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Distribution of Macroinvertebrates in English and Welsh Rivers based on the 1995 Survey

School of Computing, Staffordshire University

R&D Technical Report E12

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Distribution of Macroinvertebrates in English and Welsh Rivers based on the 1995 Survey

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This report summarises an analysis of the biological data collected as part of the National River Quality Survey 1995. The information within this document is for use by the Agency staff and others interested in the biology or biological quality of rivers in England and Wales.

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CONTENTS

TABLES

FIGURES

APPENDICES

EXECUTIVE SUMMARY

This Technical Report represents an analysis of biological data from river sites in England and Wales, sampled as part of the 1995 National River Quality Survey. It was carried out as part of National R&D Project 621 "Applications of Artificial Intelligence (AI) in River Quality Surveys". Although nationwide biological data have been available since the 1990 national survey, this report represents the first comprehensive analysis of such a database. The motivation for the analysis stemmed from a need to unlock the wealth of scientific information contained within these data, not only for the purpose of the AI aspects of the project, but also to provide the Agency's biologists and water quality managers with valuable information on the distribution of the Biological Monitoring Working Party (BMWP) families with respect to space, water quality and abundance category. The results will be of value to many working in fields related to the aquatic environment.

The main objective of the analysis was to derive geographic and frequency distributions for the BMWP families of macroinvertebrates occurring in English and Welsh rivers, and to represent them:

- in a comprehensive, yet easily understood, graphical form; and
- in the form of conditional probabilities for use in Bayesian classifiers.

This report is concerned with the first of these representations only.

The 'raw' data were subjected to validation procedures designed to produce a project database of sufficient quality and completeness to be suitable for use in the development of the proposed AI systems. Sites having incomplete records or potentially erroneous data were removed, as were all 'non-river' sites like canals, dykes and drains. Thus the retained data comprised 'natural' river sites having complete and valid records of samples taken during the spring and autumn of 1995.

Geographical distribution maps for 76 BMWP families of macroinvertebrates are presented showing their average abundance per ten kilometer square over England and Wales, and their regional occurrence in: i) 'clean' (Class 'a') sites; and ii) all sites, irrespective of water quality class. These maps show the distributions of the families in a manner which has not previously been presented for an area as large as England and Wales.

Frequency histograms are presented for 54 families showing their distributions by abundance category against both Average Score per Taxon (ASPT) and Biological GQA Quality Class. Histograms for the families are given for each of the former ten NRA administrative Regions in England and Wales, and for England and Wales as a whole. These provide valuable information on the susceptibilities of the families to environmental pollution in relation to their recorded abundance categories.

Keywords: freshwater, benthic, macroinvertebrates, BMWP, ASPT, abundance, distribution, geographic, frequency, water quality, river pollution, GQA

1. INTRODUCTION

This report provides for the first time the geographic and frequency distributions of aquatic macroinvertebrate families[1] for the whole of England and Wales based on a single survey in which:

- standard methods of sample collection and analysis were used;
- the data were subjected to full quality assurance; and
- families were recorded on a log-based scale of abundance categories.

Although data on the occurrence of the aquatic families have been published in other reports, most have been confined to a limited range of taxa or a restricted geographical area. A novel feature of the geographic and frequency distributions presented in this report is that they are related to abundance categories. The only constraint was that the samples were taken from 'river' sites, thus all samples from 'non-river' sites (e.g. canals, dikes, drains, etc.) were excluded from the study. The distribution maps therefore show the occurrence of families from this restricted habitat range only. Consequently, they differ from the maps produced by the Biological Records Centre (BRC), which are based on the occurrence of given species across all habitats within each ten kilometre grid square. The maps in this report are therefore complementary to, not a substitute for, the BRC distributions.

This report has been produced to enable biologists to gain a better understanding of the distribution of invertebrate families used for monitoring the biological quality of rivers. The report shows their geographic distributions in terms of natural conditions (i.e. based on sites with good water quality) and actual condition (i.e. all water qualities). The frequency distributions show the variation in percentage occurrence of each family with respect to 'water quality' as defined by a) its ASPT and b) its GQA biological class. These distributions will enable a better understanding to be gained of the indicator value of each family in river quality surveys. It is hoped that the report will not only provide useful information to freshwater biologists, ecologists and water managers, but also generate feedback that will lead us all to a better understanding of the data and the aquatic domain.

The results presented are the product of the data validation and analysis phase of National R&D Project 621: Applications of Artificial Intelligence in River Quality Surveys. Although the derivation of the distributions was not of primary importance to the main objectives of the project they did provide valuable in-depth understanding of both the data and the domain. The acquisition of such understanding is an important prerequisite to any Artificial Intelligence (AI) project. Since the AI aspects of the project are not covered in this report, those readers wishing to find out more about its potential applications in biological monitoring are referred to the papers by Walley (1994) and Walley and Dzeroski (1995).

[1] For the sake of simplicity, the taxa are referred to as 'families' throughout this report, despite the fact that one of them (Oligochaeta) is not a family. In addition, some of the 'families' are groups of taxonomic families.

2. THE DATA

2.1 General

The data used within R&D Project 621 were collected as part of the 1995 National River Quality Survey, primarily for the General Quality Assessment (GQA) of watercourses (Environment Agency, 1997). For the purpose of this report, England and Wales has been divided into ten Regions based upon the original ten administrative Regions of the former National Rivers Authority (NRA). The relationships between these regions and the present eight administrative Regions of the Environment Agency are given in Table 1.

Table 1. Relationship between the former ten NRA Administrative Regions used as the basis of this study and the present eight Environment Agency Administrative Regions.

No.	NRA Region	Present Environment Agency Administrative Region/Area
1	Anglian	Anglian Region
2	Northumbrian	Northumbria Area of North East Region
3	North West	North West Region
4	Severn Trent	Midlands Region
5	Southern	Southern Region
6	South West	Devon and Cornwall Areas of South West Region
7	Thames	Thames Region
8	Welsh	Welsh Region
9	Wessex	North Wessex and South Wessex Areas of South West Region
10	Yorkshire	Dales and Ridings Areas of North East Region

2.2 Sample Collection and Audit

Samples were collected by the standard procedures used by the Environment Agency for collecting RIVPACS[2]-compatible samples. At most sites this was by three minutes active sampling with a pond net, supplemented by a one minute search for taxa on the surface of the water and attached to stones. At some deeper sites, samples were collected by between three and five trawls with a medium naturalists dredge or by transects sampled by a Yorkshire pattern air-lift sampler, and supplemented by a one minute sweep of the marginal vegetation and one minute search. The sampling and analytical methods are described in a manual prepared by the Environment Agency (in prep.). Every site was sampled twice: in spring (March, April or May) and in autumn (September, October or November).

Most of the sites were at easily accessible locations, usually at the downstream end of the monitored watercourse reach. Despite their ecological importance, headwaters and springs were very under-represented, and few watercourses with flows of less than 0.3 cumecs (cubic metres per second) were included in the survey. In addition, brackish water, estuaries, still waters (ponds and lakes) and seasonal watercourses such as winterbournes were excluded from the survey. Other still water sites such as canals, dikes and drains were removed from the project database for reasons outlined in section 2.3. Thus those families which

[2] River InVertebrate Prediction And Classification Scheme - a computer program used to classify water quality.

predominate in these types of environment may be under-represented in the maps and graphs presented within this report.

The quality of the analysis of samples was audited by the Institute of Freshwater Ecology. The auditors re-analysed a number of randomly selected samples from each Region. Families found in a sample by the auditor which were not recorded as present in the data were termed 'gains', whilst those recorded in the data but not found by the auditor were termed 'losses'. Most errors occurred as a result of a failure to notice specimens in samples whilst sorting them ('gains') or as a mis-identification of specimens ('losses' and some associated 'gains'). Table 2 below gives the results of the audit of samples by Region.

Table 2. Results of the audit of samples

Region	Number of audited samples	Mean number of 'gains' / sample	Mean number of 'losses' / sample
Anglian	60	2.25	0.27
Northumbrian	17	1.12	0.12
North West	60	2.52	0.33
Severn-Trent	61	1.84	0.20
Southern	60	1.33	0.32
South West	31	1.42	0.06
Thames	60	2.05	0.27
Welsh	60	1.98	0.25
Wessex	29	1.62	0.10
Yorkshire	43	1.67	0.05
National	481	1.88	0.22

This shows that 'gains' are almost ten times as likely as 'losses', and that there are almost two 'gains' on average per sample. However, since the number of specimens associated with both gains and losses was generally very small, they only affected the data records relating to 'absent' and abundance category 1. Thus the implications of these errors for the published distributions are that:

- the frequencies of abundance category 1 are slightly underestimated;
- the extent of the geographic distributions are slightly underestimated, especially for the rarer families; and
- some of the indicated occurrences of less widespread families in unexpected locations are erroneous (e.g. the apparent occurrence of Potamanthidae in Thames Region).

Unfortunately, errors of this nature are inevitable in a survey of this size aimed primarily at water quality monitoring.

2.3 Data Validation

Central to the development of AI applications within R&D Project 621 was the construction of a clean and reliable project database. All sites with incomplete records or potentially erroneous values in any of the environmental or taxonomic fields were removed, including those sites which had only been sampled in one of the two sampling seasons. In addition, all sites which included the words canal, dike, dyke, drain, ditch, old river course or navigation in

their watercourse names were removed from the database. This was done on the basis that:

- they were not natural rivers or streams; and
- their presence could distort the AI models since many of them were serious outliers in data space.

A further problem arose with respect to abundance categories, since two Regions had not reported them at all, and one had reported them incorrectly. This resulted in some delay while the required abundances were retrieved from regional source files. In the case of one region (North West), this required the derivation of log-based family abundances from mixed-level (i.e. family, genus and species) abundance data that had been recorded using a scale not consistent with the log-based national scale. The required conversion from local scale to the national scale for each taxon (i.e. family, genus and species) within each sample was achieved by randomly generating a number (i.e. estimated number of individuals) from a logarithmic distribution specific to the recorded abundance band. The total number of individuals contributing to a given family was derived by simple summation across the taxa belonging to that family. In practice, only a small proportion of recorded families had to have their log-based abundances estimated in this way. Most were able to be converted directly from the local scale to the national scale without any need for estimation. Thus any errors introduced by the estimation method are likely to be so small as to have insignificant effect on the final distributions.

The original databases, prior to validation, contained 13,296 samples from approximately 6,700 sites. During the validation process 1,218 samples were removed, leaving 12,078 validated samples from 6,039 sites. All the distributions presented in this report were derived from these validated databases. Table 3 gives a breakdown of the percentage of samples removed from the databases in terms of the reason for their removal. The final number of samples from each of the ten Regions is given in Table 4.

Table 3. Percentage of samples removed during sample validation

Reason for removal of sample	Percentage removed
Missing / erroneous environmental data	2.34%
Sampled in one season only	0.90%
Missing abundance data	0.30%
'Non-river' sites (e.g. canals, dikes, drains, etc.)	5.62%

Table 4. Number of samples from two-season sites by Region.

Region No.	1	2	3	4	5	6	7	8	9	10
Region Name	Angl	Nrthm	N-W	S-T	Sthn	S-W	Thms	Welsh	Wssx	Yorks
No. of Samples	1276	544	1622	2066	992	1188	968	1590	996	836

3. THE DISTRIBUTIONS

Geographic and frequency distributions have been derived for selected BMWP families. The distributions incorporate abundance data based upon four abundance categories. Full details of the distributions and the basis on which they were derived are given below.

3.1 Selected Families

Table 5 lists the 76 BMWP families included in this study. Geographic distributions have been presented in Appendix A for all of these families. However, only 54 of them (marked thus * in Table 5) occurred in sufficient number to justify the presentation of their frequency distributions in Appendix B.

Table 5. The 76 BMWP families included in the study

* Planariidae	* Gammaridae	* Calopterygidae	* Rhyacophilidae
* Dendrocoelidae	Astacidae	Cordulegasteridae	Philopotamidae
* Neritidae	Siphlonuridae	Aeshnidae	* Polycentropidae
Viviparidae	* Baetidae	Libellulidae	* Psychomyiidae
* Valvatidae	* Heptageniidae	Hydrometridae	* Hydropsychidae
* Hydrobiidae	* Leptophlebiidae	Gerridae	* Hydroptilidae
* Lymnaeidae	* Ephemerellidae	Nepidae	Phryganeidae
* Physidae	Potamanthidae	Naucoridae	* Limnephilidae
* Planorbidae	* Ephemeridae	Aphelocheiridae	* Molannidae
* Ancylidae	* Caenidae	Notonectidae	Beraeidae
* Unionidae	* Taeniopterygidae	* Corixidae	* Odontoceridae
* Sphaeriidae	* Nemouridae	* Haliplidae	* Leptoceridae
* Oligochaeta	* Leuctridae	* Dytiscidae	* Goeridae
* Piscicolidae	Capniidae	* Gyrinidae	* Lepidostomatidae
* Glossiphoniidae	* Perlodidae	* Hydrophilidae	* Brachycentridae
Hirudididae	* Perlidae	Scirtidae	* Sericostomatidae
* Erpobdellidae	* Chloroperlidae	Dryopidae	* Tipulidae
* Asellidae	Platycnemidae	* Elmidae	* Chironomidae
Corophiidae	* Coenagriidae	* Sialidae	* Simuliidae

* Families for which frequency distributions have been presented.

Eight of the original BMWP families have since been split into separate families. For the purpose of this report they have been recombined into their original families. Consequently, each of these 'families' now consists of a group of families as detailed below:

Planariidae	-	includes Dugesiidae
Hydrobiidae	-	includes Bithyniidae
Ancylidae	-	includes Acroloxidae
Gammaridae	-	includes Crangonyctidae and Niphargidae
Dytiscidae	-	includes Noteridae
Hydrophilidae	-	includes Hydraenidae
Rhyacophilidae	-	includes Glossosomatidae
Psychomyiidae	-	includes Ecomidae

Three BMWP families (Lestidae, Pleidae, Hygrobiidae) were included in the 1995 survey but were not recorded from any samples. Three other families have also been removed from the list of included families because they are not used by the Agency and have been excluded from RIVPACS III. These are Clambidae, Chrysomelidae and Curculionidae. The taxonomic nomenclature used for the BMWP families follows that in Maitland (1977).

3.2 Abundance Categories

The data used for the derivation of the distributions included an abundance category for each family. Although its possible range extends up to a maximum abundance of six, the top three categories were combined into category four for the purpose of this report. Only Oligochaeta and Chironomidae are likely to occur in abundance categories five and six, and such occurrences are rare. The categories are related to the number of individuals found in the sample according to the following logarithmic scale:

0 - not found
1 - 1 - 9 individuals
2 - 10 - 99 individuals
3 - 100 - 999 individuals
4 - $\geq$ 1000 individuals

3.3 Geographic Distributions

3.3.1 Distribution of samples

The geographic distribution of the 6039 river sites used in the study is shown in Figure 1, whilst Figure 2 shows the geographic distribution of the number of samples taken in each ten kilometre grid square. Figure 2 uses the same system as that used to display the geographic distributions of the families by average abundance in Appendix A. It thus offers the reader the opportunity to take account of sample size when interpreting the distributions of individual families on a local scale. For example, a particular square might indicate a very high average abundance of a given family, whilst adjacent squares do not. If Figure 2 shows that the particular square in question has very few samples (say 2 - 4) and adjacent squares have many more, then the abundance data can be interpreted in the context of these sample sizes. Approximately 85% of grid squares had two or more samples (i.e. at least one site sampled during both spring and autumn), the actual number varying from two (262 squares) to 34 (two squares). The remaining squares were either not sampled due to a lack of river sites, or their site(s) were excluded from the database for one of the reasons mentioned earlier.

3.3.2 Distribution of families by average abundance

To provide detailed information on the geographic distribution of the families, maps were produced which show their 'average abundance' within each ten kilometre grid square. The advantage of using average abundance as opposed to occurrence can be seen from the two maps, 'a' and 'b', shown in Figure 3. Both contain the same information with respect to the geographic extent of the occurrence of Asellidae, but map 'b' which is based on the average abundance gives a better impression of its overall distribution because it displays variations in its level of abundance.

The average abundance of a family in a given ten kilometre grid square was derived by taking the mean of its abundance categories over all samples taken within the square, absence being treated as zero abundance. In view of the logarithmic nature of the abundance categories, consideration was given to the use of other ways of defining 'average' abundance. It was concluded that the matter was rather academic, since the sole purpose of the exercise was to produce a good visual impression of the geographic distribution of each family, showing both its extent and intensity of occurrence. The straight average of the abundance categories was adopted because it gave the required effect and was simple to understand.

Geographic distribution maps for each of the BMWP families are given in Appendix A. These display average abundances (in bands of 0.5) as an array of black circles, each having an area proportional to the average abundance. The smallest circle covers the range > 0 to 0.5 and ensures that any occurrence of the family, however small, will be recorded within the appropriate ten kilometre grid square.

For families that tend to occur in low numbers, such as Dytiscidae, the method merely serves to indicate the extent of their geographic distribution. However, for families which are numerically more abundant, it serves a dual function: firstly indicating their geographic extent; and secondly displaying variations in their abundance within this distribution.

3.3.3 Distribution of families by occurrence

The percentage occurrence of each family, irrespective of abundance level or water quality, was derived for each of the Regions. In addition, the percentage occurrence of each family in rivers classified as Class A was also derived. These may be regarded as unpolluted rivers and hence representative of the 'natural' biological quality of the watercourse, although the families recorded and the Average Score Per Taxon (ASPT) will vary from region to region depending upon the range of habitats within the region. The results of these analyses are given in Appendix A as distributions of percentage occurrence by region for each of the BMWP families.

3.4 Frequency Distributions

Distributions of the frequency of occurrence with respect to ASPT and GQA biological class for each of the 54 selected families have been derived for each region. The distributions are presented in Appendix B in the form of histograms in which the bars, representing percentage occurrence, are sub-divided into four abundance categories (1, 2, 3 and 4+). All distributions relating to a given family are shown on two facing pages, one showing the distributions by ASPT band and the other showing the distributions by GQA biological class. Each page displays distributions for each of the ten Regions, arranged in approximate order of their geographic location, and the combined distribution for England and Wales as a whole.

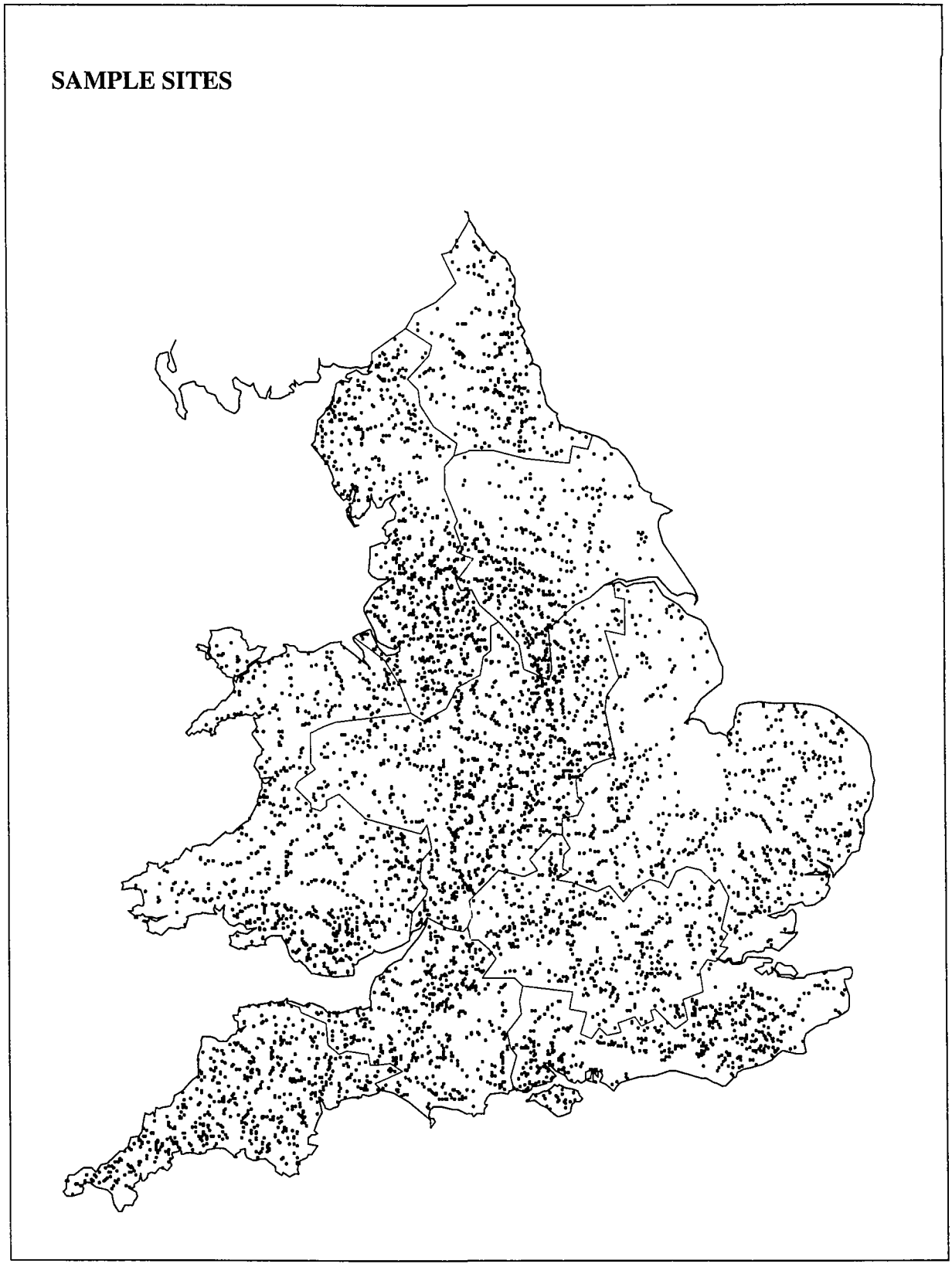

Figure 1. Distribution of river sites sampled during 1995

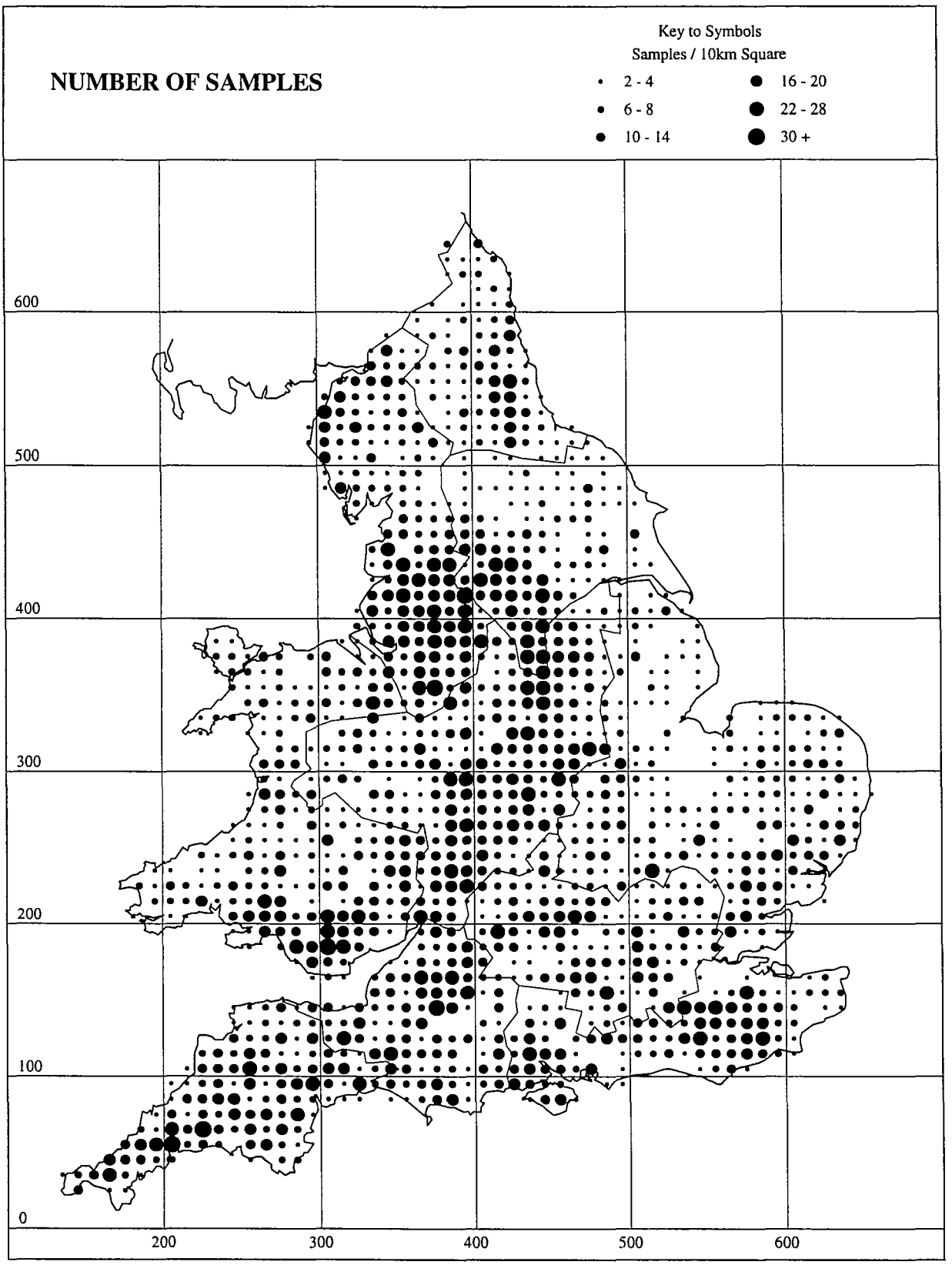

Figure 2. Number of samples taken per ten kilometre square from river sites during 1995

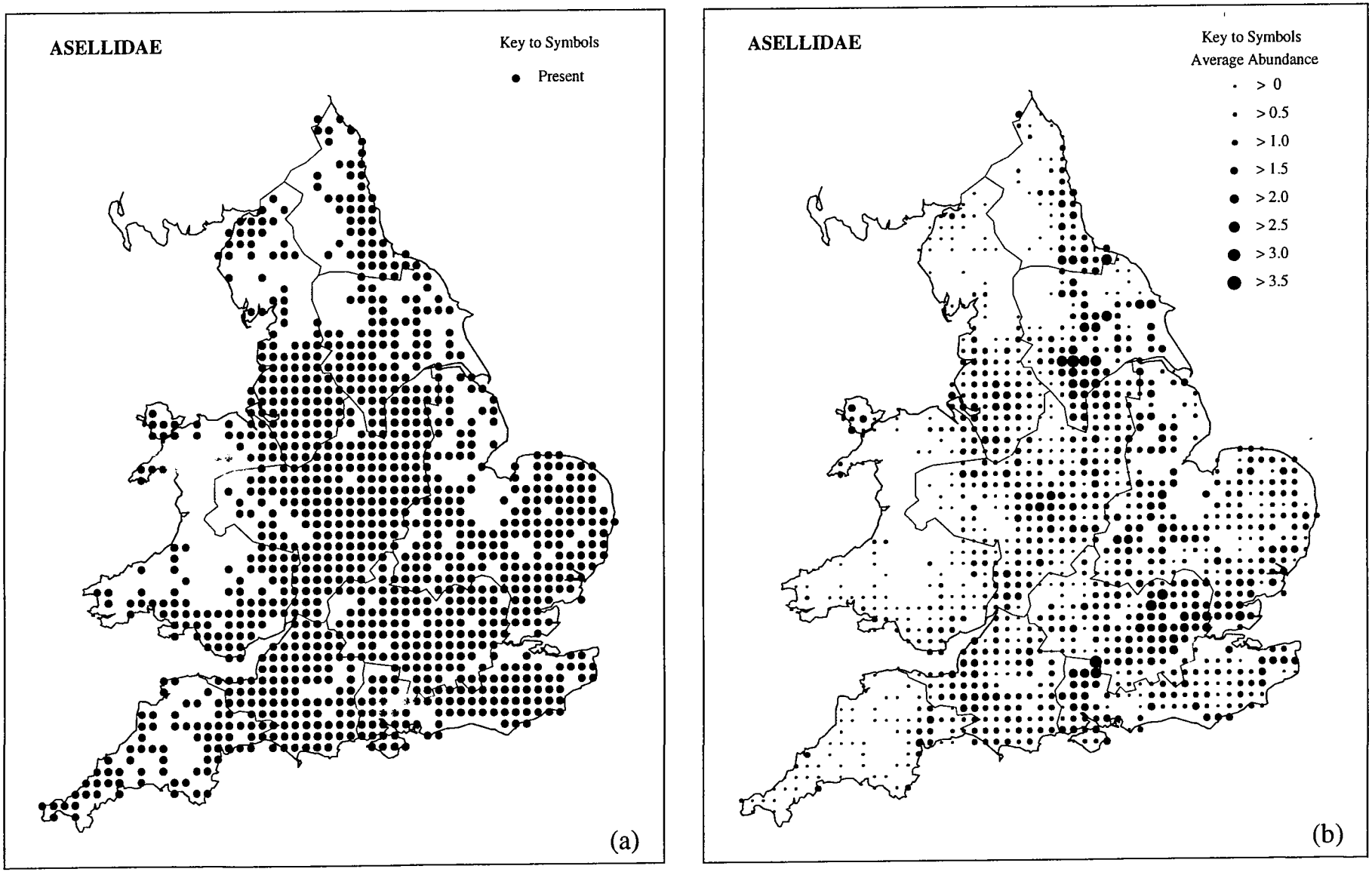

Figure 3. Comparision between distributions of BMWP families by (a) presence and (b) average abundance

4. SOME OBSERVATIONS

The following sections describe some observations made by the authors with respect to various characteristics of the distributions. These observations are not intended to be comprehensive. They are offered merely as a starting point from which the reader may begin to explore the wealth of information contained within the distributions.

4.1 General

Differences in typical habitat type, sampling methods and recording practices between Regions may account for some of the spatial variations seen in the geographic distributions. A few of the maps in Appendix A (e.g. Oligochaeta, page A-14) show changes in average abundance at regional boundaries that may be due to differences in practice between neighbouring Regions. However, these apparent differences occur with very few families, and may represent perfectly valid variations in their distributions.

Figure 3 shows two different versions of the same geographic distribution of Asellidae, one (Figure 3a) showing its presence and the other (Figure 3b) showing its average abundance. These serve to illustrate two things:

- the benefit gained by plotting average abundance of each family as opposed to its presence; and
- the need to interpret apparent anomalies with care.

The map of average abundance shows high values for Asellidae in the urbanised areas of Teesside, Leeds/Wakefield, Liverpool/Manchester, Birmingham and north London, and higher than average values in the flat lowland areas of Cambridgeshire and Somerset. This information is not available from the distribution of its presence, as shown in Figure 3a. In addition, the scarcity of Asellidae in the Lake District, northern Pennines, Wales, Devon and Cornwall is more clearly seen on the map of average abundance than that of its presence. However, care needs to be exercised in the interpretation of the average abundance maps, because of the unequal sampling effort within grid squares. For example, two squares show Asellidae as having an average abundance of greater than three, one in Hampshire and one in Yorkshire. Reference to Figure 2 shows that the Hampshire square had very few samples (just two), whereas the Yorkshire square had many more (ten to be precise). Thus the first appears to be an isolated case of Asellidae occurring in large numbers, whereas the second clearly indicates a more widespread effect.

4.2 Geographic Distributions

Examination of the maps of average abundance given in Appendix A reveals several different types of distribution. Lymnaeidae and Dytiscidae show widespread and fairly uniform distributions, whilst those of Hydrobiidae, Oligochaeta, Gammaridae, Baetidae and Chironomidae are widespread but uneven. This unevenness is possibly due to the higher abundances which tend to occur with these families. Caenidae and Asellidae are also widespread, but the former is apparently absent from the main industrialised areas, whilst the latter is absent from the uplands of northern England, Wales and the South West as one might expect of these species.

Some families are geographically biased, examples being Valvatidae and Coenagriidae which occur more commonly in the south and east of England. Calopterygidae has a similar distribution but extends its range more into South West Region. Families requiring the 'cleanest' waters occur more in northern England, Wales and the South West, examples being Heptageniidae and Leuctridae. Gammaridae appears to be found more abundantly in areas of chalk and limestone. Elmidae (the 'Riffle' Beetle) is widespread, occurring abundantly in clean upland waters, but far less so in the lowland Regions where riffle areas with turbulent flows are scarce, and hardly at all in the main industrialised areas.

The distributions of the families of Plecoptera show a gradation from rare to more common and may be placed in order of increasing occurrence as follows:

Perlidae → Chloroperlidae → Taeniopterygidae → Perlodidae → Leuctridae → Nemouridae

Capniidae has not been included in the list as it was only recorded in 49 of the squares, with a maximum abundance category of one, thus appearing even more sensitive than Perlidae.

4.3 Frequency Distributions

The distributions of frequency of occurrence with respect to ASPT and biological GQA quality class for the 54 selected BMWP families are presented in Appendix B. The main difference between the two sets of distributions is that one (GQA class) attempts to remove the effect of site type whereas the other (ASPT) does not, except to the extent that some Regions are predominantly of one site type.

4.3.1 Distributions based on biological GQA class

Examination of the frequency distributions by biological GQA quality class given in Appendix B reveals two main types. Firstly there is the type (Type A) associated with those families which prefer the unpolluted conditions of GQA class 'a' waters, and secondly the type (Type B) which is associated with families preferring waters of intermediate quality, somewhere between GQA classes 'a' and 'f'. In addition there is a minor type (Type C) associated with just two families, Oligochaeta and Chironomidae, in which frequency of occurrence remains at a very high level across all GQA classes, whilst abundance level increases with decreasing quality, normally peaking in class 'f'.

The many families that fall into Type A include the stoneflies, mayflies, some beetles (notably Elmidae), most of the caddis-flies, the true flies (Tipulidae and Simuliidae) and the river limpet (Ancylidae). These families display a wide range of sensitivity to pollution, but they all display the same characteristic of occurring most frequently in GQA class 'a' waters. The most sensitive families are the stoneflies and the mayflies, with the exception of Baetidae which is clearly more tolerant of pollution. Frequencies of occurrence and abundance categories of these sensitive families typically decline very quickly from high values in class 'a' to zero or very low values in class 'd', rarely extending into class 'e'.

The Type B families include the flatworms, snails, mussels, worms, leeches, crustaceans, most beetles and some caddis-flies. Once again, they represent a wide range of sensitivities to pollution, from families like Gammaridae whose preferred quality class varies between Regions within the range class 'a' to 'c', to those like Asellidae with a preference for waters in the range class 'c/d' to 'e'. Unlike the Type A families, the Type B families typically show

significant variation in their preferred quality class from region to region. It seems that this may be due to an interaction between site characteristics and level of pollution, which does not occur with the Type A families because their preferred class is the 'unpolluted' class 'a'. A clearer picture of the water quality preferences of the Type B families could be gained by plotting their distributions on the basis of site type instead of region.

The Type C families[1], Oligochaeta and Chironomidae, are noticeably different from the rest in that they occur in almost all samples. Their widespread occurrence is due to the large number of species which make up these taxonomic groups, and the vast range of pollution tolerances which they collectively represent. The only feature of the occurrence of these two taxa which differs across the ASPT bands and GQA classes is their abundance, the higher abundances tending to occur in the lower ASPT bands and GQA classes. Consequently, these two families are of little value in water quality assessments unless their abundances are taken into account.

4.3.2 Distributions based on ASPT

These are distributed with respect to ASPT, in bands of 0.5, instead of in bands representing the biological GQA quality classes. The division into Types A, B and C distributions used previously also apply here, although not all of the families associated with them are the same. For example, Elmidae was a Type A family with respect to GQA class, peaking in class 'a', but is a Type B family with respect to ASPT, peaking at a value of ASPT of about 6.0. The reason for this is that the ASPT bands are more finely divided than the quality classes, and that GQA class 'a' is approximately equivalent to the top three or four ASPT bands, thus making it possible to peak at some point within this range. That is, a family whose occurrence peaks in GQA class 'a' may not peak in the highest ASPT band but in a slightly lower one.

Those families that do retain Type A distributions are, as one would expect, the most pollution-sensitive families. Their distributions are limited in extent, being restricted to sites having high ASPTs. The Plecoptera, for example, mainly occur at ASPTs of 5.0 or more, peaking in the highest ASPT band of 7.0 to 7.5. Perlidae appears the most restricted in its ASPT range, with a minimum of about 6.0, whilst Nemouridae is clearly the most tolerant, occurring at ASPTs of 4.0 or less in some Regions. When ordered in terms of their lower bound ASPTs, as estimated from the ten regional distributions, the families of Plecoptera rank as follows:

$$\text{Perlidae} \rightarrow \text{Chloroperlidae} \rightarrow \begin{pmatrix} \text{Perlodidae} \\ \text{Taeniopterygidae} \\ \text{Leuctridae} \end{pmatrix} \rightarrow \text{Nemouridae}$$

The three families - Perlodidae, Taeniopterygidae and Leuctridae - could not be separated on the basis of their minimum ASPTs. Nevertheless, the overall order of the families of Plecoptera shown above is very similar to that given earlier in relation to the geographic extent of the families. This seems to indicate that water quality is the key factor governing their geographic extent, although the availability of appropriate site types is no doubt also an important factor.

The families which have Type B distributions with respect to ASPT tend to display sharper mid-range peaks than they did with respect to GQA class. Their distributions of percentage occurrence increase as ASPT increases, peak at some intermediate value and then decrease

with further increases of ASPT. The position of the peak varies from family to family and even region to region, probably due to the site type / pollution interaction mentioned earlier. The ASPT values corresponding to these peaks, for some commonly occurring families, are approximately as follows: 4.0 for Asellidae, 5.0 for Gammaridae, 5.5 for Dytiscidae and Ancylidae and 6.0 for Elmidae. It is also interesting to note that the rank order of these families, and those of the Plecoptera, are consistent with the family scores derived by Walley and Hawkes (1996) in their paper on the reappraisal of BMWP scores based on the 1990 Survey data.

A further point of interest is the distribution of specific categories of abundance with respect to ASPT. These distributions can provide valuable information about water quality. For example, the frequency distribution of Oligochaeta in the Dales and Riding Areas of North East Region (page B-24) shows a uniform frequency of occurrence of about 99% across all ASPT bands, but their frequency of occurrence at high levels of abundance increases significantly with decreasing ASPT. Thus abundance data transform Oligochaeta from a worthless to a valuable indicator of water quality, since they clearly reflect its preference for the poorer quality waters. This same argument also applies to Chironomidae and reinforces the point made in section 4.3.1 about the value of these two taxa in water quality assessments.

4.4 Some Apparent Anomalies

Anomalies appear to exist between Regions with respect to the frequency distributions of some families. For example, the distributions of Erpobdellidae and Asellidae by GQA class differ significantly between lowland Regions and upland Regions, especially with respect to their occurrence in class 'a' waters. In Anglian, Thames and Southern Regions the average percentage occurrence of Erpobdellidae and Asellidae in class 'a' waters is approximately 70% in both cases, whereas in Welsh and North West Regions they average 34% and 13% respectively. In these cases, it is clear that the main causes of the differences are:

- that upland Regions have a much higher ratio of riffles sites to pool sites than do lowland Regions; and
- that these families behave differently in riffles with respect to water quality than they do in pools (Walley and Hawkes, 1997).

There are other cases similar to these which could have been highlighted, some of which might call for different explanations.

Another possible anomaly is that Gammaridae occurs in 28% of North West Region's 118 GQA class 'f' sites, one fifth of which occur at abundance level 3. Since most other Regions show much lower occurrences of Gammaridae in class 'f', is it possible that some of these sites are not strictly class 'f' but class 'e' ? Similarly, one wonders whether some of North East Region's class 'a' sites with high numbers of Asellidae should perhaps be class 'b' sites.

5. FEEDBACK

The distributions presented in the appendices of this report will, no doubt, prove very informative to many. The experienced freshwater ecologist might find that they confirm most of his or her own long-held beliefs, but conflict with others. There may be anomalies that raise important questions or are difficult to explain. The authors would appreciate feedback from readers in relation to any feature of the distributions that seems contrary to their experience, or that provokes thought leading to new explanations of observed characteristics. Such comments could prove valuable in the development of the AI applications that are the ultimate goal of this project. If you have any comments on any aspect of the distributions please send them to the Project Manager:

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6. REFERENCES

Biological Monitoring Working Party (1978) *Final Report: Assessment and Presentation of the Biological Quality of Rivers in Great Britain.* Unpublished report. Dept. of Envir., Water Data Unit.

Environment Agency (1996) *The quality of rivers in England and Wales (1990 to 1995). A report by the Environment Agency.* Bristol: Environment Agency.

Environment Agency (1997) *Assessing water quality - General Quality Assessment (GQA) scheme for biology.* Fact Sheet. Bristol: Environment Agency.

Environment Agency (in prep.) *Procedures for collecting and analysing macro-invertebrate samples. Quality Assurance Systems for Environmental Monitoring: Biological Techniques, BT001.* Bristol: Environment Agency.

Environment Agency (in prep.) *Procedure for quality assurance for RIVPACS macro-invertebrate samples analysed to the taxonomic level needed for the BMWP-score system. Quality Assurance Systems for Environmental Monitoring: Biological Techniques, BT003.* Bristol: Environment Agency.

Maitland P.S. (1977) *A coded checklist of Animals occurring in Fresh Water in the British Isles.* Edinburgh: Institute of Terrestrial Ecology.

Walley W. J. (1994) New approaches to the interpretation and classification of water quality data based on techniques from the field of artificial intelligence. In *Proc. Monitoring Tailor-made* (ed. M. Adriaanse, J. Kraats, P.G. Stoks and R.C. Ward), RIZA, The Netherlands. Sept 1994. pp.195-210.

Walley W. J. and Dzeroski S. (1995) Biological monitoring: a comparison between Bayesian, neural and machine learning methods of water quality classification. In *Int. Symp. on Environmental Software Systems* (ed. R. Denzer, G. Schimak and D. Russell), IFIP Conference Series, Chapman & Hall, London. pp. 229-240.

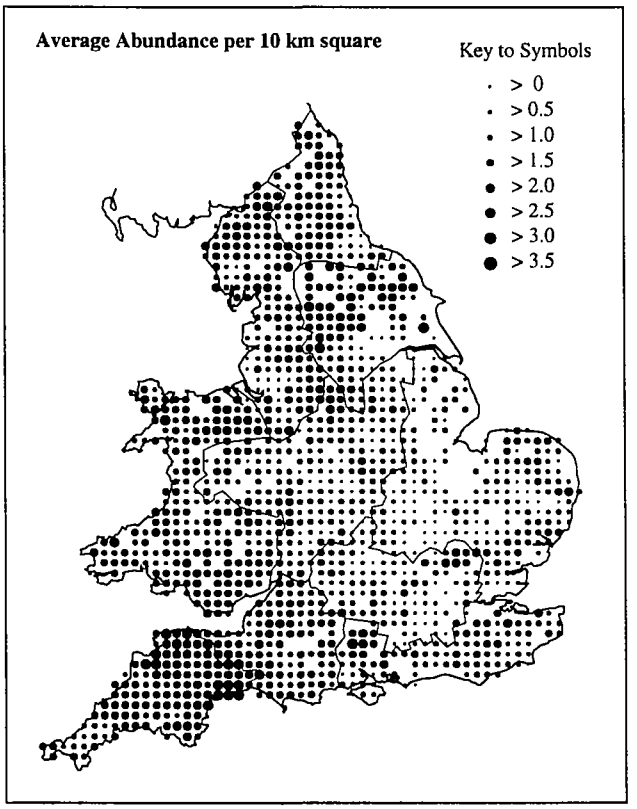
Walley W. J. and Hawkes H. A. (1996) A computer-based reappraisal of Biological Monitoring Working Party scores using data from the 1990 River Quality Survey of England and Wales. *Water Research* , **30** (9), 2086-2094.

Walley W. J. and Hawkes H. A. (1997) A computer-based development of the Biological Monitoring Working Party score system incorporating abundance rating, biotope type and indicator value. *Water Research*, **31** (2), 201-210.

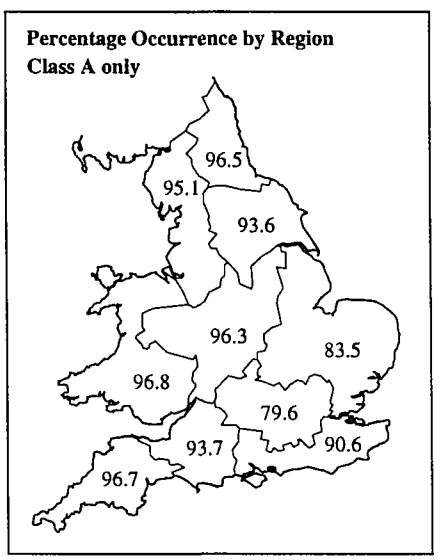
Appendix A

Distribution of BMWP Families - River Sites 1995

TYPICAL DISTRIBUTIONS



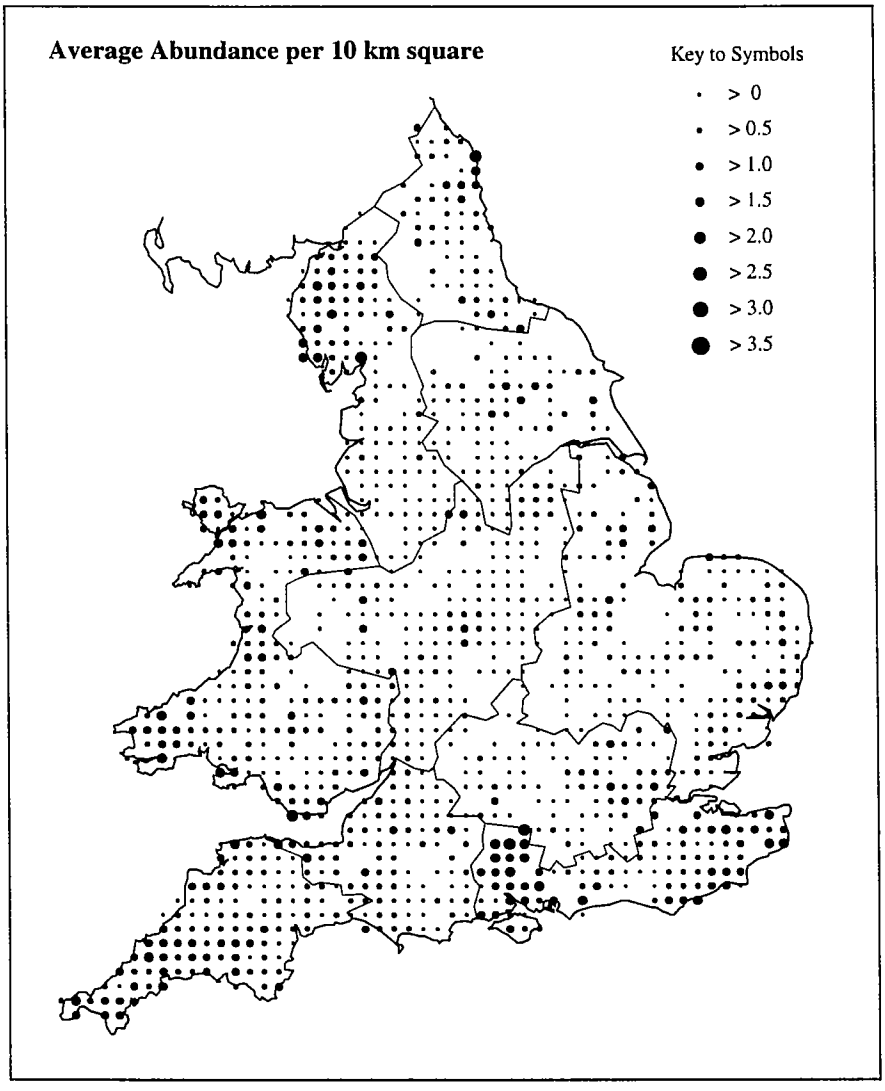
The diameter of the symbol is proportional to the average abundance of the family recorded from samples collected within the 10km square.

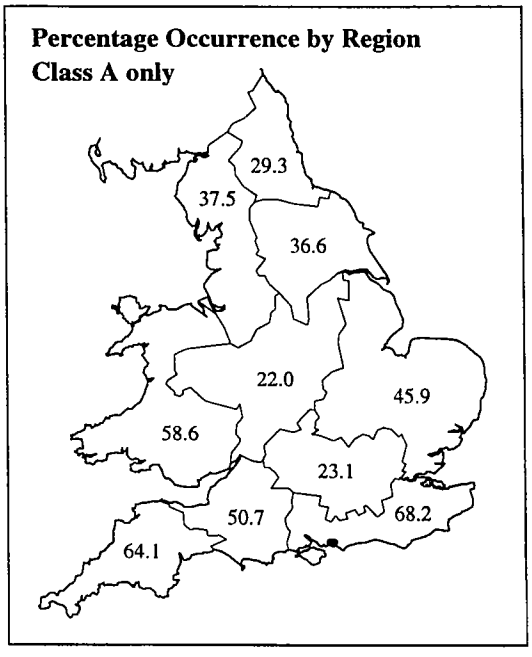


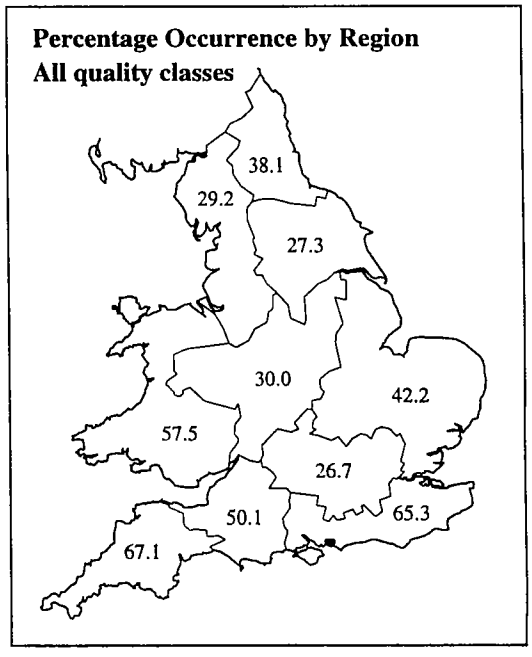
The number within each region is the occurrence of the family expressed as a percentage of the number of river sites of the given quality class sampled within the region.

Distribution of BMWP Families - River Sites 1995

PLANARIIDAE

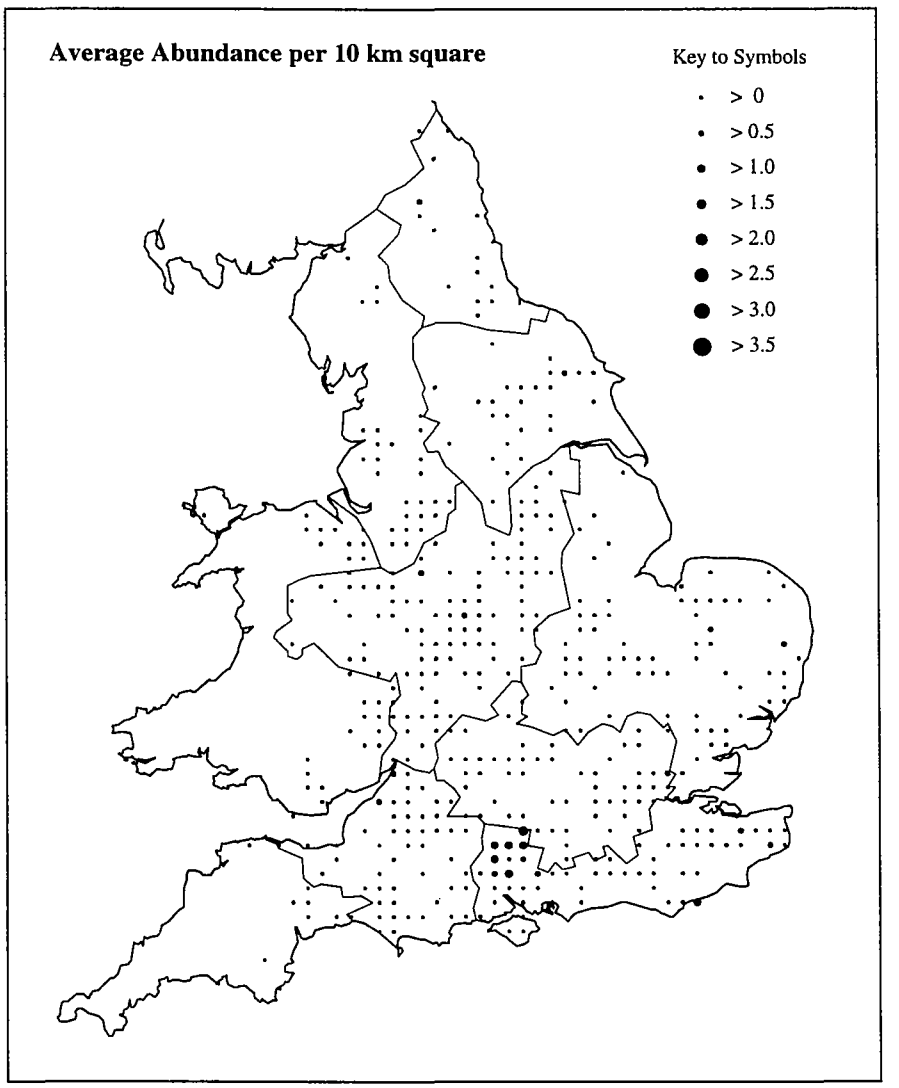


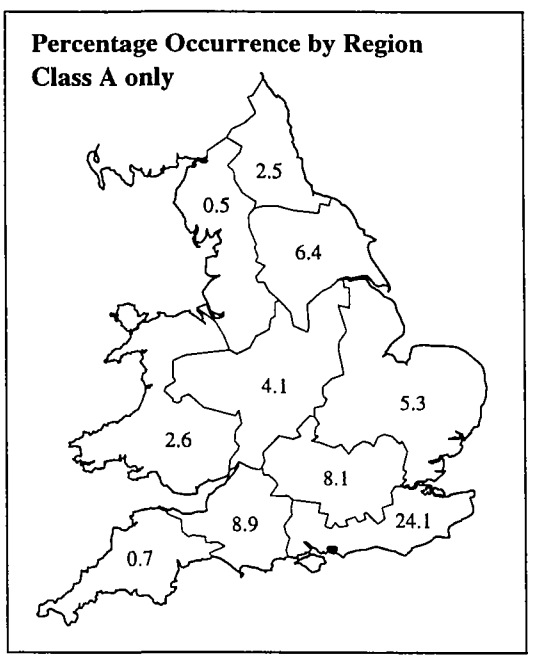


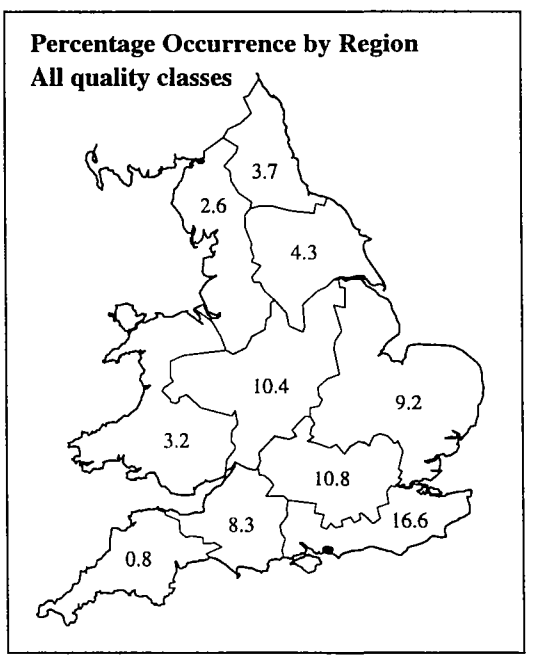


Distribution of BMWP Families - River Sites 1995

DENDROCOELIDAE

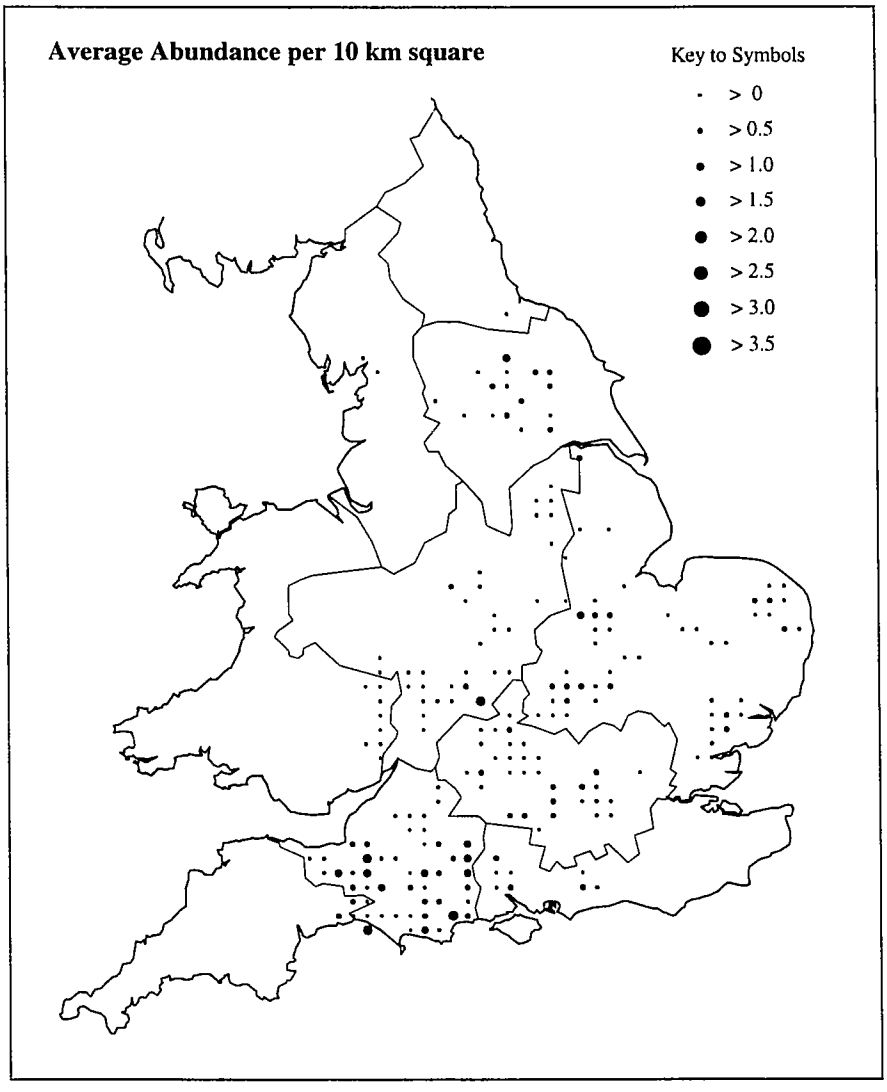


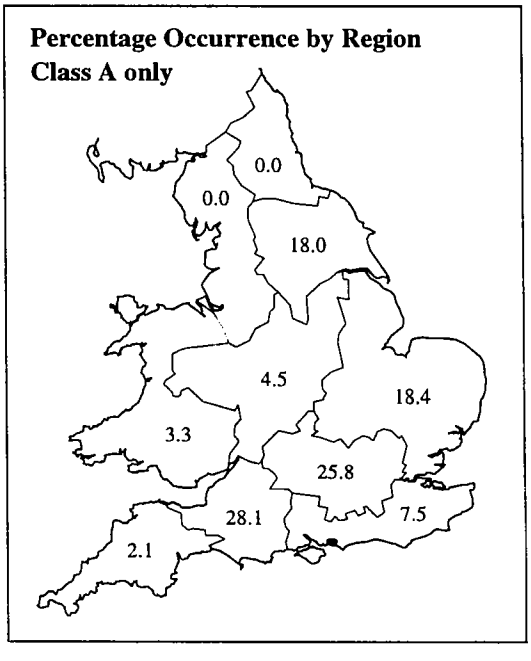


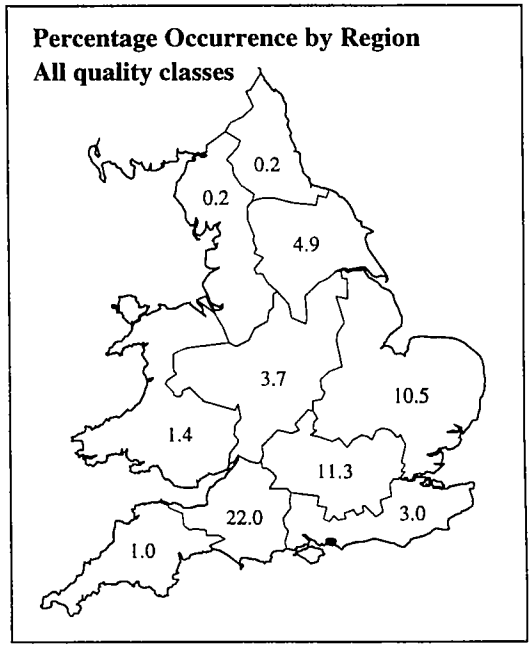


Distribution of BMWP Families - River Sites 1995

NERITIDAE







Distribution of BMWP Families - River Sites 1995

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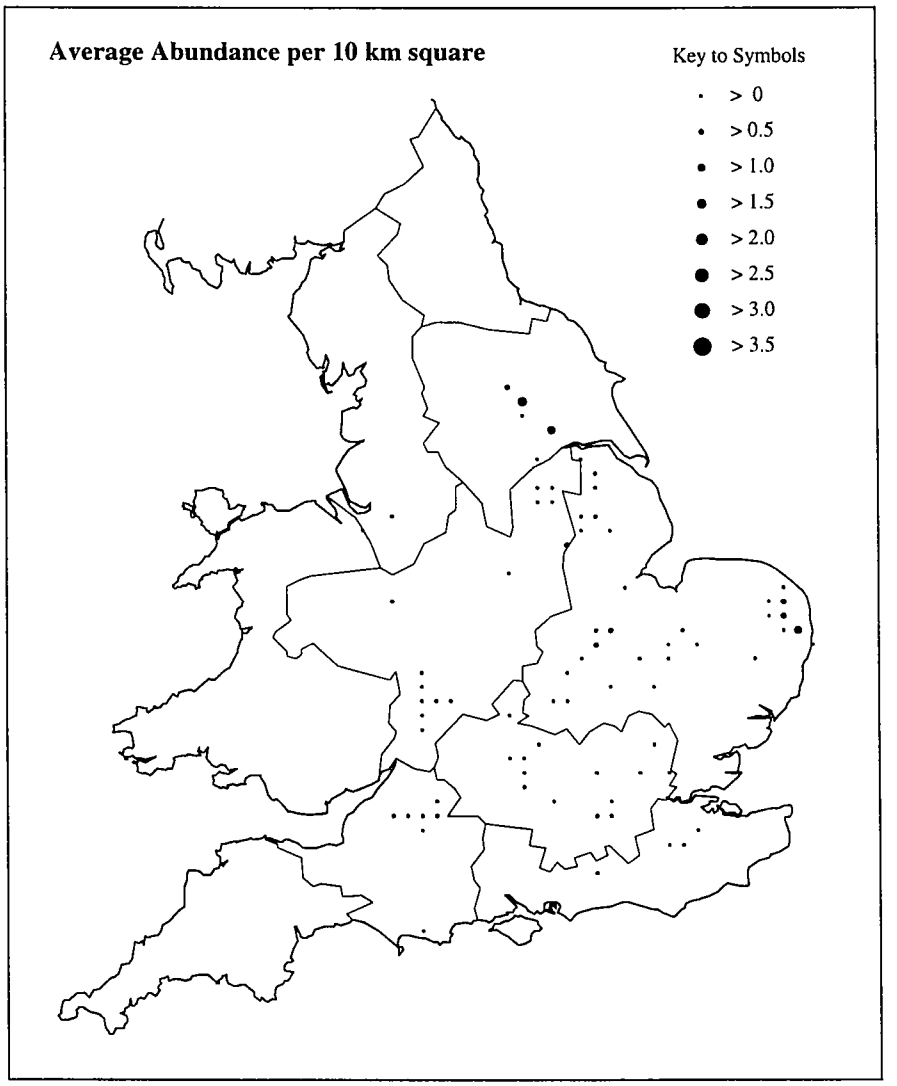
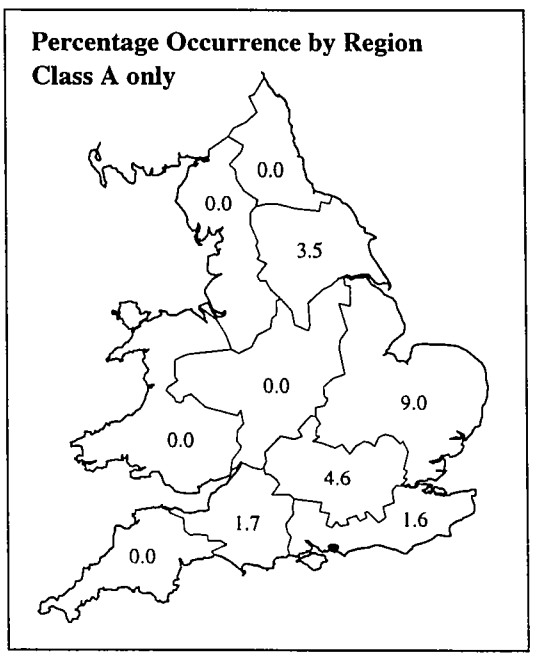
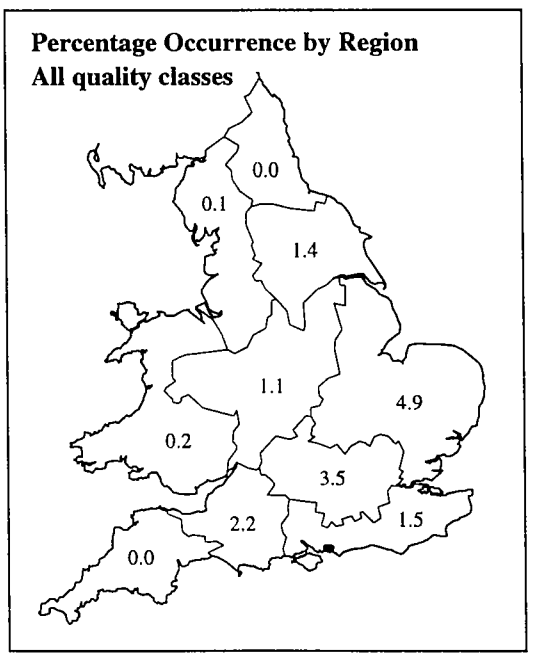
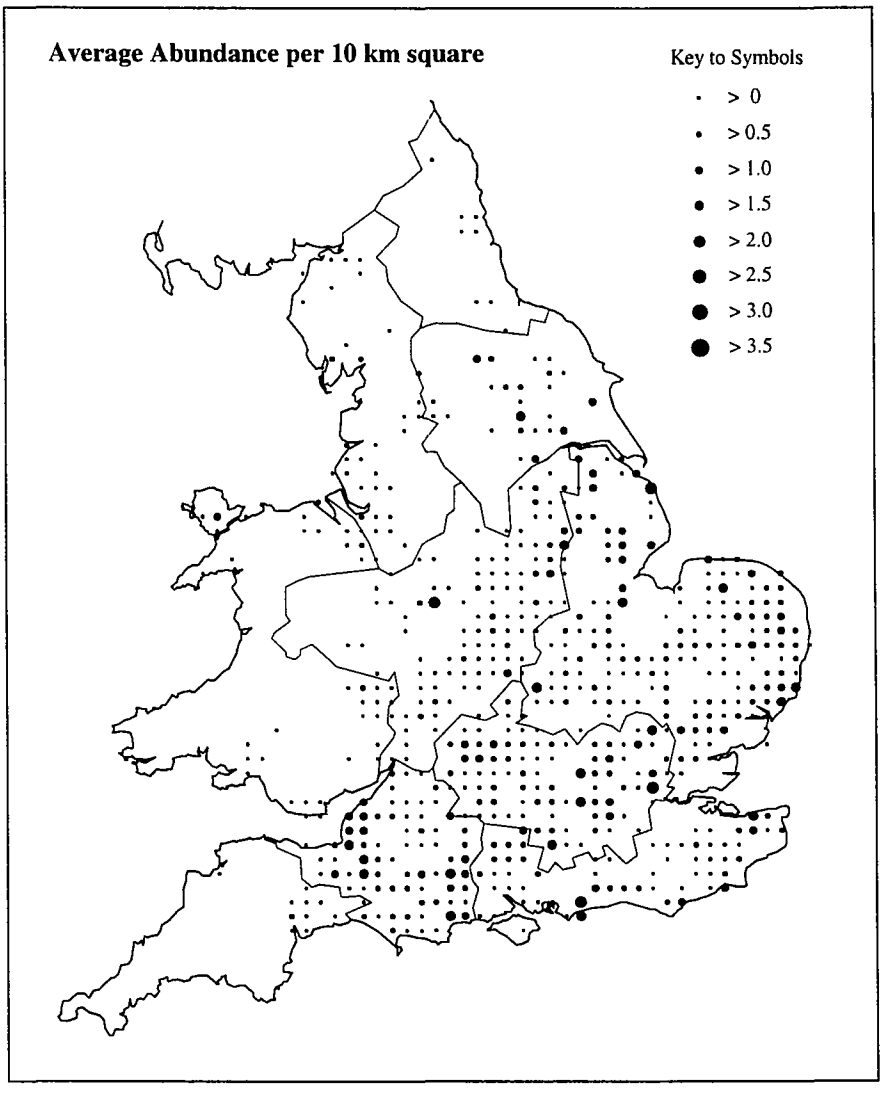


