.51	16	2.08	24	2.74
Baetis B	5	1.73	7	4.19	18	9.42	14	7.94	308	33.12	74	7.45
MEDIUM												
Baetis A	5	0.65	178	23.1	80	15.98	20	6.77	28	1.93	16	0.94
Baetis B	0	0	3	1.03	2	1.9	0	0	0	0	102	14.38

River Wear

	I		II		III		IV		V		VI	
FAST	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Baetis A	2	0.99	4	0.43	266	26.8	162	23.78	128	34.0	2	1.34
Baetis B	0	0	0	0	2	0.26	6	0.78	28	5.42	0	0
MEDIUM												
Baetis A	7	3.94	303	22.49	262	32.99	48	6.37	0	0	2	0.26
Baetis B	0	0	0	0	0	0	0	0	0	0	12	2.45

TABLE NO. 15.

Relative weights in milligrams of samples of Ecdyonurus

River Deerness

	SAMPLE	I		II		III		IV		V		VI	
	Length in mm.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
FAST	2	0	0	4	1.04	24	6.24	2	0.52	4	1.04	0	0
	4	1	0.68	0	0	12	8.16	4	2.72	8	5.44	0	0
	6	0	0	0	0	0	0	6	23.4	10	39	8	31.2
	8	0	0	0	0	0	0	2	8.8	0	0	12	52.8
	10	0	0	0	0	0	0	0	0	0	0	2	11.6
MEDIUM	2	0	0	29	7.54	66	17.16	0	0	0	0	0	0
	4	0	0	1	0.68	30	20.4	12	8.16	8	5.44	4	2.72
	6	0	0	0	0	2	7.8	12	46.8	14	54.6	2	7.8
	8	1	4.4	0	0	0	0	10	44	8	35.2	8	35.2
	10	1	5.8	0	0	0	0	0	0	2	11.6	6	34.8

River Wear

	SAMPLE	I		II		III		IV		V		VI	
	Length in mm.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
FAST	2	0	0	2	0.52	12	3.12	6	1.56	0	0	0	0
	4	0	0	0	0	16	10.88	14	9.52	4	2.72	4	2.72
	6	0	0	0	0	2	7.8	16	62.4	0	0	6	23.4
	8	0	0	0	0	0	0	0	0	0	0	12	52.8
	10	0	0	0	0	0	0	2	11.6	0	0	6	34.8
MEDIUM	2	0	0	3	0.78	12	3.12	4	1.04	0	0	0	0
	4	0	0	1	0.68	20	13.6	32	21.76	2	1.36	4	2.72
	6	0	0	0	0	4	15.6	14	54.6	4	15.6	14	54.6
	8	1	4.4	0	0	0	0	4	17.6	2	8.8	4	17.6
	10	0	0	0	0	0	0	6	34.8	4	23.2	4	23.2

TABLE NO. 15. (cont.)

Total *Ecdyonurus* weights (in milligrams) of size classes 2, 4, 6, 8 and 10mm added together

River Deerness

	I	II	III	IV	V	VI
FAST						
Weight	0.68	1.04	14.40	35.44	45.48	105.6
No. of animals	1	4	36	14	22	22
MEDIUM						
Weight	10.2	8.22	45.36	98.96	106.84	80.52
No. of animals	2	30	98	34	32	20

River Wear

	I	II	III	IV	V	VI
FAST						
Weight	0	0.52	21.8	85.08	2.72	113.72
No. of animals	0	2	30	38	4	28
MEDIUM						
Weight	4.4	1.46	32.32	129.8	48.96	98.12
No. of animals	1	4	34	60	12	26

TABLE NO. 16.

Diatom counts from gut contents of Baetis Specimens
from River Deerness AFTER 30 mins captivity

Using Haemocytometer slide $1mm^2 \times \frac{1}{10}$ mm Deep 30.6.74

	Count No.	Diatoms per count	No. diatoms per gut
Specimen 1A. 8mm long. Tube capacity 0.49 ml.	1	4	1960
	2	2	980
	3	3	1470
	4	5	2450
	5	4	1960
Specimen 2A. 6mm long. Tube capacity 0.46 ml.	1	4	1840
	2	8	3680
	3	4	1840
	4	9	4140
	5	3	1380
Specimen 3A. 7mm long. Tube capacity 0.49 ml.	1	21	10290
	2	15	7350
	3	11	5390
	4	16	7840
	5	18	8820

Counts from specimens collected on 8.7.74

	Count No.	Diatoms per count	No. diatoms per gut
Specimen 1B. 8mm long. Tube capacity 0.49 ml.	1	38	18620
	2	55	26950
	3	57	27930
	4	87	42630
	5	49	24010
Specimen 2B. length 8mm tube 0.46 ml. (Stigeoclonium present in gut contents)	1	76	34960
	2	45	20700
	3	48	22080
	4	36	16560
	5	46	21160
Specimen 3B. length 9mm tube 0.49 ml. (Stigeoclonium present in gut)	1	31	15190
	2	19	9310
	3	21	10290
	4	19	9310
	5	14	6860

TABLE NO. 16. (cont.)