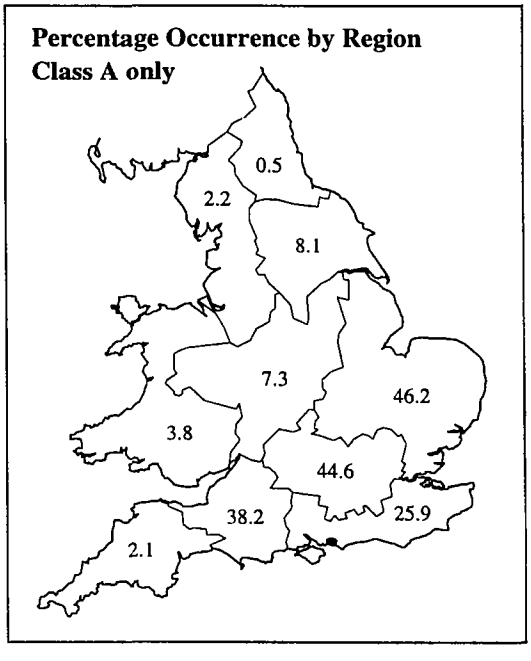


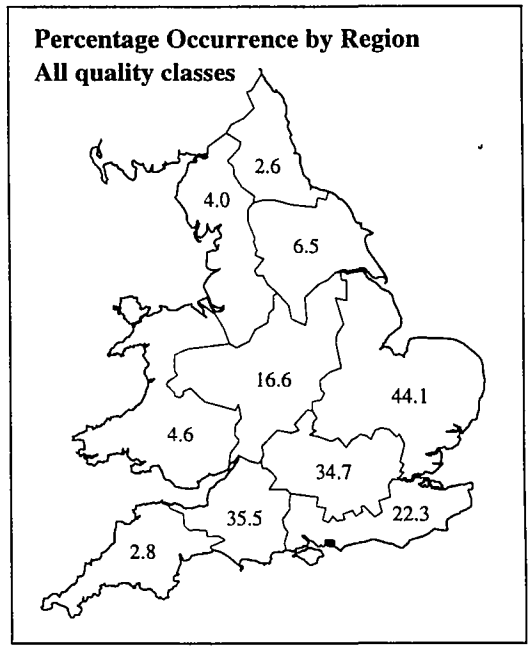


Distribution of BMWP Families - River Sites 1995

VALVATIDAE

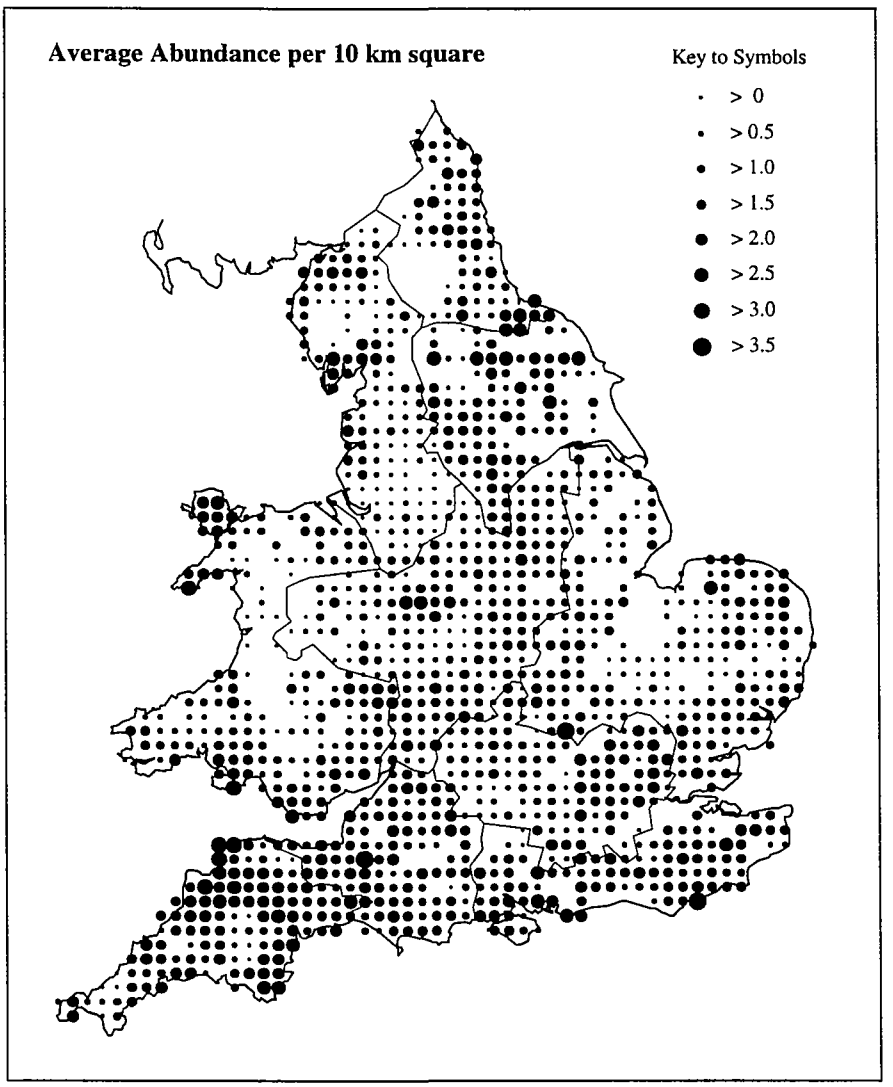


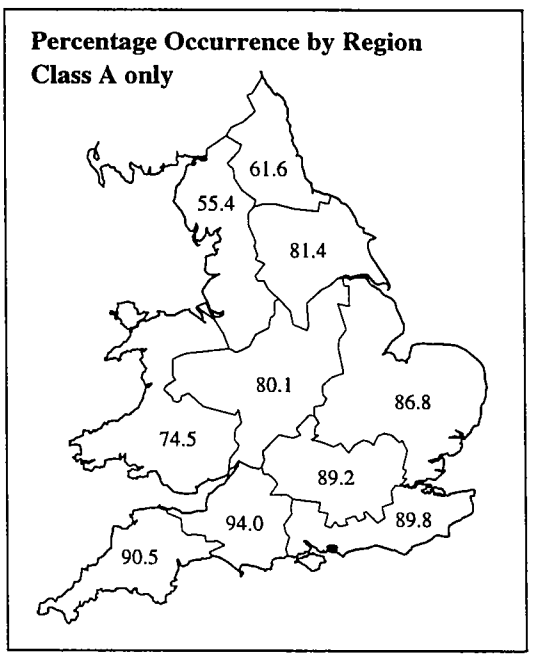


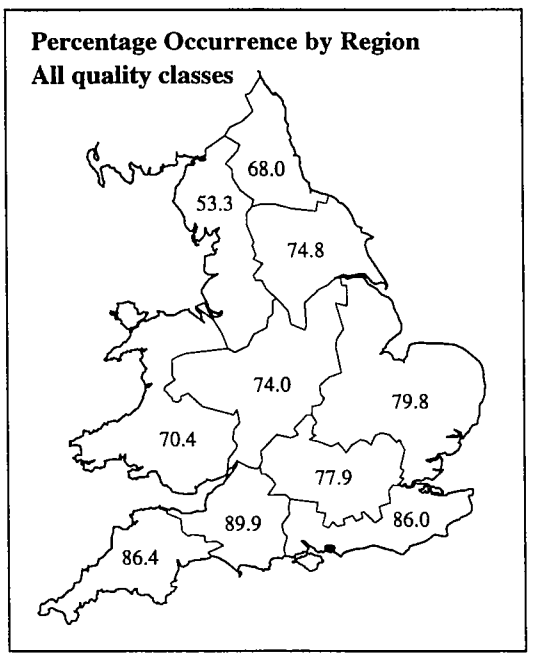


Distribution of BMWP Families - River Sites 1995

HYDROBIIDAE

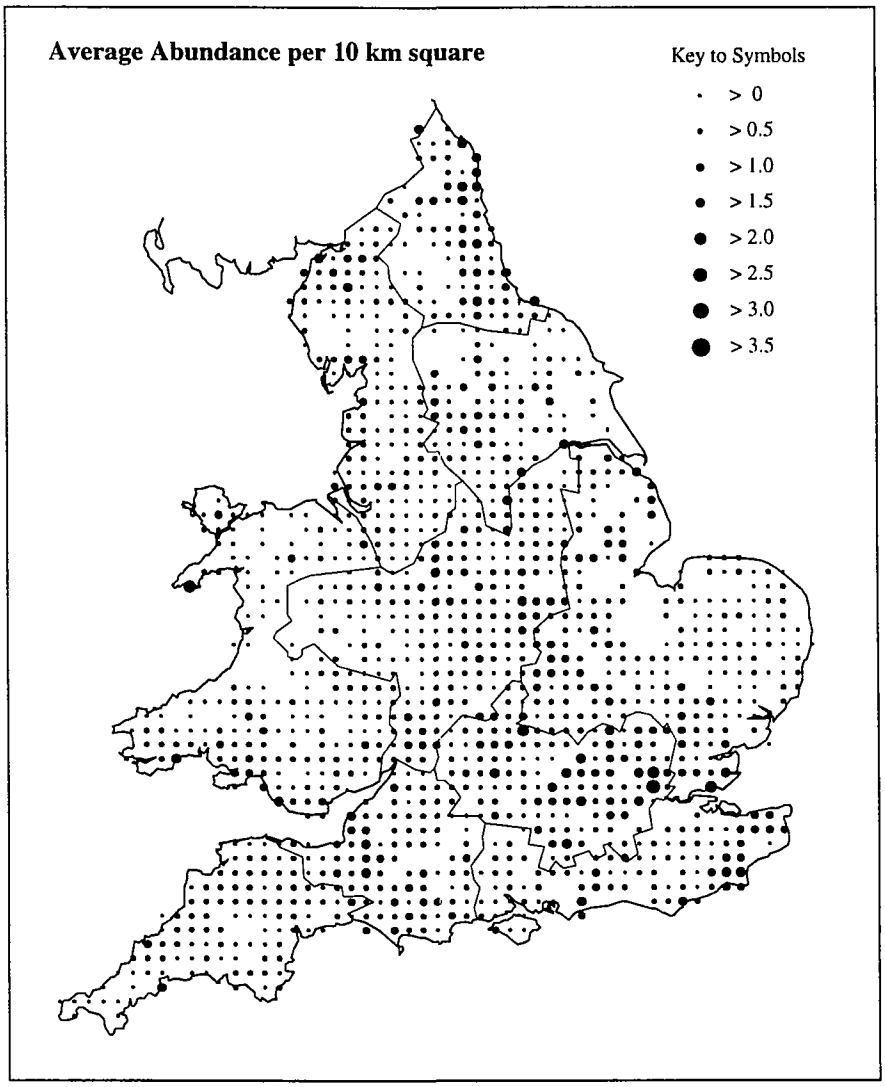


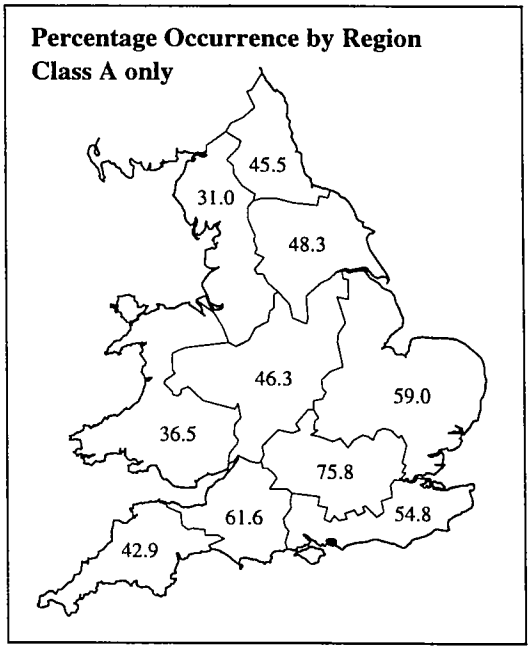


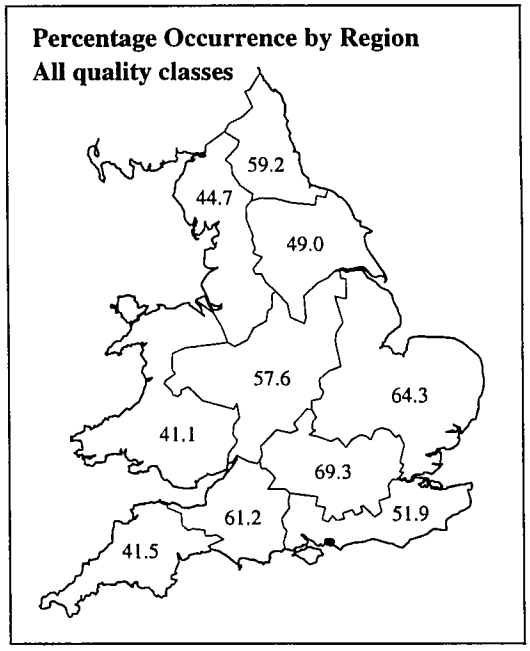


Distribution of BMWP Families - River Sites 1995

LYMNAEIDAE

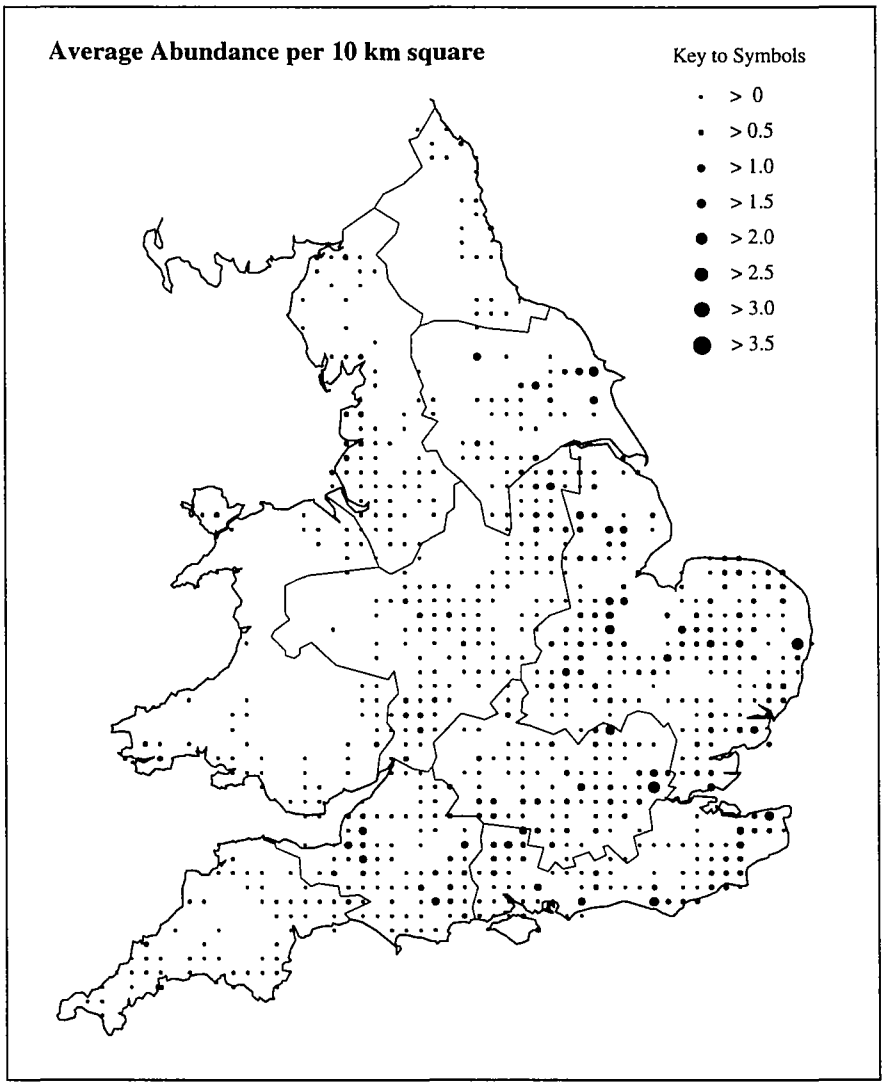


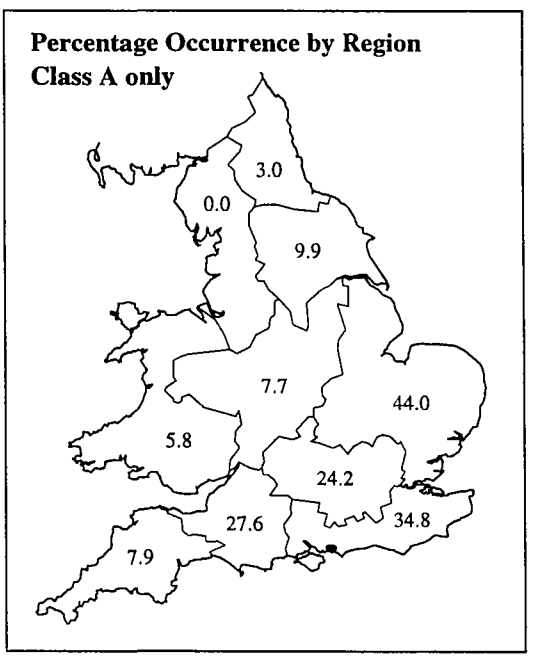


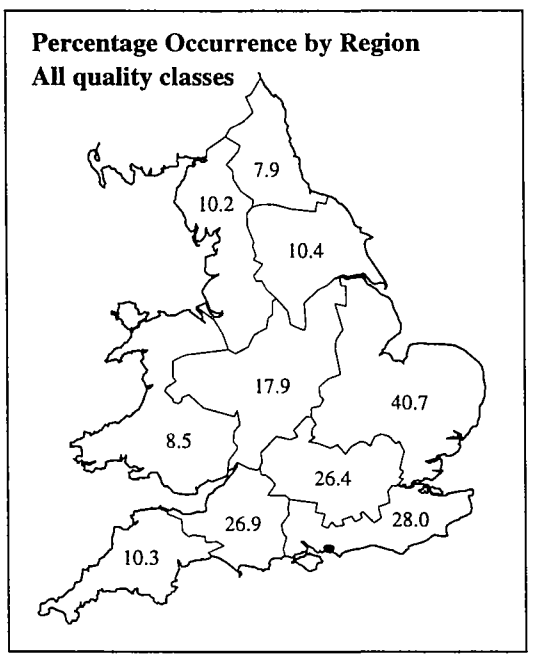


Distribution of BMWP Families - River Sites 1995

PHYSIDAE

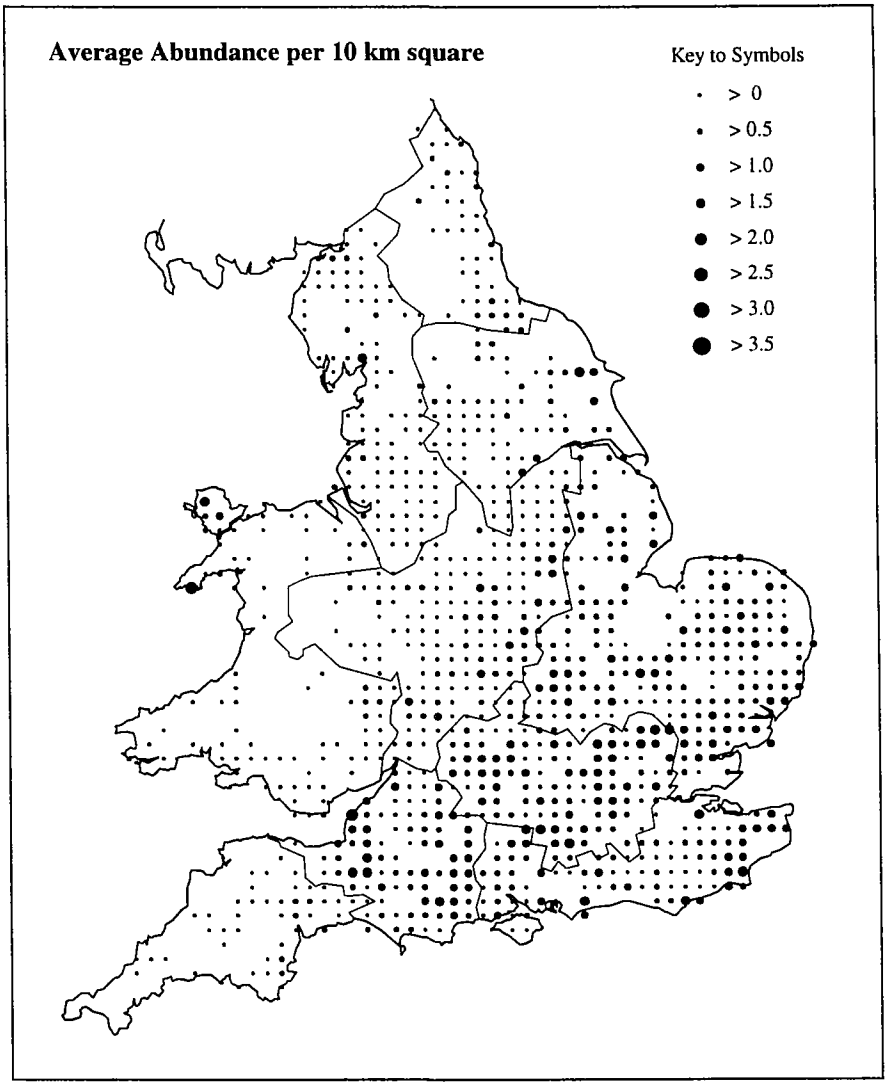


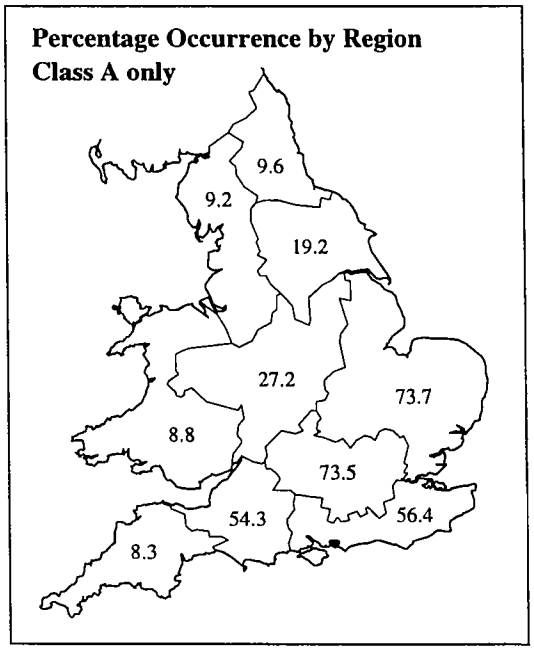


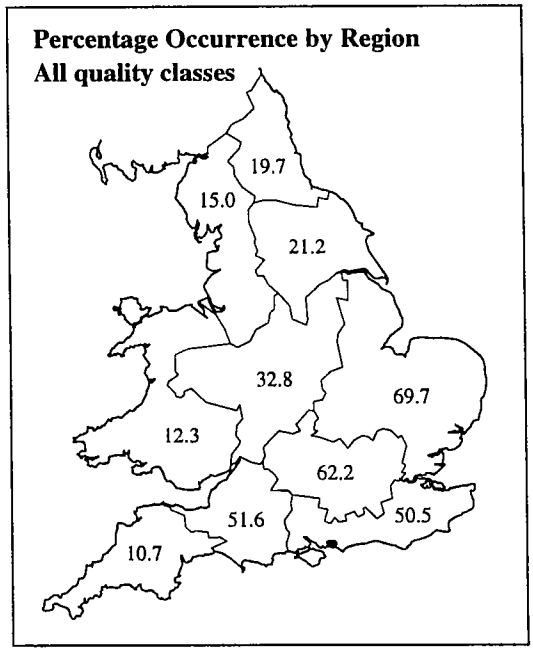


Distribution of BMWP Families - River Sites 1995

PLANORBIDAE

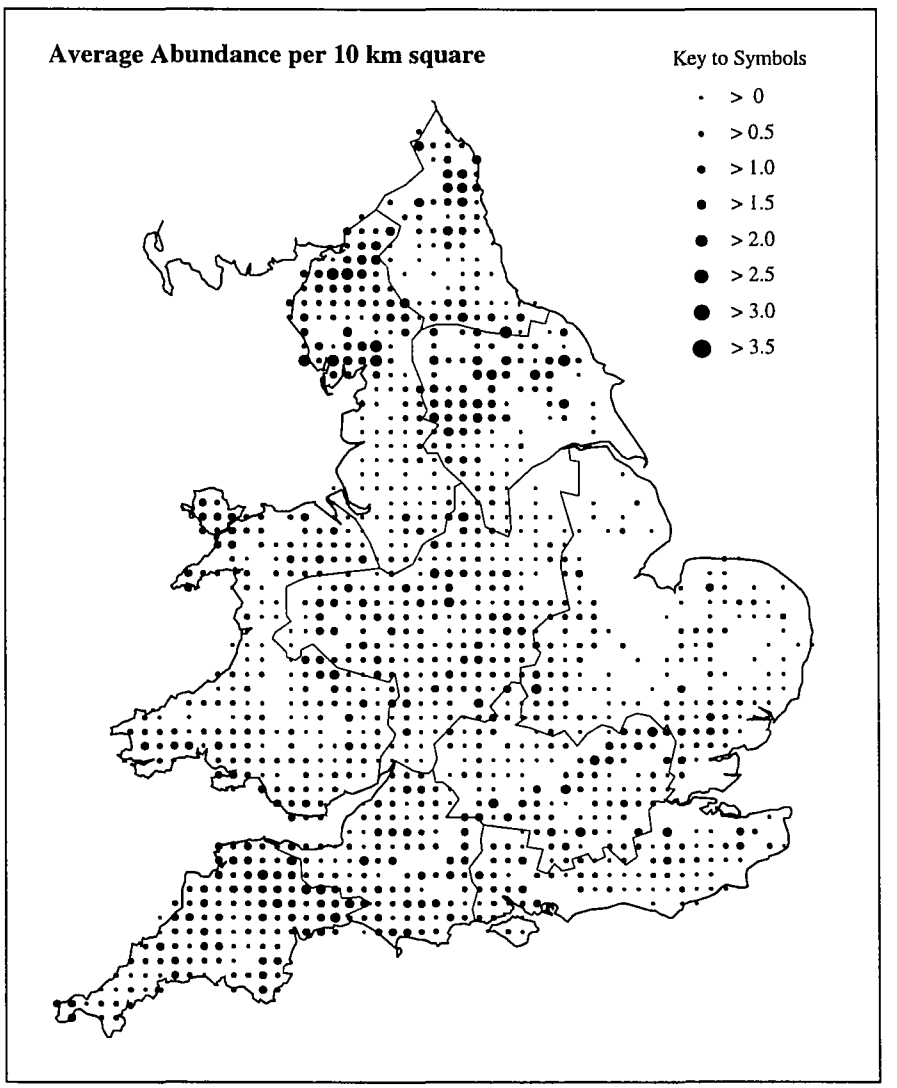


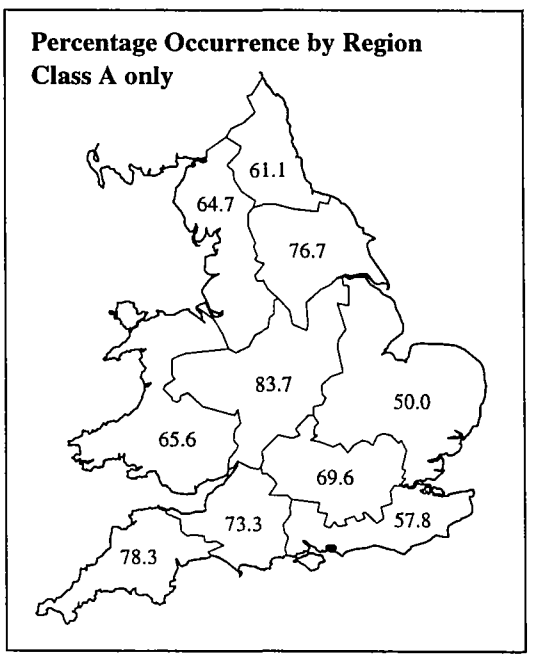


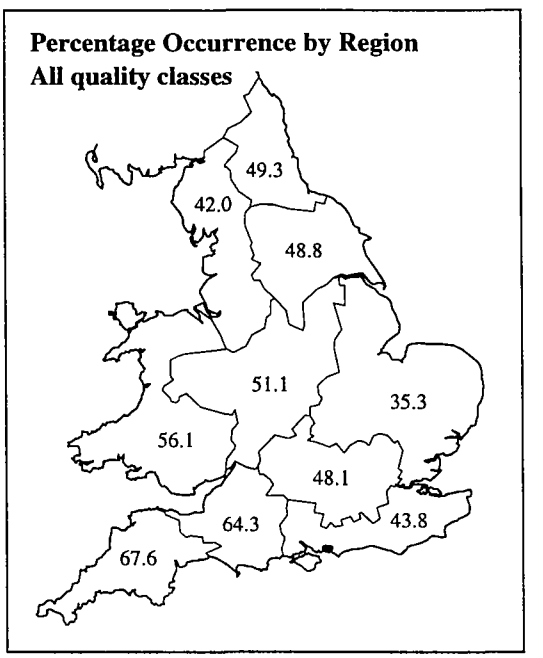


Distribution of BMWP Families - River Sites 1995

ANCYLIDAE

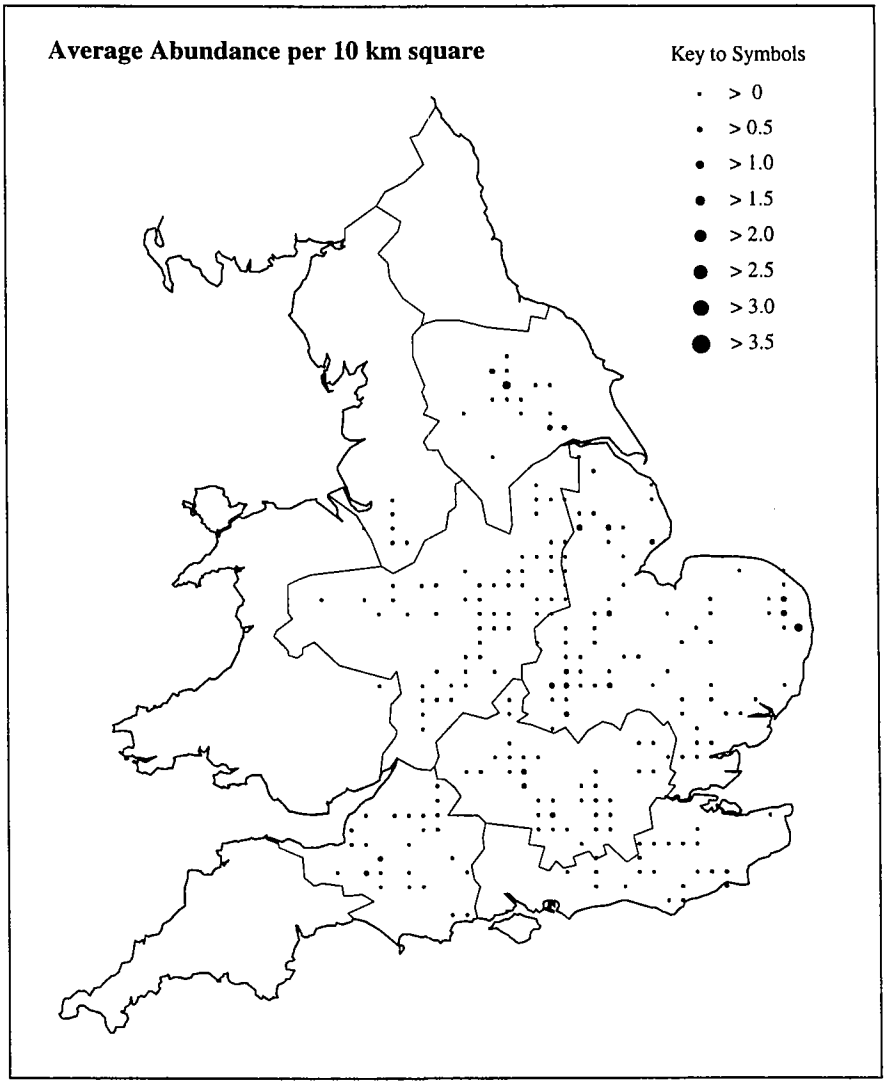


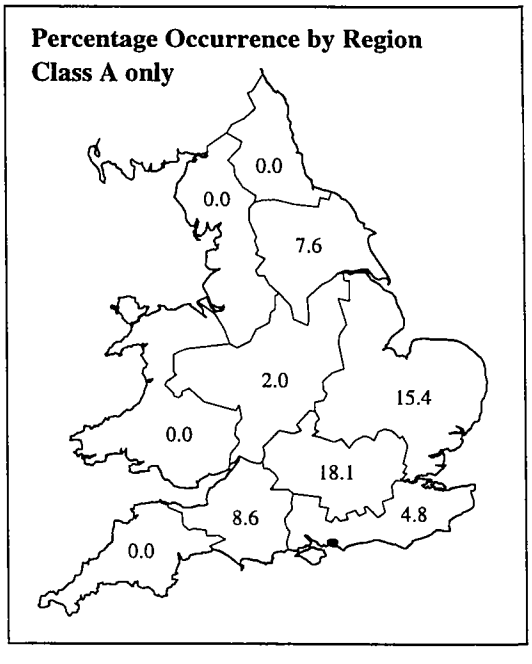


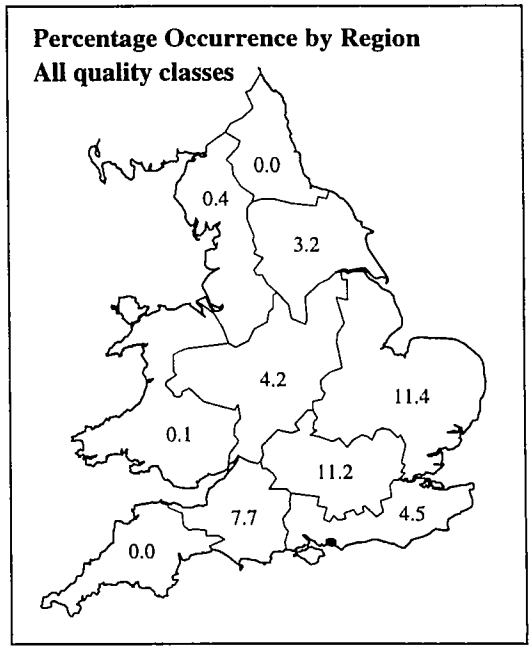


Distribution of BMWP Families - River Sites 1995

UNIONIDAE

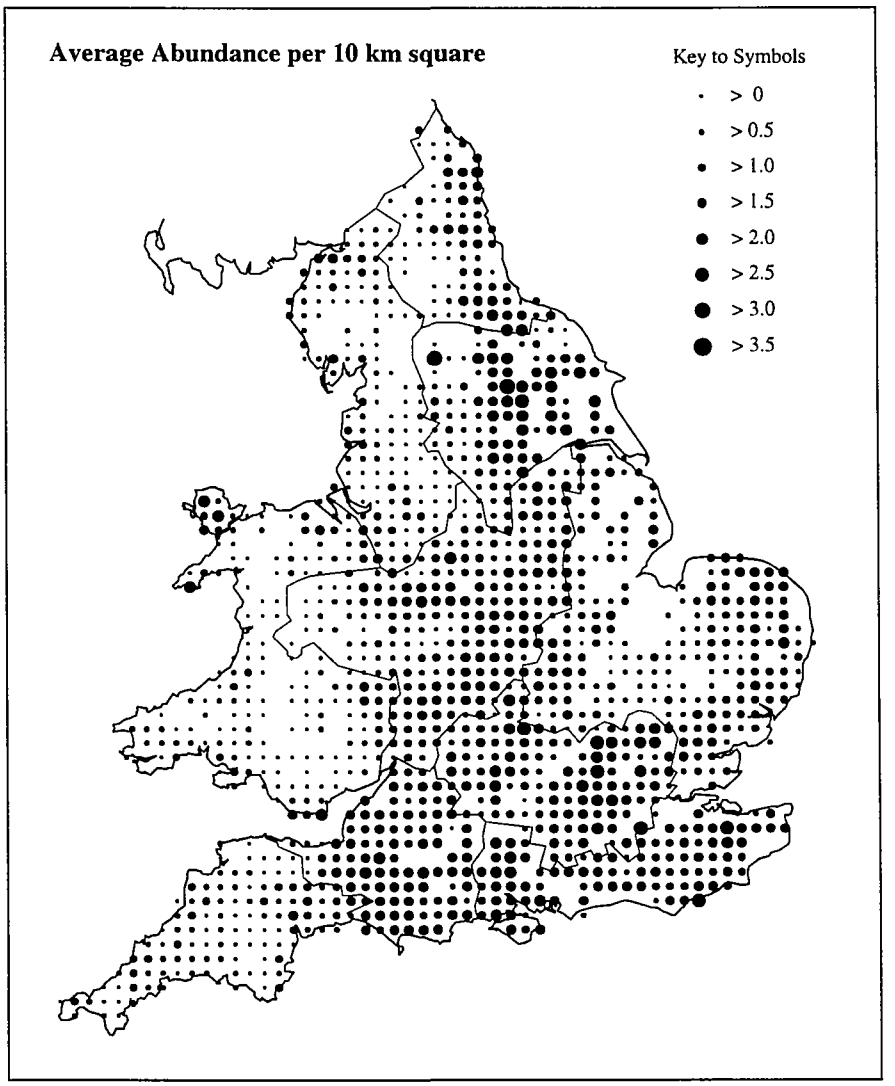


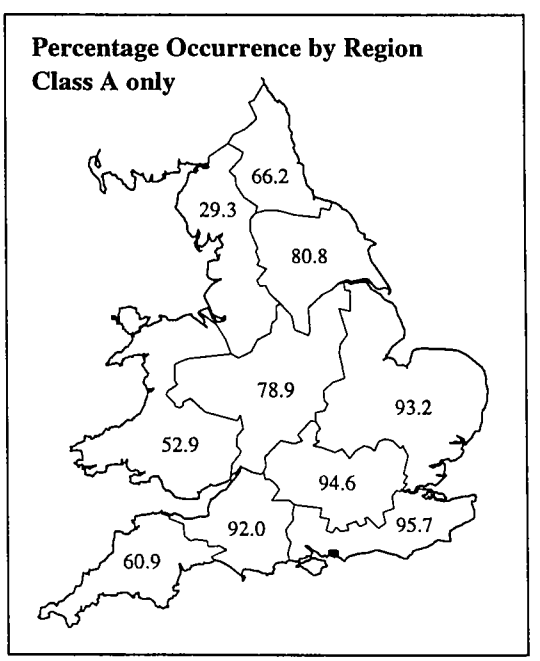


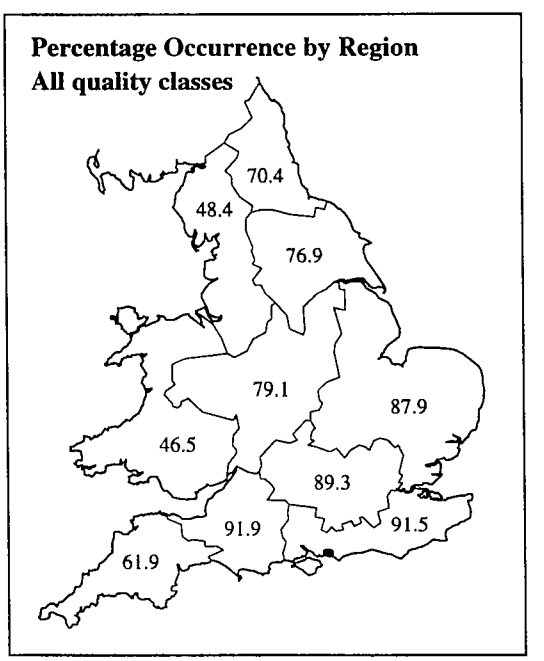


Distribution of BMWP Families - River Sites 1995

SPHAERIIDAE

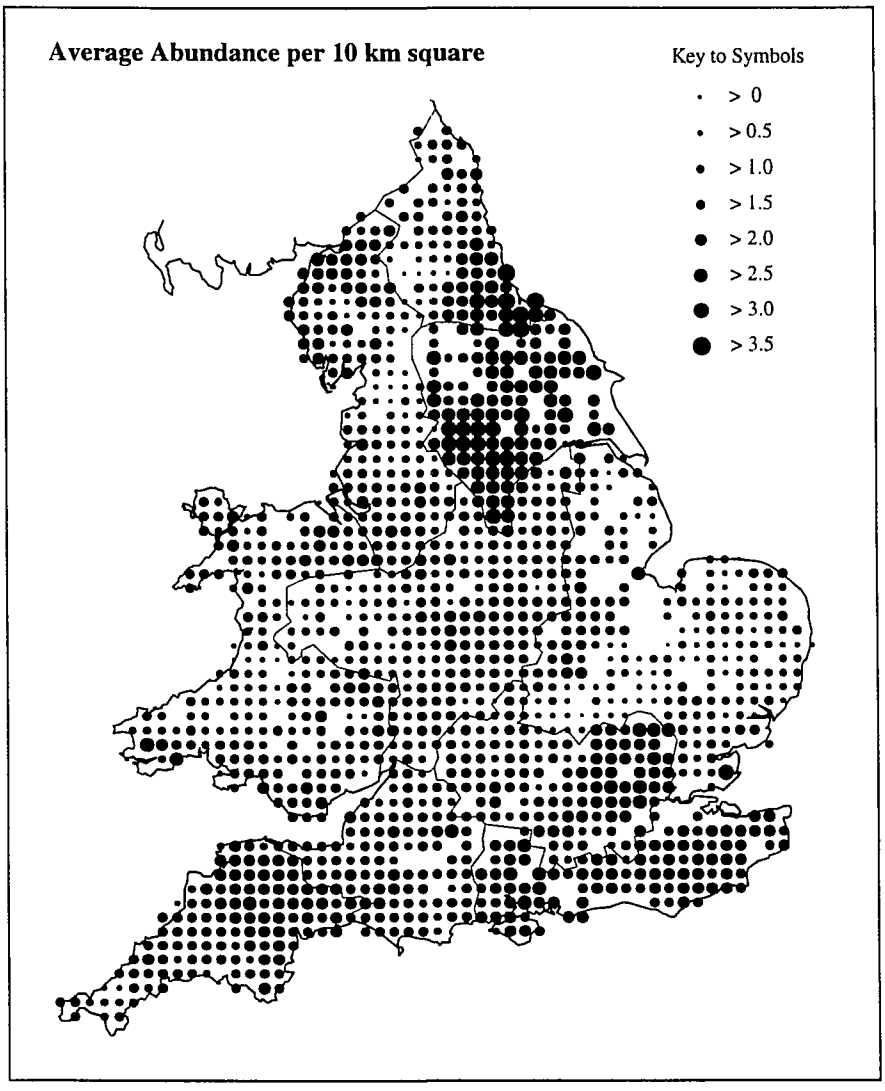


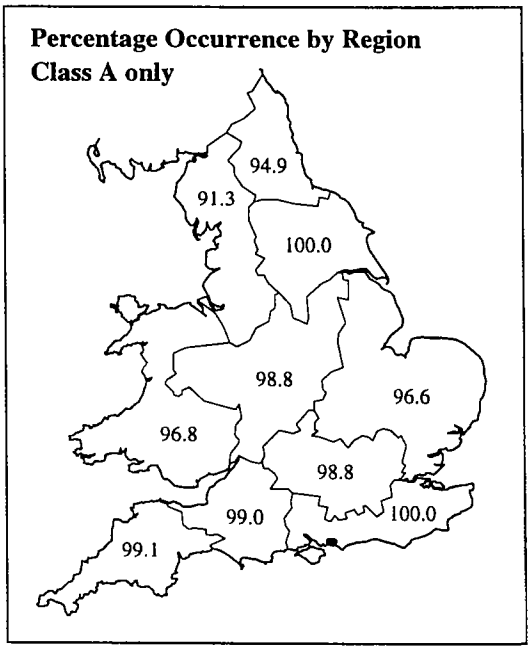


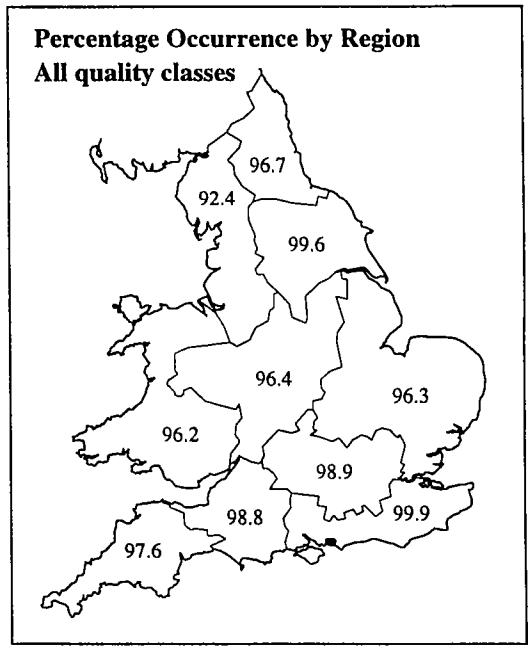


Distribution of BMWP Families - River Sites 1995

OLIGOCHAETA

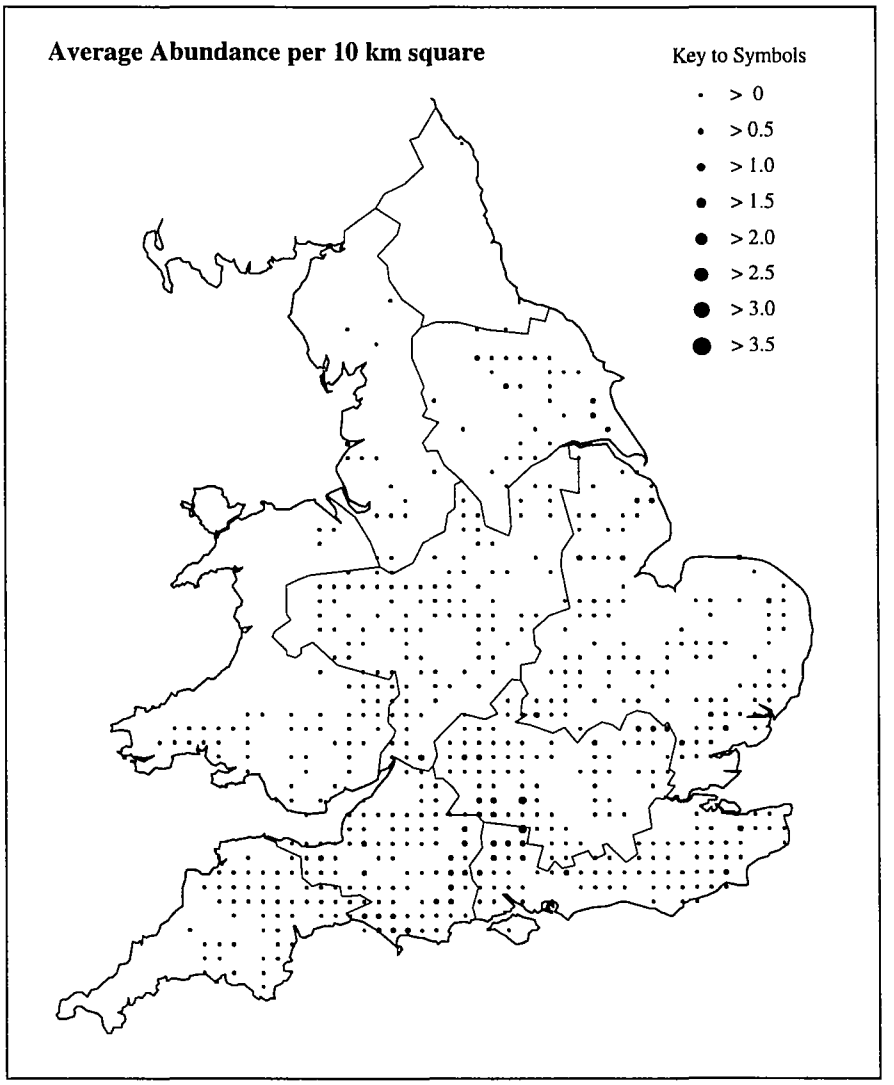


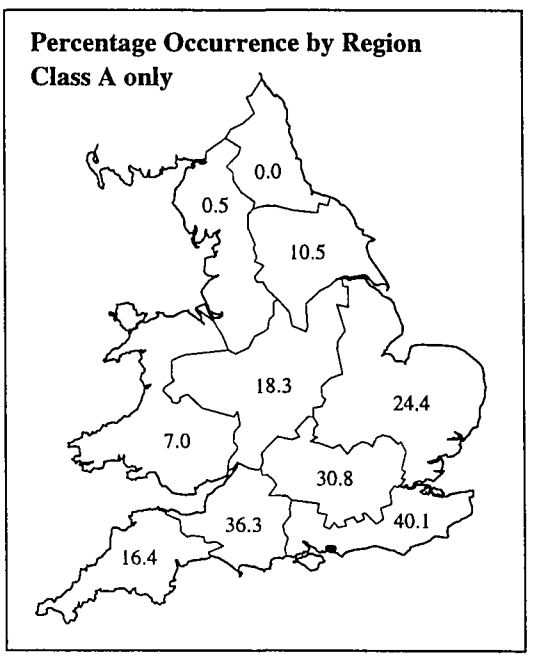


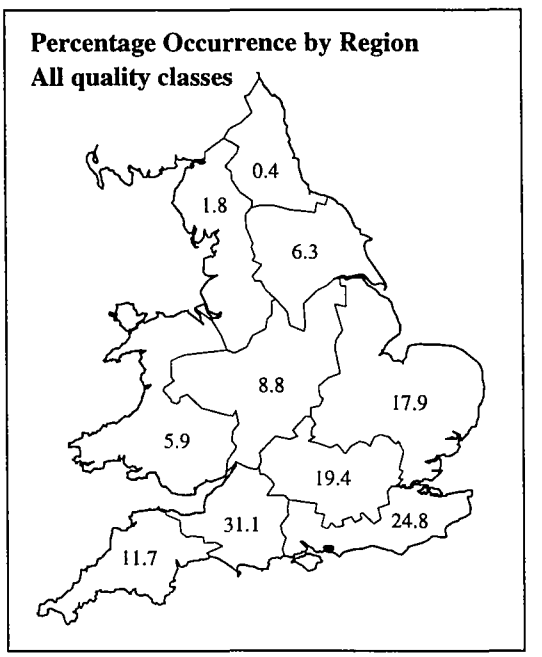


Distribution of BMWP Families - River Sites 1995

PISCICOLIDAE

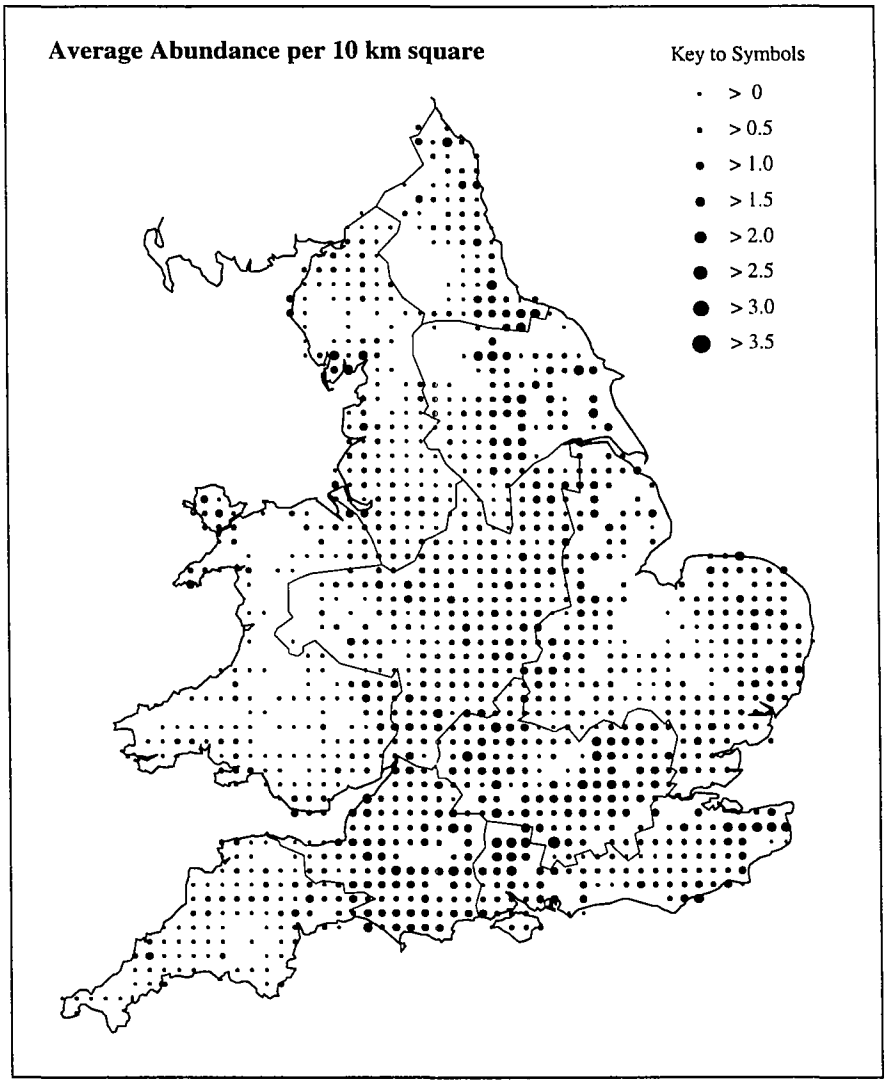


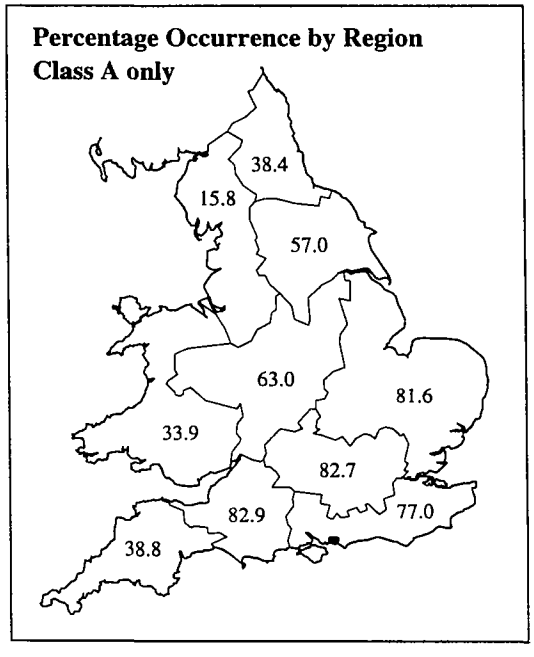


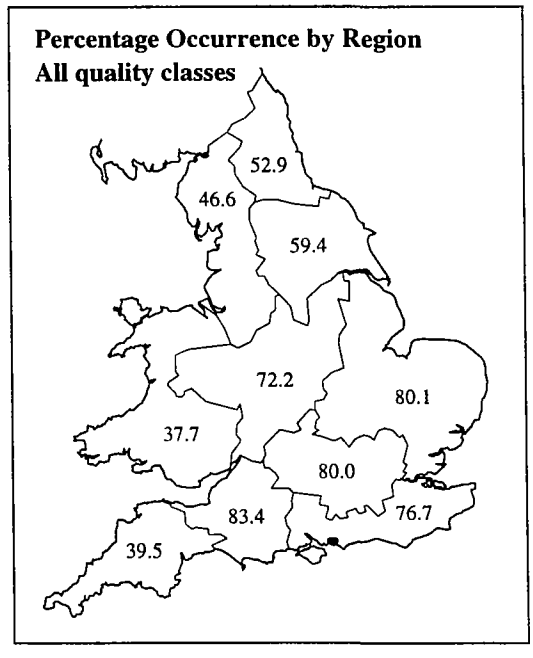


Distribution of BMWP Families - River Sites 1995

GLOSSIPHONIIDAE

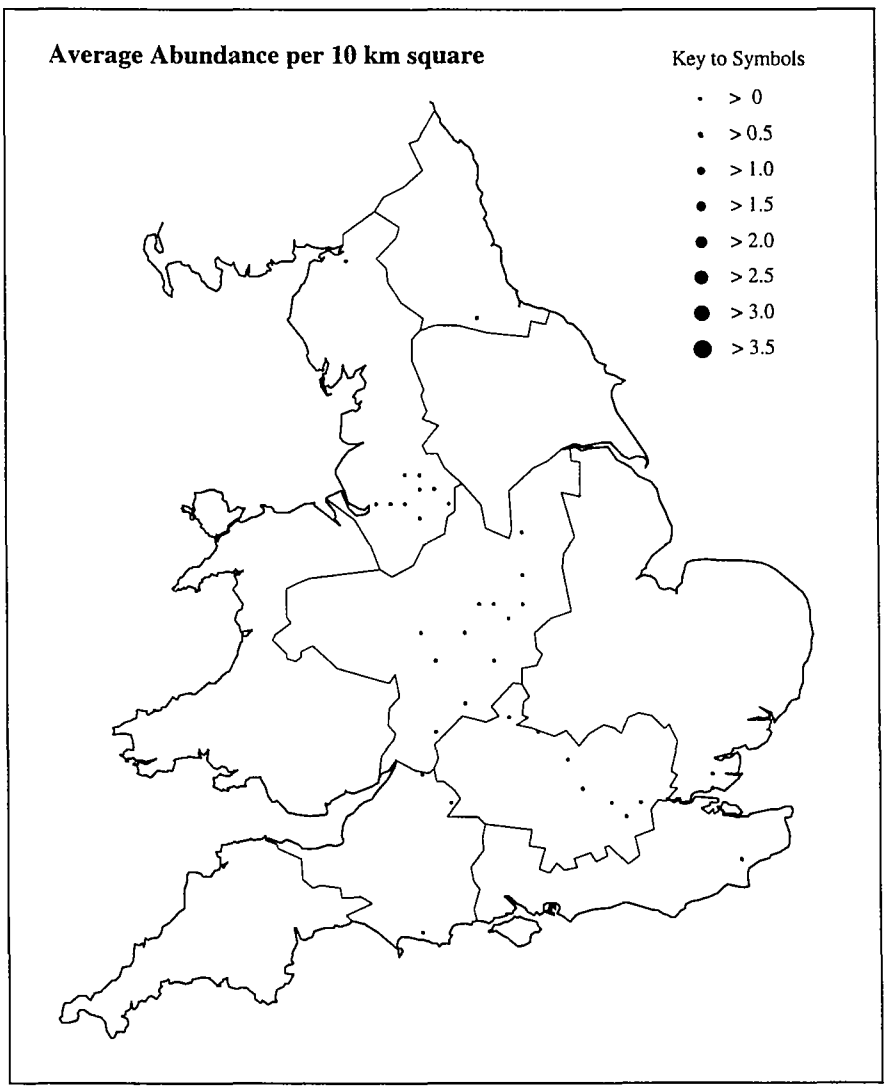


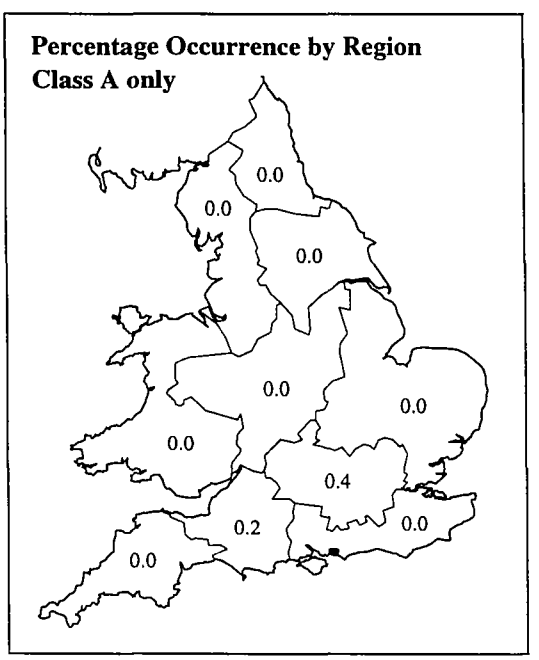


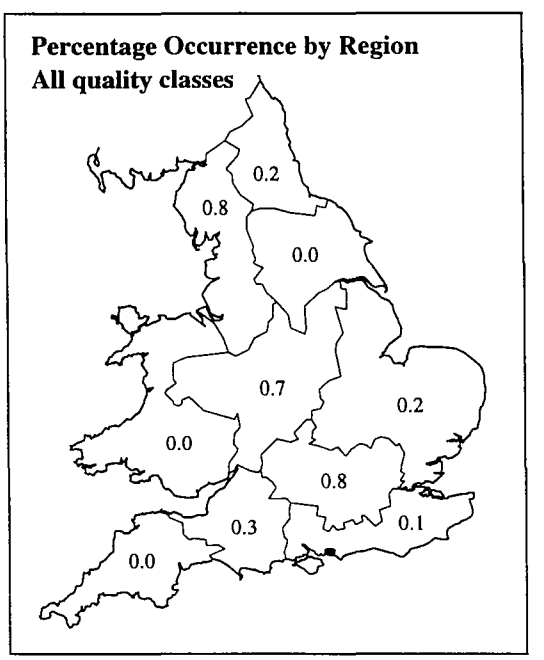


Distribution of BMWP Families - River Sites 1995

HIRUDIDIDAE







Distribution of BMWP Families - River Sites 1995

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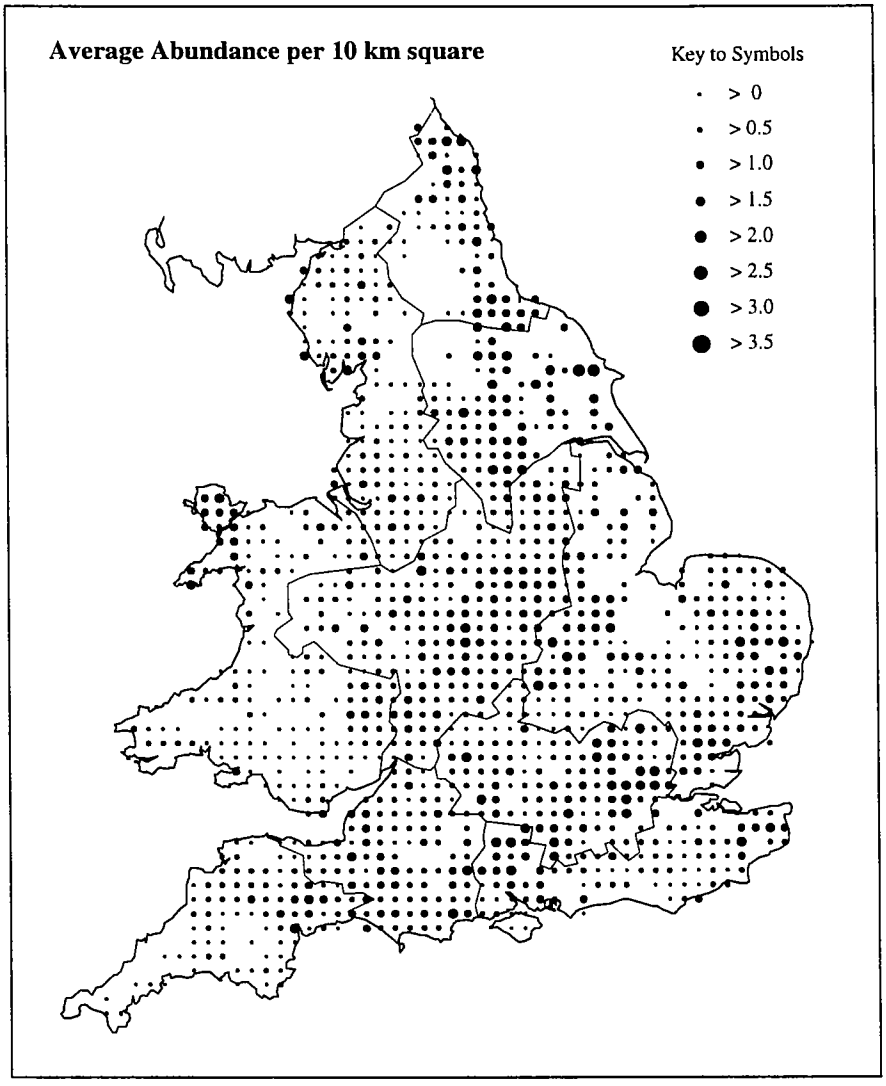
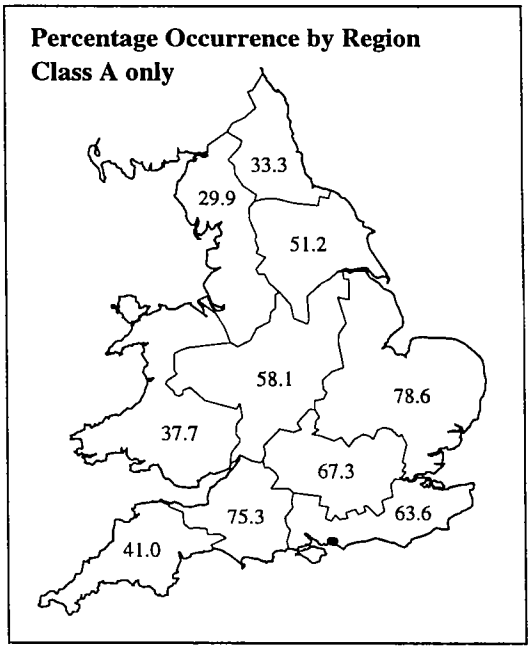
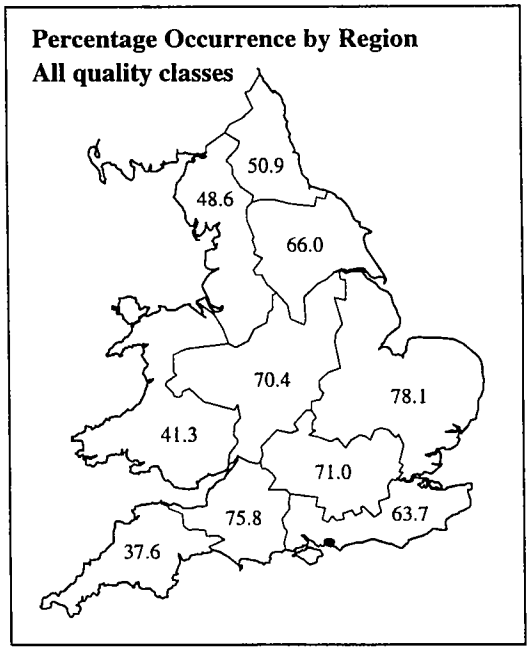
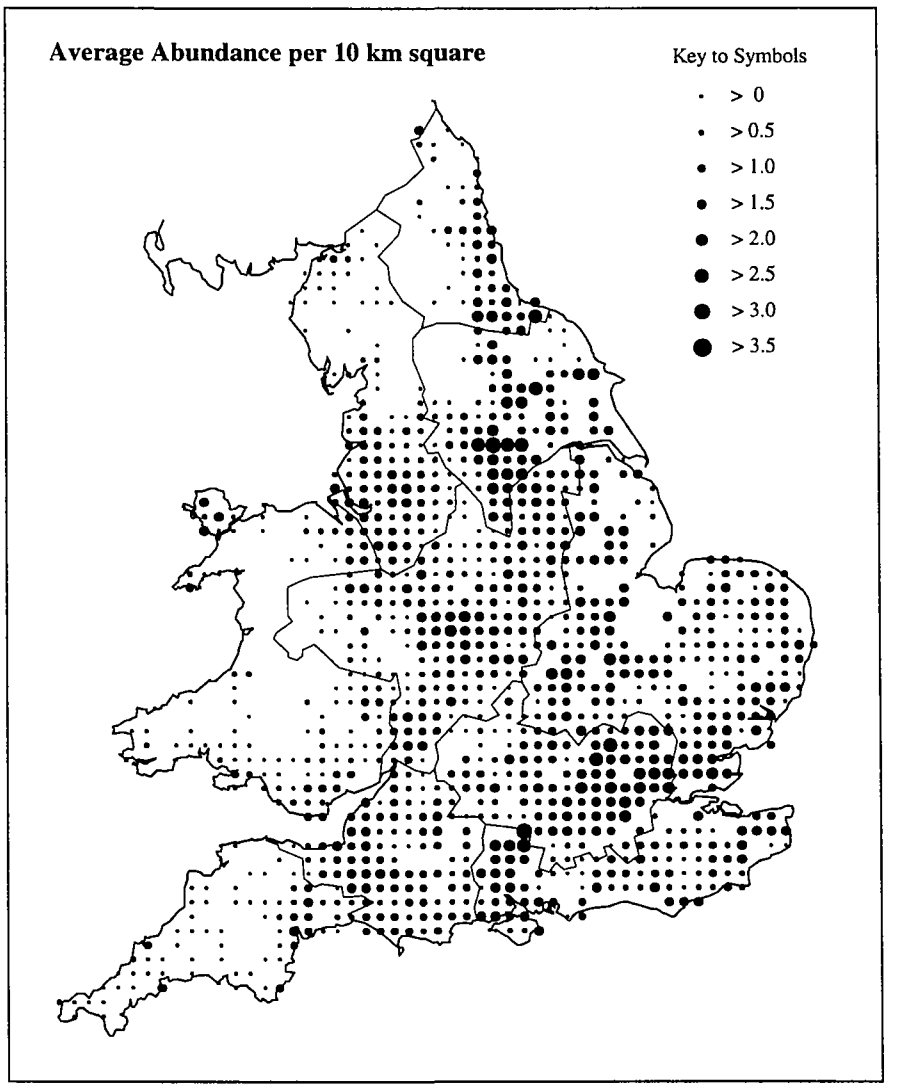


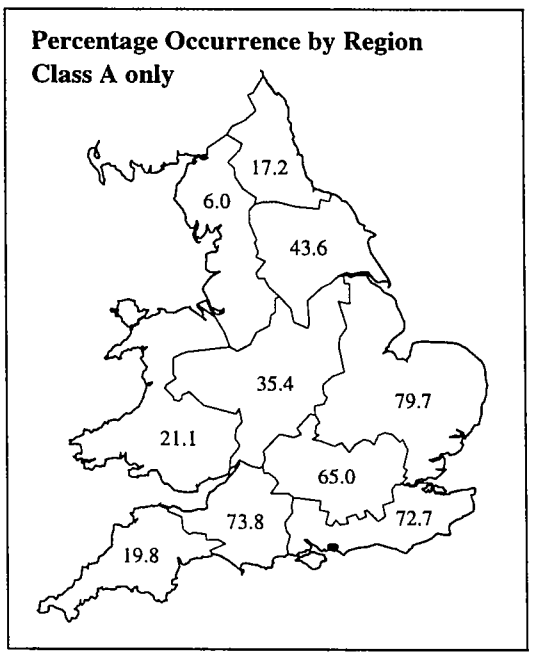


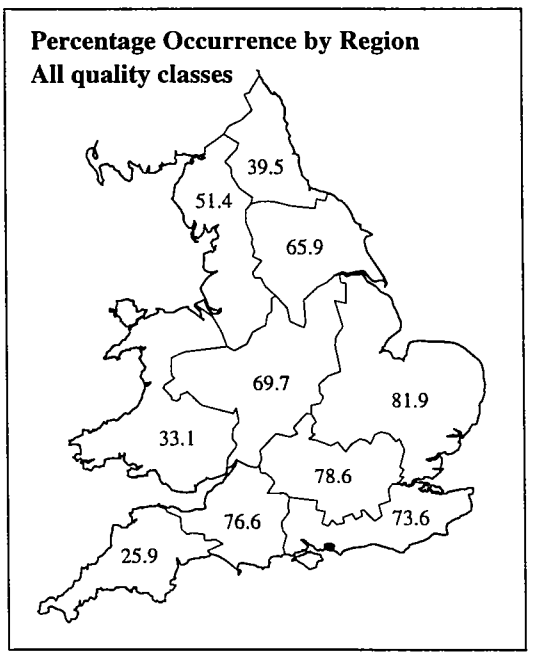


Distribution of BMWP Families - River Sites 1995

ASELLIDAE

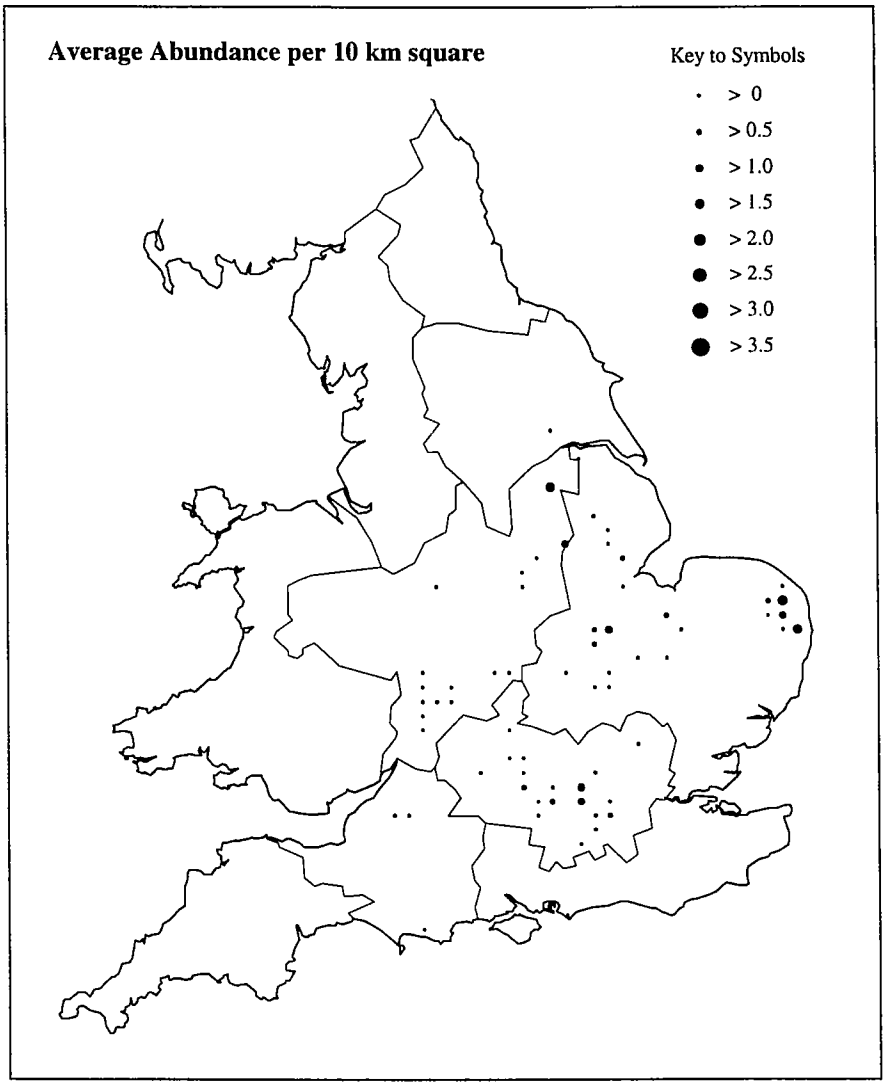


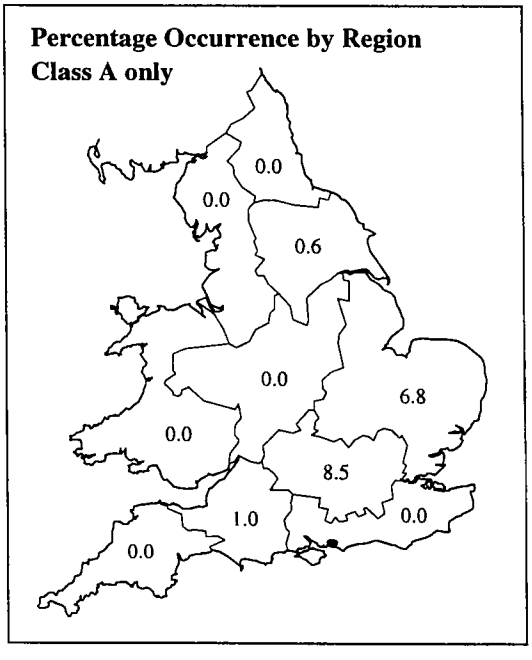


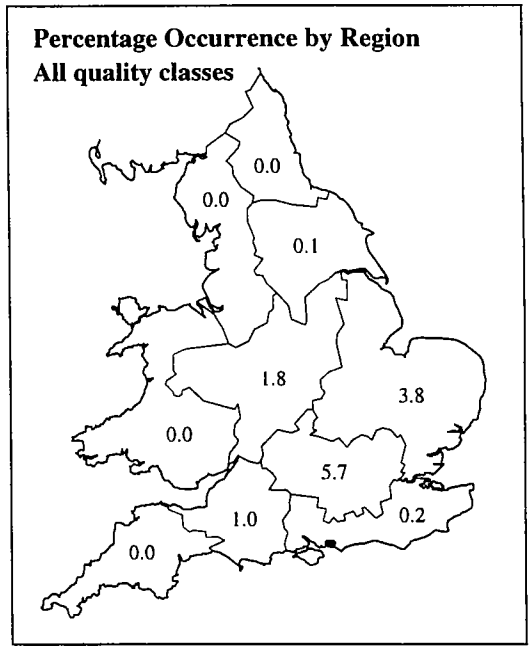


Distribution of BMWP Families - River Sites 1995

COROPHIIDAE

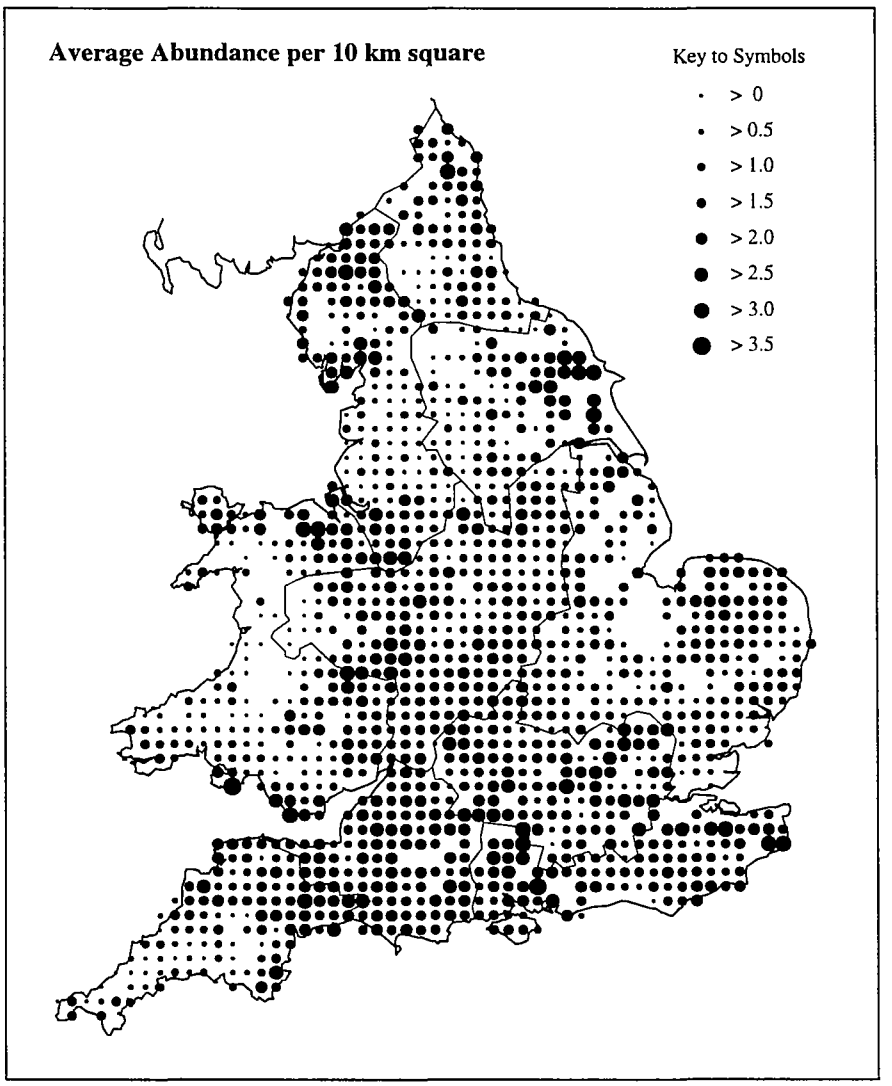


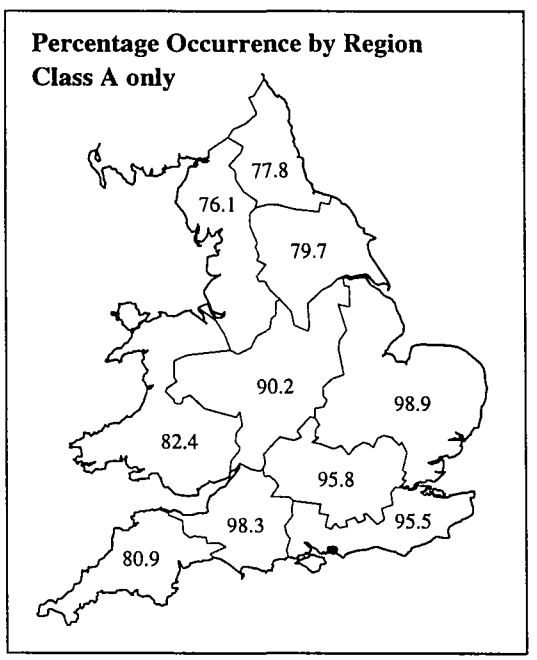


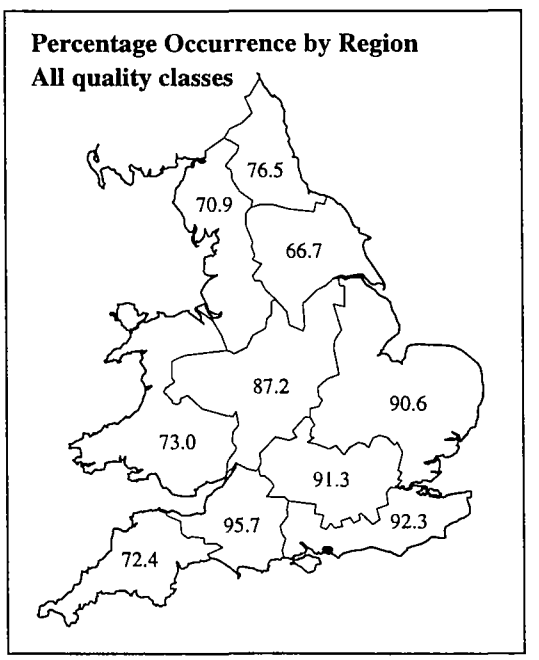


Distribution of BMWP Families - River Sites 1995

GAMMARIDAE

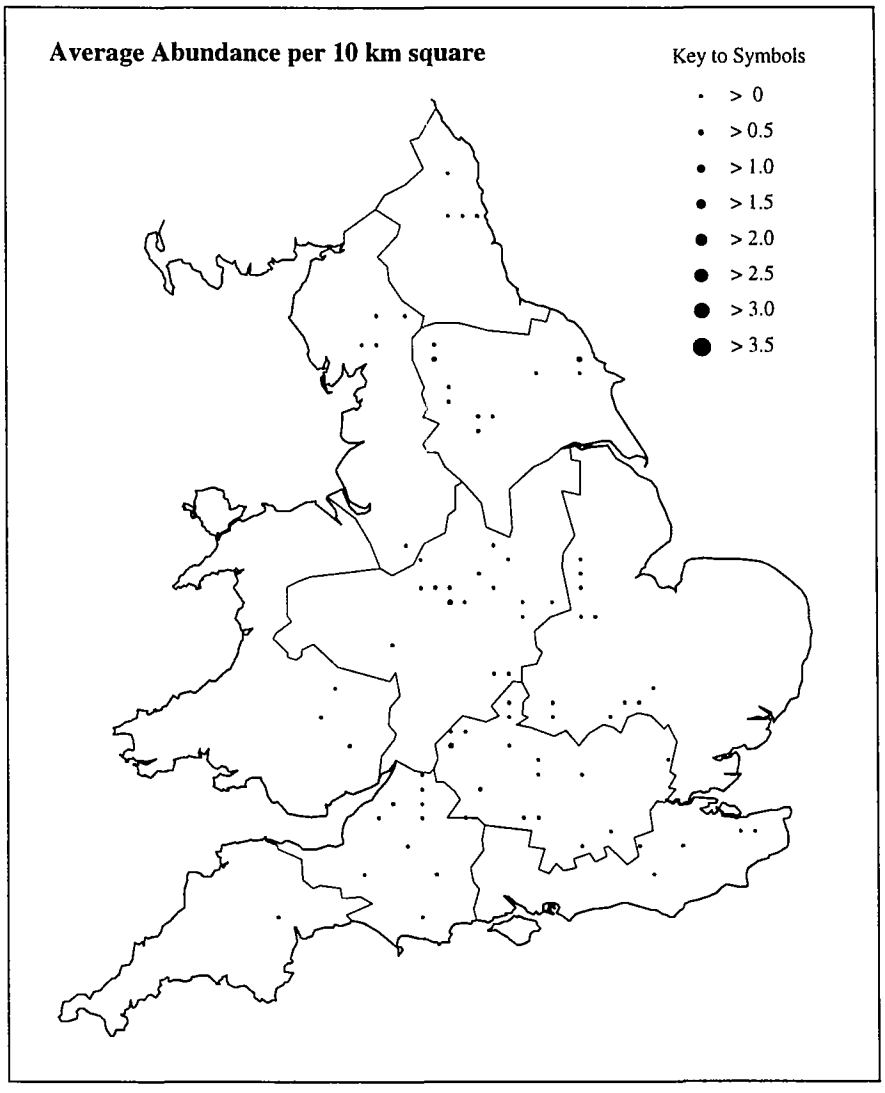


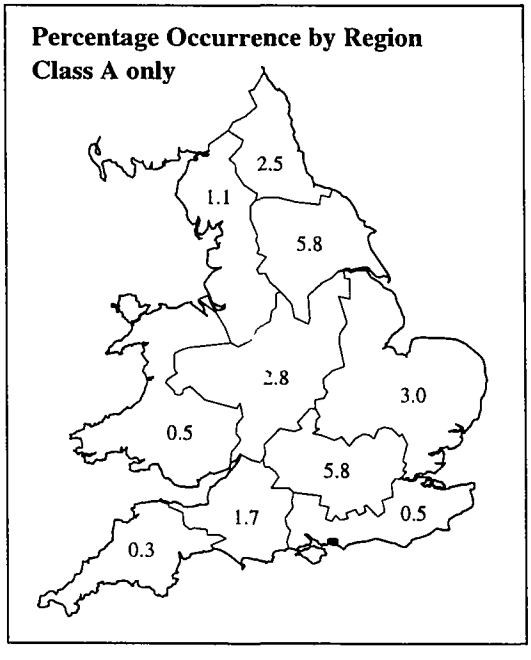


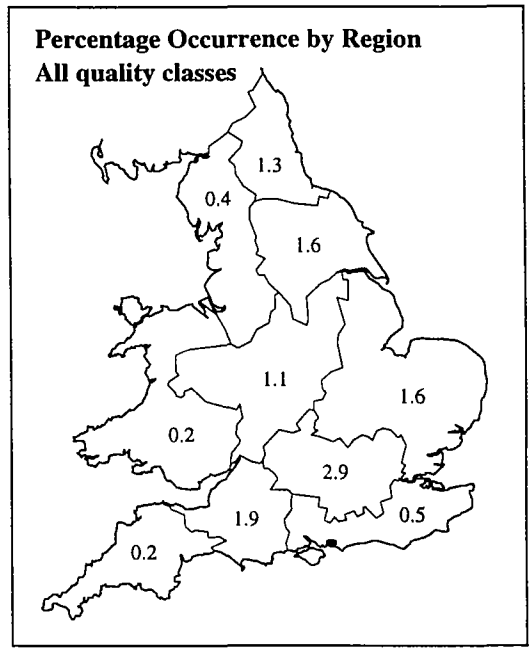


Distribution of BMWP Families - River Sites 1995

ASTACIDAE

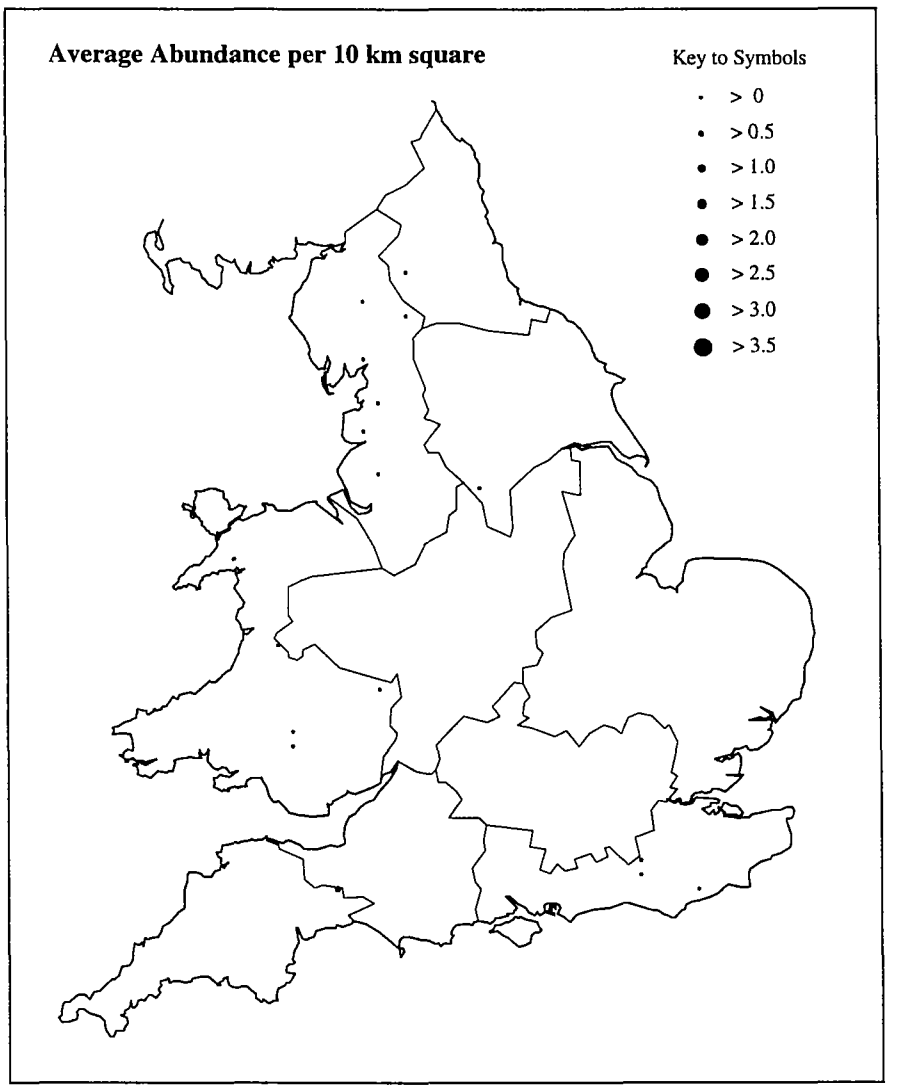


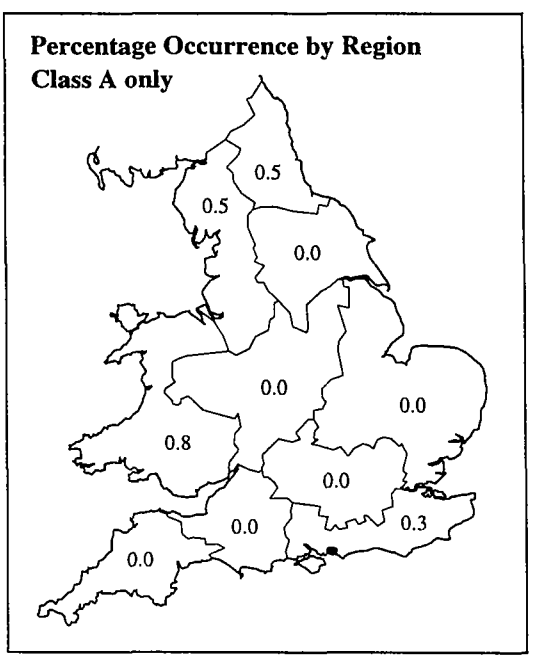


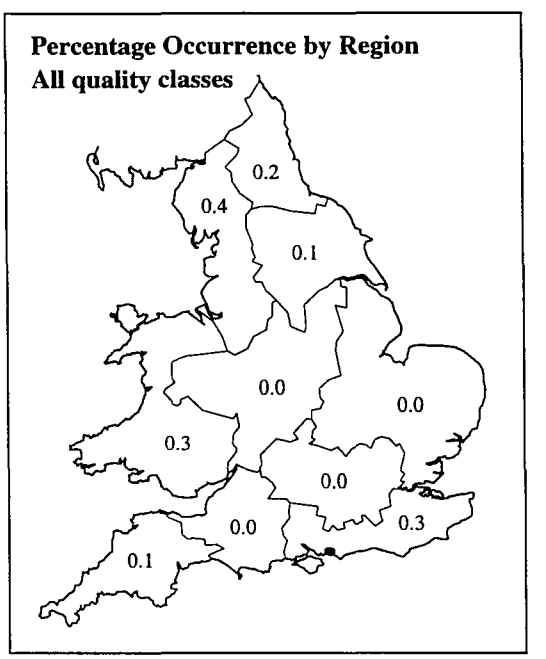


Distribution of BMWP Families - River Sites 1995

SIPHLONURIDAE

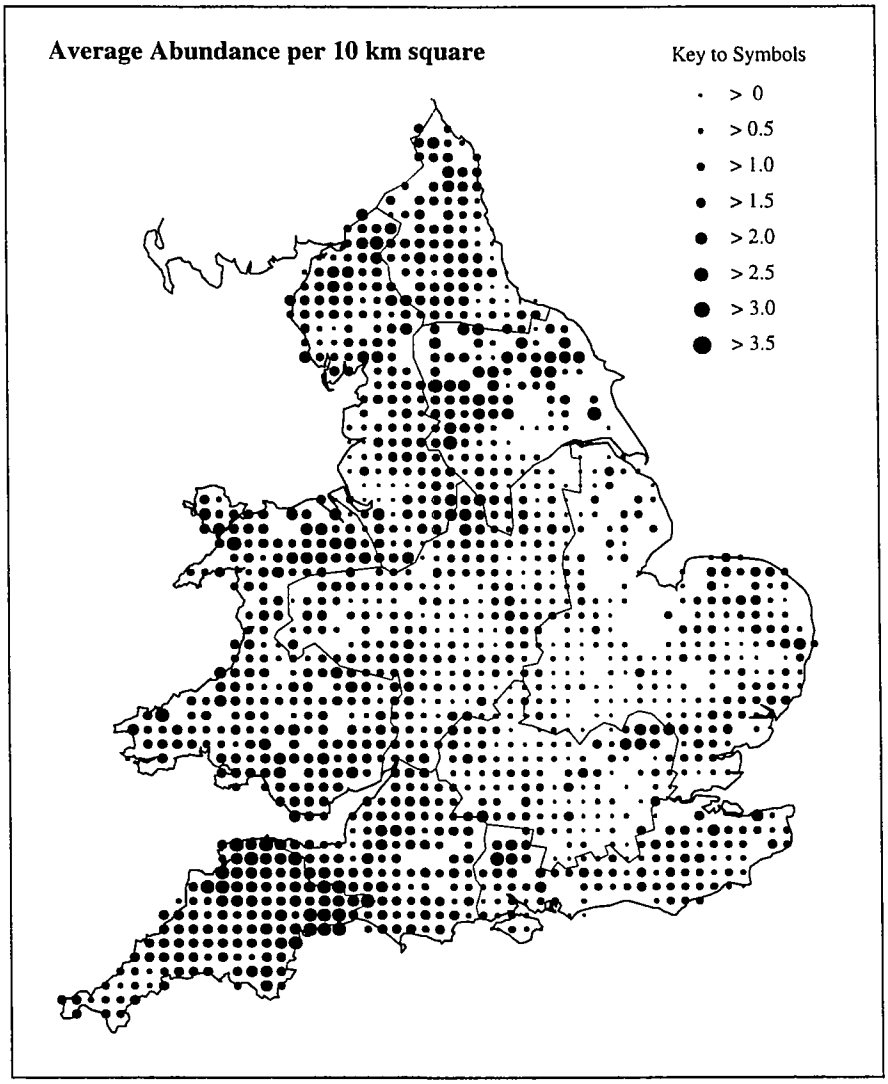


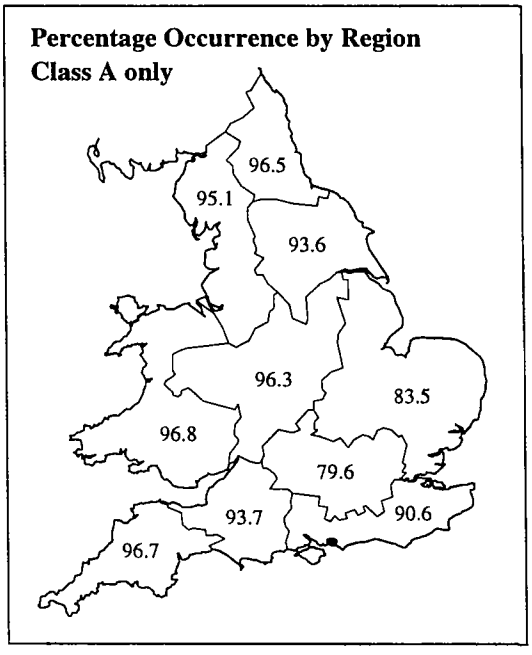


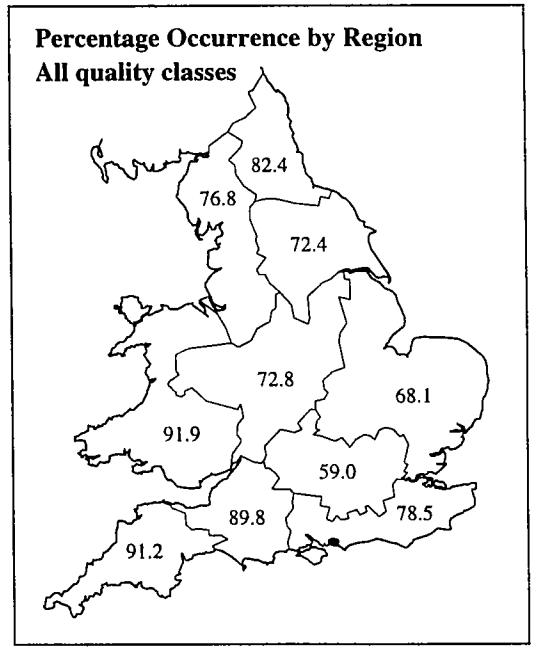


Distribution of BMWP Families - River Sites 1995

BAETIDAE

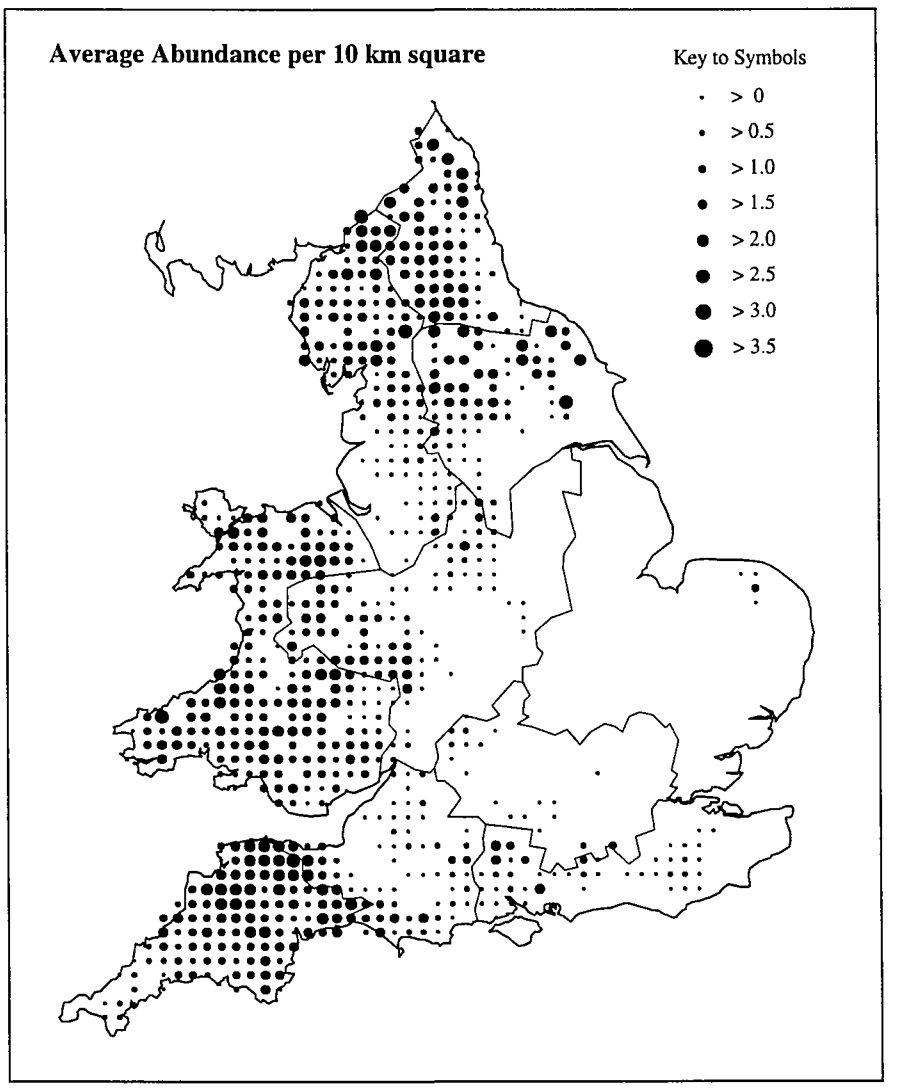


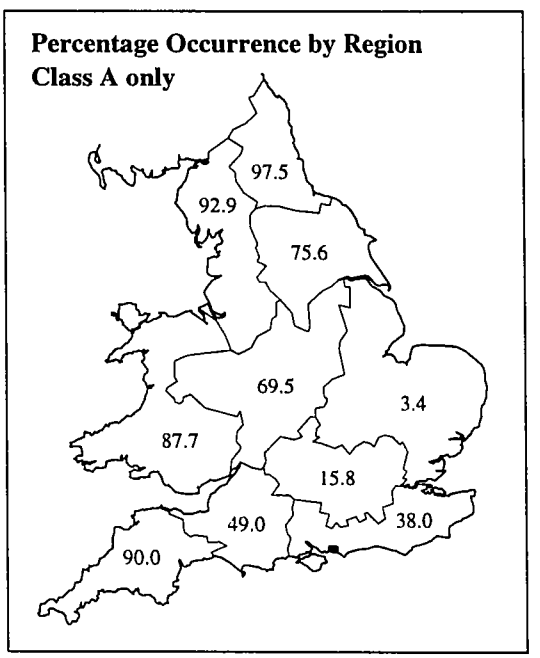


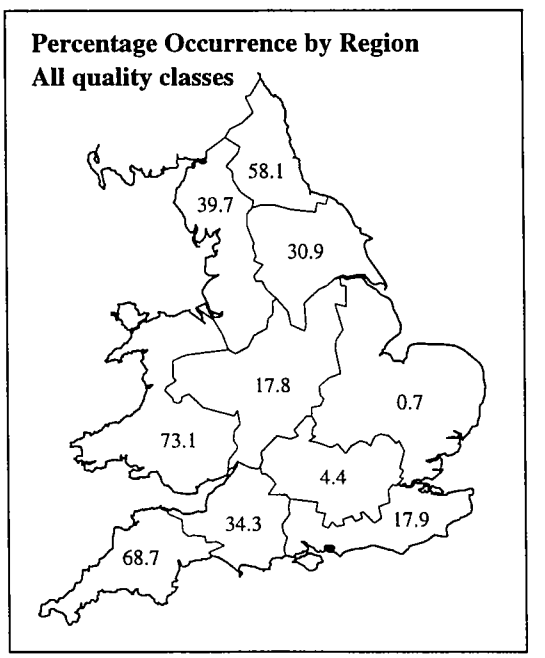


Distribution of BMWP Families - River Sites 1995

HEPTAGENIIDAE

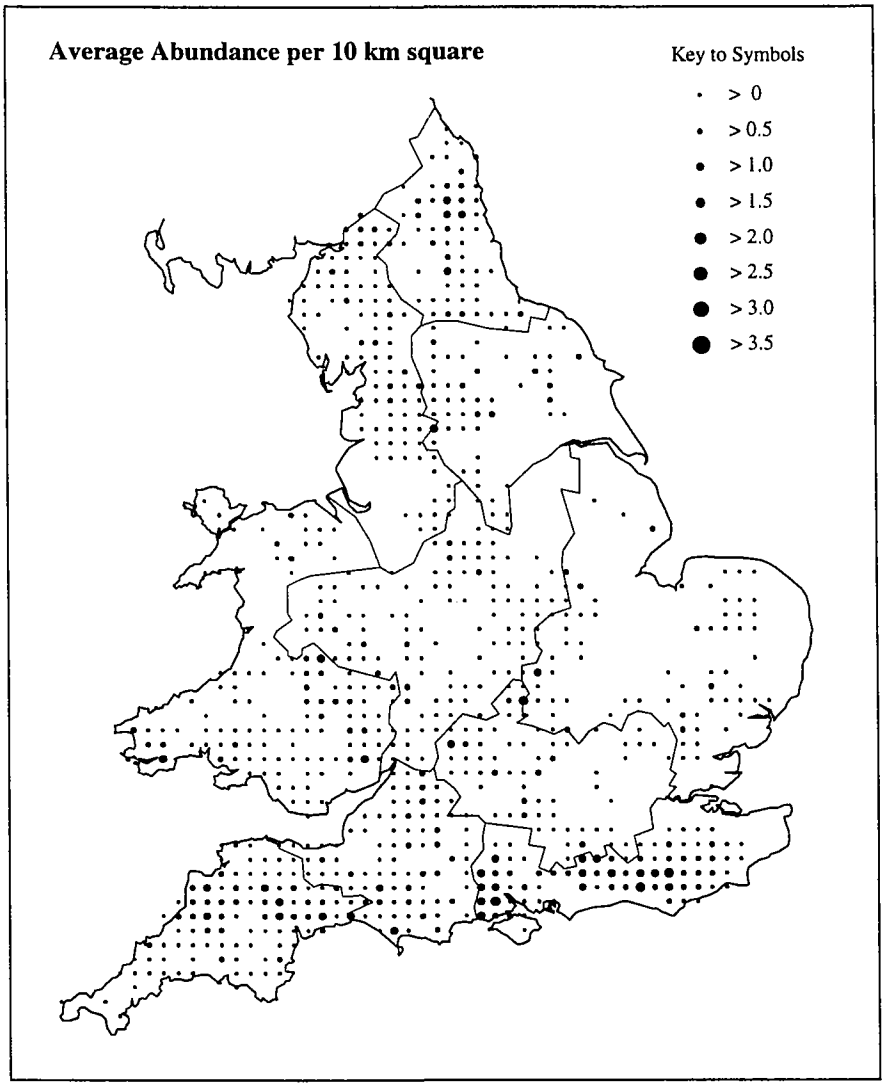


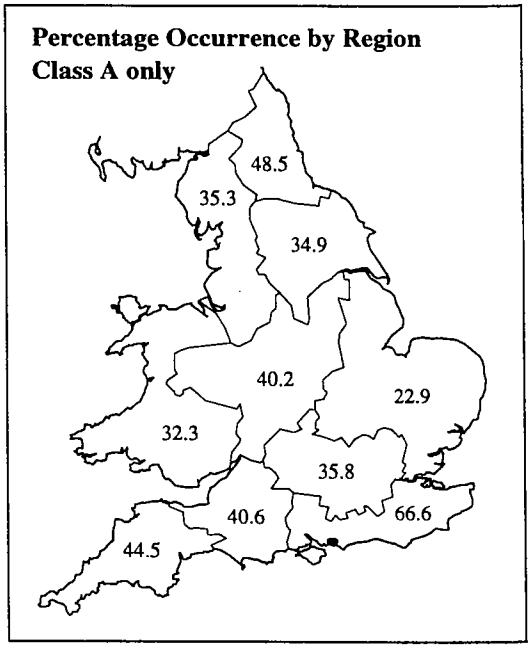


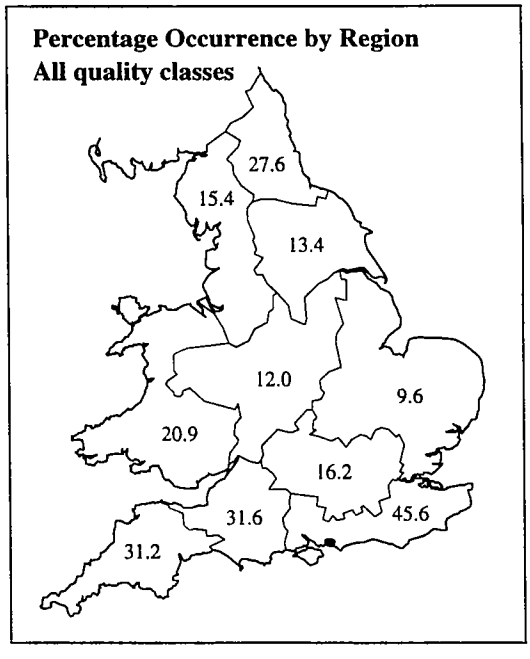


Distribution of BMWP Families - River Sites 1995

LEPTOPHLEBIIDAE

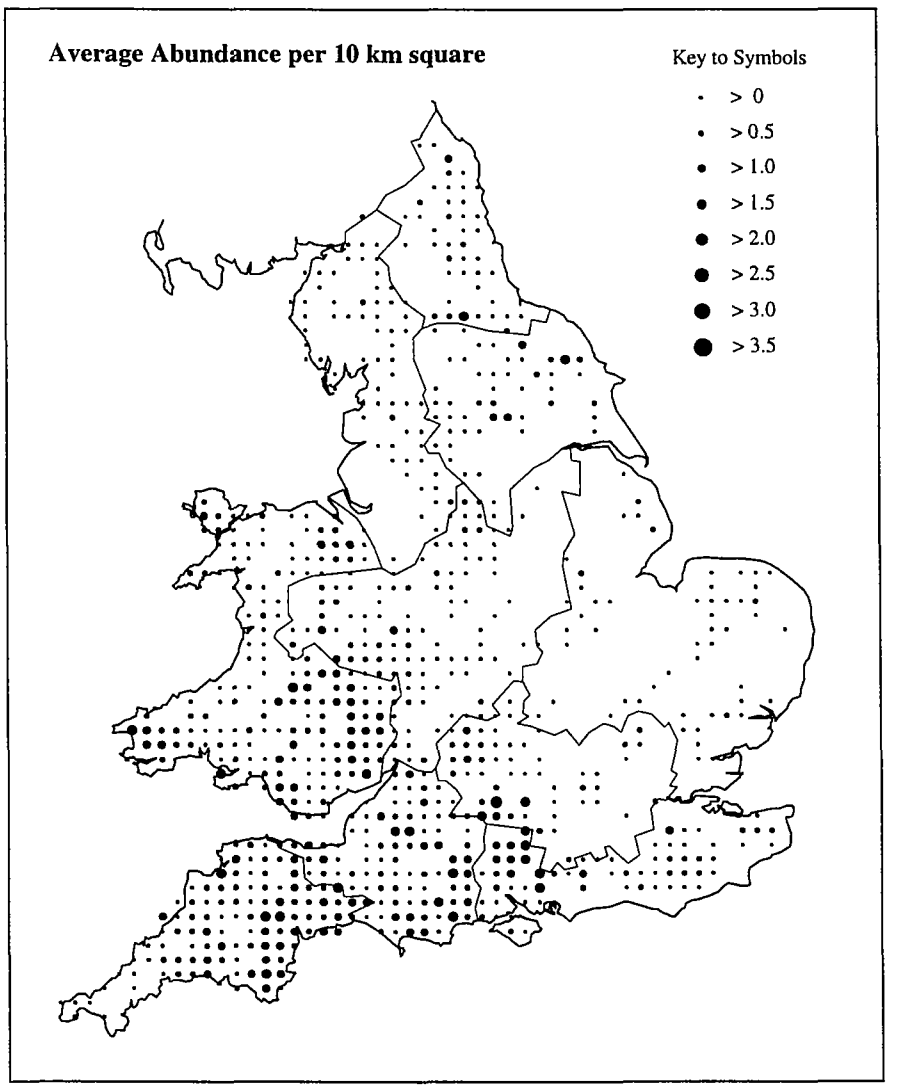


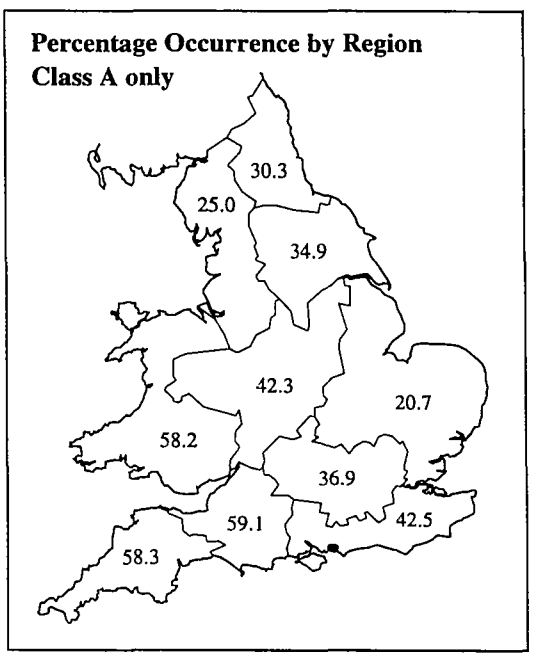


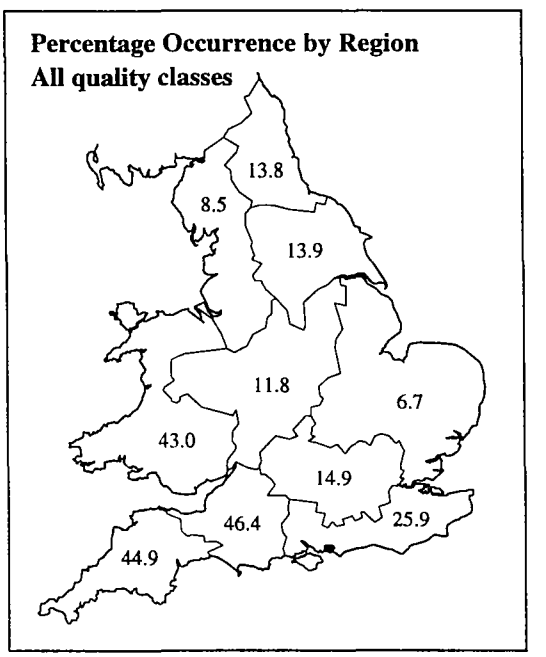


Distribution of BMWP Families - River Sites 1995

EPHEMERELLIDAE

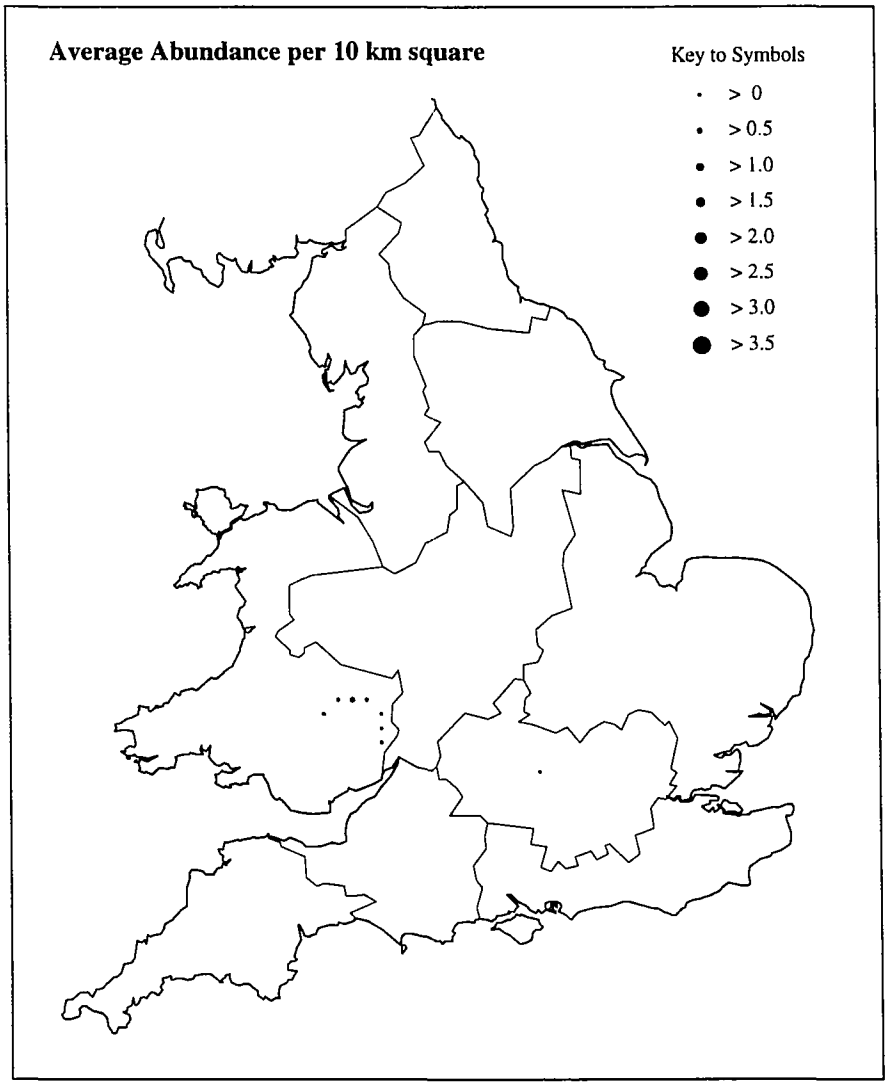


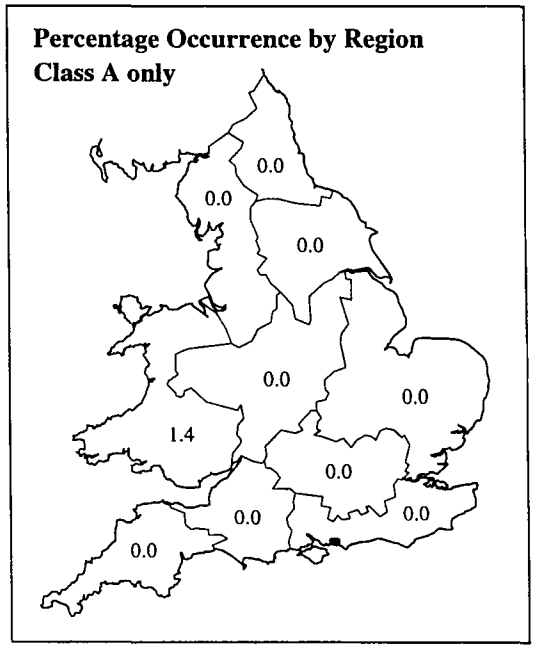


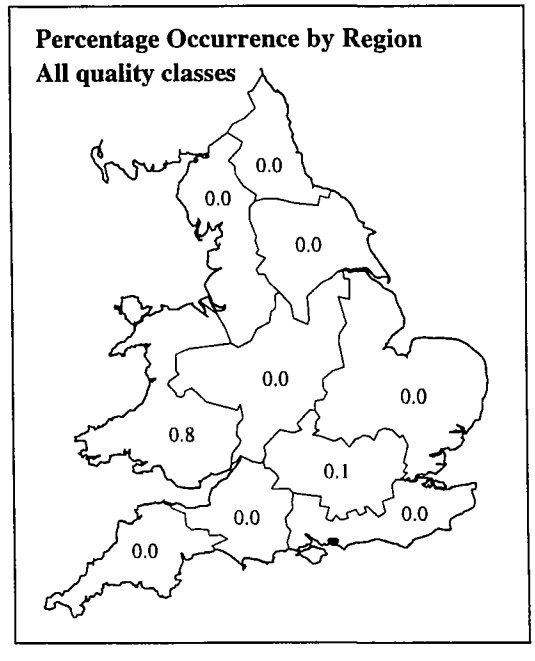


Distribution of BMWP Families - River Sites 1995

POTAMANTHIDAE







Distribution of BMWP Families - River Sites 1995

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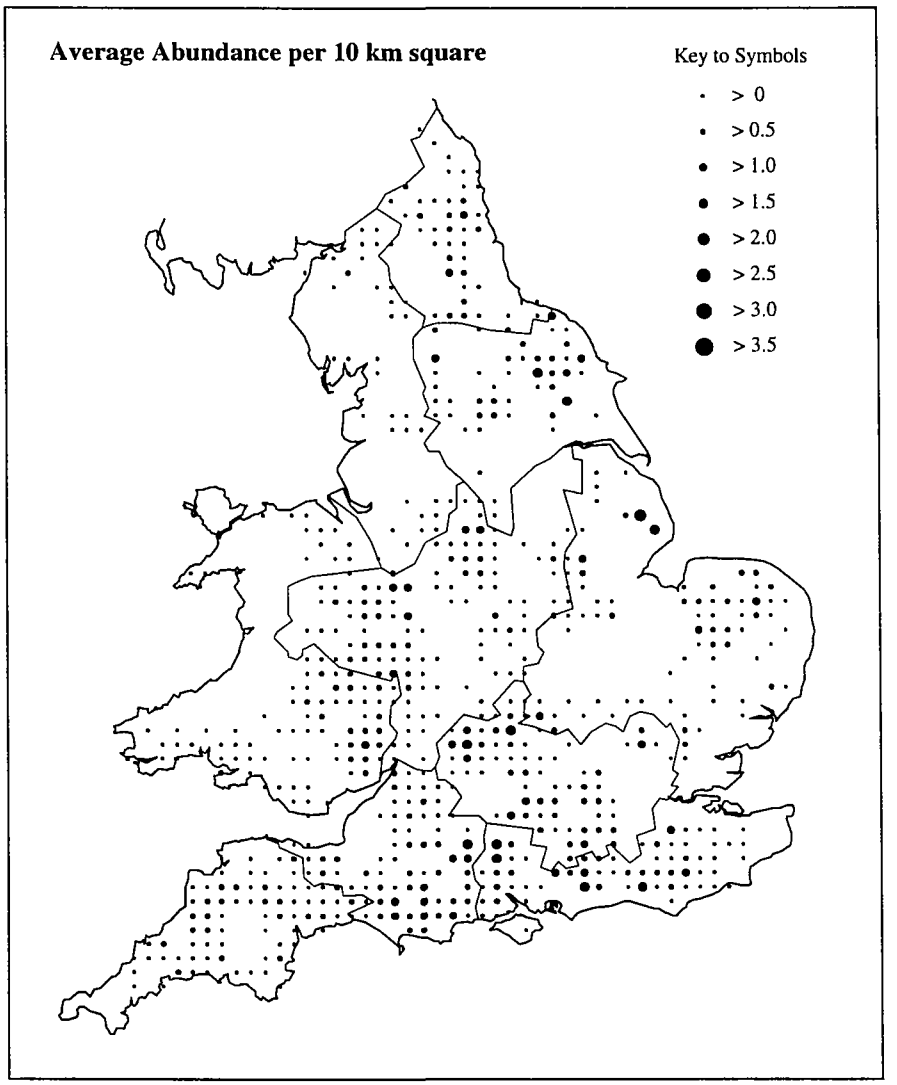