	Count No.	Diatoms per count	No. diatoms per gut
Specimen 4B.	1	11	5170
length 8mm	2	6	2820
tube 0.47 ml.	3	4	1880
(Filamentous algae present	4	9	4230
in gut)	5	4	1880
Specimen 5B.	1	2	920
length 8mm	2	5	2300
tube 0.46 ml.	3	4	1840
(Stigeoclonium present	4	6	2760
in quantity)	5	4	1840
Specimen 6B.	1	21	10290
length 7mm	2	39	17940
tube 0.49 ml.	3	67	32830
	4	27	13230
	5	30	14700
Specimen 7B.	1	41	20910
length 8mm	2	32	16320
tube 0.51 ml.	3	32	16320
	4	19	9690
	5	41	20910
Specimen 8B.	1	54	28080
length 7mm	2	20	10400
tube 0.52 ml.	3	24	12480
	4	36	18720
	5	23	11960
Specimen 9B.	1	4	1840
length 6mm	2	4	1840
tube 0.46 ml.	3	3	1380
(Filamentous green algae	4	2	920
present in quantity)	5	8	3680
Specimen 10B.	1	18	8820
length 6mm	2	21	10290
tube 0.49 ml.	3	11	5390
	4	9	4410
	5	18	8820
Specimen 11B.	1	15	6900
length 6mm	2	9	4140
tube 0.46 ml.	3	8	3680
	4	12	5520
	5	9	4140

TABLE NO. 17.

Diatom Samples from Gut contents of *Baetis scambus*

Collected 23.7.74 R. Deerness

Counts after ½ hour captivity

	Count No.	Diatoms per count	No. diatoms per gut
Specimen S1.	1	7	3200
length 4mm	2	4	1840
tube 0.46 ml.	3	5	2300
	4	4	1840
	5	4	1840
Specimen S2.	1	6	2760
length 4mm	2	4	1840
tube 0.46 ml.	3	3	1380
	4	2	920
	5	3	1380
Specimen S3.	1	2	1000
length 3mm	2	3	1500
tube 0.50 ml.	3	1	500
(Remains of xylem vessels	4	0	0
from dicot plants in gut)	5	1	500

TABLE NO. 18. (SAMPLE A)

Diatom counts from Baetis rhodani - 5mm specimens

Material collected 10.8.74. R. Deerness

Animal guts removed ½ hr. after collection

	Count No.	Diatoms per count	Calculated total number of Diatoms
Specimen 6R. Tube capacity 0.51 ml. (Bacteria present in quantity)	1	3	1530
	2	3	1530
	3	1	510
	4	0	0
	5	2	1020
Specimen 7R. Tube capacity 0.51 ml. (Bacteria present in quantity)	1	10	5100
	2	3	1530
	3	4	2040
	4	7	3570
	5	9	4590
Specimen 8R. Tube capacity 0.48 ml. (Bacteria present in quantity)	1	3	1440
	2	3	1440
	3	6	2880
	4	9	4320
	5	5	2400
Specimen 9R. Tube capacity 0.48 ml. (Bacteria present in quantity)	1	0	0
	2	1	480
	3	0	0
	4	0	0
	5	5	2400
Specimen 10R. Tube capacity 0.47 ml. (Some bacteria present)	1	1	470
	2	1	470
	3	3	1410
	4	3	1410
	5	6	2820

TABLE NO. 19. (SAMPLE B)

Diatom counts from *Baetis rhodani* - 8mm specimens

Material collected 10.8.74. R. Deerness

Animal guts removed ½ hr. after collection

	Count No.	Diatoms per count	Calculated total number of Diatoms
Specimen 1R. Tube capacity 0.50 ml.	1	5	2500
	2	7	3500
	3	6	3000
	4	5	2500
	5	5	2500
Specimen 2R. Tube capacity 0.48 ml.	1	3	1440
	2	5	2400
	3	4	1920
	4	2	960
	5	4	1920
Specimen 3R. Tube capacity 0.49 ml.	1	17	8330
	2	15	7350
	3	15	7350
	4	9	4410
	5	11	5390
Specimen 4R. Tube capacity 0.50 ml.	1	19	9500
	2	13	6500
	3	11	5500
	4	12	6000
	5	17	8500
Specimen 5R. Tube capacity 0.49 ml.	1	3	1470
	2	4	1960
	3	6	2940
	4	8	3920
	5	10	4900

TABLE NO. 20.