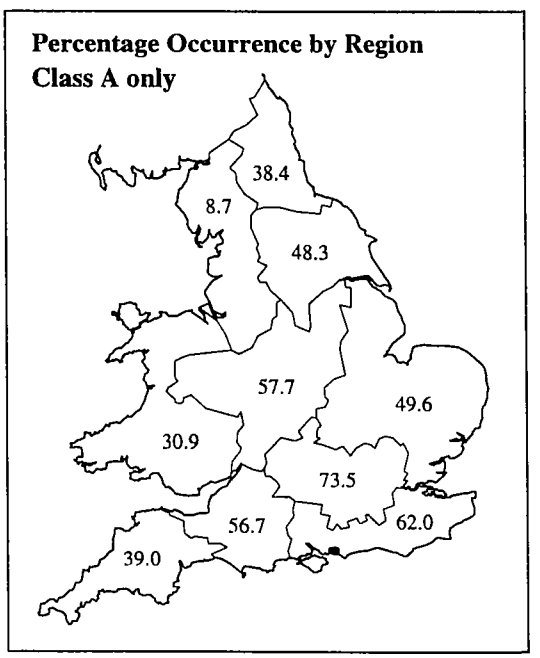

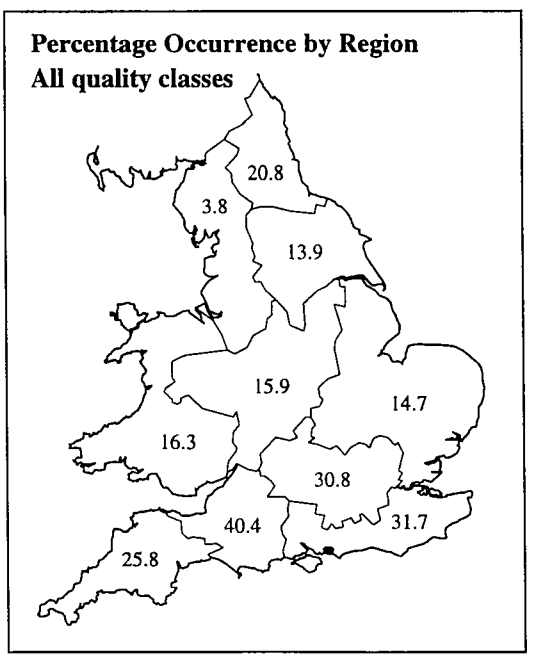

Distribution of BMWP Families - River Sites 1995

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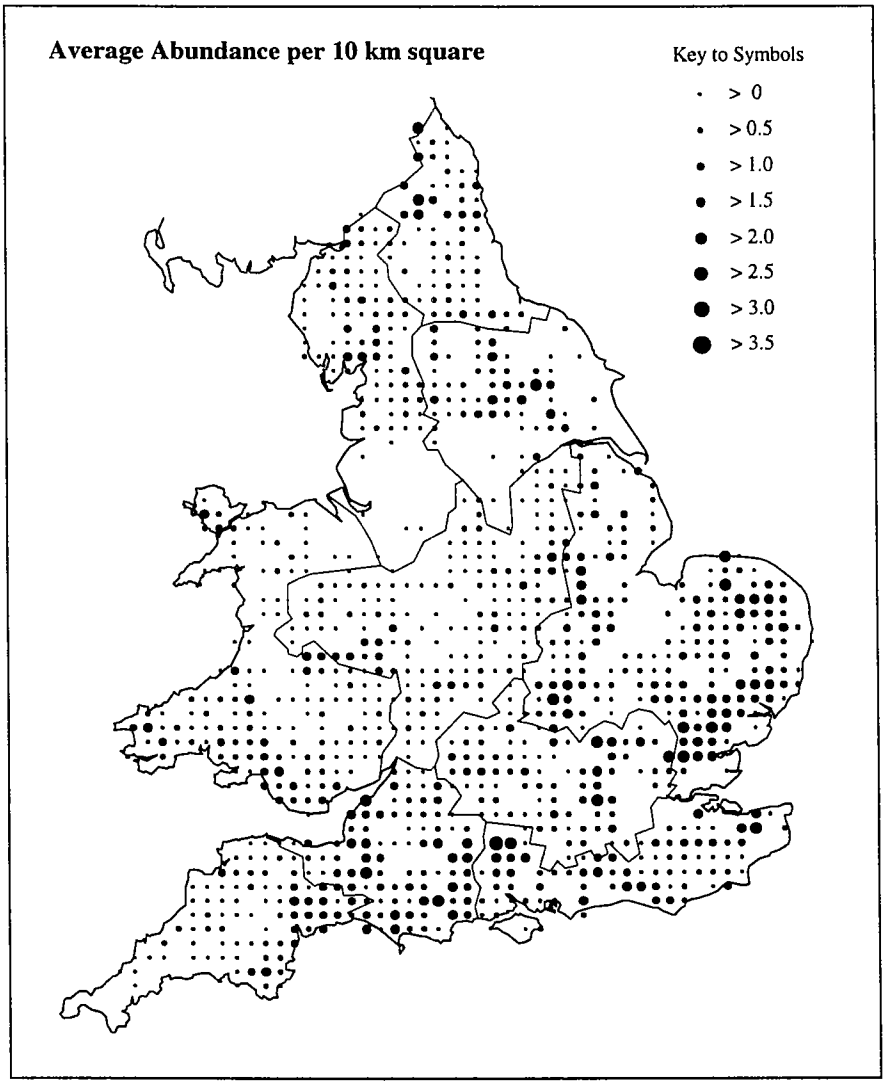
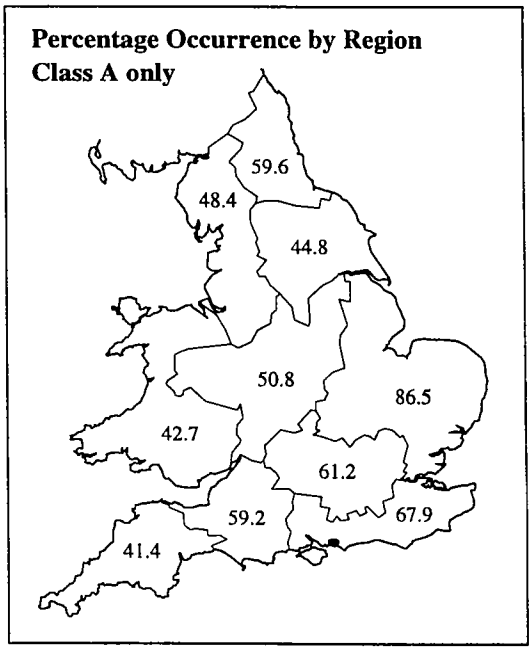
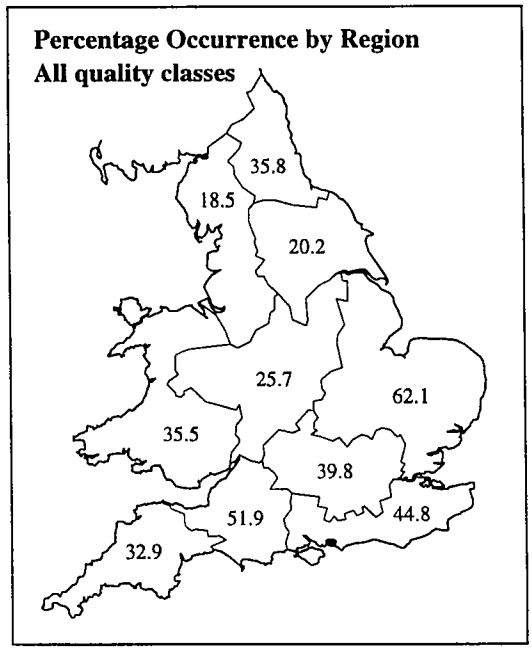
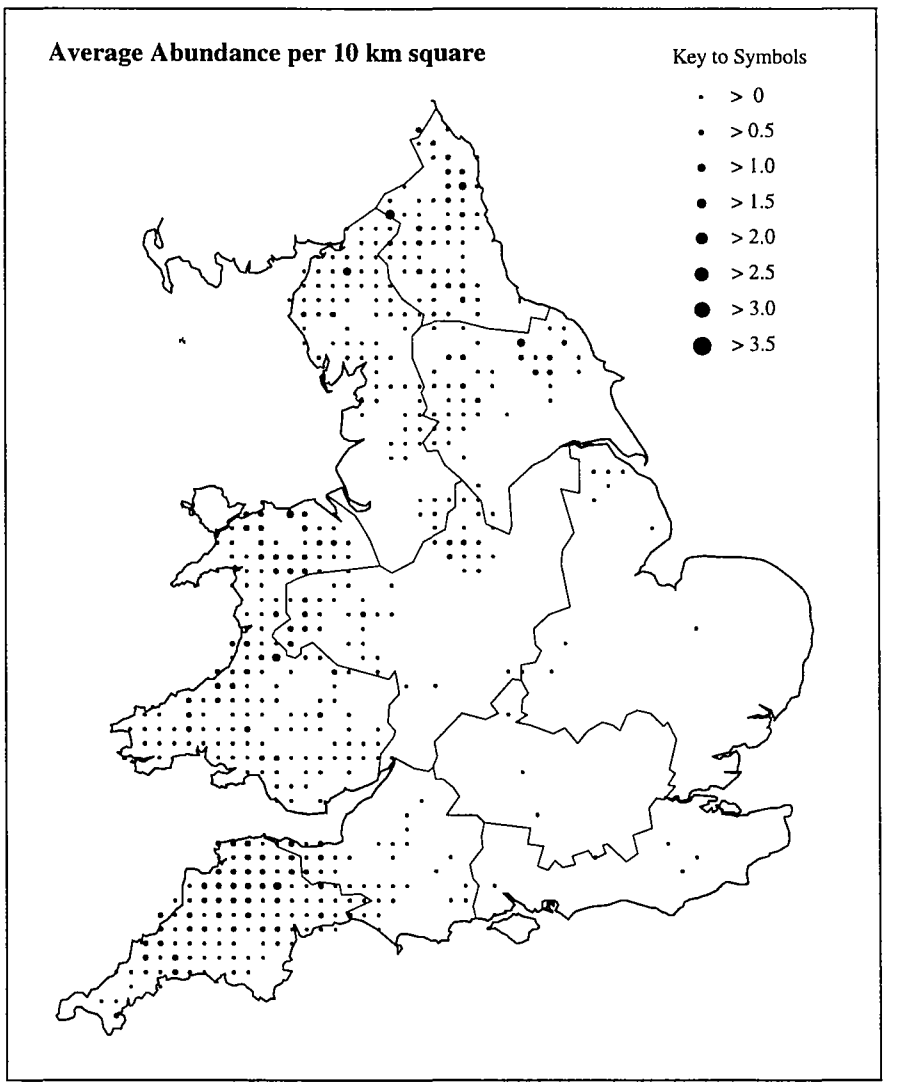


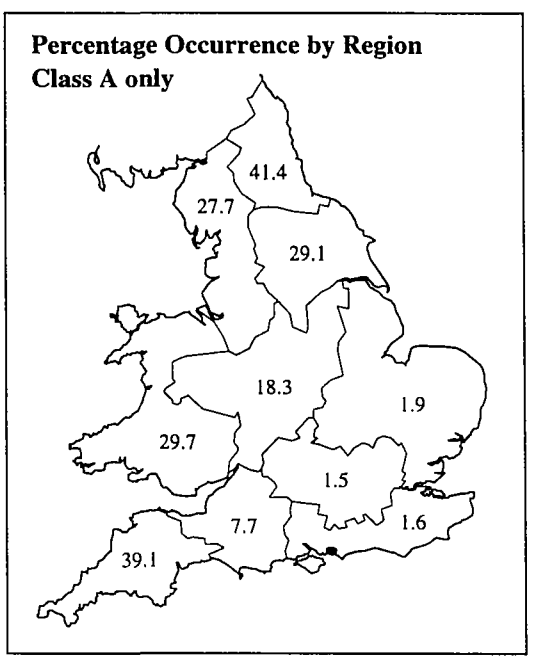


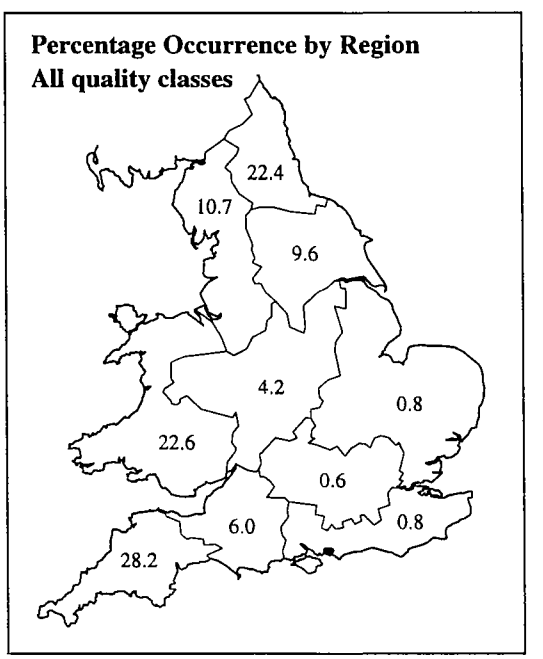


Distribution of BMWP Families - River Sites 1995

TAENIOPTERYGIDAE

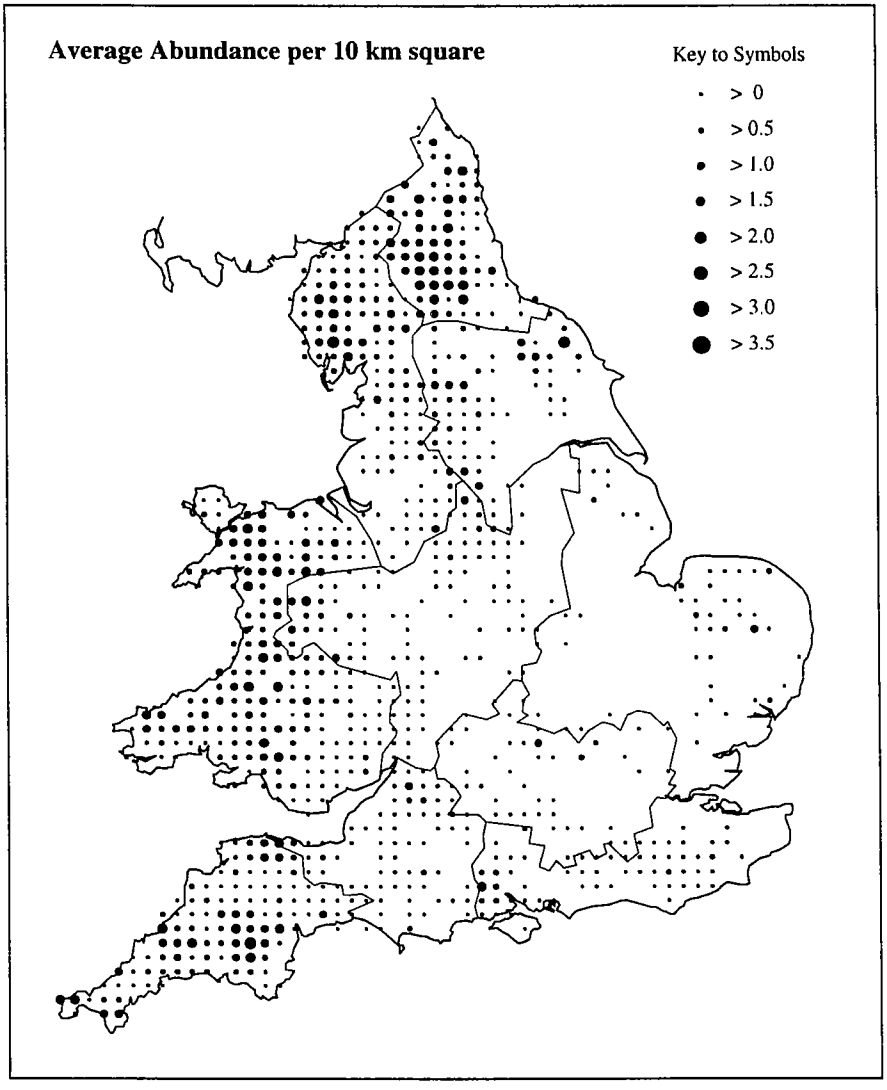


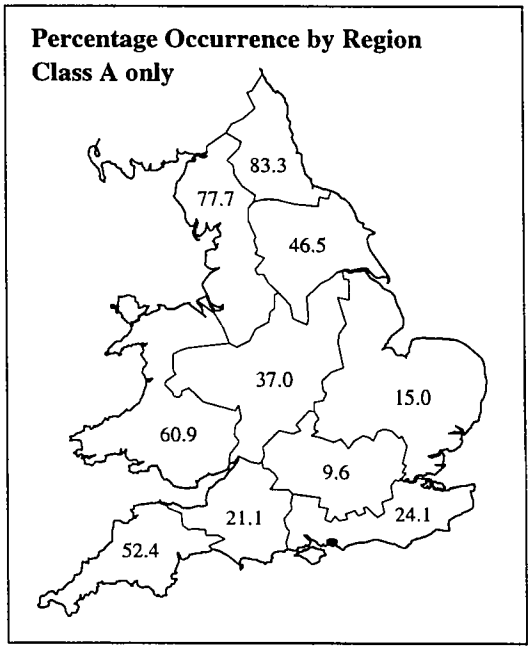


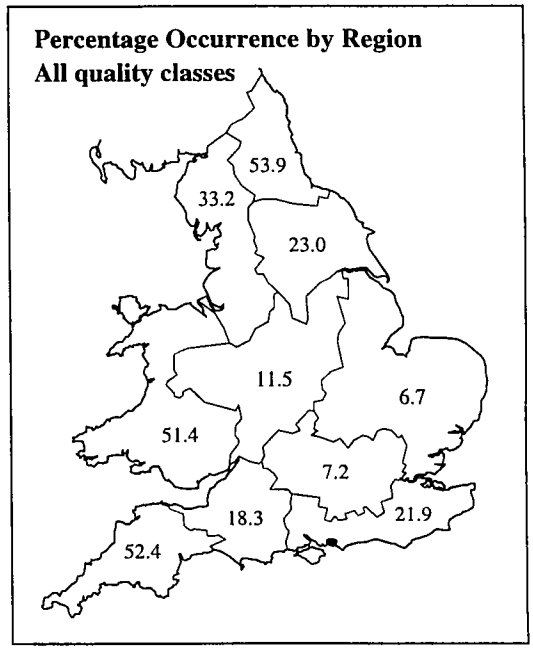


Distribution of BMWP Families - River Sites 1995

NEMOURIDAE

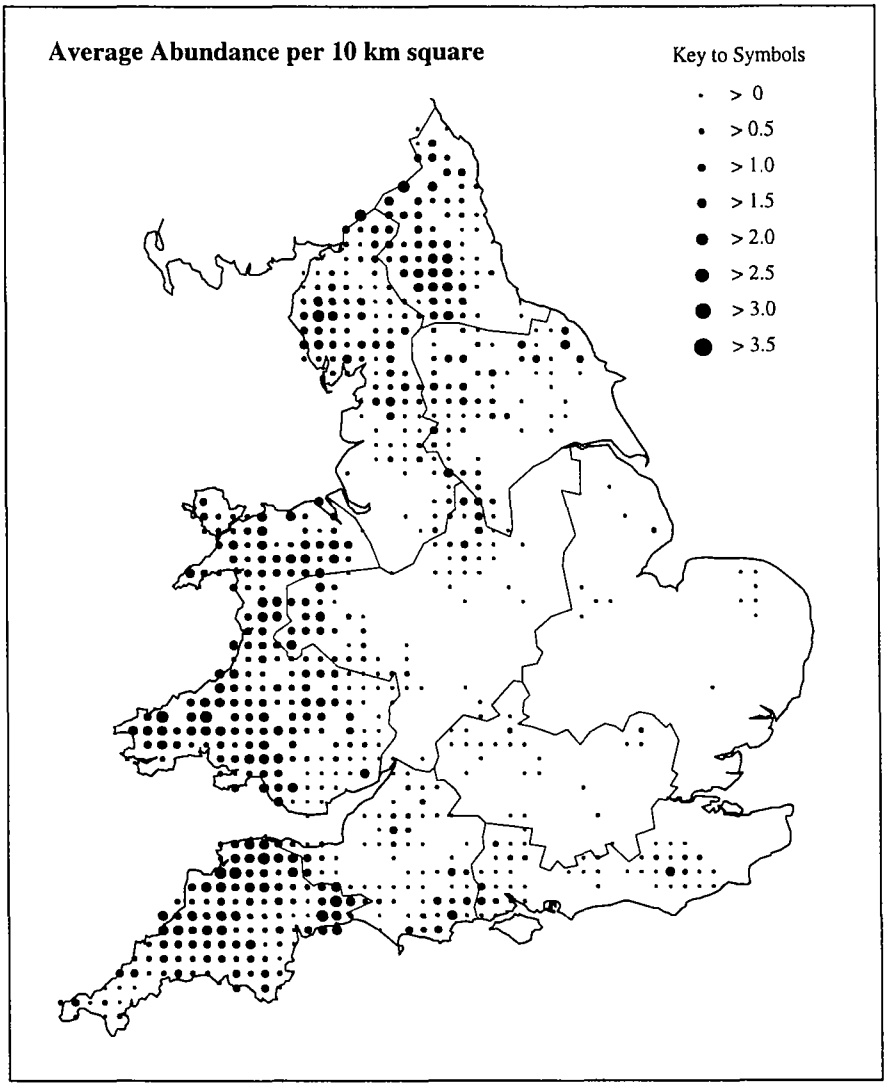


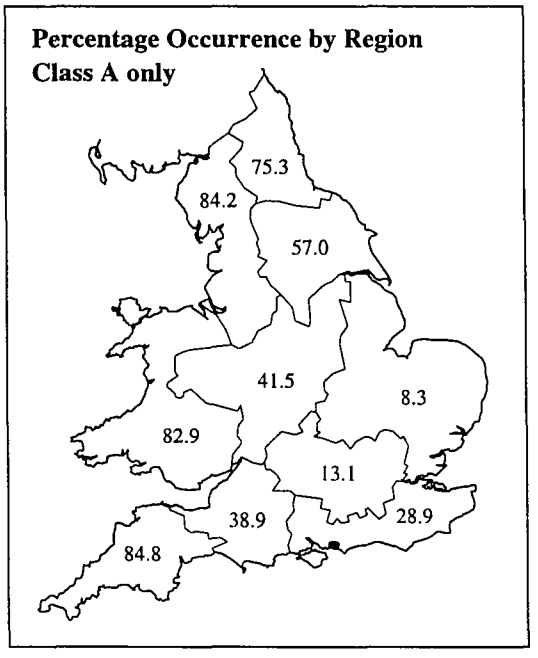


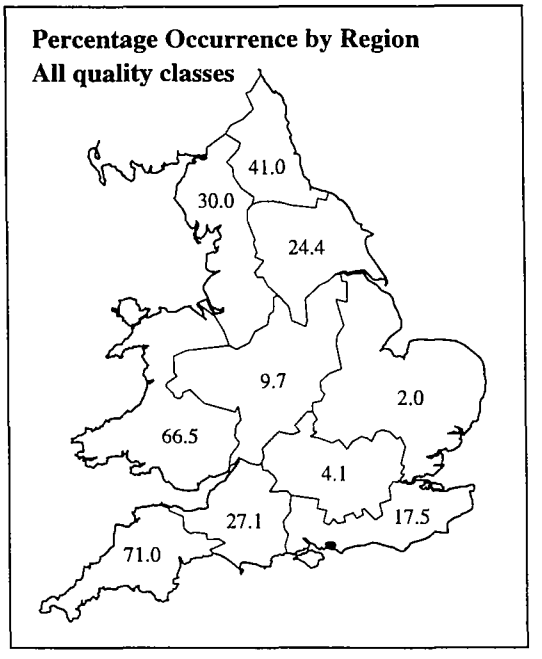


Distribution of BMWP Families - River Sites 1995

LEUCTRIDAE

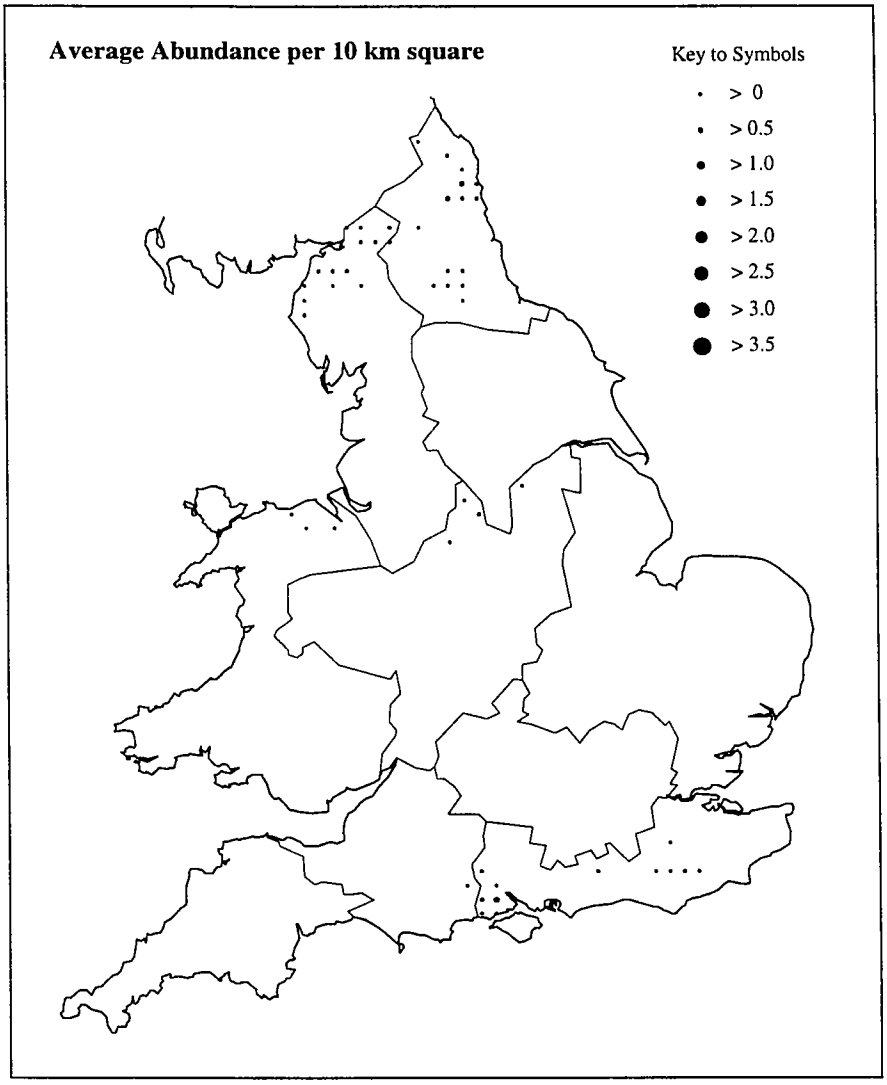


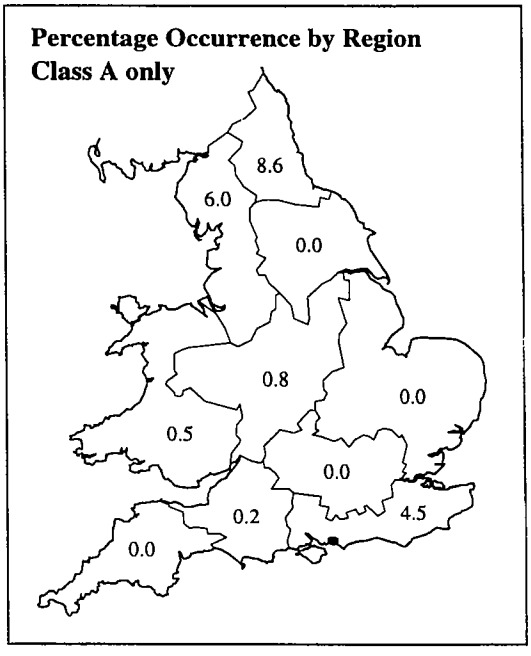


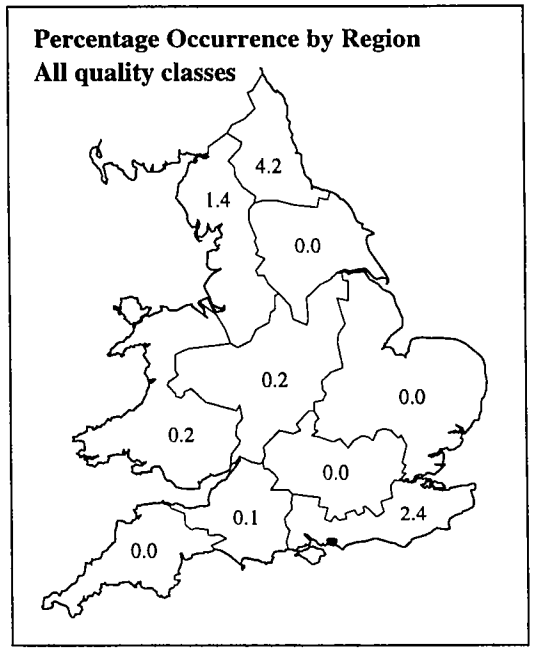


Distribution of BMWP Families - River Sites 1995

CAPNIIDAE

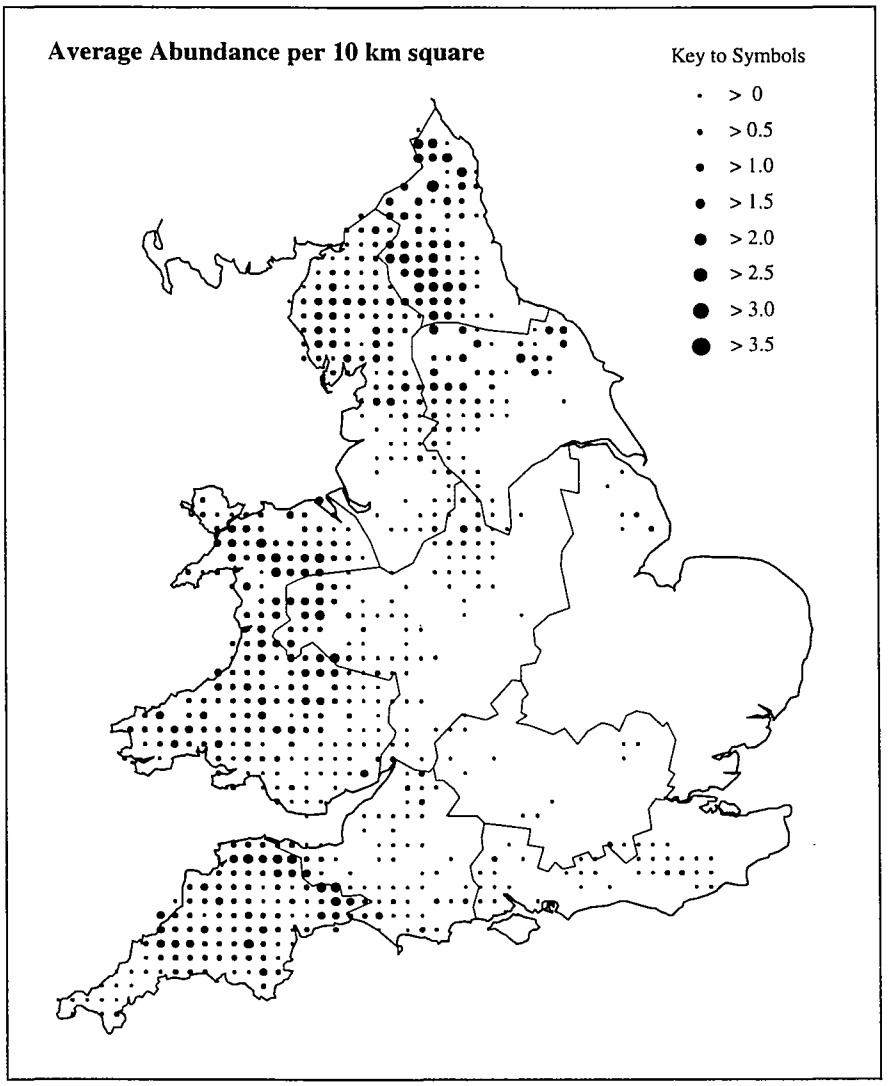


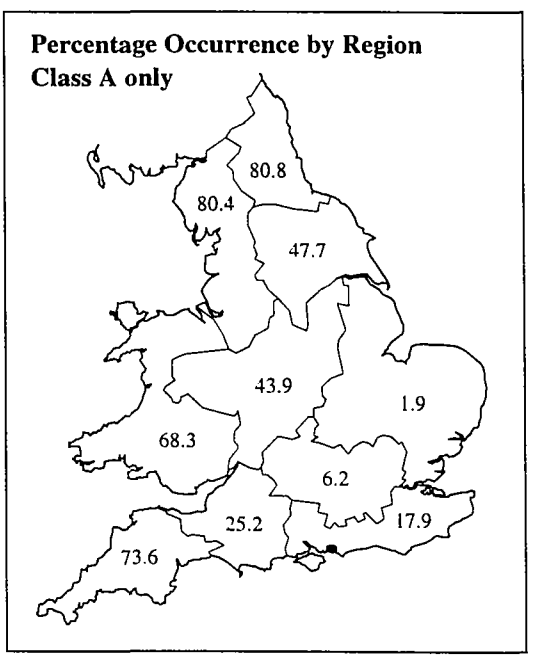


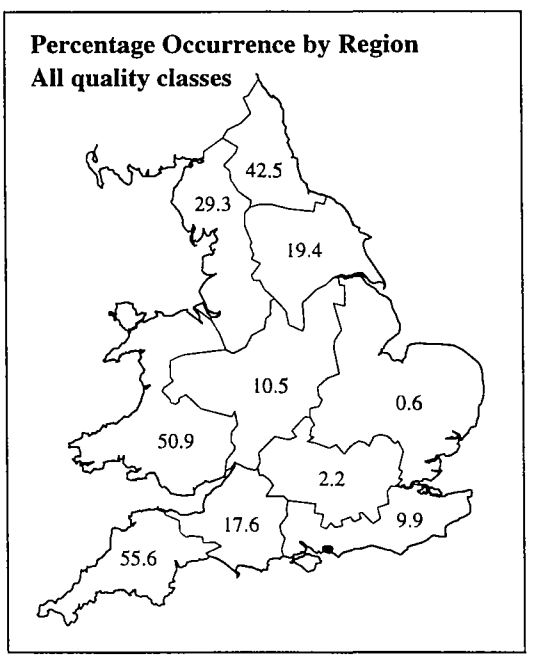


Distribution of BMWP Families - River Sites 1995

PERLODIDAE

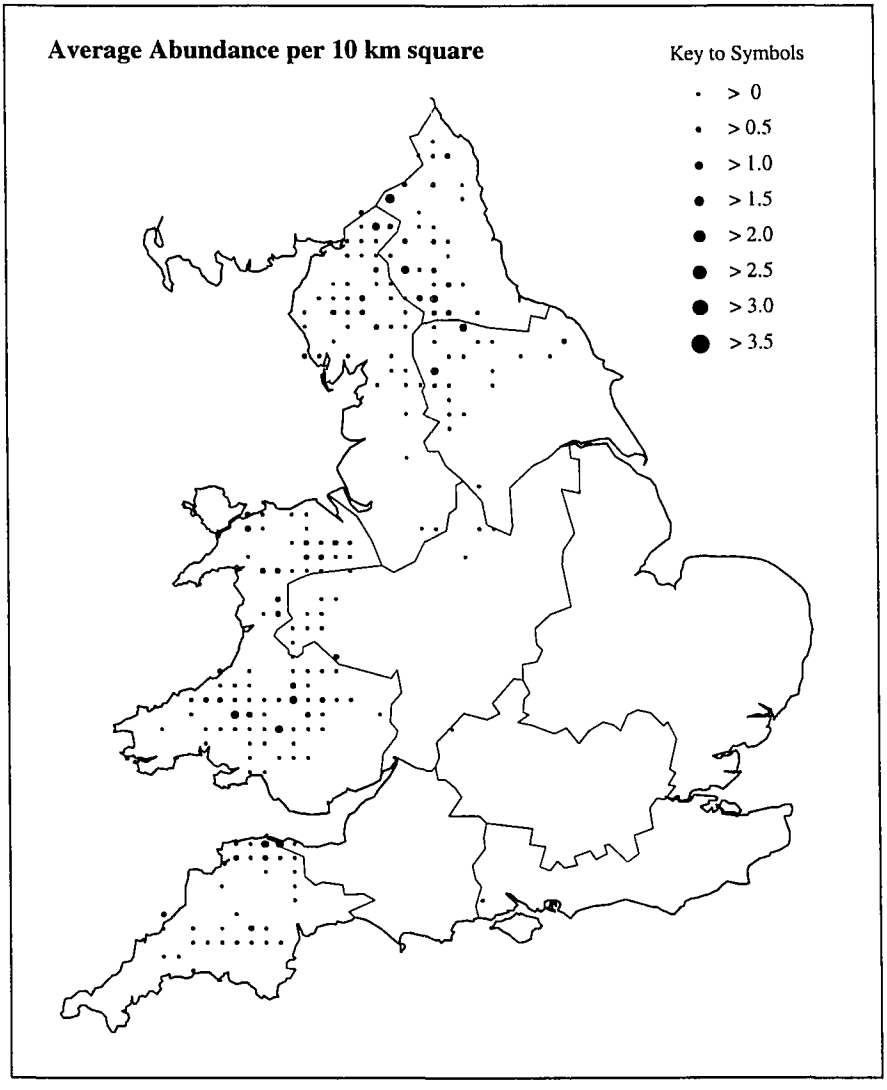


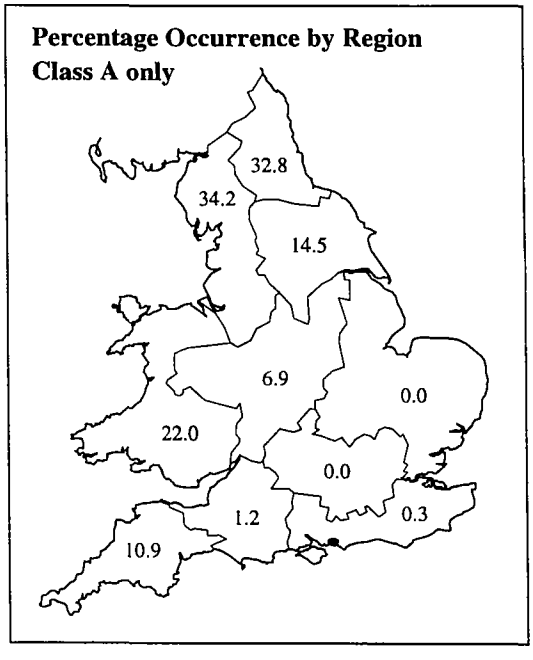


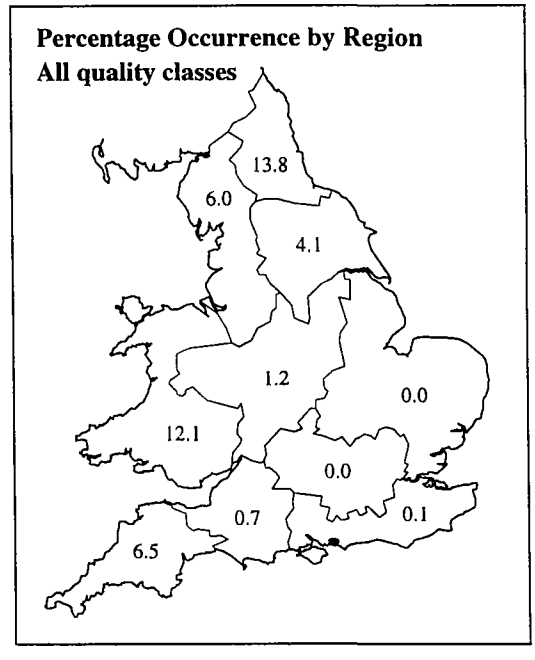


Distribution of BMWP Families - River Sites 1995

PERLIDAE

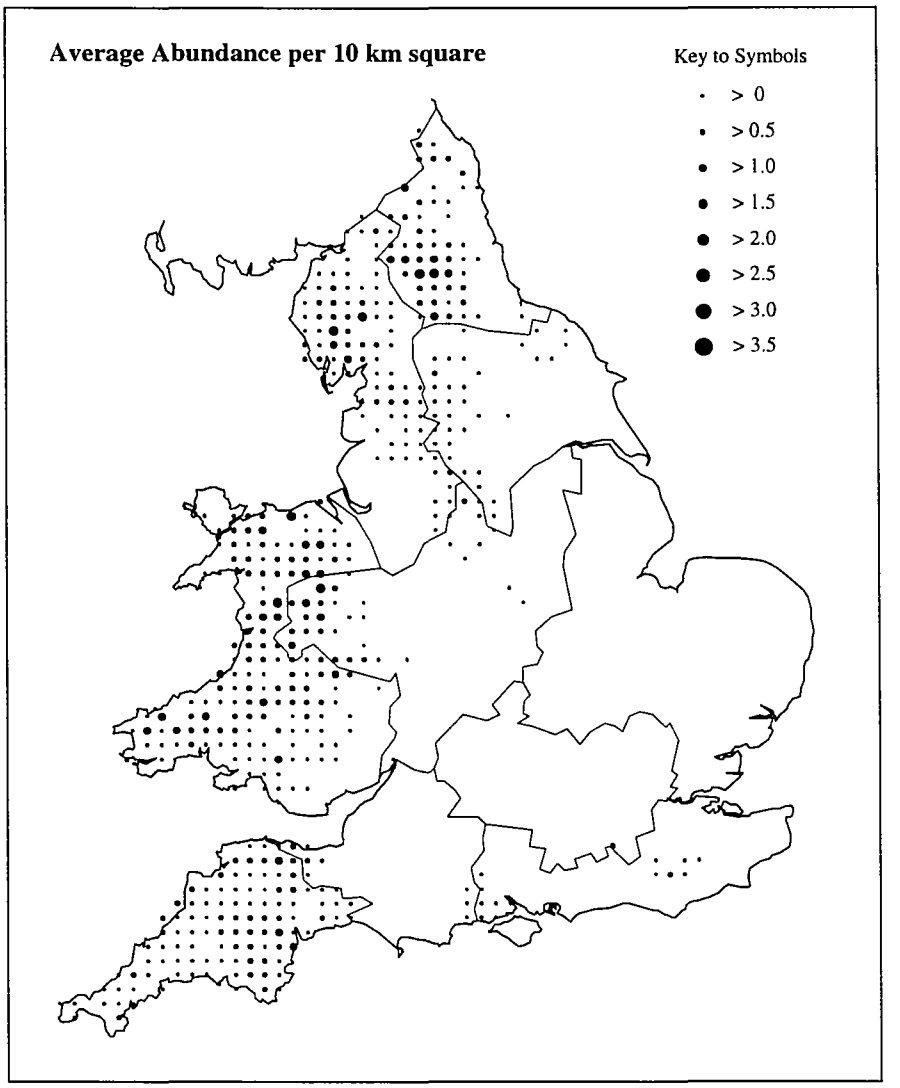


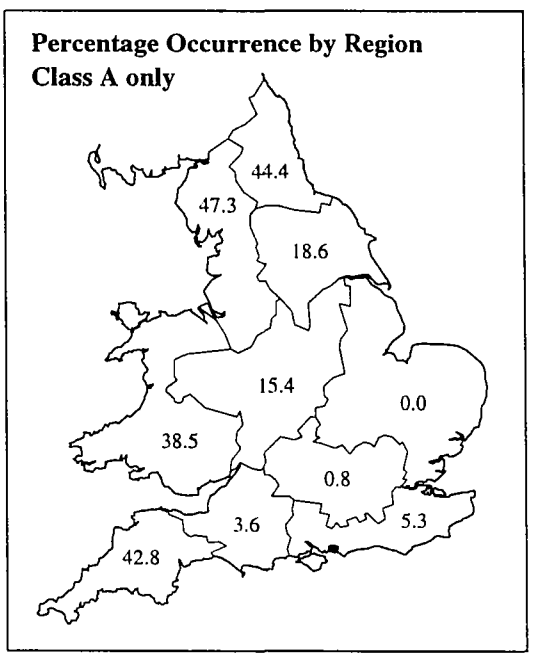


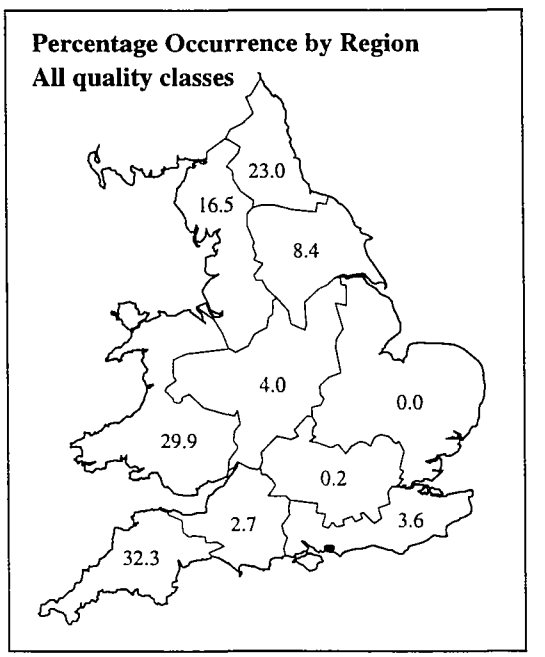


Distribution of BMWP Families - River Sites 1995

CHLOROPERLIDAE







Distribution of BMWP Families - River Sites 1995

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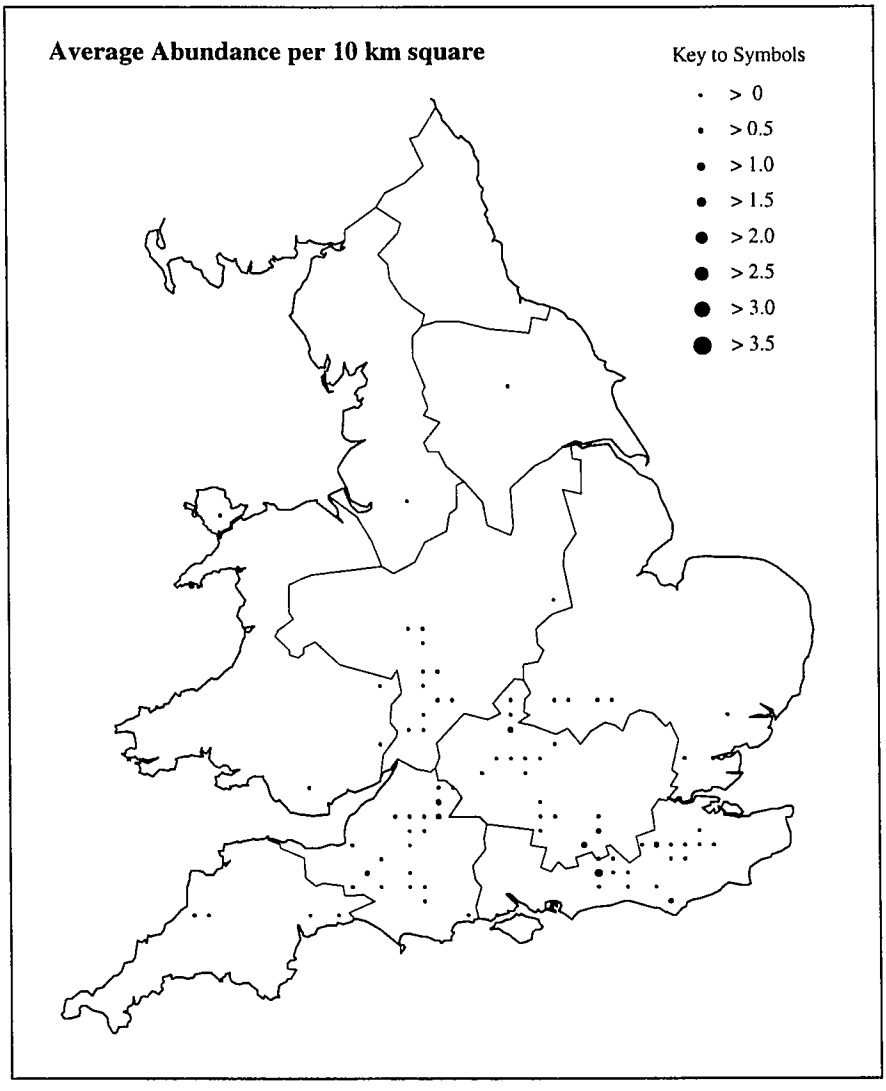
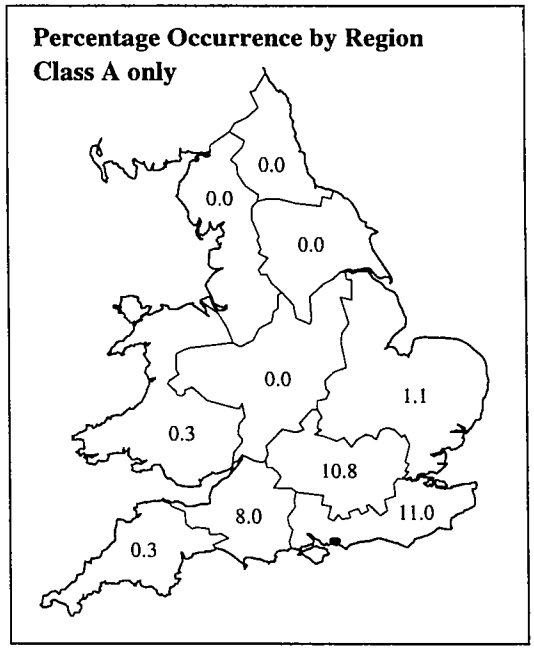
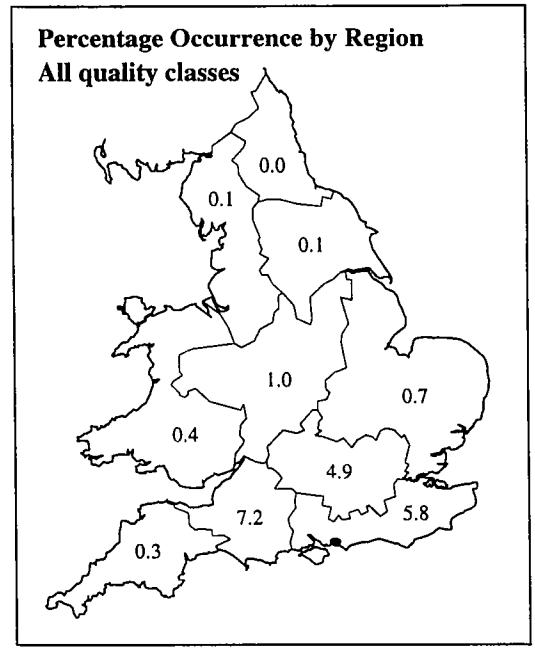
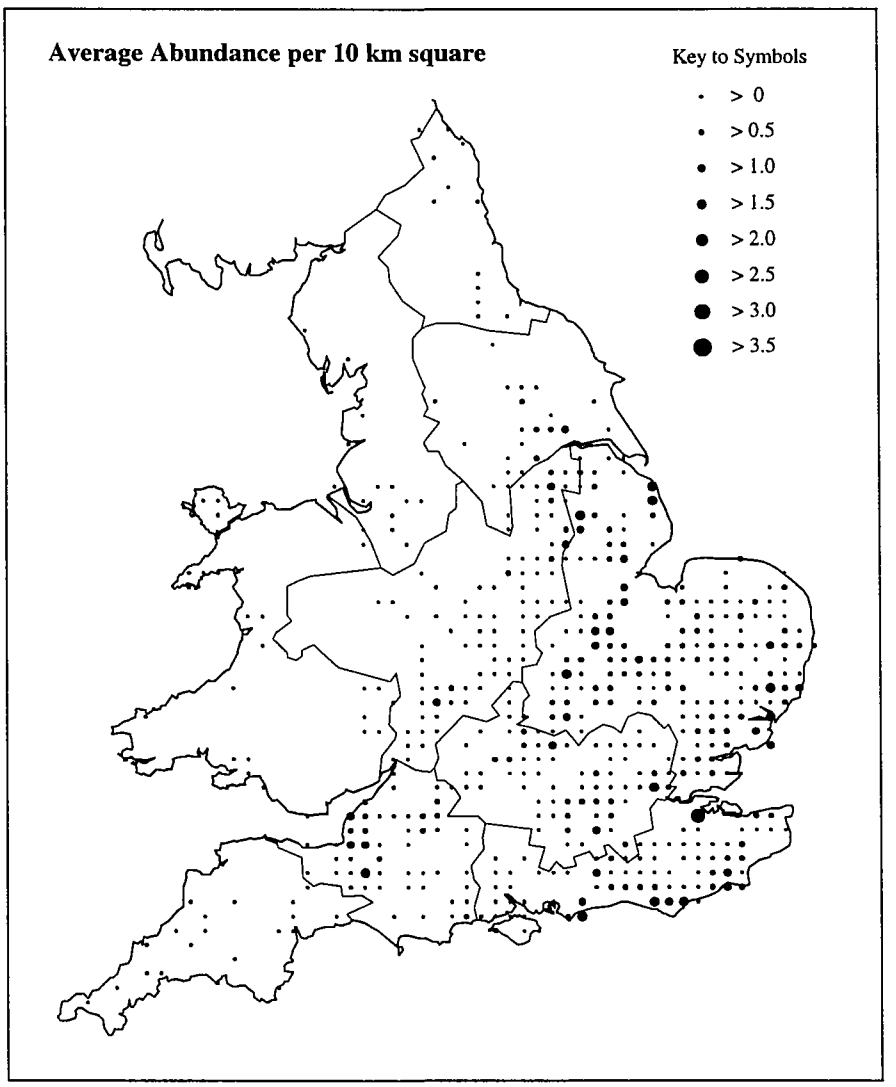


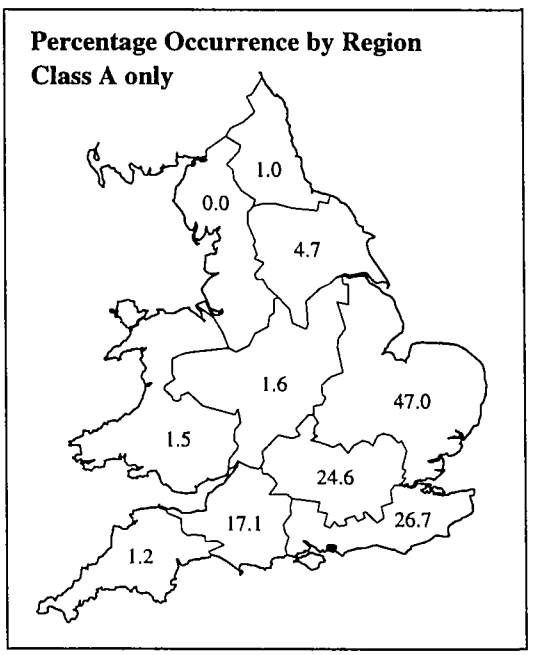


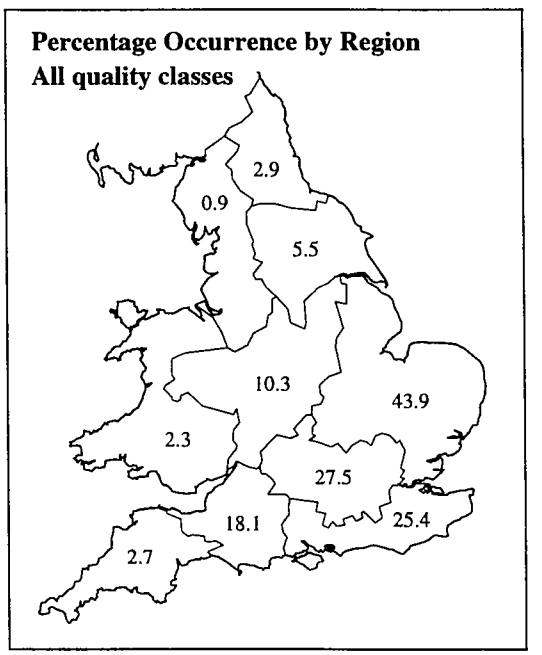


Distribution of BMWP Families - River Sites 1995

COENAGRIIDAE







Distribution of BMWP Families - River Sites 1995

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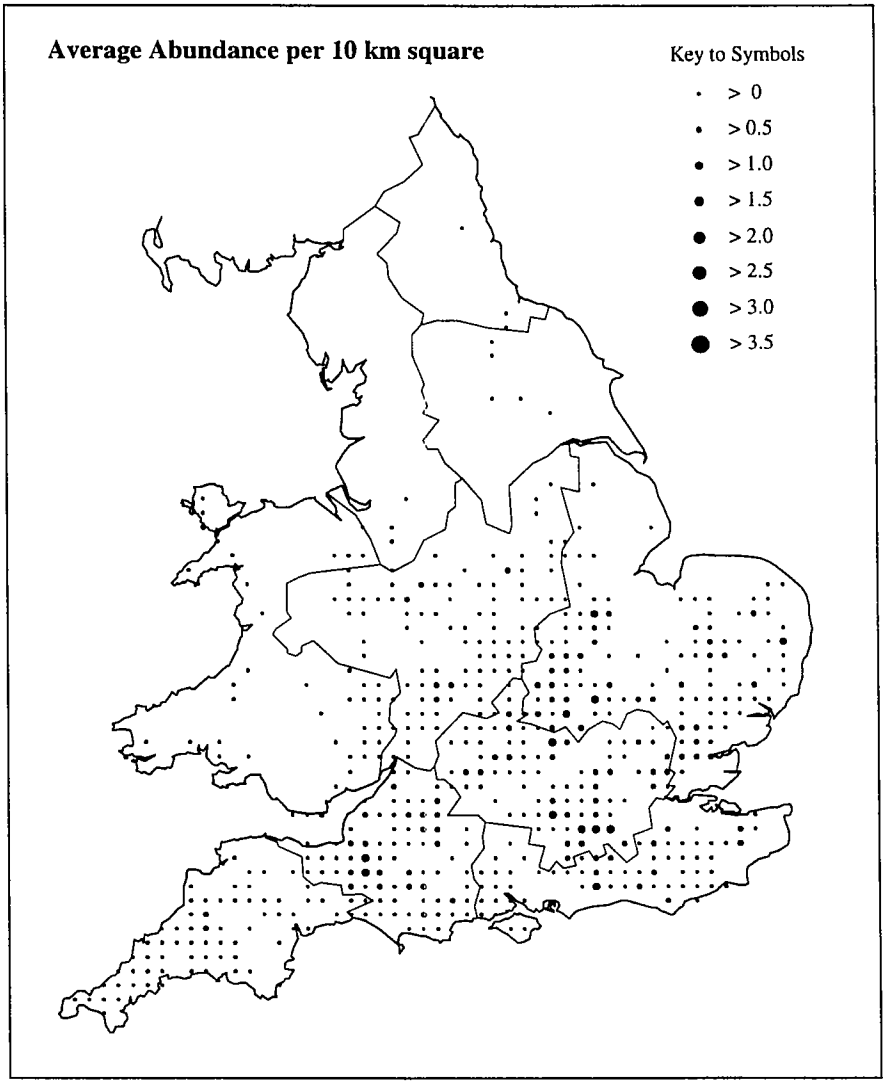
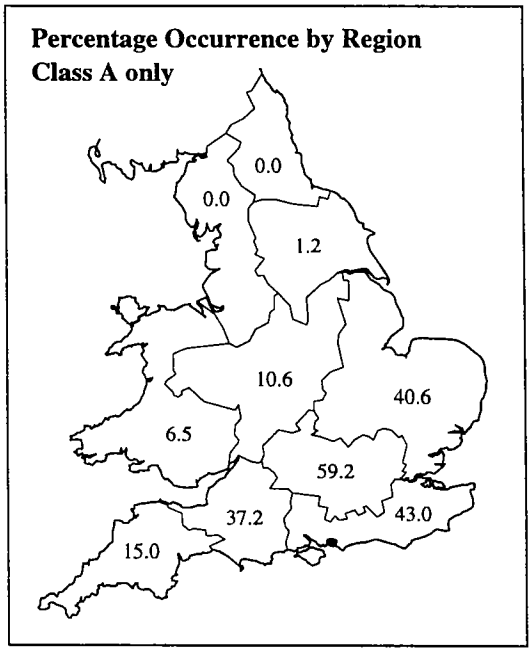
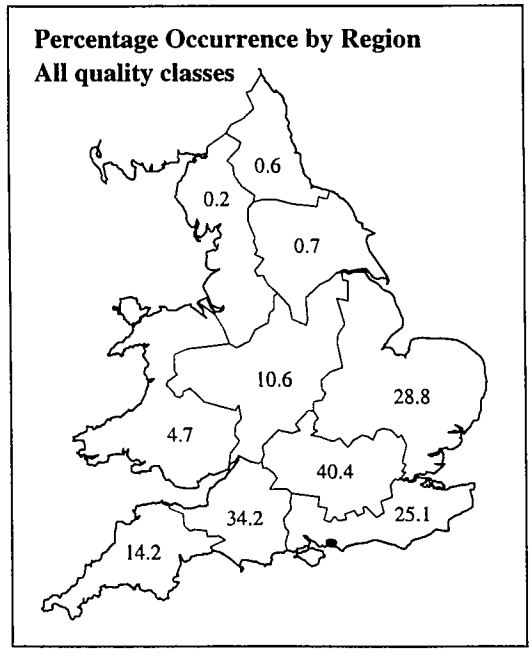
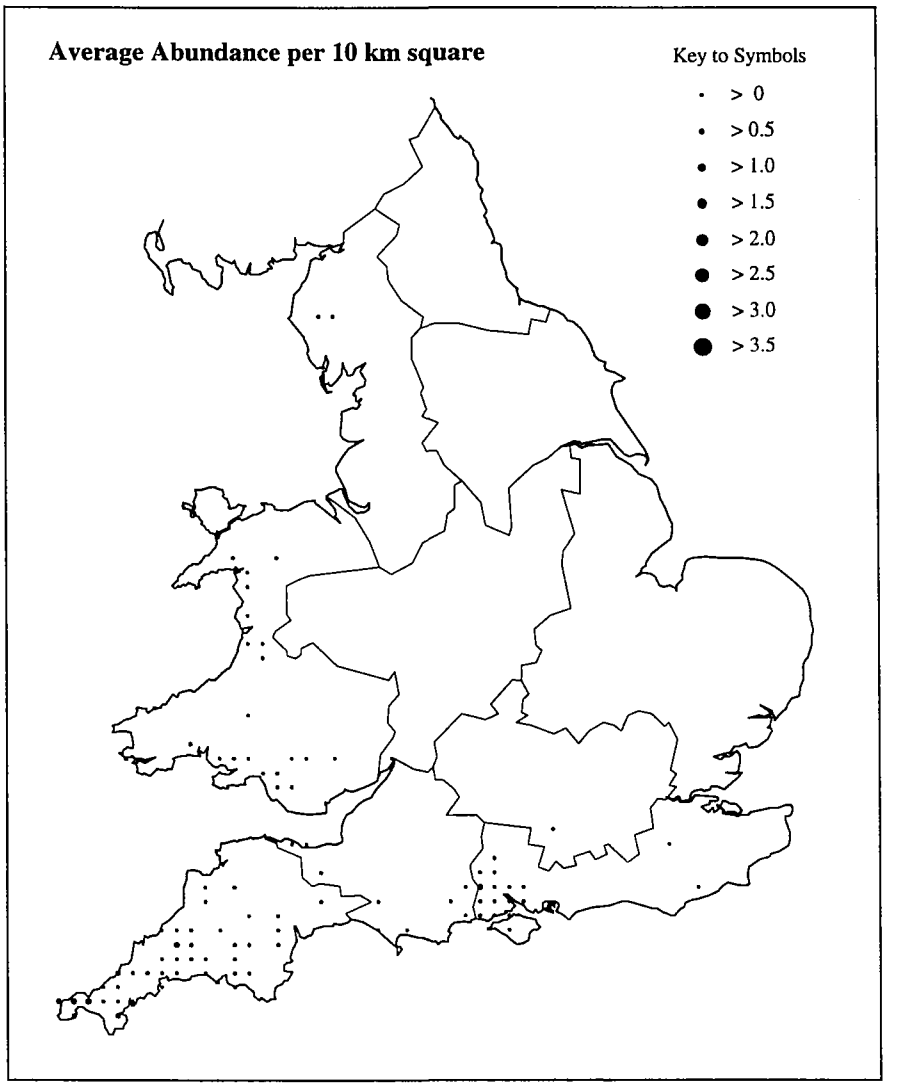


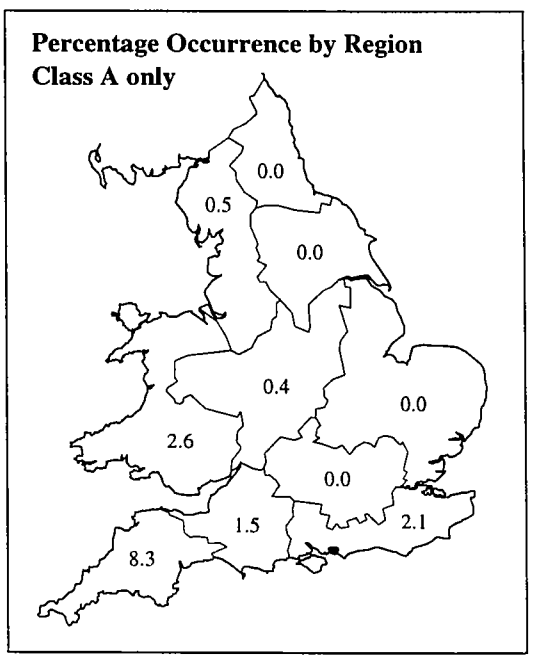


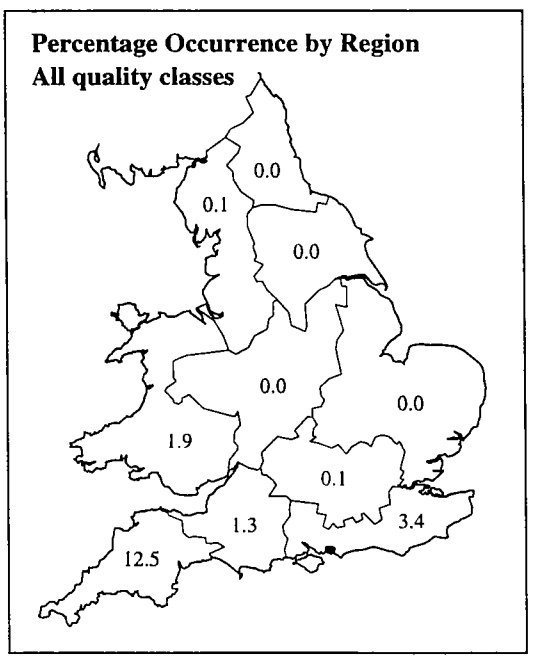


Distribution of BMWP Families - River Sites 1995

CORDULEGASTERIDAE

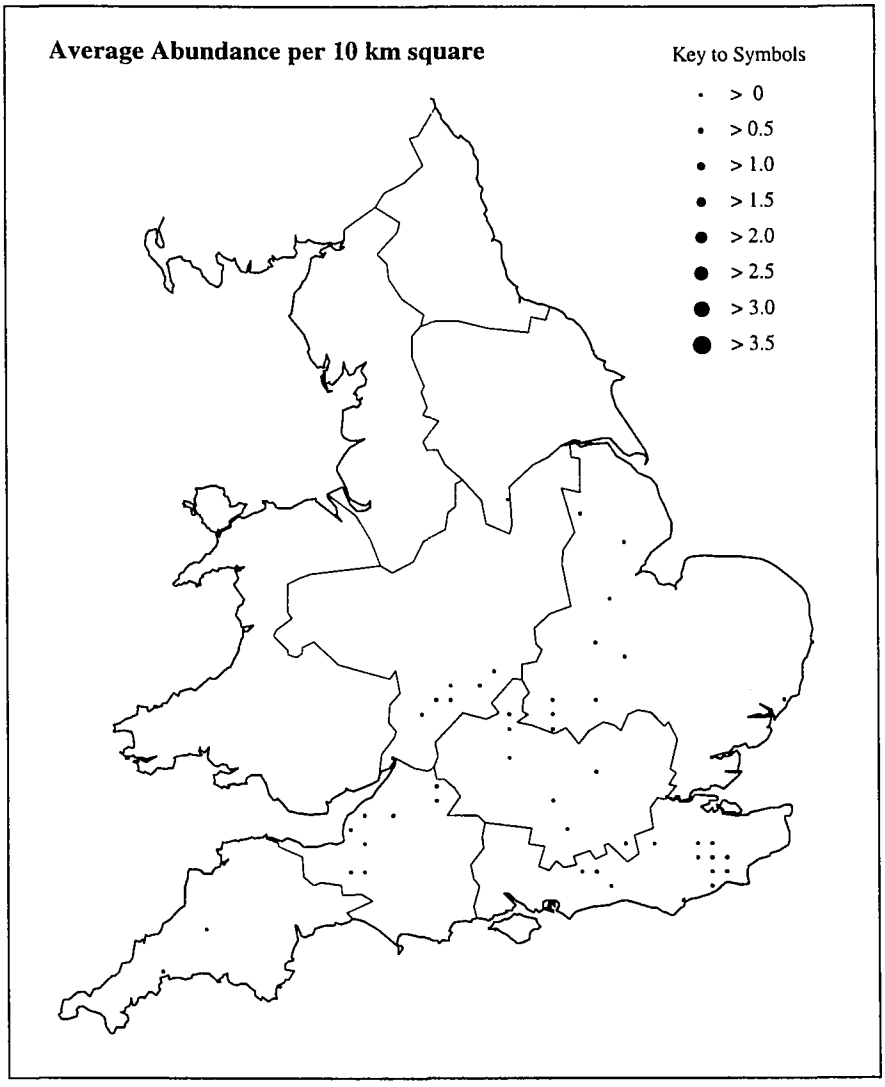


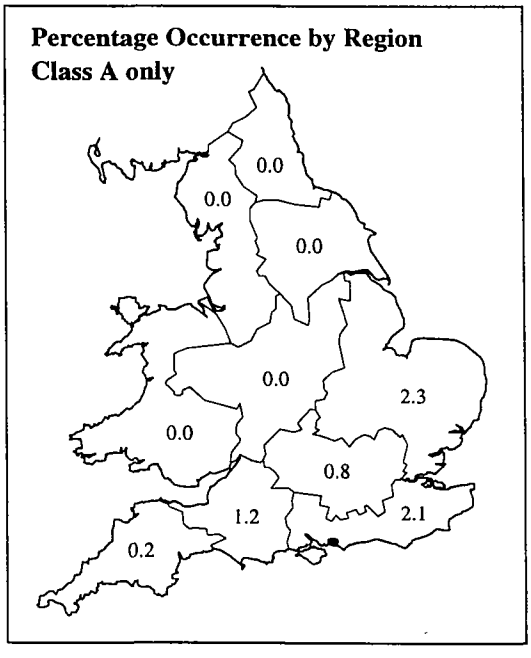


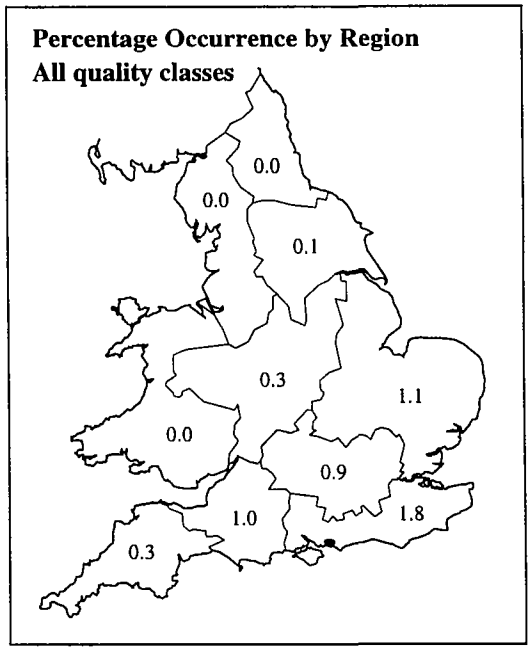


Distribution of BMWP Families - River Sites 1995

AESHNIDAE

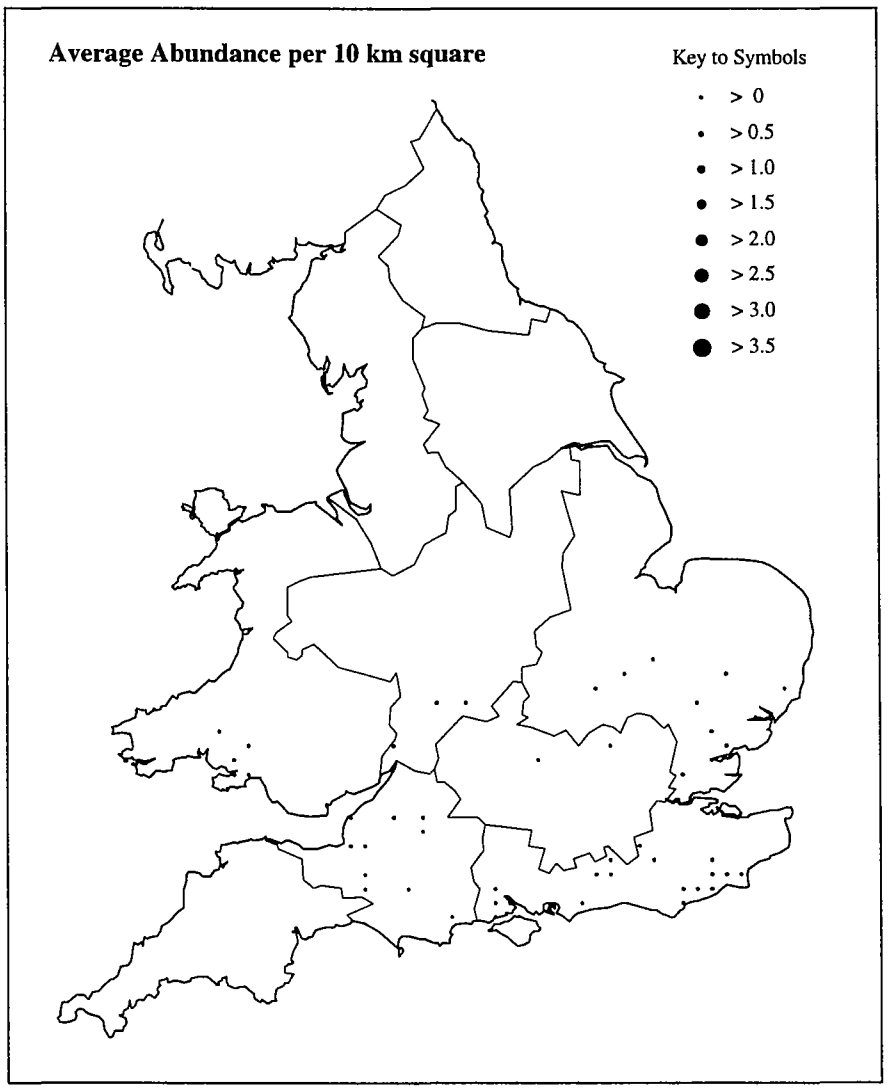


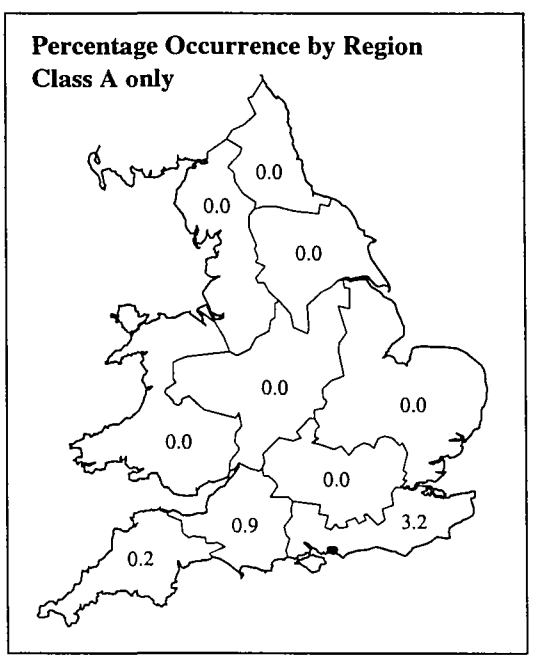


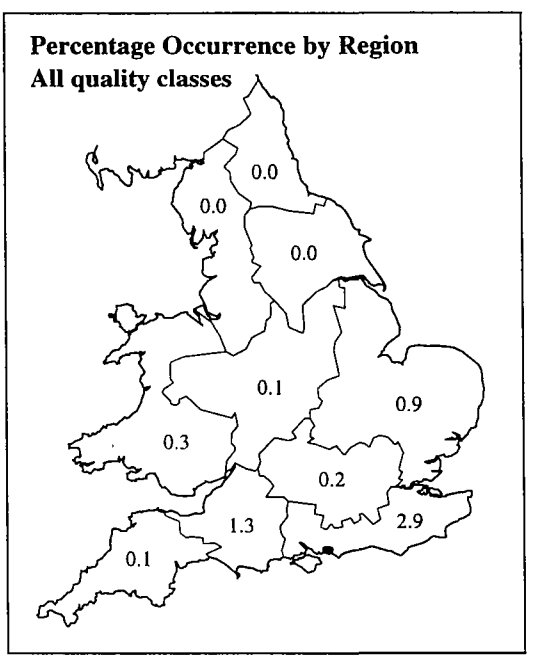


Distribution of BMWP Families - River Sites 1995

LIBELLULIDAE

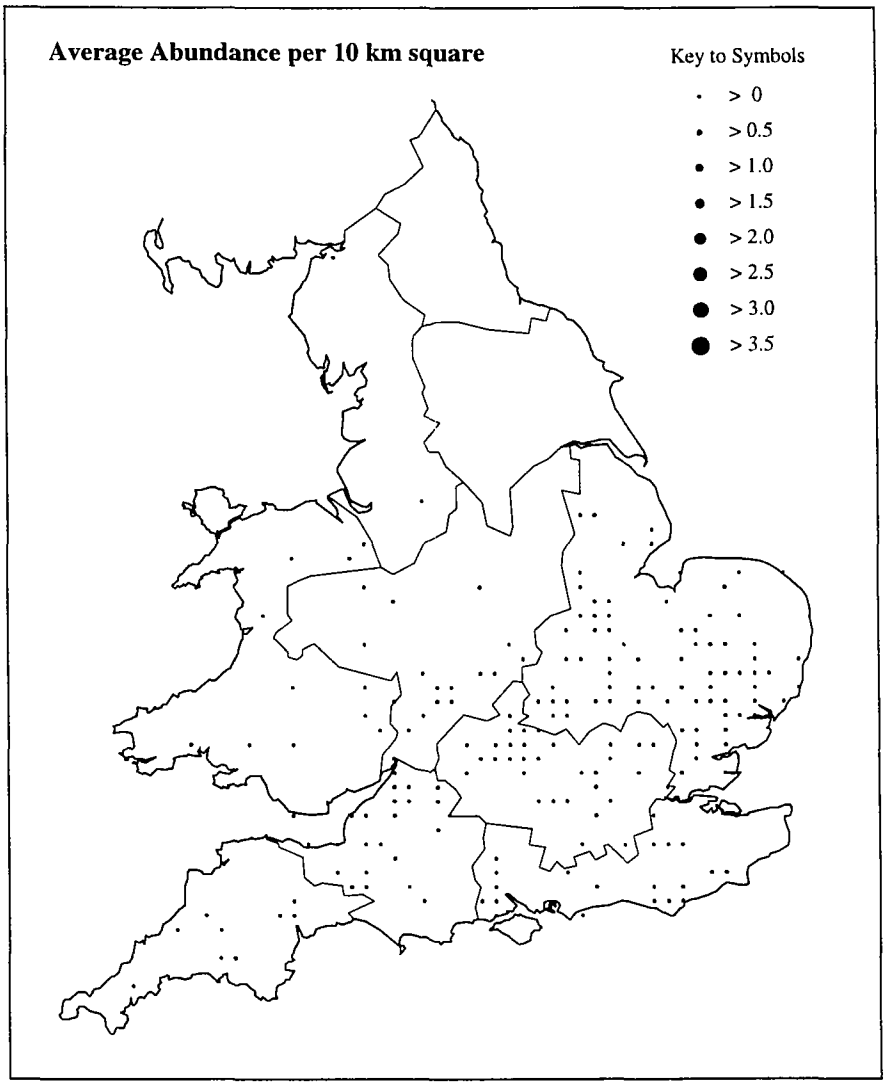


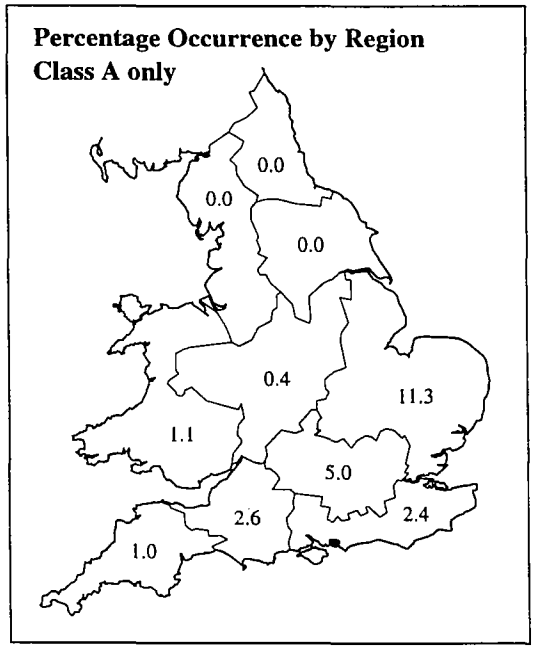


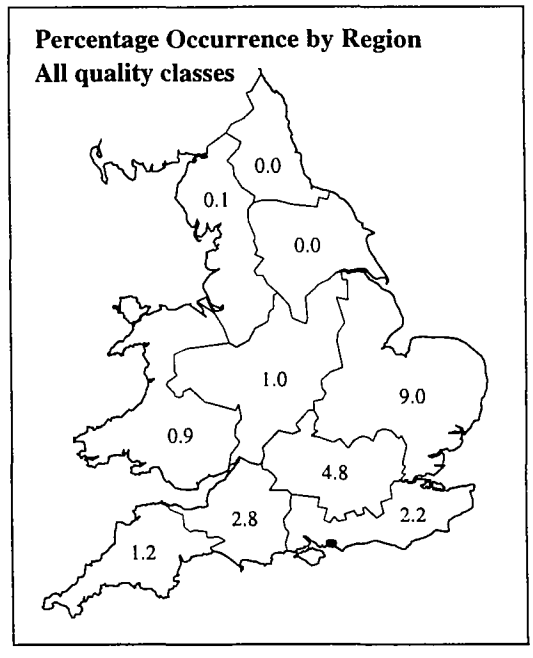


Distribution of BMWP Families - River Sites 1995

HYDROMETRIDAE

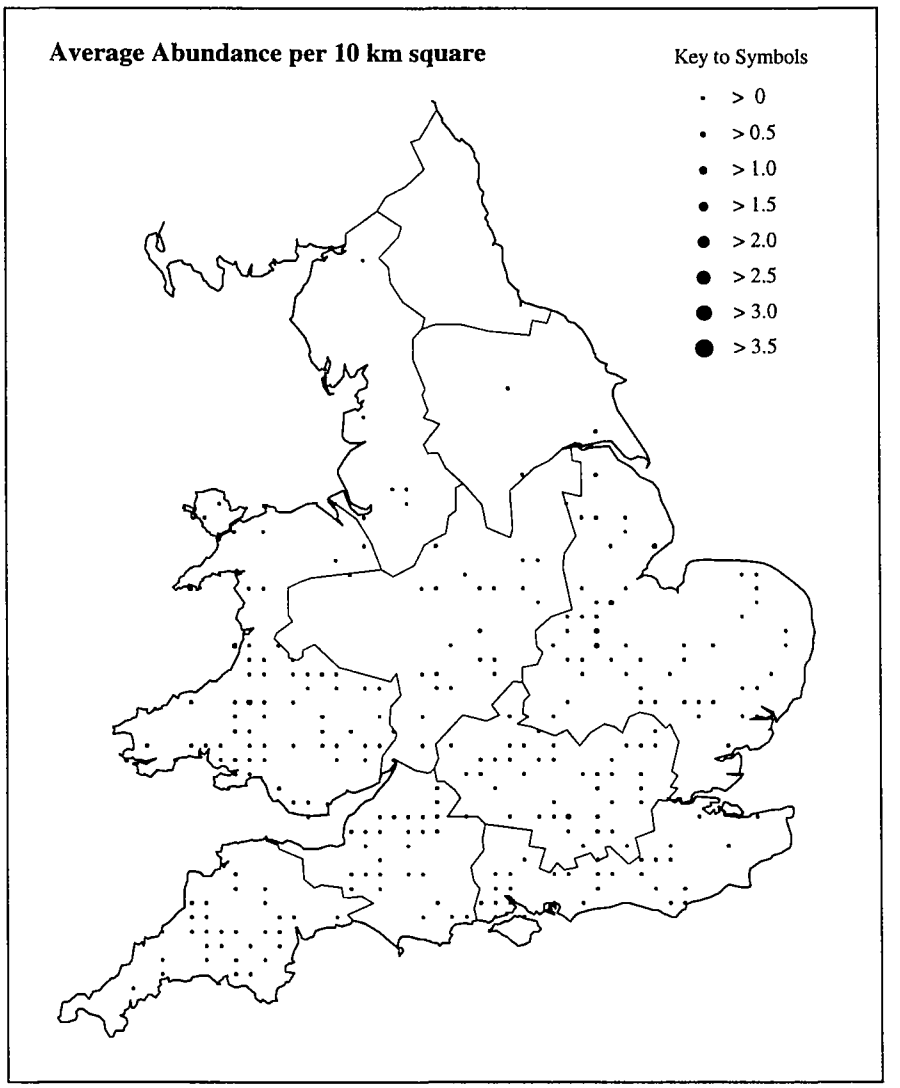


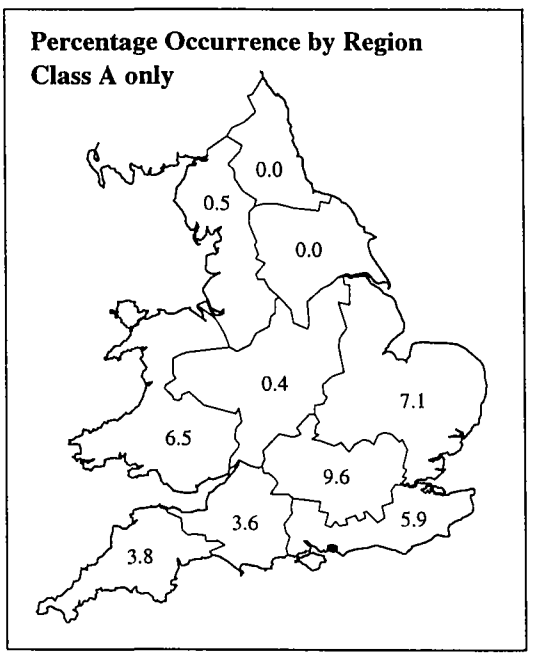


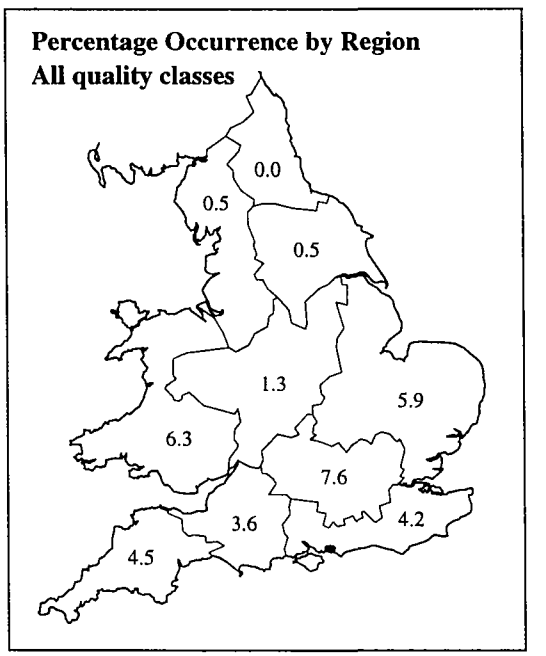


Distribution of BMWP Families - River Sites 1995

GERRIDAE

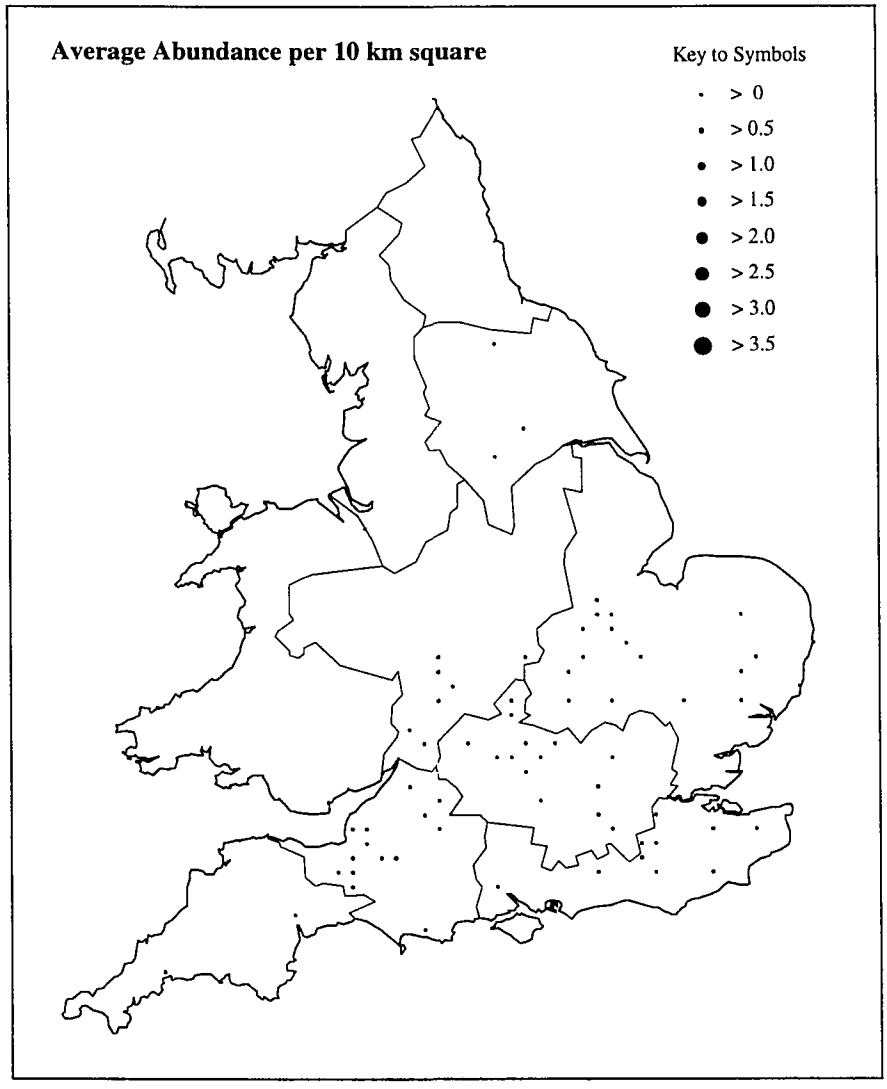


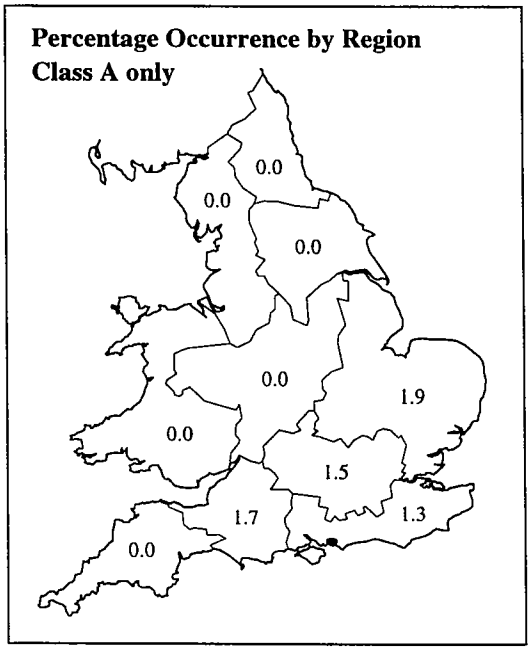


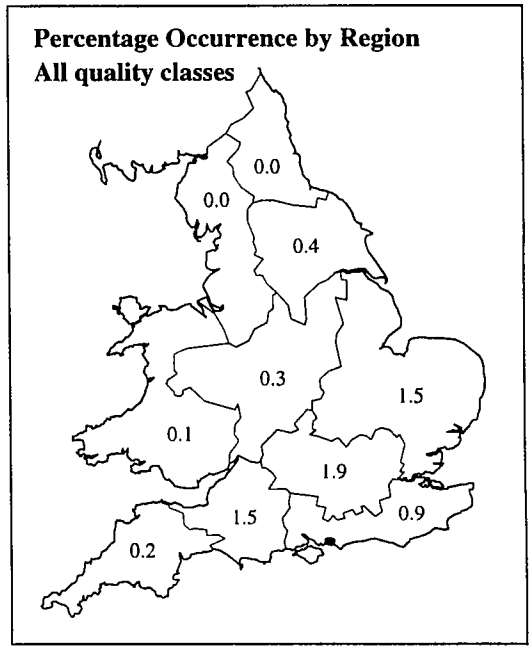


Distribution of BMWP Families - River Sites 1995

NEPIDAE

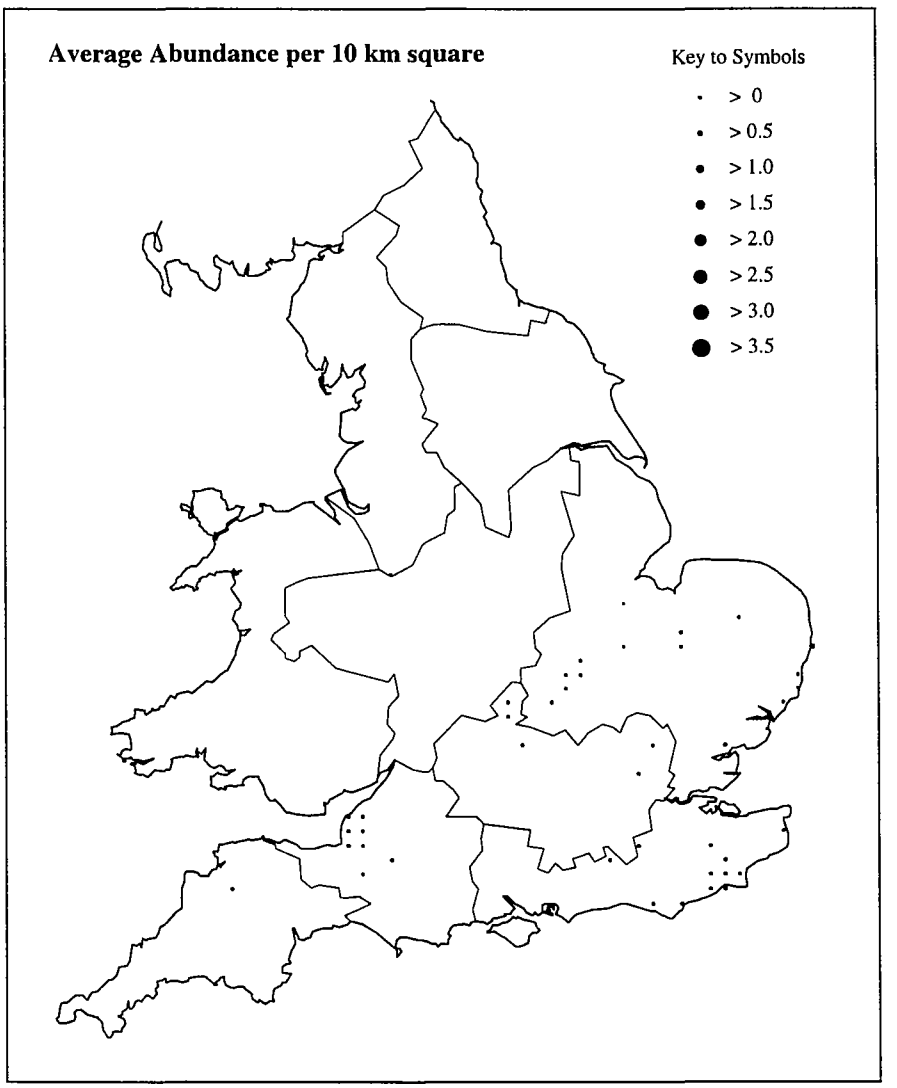


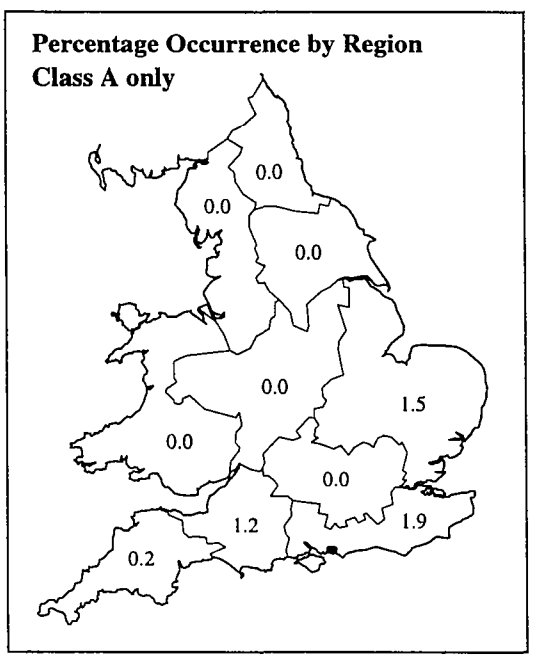


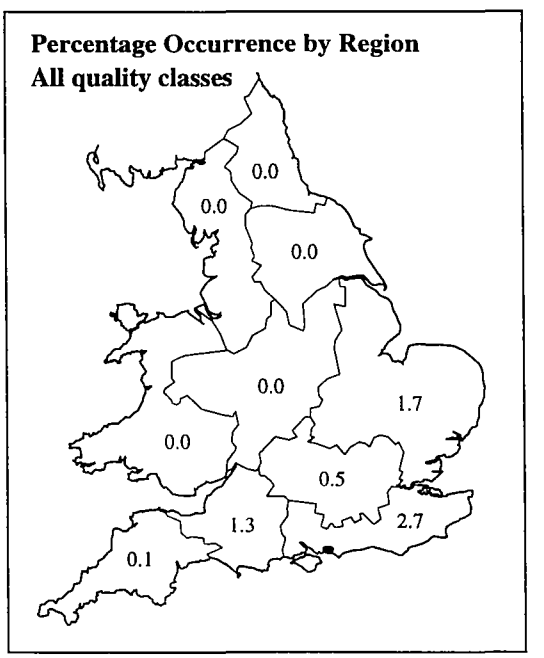


Distribution of BMWP Families - River Sites 1995

NAUCORIDAE

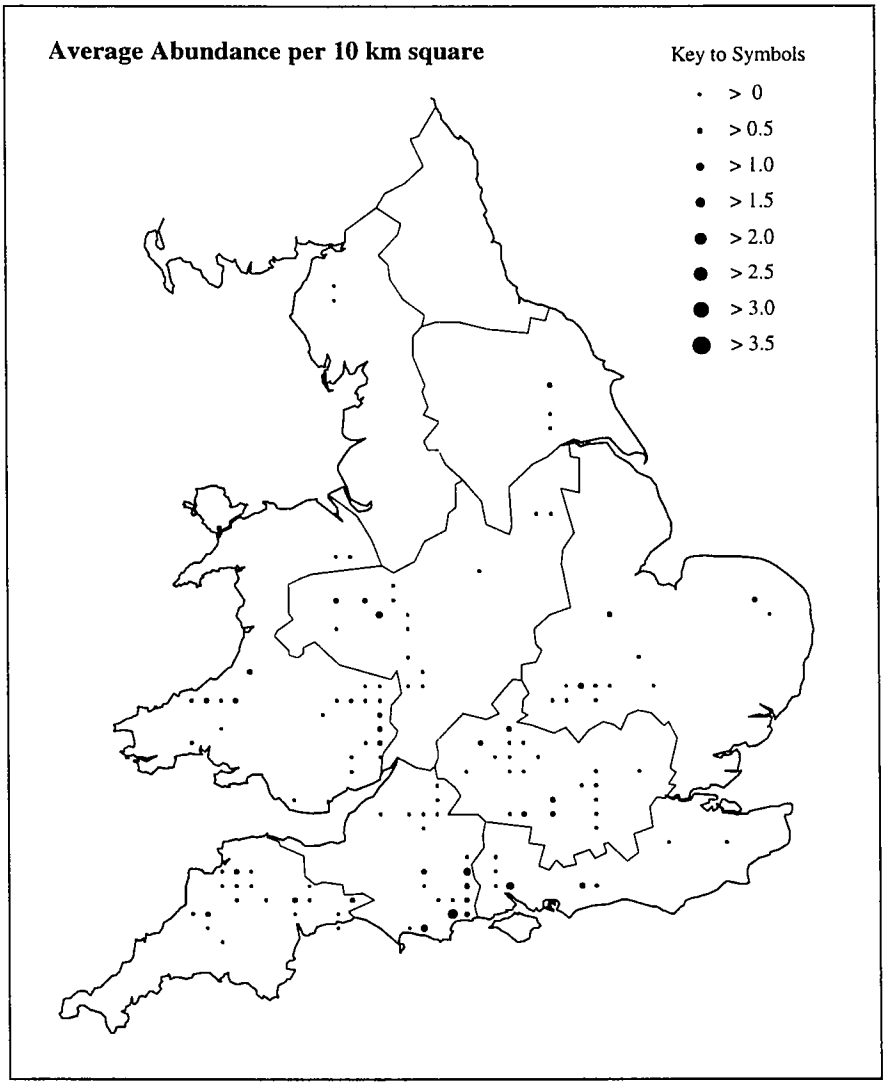


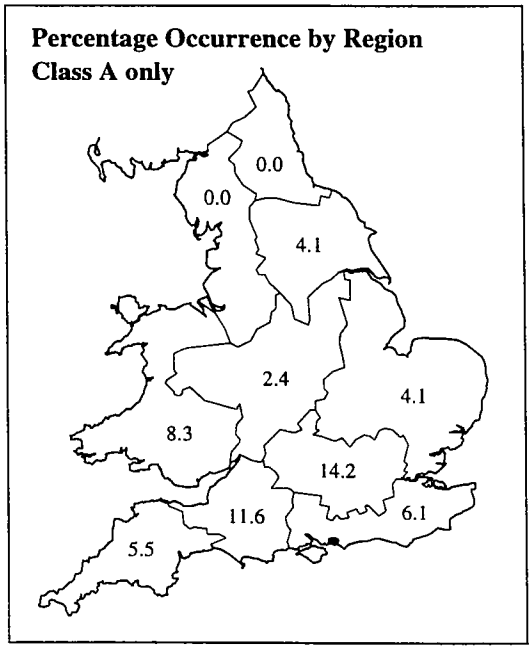


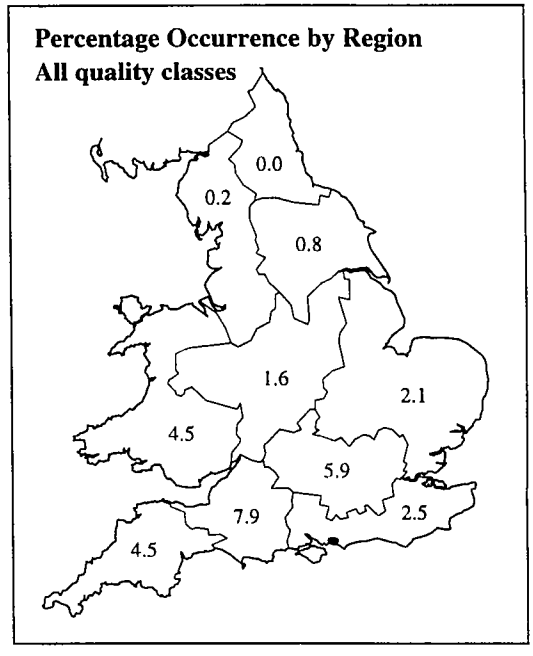


Distribution of BMWP Families - River Sites 1995

APHELOCHEIRIDAE

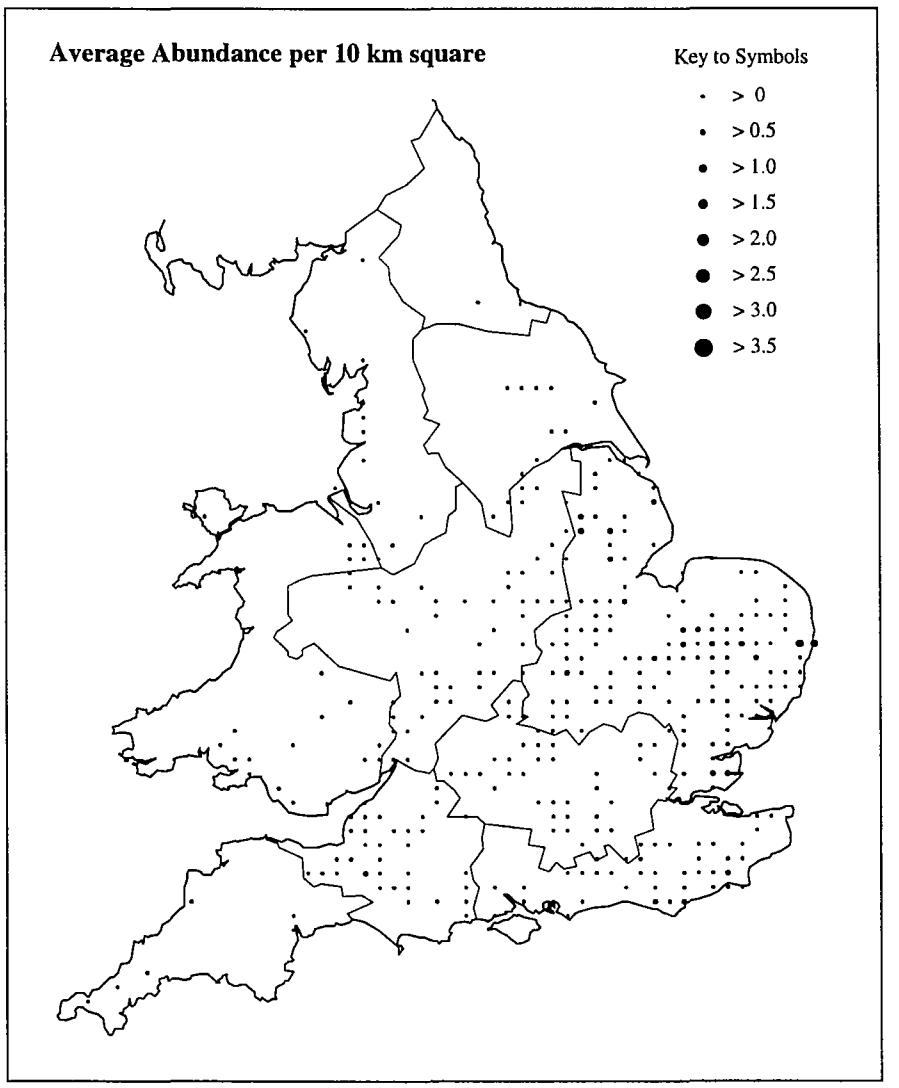


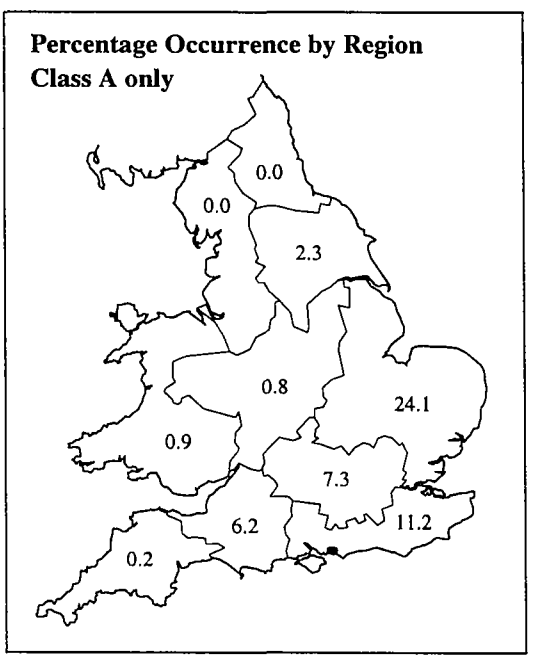


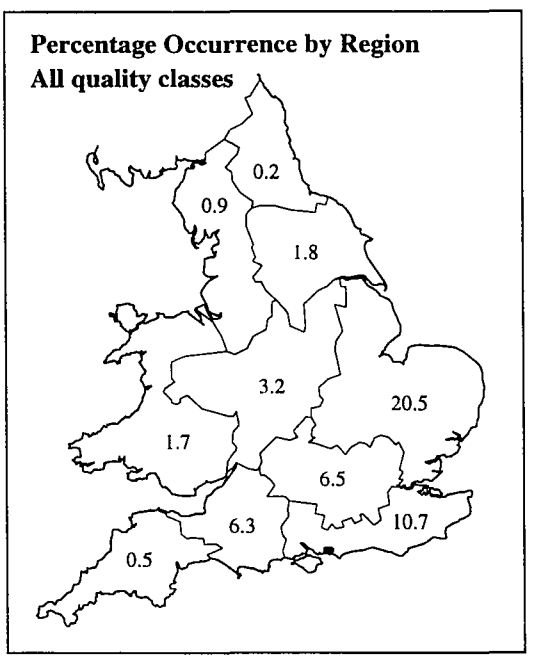


Distribution of BMWP Families - River Sites 1995

NOTONECTIDAE

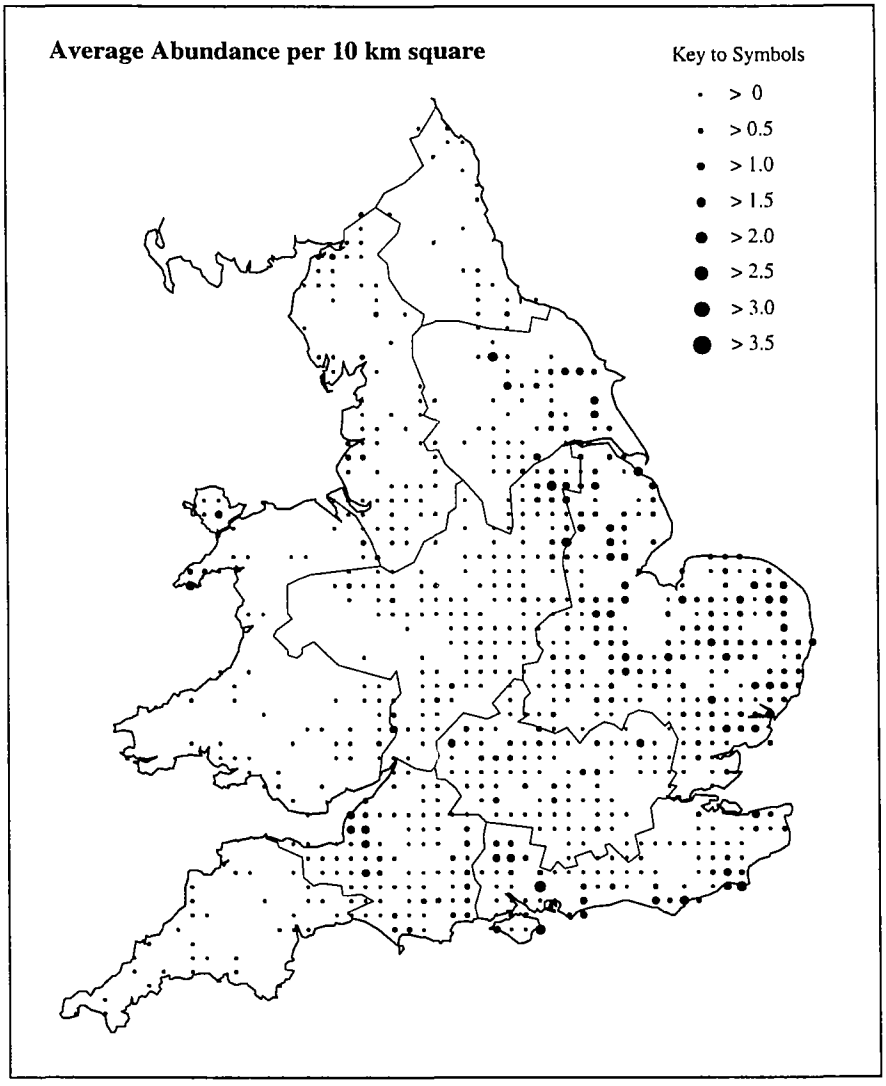


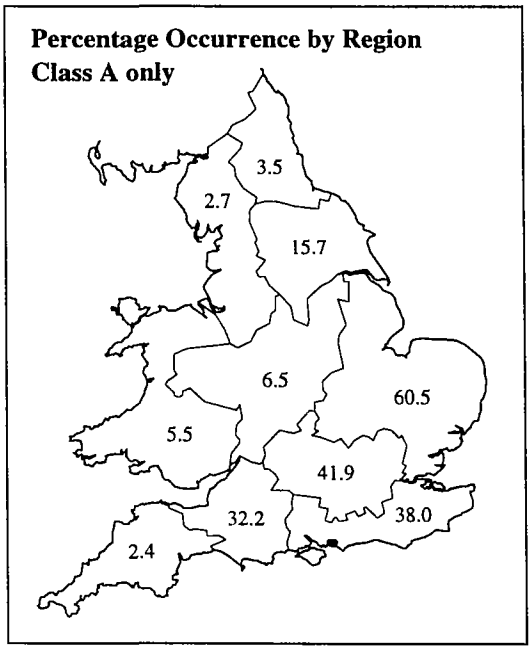


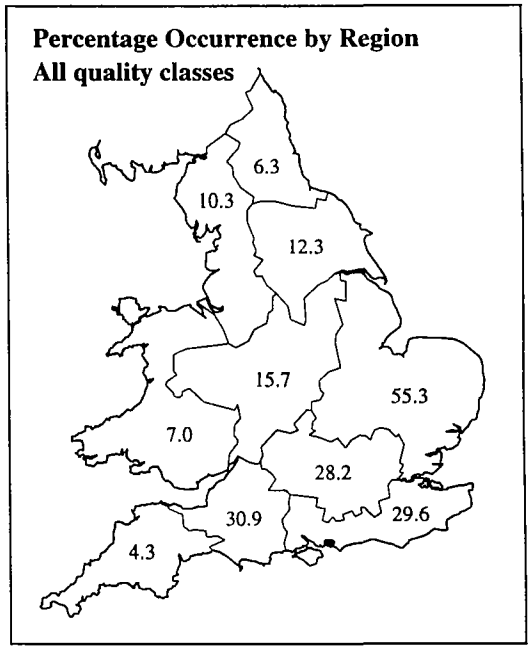


Distribution of BMWP Families - River Sites 1995

CORIXIDAE

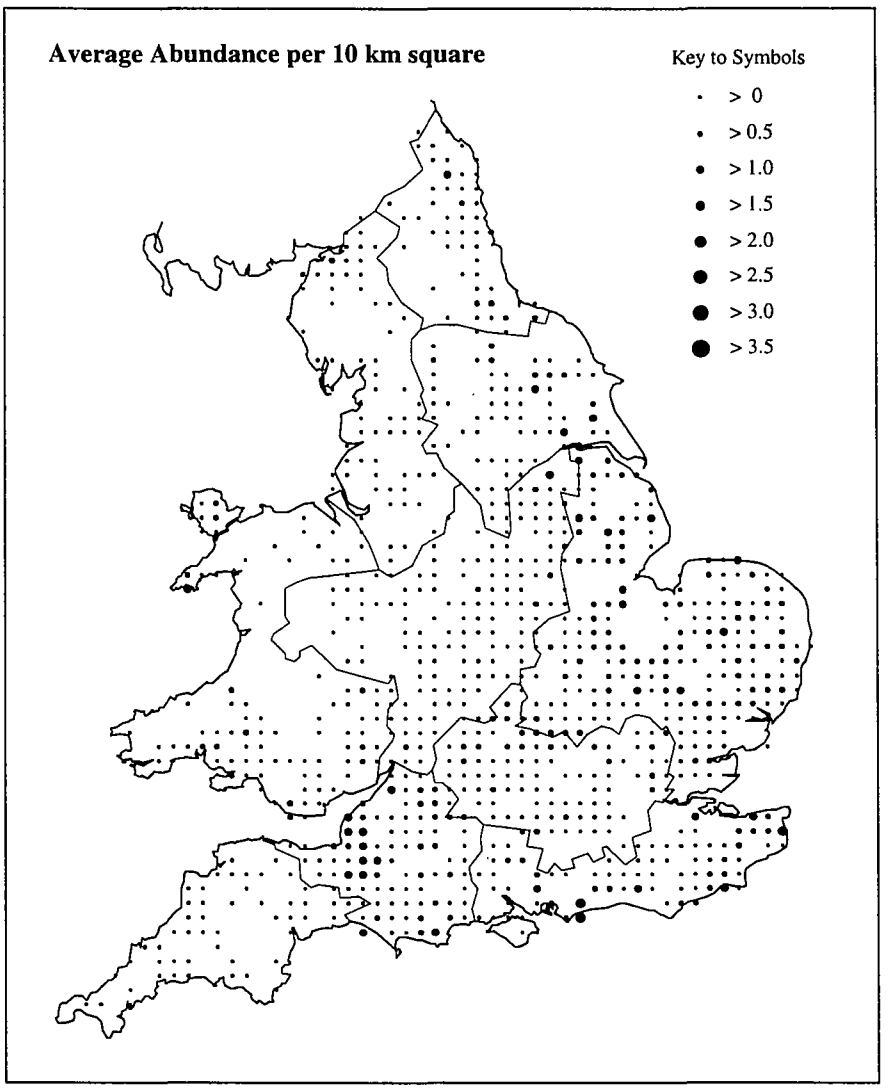


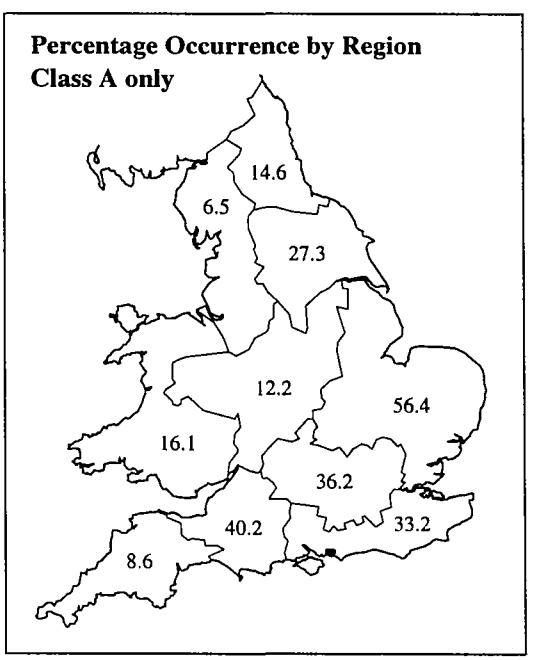


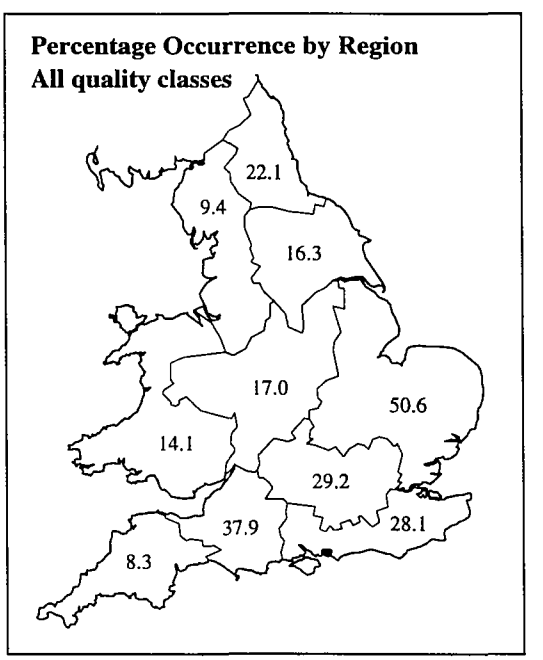


Distribution of BMWP Families - River Sites 1995

HALIPLIDAE

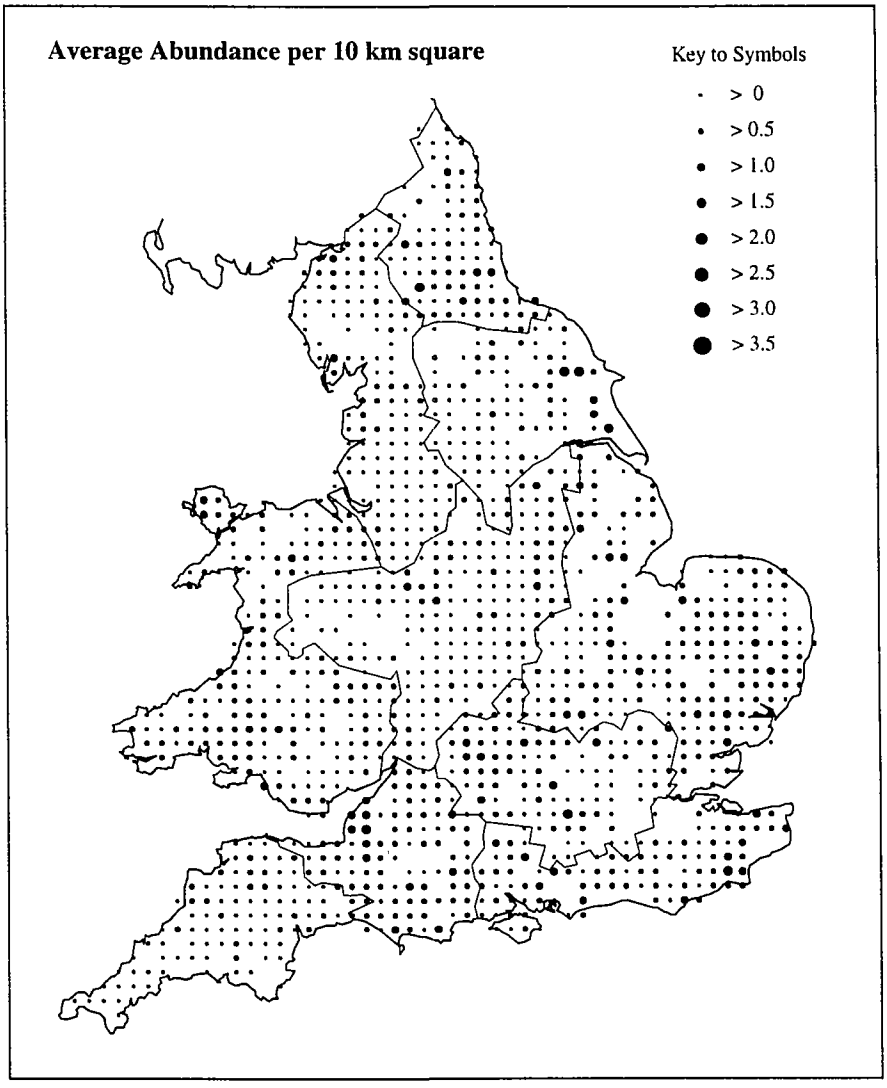


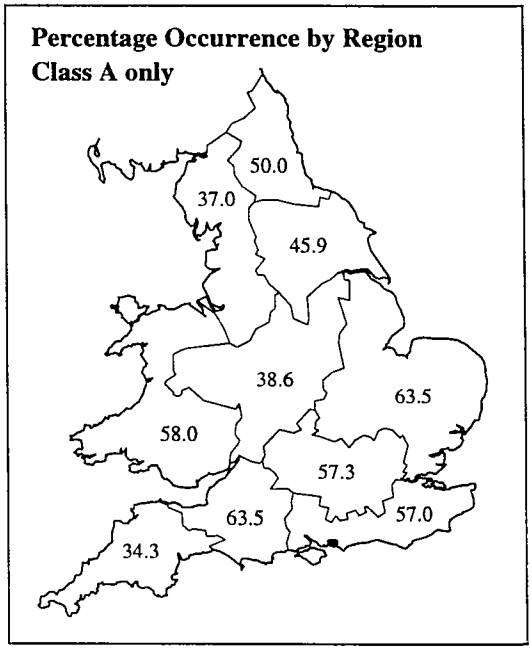


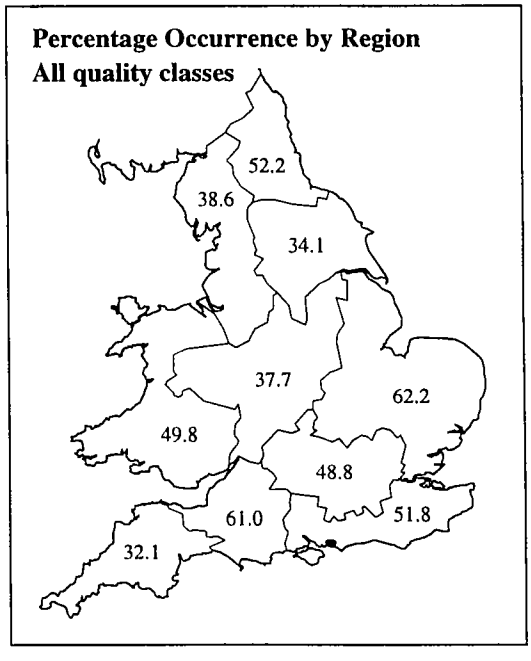


Distribution of BMWP Families - River Sites 1995

DYTISCIDAE

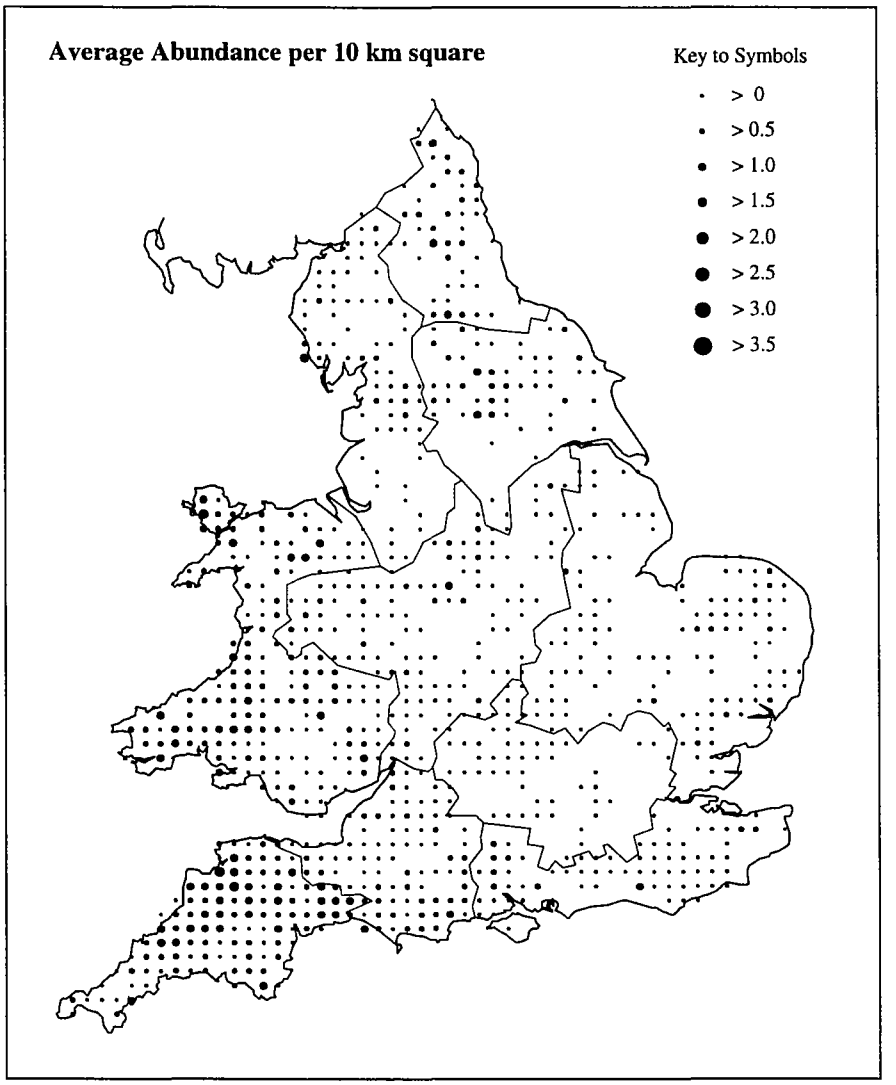


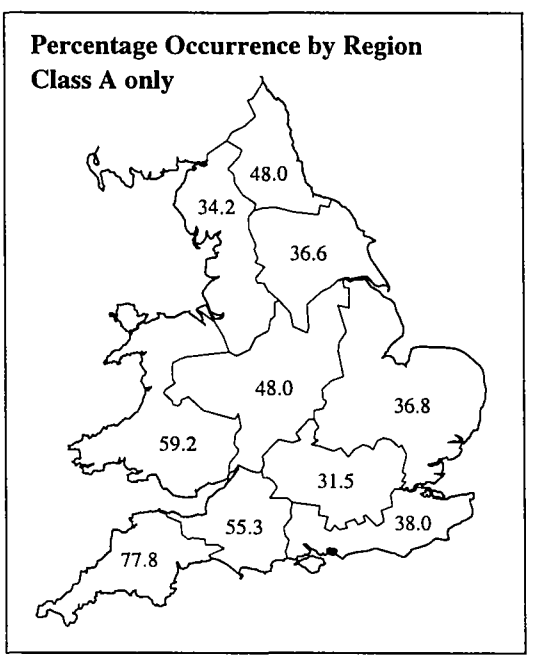


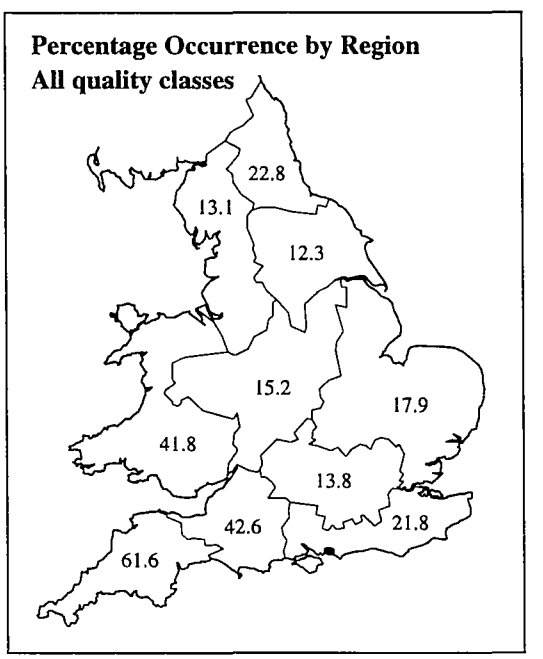


Distribution of BMWP Families - River Sites 1995

GYRINIDAE

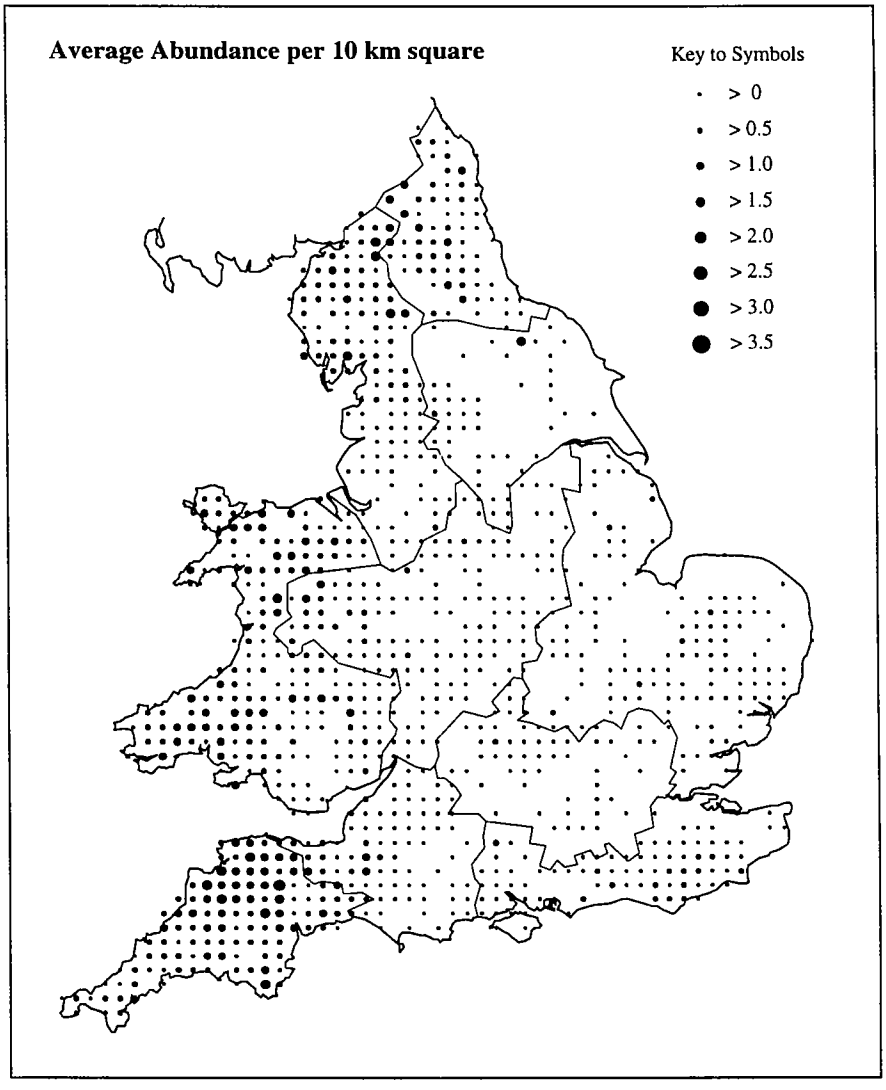


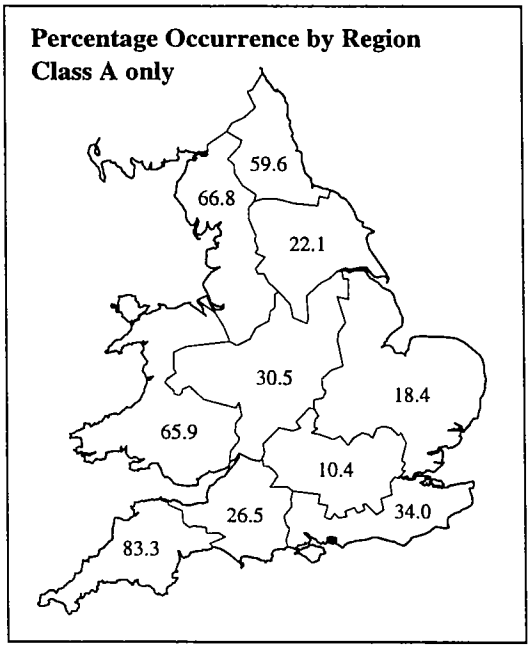


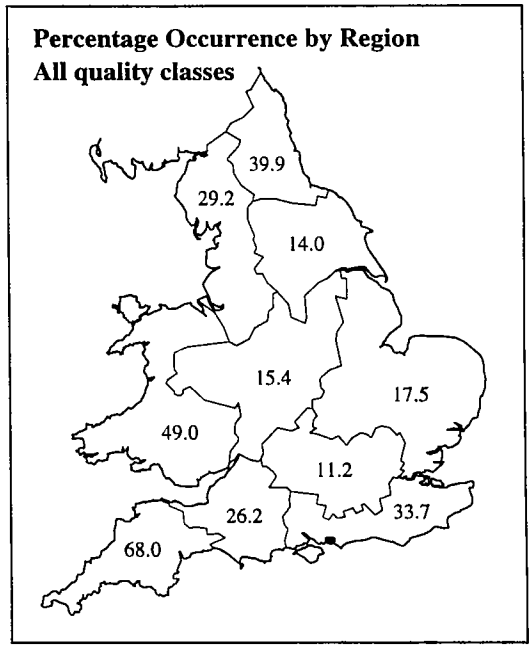


Distribution of BMWP Families - River Sites 1995

HYDROPHILIDAE

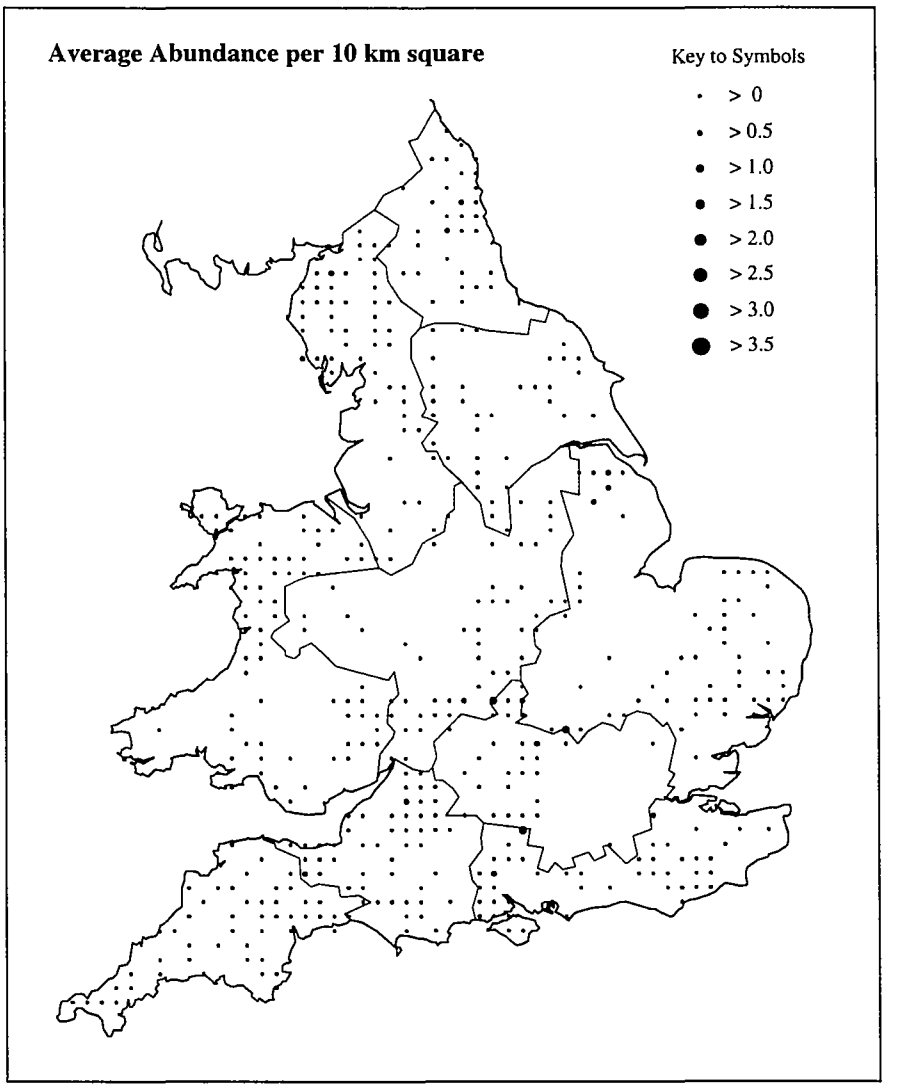


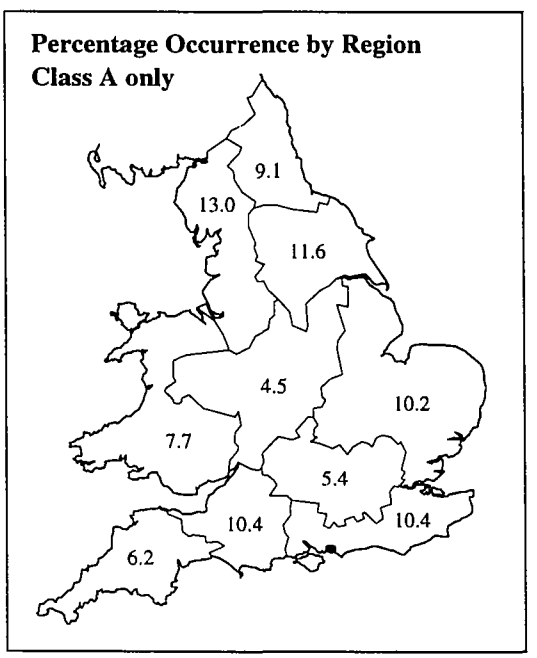


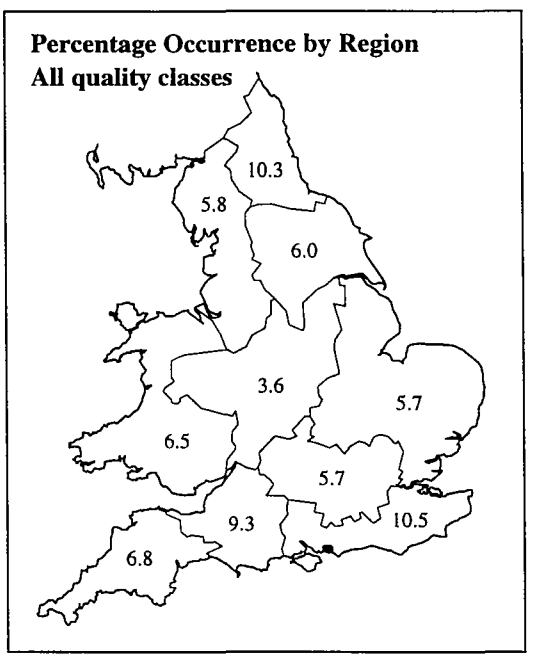


Distribution of BMWP Families - River Sites 1995

SCIRTIDAE

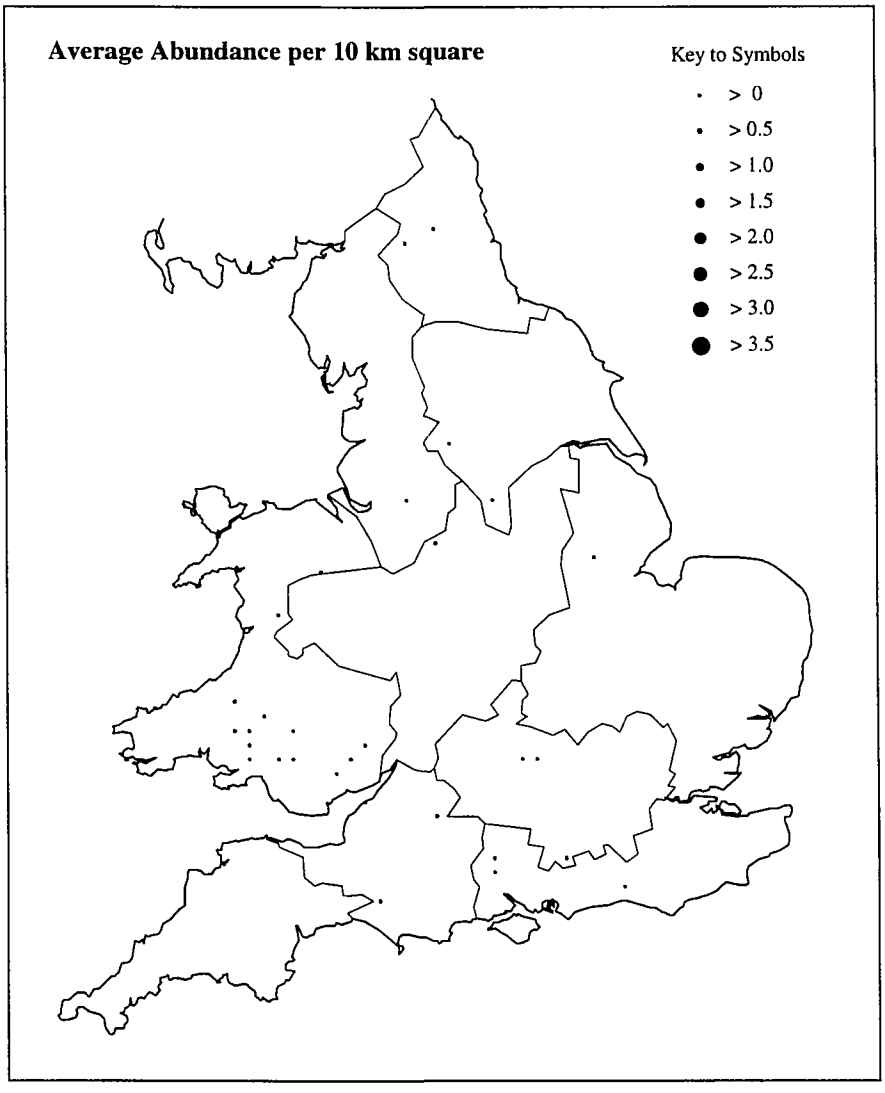


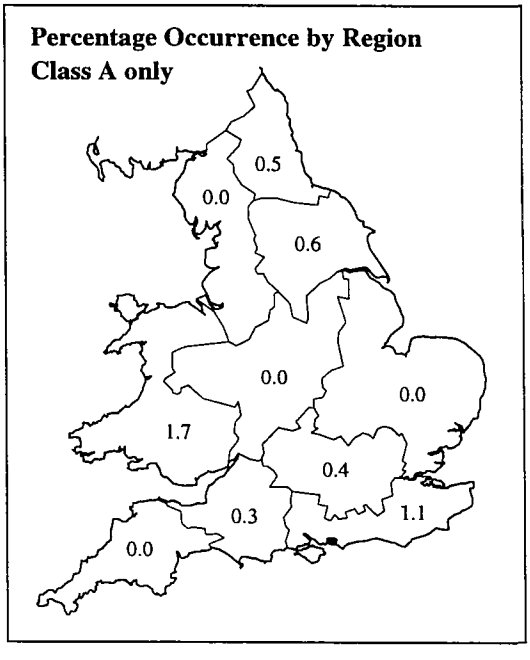


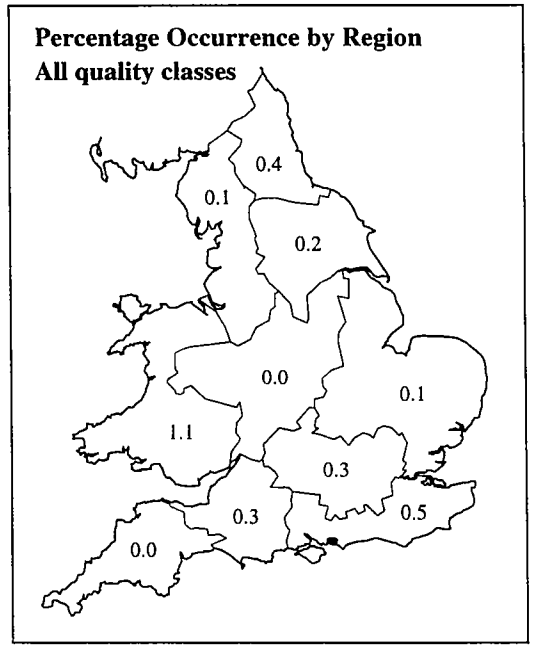


Distribution of BMWP Families - River Sites 1995

DRYOPIDAE

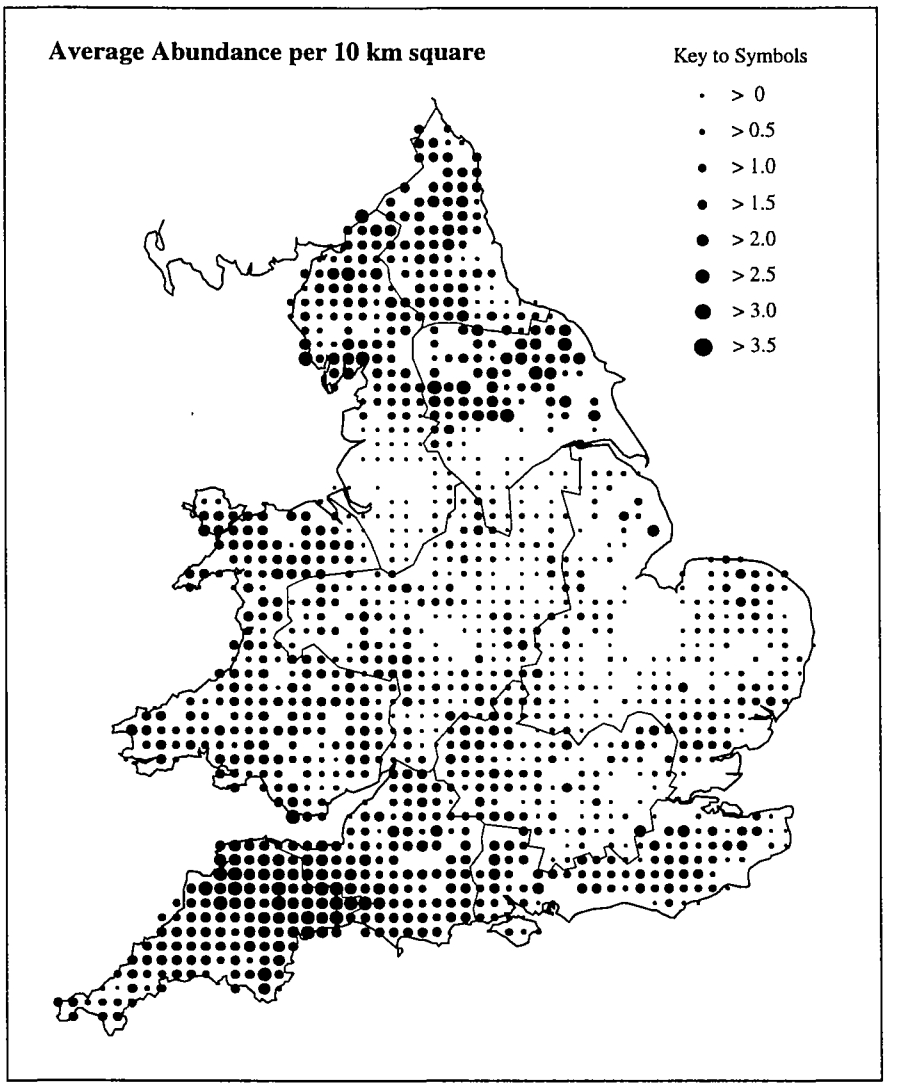


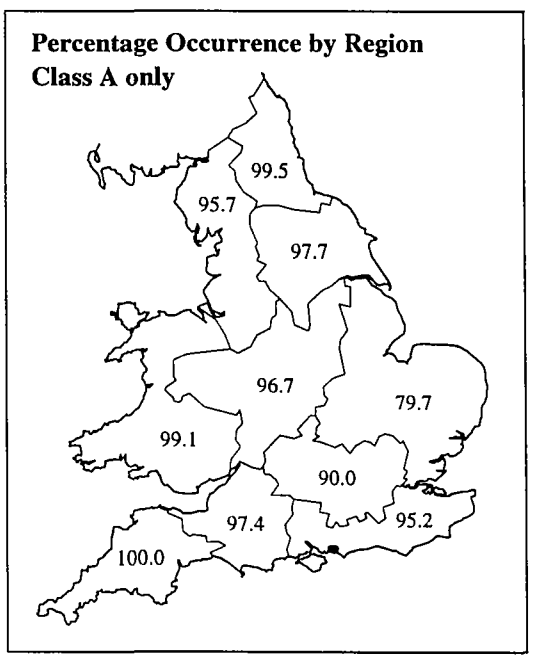


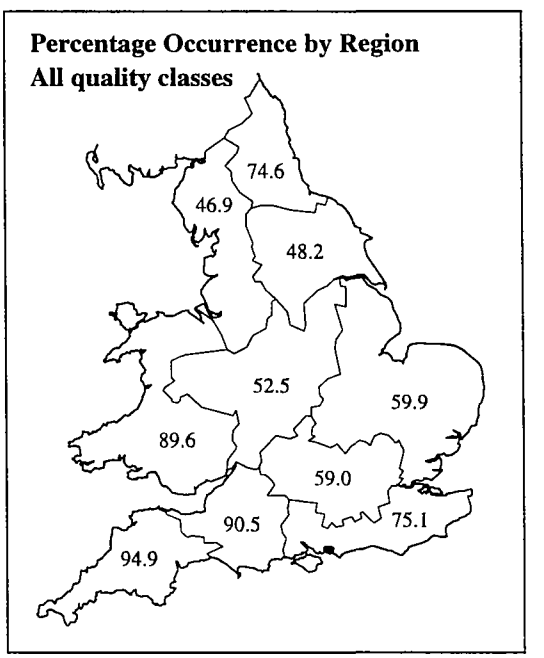


Distribution of BMWP Families - River Sites 1995

ELMIDAE

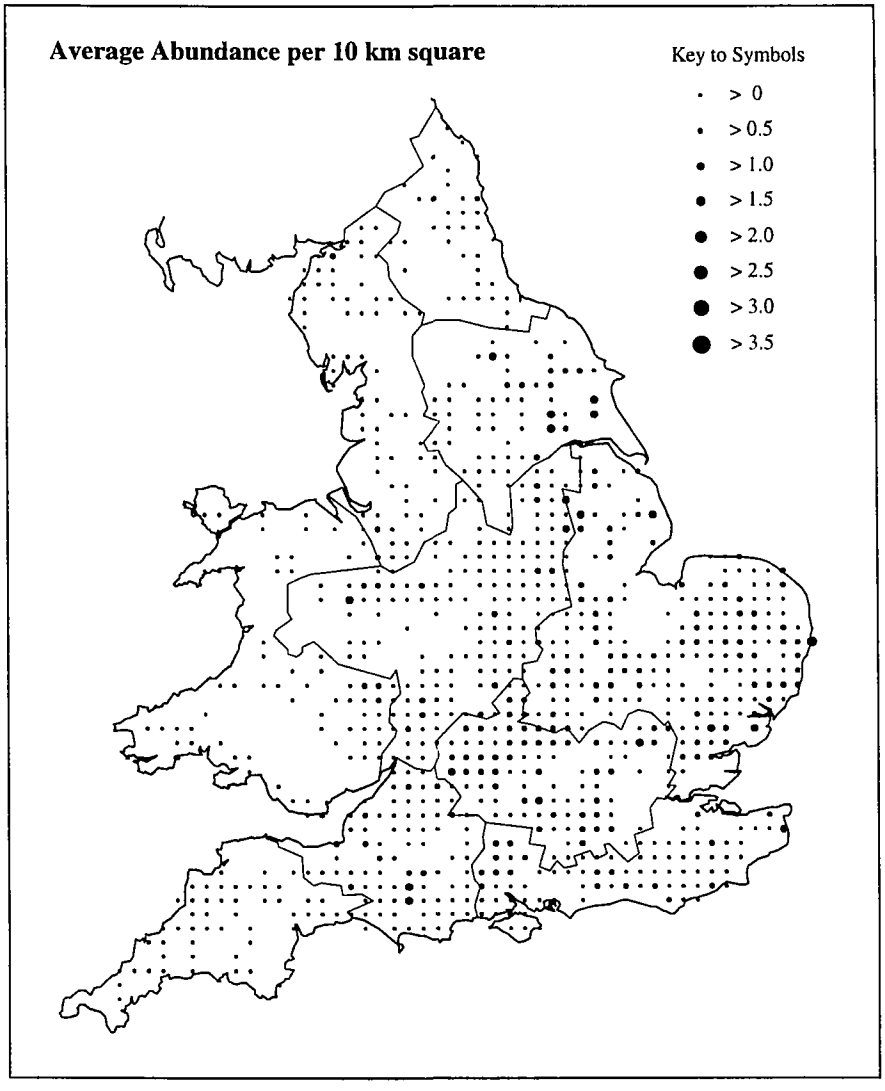


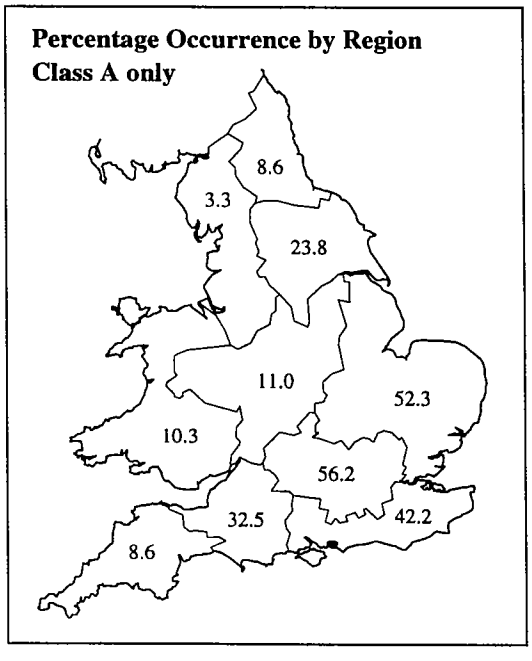


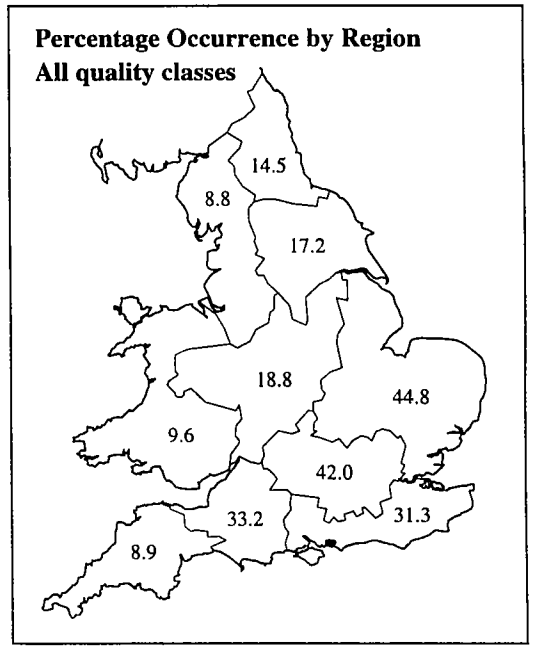


Distribution of BMWP Families - River Sites 1995

SIALIDAE

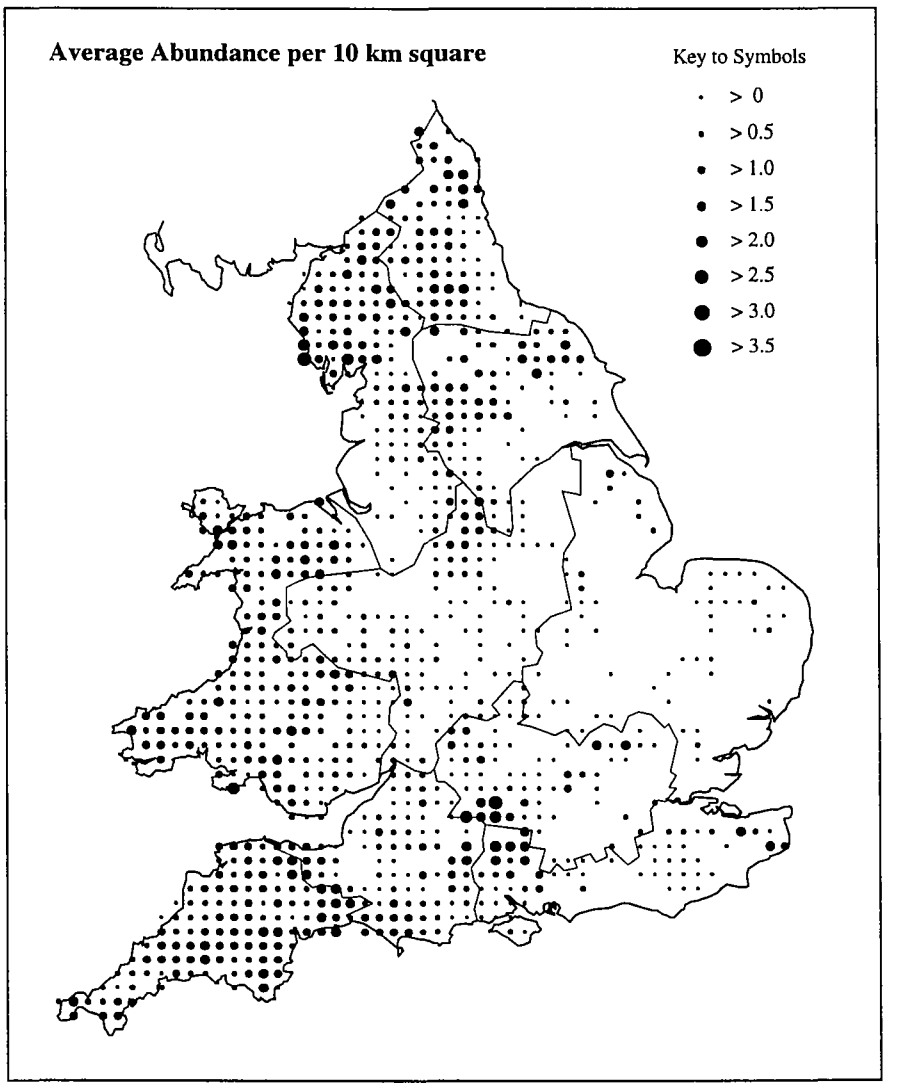


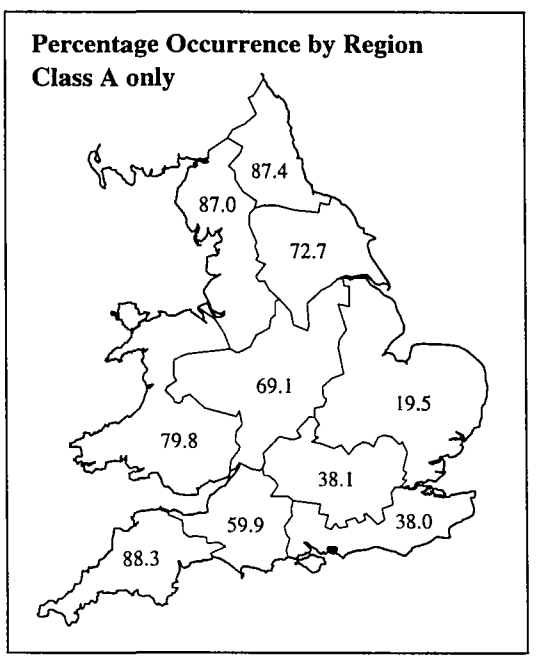


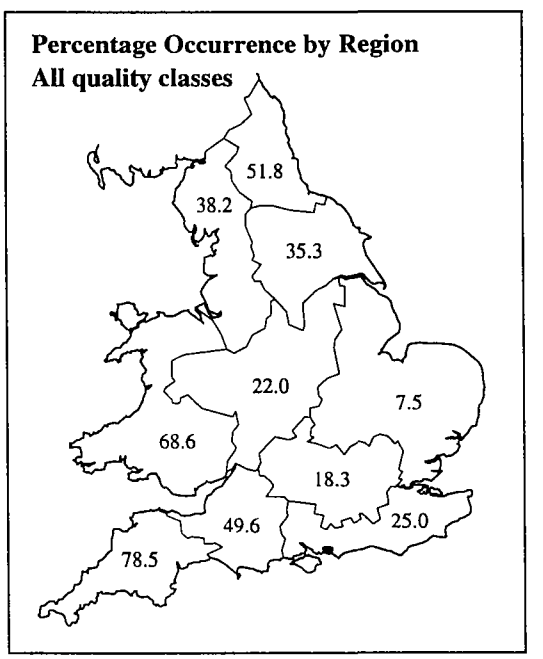


Distribution of BMWP Families - River Sites 1995

RHYACOPHILIDAE







Distribution of BMWP Families - River Sites 1995

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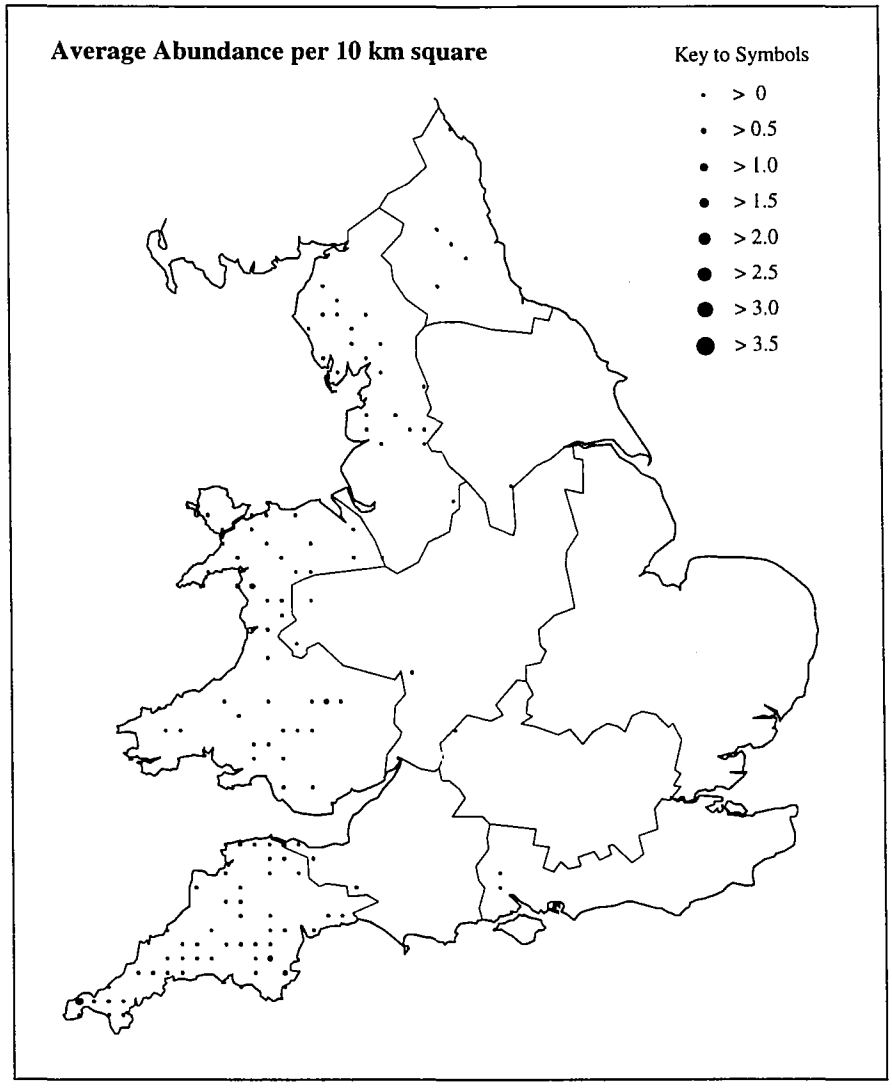
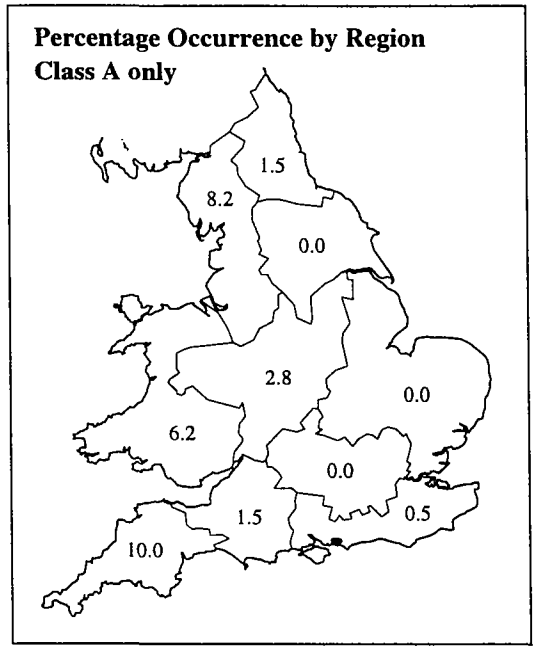
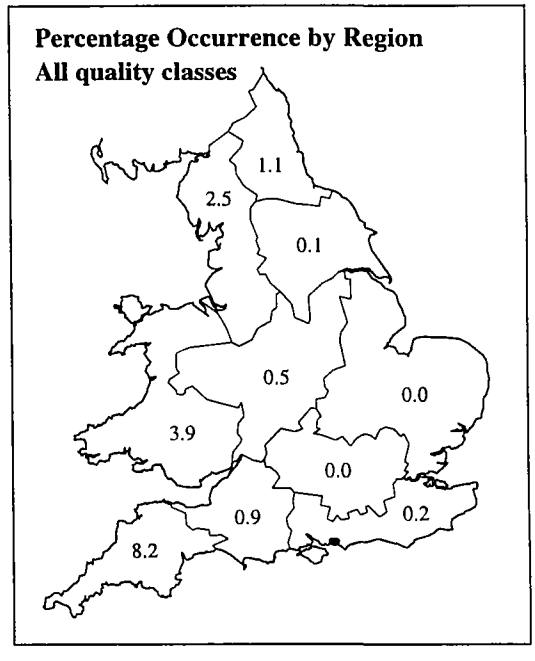
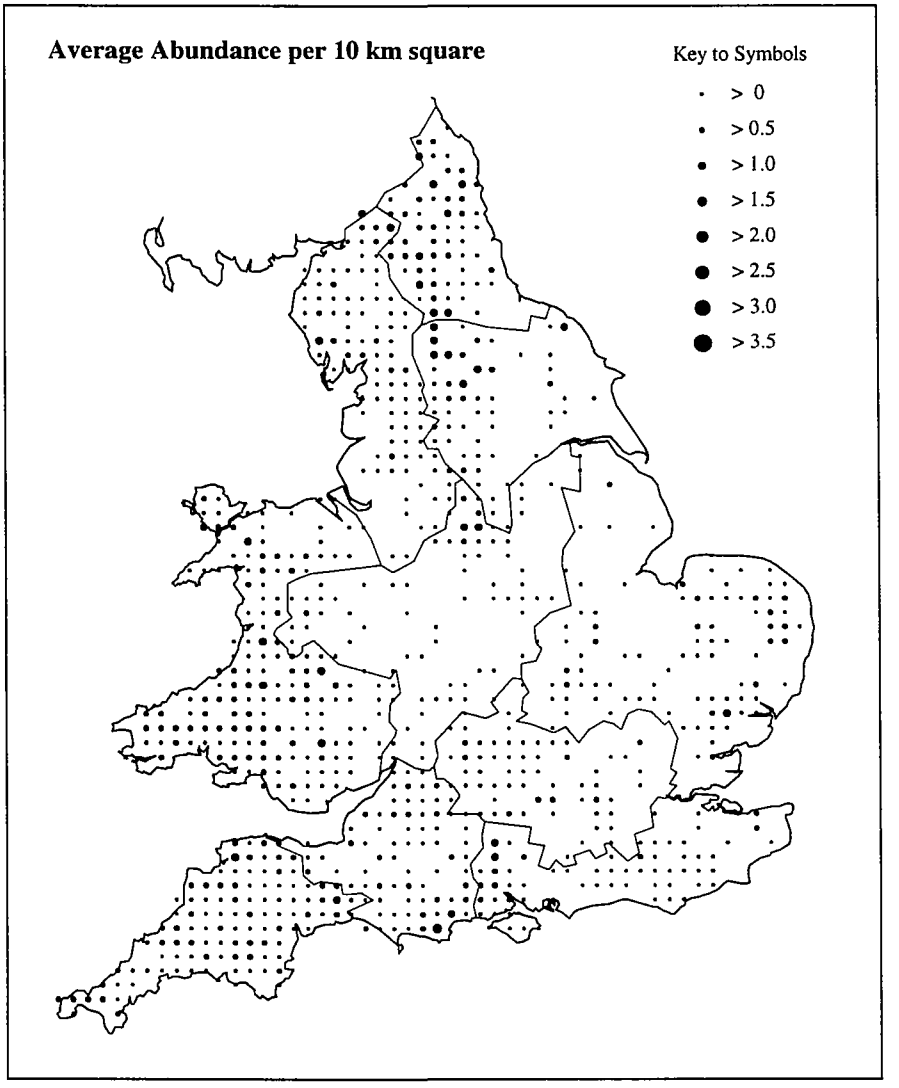