Diatom Samples from Gut contents of *Baetis scambus*

Collected 23.7.74 R. Deerness

Counts after 6 hours in distilled water at 15°C.

	Count No.	Diatoms per count	No. diatoms per gut
Specimen S4	1	4	1960
length 4mm	2	3	1470
tube 0.49 ml.	3	1	490
	4	3	1470
	5	2	980
Specimen S5	1	2	980
length 4mm	2	0	0
tube 0.46 ml.	3	1	460
	4	0	0
	5	1	460
Specimen S6	1	1	490
length 5mm	2	0	0
tube 0.49 ml.	3	0	0
	4	2	980
	5	0	0
Specimen S7	1	2	960
length 4mm	2	1	480
tube 0.48 ml.	3	0	0
	4	0	0
	5	0	0
Specimen S8	1	2	980
length 5mm	2	1	490
tube 0.49 ml.	3	0	0
	4	1	490
	5	0	0

TABLE NO. 21.

Diatom counts after 12 hours. Specimens collected 12.7.74

	Count No.	Diatoms per count	No. diatoms per gut
Specimen 1C.	1	8	3920
length 7mm	2	4	1960
tube 0.49 ml.	3	8	3920
	4	5	2450
	5	9	4410
Specimen 2C.	1	9	4140
length 8mm	2	5	2300
tube 0.46 ml.	3	2	920
	4	6	2760
	5	8	3680

TABLE NO. 22.

Diatom counts after 18 hours. 16.7.74

Specimen	Count No.	Diatoms per count
Specimen 1D. length 6mm, tube 0.46 ml.	1	0
	2	0
	3	0
	4	0
	5	0
Specimen 2D. length 8mm, tube 0.49 ml.	1	0
	2	2 *
	3	0
	4	0
	5	0
Specimen 3D. length 5mm, tube 0.51 ml.	1	0
	2	0
	3	0
	4	0
	5	0
Specimen 4D. length 6mm, tube 0.49 ml.	1	0
	2	0
	3	0
	4	0
	5	0
Specimen 5D. length 5mm, tube 0.49 ml.	1	0
	2	0
	3	0
	4	0
	5	0
Specimen 6D. length 4mm, tube 0.48 ml.	1	0
	2	0
	3	0
	4	0
	5	0

TABLE NO. 23.

Numbers of Stones in 50 x 50cm sq. on bed of river

River Wear, Bishop Auckland

Stones from slow running water. Width of River 21.25m.

Sample No.	No. of Stones
1	12
2	9
3	8
4	17
5	13

Medium speed water. Width of River 21.25m.

1	14
2	15
3	14
4	12
5	14

Fast speed water. Width of River 7.92m.

1	6
2	8
3	9
4	9
5	10

River Deerness - Ushaw Moor

Slow speed water. Width of River 9.17m

Sample No.	No. of Stones
1	20
2	19
3	17
4	17
5	16

TABLE NO. 23. (cont.)

River Deerness - Ushaw Moor (continued)

Medium speed water. Width of River 10m.

Sample No.	No. of Stones
1	31
2	23
3	20
4	22
5	18

Fast speed water. Width of River 6.5m.

Sample No.	No. of Stones
1	22
2	28
3	29
4	32
5	30

TABLE NO. 24.

Animal defæcation in distilled water in 15°C. Room

Freshly caught animals kept in 20ml centrifuge tubes in aerated distilled water.

Ephemerella

2.7.74	3.00 p.m.	2 specimens in 2 tubes.
3.7.74	3.00 p.m.	Specimens removed from tubes.
	Tubes centrifuged - live and dead diatoms recovered from water.	
3.7.74	11.00 a.m.	2 specimens in 2 tubes.
	3.00 p.m.	Specimens removed.
	Tubes centrifuged - live and dead diatoms recovered from water.	

Ecdyonurus

2.7.74	3.00 p.m.	2 specimens in 2 tubes.
3.7.74	3.00 p.m.	Both dead - removed.
	Tubes centrifuged - live and dead diatoms recovered from water.	

Baetis

2.7.74	3.00 p.m.	5 specimens in 2 tubes.
3.7.74	3.00 p.m.	All dead.
	Tubes centrifuged - live and dead diatoms recovered from water.	

TABLE NO. 25.

Total Numbers of Animals at each site for fast and medium water

SITE	BAETIS A	BAETIS B	ECDYONURUS	EPHEMERELLA	RITHROGENA	CAENIS	SAMPLE NUMBER
RIVER DEERNESS FAST	82	9	8	0	1	1	I
	136	21	6	41	0	0	II
	214	22	52	150	0	2	III
	306	27	22	304	0	0	IV
	28	434	52	48	0	0	V
	34	122	40	27	0	0	VI
TOTAL	800	635	180	570	1	3	
RIVER DEERNESS MEDIUM	12	0	12	0	0	0	I
	259	9	37	48	0	1	II
	148	8	206	352	0	10	III
	60	0	52	138	0	2	IV
	38	0	60	98	0	0	V
	28	146	32	18	0	0	VI
TOTAL	545	163	399	654	0	13	
RIVER WEAR FAST	6	0	2	0	33	0	I
	10	0	2	4	0	7	II
	444	8	54	88	6	0	III
	354	18	62	148	0	0	IV
	228	32	4	160	0	0	V
	4	0	46	14	0	0	VI
TOTAL	1046	58	170	414	39	7	
RIVER WEAR MEDIUM	18	0	3	0	11	0	I
	435	0	12	17	5	9	II
	502	0	52	80	0	0	III
	84	0	138	184	0	0	IV
	0	0	20	108	0	0	V
	12	20	48	90	0	0	VI
TOTAL	1051	20	273	479	16	9	

TABLE NO. 26.

Numbers of larvae with black wing cases - last instar larvae

				Length	Number
Baetis sp.	R. Wear	Fast	9.5.74	9mm	1
	R. Deerness	Slow	16.5.74	11mm	1
	R. Deerness	Fast	16.5.74	12mm	1
	R. Deerness	Fast	23.5.74	10mm	3
	R. Wear	Medium	23.5.74	7mm	2
	R. Deerness	Medium	6.6.74	8mm	1
	R. Deerness	Fast	6.6.74	8mm	5
	R. Deerness	Fast	20.6.74	8mm 9mm	2 1
	R. Wear	Fast	8.7.74	8mm	2
Ecdyonurus	R. Wear		9.5.74	13mm 14mm 15mm	2 3 1
	R. Deerness	Fast	16.5.74	All above 13mm	
		Medium		All 14,15+ 16mm	
		Slow		15mm 12mm	2 1
	R. Deerness	Medium	23.5.74	16mm	1
	R. Wear			15 + 16mm All B.W.	
	R. Deerness		6.6.74	15mm	
Ephemerella	All 8mm larvae had Black Wing cases.				
Rithrogena	R. Wear	Fast	9.5.74	10mm 11mm	3 1
		Medium		10mm	5

TABLE NO. 27.

Animal Survival in 15°C. Room

Freshly caught animals kept in 250ml beakers in aerated river water.
(18 hours Light, 6 hours Dark)

Sample 1.

14.6.74	6 Baetis alive
17.6.74	1 Baetis alive
18.6.74	All dead

Sample 2.

14.6.74	2 Ecdyonurus alive
17.6.74	1 Ecdyonurus alive
18.6.74	All dead

Sample 3.

21.6.74	6 Baetis alive
24.6.74	All dead

Sample 4.

25.6.74	4 Ephemerella alive
1.7.74	4 Ephemerella alive
5.7.74	4 Ephemerella alive
6.7.74	All dead

Sample 5.

25.6.74	6 Baetis + 1 Ecdyonurus alive
1.7.74	All dead

TABLE NO. 28.

Diatoms found in gut analysis

The following types of diatoms were found in the gut contents of Ephemeropteran nymphs examined from the River Deerness:

Naricula sp.

Pinnularia sp.

Gomphonema sp.

Nitzschia sp.

Cymbella sp.