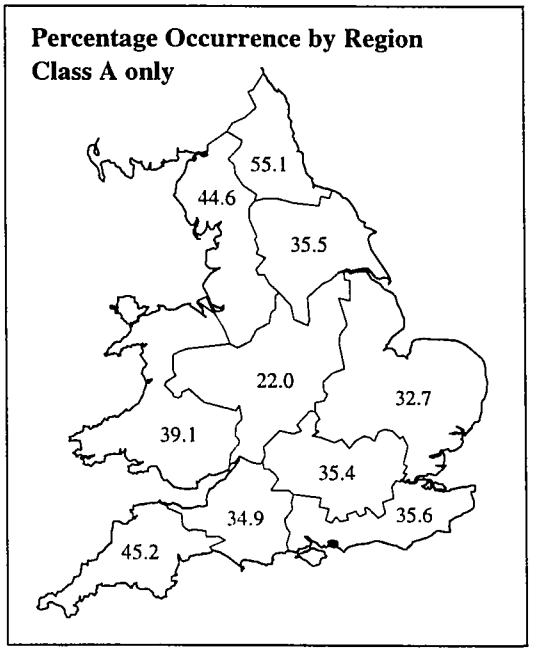


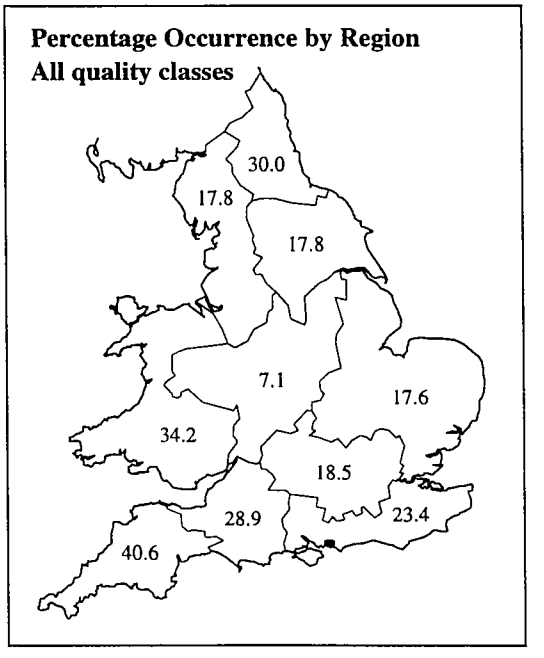


Distribution of BMWP Families - River Sites 1995

POLYCENTROPIDAE

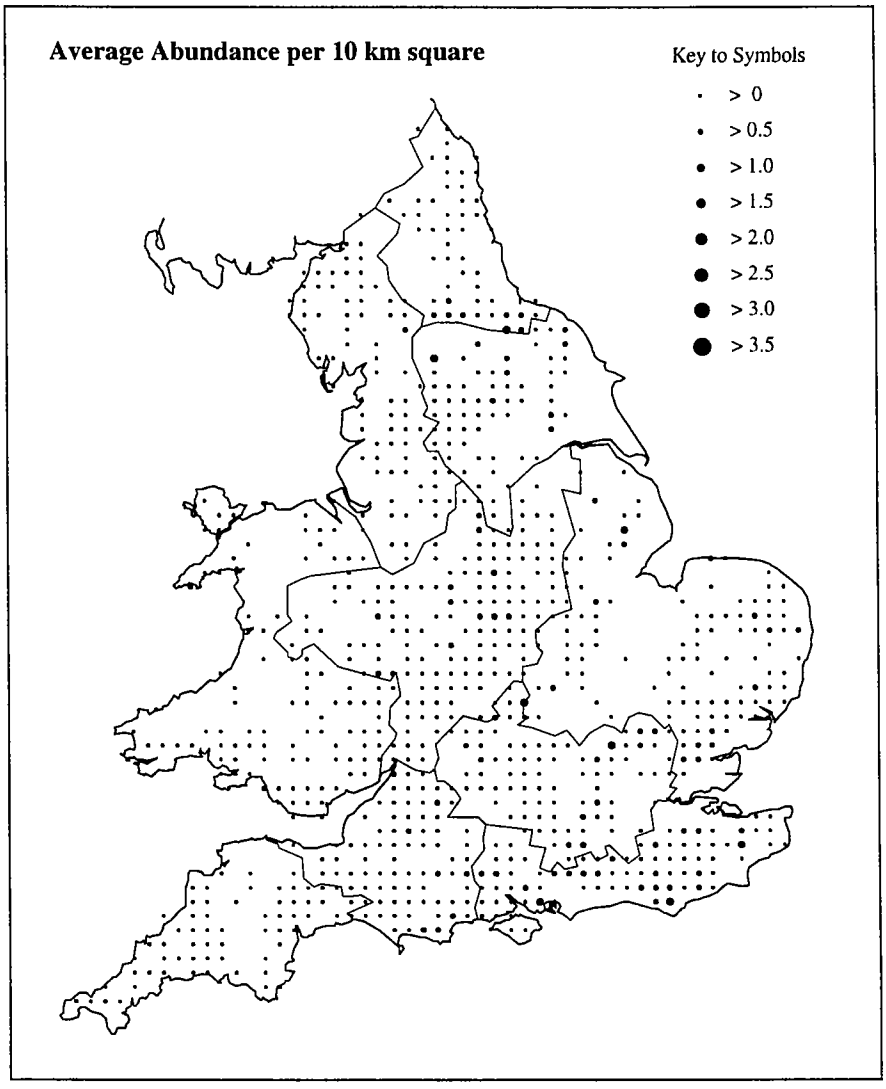


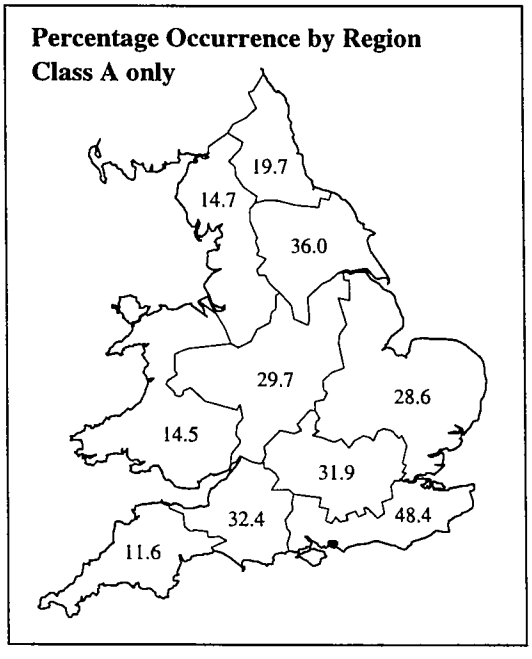


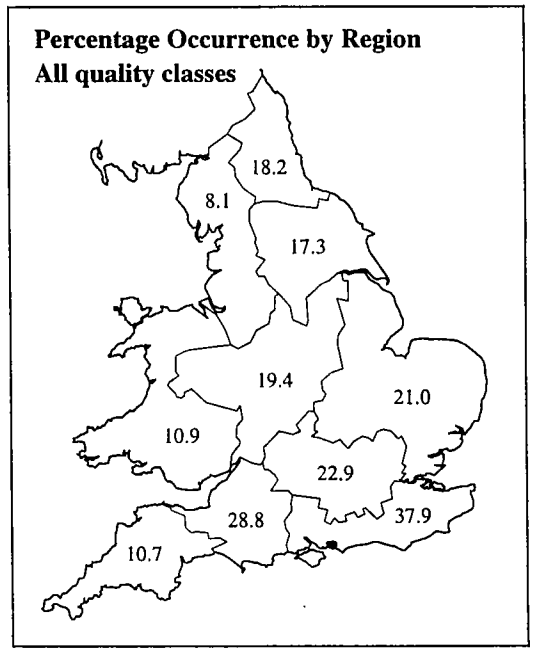


Distribution of BMWP Families - River Sites 1995

PSYCHOMYIIDAE

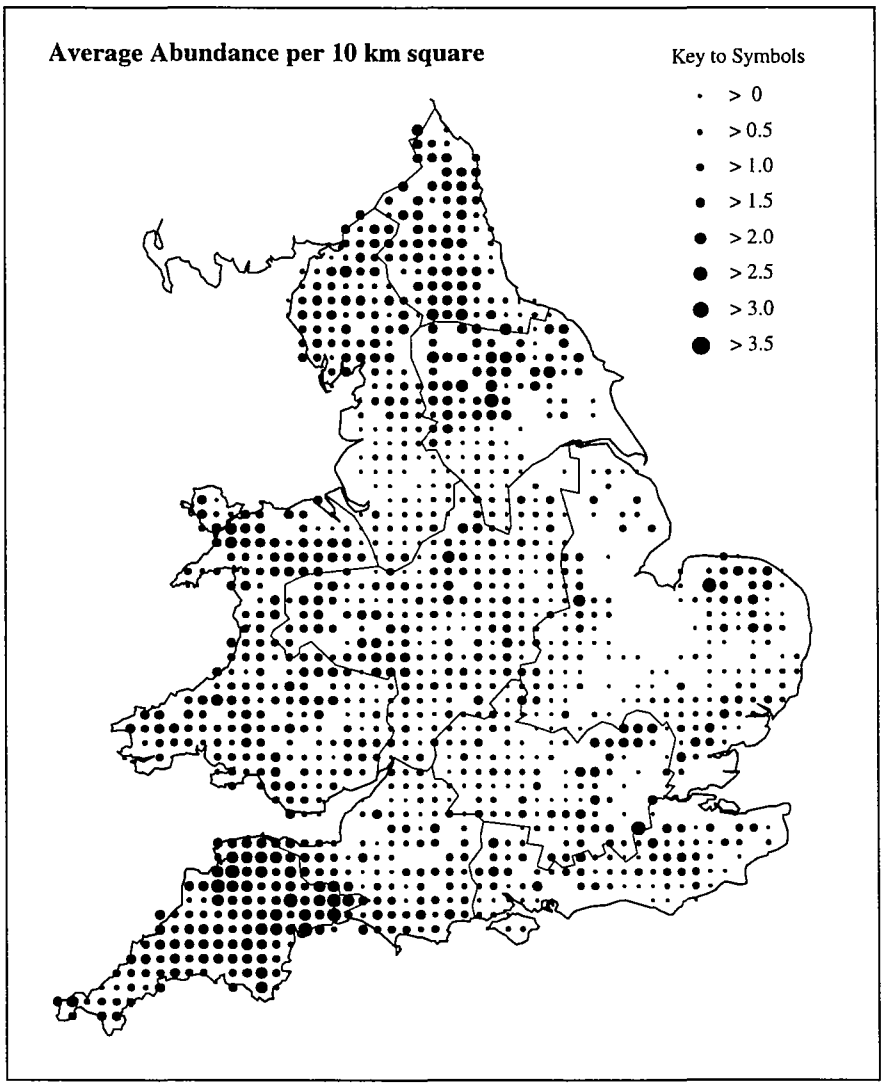


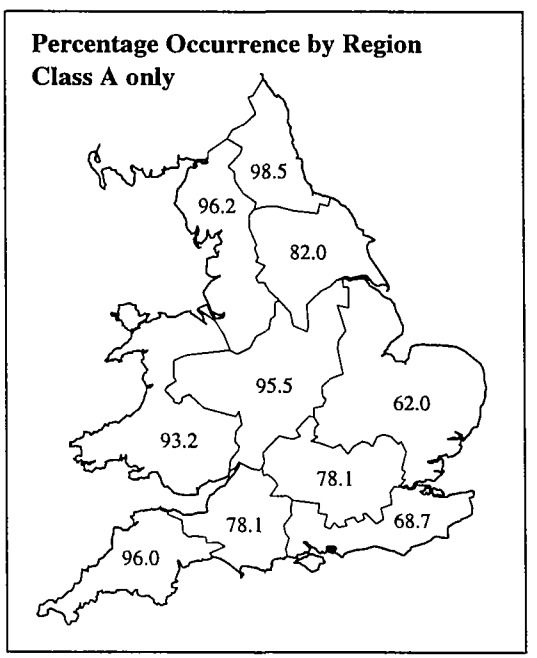


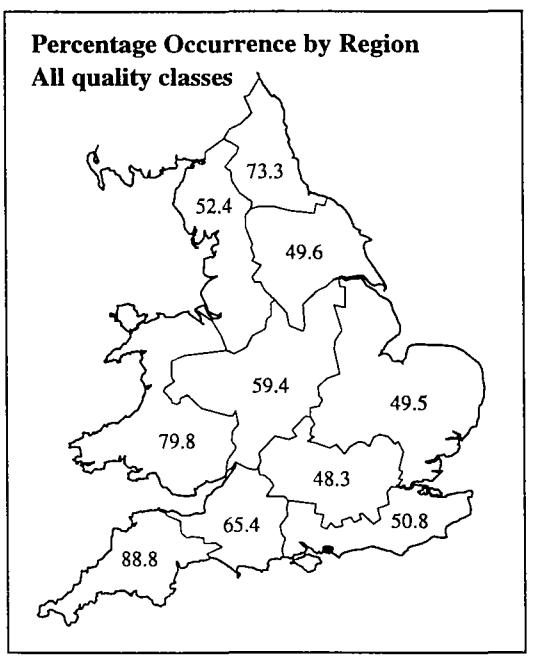


Distribution of BMWP Families - River Sites 1995

HYDROPSYCHIDAE

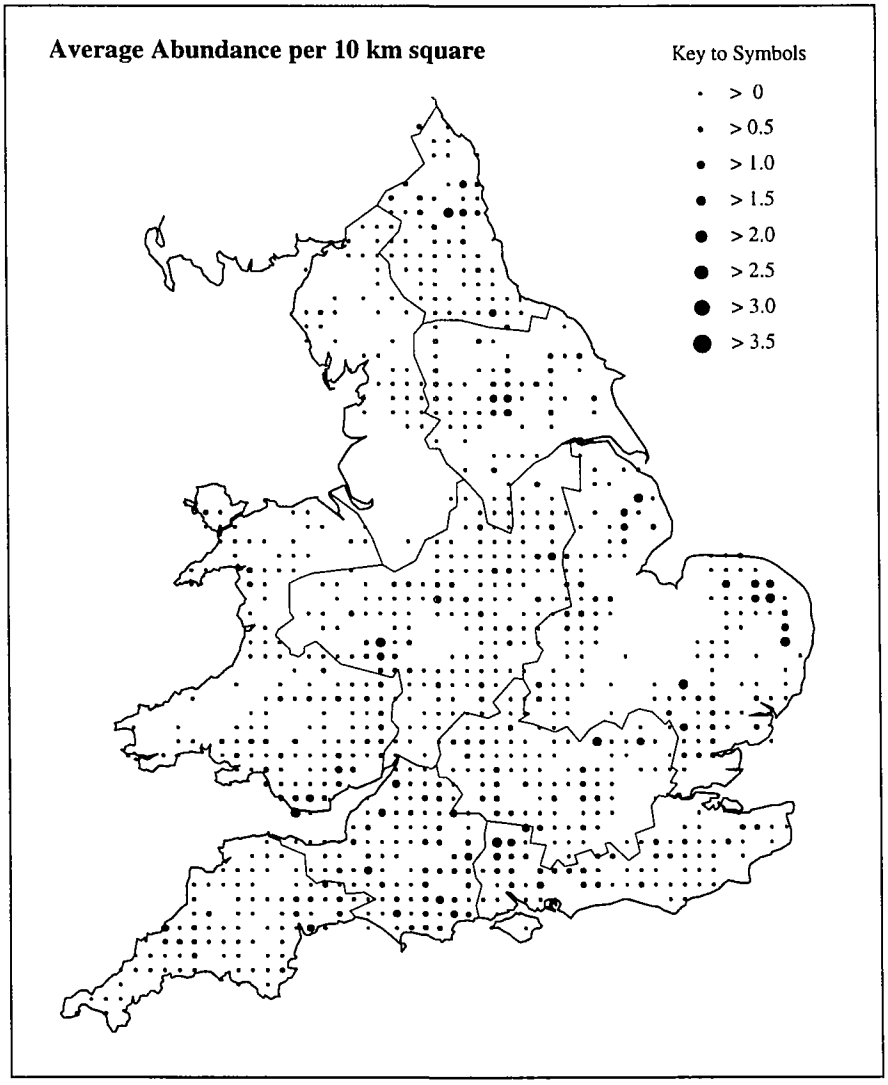


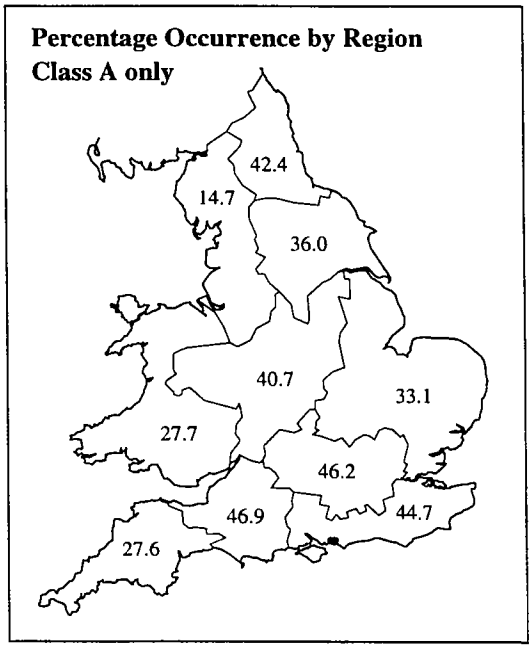


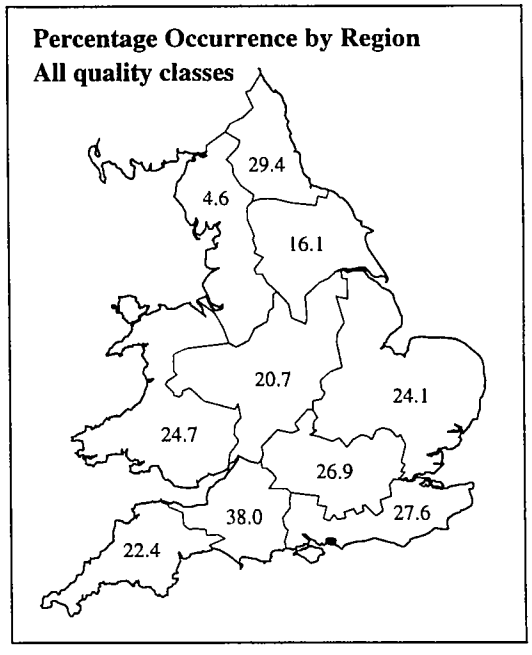


Distribution of BMWP Families - River Sites 1995

HYDROPTILIDAE

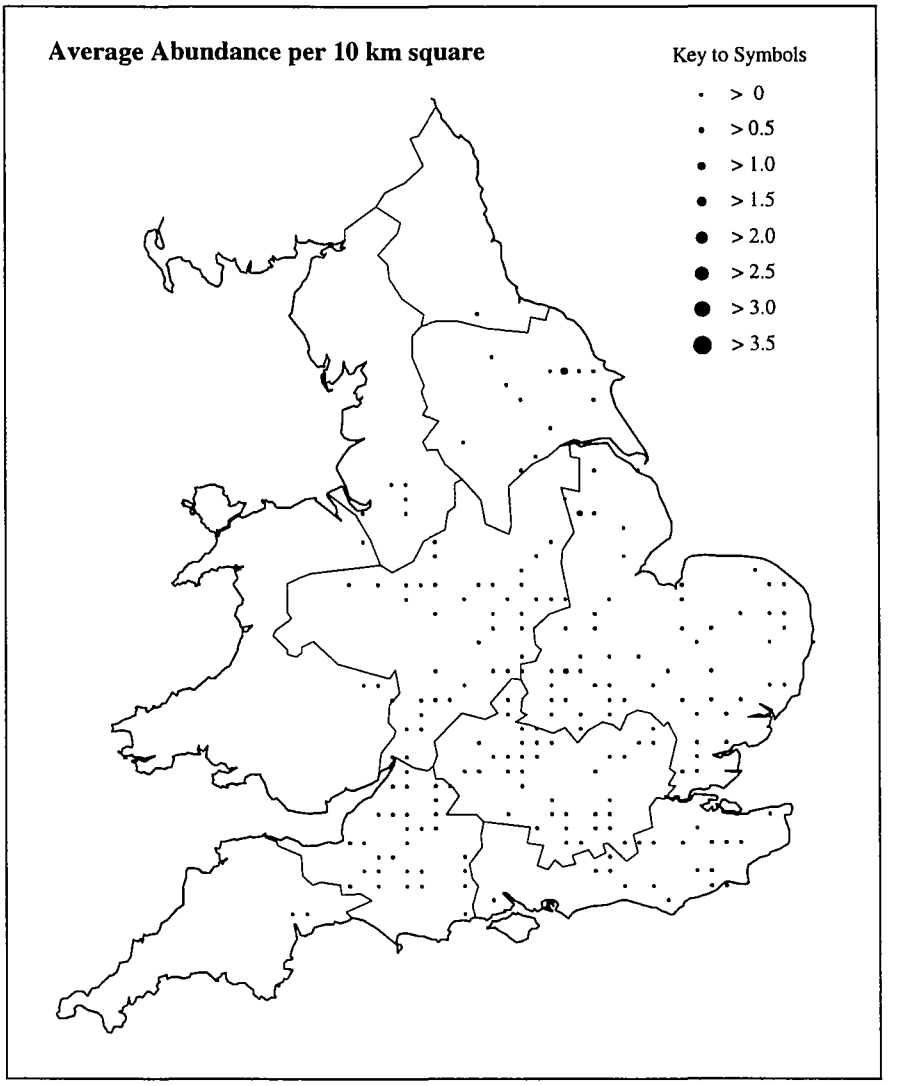


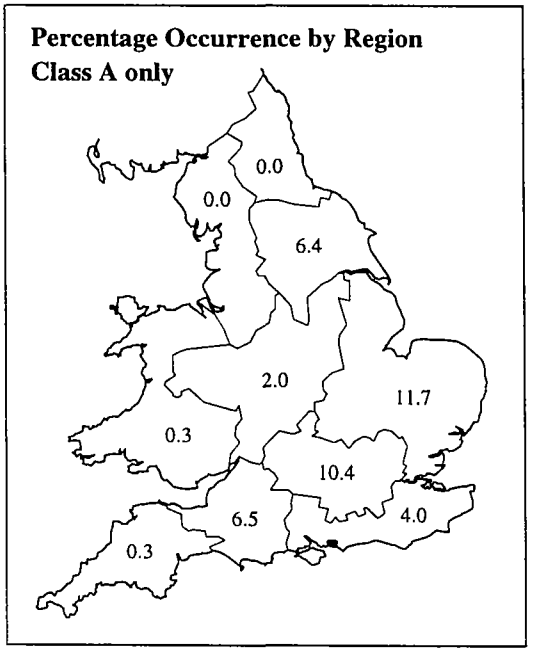


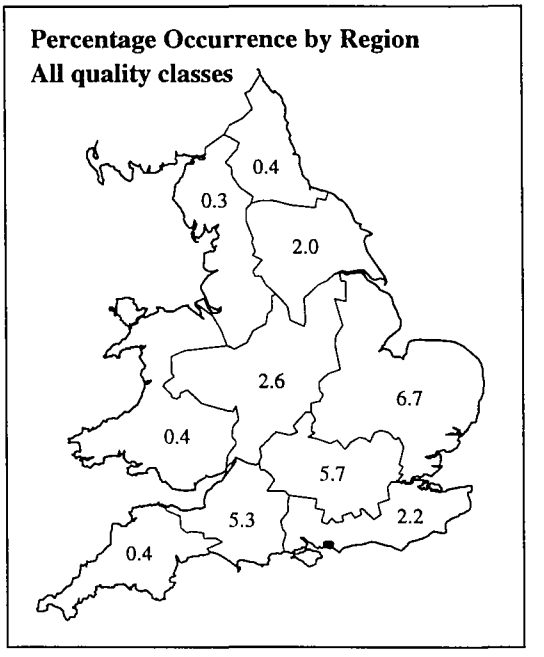


Distribution of BMWP Families - River Sites 1995

PHRYGANEIDAE

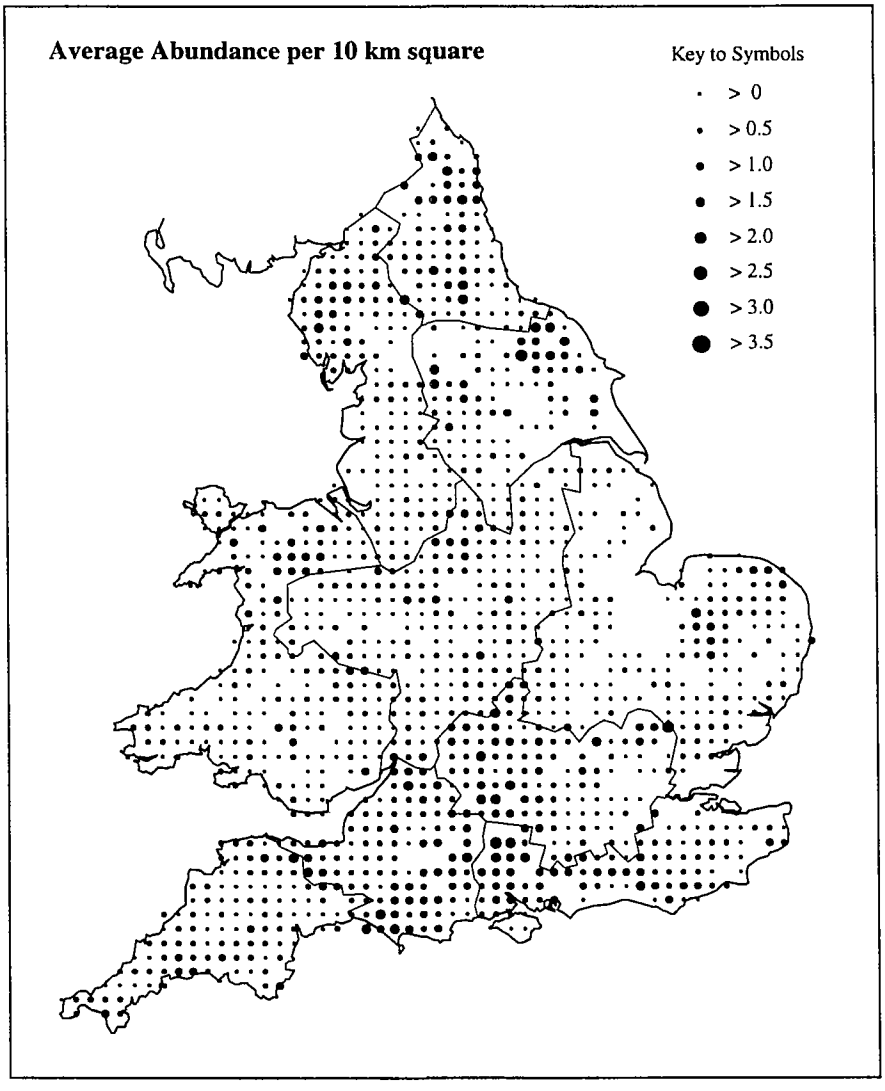


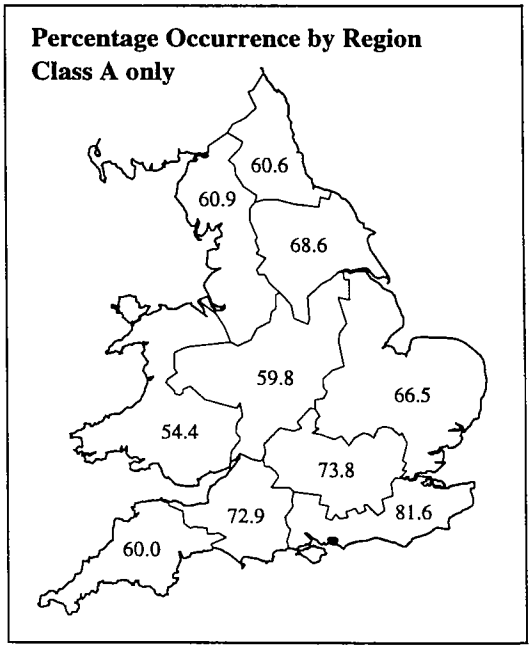


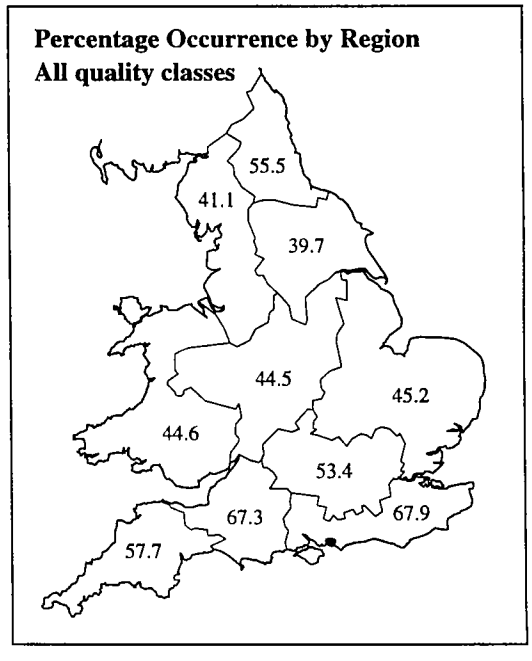


Distribution of BMWP Families - River Sites 1995

LIMNEPHILIDAE

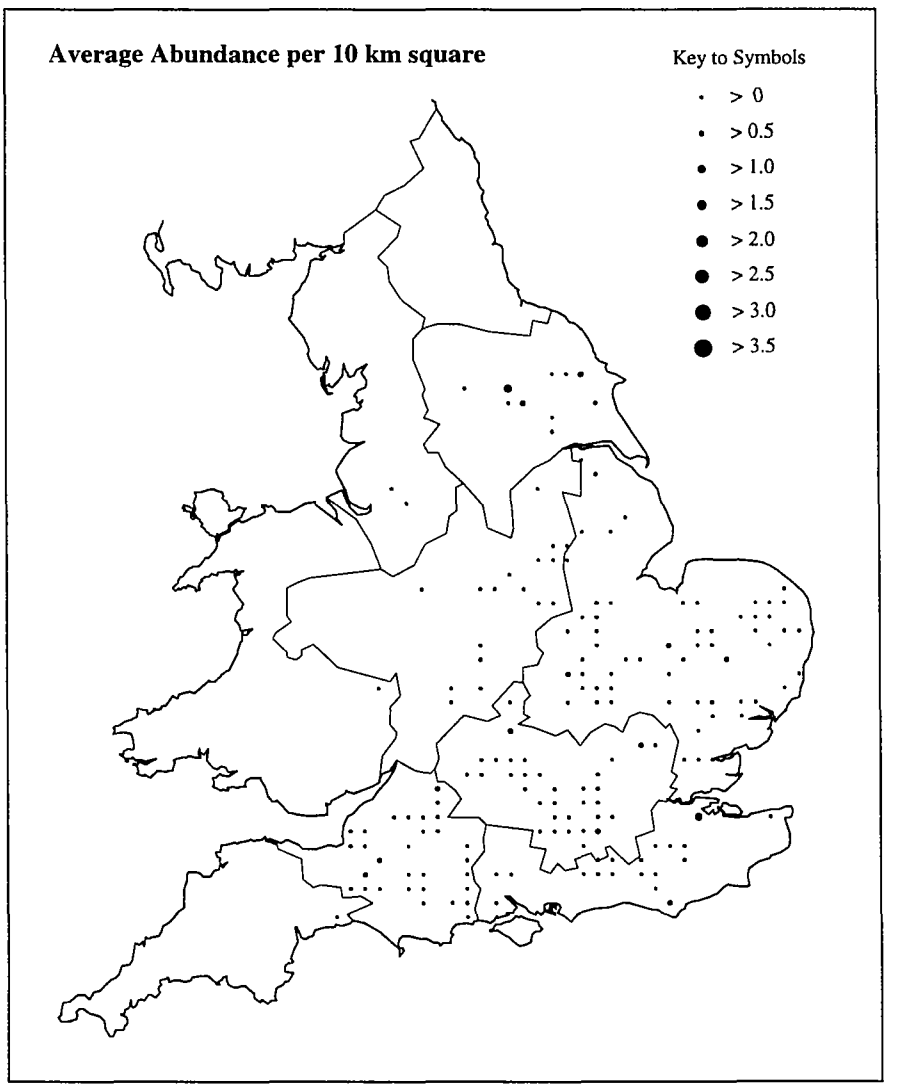


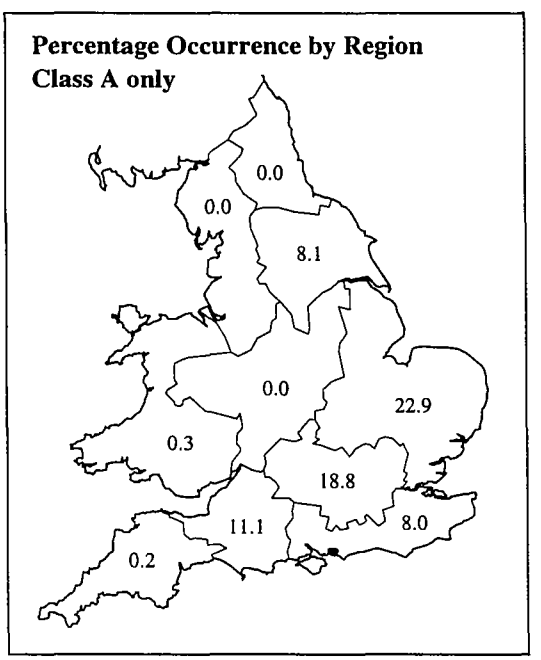


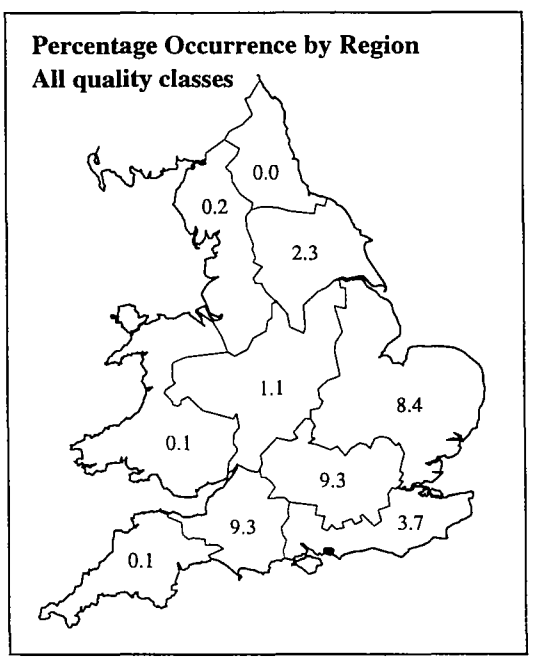


Distribution of BMWP Families - River Sites 1995

MOLANNIDAE

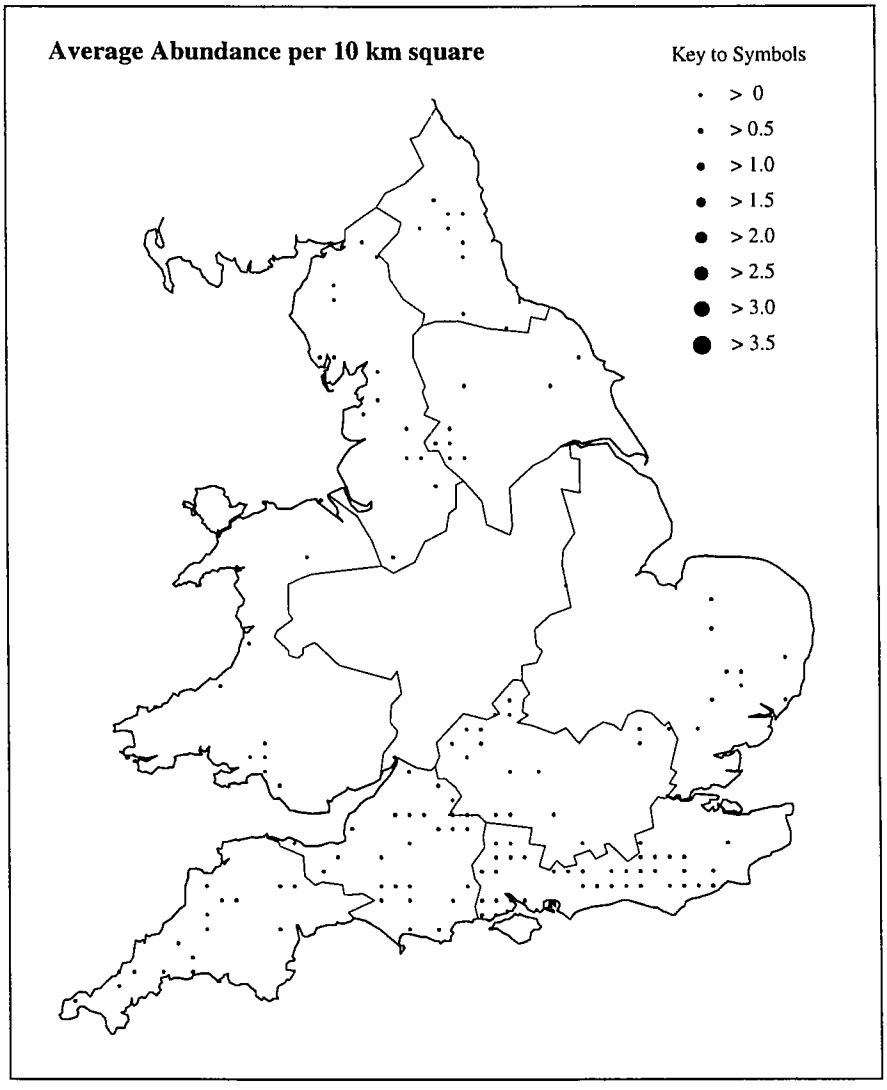


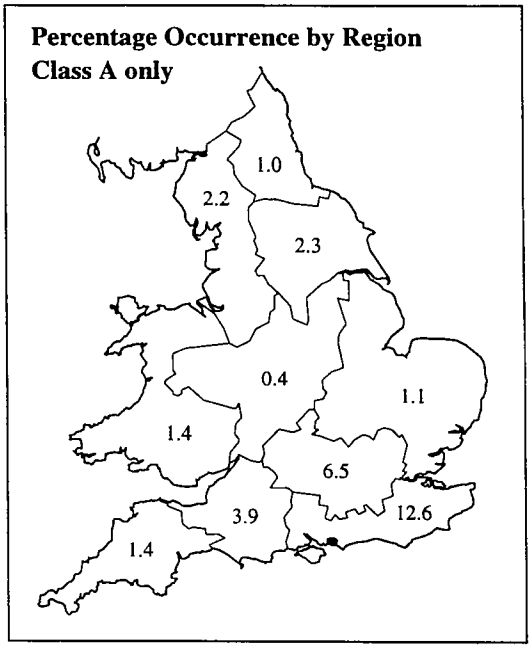


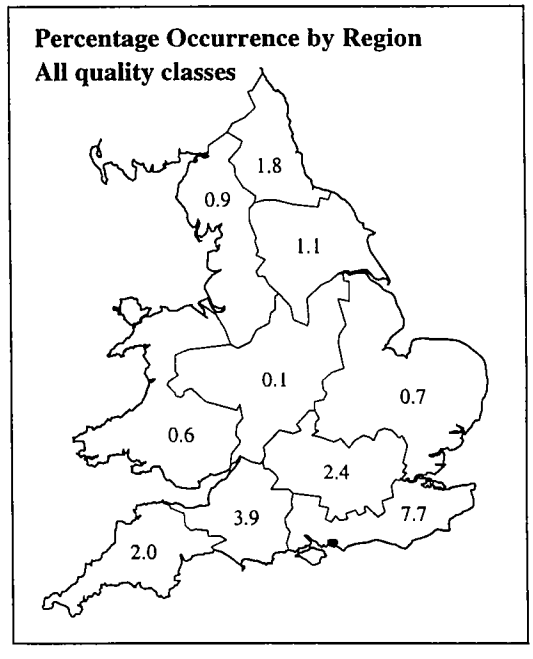


Distribution of BMWP Families - River Sites 1995

BERAEIDAE

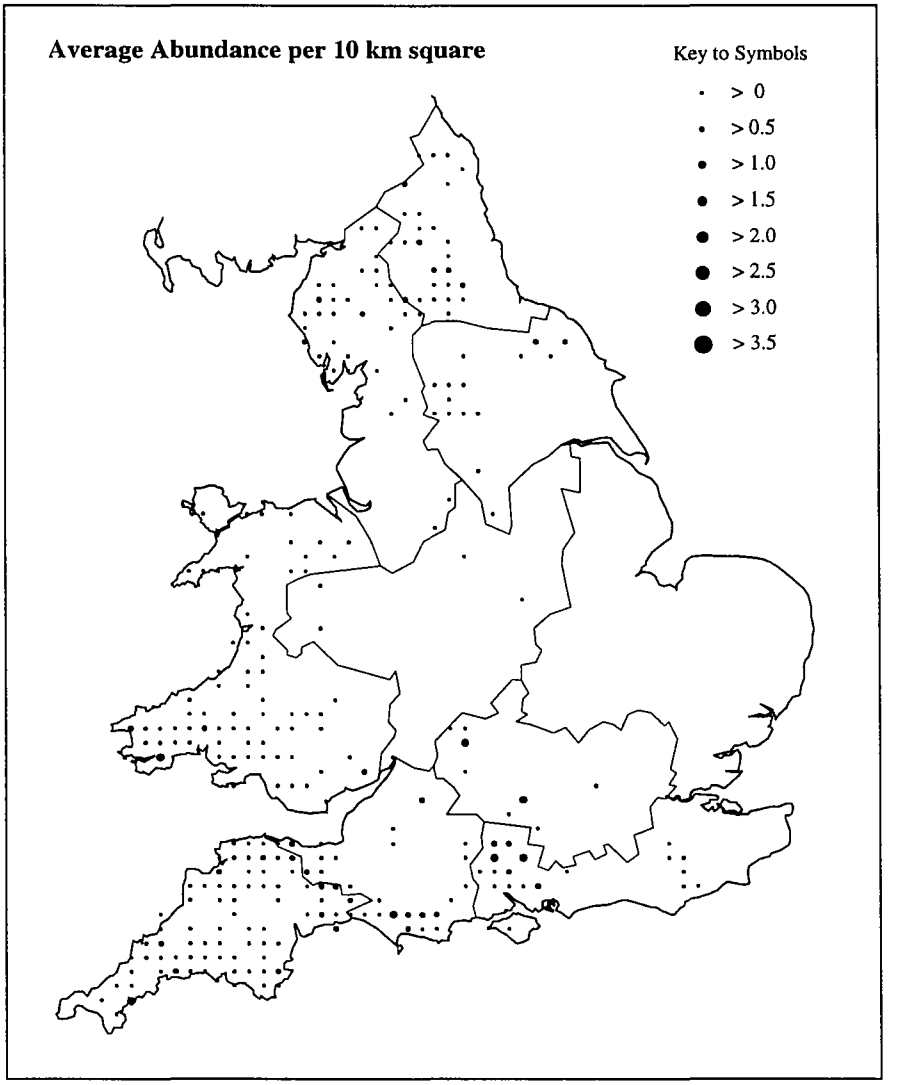


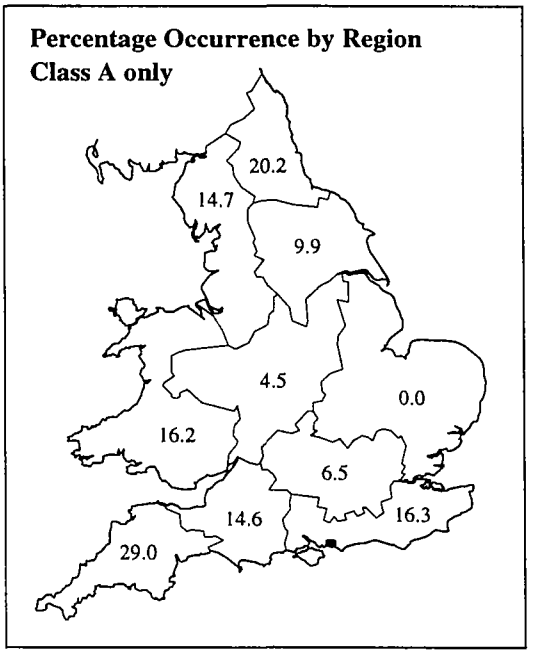


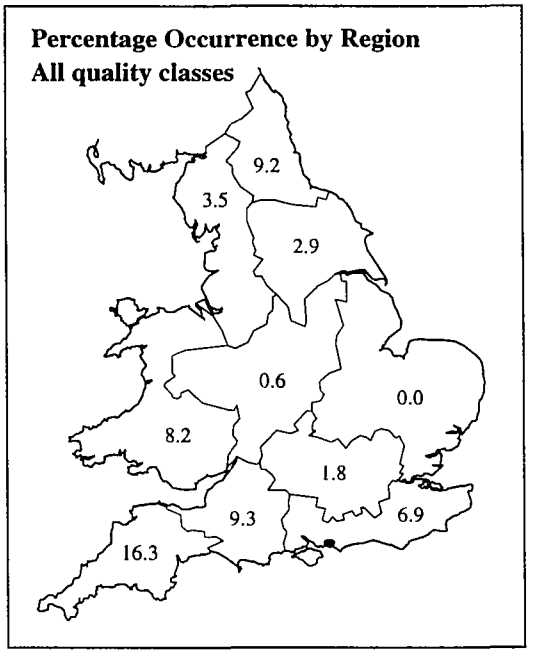


Distribution of BMWP Families - River Sites 1995

ODONTOCERIDAE

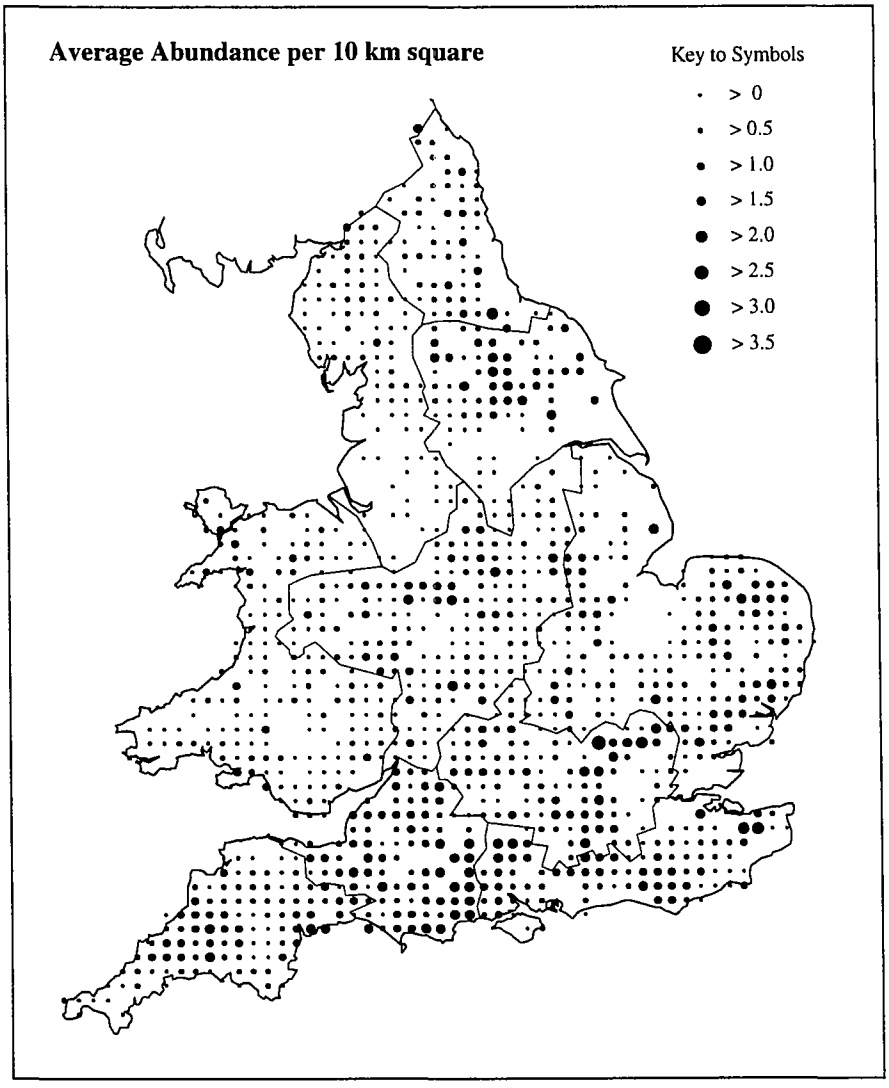


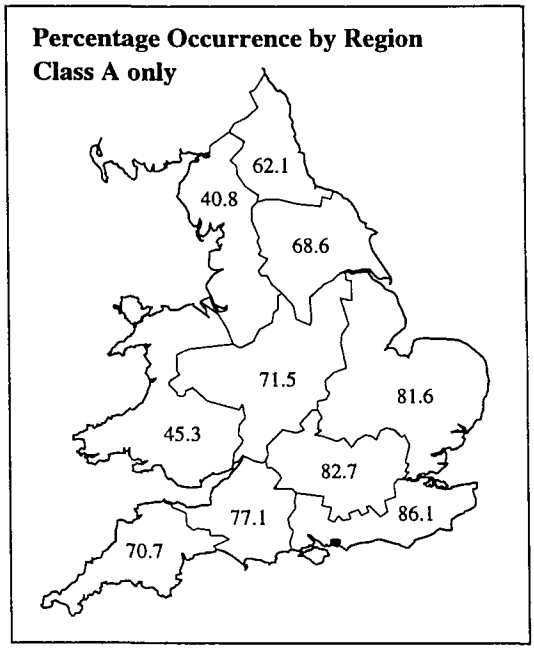


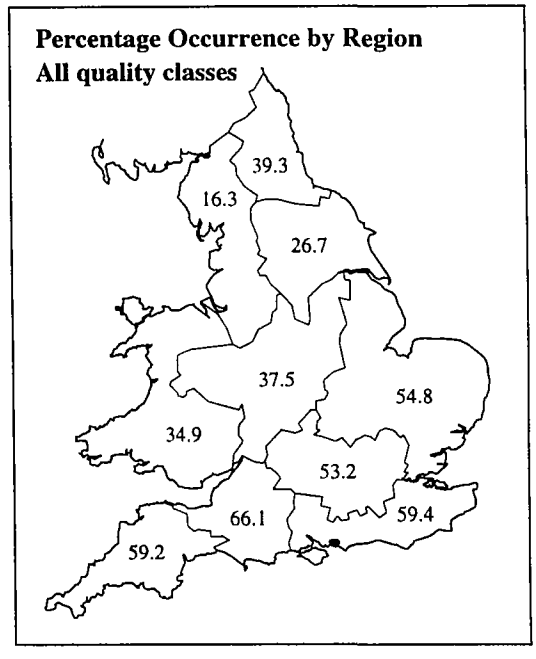


Distribution of BMWP Families - River Sites 1995

LEPTOCERIDAE

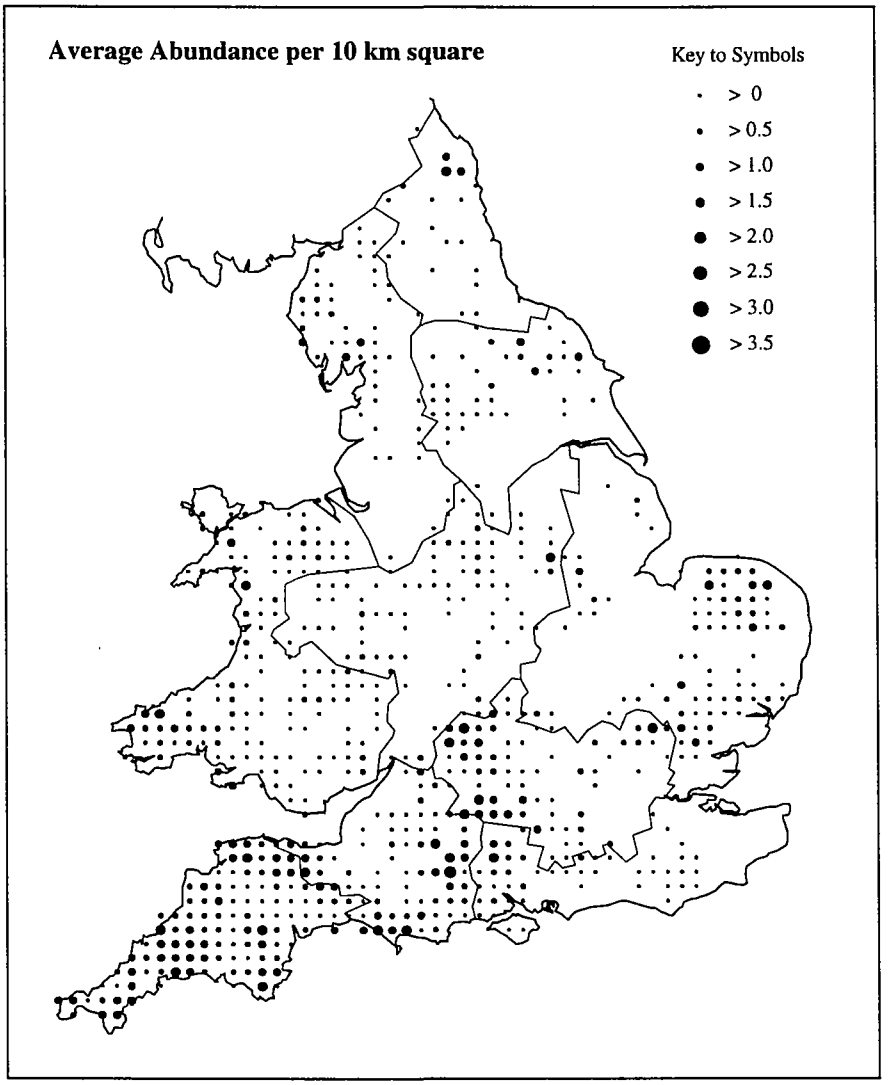


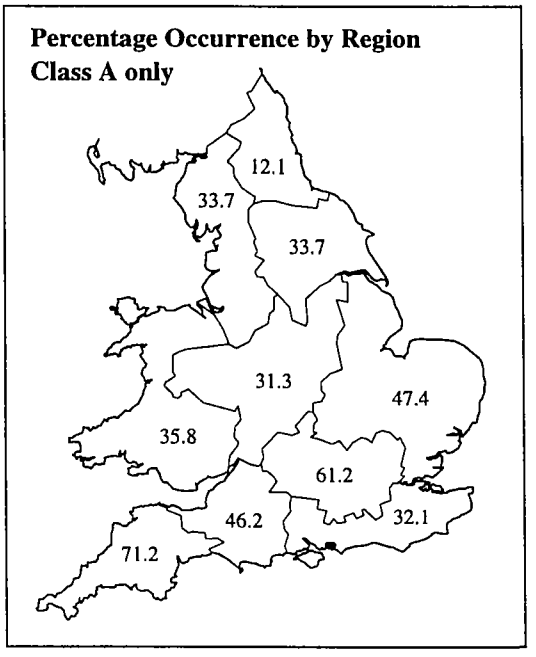


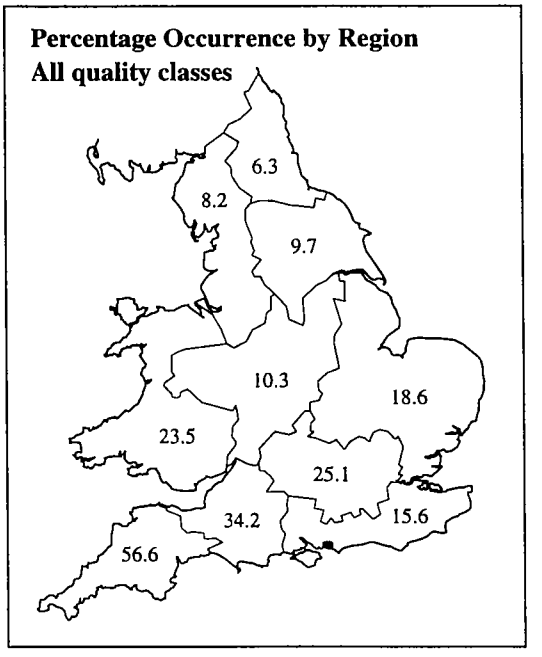


Distribution of BMWP Families - River Sites 1995

GOERIDAE

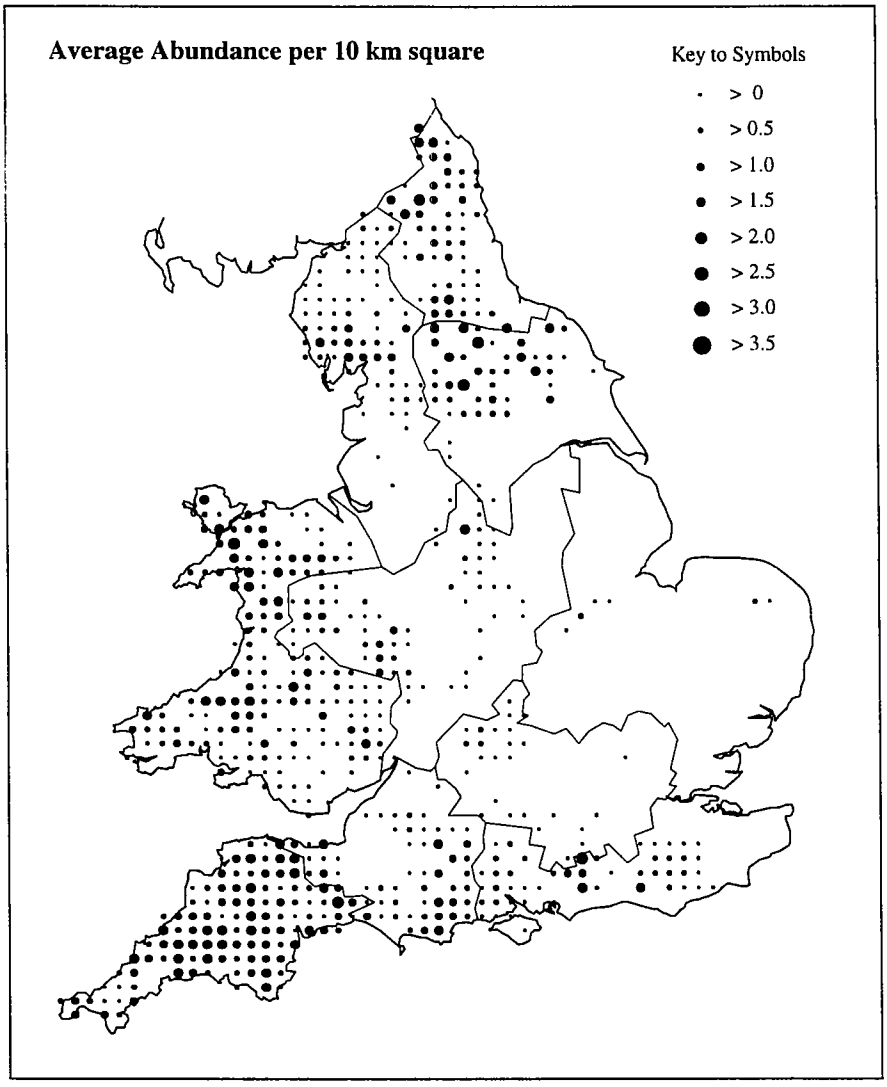


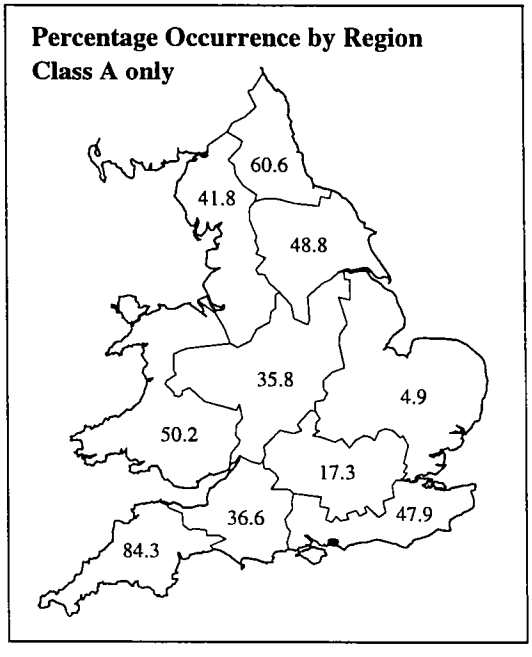


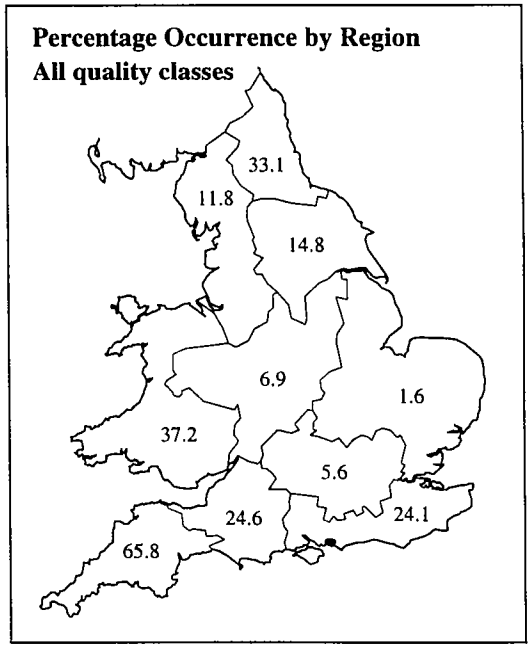


Distribution of BMWP Families - River Sites 1995

LEPIDOSTOMATIDAE

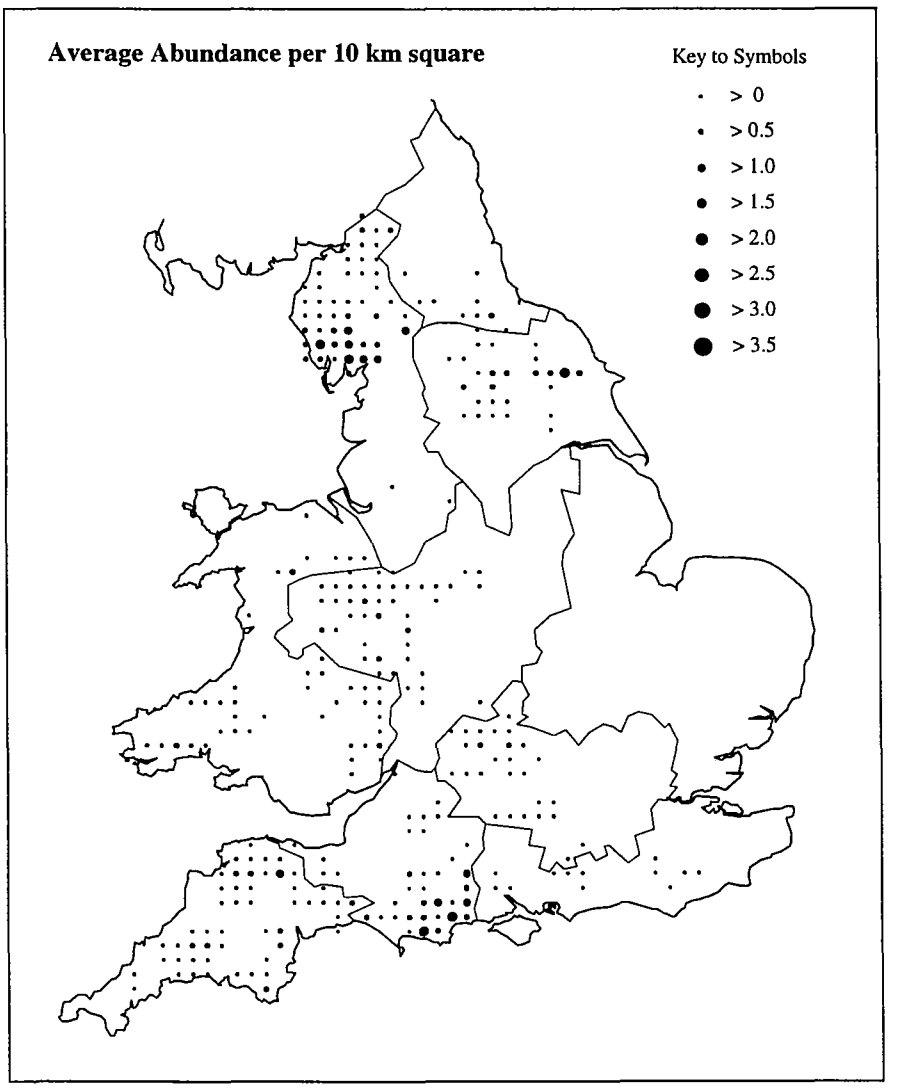


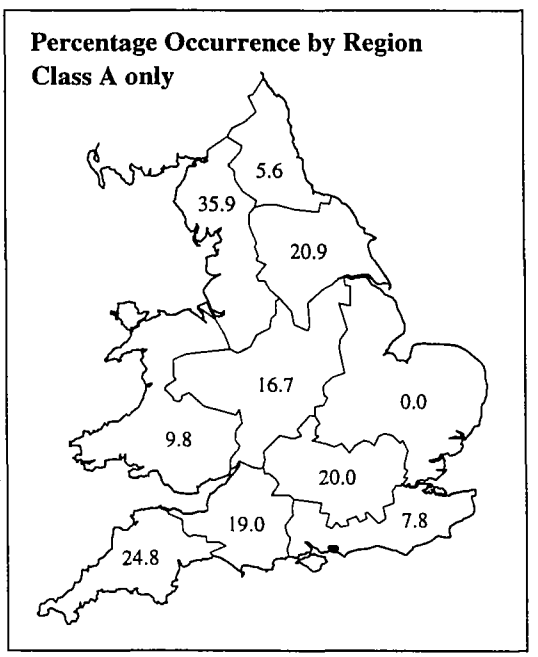


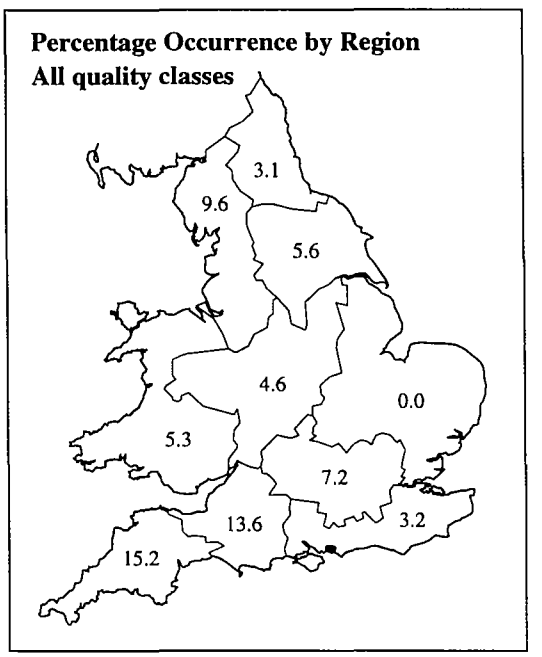


Distribution of BMWP Families - River Sites 1995

BRACHYCENTRIDAE

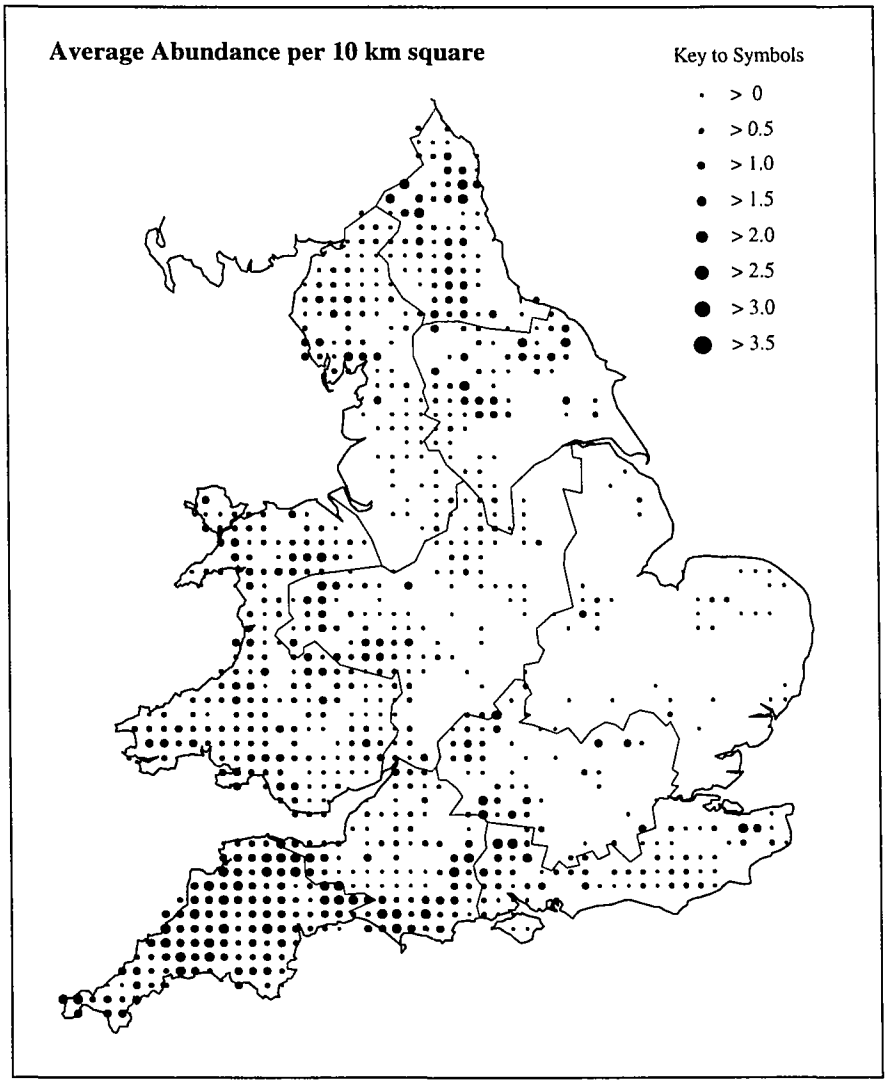


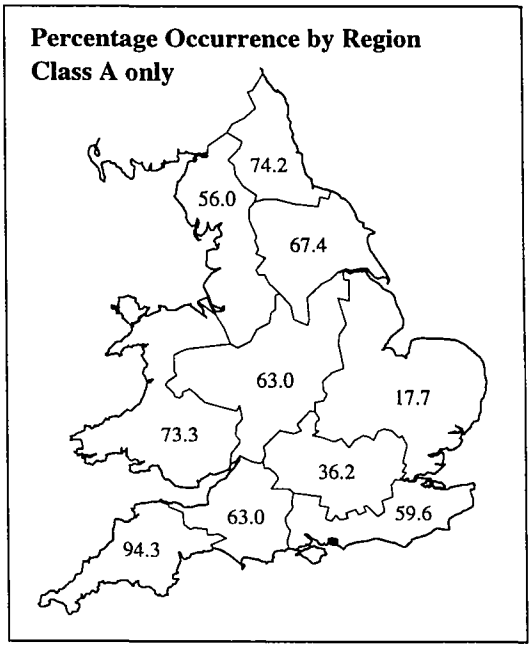


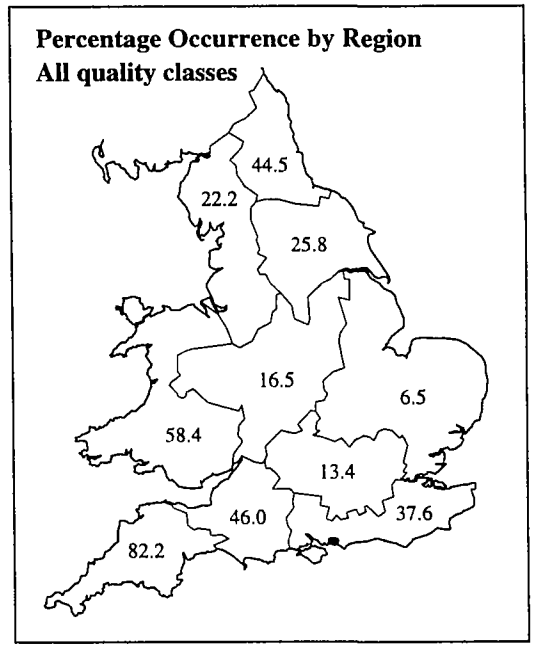


Distribution of BMWP Families - River Sites 1995

SERICOSTOMATIDAE

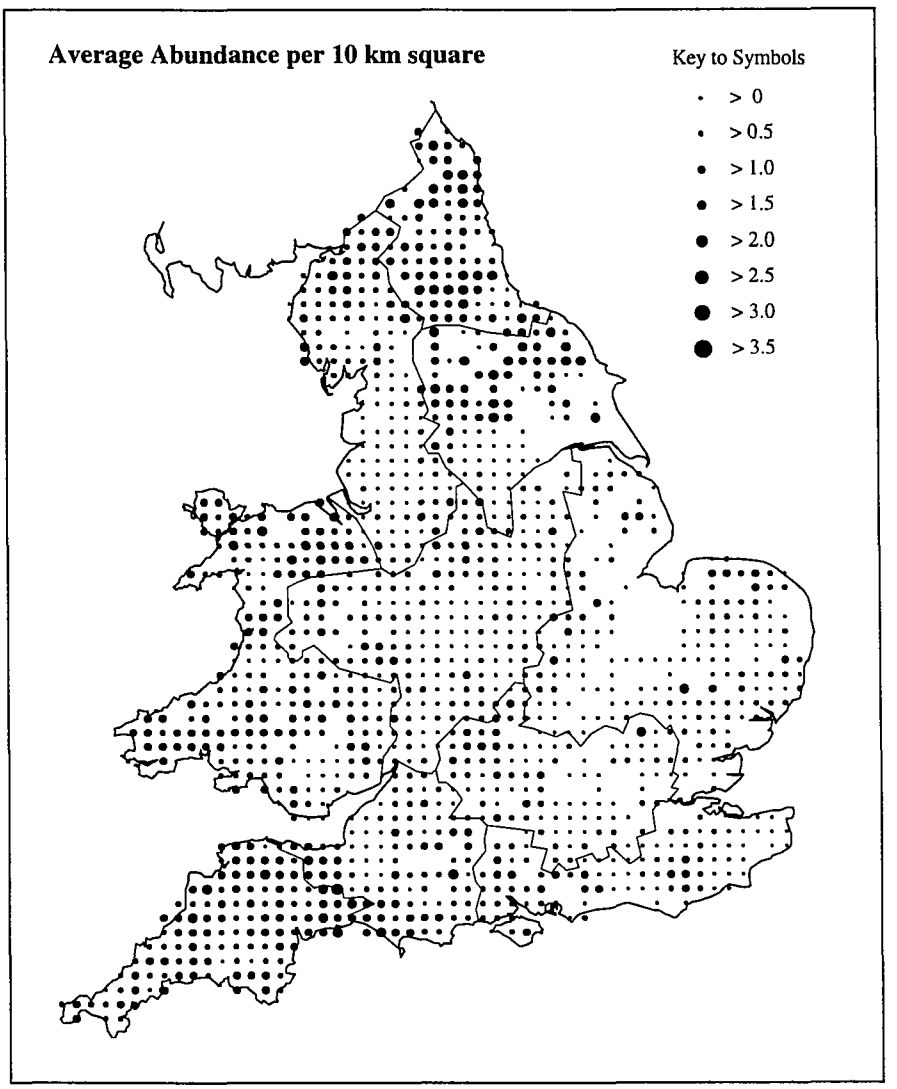


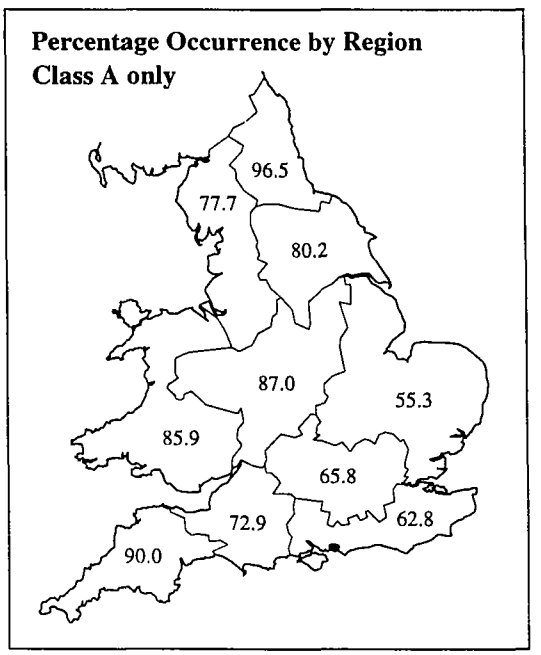


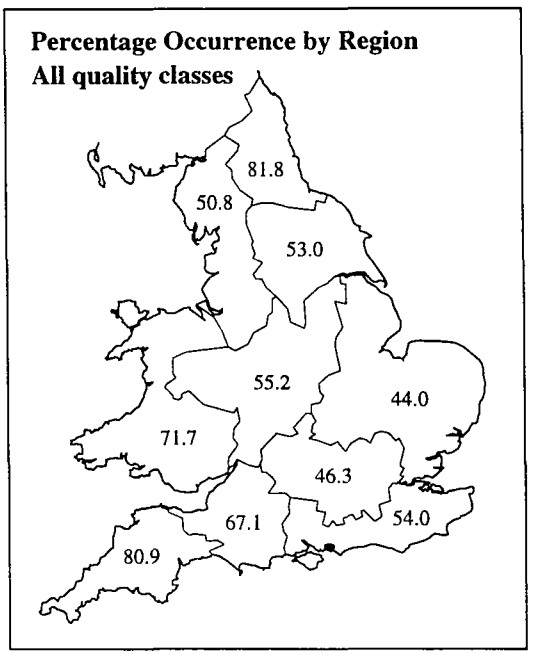


Distribution of BMWP Families - River Sites 1995

TIPULIDAE

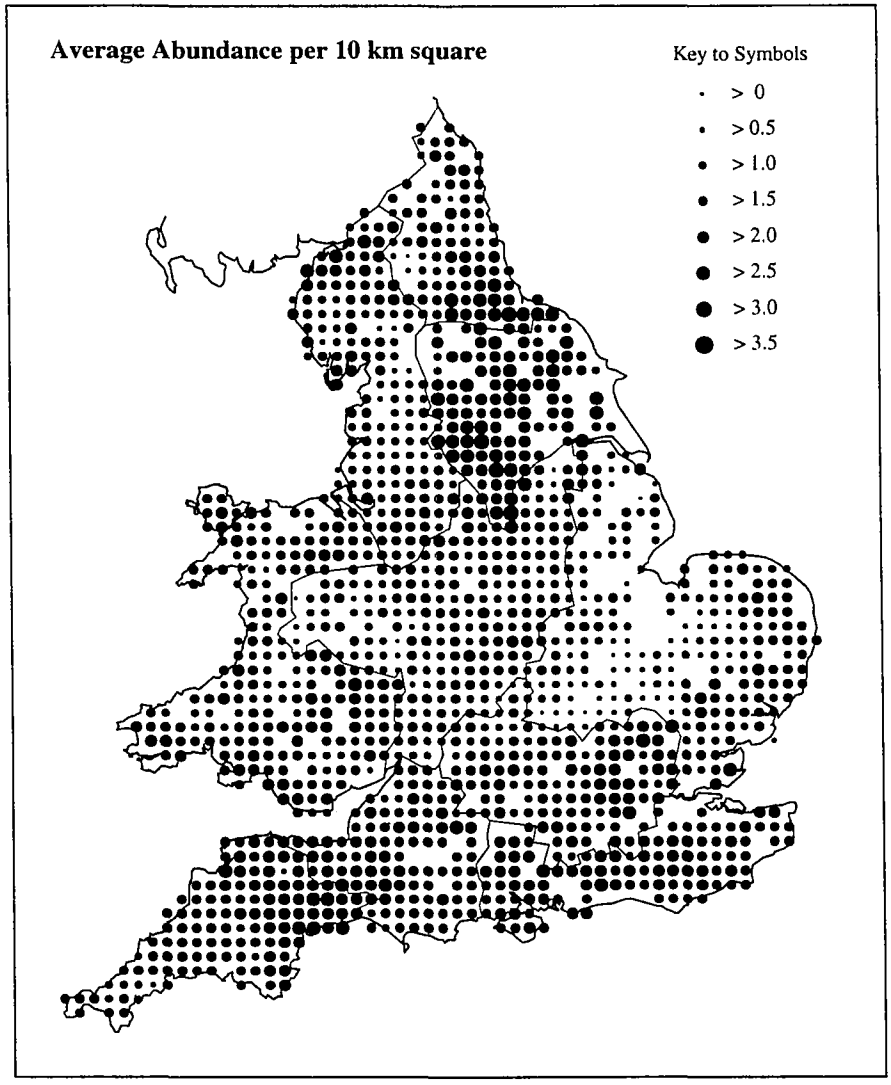


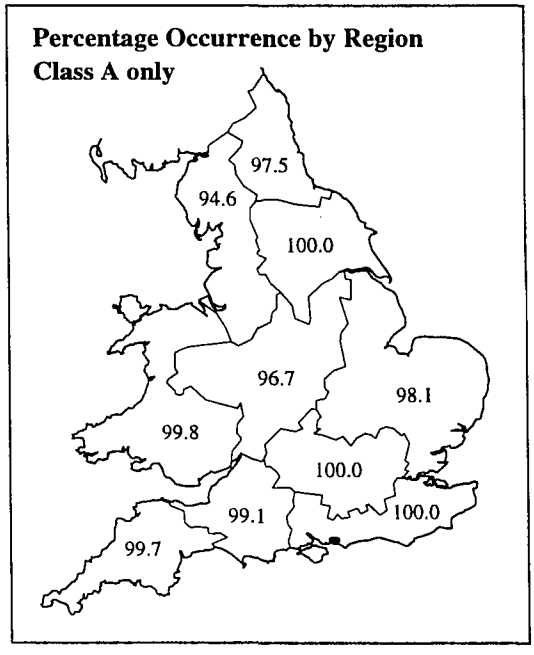


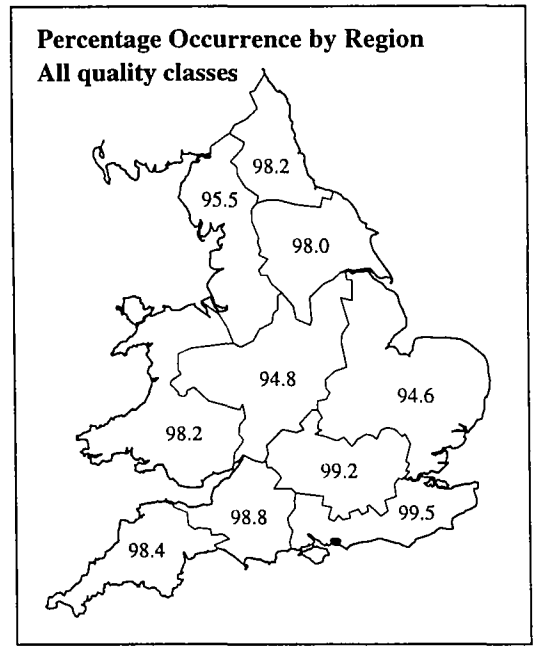


Distribution of BMWP Families - River Sites 1995

CHIRONOMIDAE

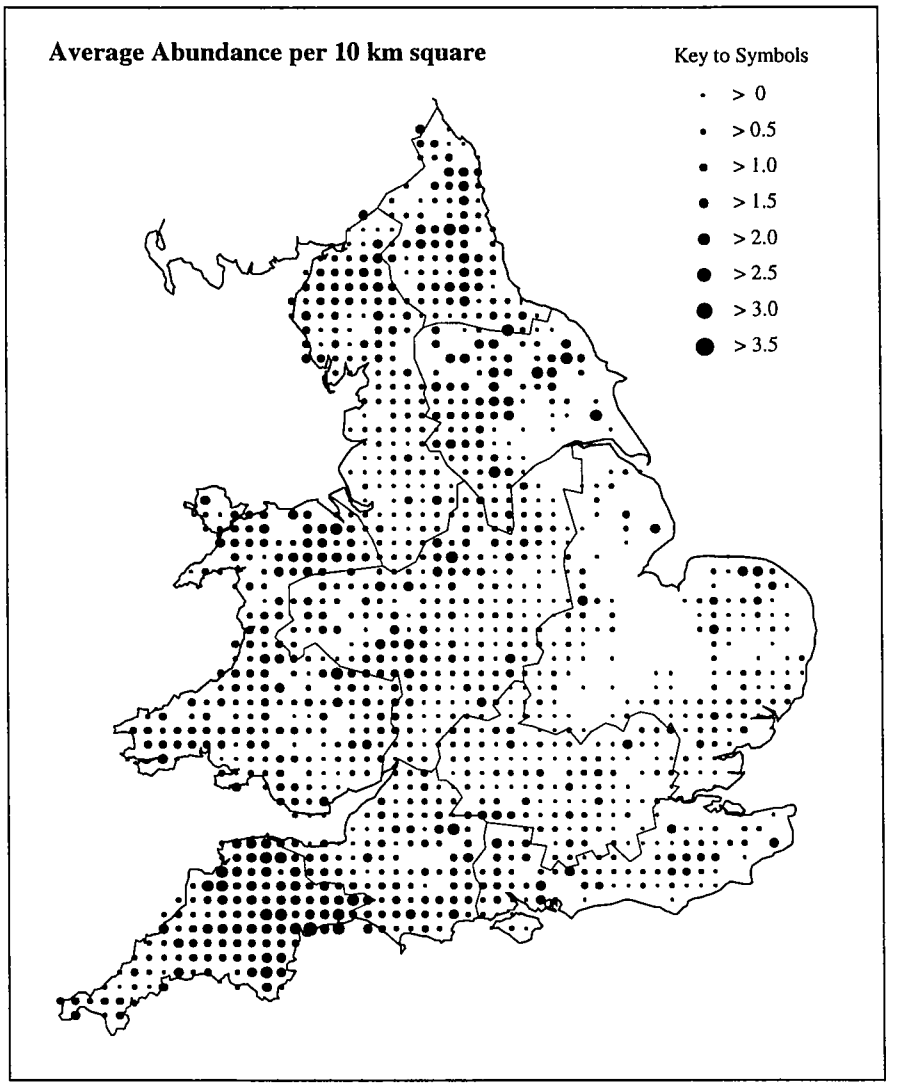


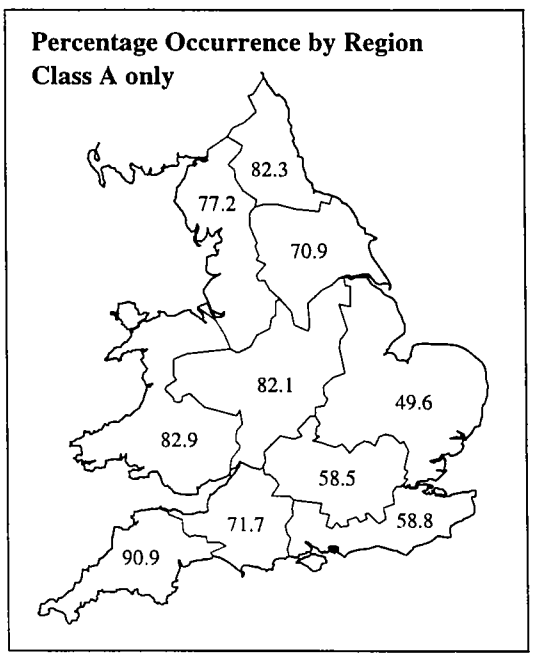


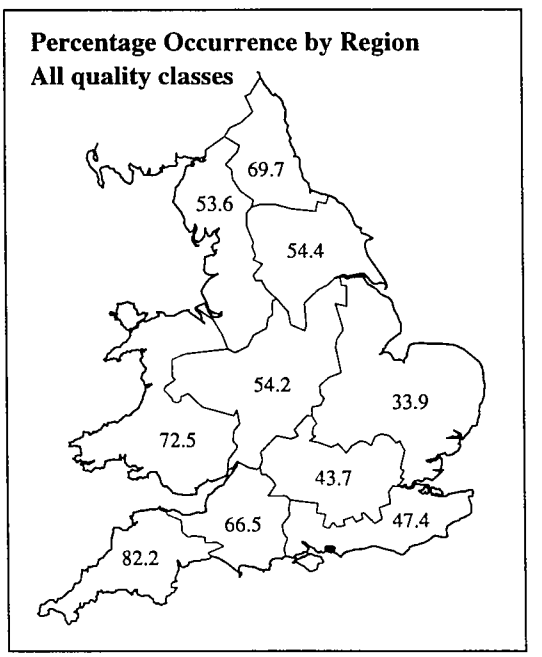


Distribution of BMWP Families - River Sites 1995

SIMULIIDAE





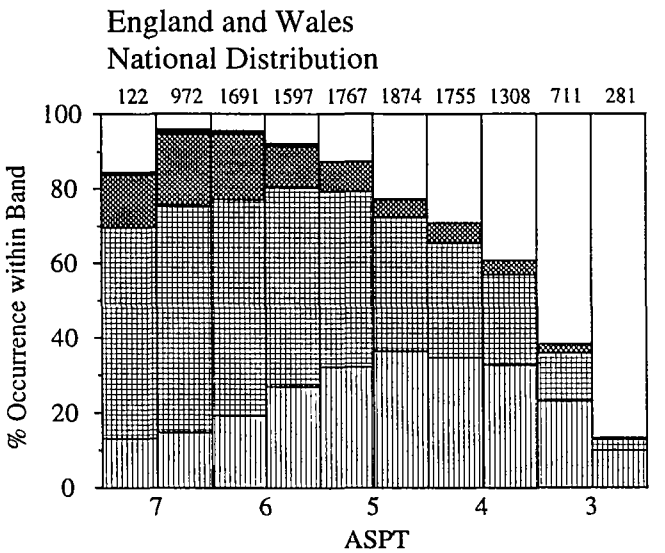


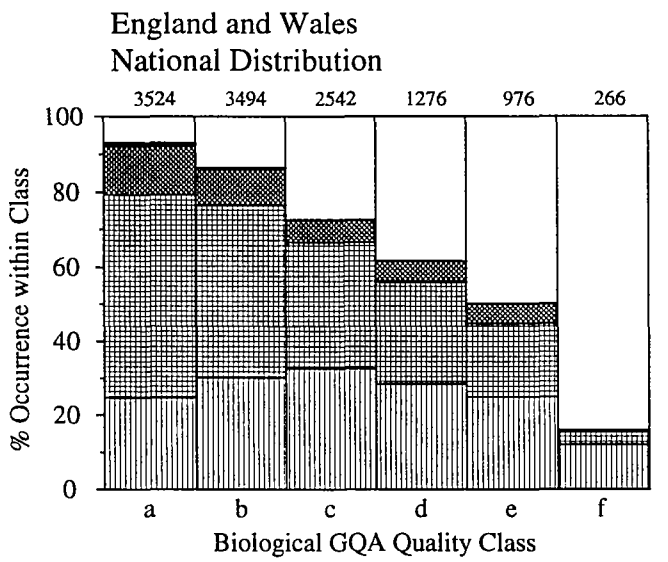
Appendix B

Regional Frequency Distributions by ASPT and Class

River Sites - 1995

TYPICAL DISTRIBUTIONS





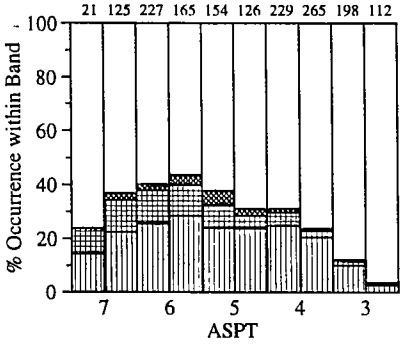
The number given above each column is the total number of samples recorded within that band or class. They differ from region to region but not from taxon to taxon. The numbers corresponding to the distribution for England and Wales are only given on this leading page.

On each page, the ten regional distributions have been arranged in their approximate geographical location. The national distribution for England and Wales is shown in the bottom right hand corner.

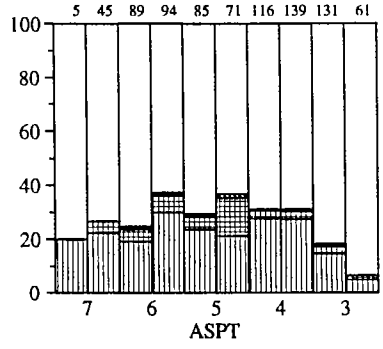
Regional Frequency Distributions by ASPT - River Sites 1995

PLANARIIDAE

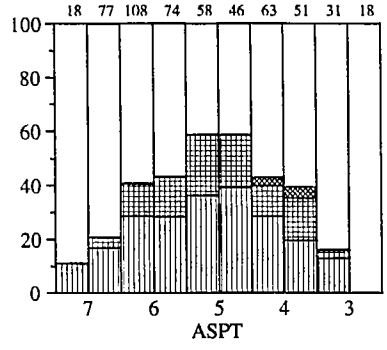
North West Region



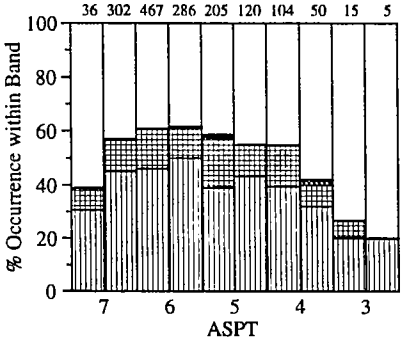
Dales and Ridings Areas
North East Region



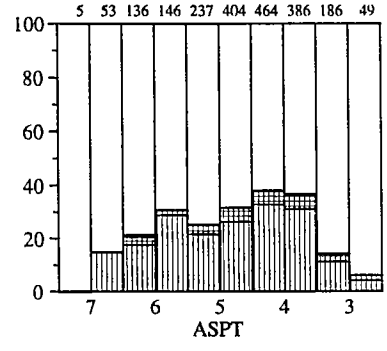
Northumbria Area
North East Region



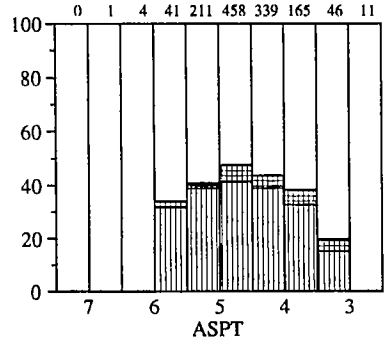
Welsh Region



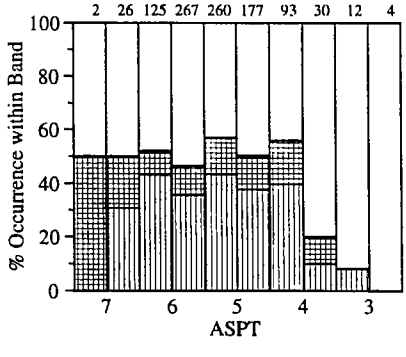
Midlands Region



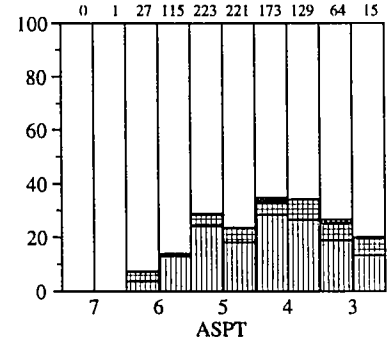
Anglian Region



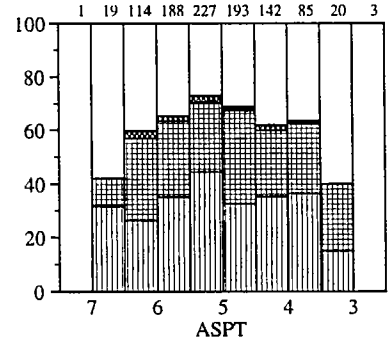
North and South Wessex Areas
South West Region



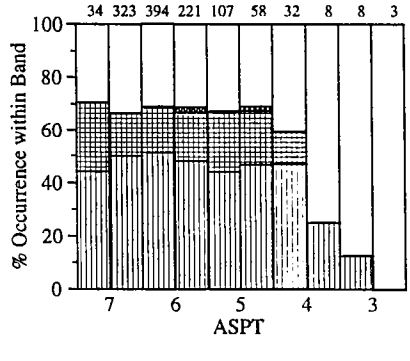
Thames Region



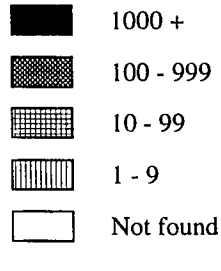
Southern Region



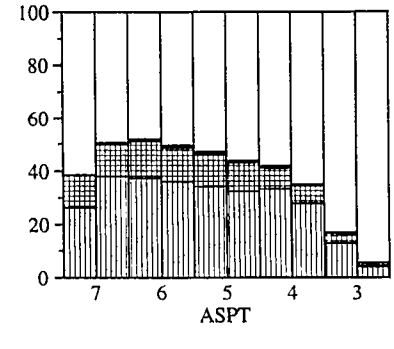
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

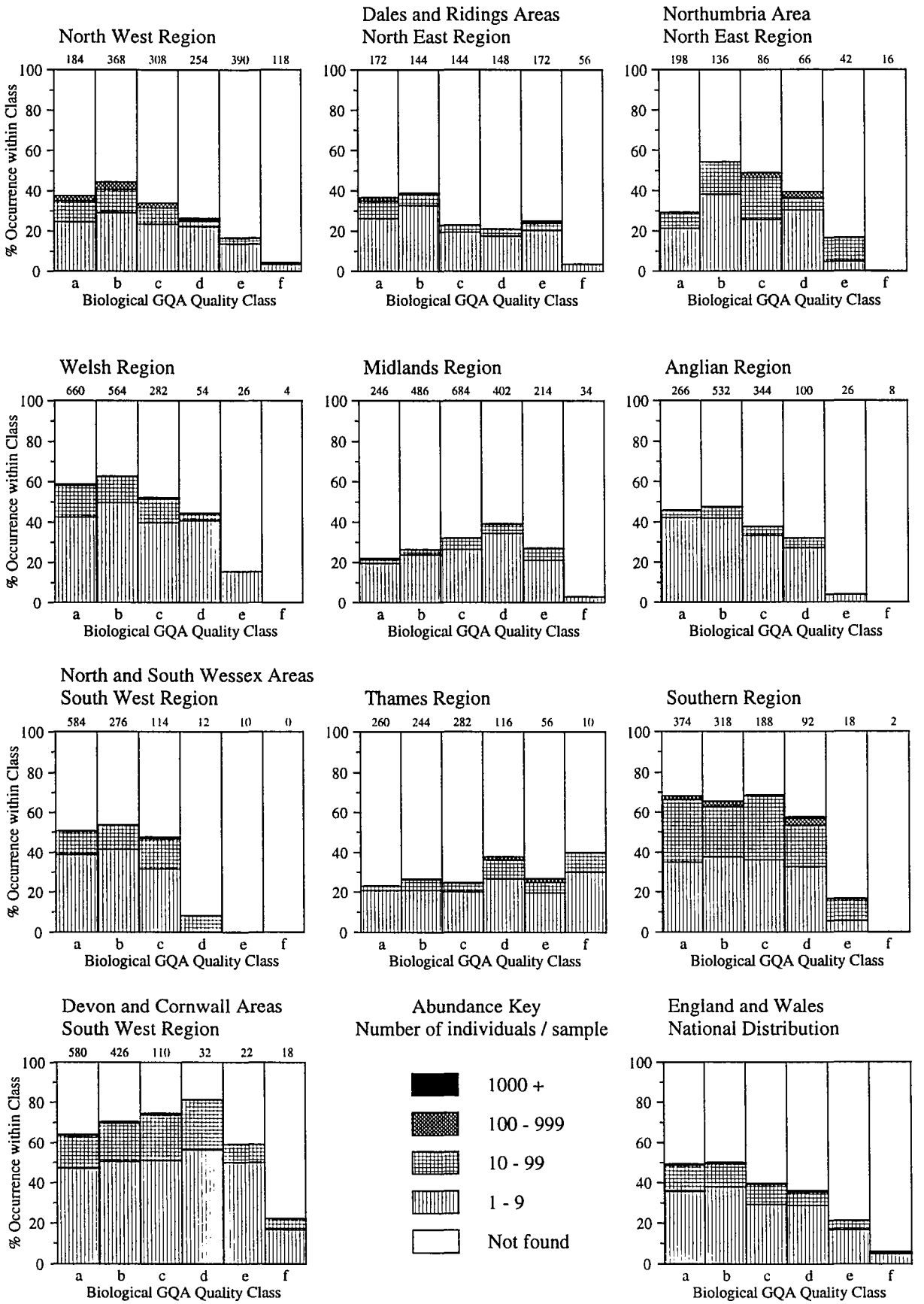


England and Wales
National Distribution



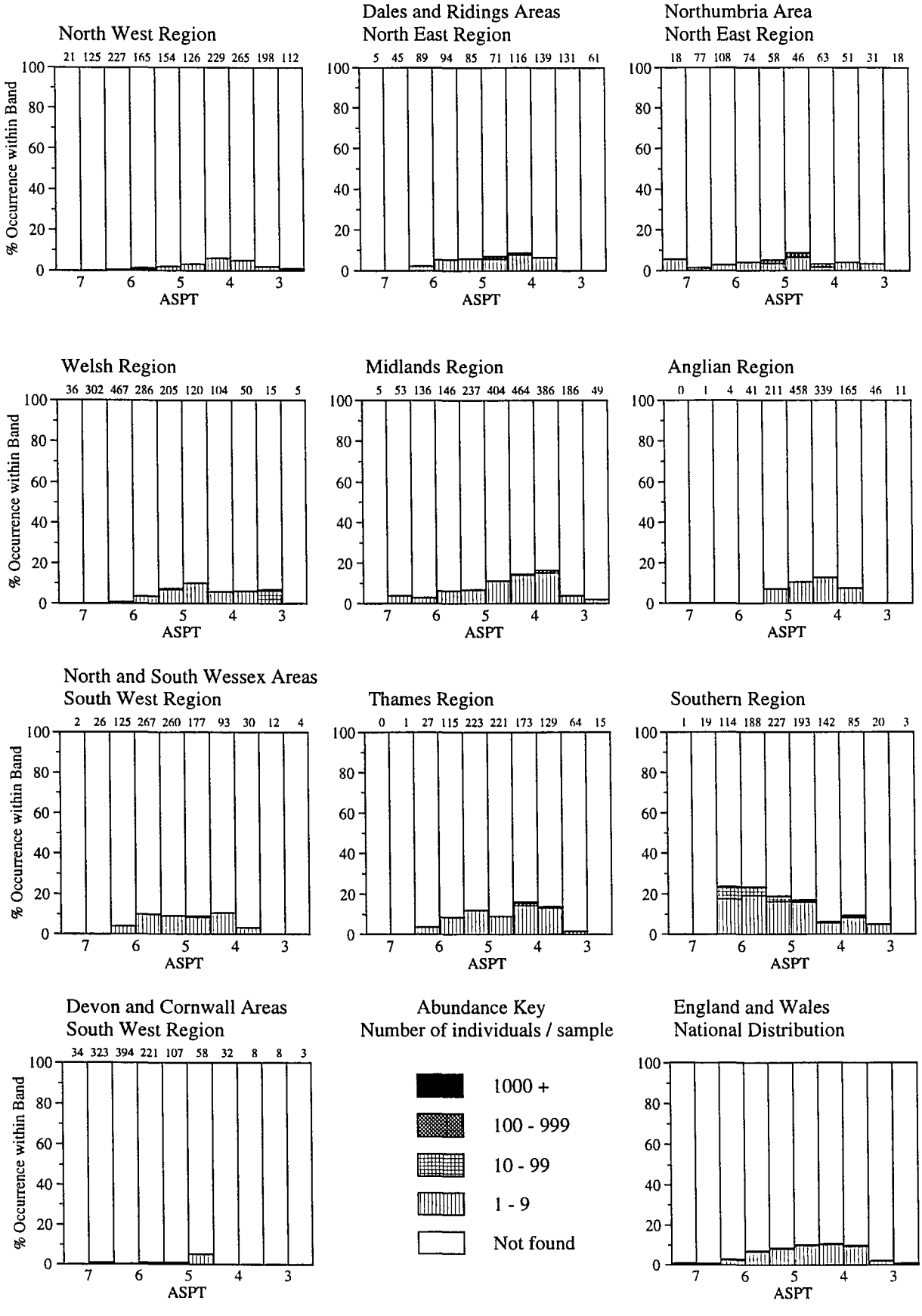
Regional Frequency Distributions by Class - River Sites 1995

PLANARIIDAE



Regional Frequency Distributions by ASPT - River Sites 1995

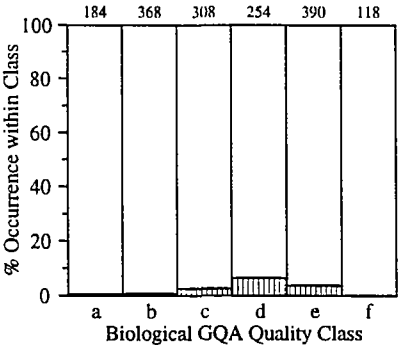
DENDROCOELIDAE



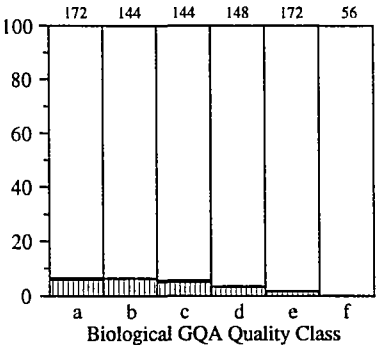
Regional Frequency Distributions by Class - River Sites 1995

DENDROCOELIDAE

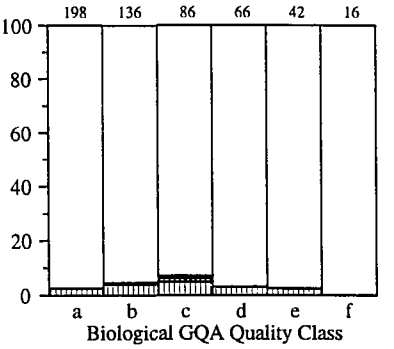
North West Region



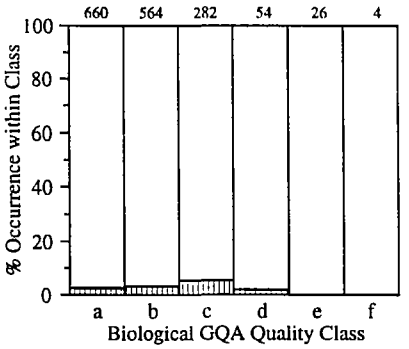
Dales and Ridings Areas
North East Region



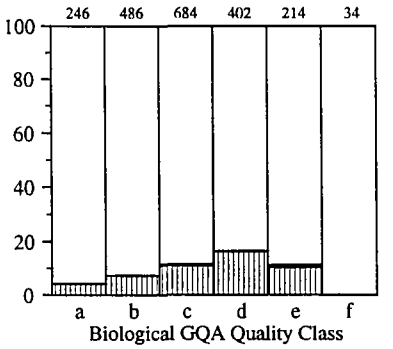
Northumbria Area
North East Region



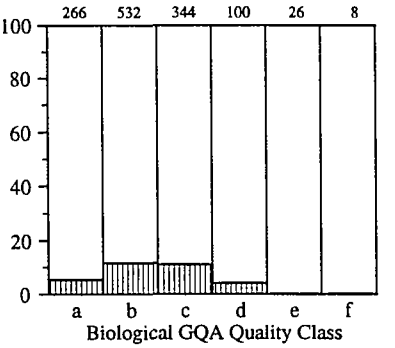
Welsh Region



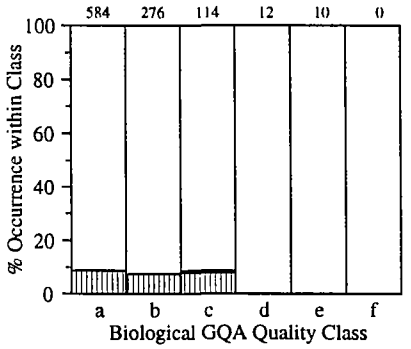
Midlands Region



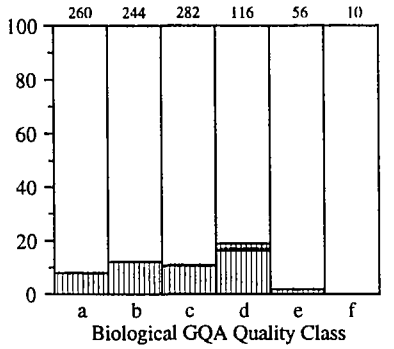
Anglian Region



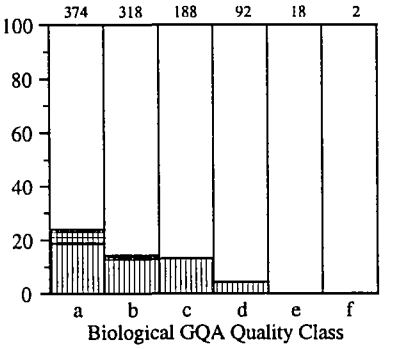
North and South Wessex Areas
South West Region



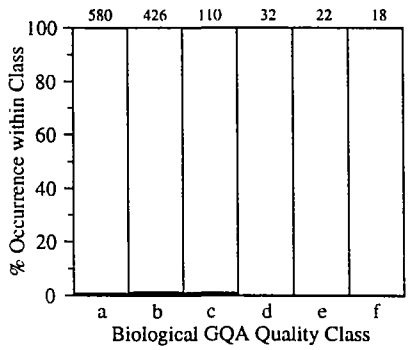
Thames Region



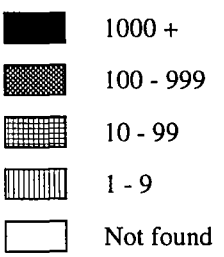
Southern Region



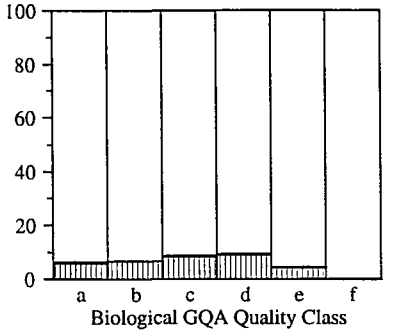
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



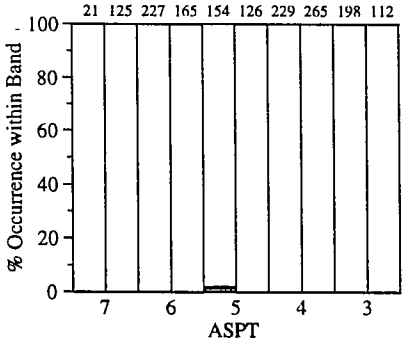
England and Wales
National Distribution



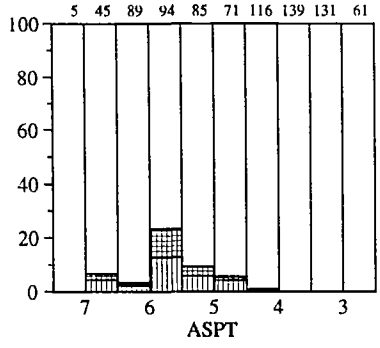
Regional Frequency Distributions by ASPT - River Sites 1995

NERITIDAE

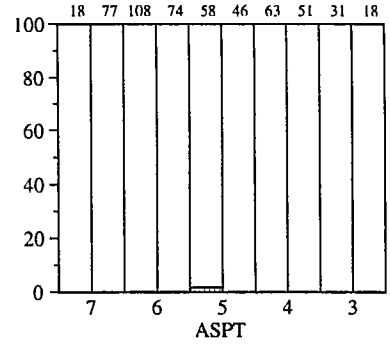
North West Region



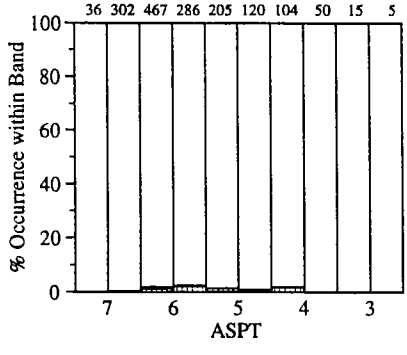
Dales and Ridings Areas
North East Region



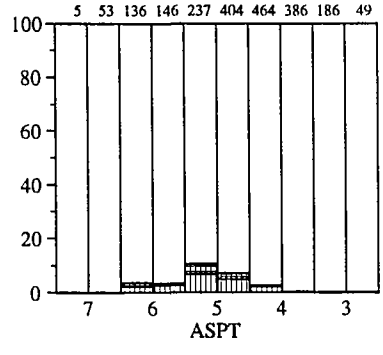
Northumbria Area
North East Region



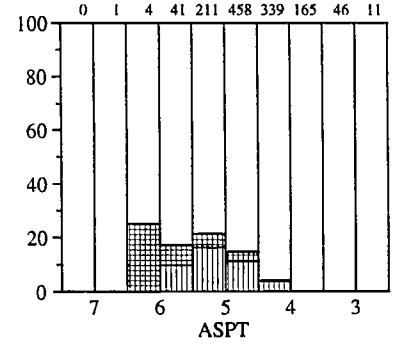
Welsh Region



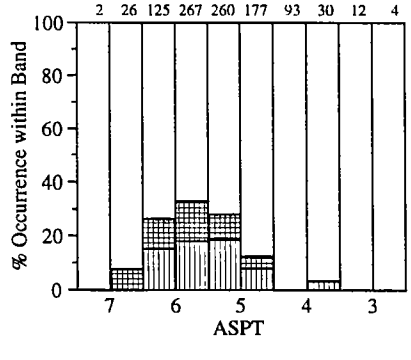
Midlands Region



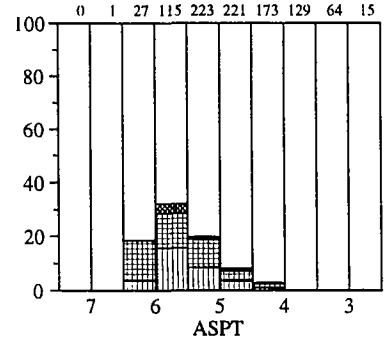
Anglian Region



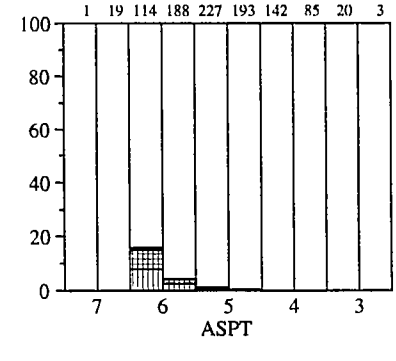
North and South Wessex Areas
South West Region



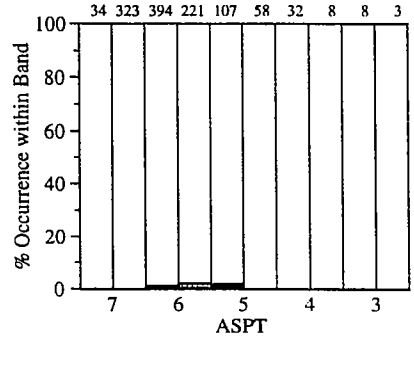
Thames Region



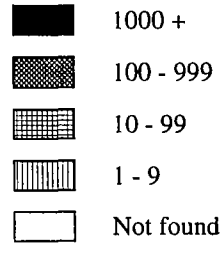
Southern Region



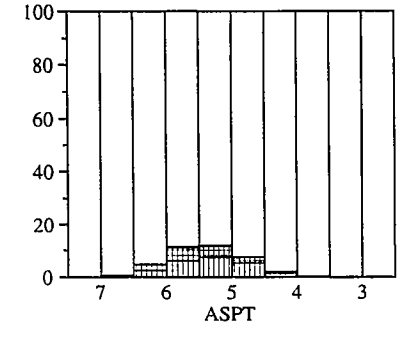
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



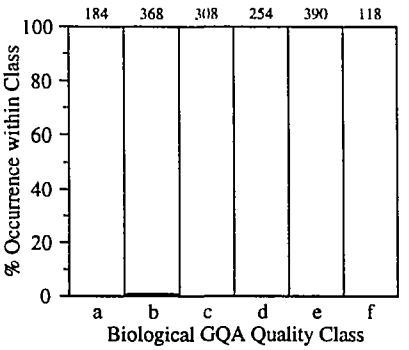
England and Wales
National Distribution



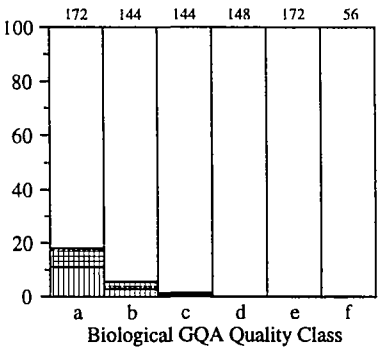
Regional Frequency Distributions by Class - River Sites 1995

NERITIDAE

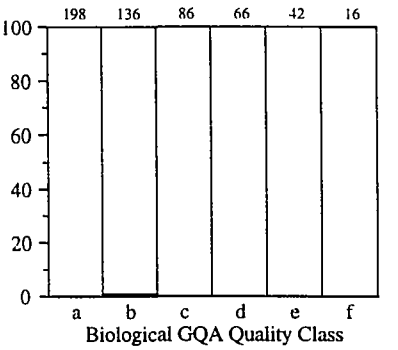
North West Region



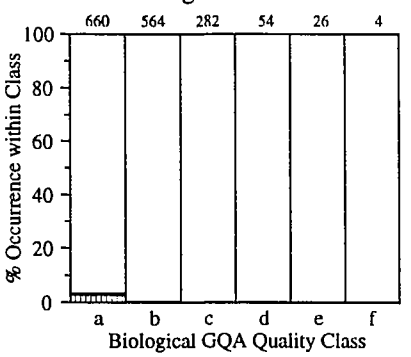
Dales and Ridings Areas
North East Region



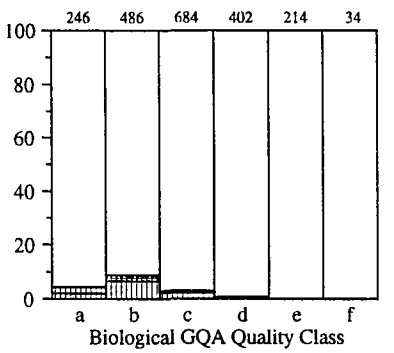
Northumbria Area
North East Region



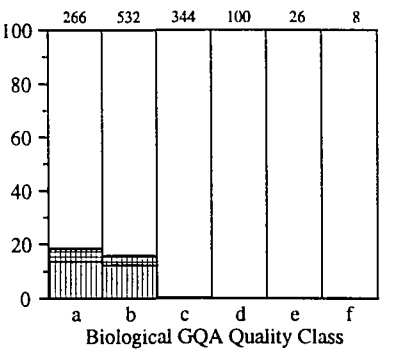
Welsh Region



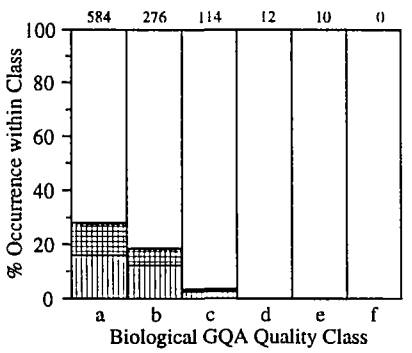
Midlands Region



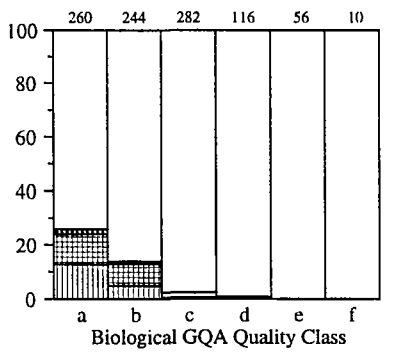
Anglian Region



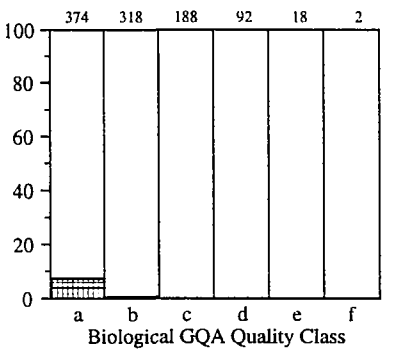
North and South Wessex Areas
South West Region



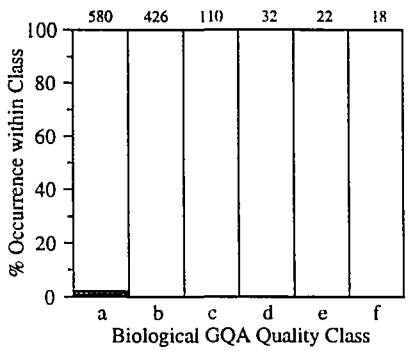
Thames Region



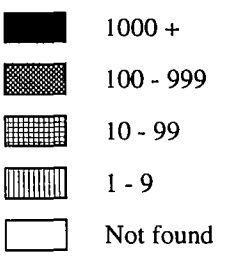
Southern Region



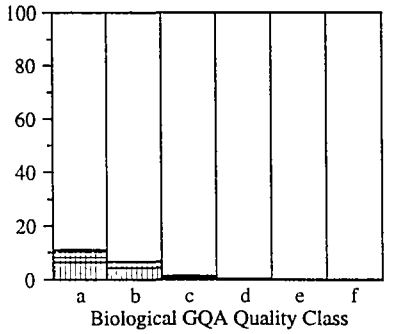
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

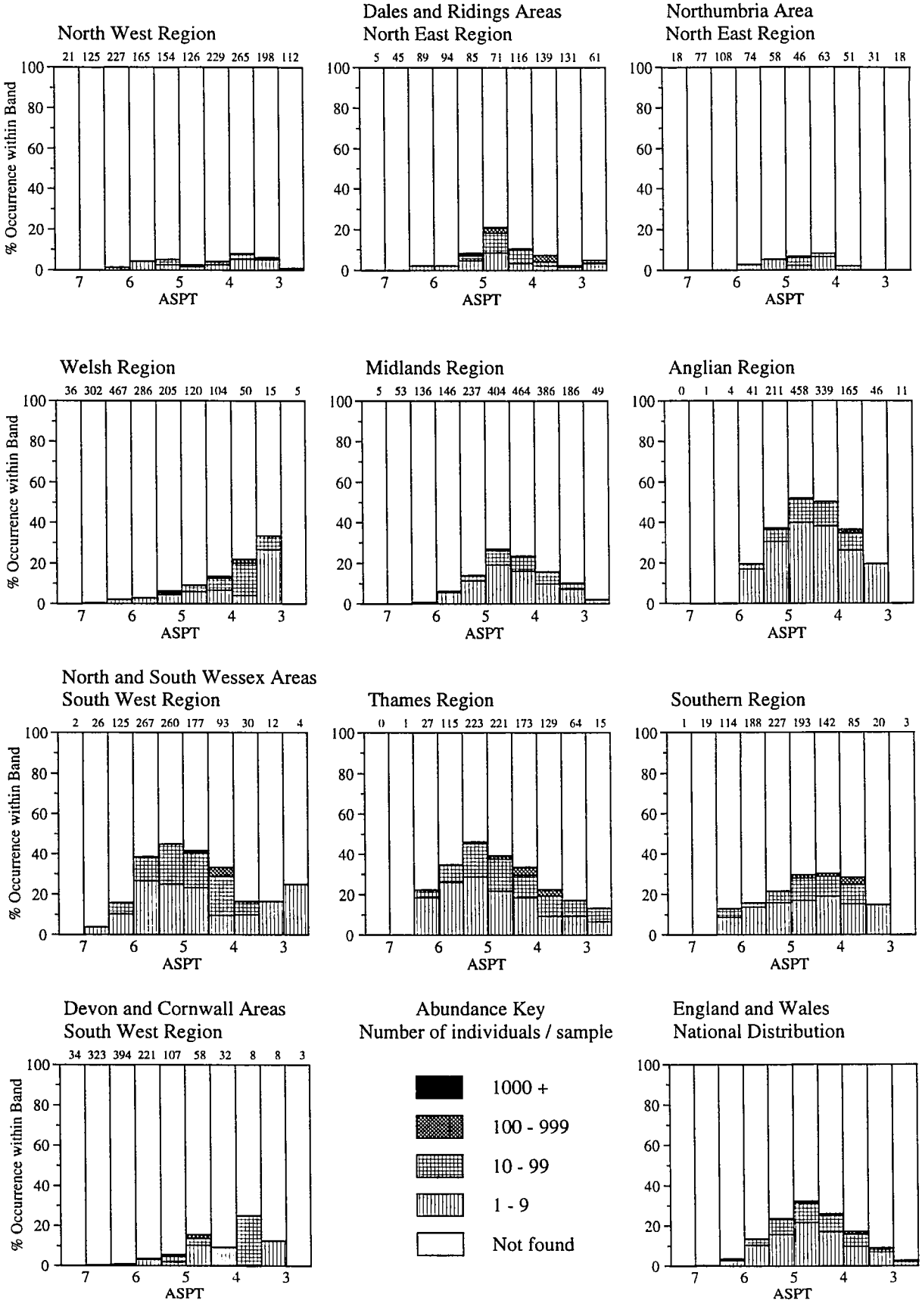


England and Wales
National Distribution



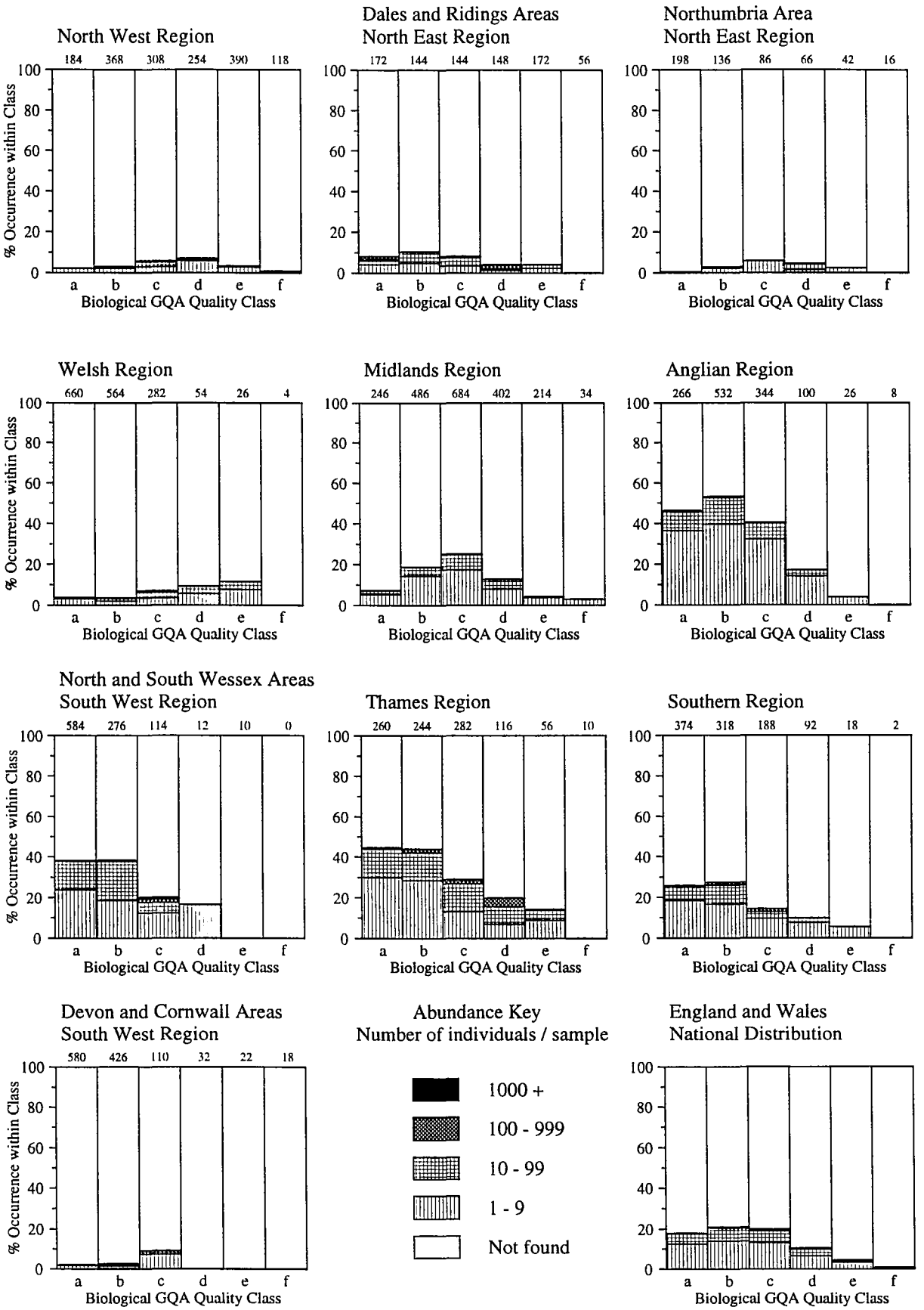
Regional Frequency Distributions by ASPT - River Sites 1995