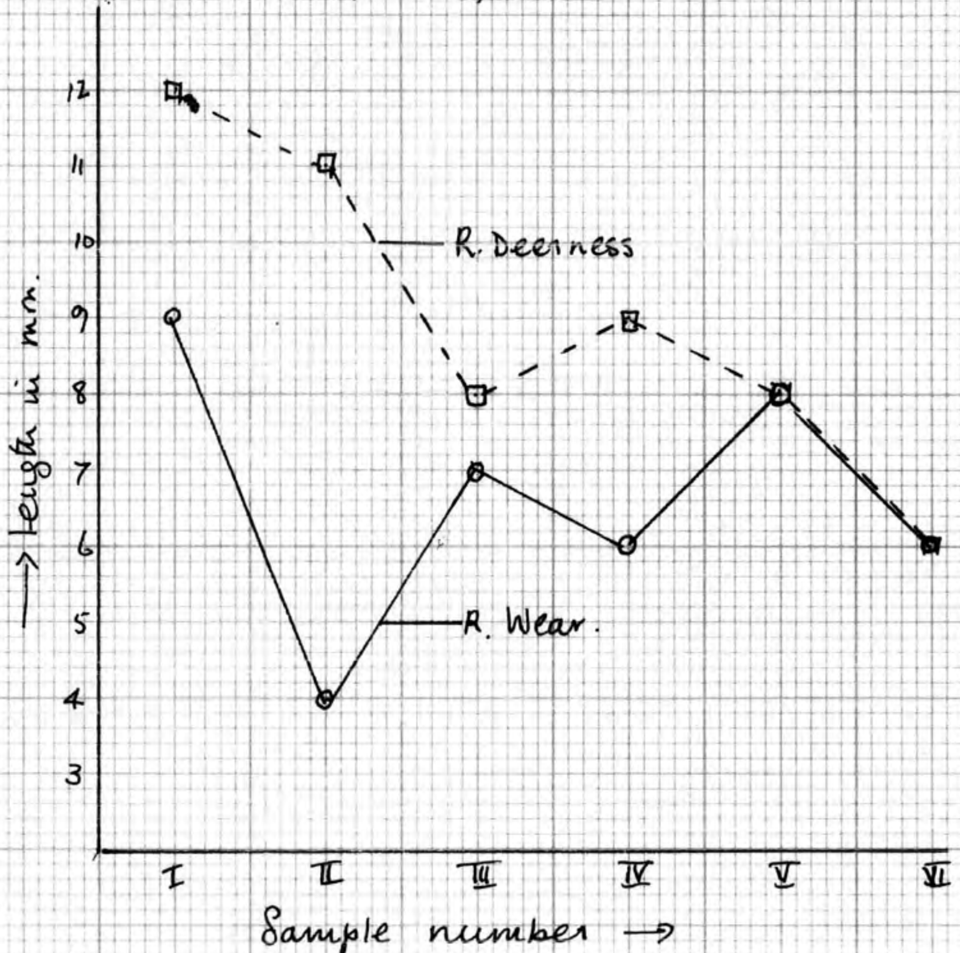
Achnanthes sp.

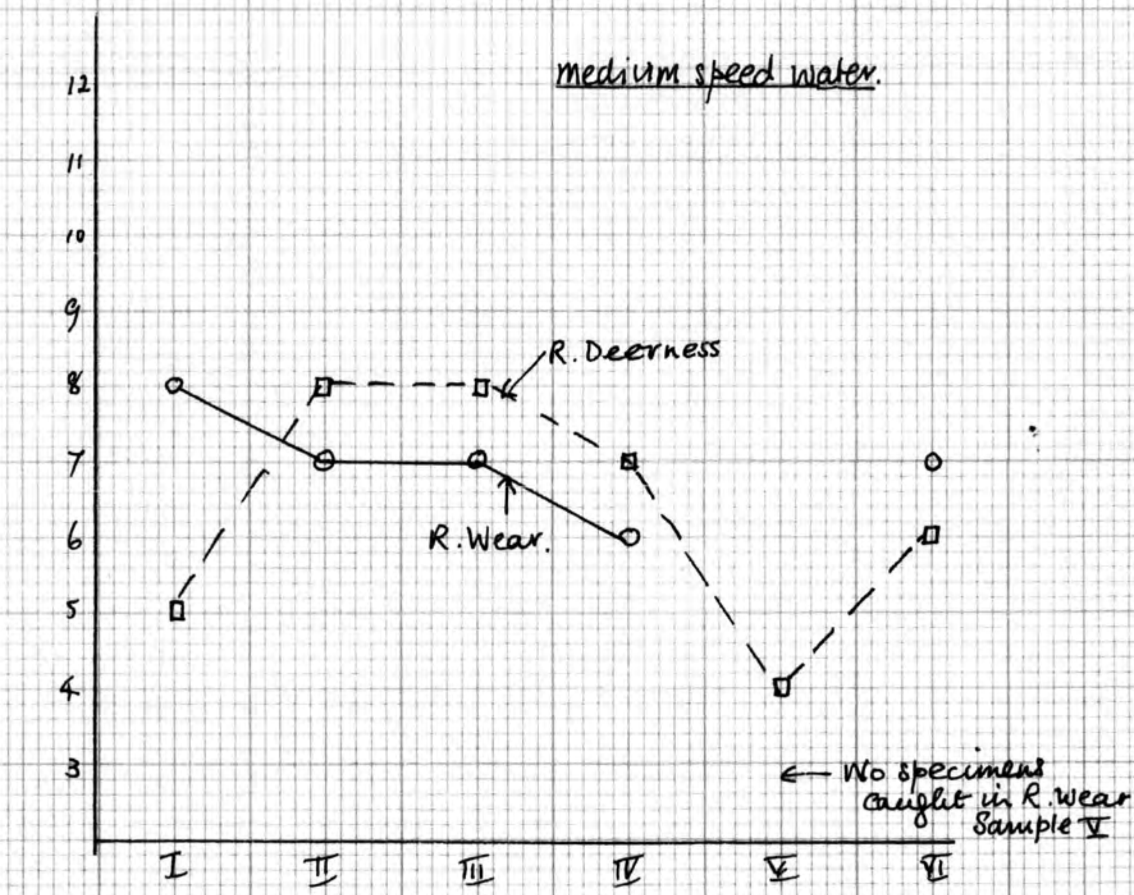
Coccoeneis sp.