VALVATIDAE



Regional Frequency Distributions by Class - River Sites 1995

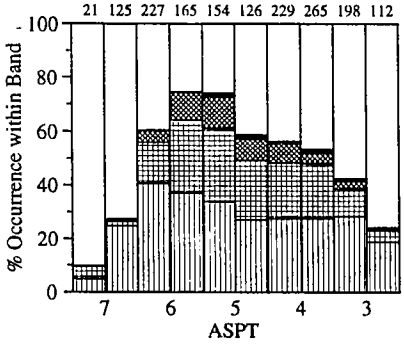
VALVATIDAE



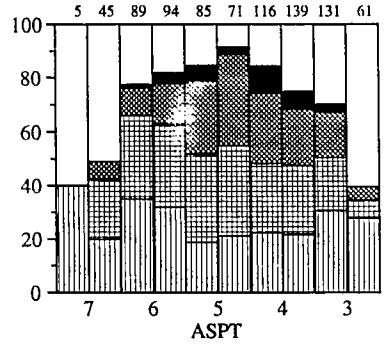
Regional Frequency Distributions by ASPT - River Sites 1995

HYDROBIIDAE

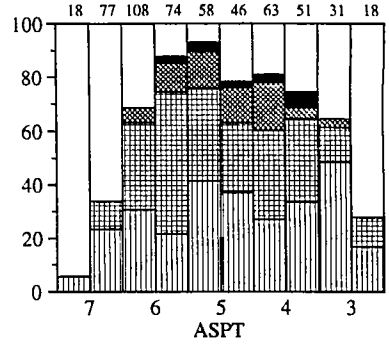
North West Region



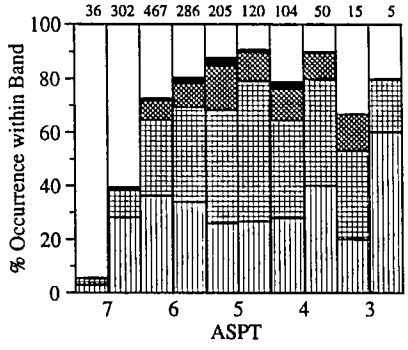
Dales and Ridings Areas
North East Region



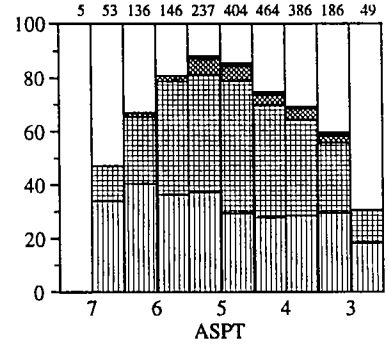
Northumbria Area
North East Region



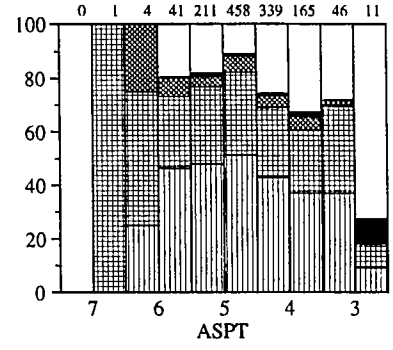
Welsh Region



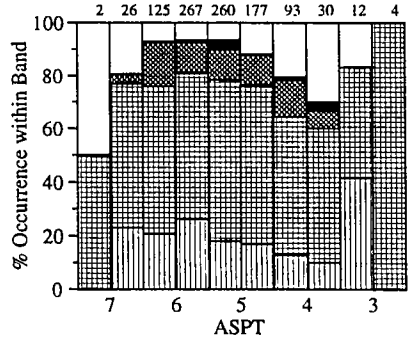
Midlands Region



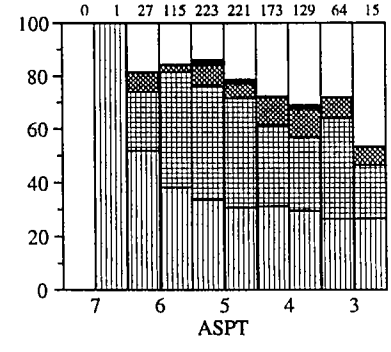
Anglian Region



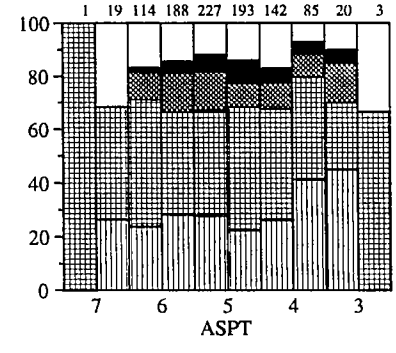
North and South Wessex Areas
South West Region



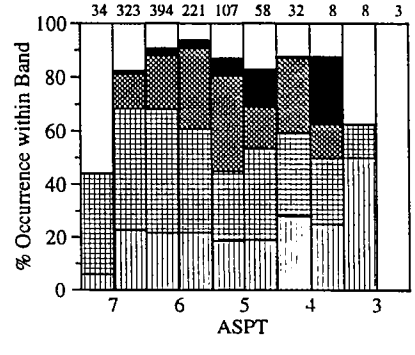
Thames Region



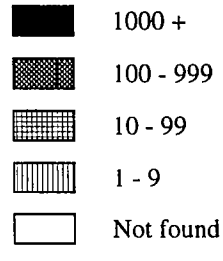
Southern Region



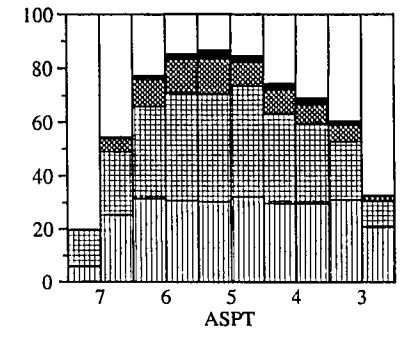
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



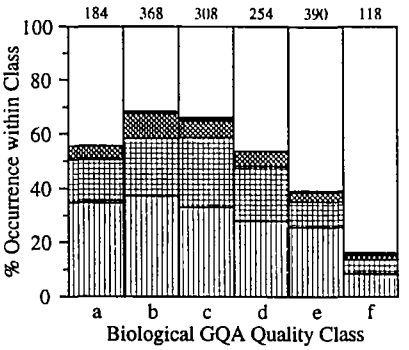
England and Wales
National Distribution



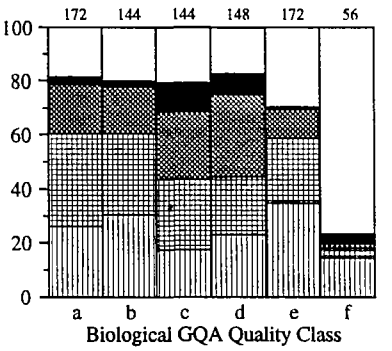
Regional Frequency Distributions by Class - River Sites 1995

HYDROBIIDAE

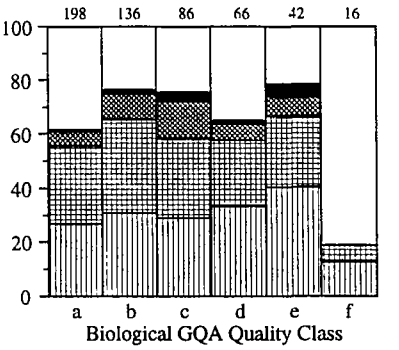
North West Region



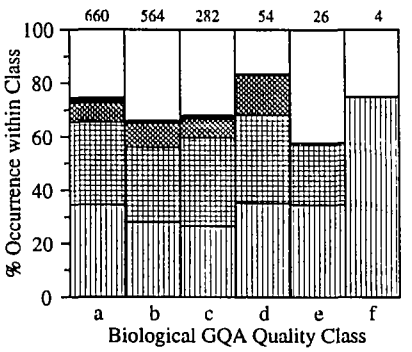
Dales and Ridings Areas
North East Region



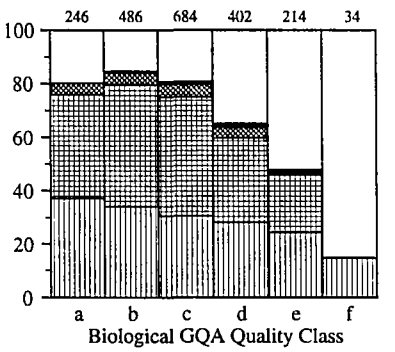
Northumbria Area
North East Region



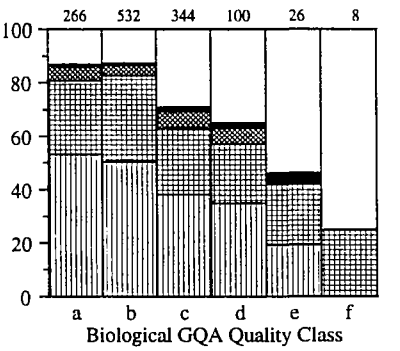
Welsh Region



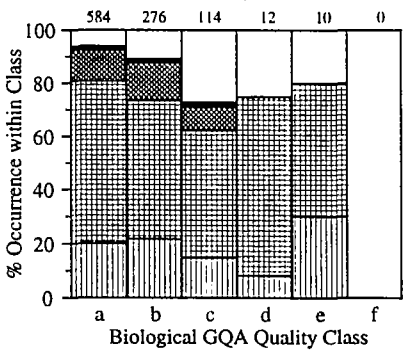
Midlands Region



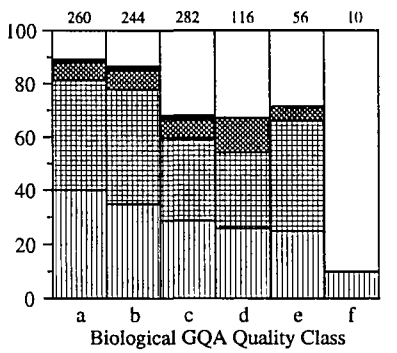
Anglian Region



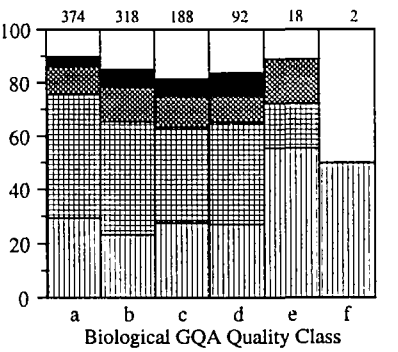
North and South Wessex Areas
South West Region



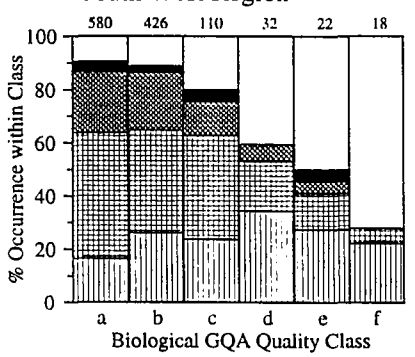
Thames Region



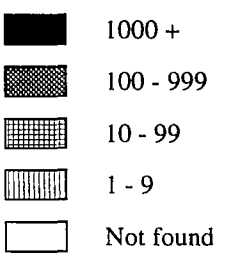
Southern Region



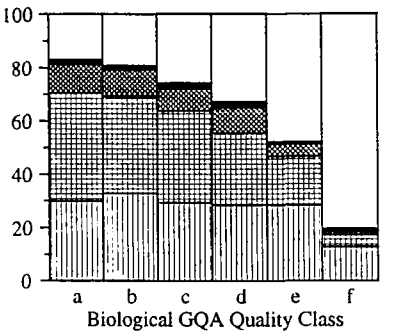
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



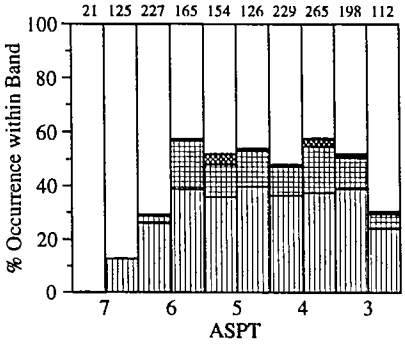
England and Wales
National Distribution



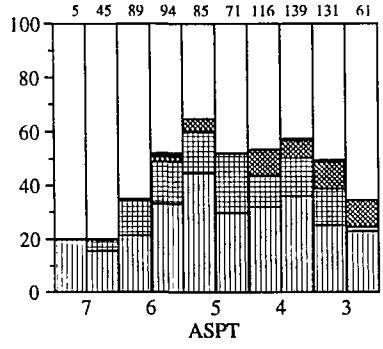
Regional Frequency Distributions by ASPT - River Sites 1995

LYMNAEIDAE

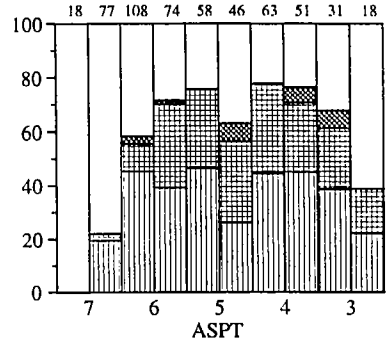
North West Region



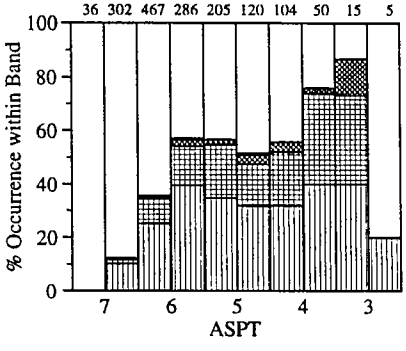
Dales and Ridings Areas
North East Region



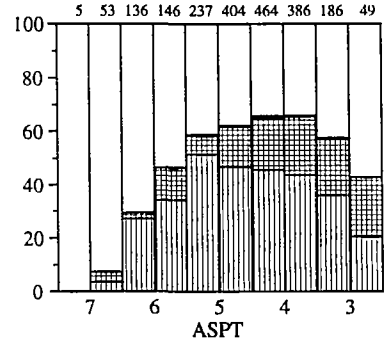
Northumbria Area
North East Region



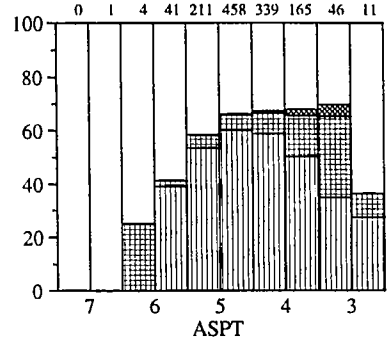
Welsh Region



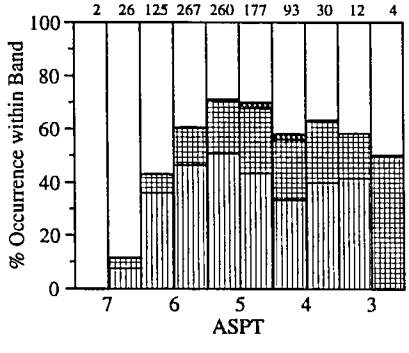
Midlands Region



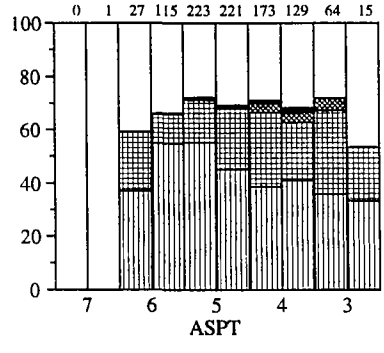
Anglian Region



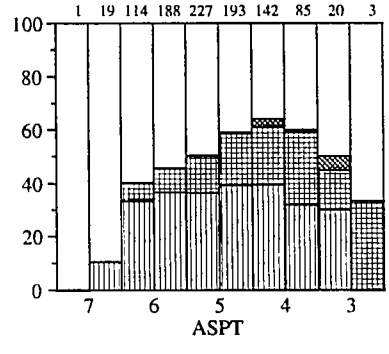
North and South Wessex Areas
South West Region



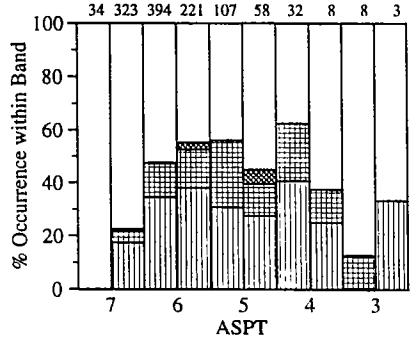
Thames Region



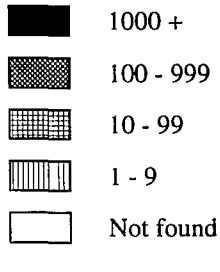
Southern Region



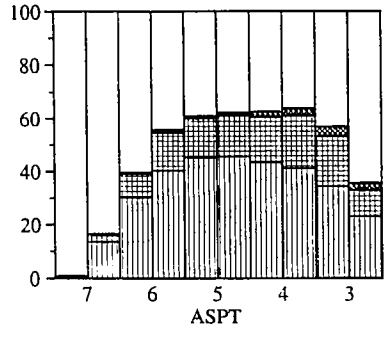
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



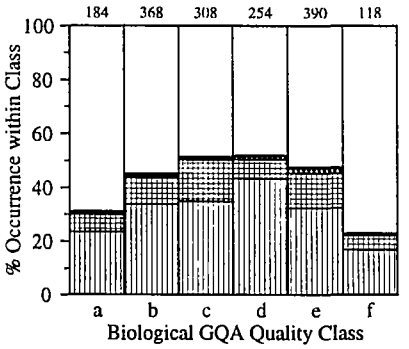
England and Wales
National Distribution



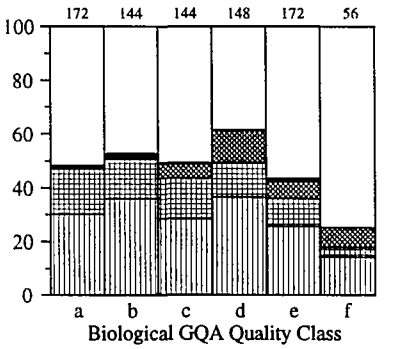
Regional Frequency Distributions by Class - River Sites 1995

LYMNAEIDAE

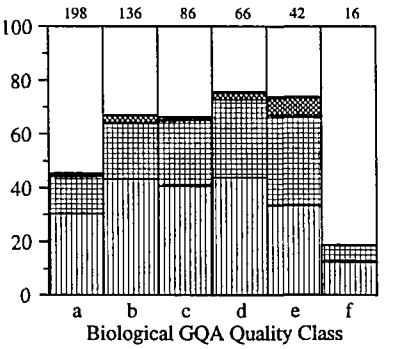
North West Region



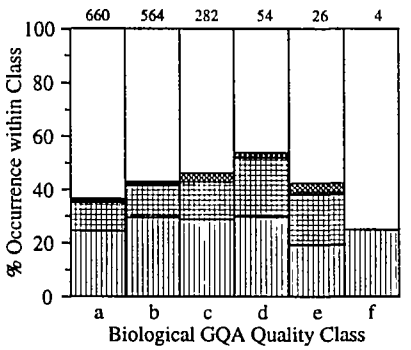
Dales and Ridings Areas
North East Region



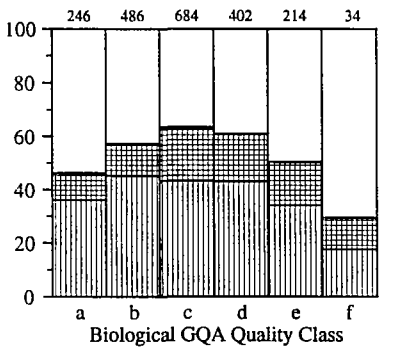
Northumbria Area
North East Region



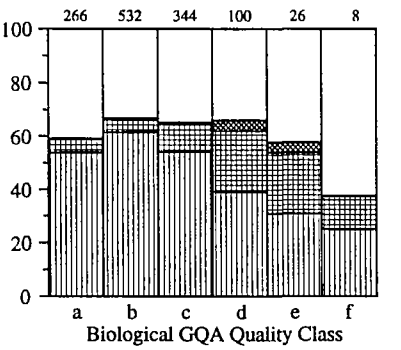
Welsh Region



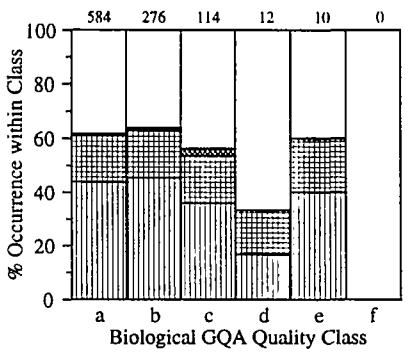
Midlands Region



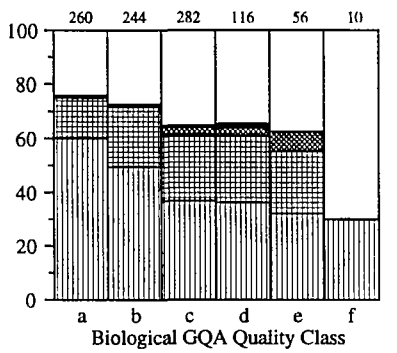
Anglian Region



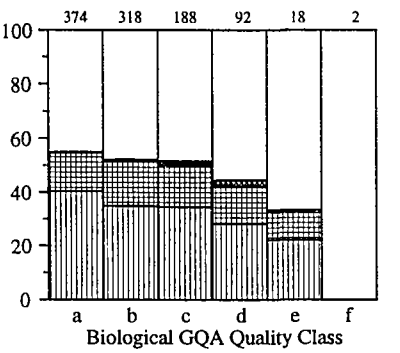
North and South Wessex Areas
South West Region



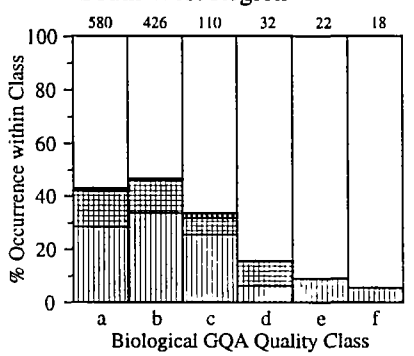
Thames Region



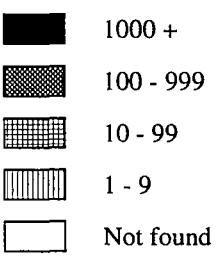
Southern Region



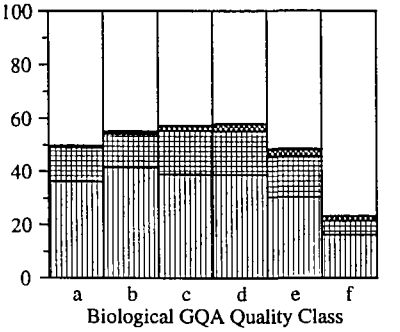
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



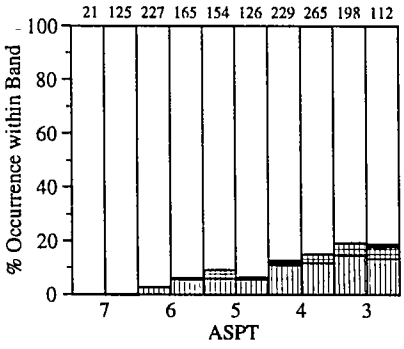
England and Wales
National Distribution



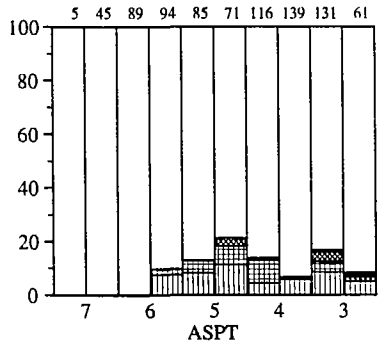
Regional Frequency Distributions by ASPT - River Sites 1995

PHYSIDAE

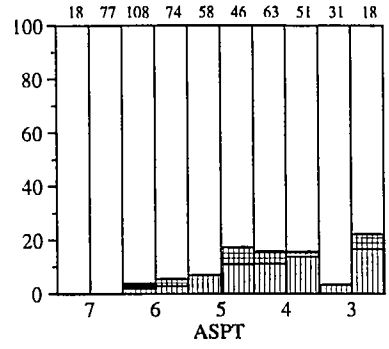
North West Region



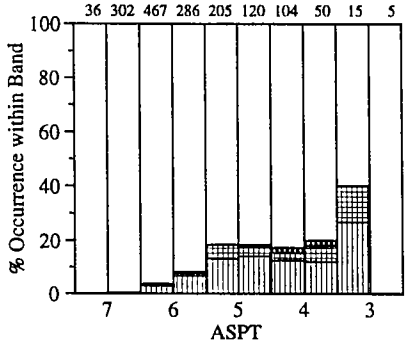
Dales and Ridings Areas
North East Region



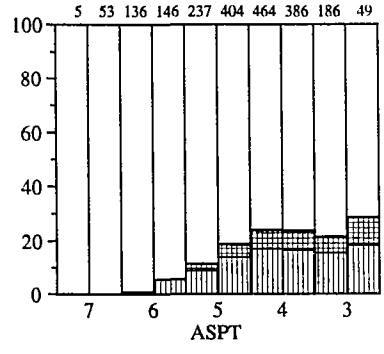
Northumbria Area
North East Region



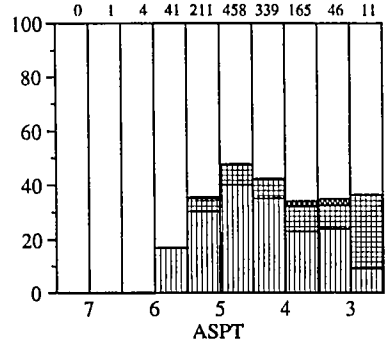
Welsh Region



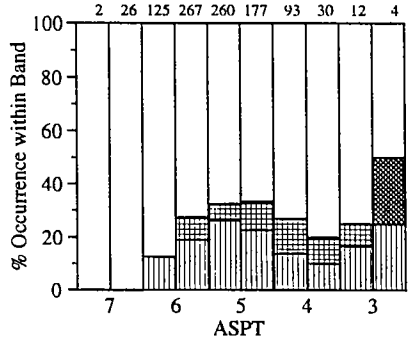
Midlands Region



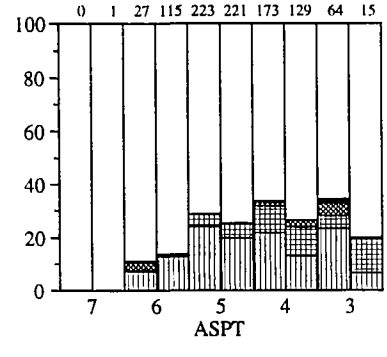
Anglian Region



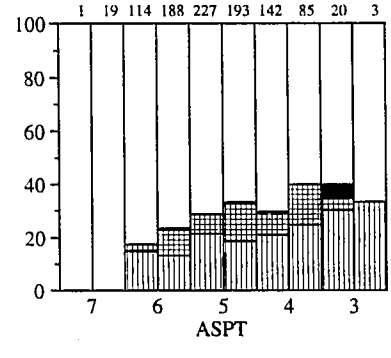
North and South Wessex Areas
South West Region



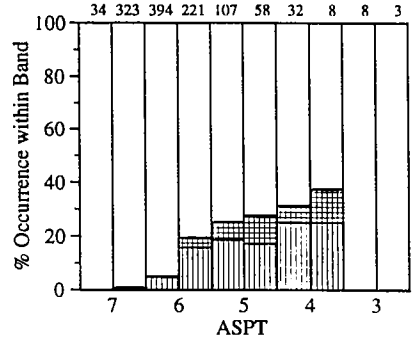
Thames Region



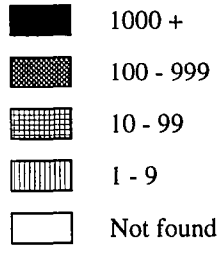
Southern Region



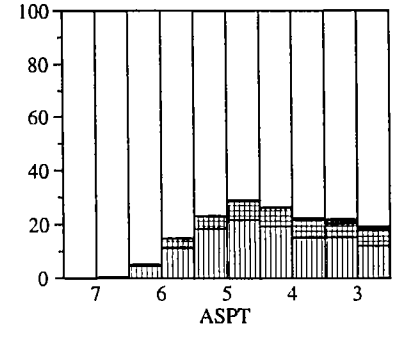
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



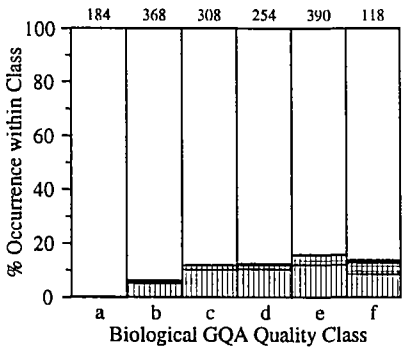
England and Wales
National Distribution



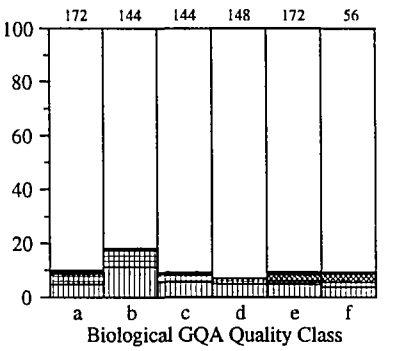
Regional Frequency Distributions by Class - River Sites 1995

PHYSIDAE

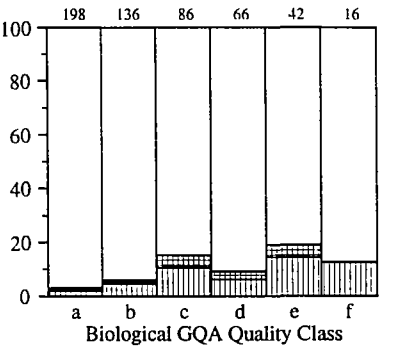
North West Region



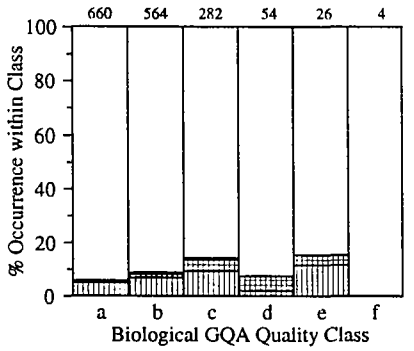
Dales and Ridings Areas
North East Region



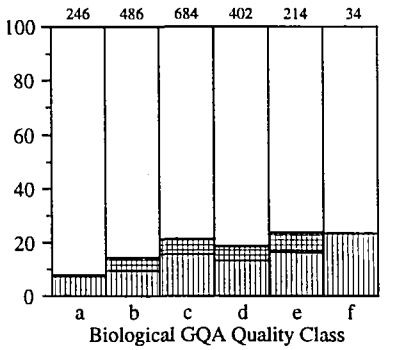
Northumbria Area
North East Region



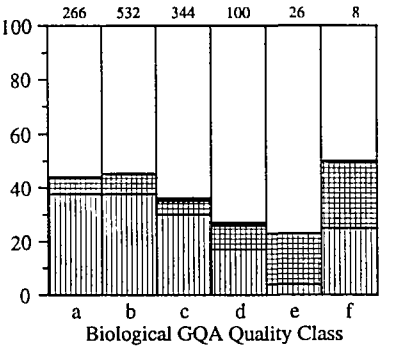
Welsh Region



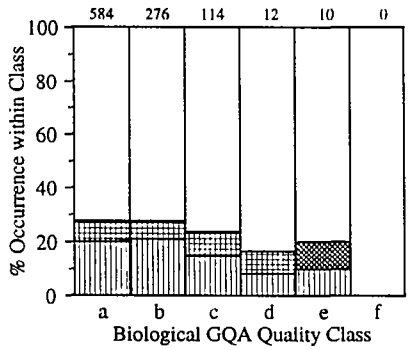
Midlands Region



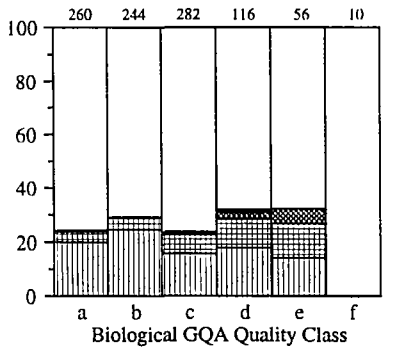
Anglian Region



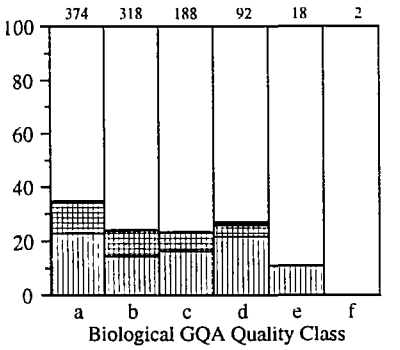
North and South Wessex Areas
South West Region



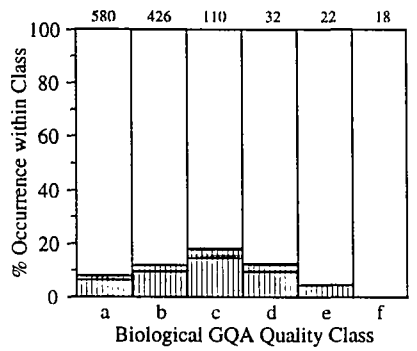
Thames Region



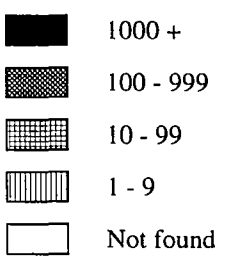
Southern Region



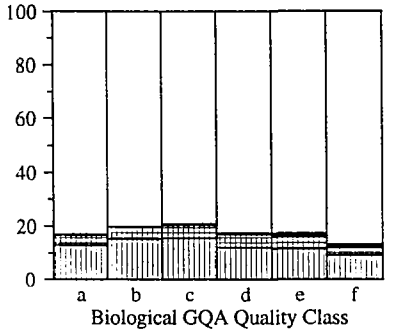
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

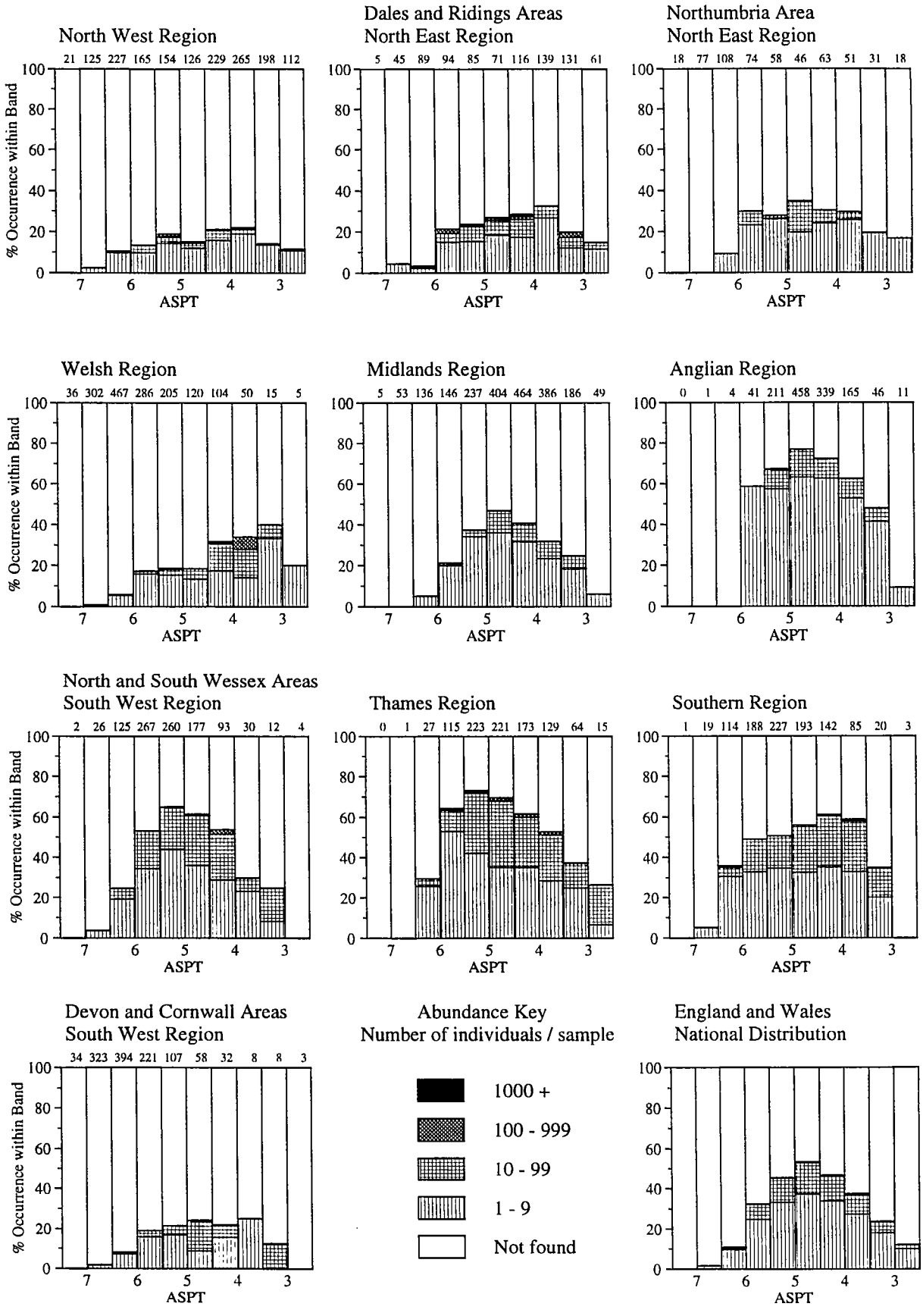


England and Wales
National Distribution



Regional Frequency Distributions by ASPT - River Sites 1995

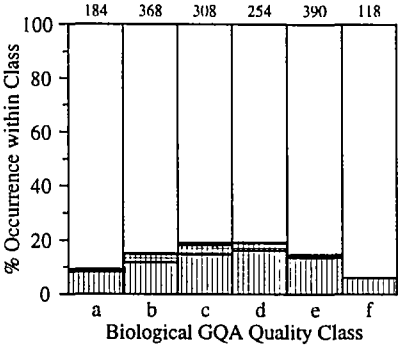
PLANORBIDAE



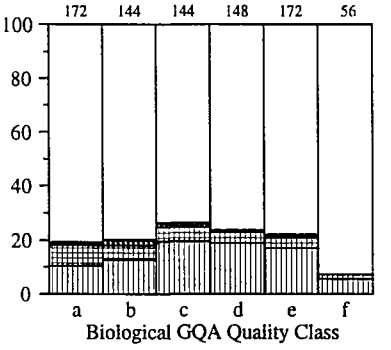
Regional Frequency Distributions by Class - River Sites 1995

PLANORBIDAE

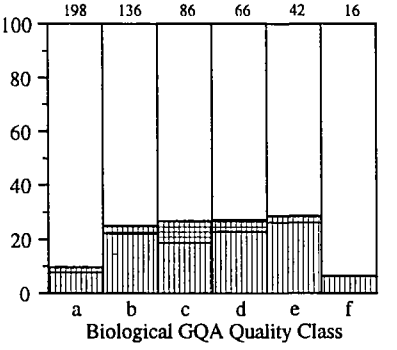
North West Region



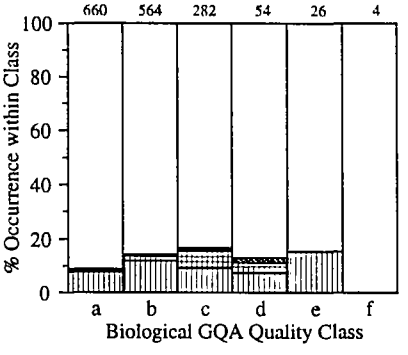
Dales and Ridings Areas
North East Region



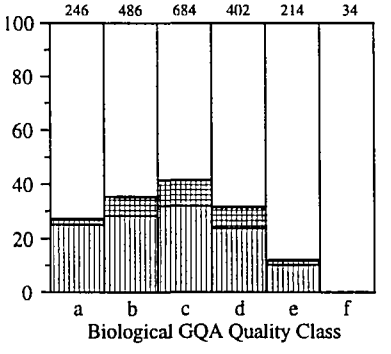
Northumbria Area
North East Region



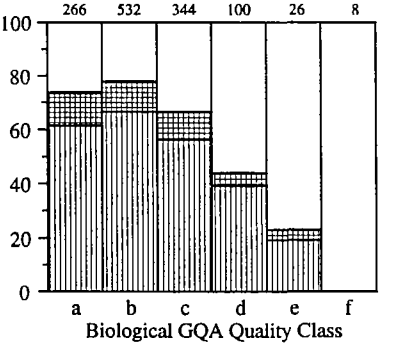
Welsh Region



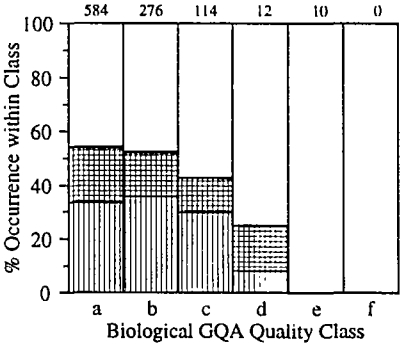
Midlands Region



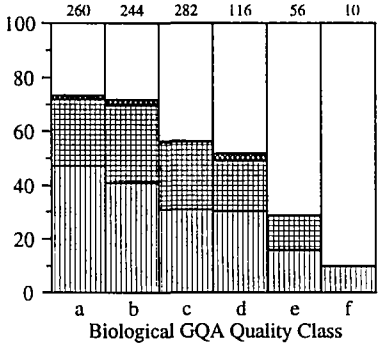
Anglian Region



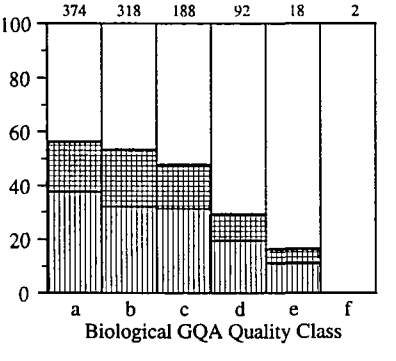
North and South Wessex Areas
South West Region



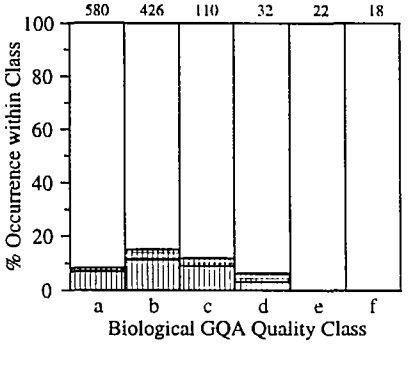
Thames Region



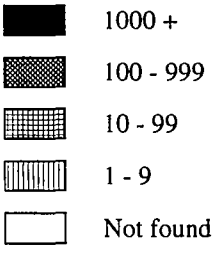
Southern Region



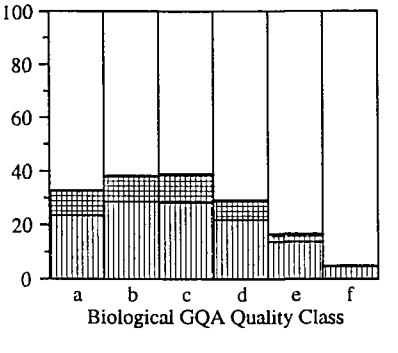
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



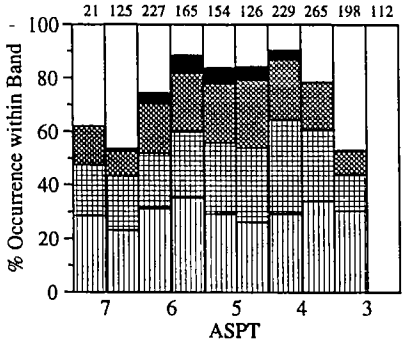
England and Wales
National Distribution



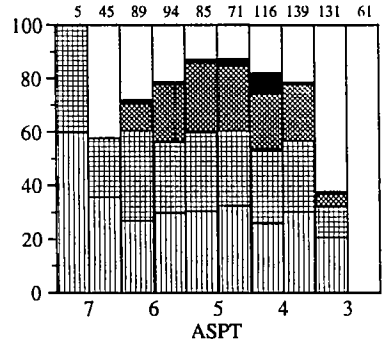
Regional Frequency Distributions by ASPT - River Sites 1995

GAMMARIDAE

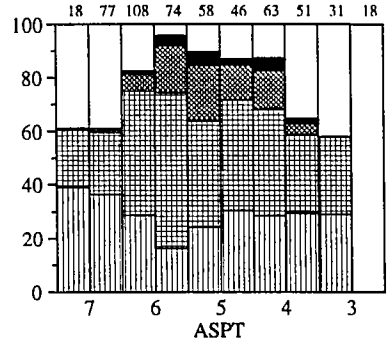
North West Region



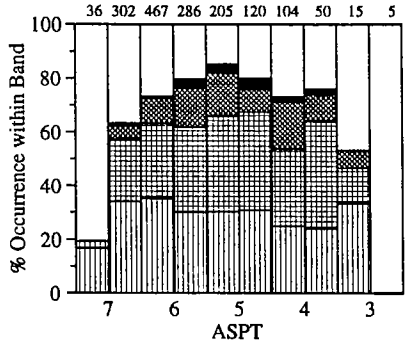
Dales and Ridings Areas
North East Region



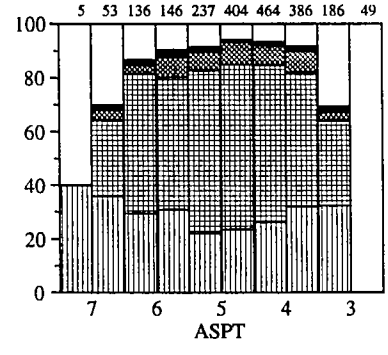
Northumbria Area
North East Region



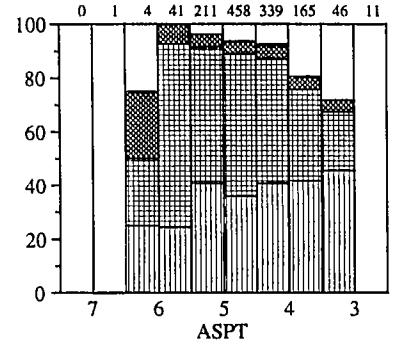
Welsh Region



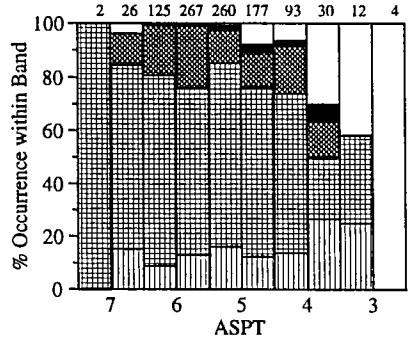
Midlands Region



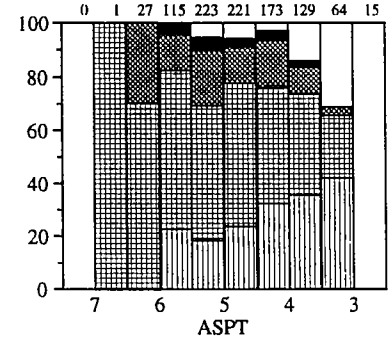
Anglian Region



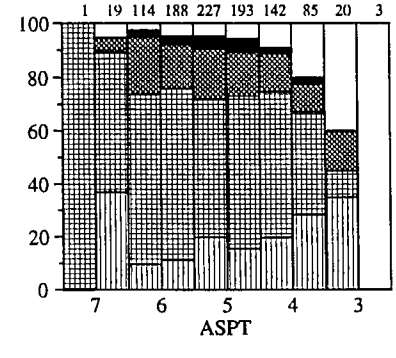
North and South Wessex Areas
South West Region



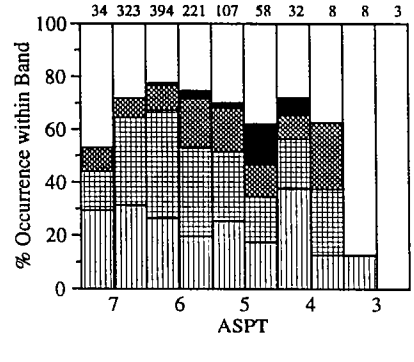
Thames Region



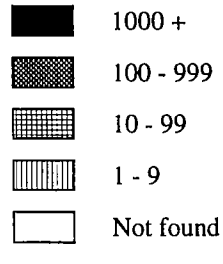
Southern Region



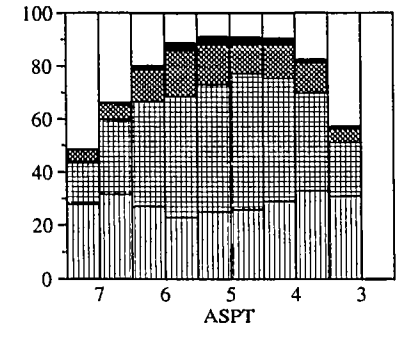
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

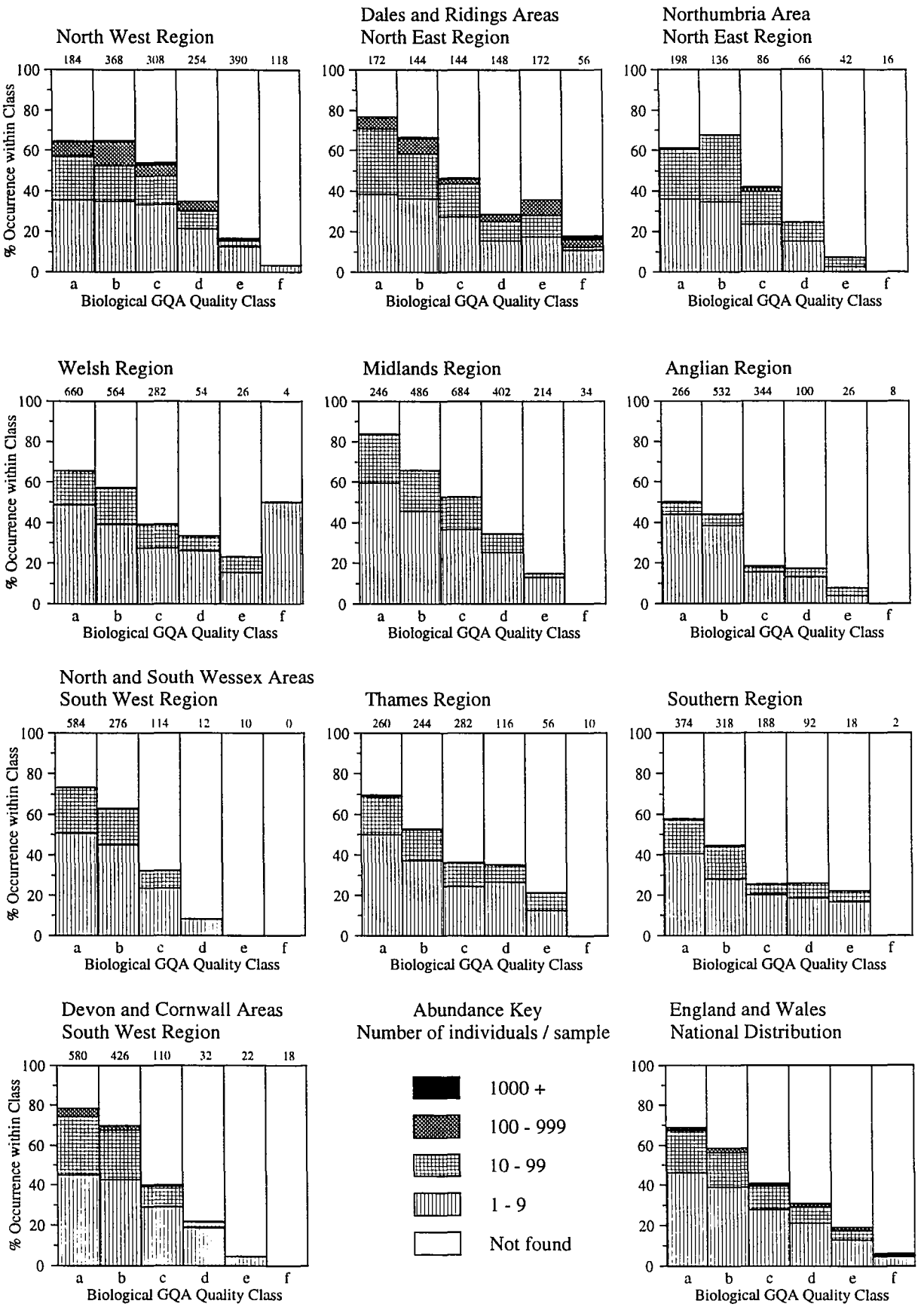


England and Wales
National Distribution



Regional Frequency Distributions by Class - River Sites 1995

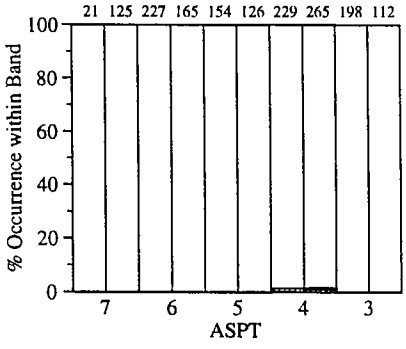
ANCYLIDAE



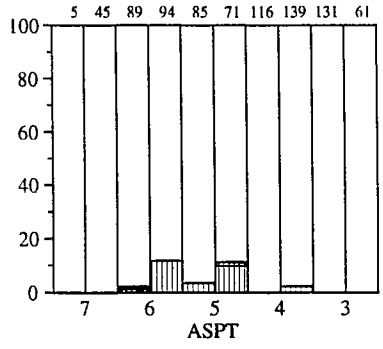
Regional Frequency Distributions by ASPT - River Sites 1995

UNIONIDAE

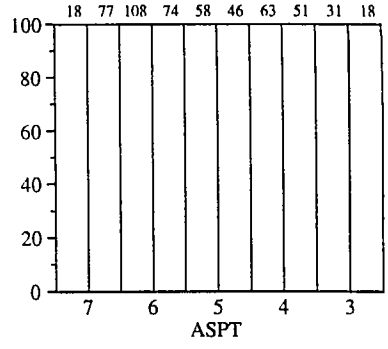
North West Region



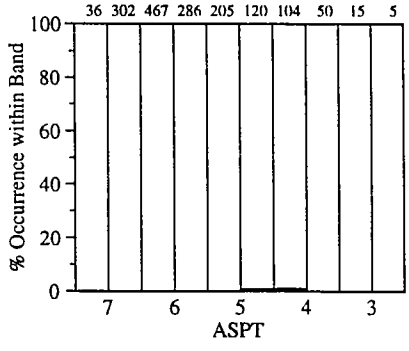
Dales and Ridings Areas
North East Region



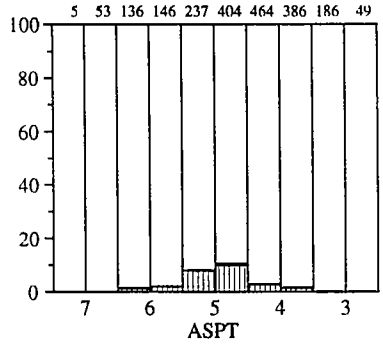
Northumbria Area
North East Region



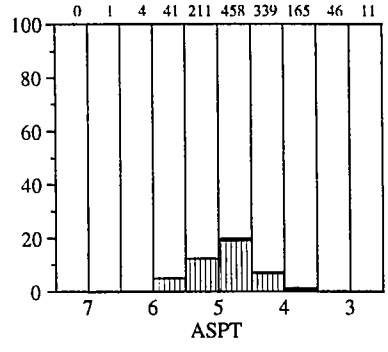
Welsh Region



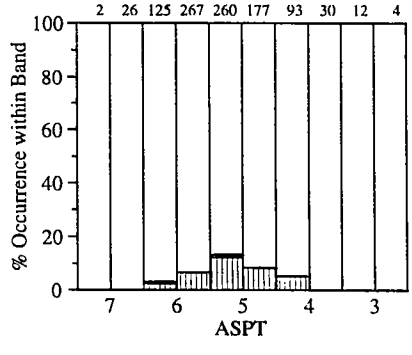
Midlands Region



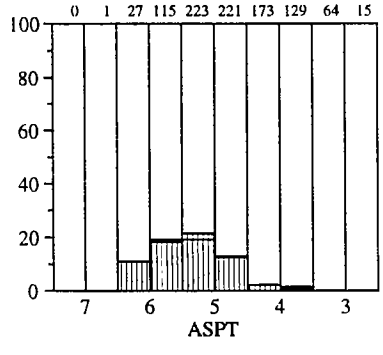
Anglian Region



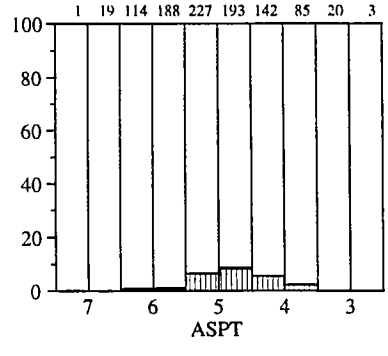
North and South Wessex Areas
South West Region



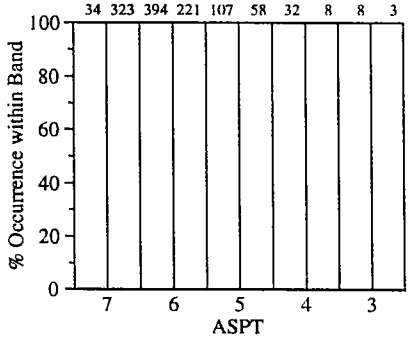
Thames Region



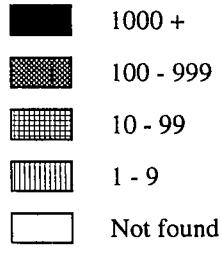
Southern Region



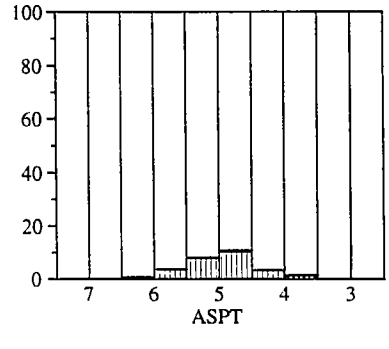
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



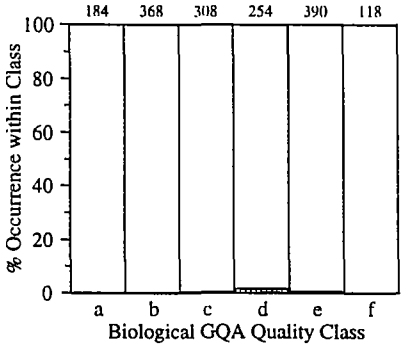
England and Wales
National Distribution



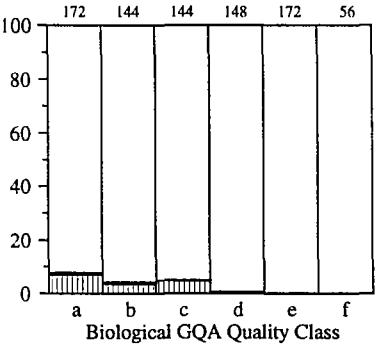
Regional Frequency Distributions by Class - River Sites 1995

UNIONIDAE

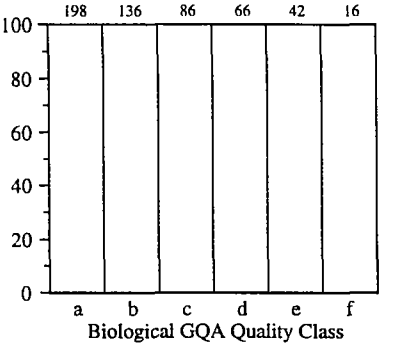
North West Region



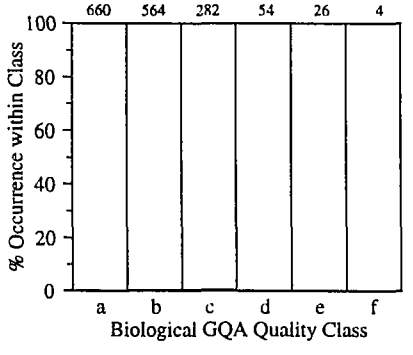
Dales and Ridings Areas
North East Region



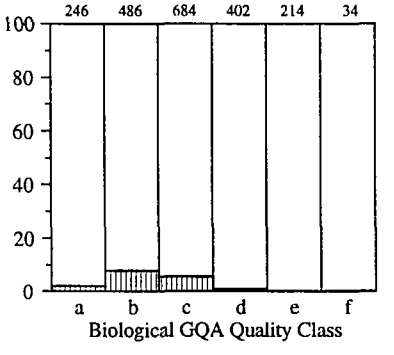
Northumbria Area
North East Region



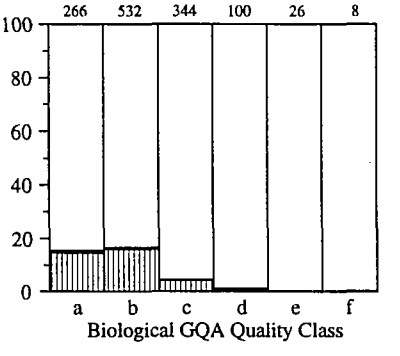
Welsh Region



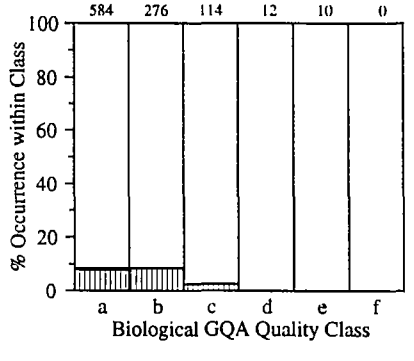
Midlands Region



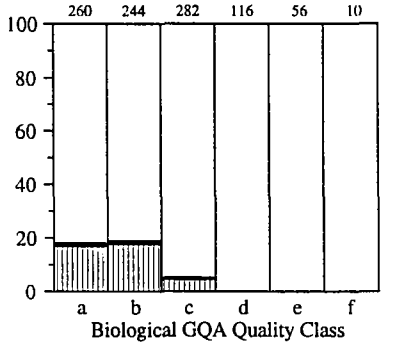
Anglian Region



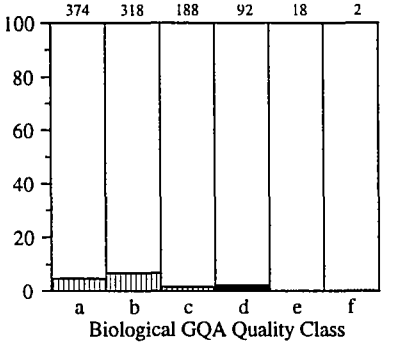
North and South Wessex Areas
South West Region



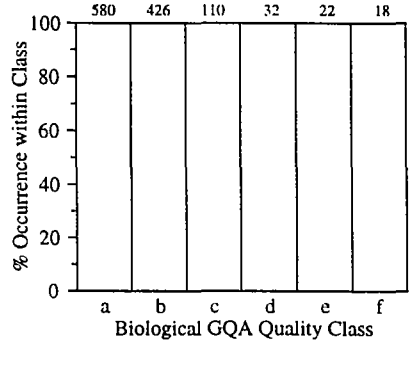
Thames Region



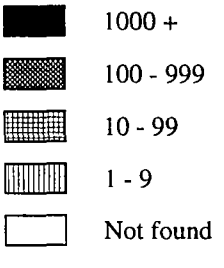
Southern Region



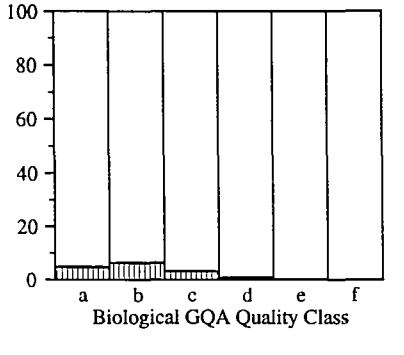
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



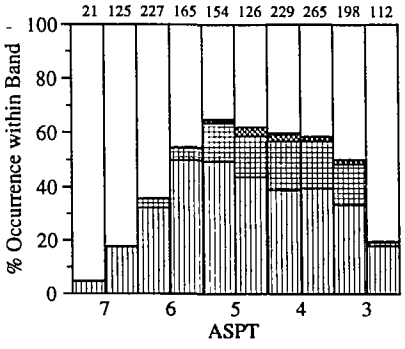
England and Wales
National Distribution



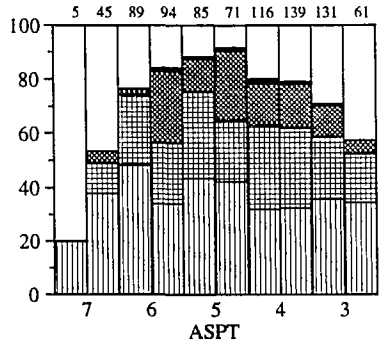
Regional Frequency Distributions by ASPT - River Sites 1995

SPHAERIIDAE

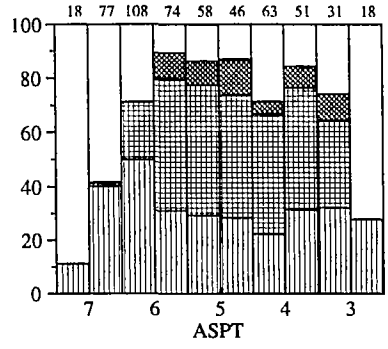
North West Region



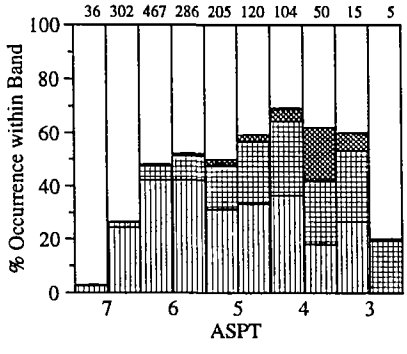
Dales and Ridings Areas
North East Region



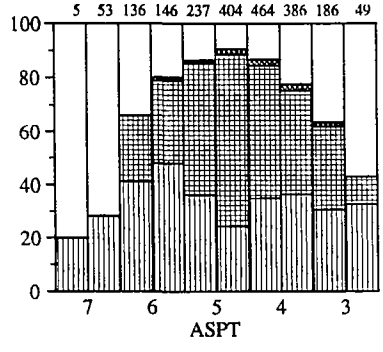
Northumbria Area
North East Region



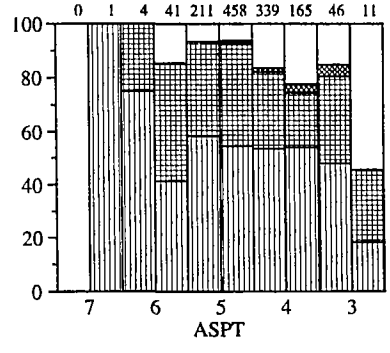
Welsh Region



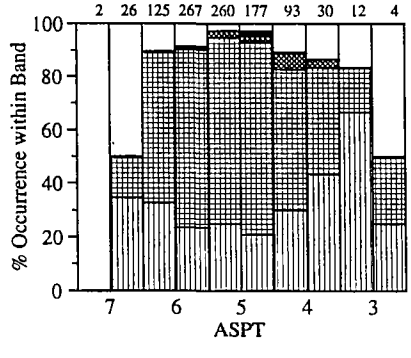
Midlands Region



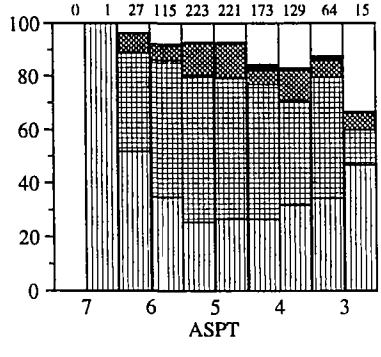
Anglian Region



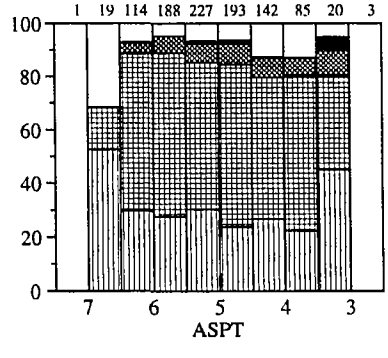
North and South Wessex Areas
South West Region



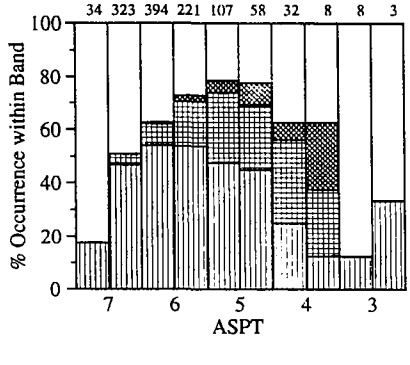
Thames Region



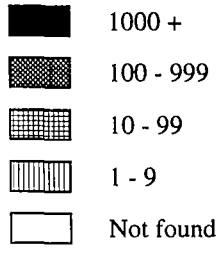
Southern Region



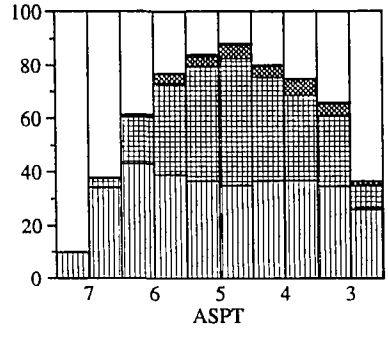
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

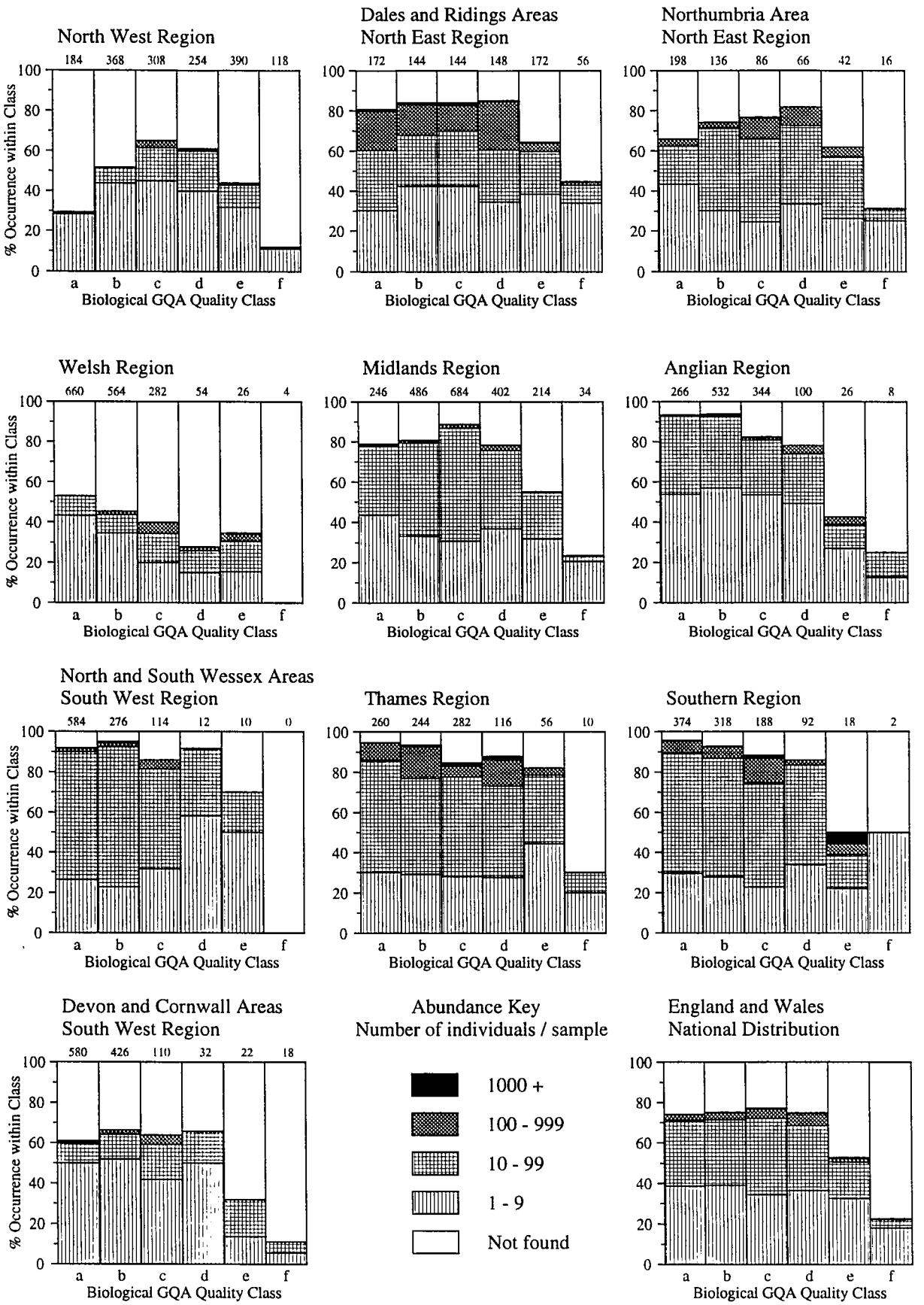


England and Wales
National Distribution



Regional Frequency Distributions by Class - River Sites 1995

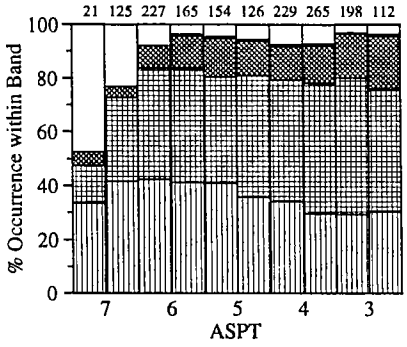
SPHAERIIDAE



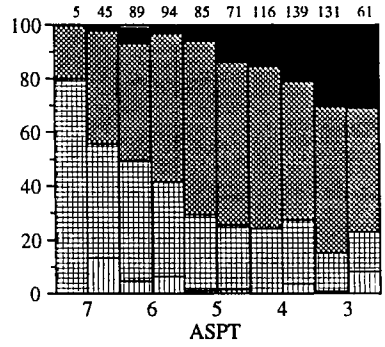
Regional Frequency Distributions by ASPT - River Sites 1995

OLIGOCHAETA

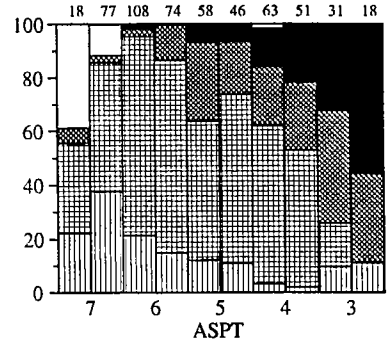
North West Region



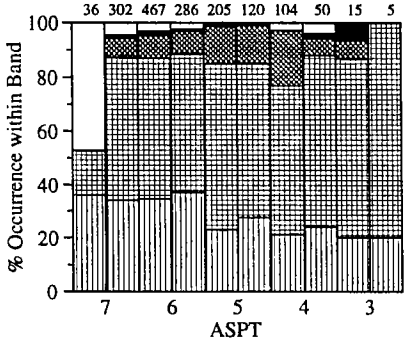
Dales and Ridings Areas
North East Region



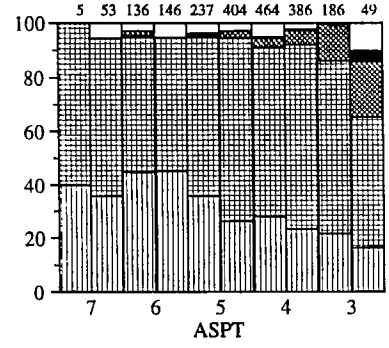
Northumbria Area
North East Region



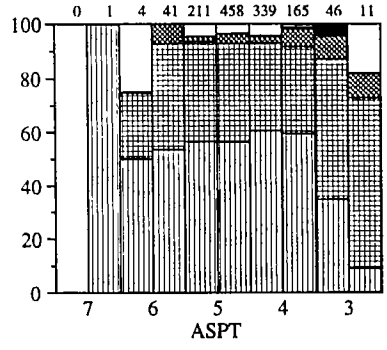
Welsh Region



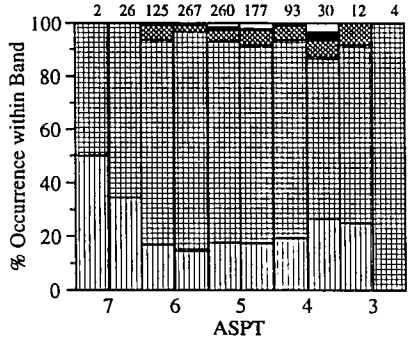
Midlands Region



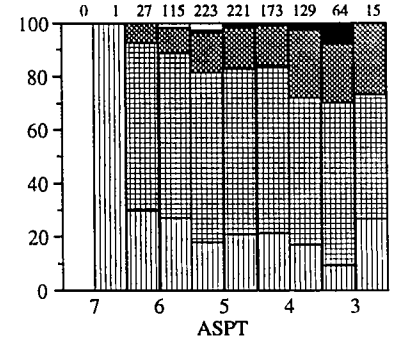
Anglian Region



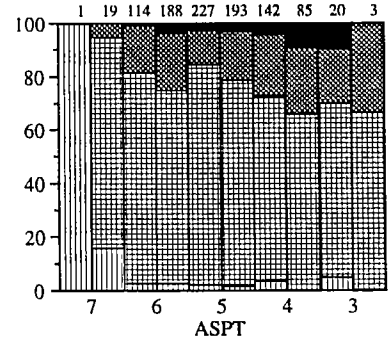
North and South Wessex Areas
South West Region



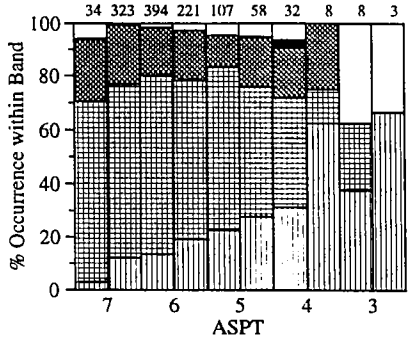
Thames Region



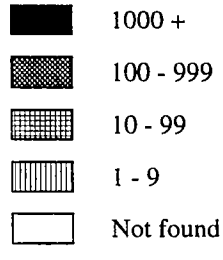
Southern Region



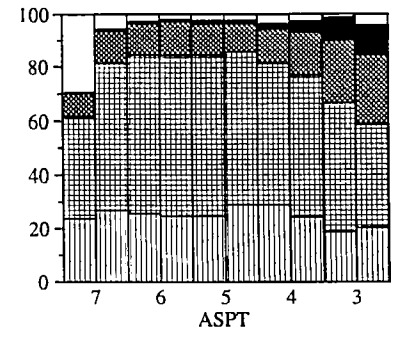
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



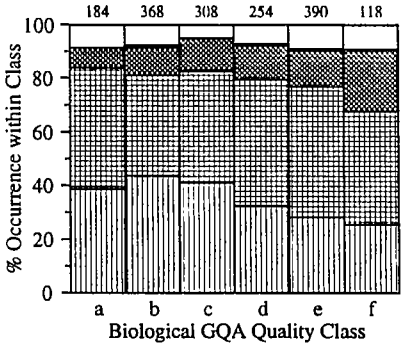
England and Wales
National Distribution



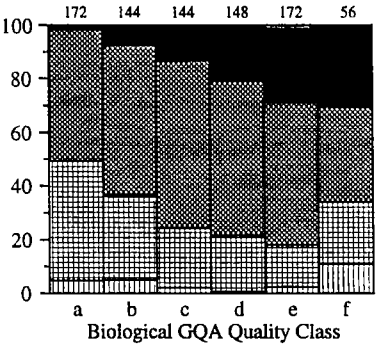
Regional Frequency Distributions by Class - River Sites 1995

OLIGOCHAETA

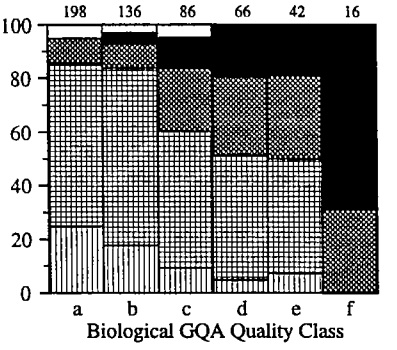
North West Region



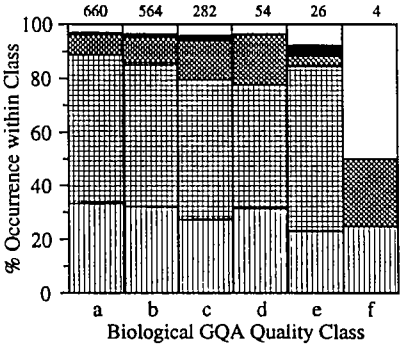
Dales and Ridings Areas
North East Region



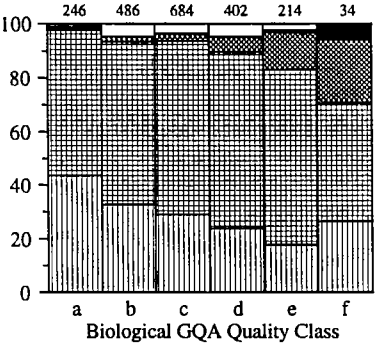
Northumbria Area
North East Region



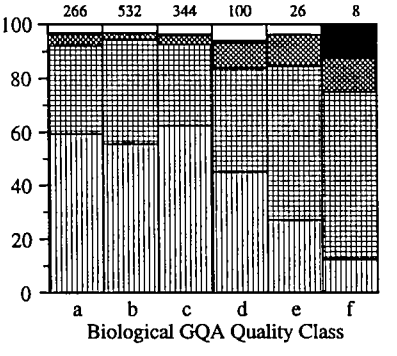
Welsh Region



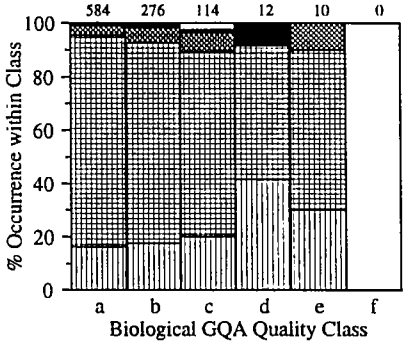
Midlands Region



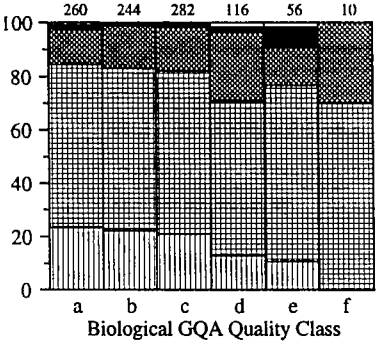
Anglian Region



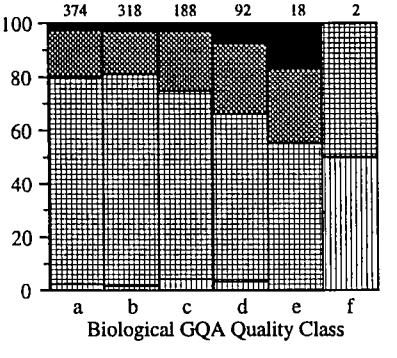
North and South Wessex Areas
South West Region



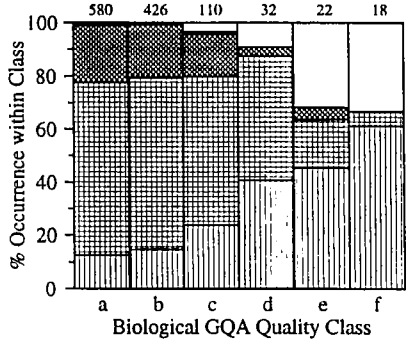
Thames Region



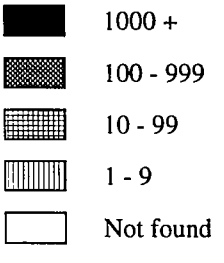
Southern Region



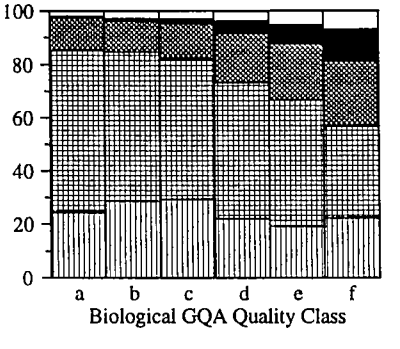
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



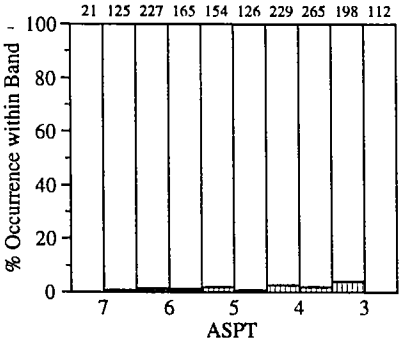
England and Wales
National Distribution



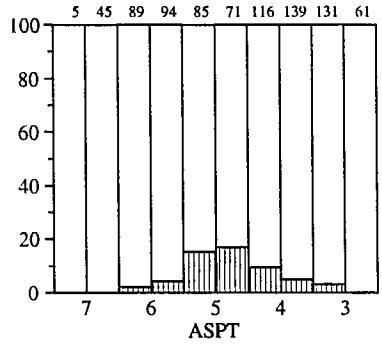
Regional Frequency Distributions by ASPT - River Sites 1995

PISCICOLIDAE

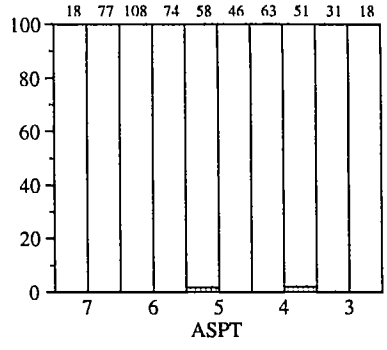
North West Region



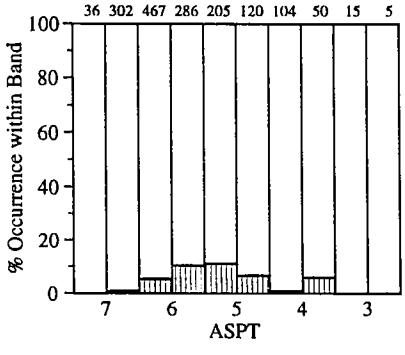
Dales and Ridings Areas
North East Region



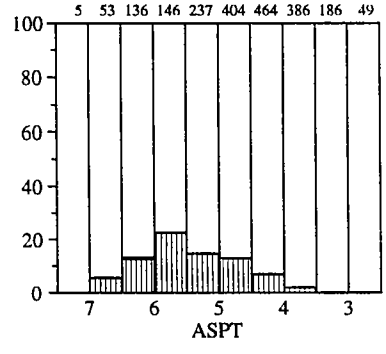
Northumbria Area
North East Region



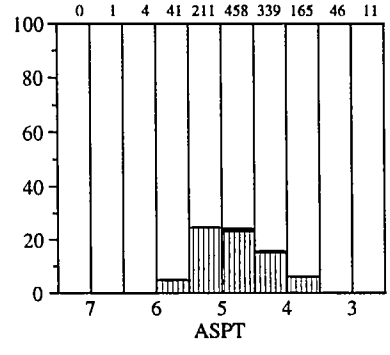
Welsh Region



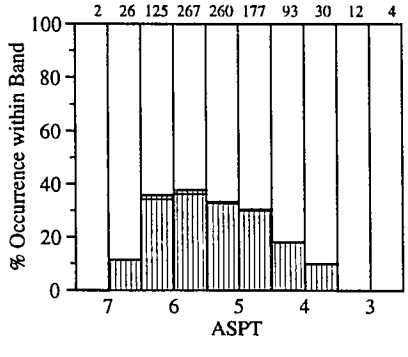
Midlands Region



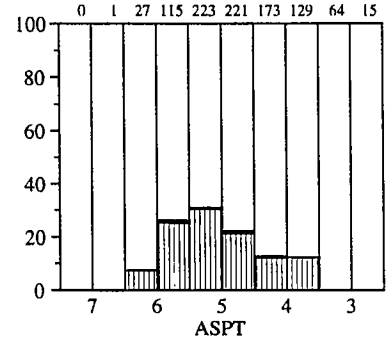
Anglian Region



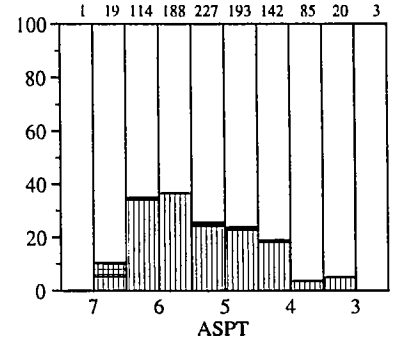
North and South Wessex Areas
South West Region



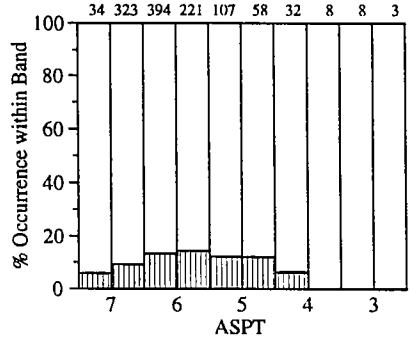
Thames Region



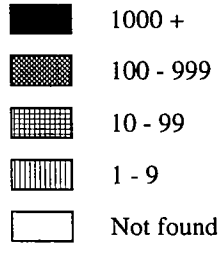
Southern Region



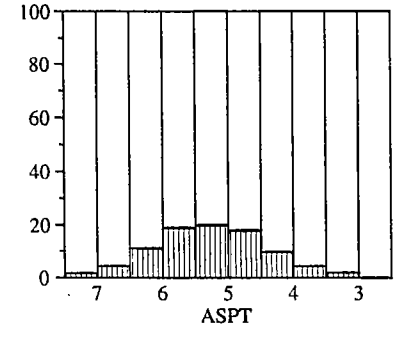
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

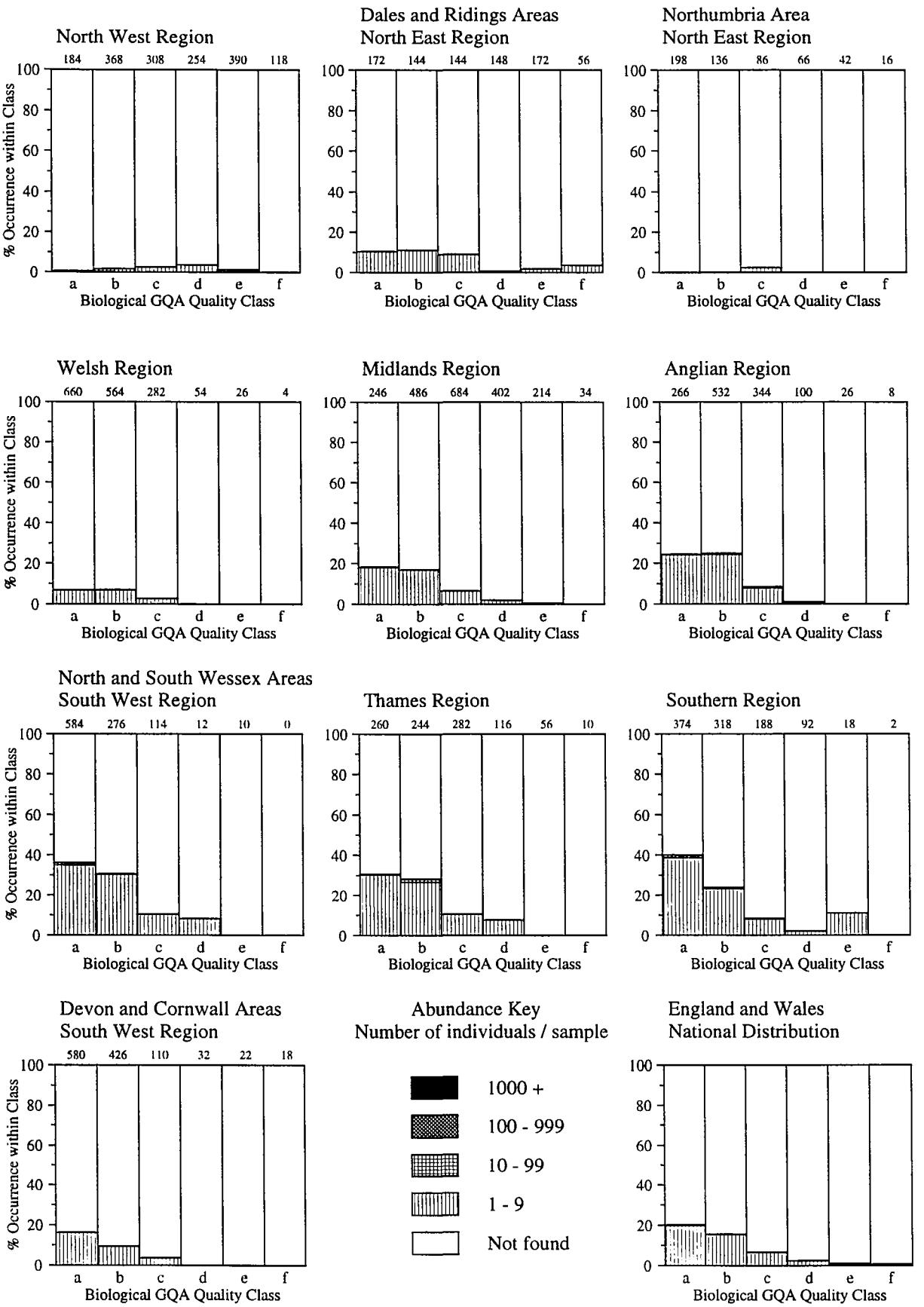


England and Wales
National Distribution



Regional Frequency Distributions by Class - River Sites 1995

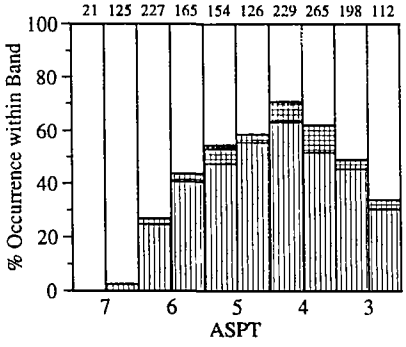
PISCICOLIDAE



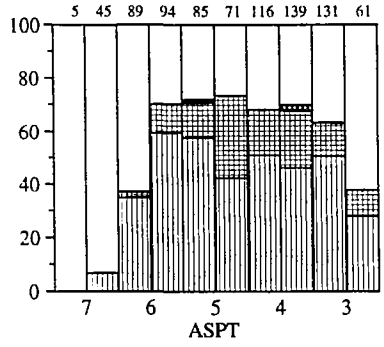
Regional Frequency Distributions by ASPT - River Sites 1995