The first three genera were the most commonly found in the animals investigated.

To show largest animal caught per sample in R. Deerness and R. Wear

Baetis sp. - fast water.

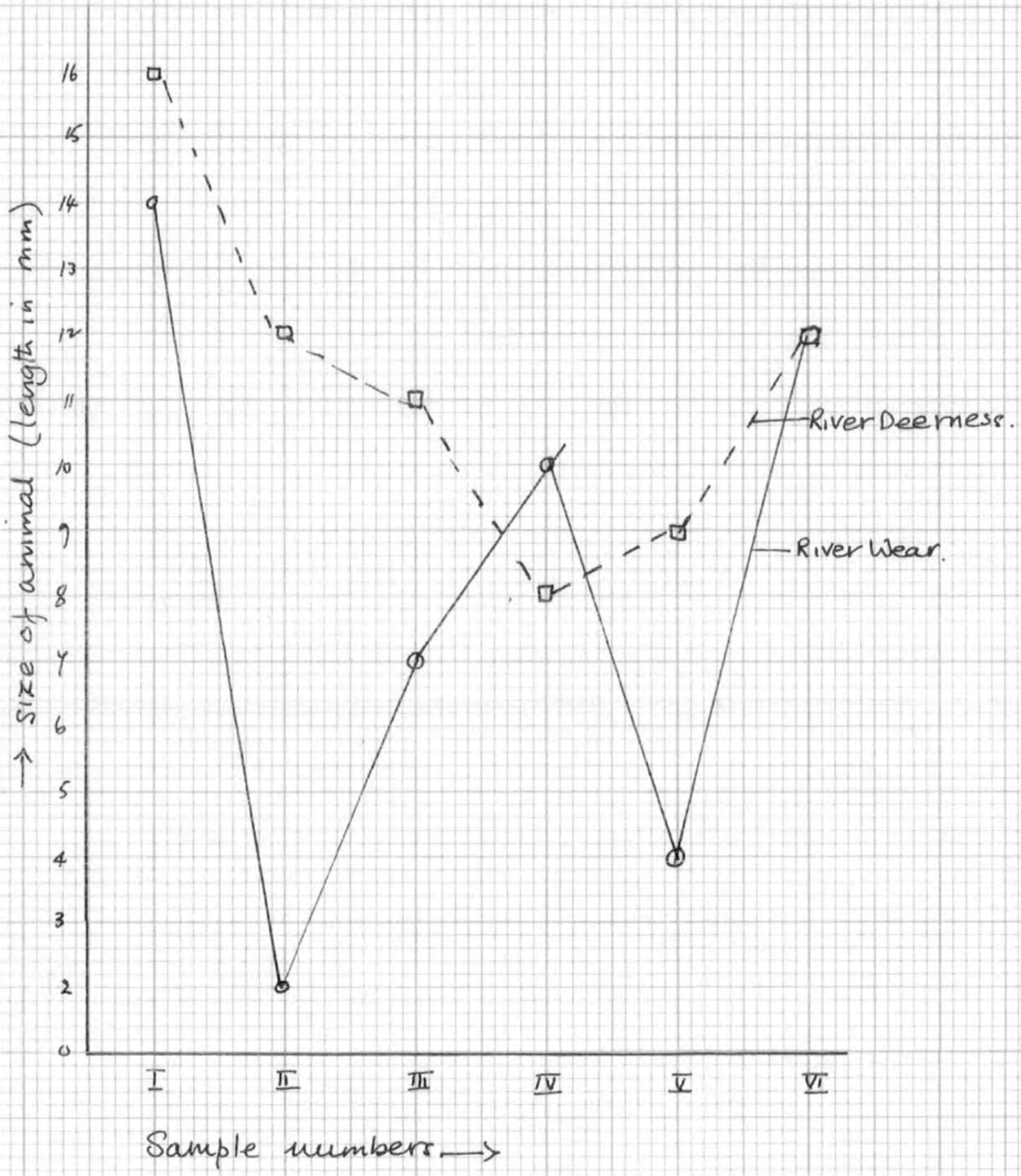




GRAPH 4.