GLOSSIPHONIIDAE

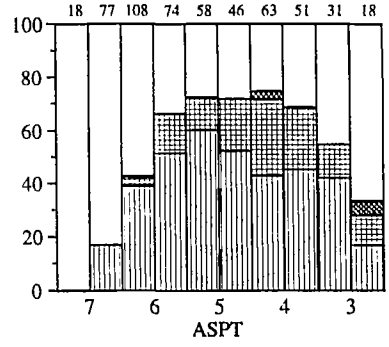
North West Region



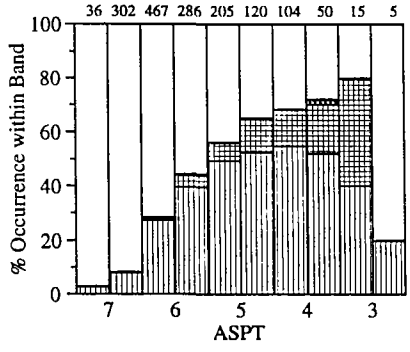
Dales and Ridings Areas
North East Region



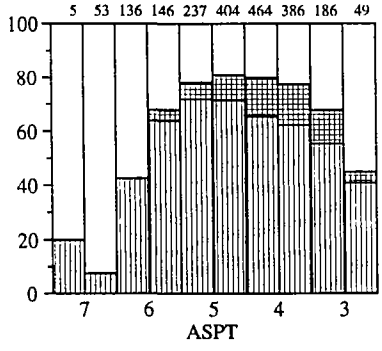
Northumbria Area
North East Region



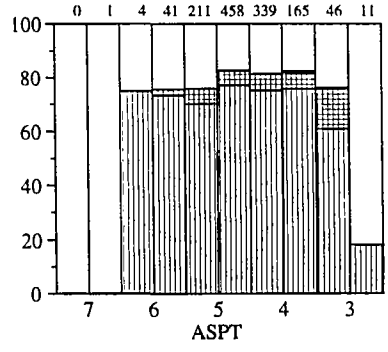
Welsh Region



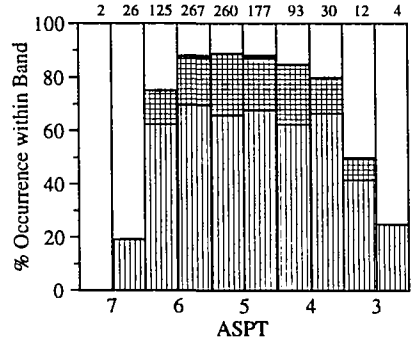
Midlands Region



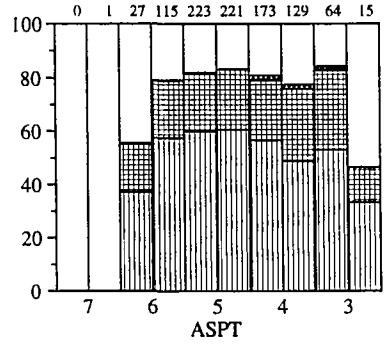
Anglian Region



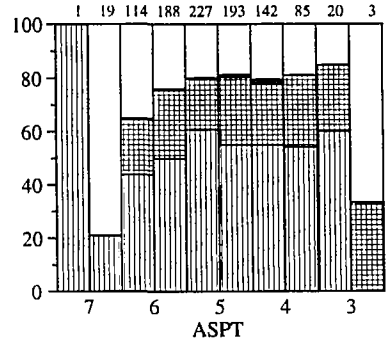
North and South Wessex Areas
South West Region



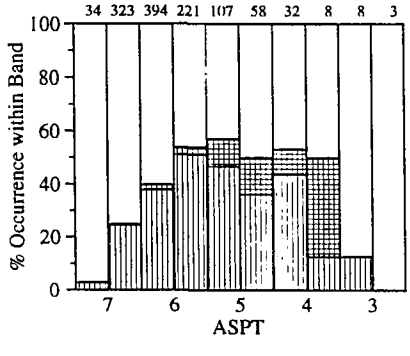
Thames Region



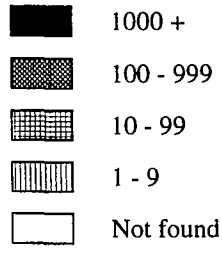
Southern Region



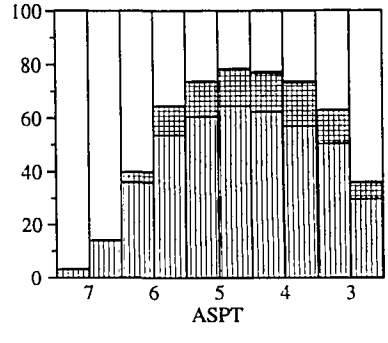
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



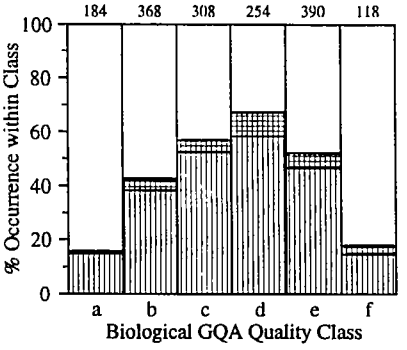
England and Wales
National Distribution



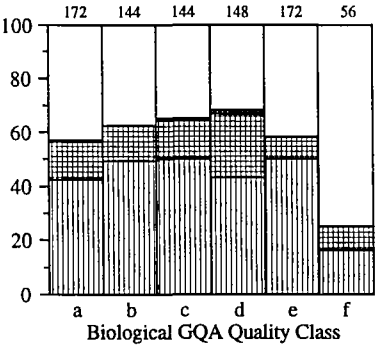
Regional Frequency Distributions by Class - River Sites 1995

GLOSSIPHONIIDAE

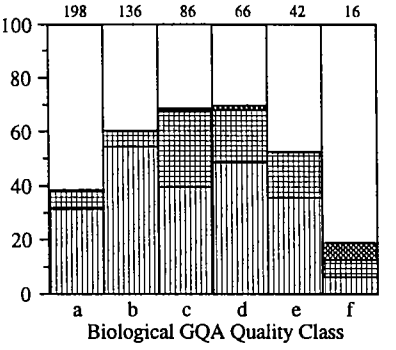
North West Region



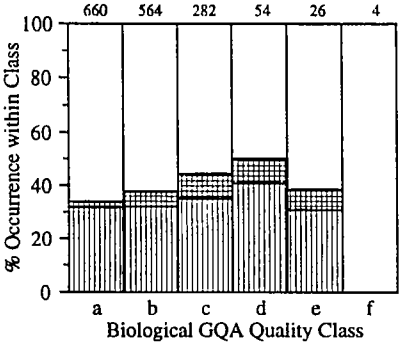
Dales and Ridings Areas
North East Region



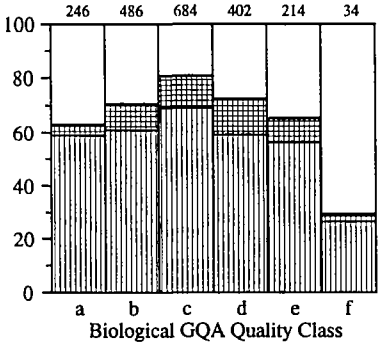
Northumbria Area
North East Region



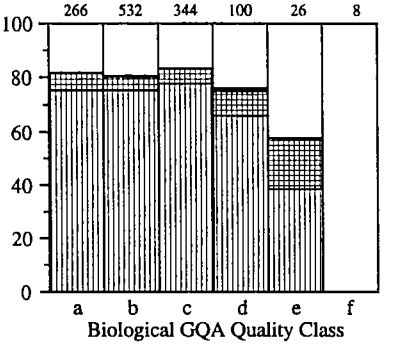
Welsh Region



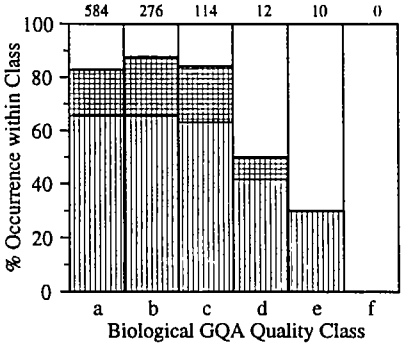
Midlands Region



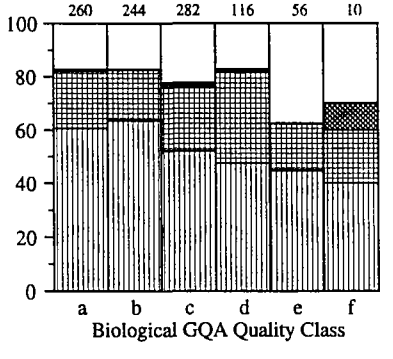
Anglian Region



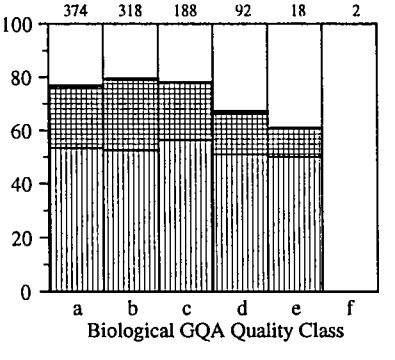
North and South Wessex Areas
South West Region



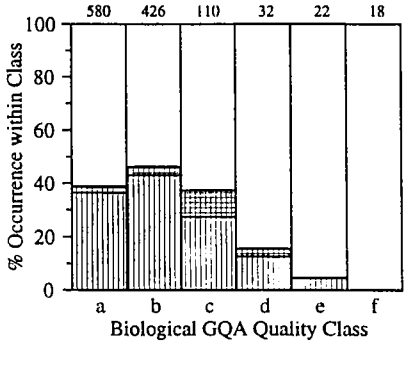
Thames Region



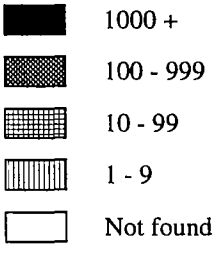
Southern Region



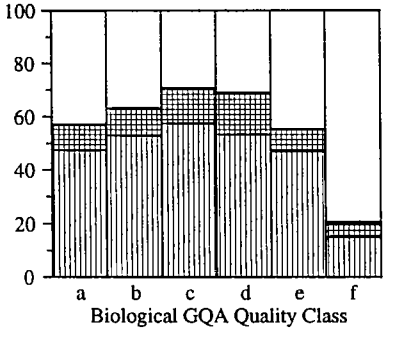
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

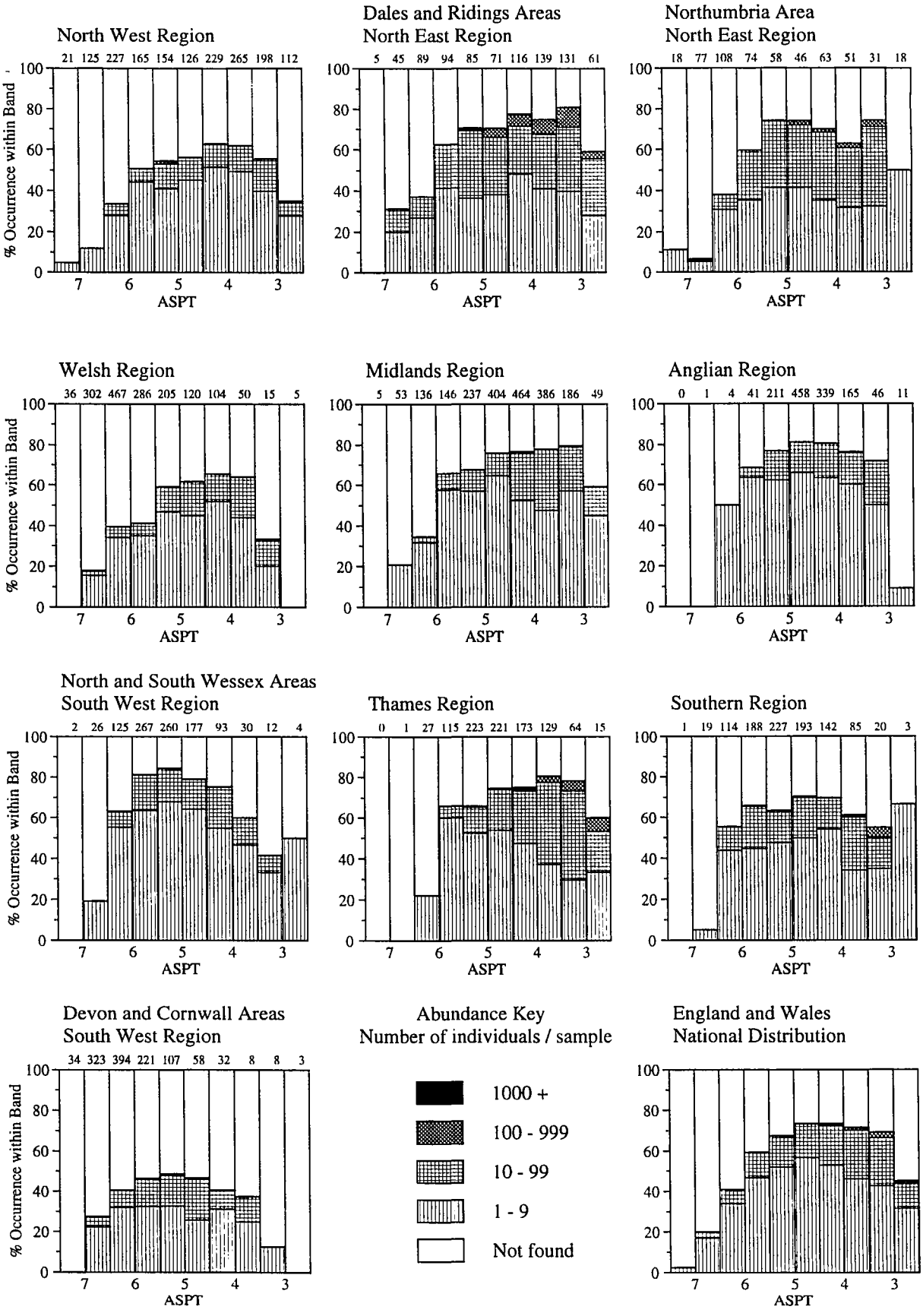


England and Wales
National Distribution



Regional Frequency Distributions by ASPT - River Sites 1995

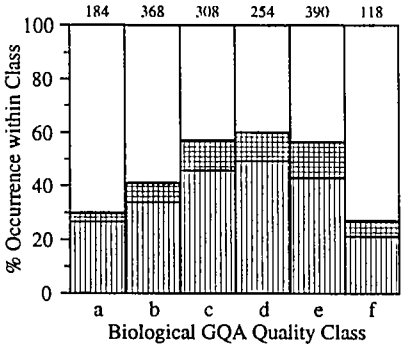
ERPOBDELLIDAE



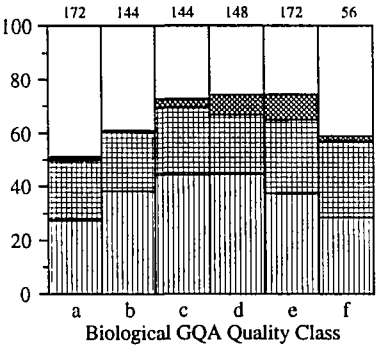
Regional Frequency Distributions by Class - River Sites 1995

ERPOBDELLIDAE

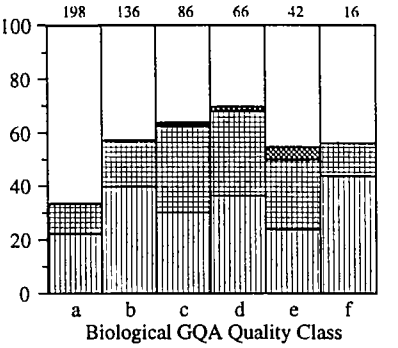
North West Region



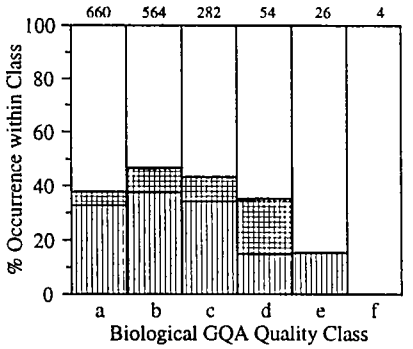
Dales and Ridings Areas
North East Region



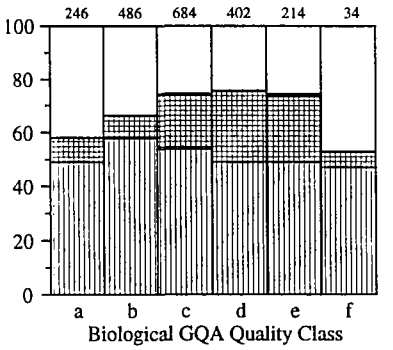
Northumbria Area
North East Region



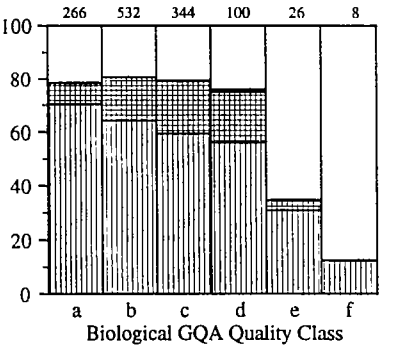
Welsh Region



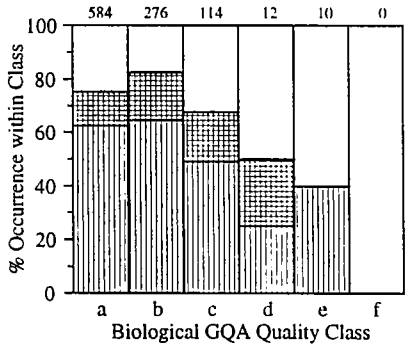
Midlands Region



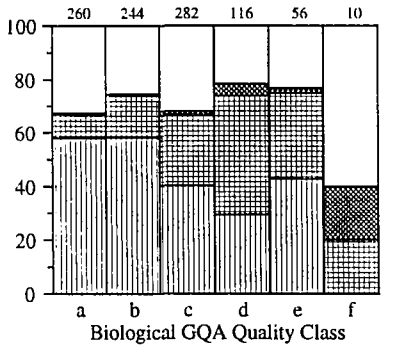
Anglian Region



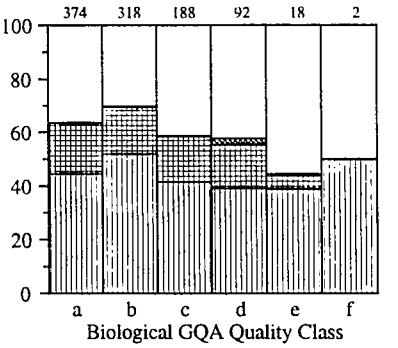
North and South Wessex Areas
South West Region



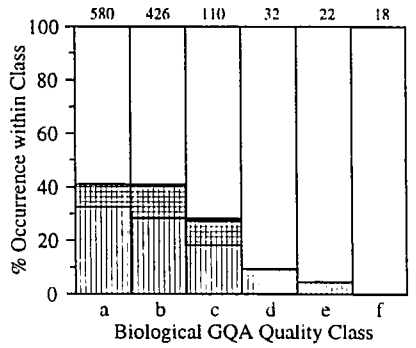
Thames Region



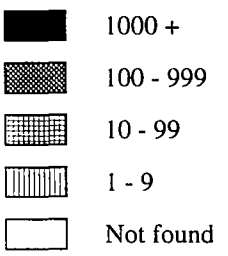
Southern Region



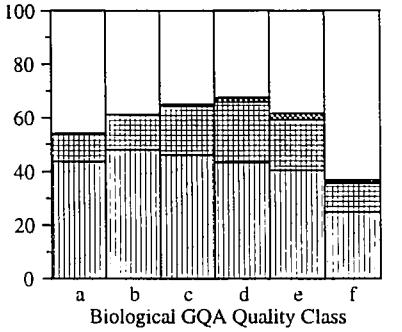
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



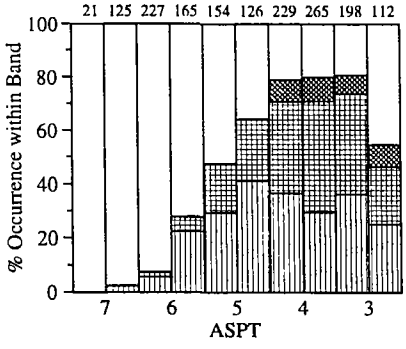
England and Wales
National Distribution



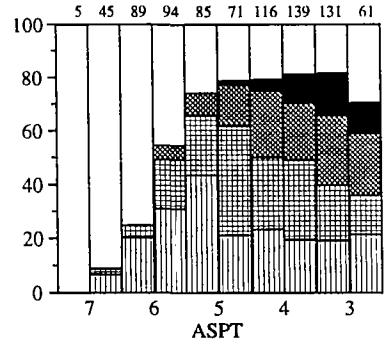
Regional Frequency Distributions by ASPT - River Sites 1995

ASELLIDAE

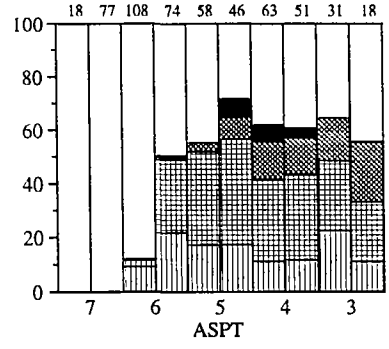
North West Region



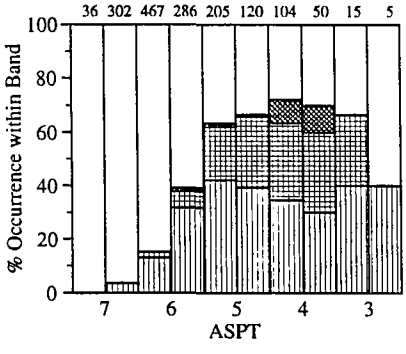
Dales and Ridings Areas
North East Region



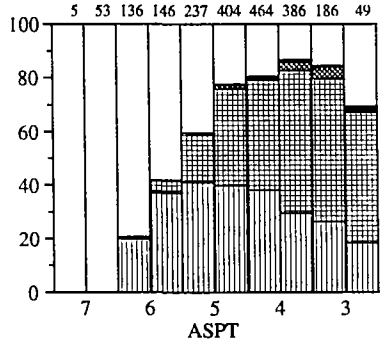
Northumbria Area
North East Region



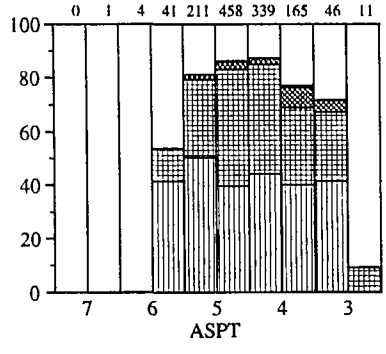
Welsh Region



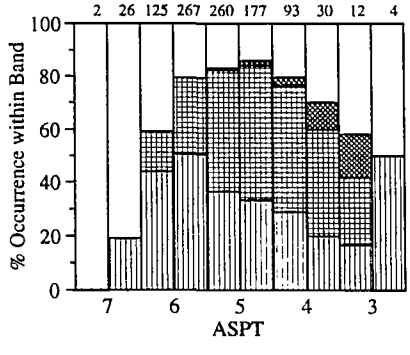
Midlands Region



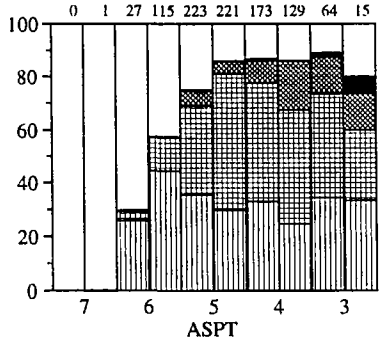
Anglian Region



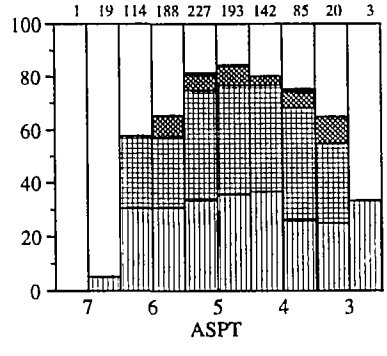
North and South Wessex Areas
South West Region



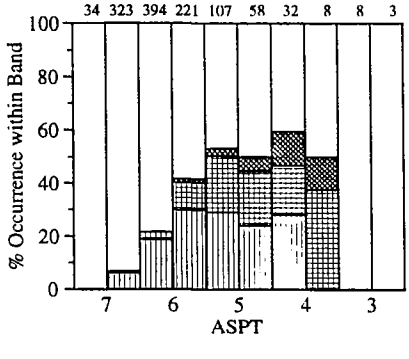
Thames Region



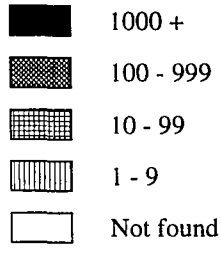
Southern Region



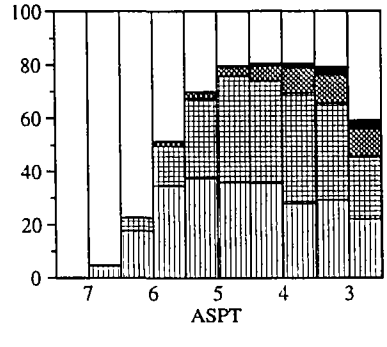
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



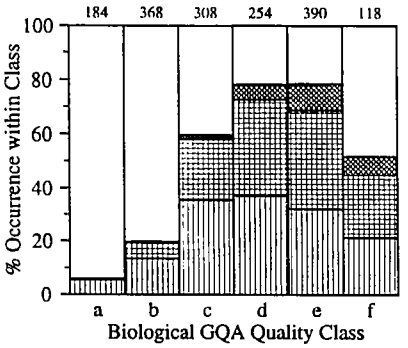
England and Wales
National Distribution



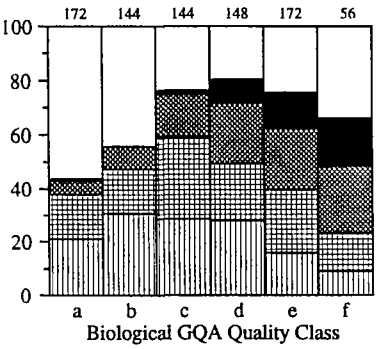
Regional Frequency Distributions by Class - River Sites 1995

ASELLIDAE

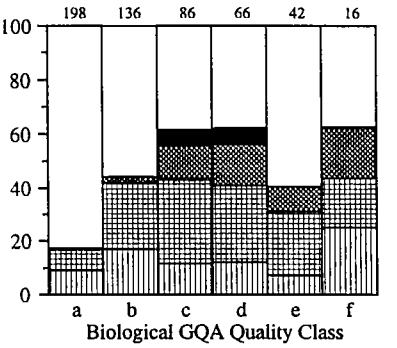
North West Region



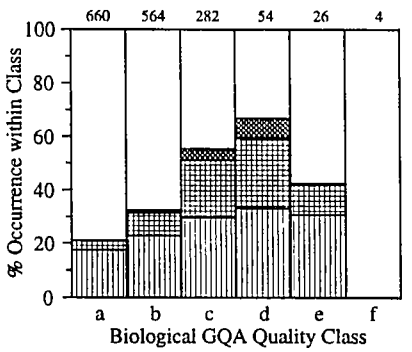
Dales and Ridings Areas
North East Region



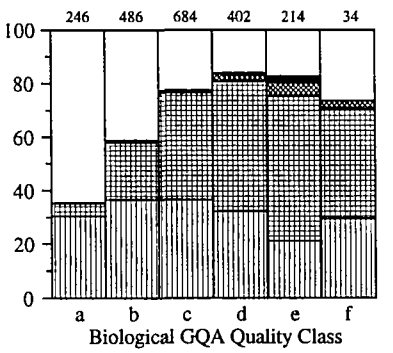
Northumbria Area
North East Region



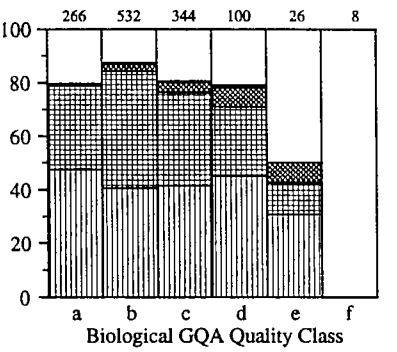
Welsh Region



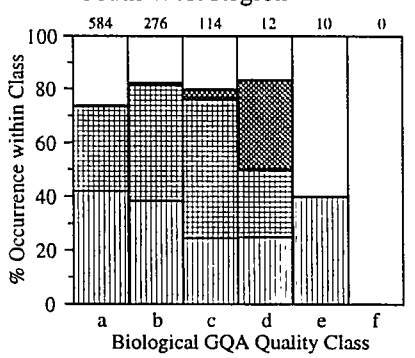
Midlands Region



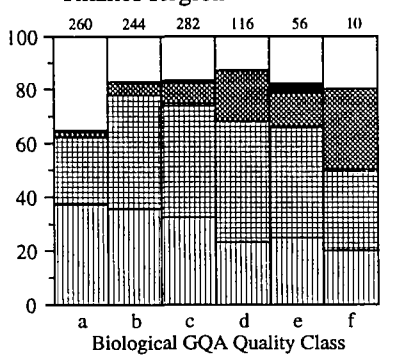
Anglian Region



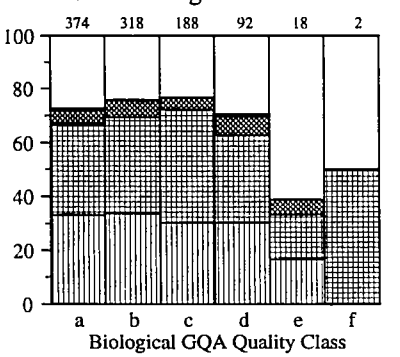
North and South Wessex Areas
South West Region



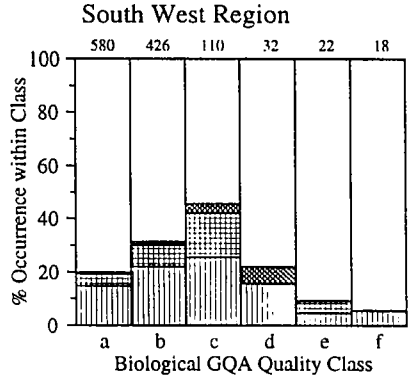
Thames Region



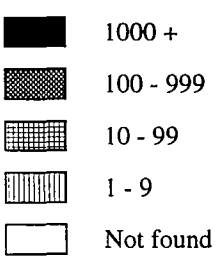
Southern Region



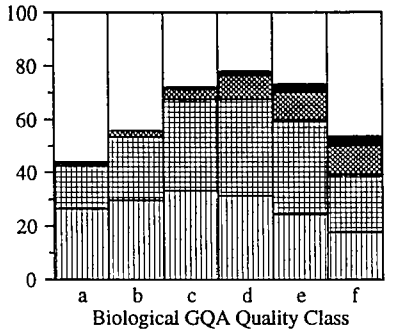
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



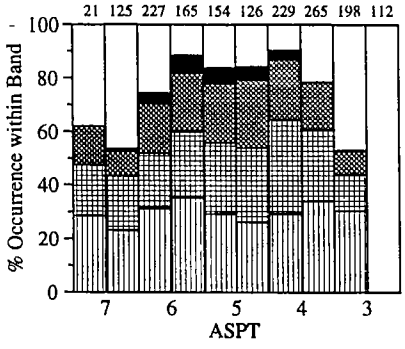
England and Wales
National Distribution



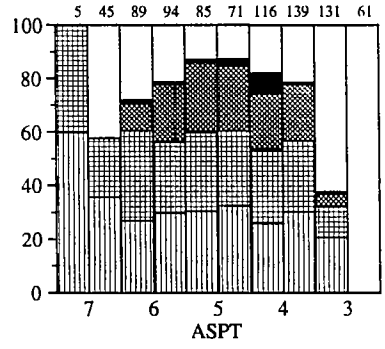
Regional Frequency Distributions by ASPT - River Sites 1995

GAMMARIDAE

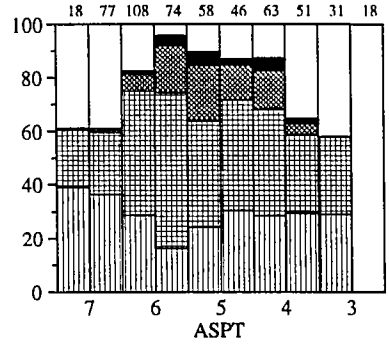
North West Region



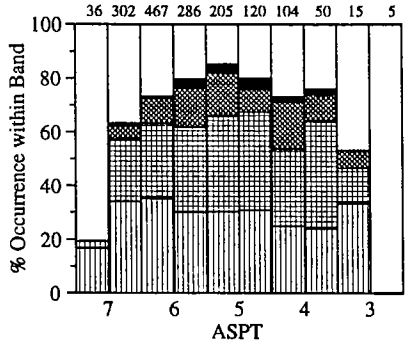
Dales and Ridings Areas
North East Region



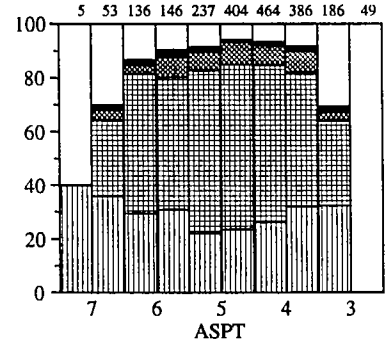
Northumbria Area
North East Region



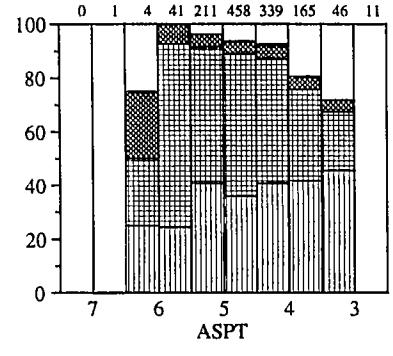
Welsh Region



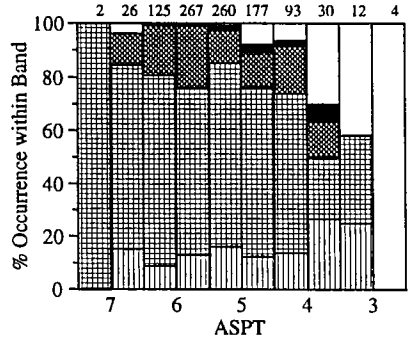
Midlands Region



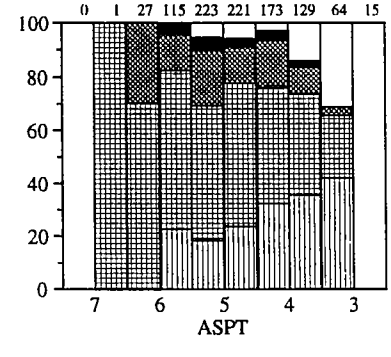
Anglian Region



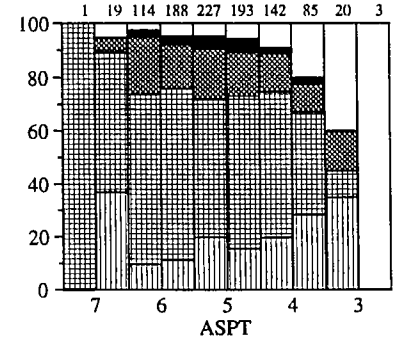
North and South Wessex Areas
South West Region



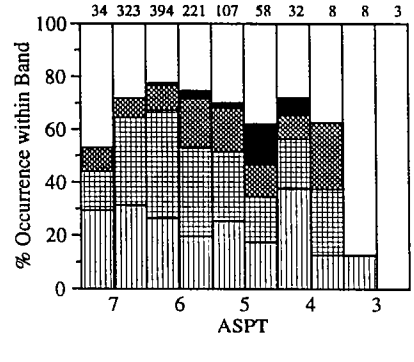
Thames Region



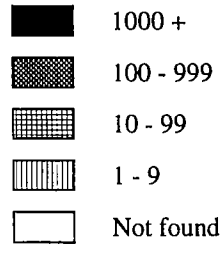
Southern Region



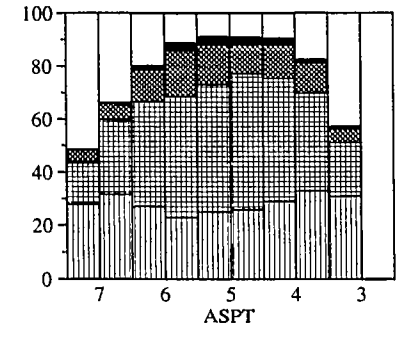
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



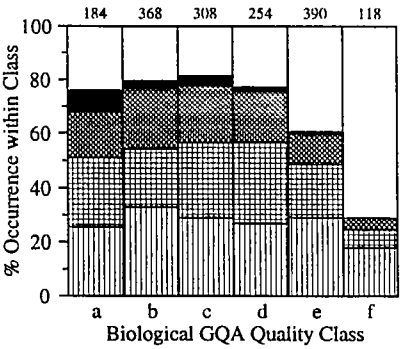
England and Wales
National Distribution



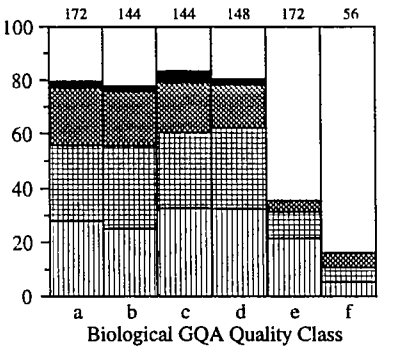
Regional Frequency Distributions by Class - River Sites 1995

GAMMARIDAE

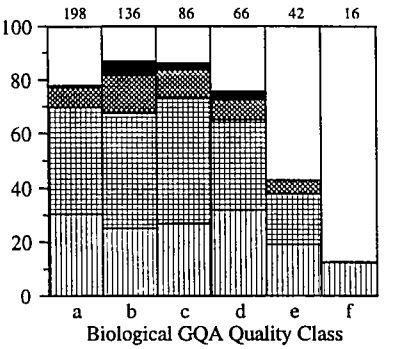
North West Region



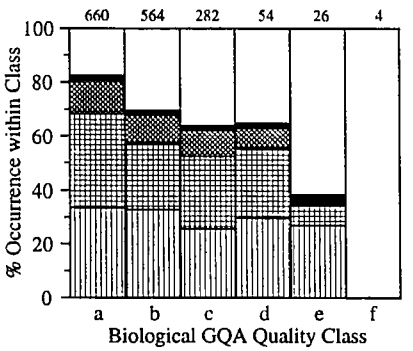
Dales and Ridings Areas
North East Region



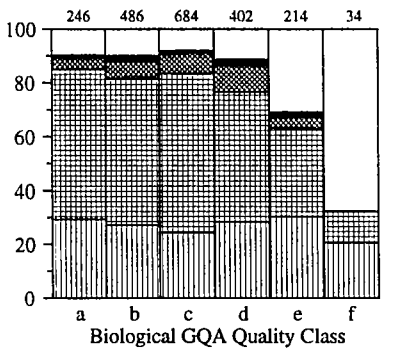
Northumbria Area
North East Region



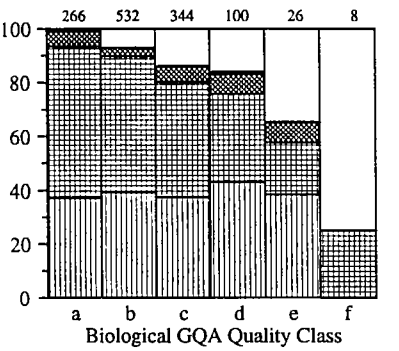
Welsh Region



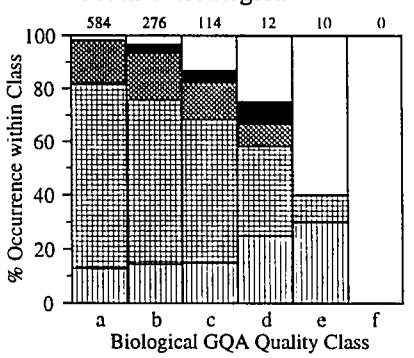
Midlands Region



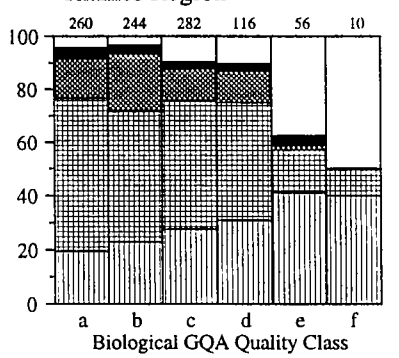
Anglian Region



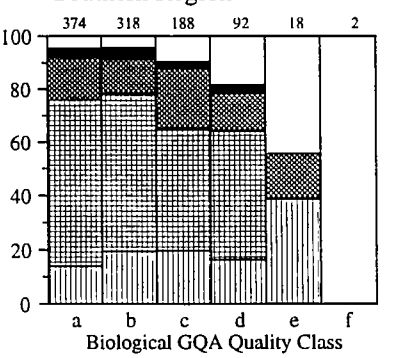
North and South Wessex Areas
South West Region



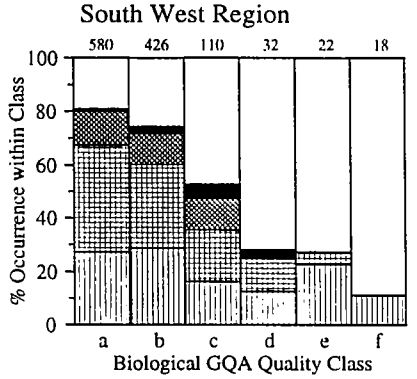
Thames Region



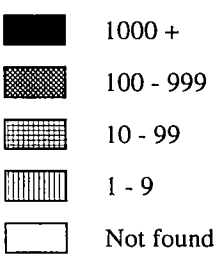
Southern Region



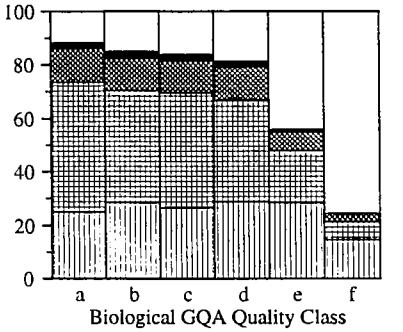
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



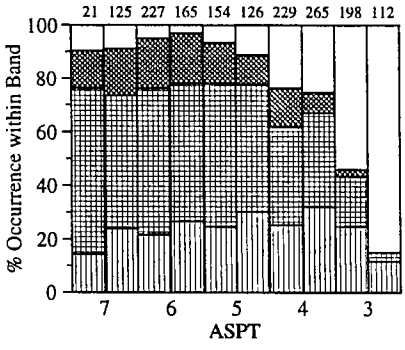
England and Wales
National Distribution



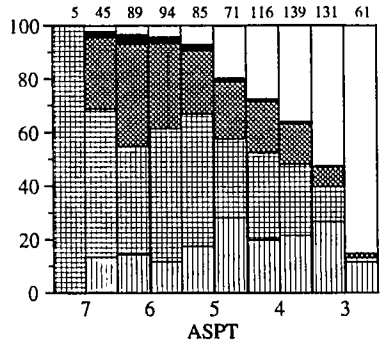
Regional Frequency Distributions by ASPT - River Sites 1995

BAETIDAE

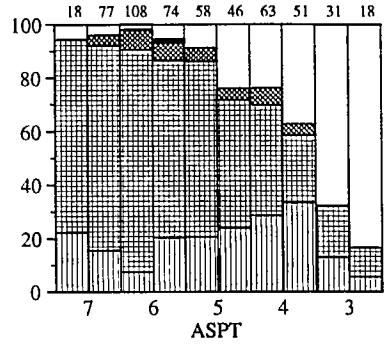
North West Region



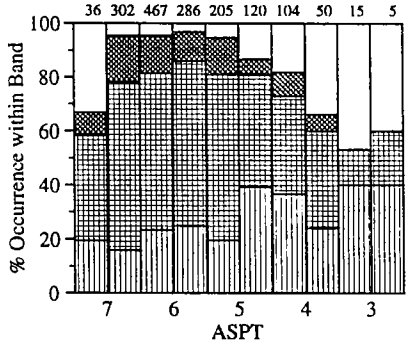
Dales and Ridings Areas
North East Region



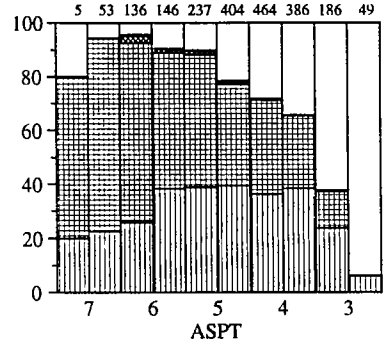
Northumbria Area
North East Region



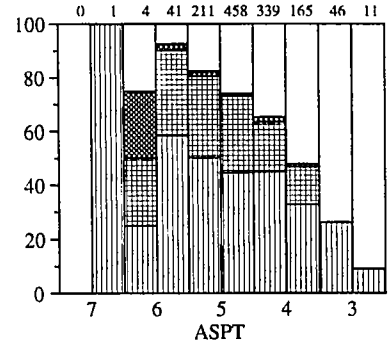
Welsh Region



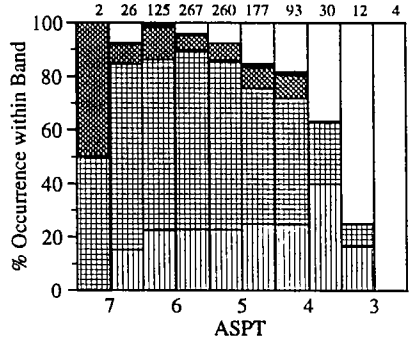
Midlands Region



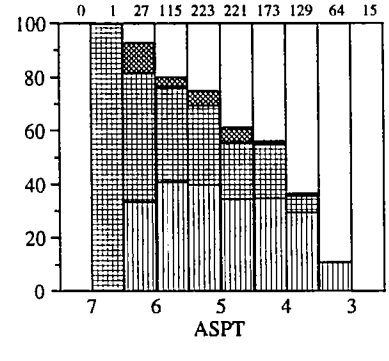
Anglian Region



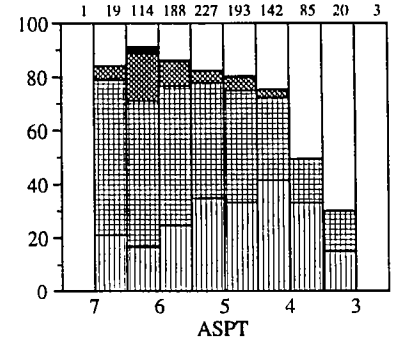
North and South Wessex Areas
South West Region



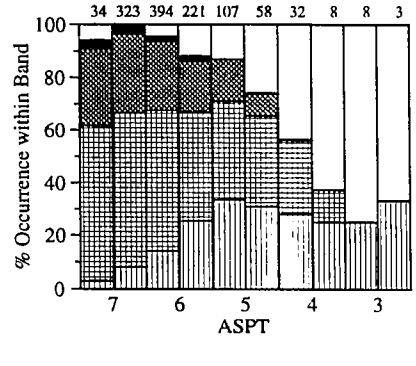
Thames Region



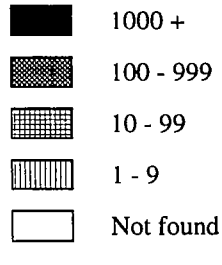
Southern Region



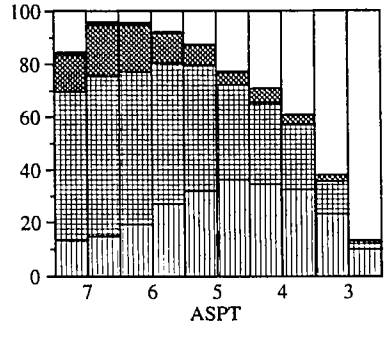
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



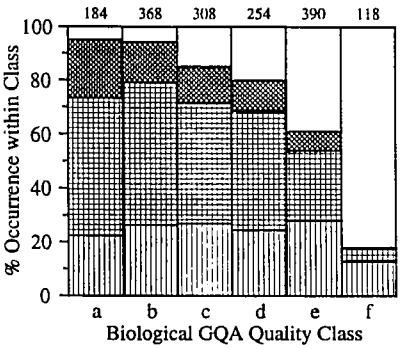
England and Wales
National Distribution



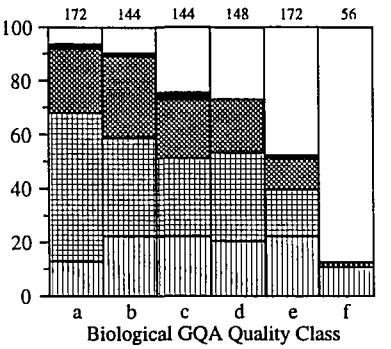
Regional Frequency Distributions by Class - River Sites 1995

BAETIDAE

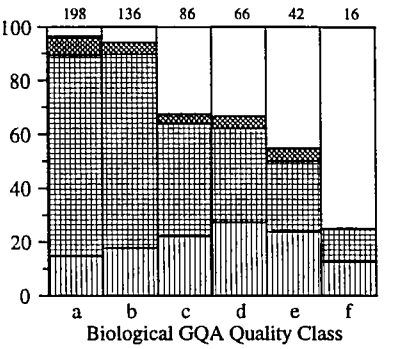
North West Region



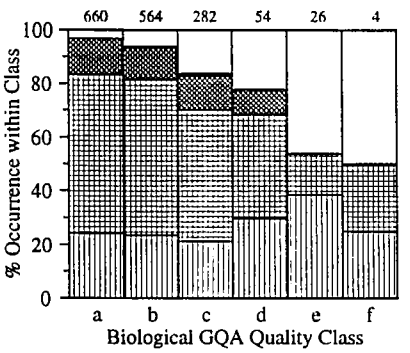
Dales and Ridings Areas
North East Region



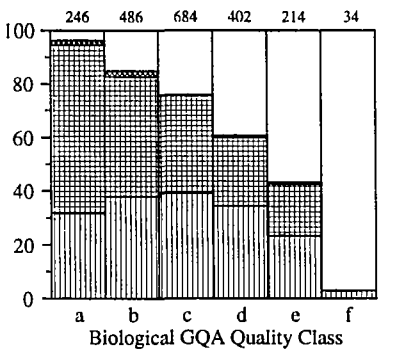
Northumbria Area
North East Region



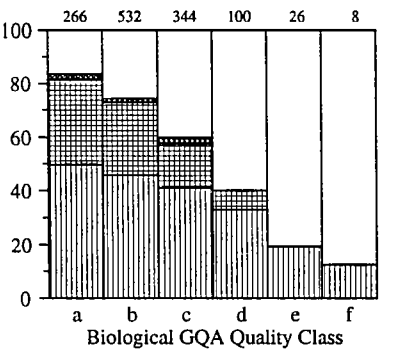
Welsh Region



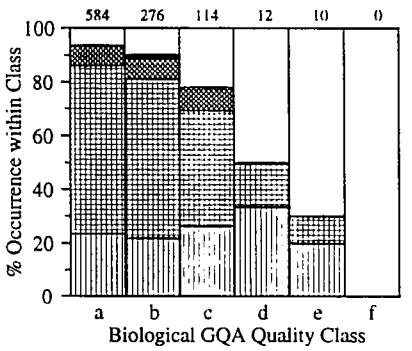
Midlands Region



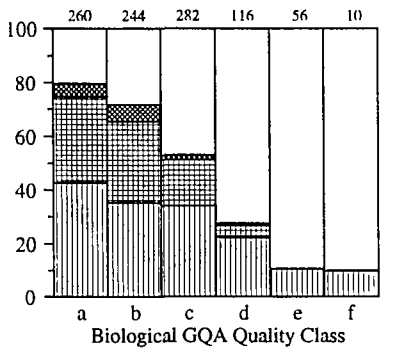
Anglian Region



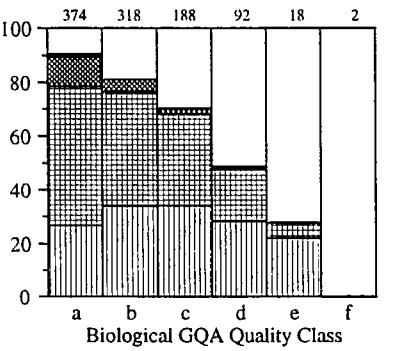
North and South Wessex Areas
South West Region



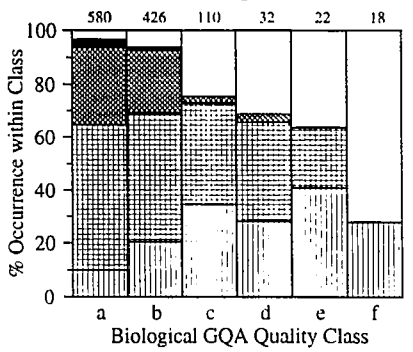
Thames Region



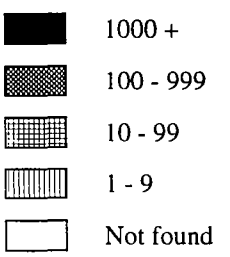
Southern Region



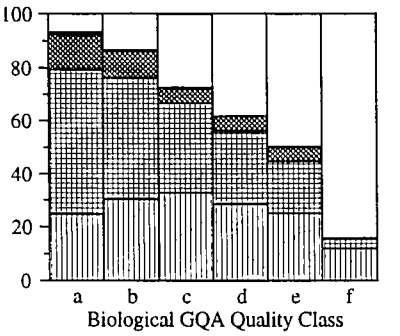
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



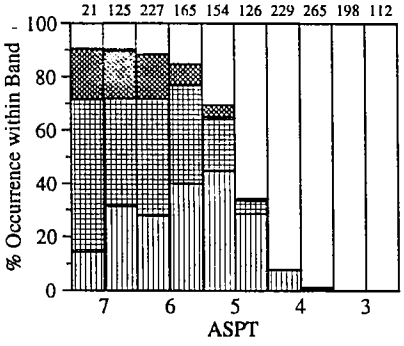
England and Wales
National Distribution



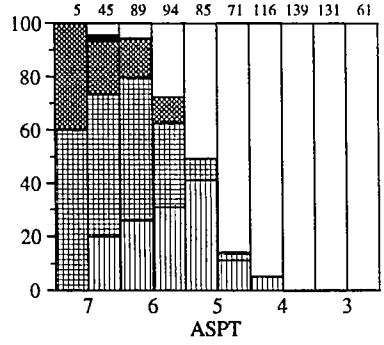
Regional Frequency Distributions by ASPT - River Sites 1995

HEPTAGENIIDAE

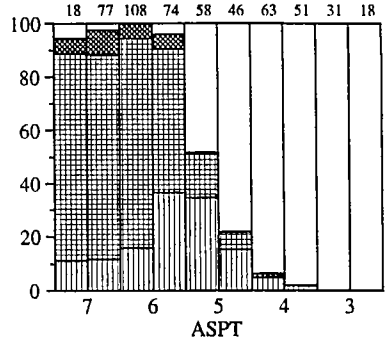
North West Region



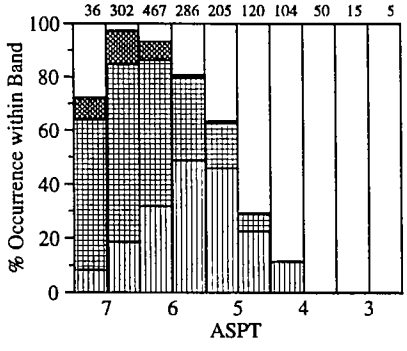
Dales and Ridings Areas
North East Region



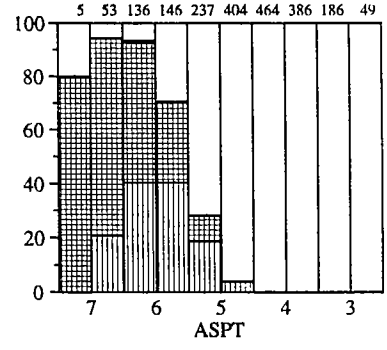
Northumbria Area
North East Region



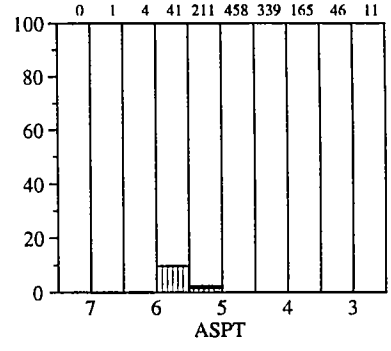
Welsh Region



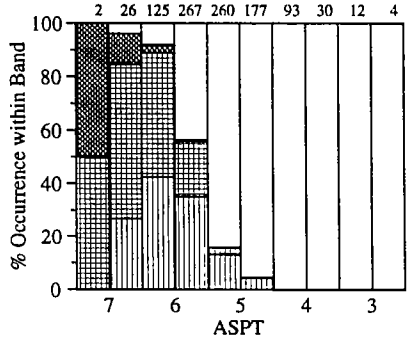
Midlands Region



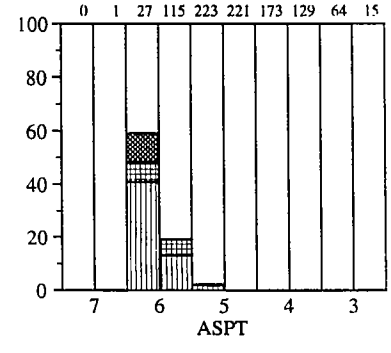
Anglian Region



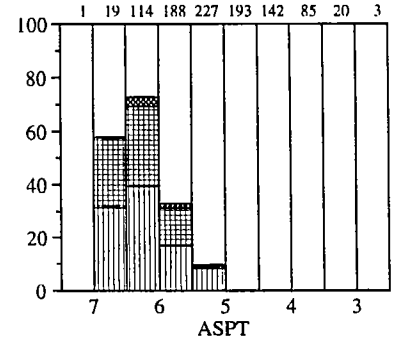
North and South Wessex Areas
South West Region



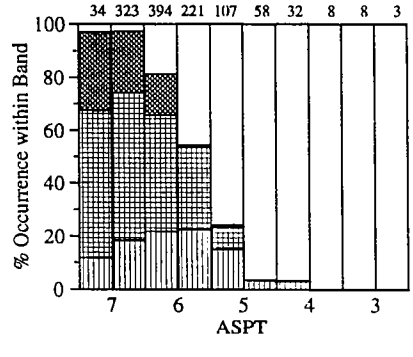
Thames Region



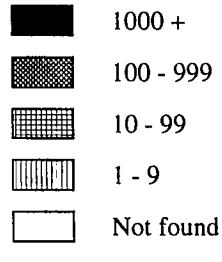
Southern Region



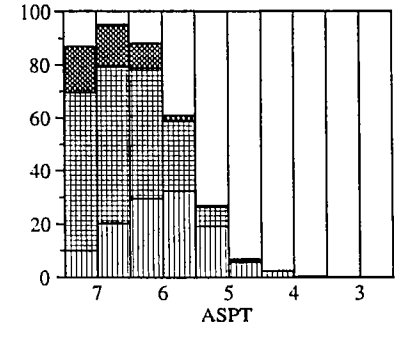
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

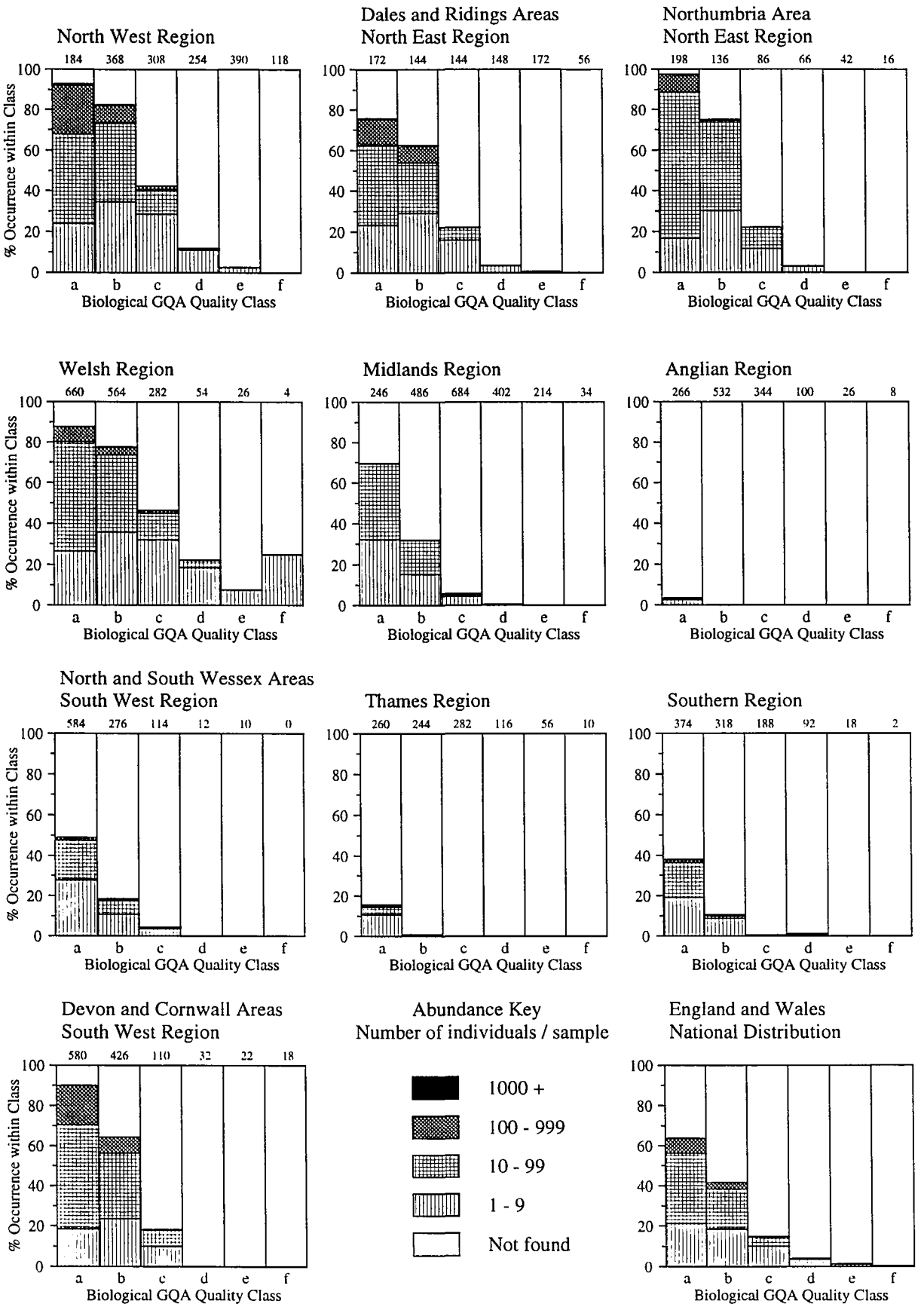


England and Wales
National Distribution



Regional Frequency Distributions by Class - River Sites 1995

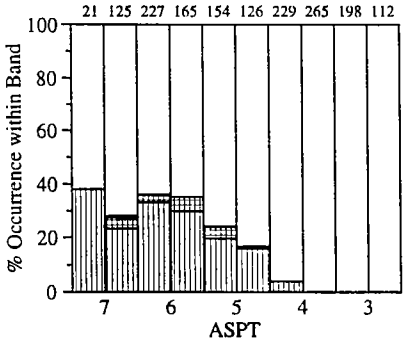
HEPTAGENIIDAE



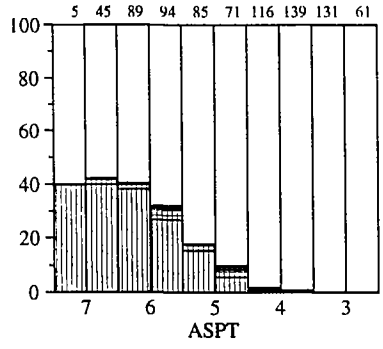
Regional Frequency Distributions by ASPT - River Sites 1995

LEPTOPHLEBIIDAE

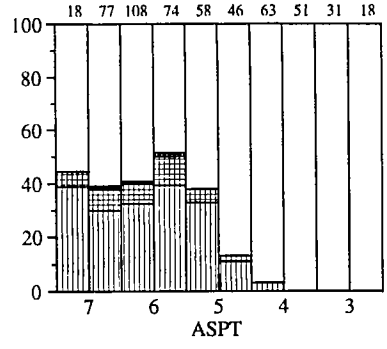
North West Region



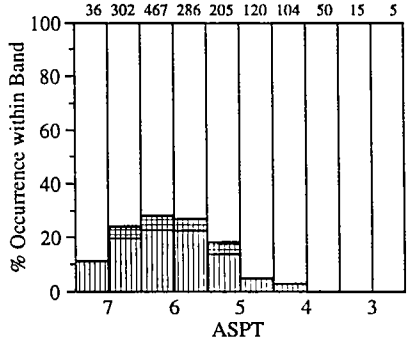
Dales and Ridings Areas
North East Region



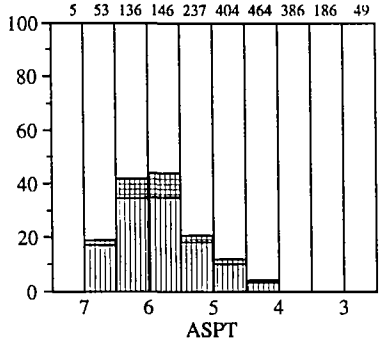
Northumbria Area
North East Region



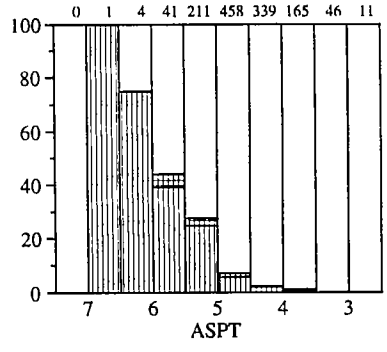
Welsh Region



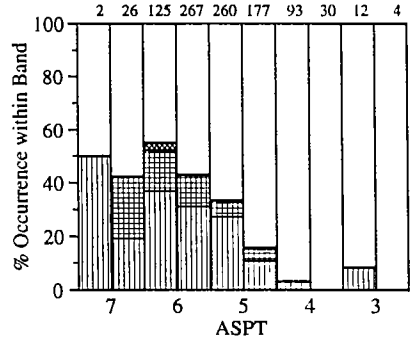
Midlands Region



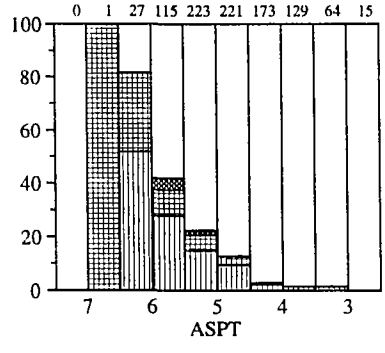
Anglian Region



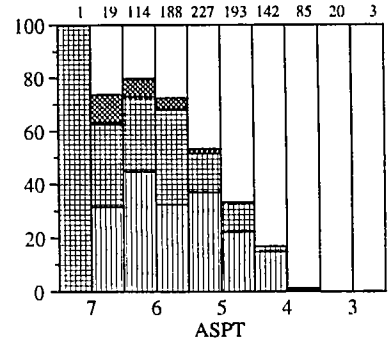
North and South Wessex Areas
South West Region



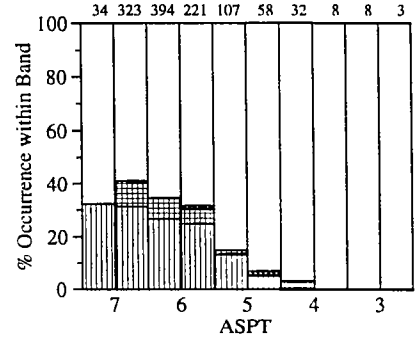
Thames Region



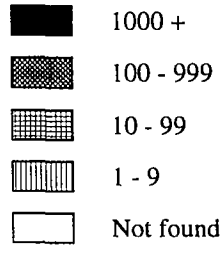
Southern Region



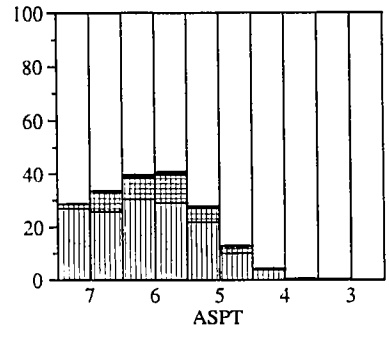
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

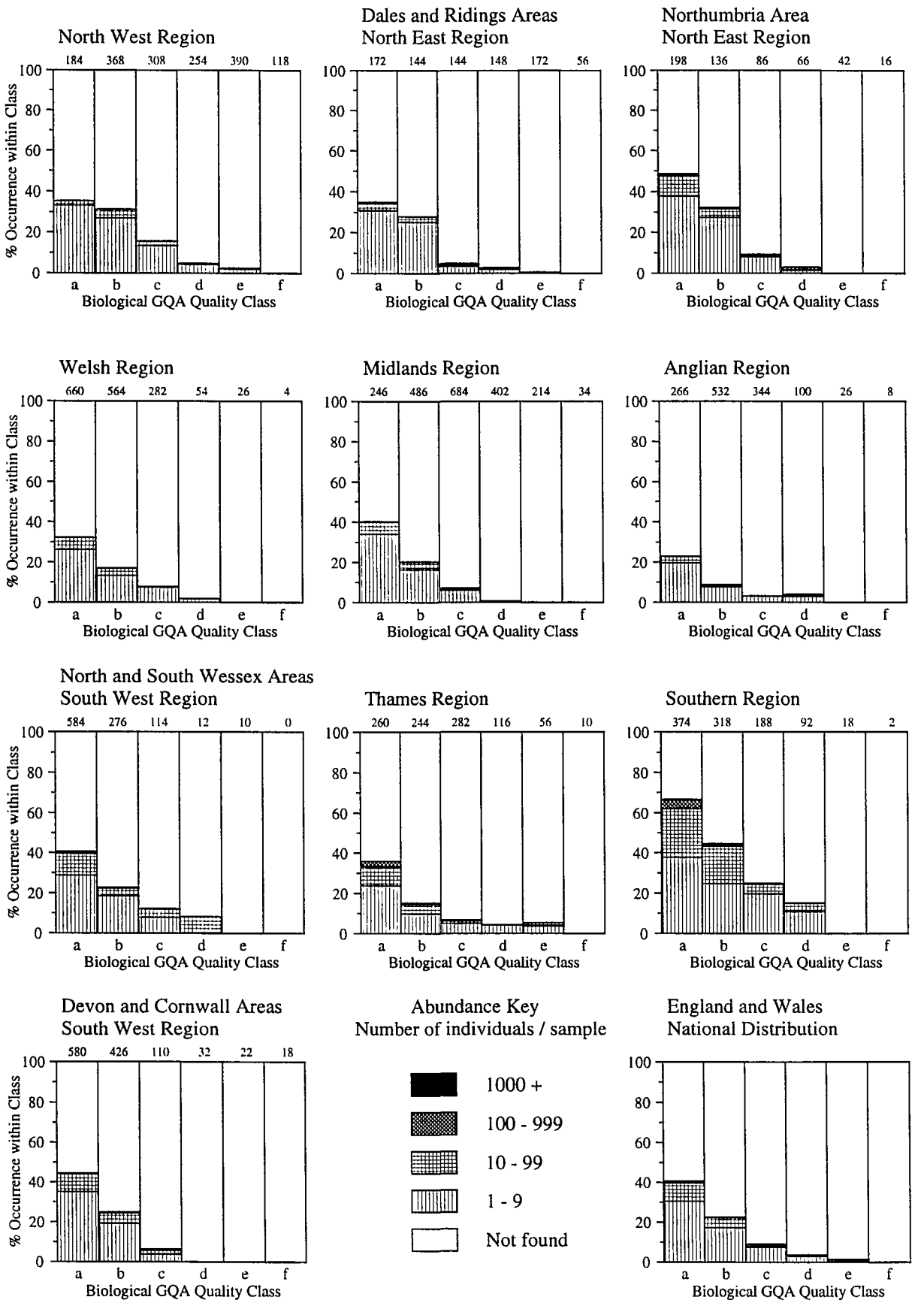


England and Wales
National Distribution



Regional Frequency Distributions by Class - River Sites 1995

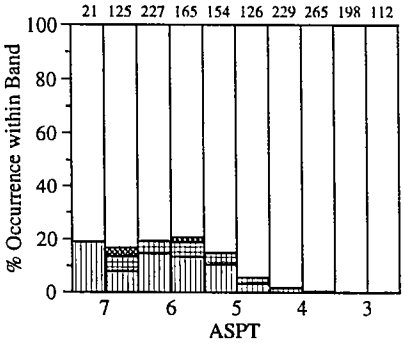
LEPTOPHLEBIIDAE



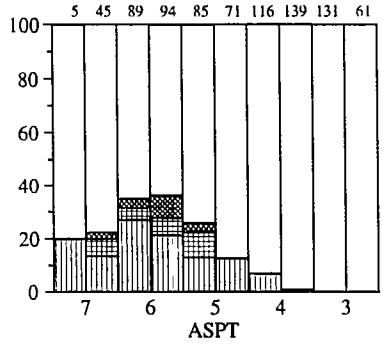
Regional Frequency Distributions by ASPT - River Sites 1995

EPHEMERELLIDAE

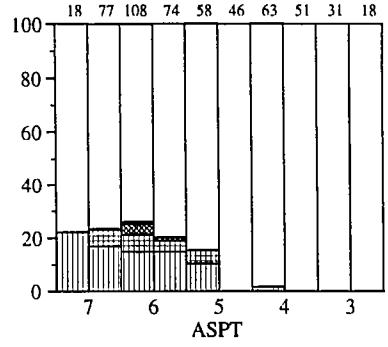
North West Region



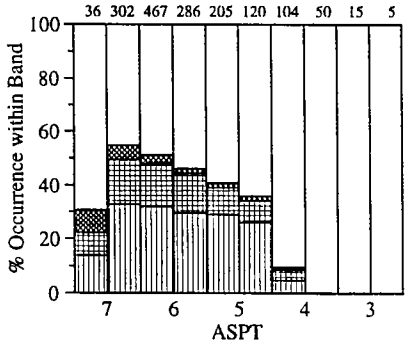
Dales and Ridings Areas
North East Region



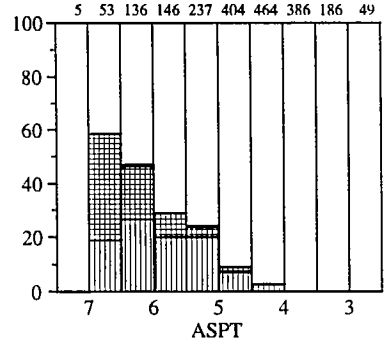
Northumbria Area
North East Region



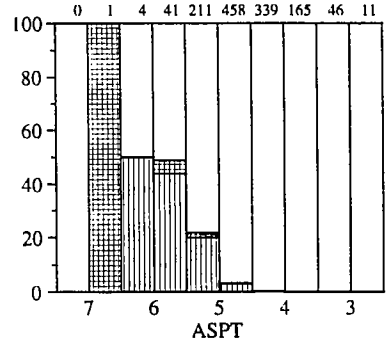
Welsh Region



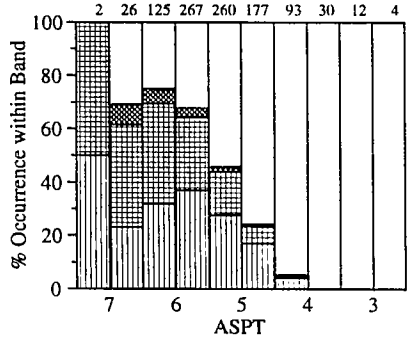
Midlands Region



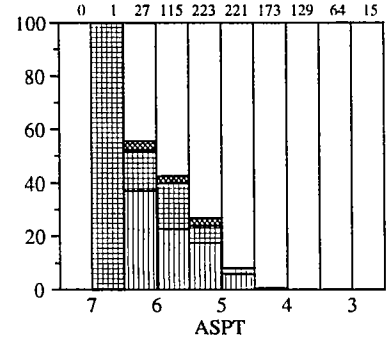
Anglian Region



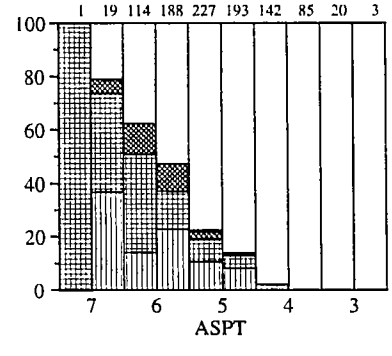
North and South Wessex Areas
South West Region



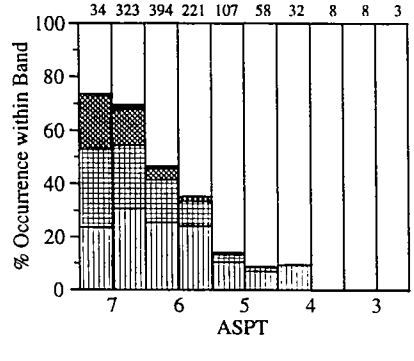
Thames Region



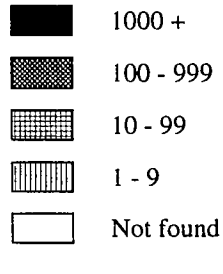
Southern Region



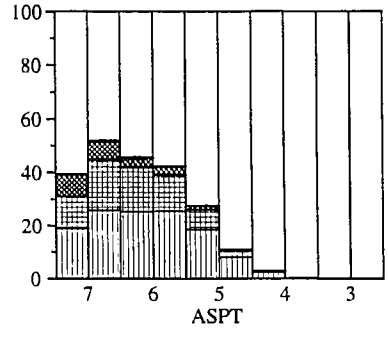
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

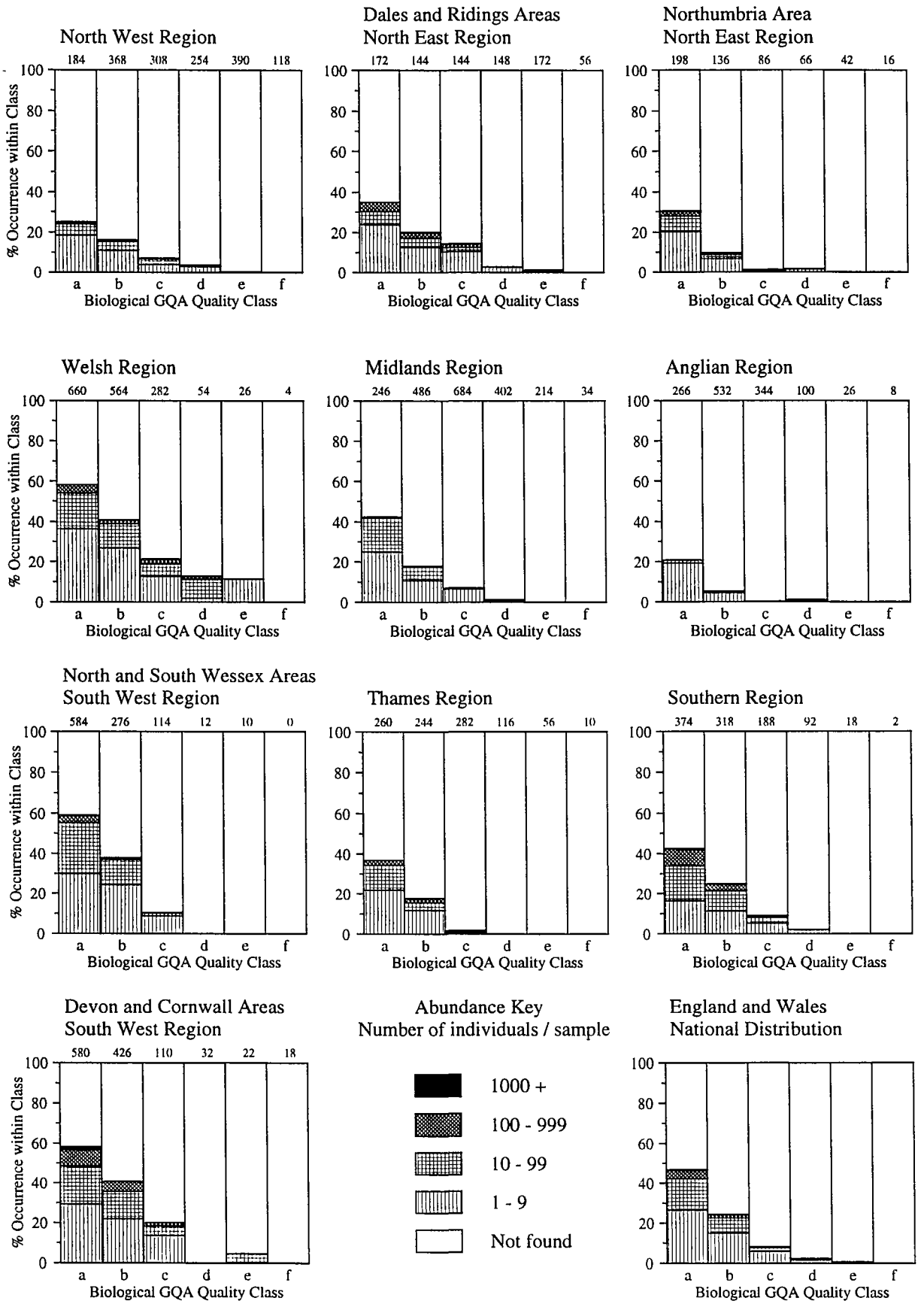


England and Wales
National Distribution



Regional Frequency Distributions by Class - River Sites 1995

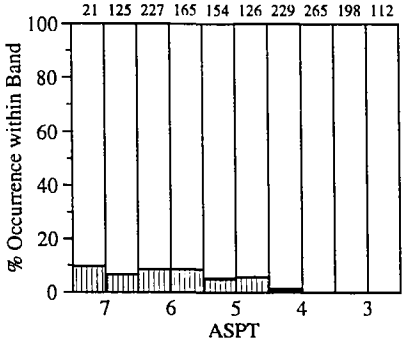
EPHEMERELLIDAE



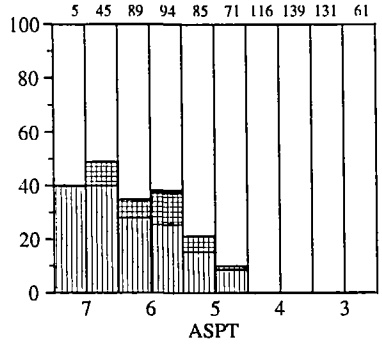
Regional Frequency Distributions by ASPT - River Sites 1995

EPHEMERIDAE

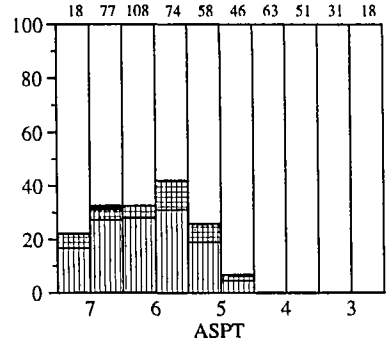
North West Region



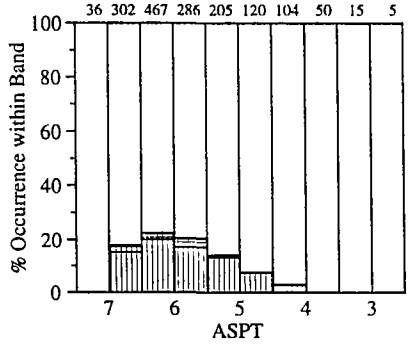
Dales and Ridings Areas
North East Region



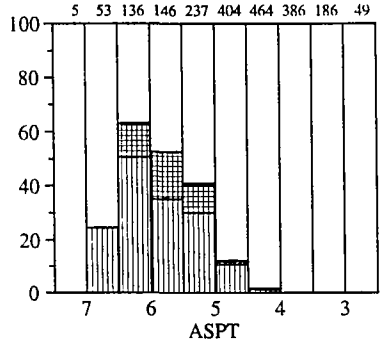
Northumbria Area
North East Region



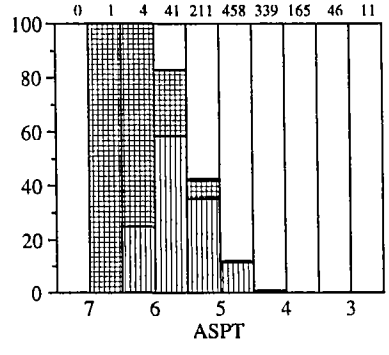
Welsh Region



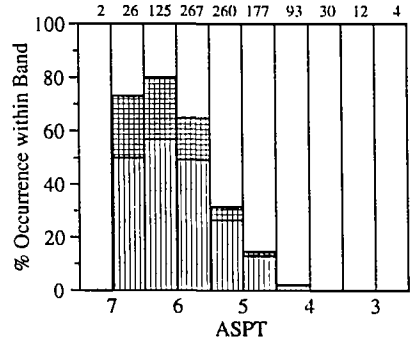
Midlands Region



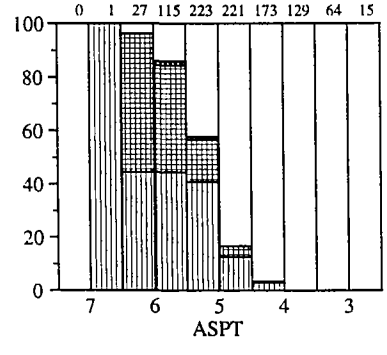
Anglian Region



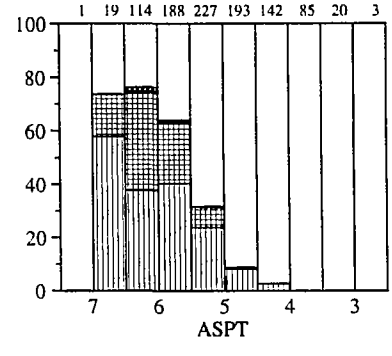
North and South Wessex Areas
South West Region



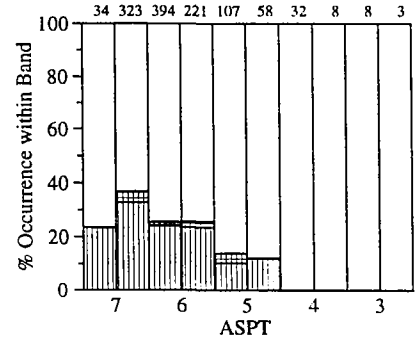
Thames Region



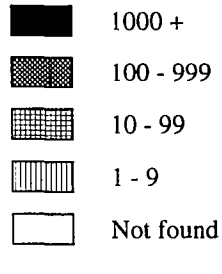
Southern Region



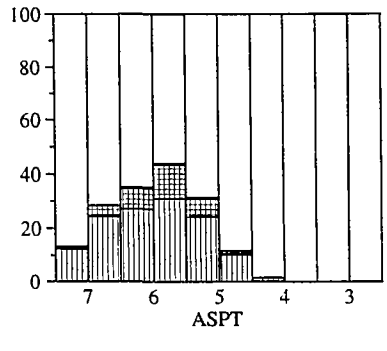
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



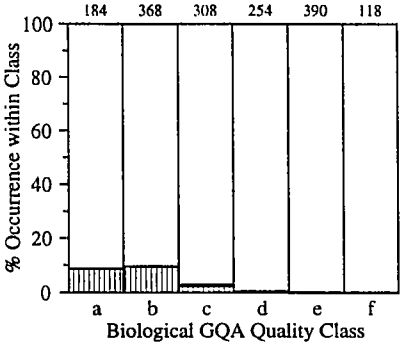
England and Wales
National Distribution



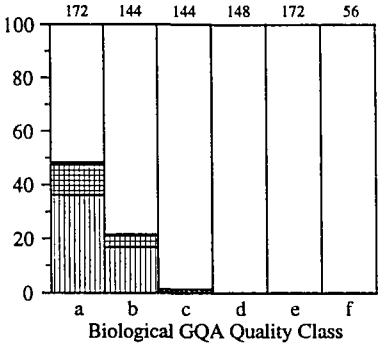
Regional Frequency Distributions by Class - River Sites 1995

EPHEMERIDAE

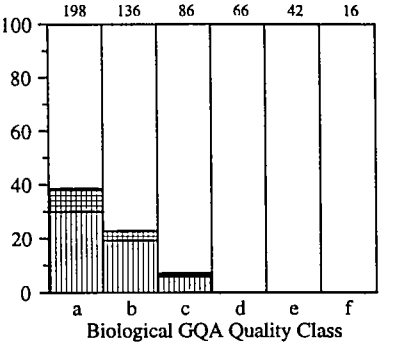
North West Region



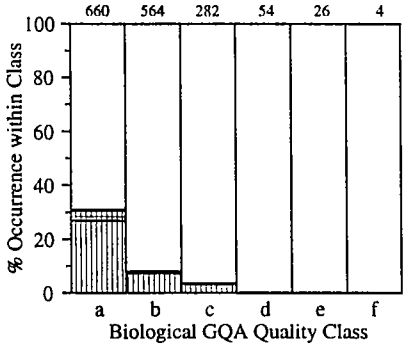
Dales and Ridings Areas
North East Region



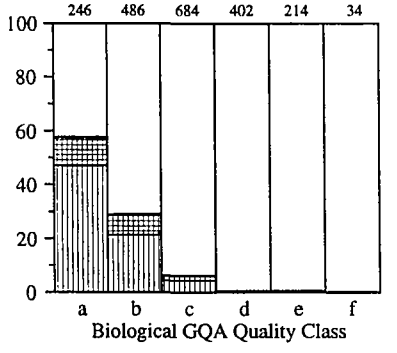
Northumbria Area
North East Region



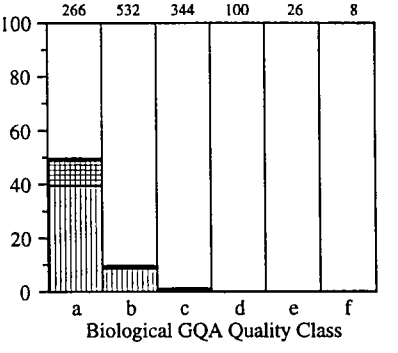
Welsh Region



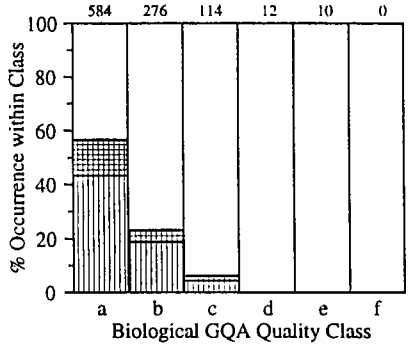
Midlands Region



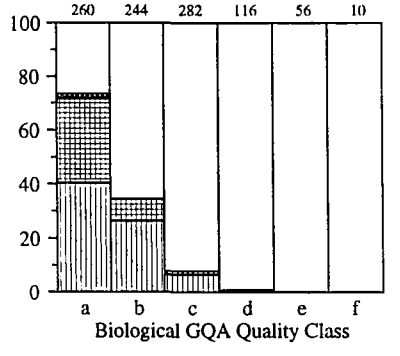
Anglian Region



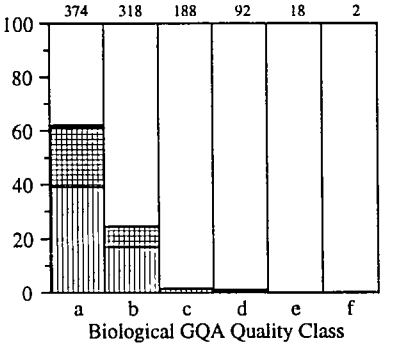
North and South Wessex Areas
South West Region



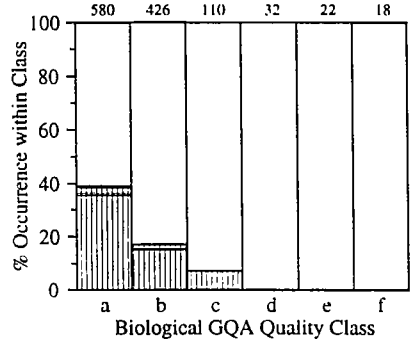
Thames Region



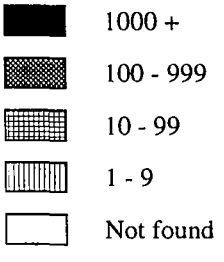
Southern Region



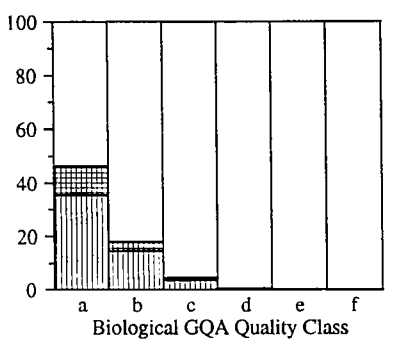
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



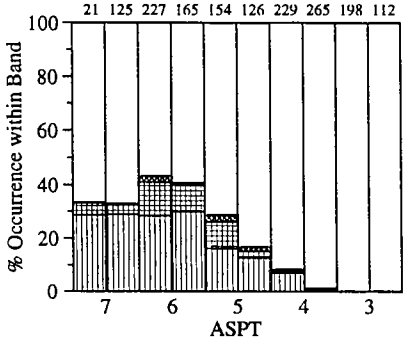
England and Wales
National Distribution



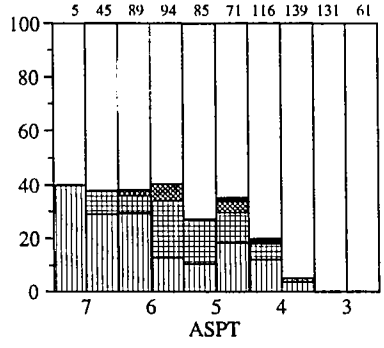
Regional Frequency Distributions by ASPT - River Sites 1995

CAENIDAE

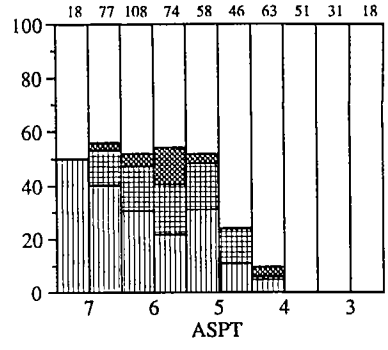
North West Region



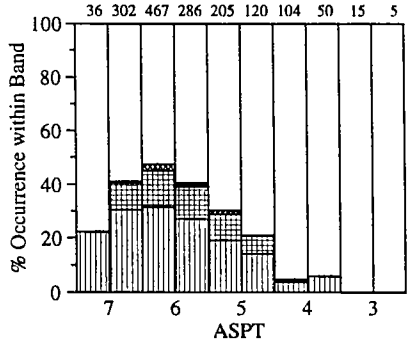
Dales and Ridings Areas
North East Region



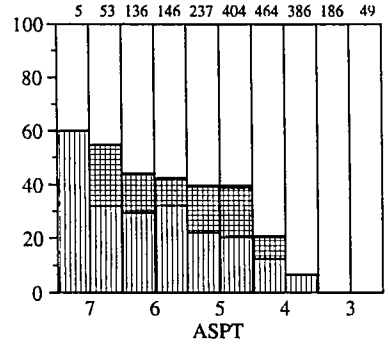
Northumbria Area
North East Region



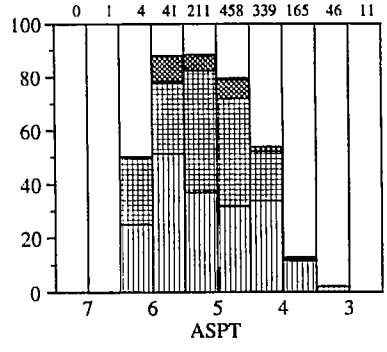
Welsh Region



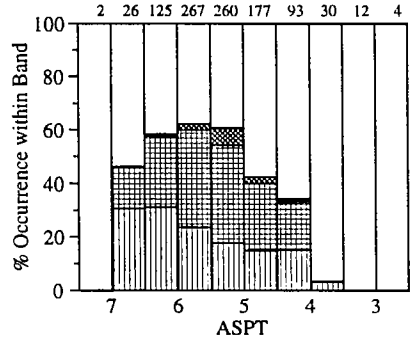
Midlands Region



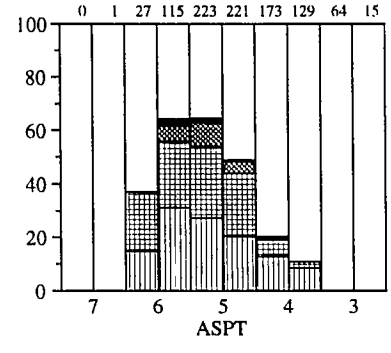
Anglian Region



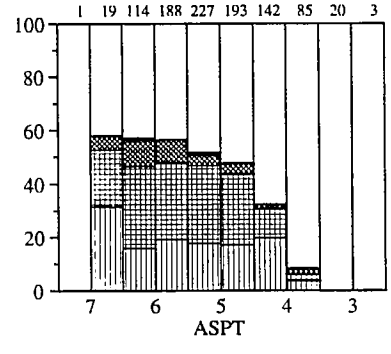
North and South Wessex Areas
South West Region



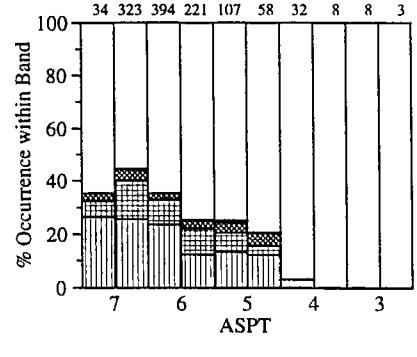
Thames Region



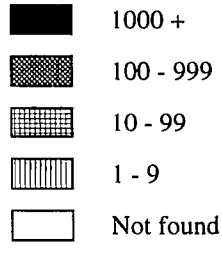
Southern Region



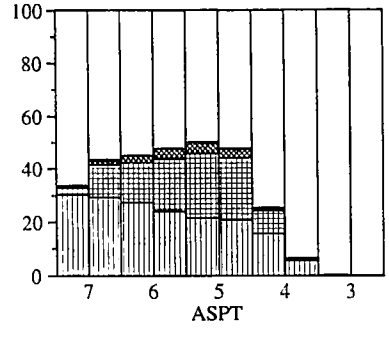
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