To show size of largest animal caught per sample in River Deerness and River Wear.

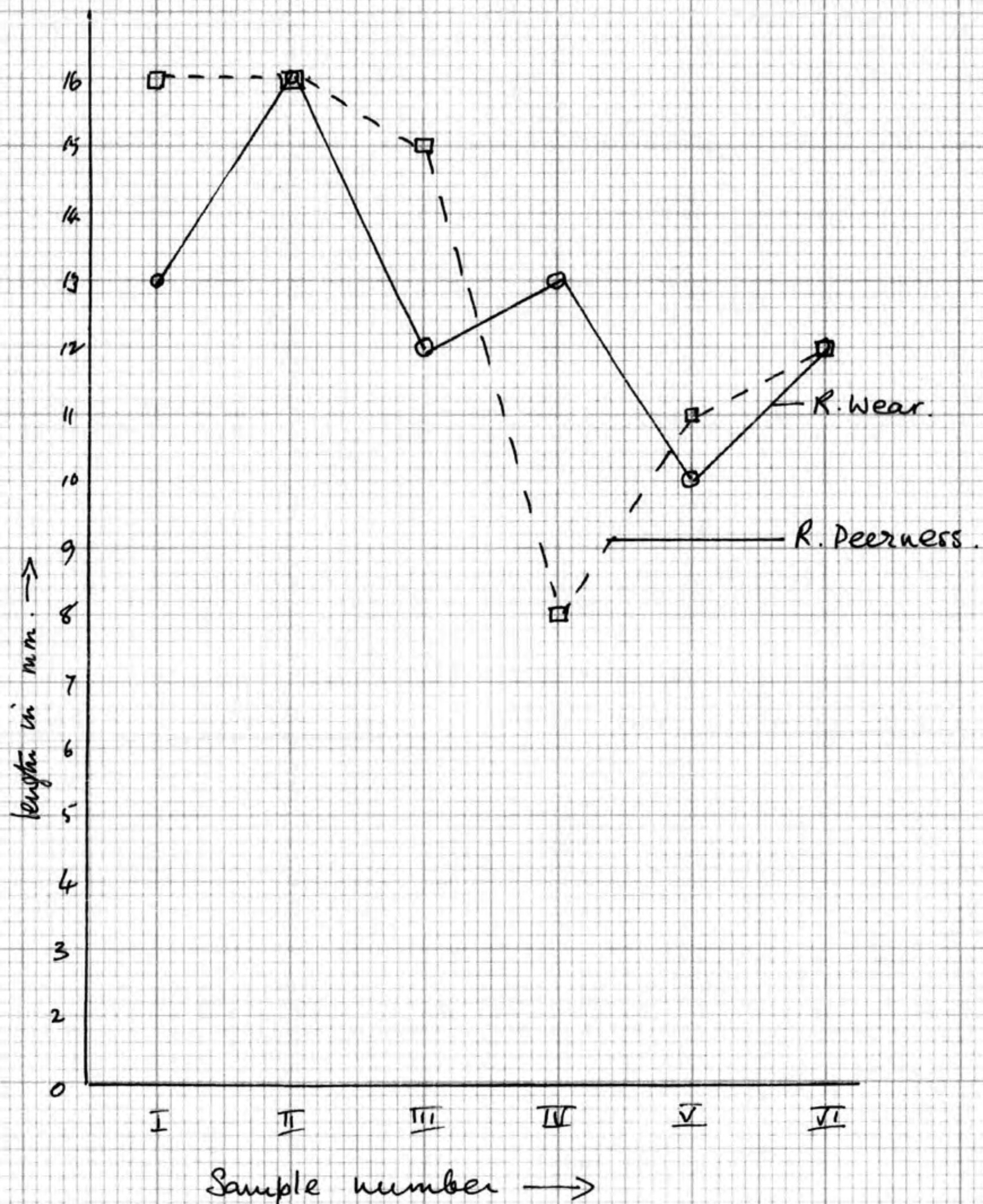
Ecdyonurus sp. Fast speed water.



GRAPH 5.

To show size of largest animal caught per sample in R. Deerness and R. Wear.

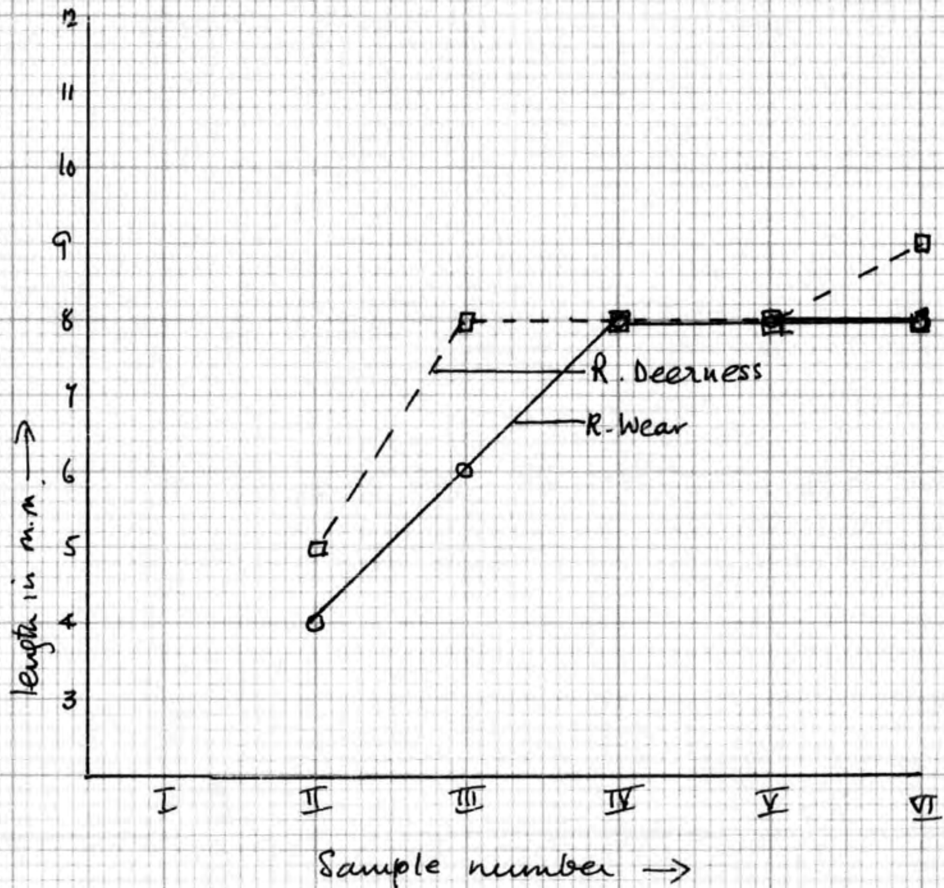
Ecdyonurus sp. Medium speed water.



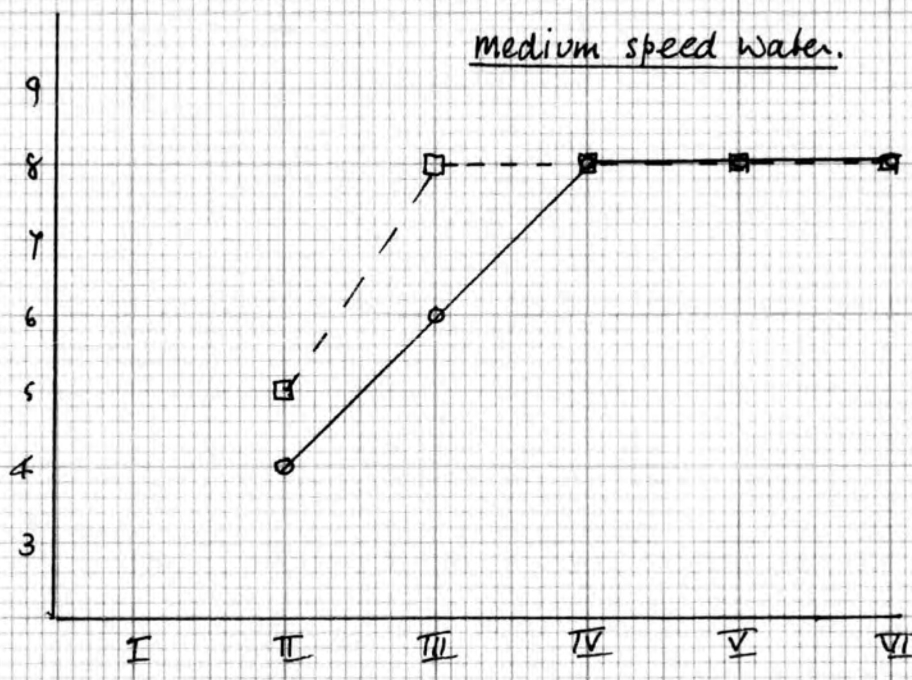
GRAPH 6

To show largest animal caught per sample in R. Deerness & R. Wear.

Ephemerella ignita – fast speed water.



medium speed water.



Note No Ephemerella present in first samples.

GRAPHY