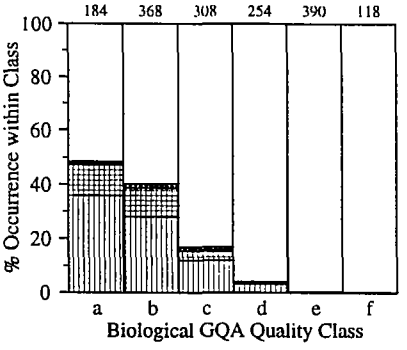
England and Wales
National Distribution



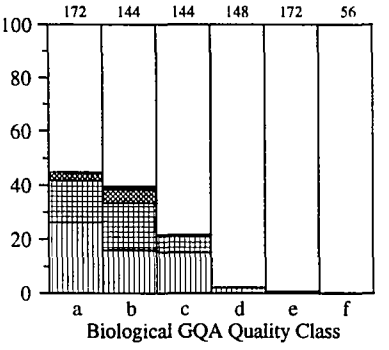
Regional Frequency Distributions by Class - River Sites 1995

CAENIDAE

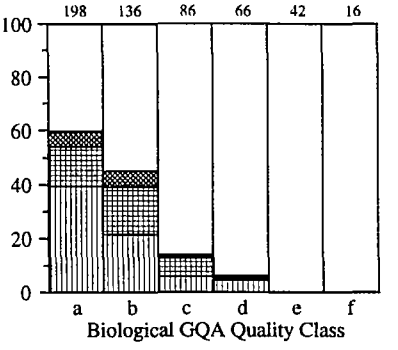
North West Region



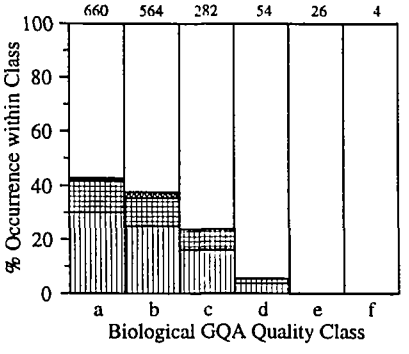
Dales and Ridings Areas
North East Region



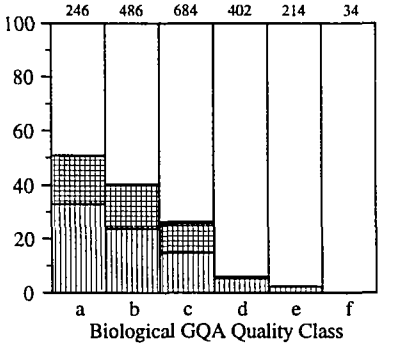
Northumbria Area
North East Region



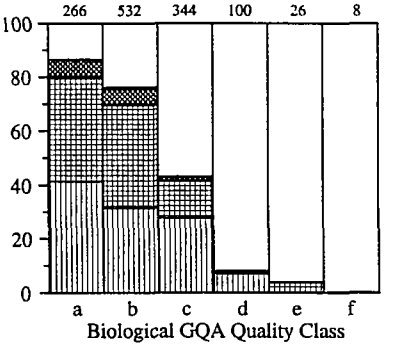
Welsh Region



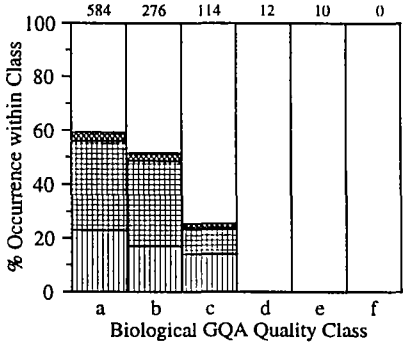
Midlands Region



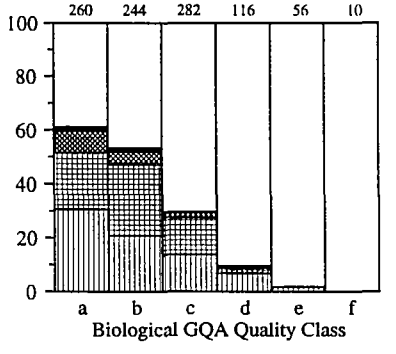
Anglian Region



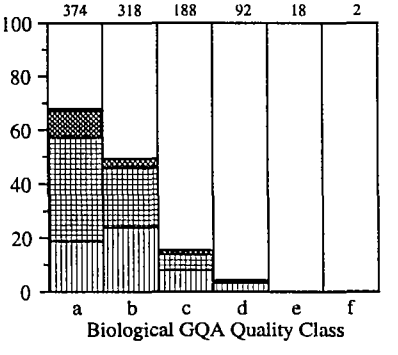
North and South Wessex Areas
South West Region



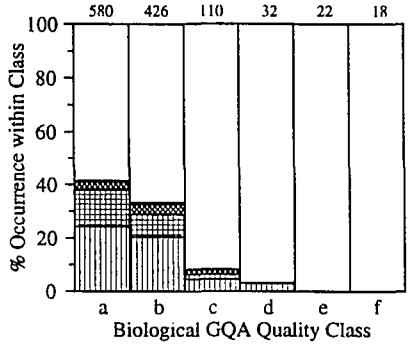
Thames Region



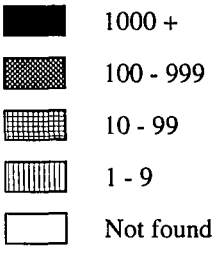
Southern Region



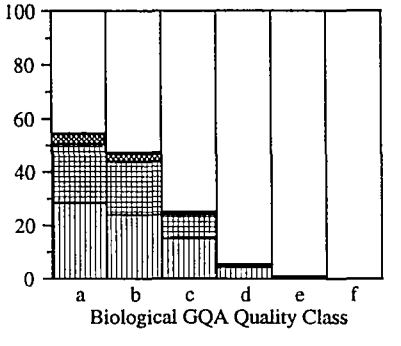
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

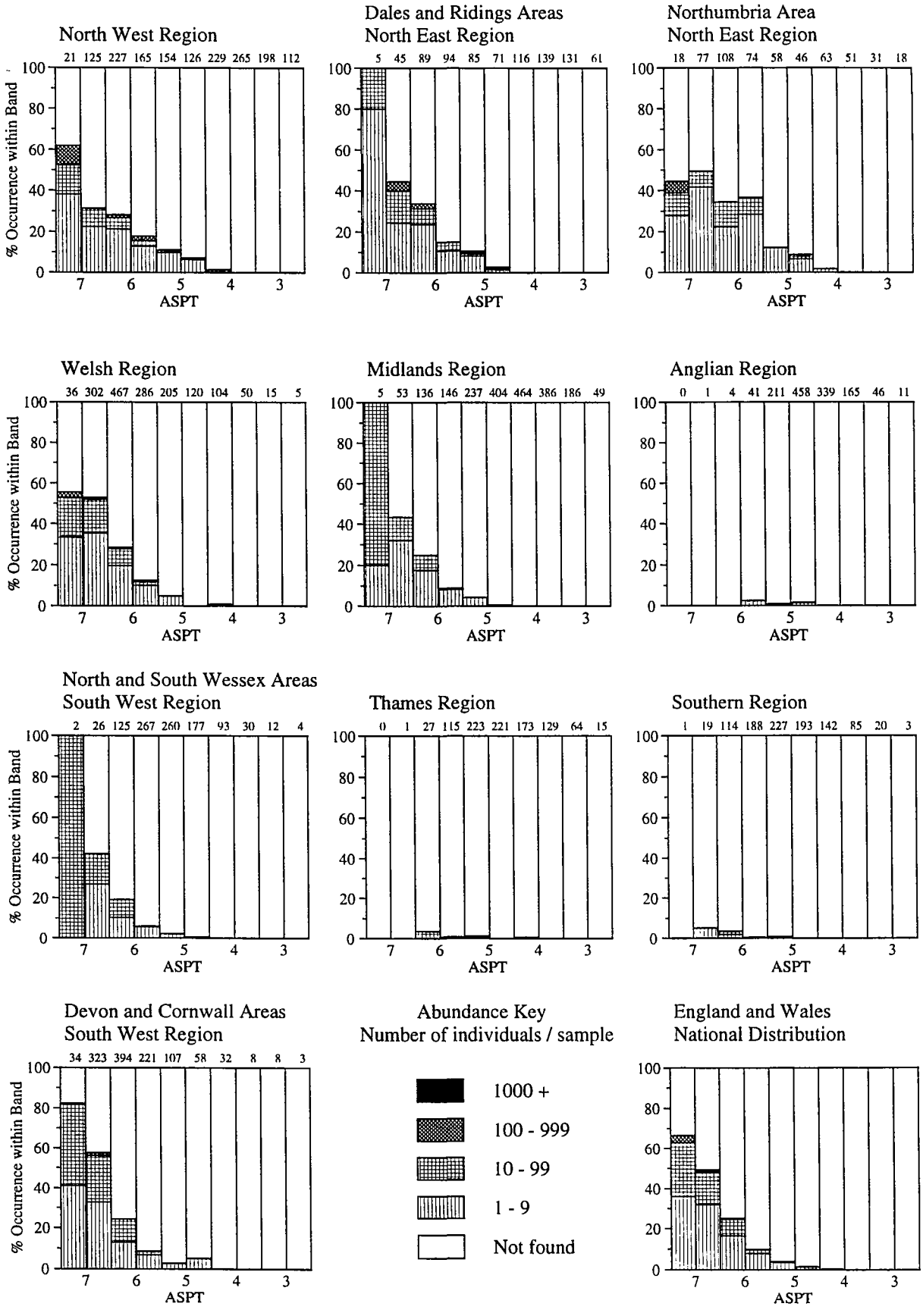


England and Wales
National Distribution



Regional Frequency Distributions by ASPT - River Sites 1995

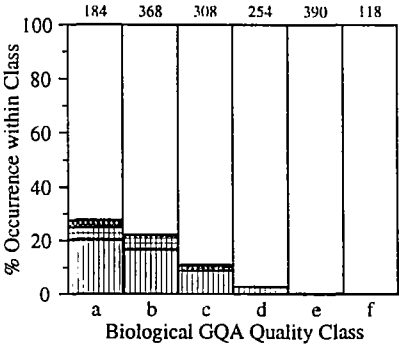
TAENIOPTERYGIDAE



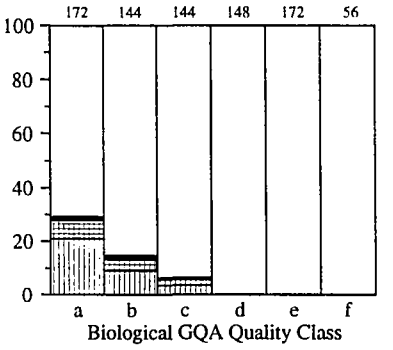
Regional Frequency Distributions by Class - River Sites 1995

TAENIOPTERYGIDAE

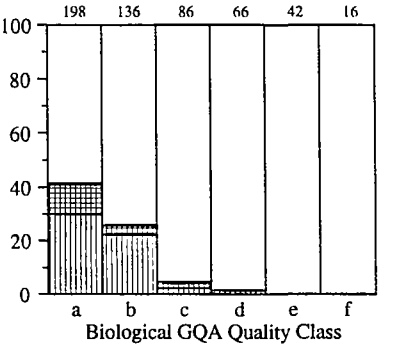
North West Region



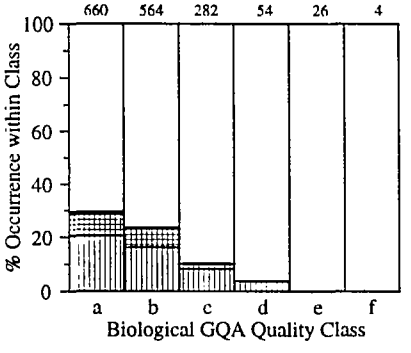
Dales and Ridings Areas
North East Region



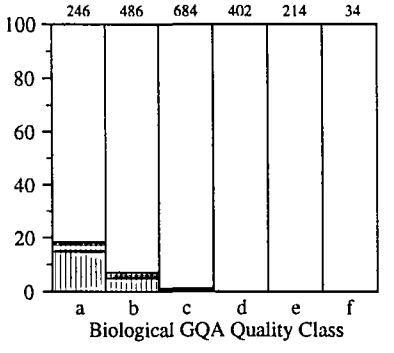
Northumbria Area
North East Region



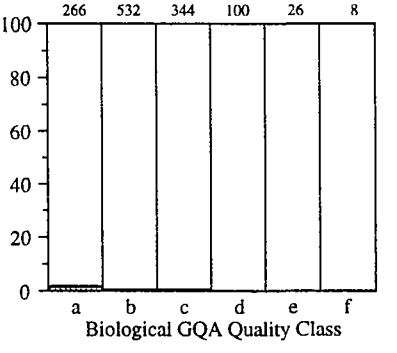
Welsh Region



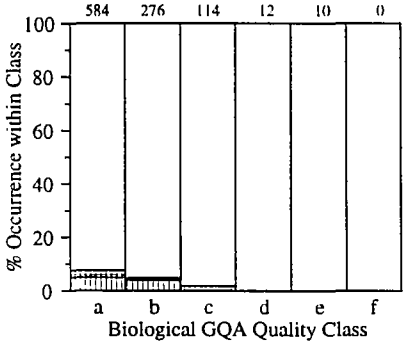
Midlands Region



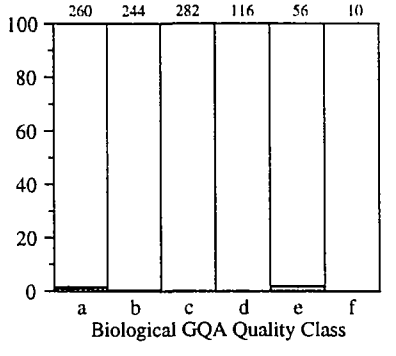
Anglian Region



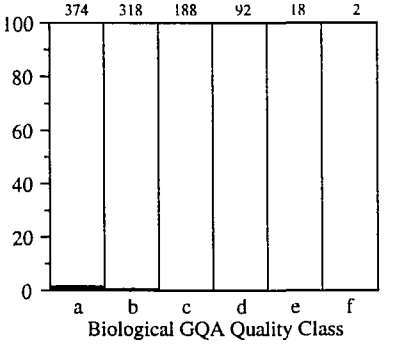
North and South Wessex Areas
South West Region



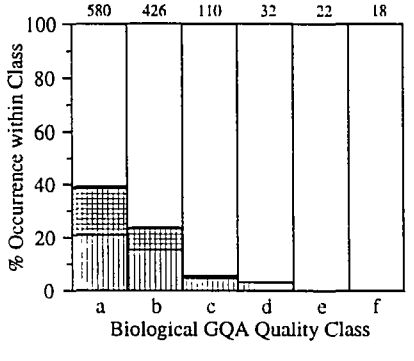
Thames Region



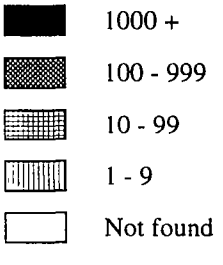
Southern Region



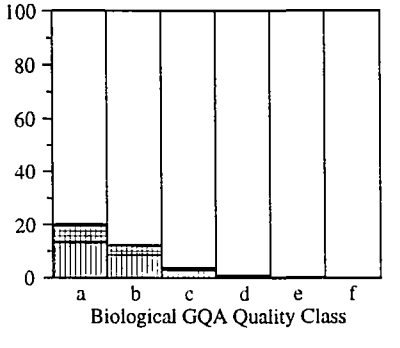
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

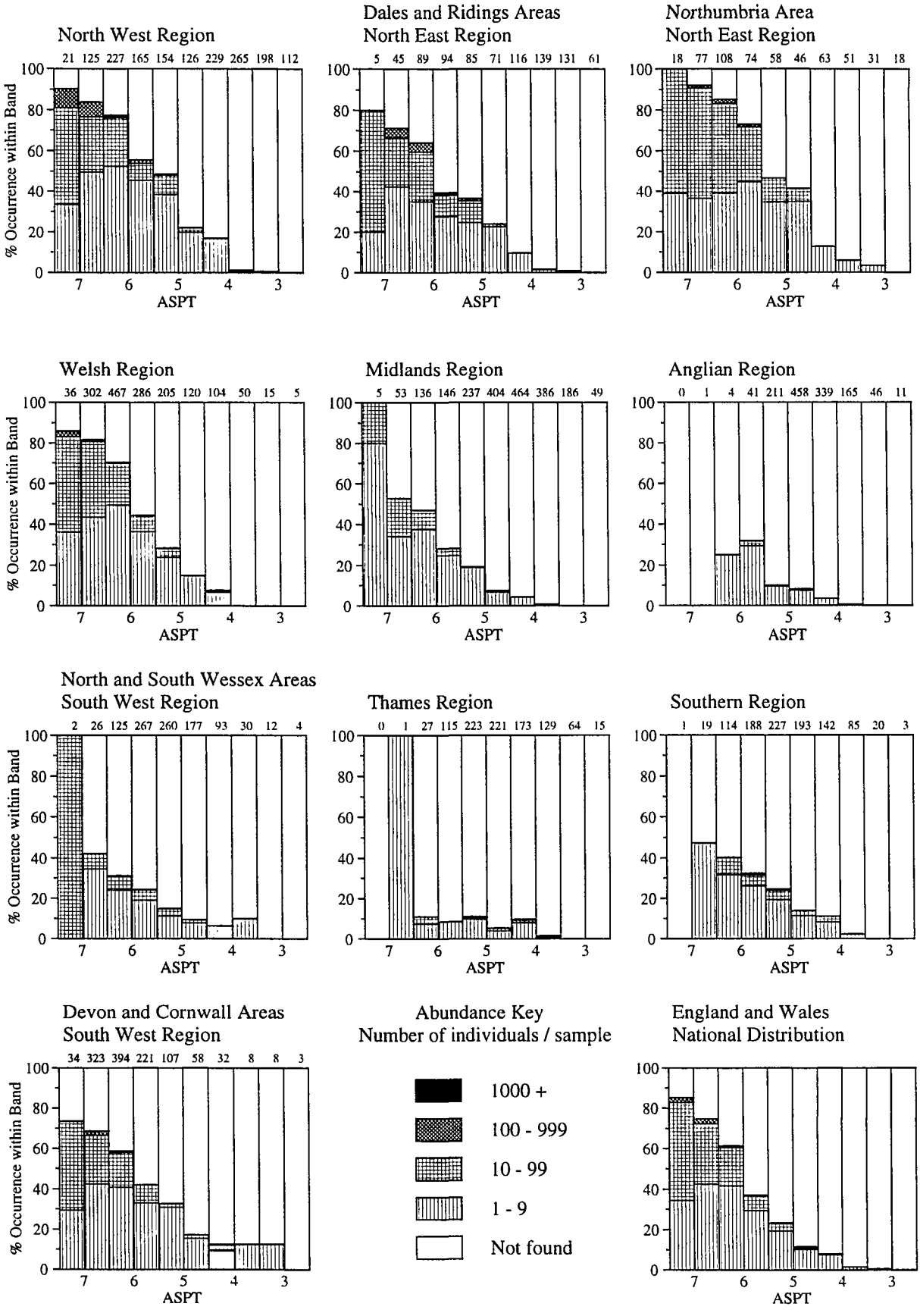


England and Wales
National Distribution



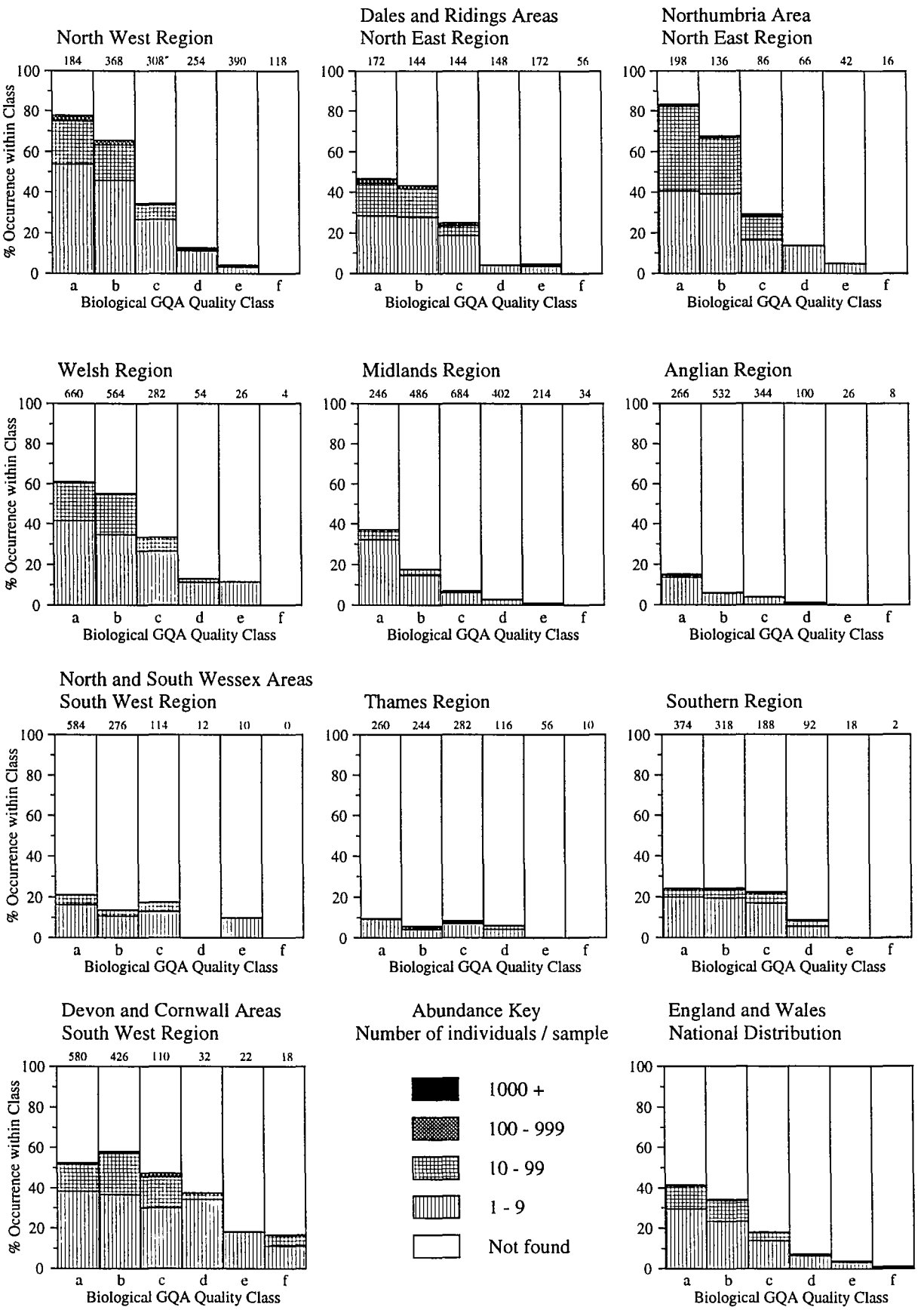
Regional Frequency Distributions by ASPT - River Sites 1995

NEMOURIDAE



Regional Frequency Distributions by Class - River Sites 1995

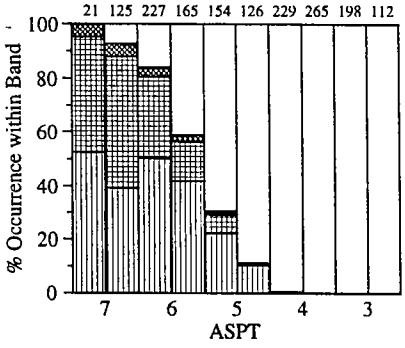
NEMOURIDAE



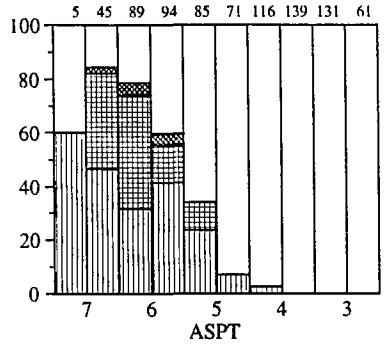
Regional Frequency Distributions by ASPT - River Sites 1995

LEUCTRIDAE

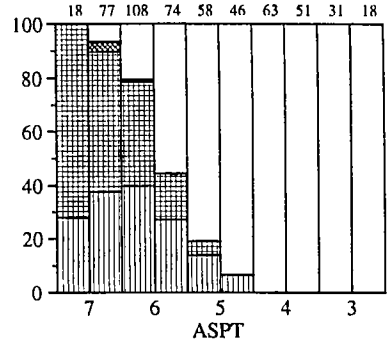
North West Region



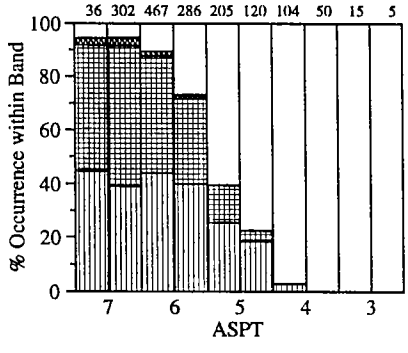
Dales and Ridings Areas
North East Region



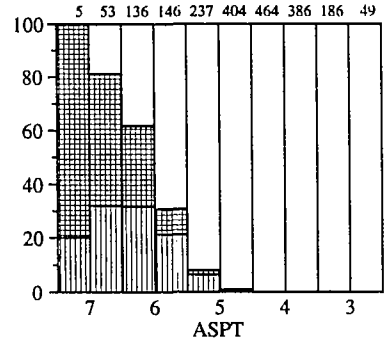
Northumbria Area
North East Region



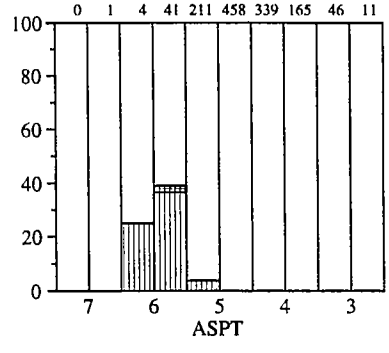
Welsh Region



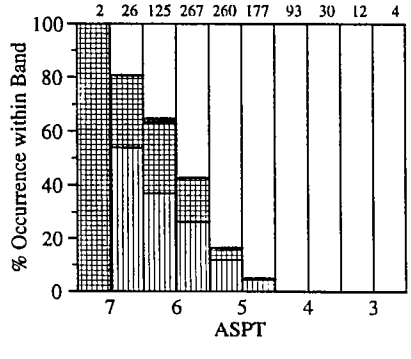
Midlands Region



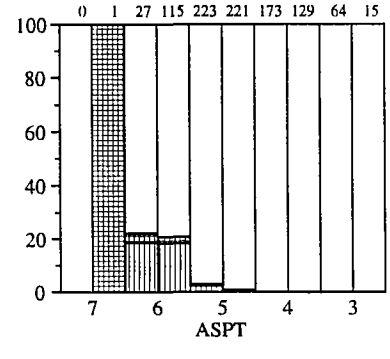
Anglian Region



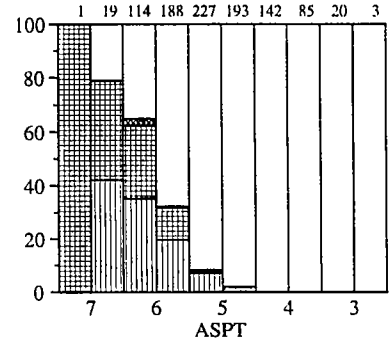
North and South Wessex Areas
South West Region



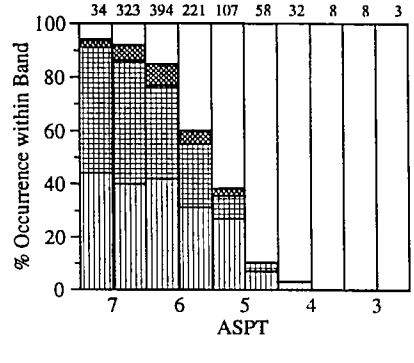
Thames Region



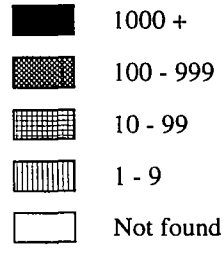
Southern Region



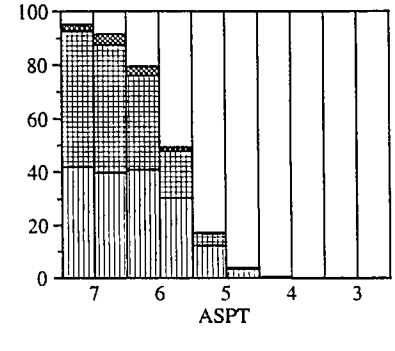
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



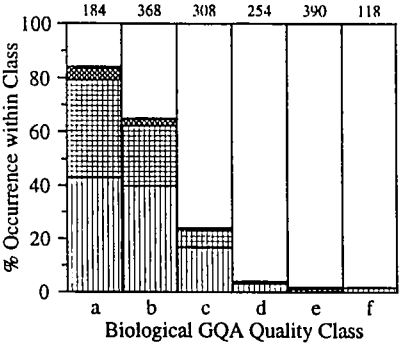
England and Wales
National Distribution



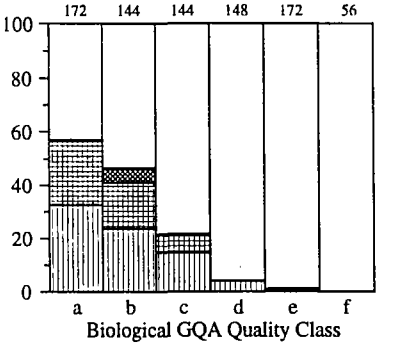
Regional Frequency Distributions by Class - River Sites 1995

LEUCTRIDAE

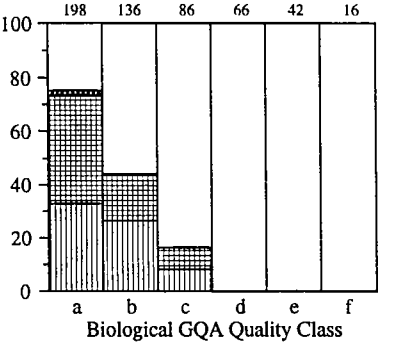
North West Region



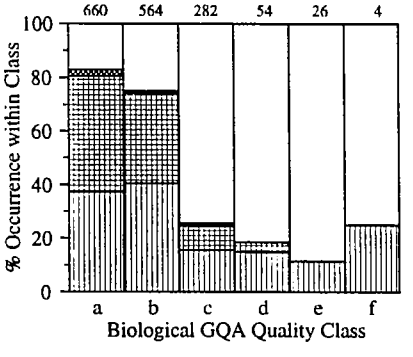
Dales and Ridings Areas
North East Region



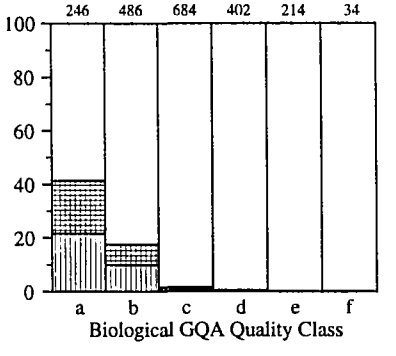
Northumbria Area
North East Region



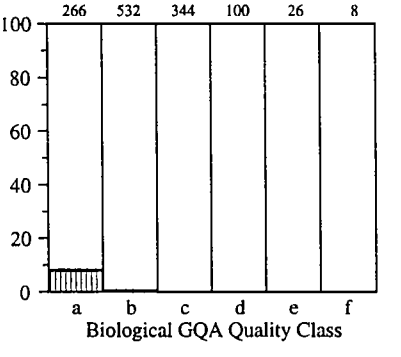
Welsh Region



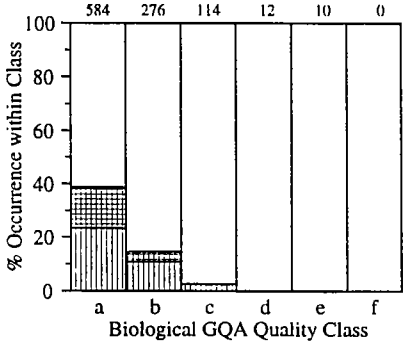
Midlands Region



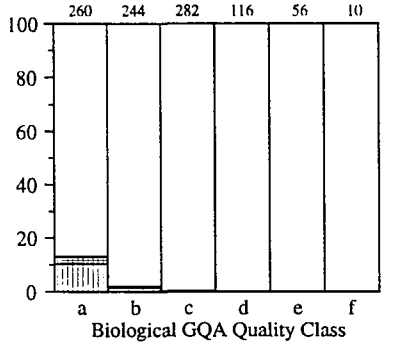
Anglian Region



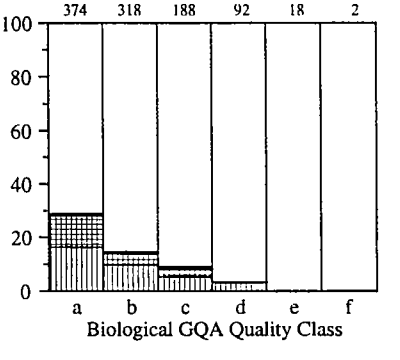
North and South Wessex Areas
South West Region



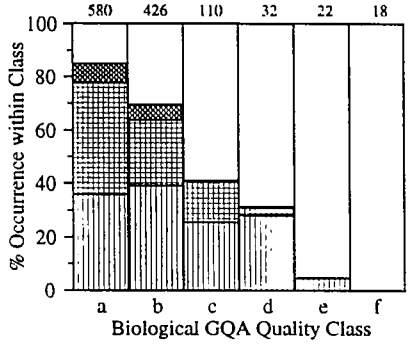
Thames Region



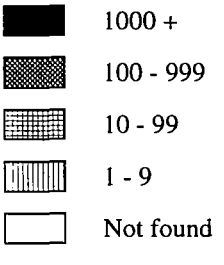
Southern Region



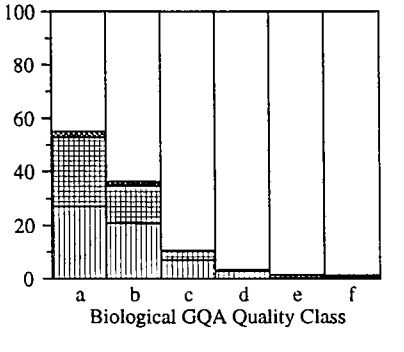
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



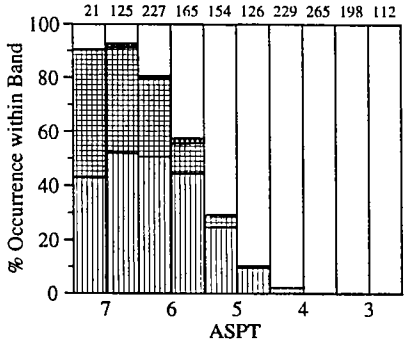
England and Wales
National Distribution



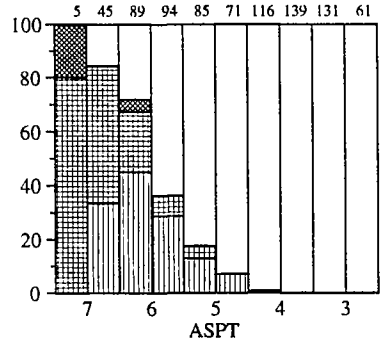
Regional Frequency Distributions by ASPT - River Sites 1995

PERLODIDAE

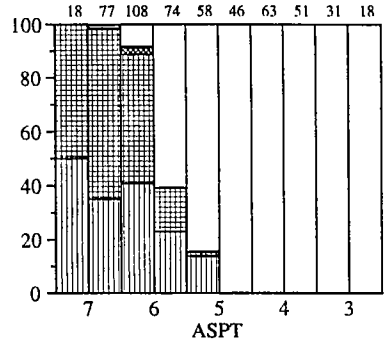
North West Region



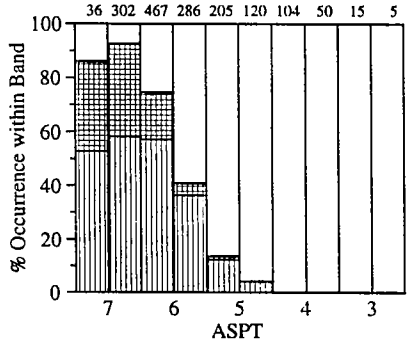
Dales and Ridings Areas
North East Region



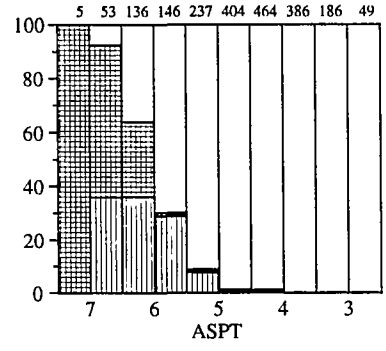
Northumbria Area
North East Region



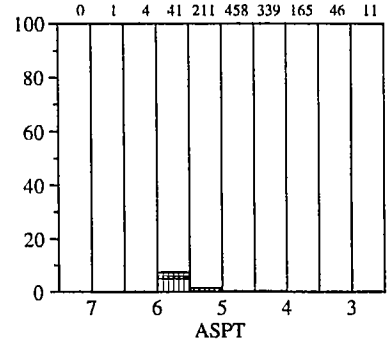
Welsh Region



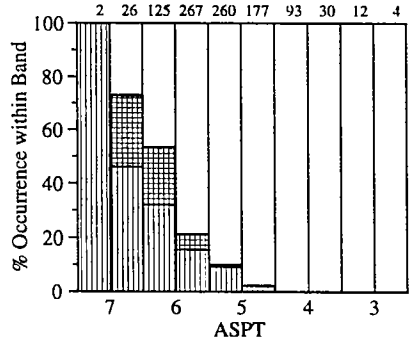
Midlands Region



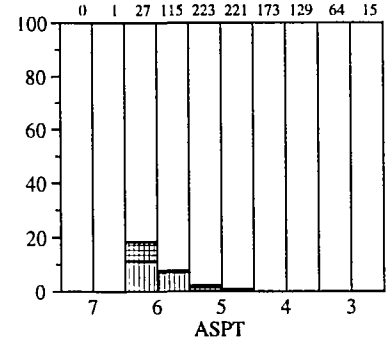
Anglian Region



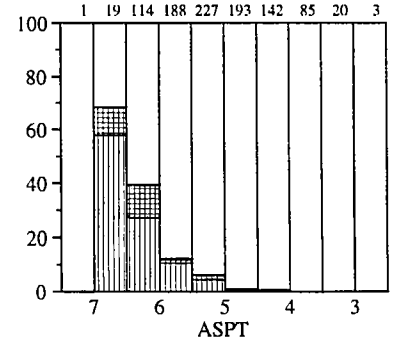
North and South Wessex Areas
South West Region



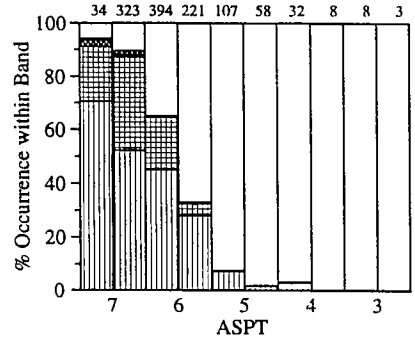
Thames Region



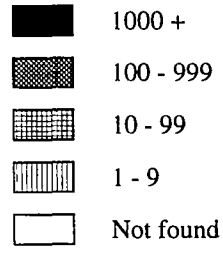
Southern Region



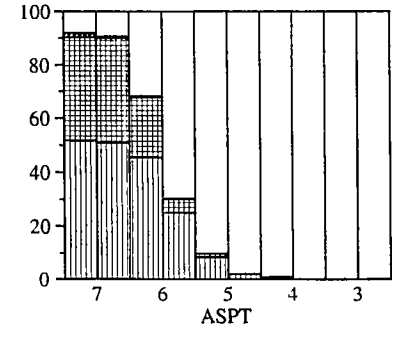
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



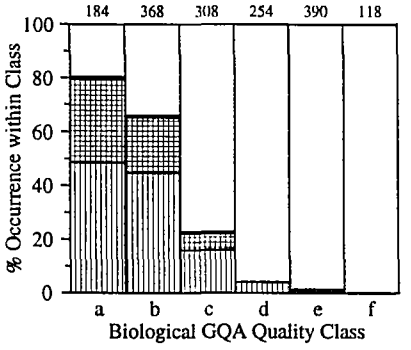
England and Wales
National Distribution



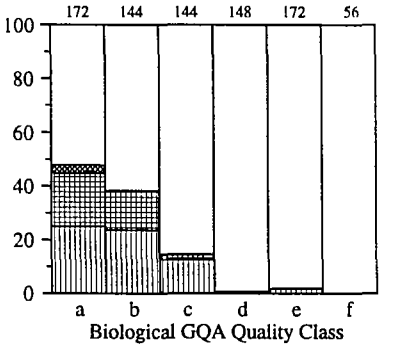
Regional Frequency Distributions by Class - River Sites 1995

PERLODIDAE

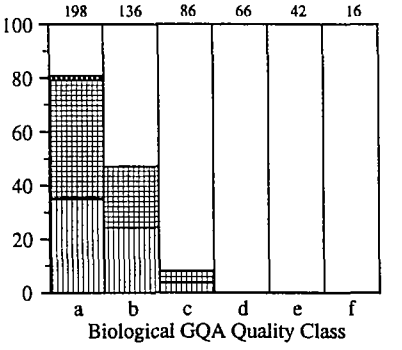
North West Region



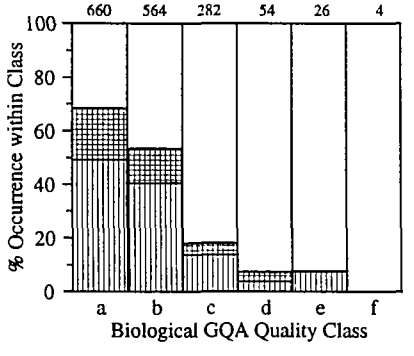
Dales and Ridings Areas
North East Region



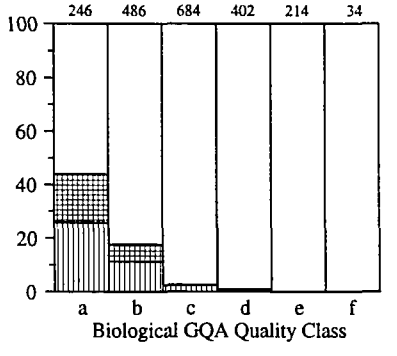
Northumbria Area
North East Region



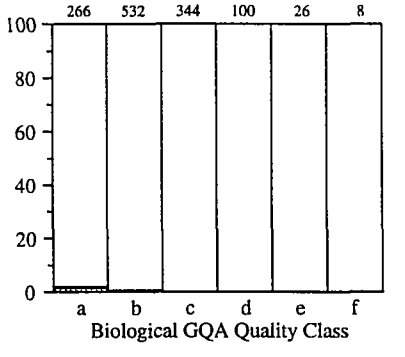
Welsh Region



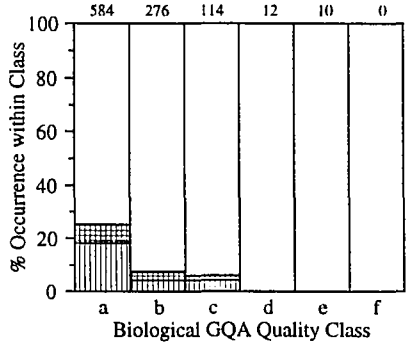
Midlands Region



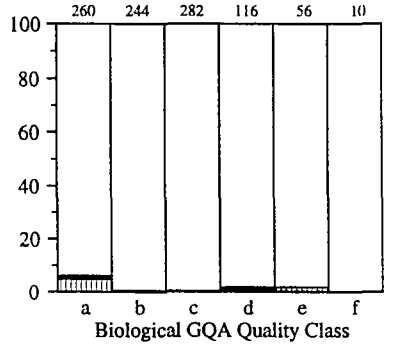
Anglian Region



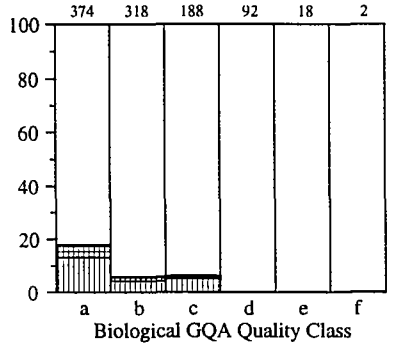
North and South Wessex Areas
South West Region



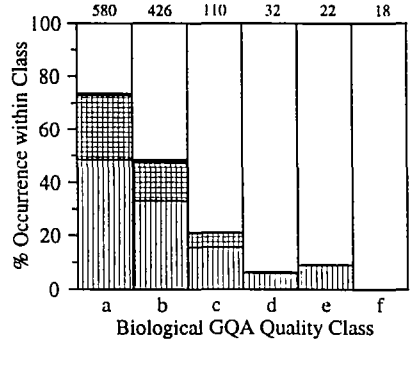
Thames Region



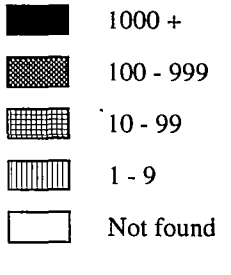
Southern Region



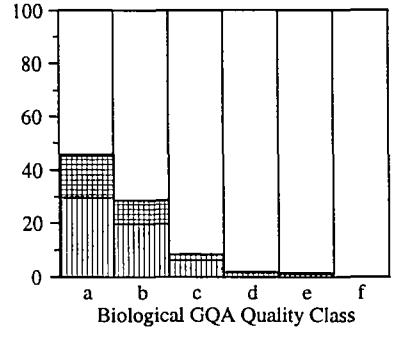
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

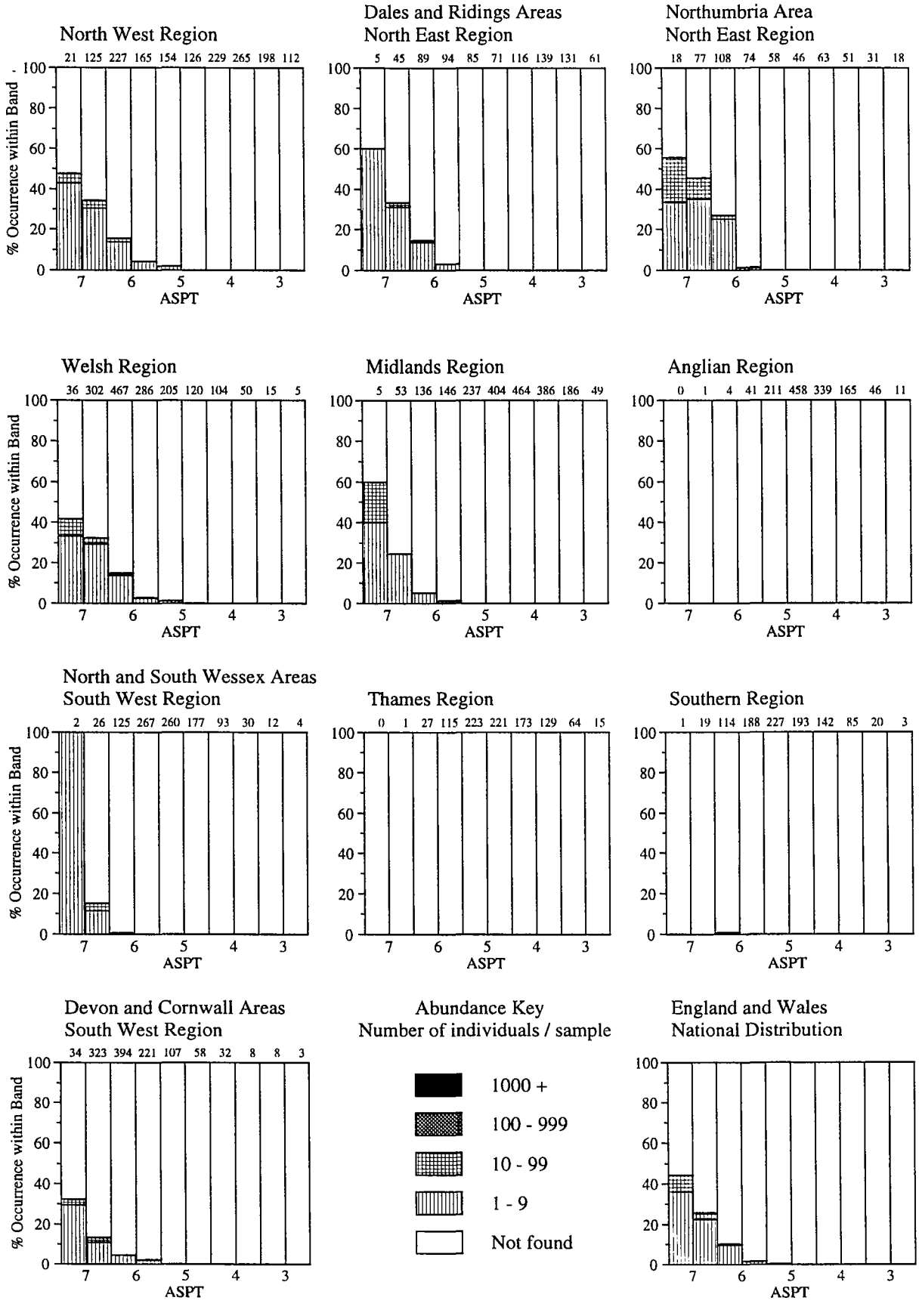


England and Wales
National Distribution



Regional Frequency Distributions by ASPT - River Sites 1995

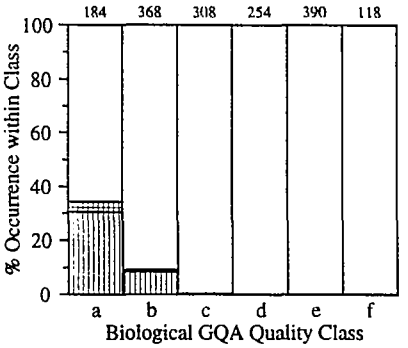
PERLIDAE



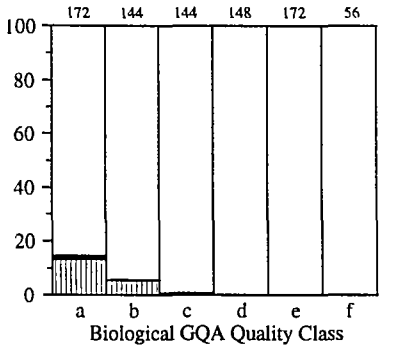
Regional Frequency Distributions by Class - River Sites 1995

PERLIDAE

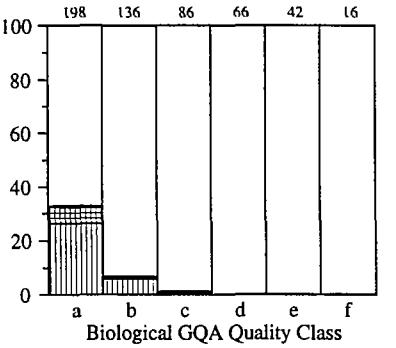
North West Region



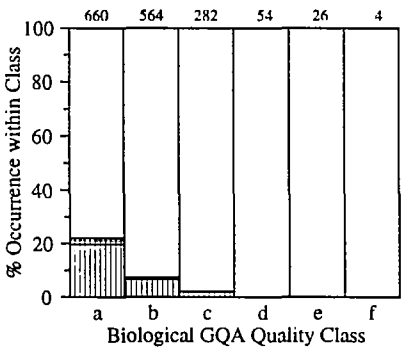
Dales and Ridings Areas
North East Region



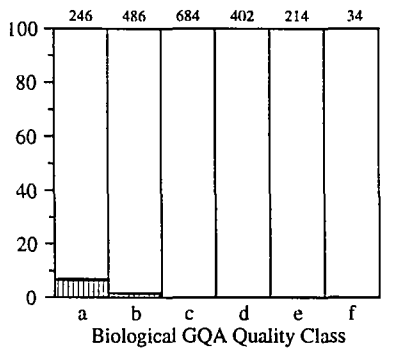
Northumbria Area
North East Region



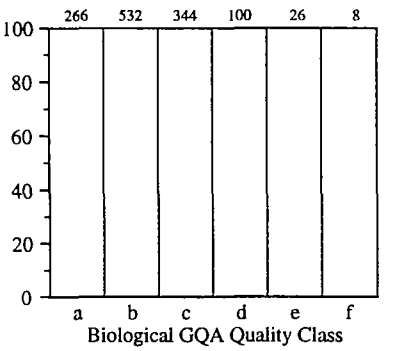
Welsh Region



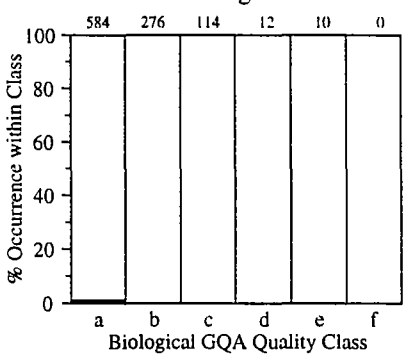
Midlands Region



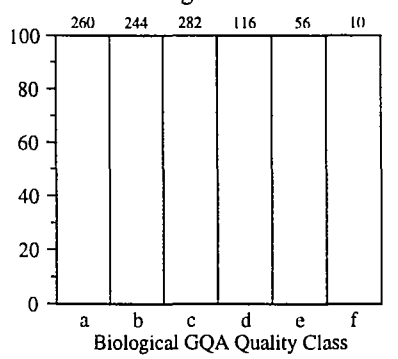
Anglian Region



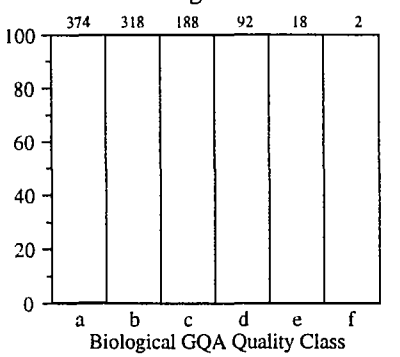
North and South Wessex Areas
South West Region



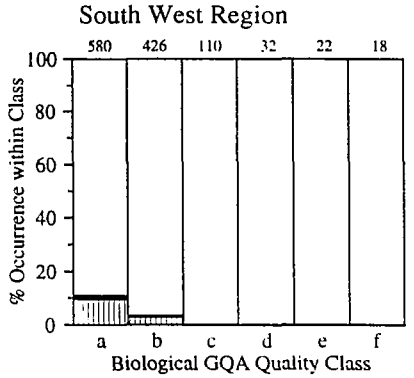
Thames Region



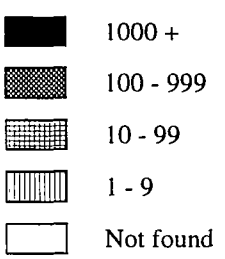
Southern Region



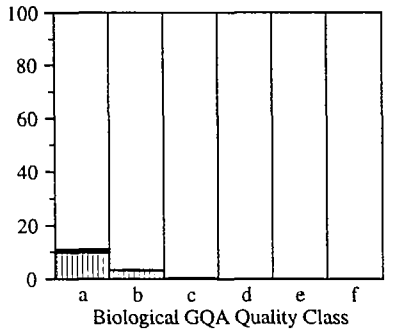
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

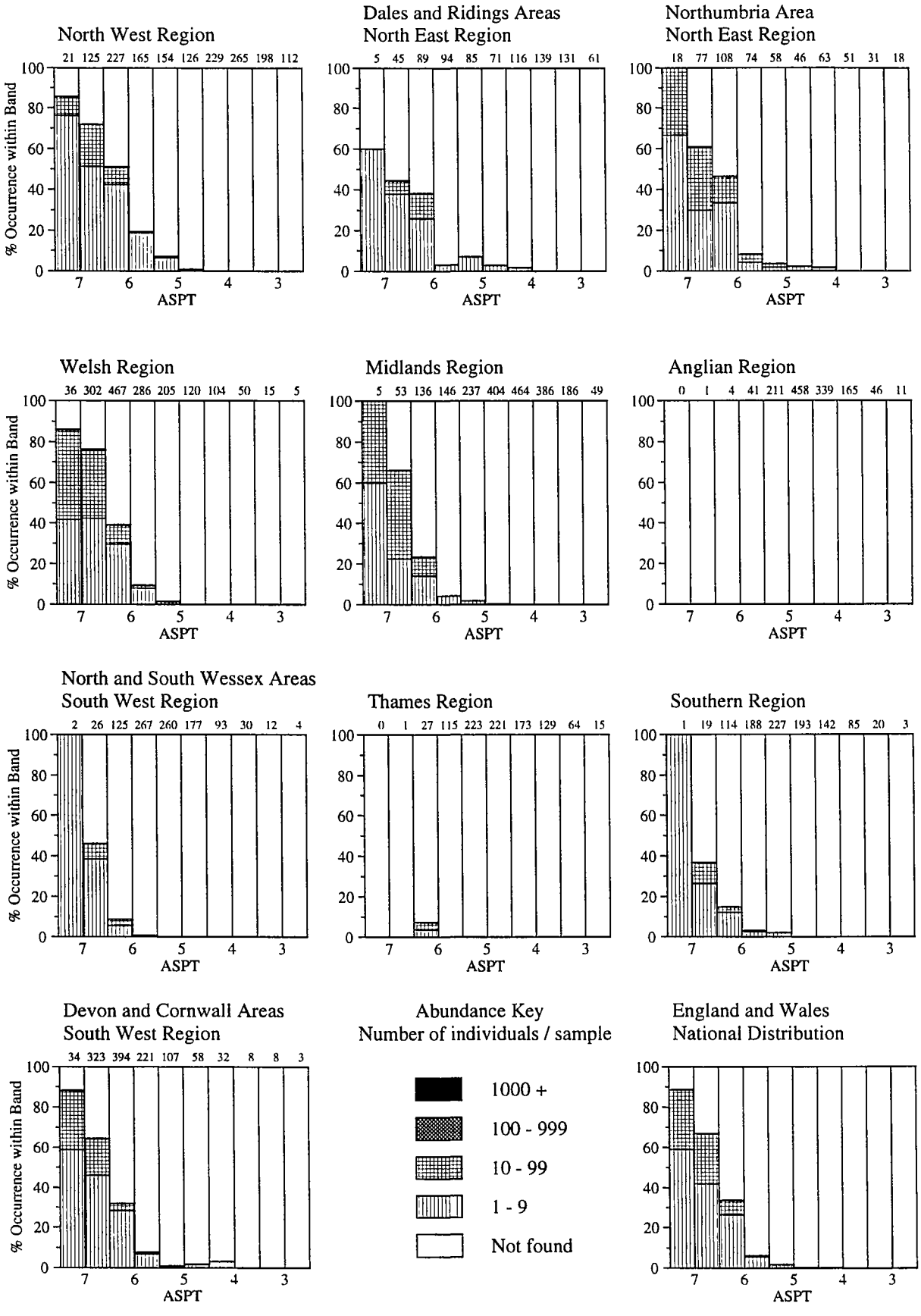


England and Wales
National Distribution



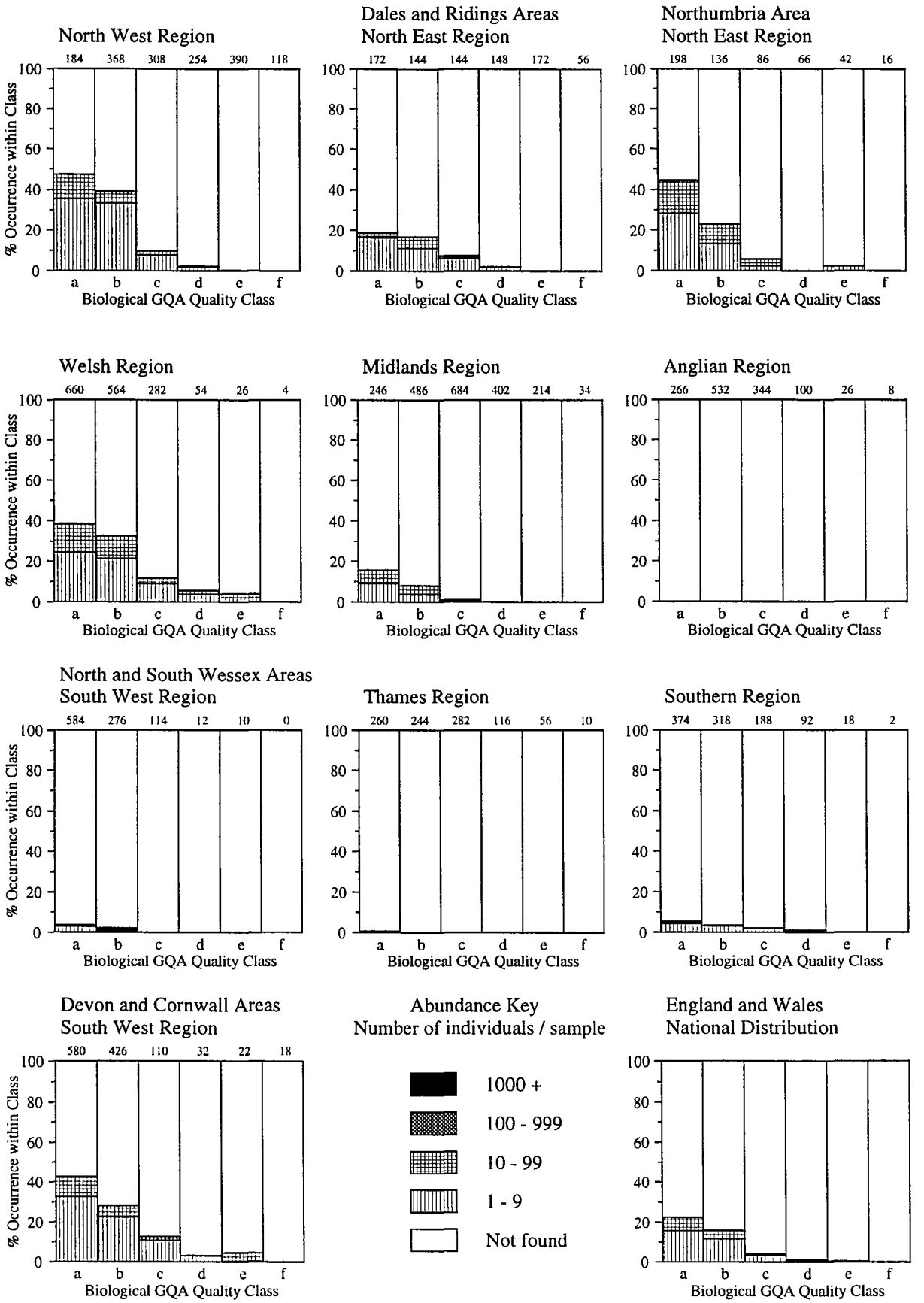
Regional Frequency Distributions by ASPT - River Sites 1995

CHLOROPERLIDAE



Regional Frequency Distributions by Class - River Sites 1995

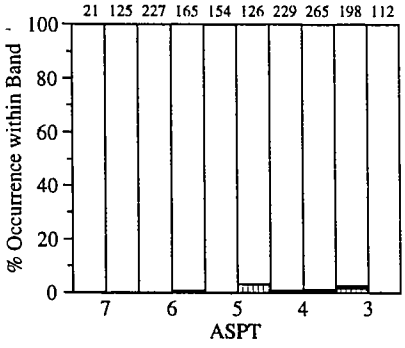
CHLOROPERLIDAE



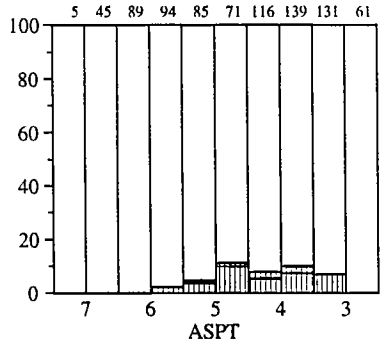
Regional Frequency Distributions by ASPT - River Sites 1995

COENAGRIIDAE

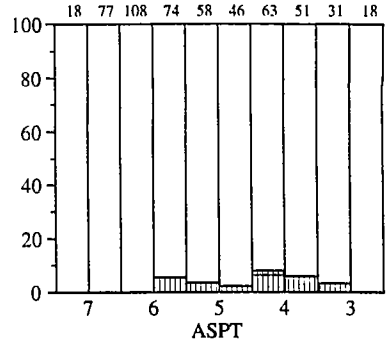
North West Region



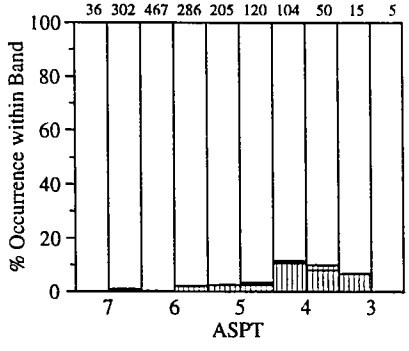
Dales and Ridings Areas
North East Region



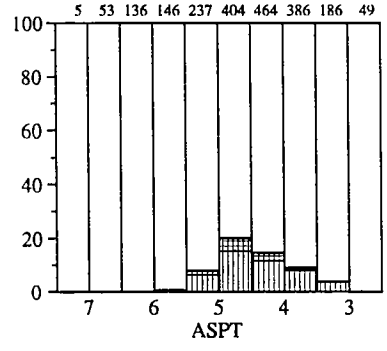
Northumbria Area
North East Region



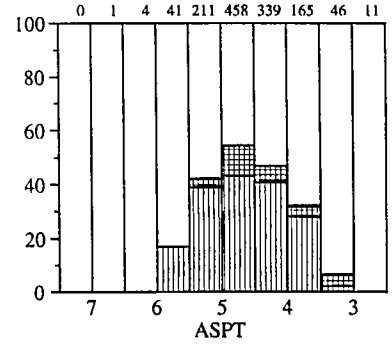
Welsh Region



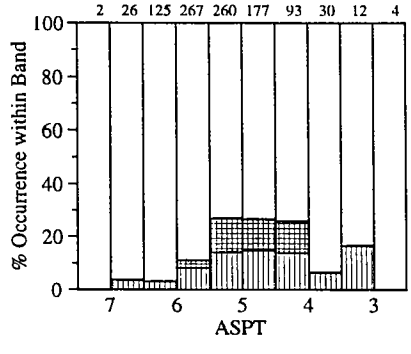
Midlands Region



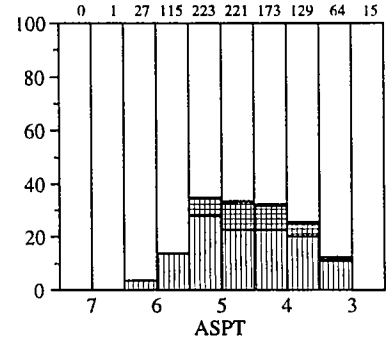
Anglian Region



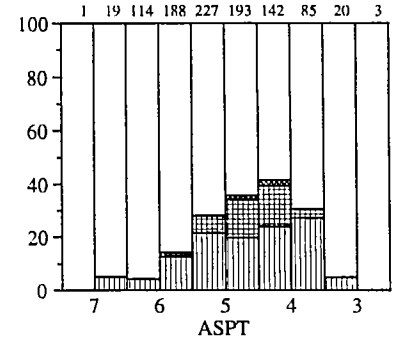
North and South Wessex Areas
South West Region



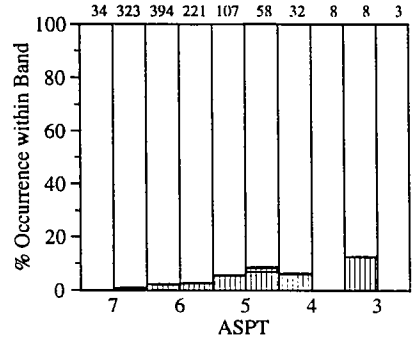
Thames Region



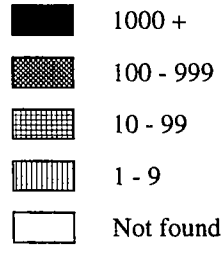
Southern Region



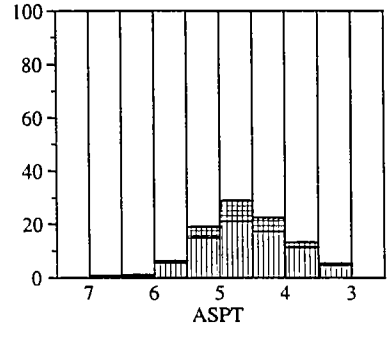
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



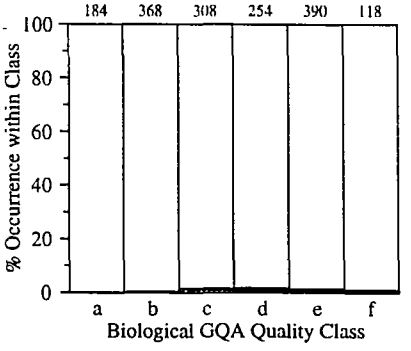
England and Wales
National Distribution



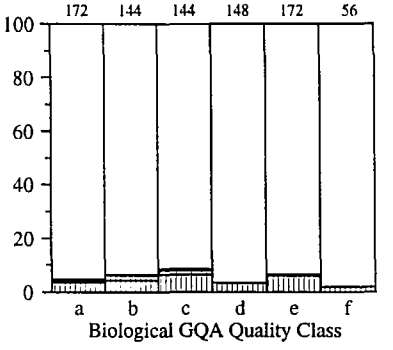
Regional Frequency Distributions by Class - River Sites 1995

COENAGRIIDAE

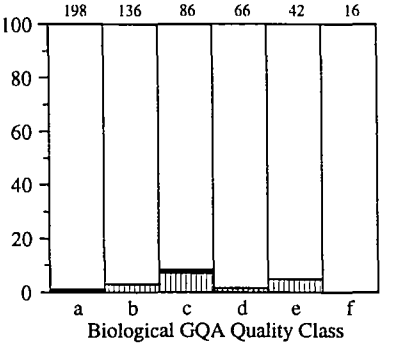
North West Region



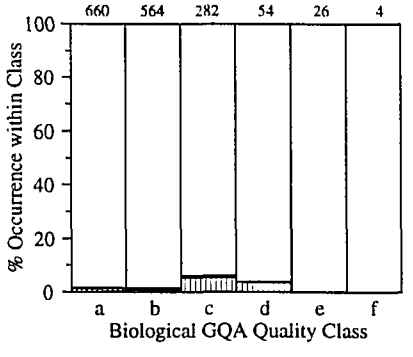
Dales and Ridings Areas
North East Region



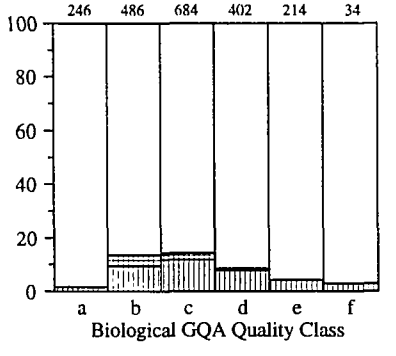
Northumbria Area
North East Region



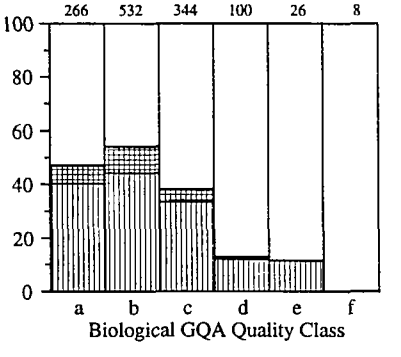
Welsh Region



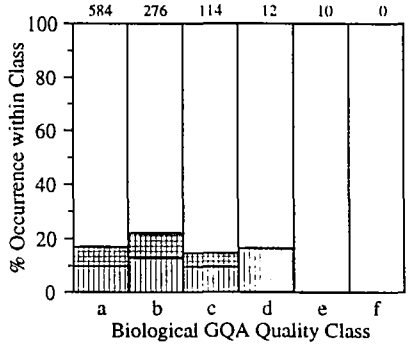
Midlands Region



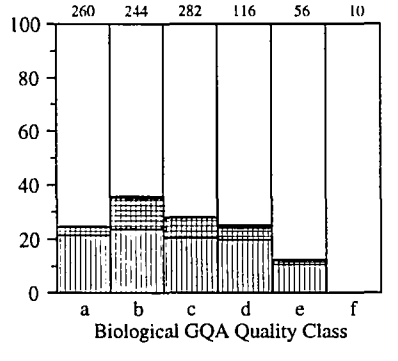
Anglian Region



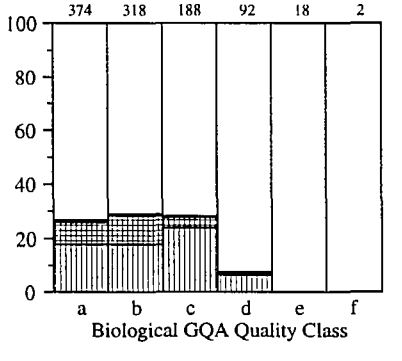
North and South Wessex Areas
South West Region



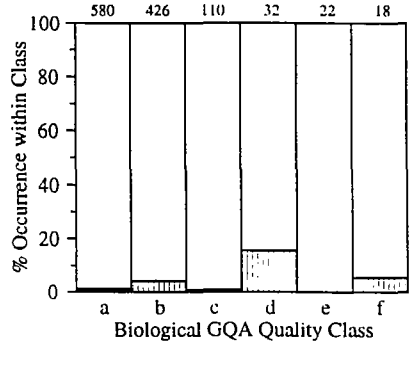
Thames Region



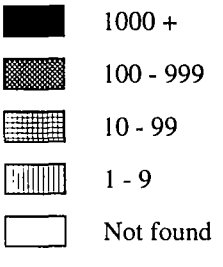
Southern Region



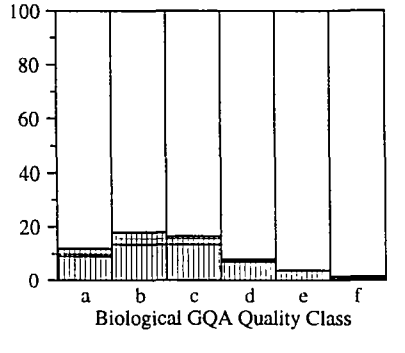
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

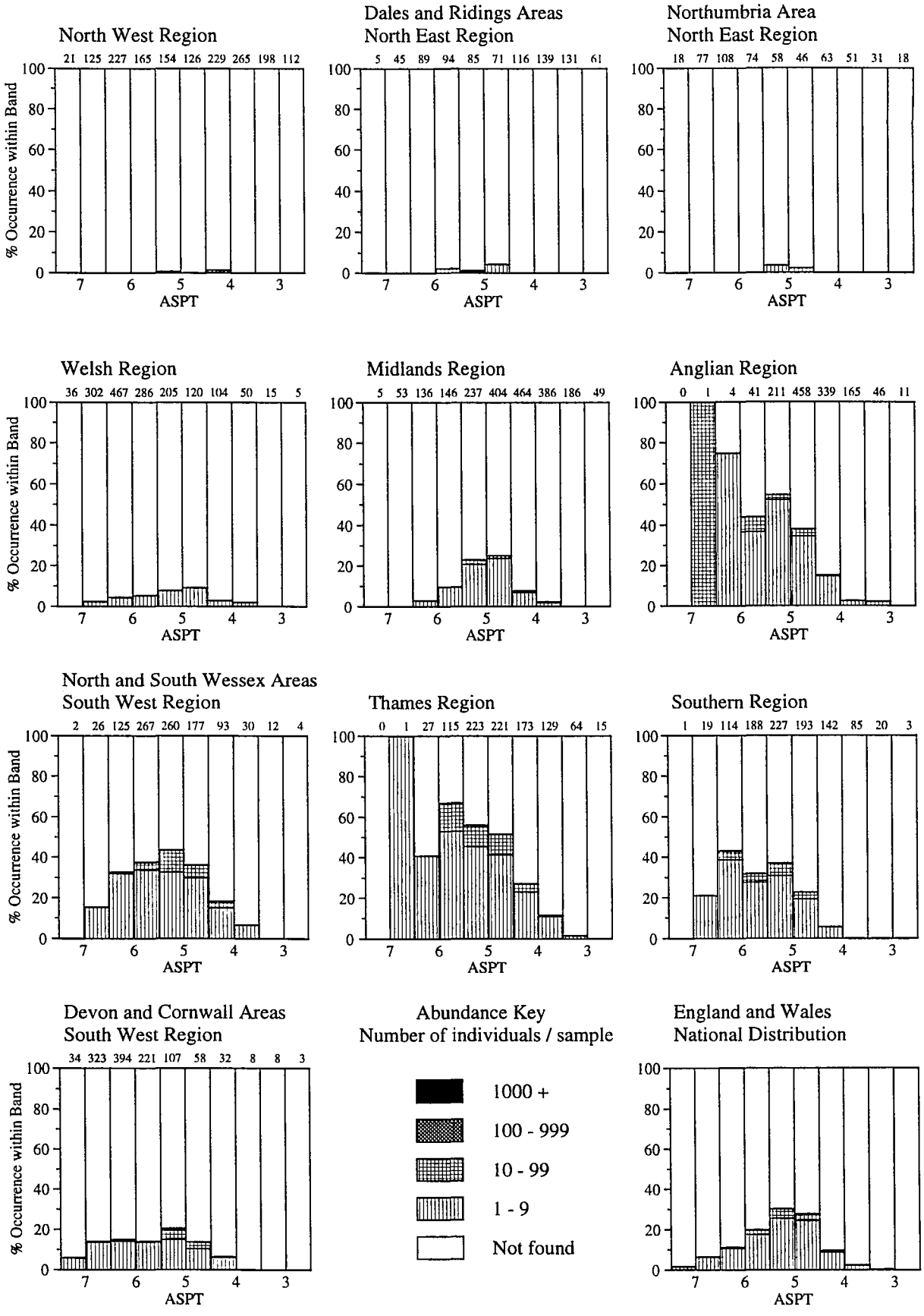


England and Wales
National Distribution



Regional Frequency Distributions by ASPT - River Sites 1995

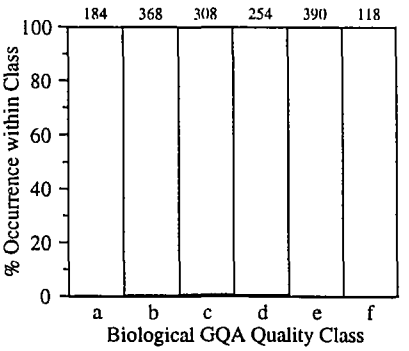
CALOPTERYGIDAE



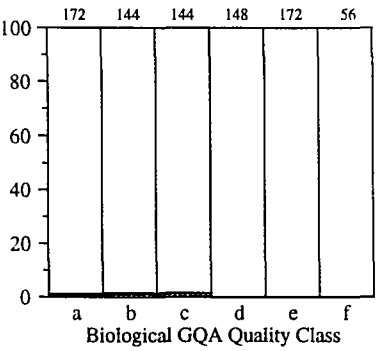
Regional Frequency Distributions by Class - River Sites 1995

CALOPTERYGIDAE

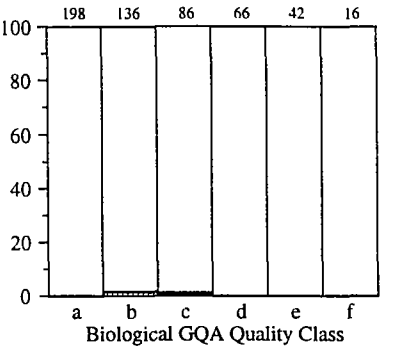
North West Region



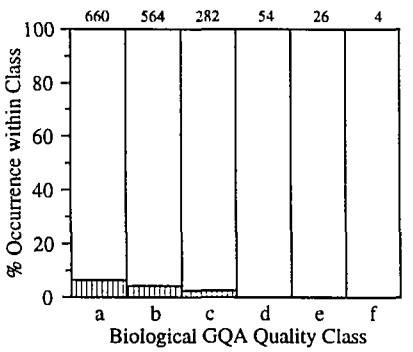
Dales and Ridings Areas
North East Region



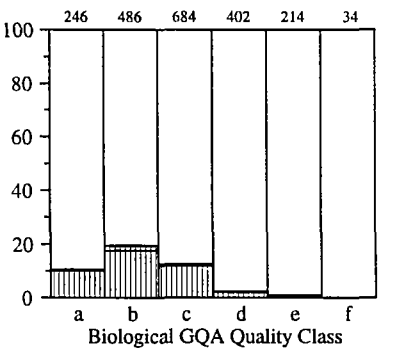
Northumbria Area
North East Region



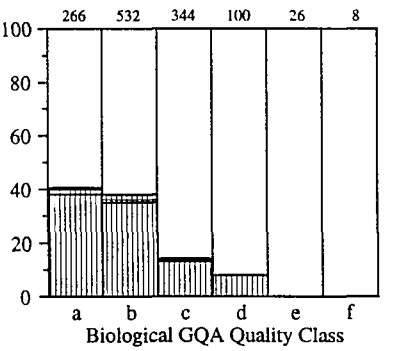
Welsh Region



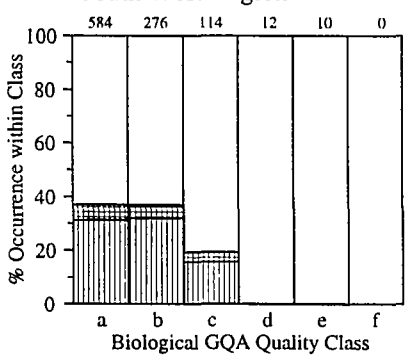
Midlands Region



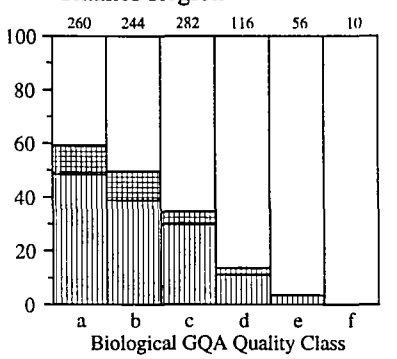
Anglian Region



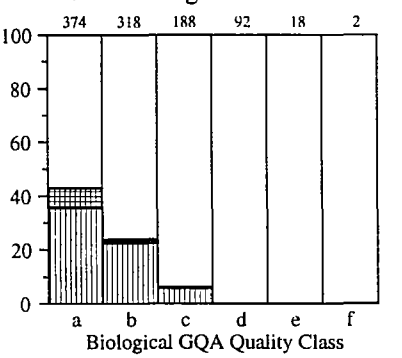
North and South Wessex Areas
South West Region



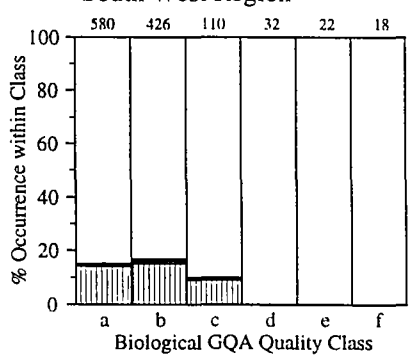
Thames Region



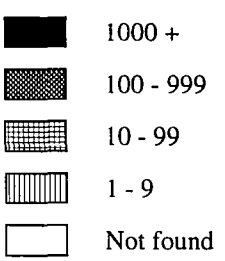
Southern Region



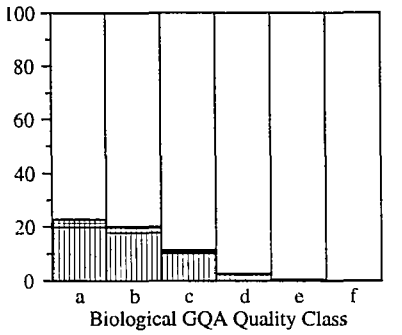
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



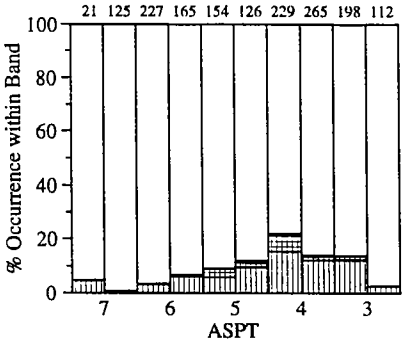
England and Wales
National Distribution



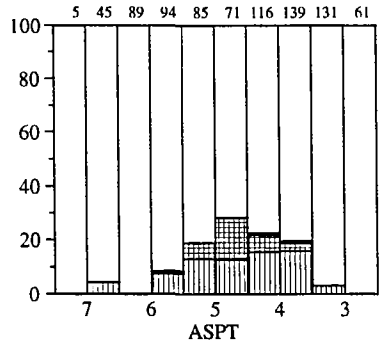
Regional Frequency Distributions by ASPT - River Sites 1995

CORIXIDAE

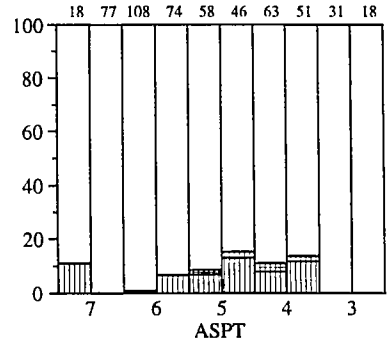
North West Region



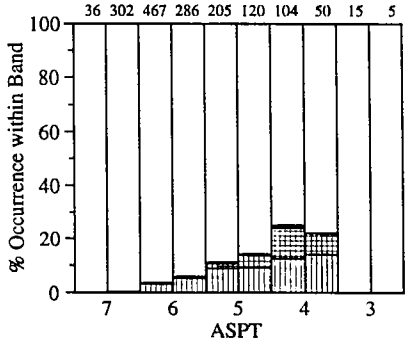
Dales and Ridings Areas
North East Region



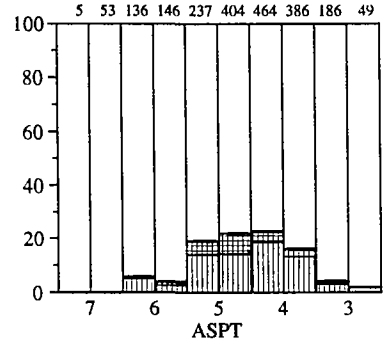
Northumbria Area
North East Region



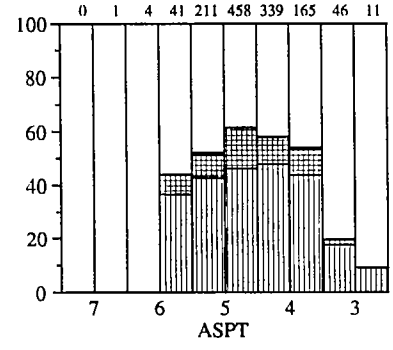
Welsh Region



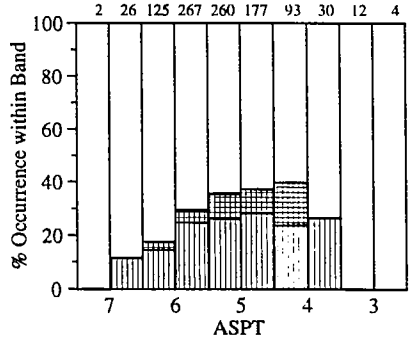
Midlands Region



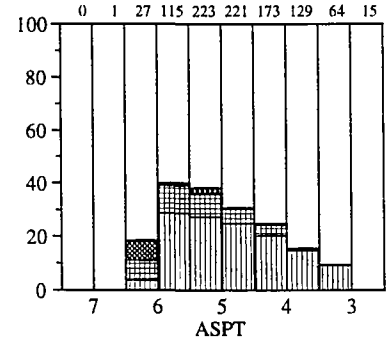
Anglian Region



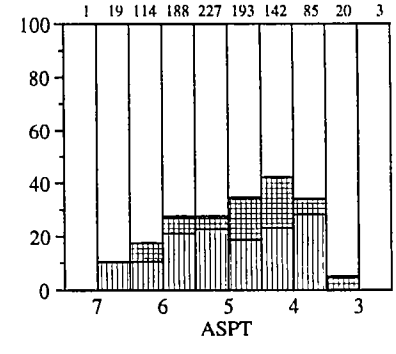
North and South Wessex Areas
South West Region



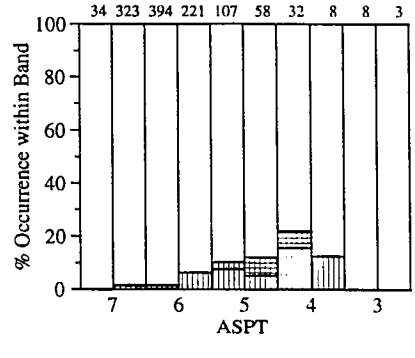
Thames Region



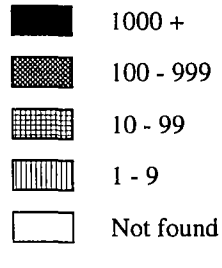
Southern Region



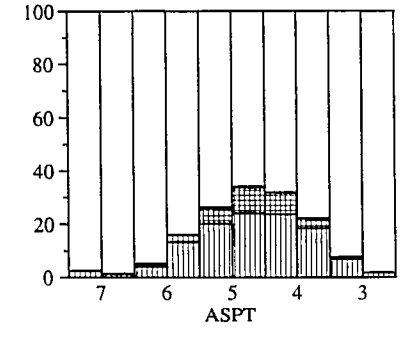
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

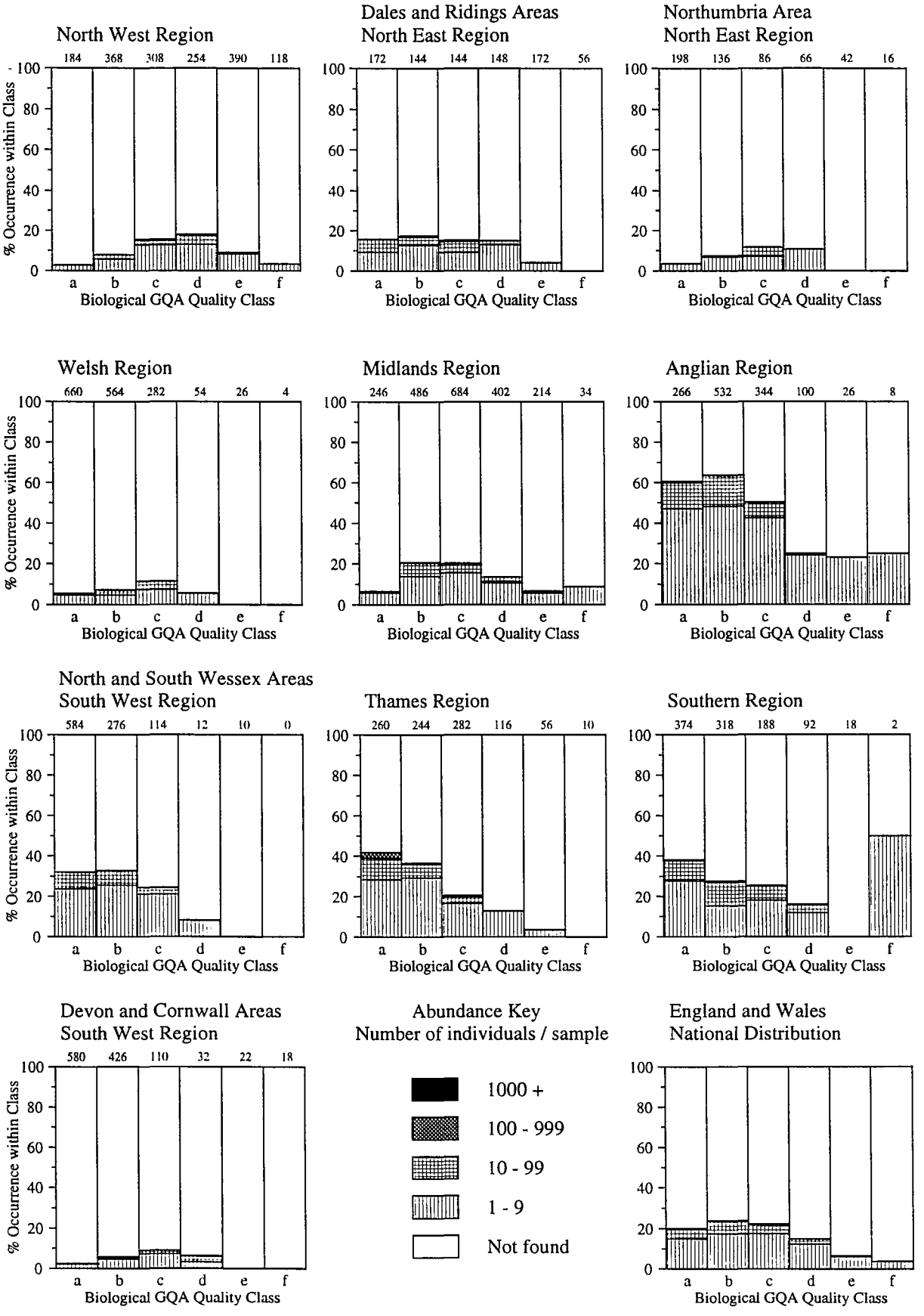


England and Wales
National Distribution



Regional Frequency Distributions by Class - River Sites 1995

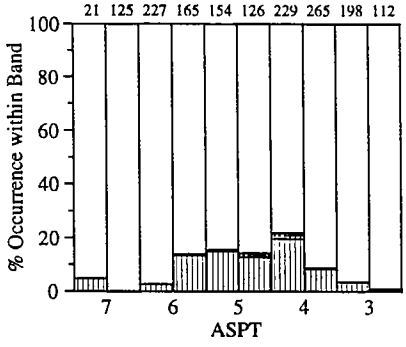
CORIXIDAE



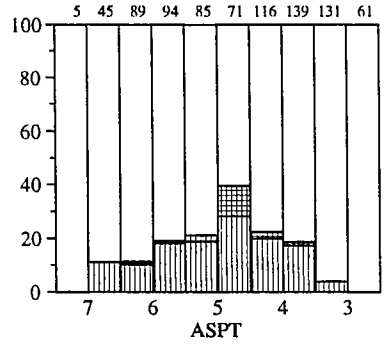
Regional Frequency Distributions by ASPT - River Sites 1995

HALIPLIDAE

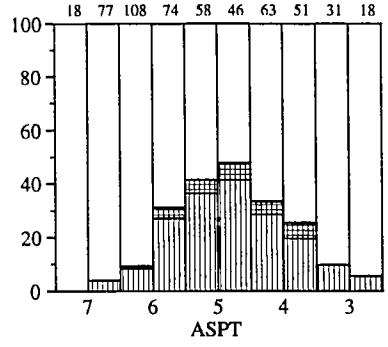
North West Region



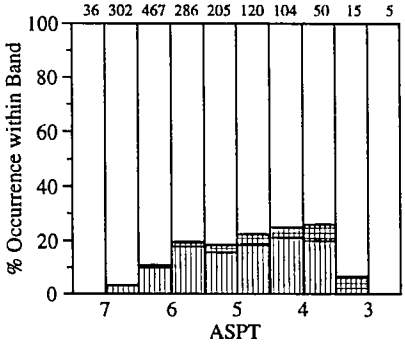
Dales and Ridings Areas
North East Region



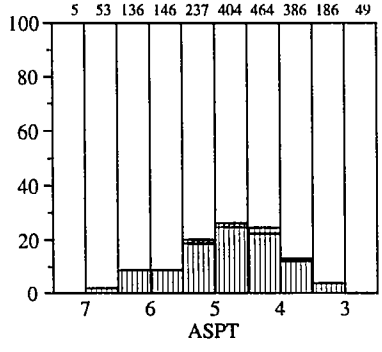
Northumbria Area
North East Region



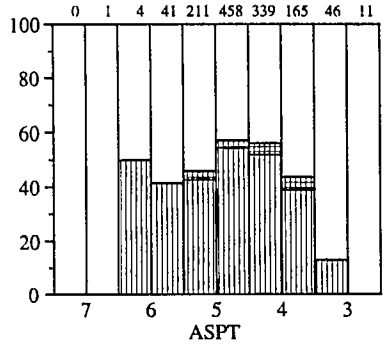
Welsh Region



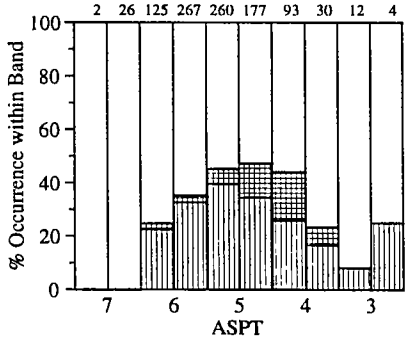
Midlands Region



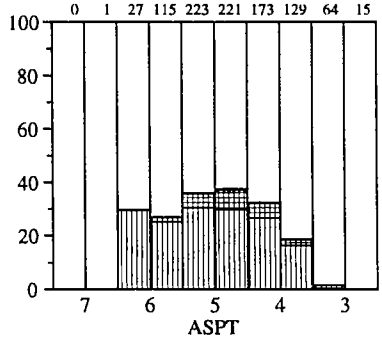
Anglian Region



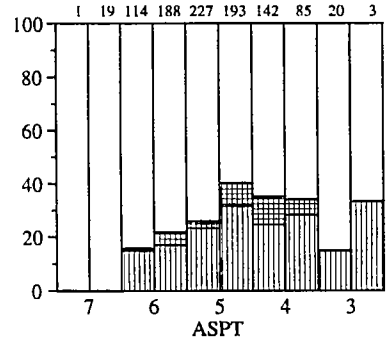
North and South Wessex Areas
South West Region



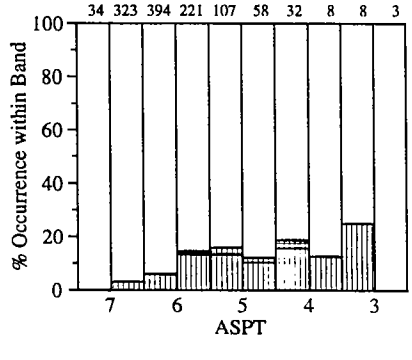
Thames Region



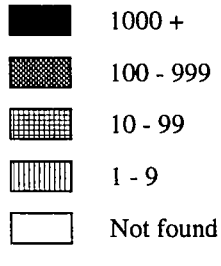
Southern Region



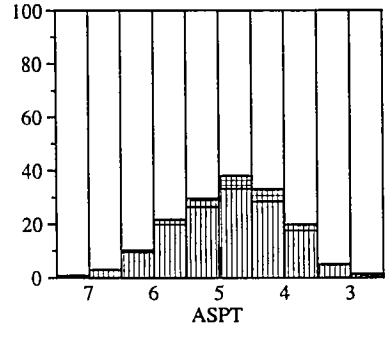
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

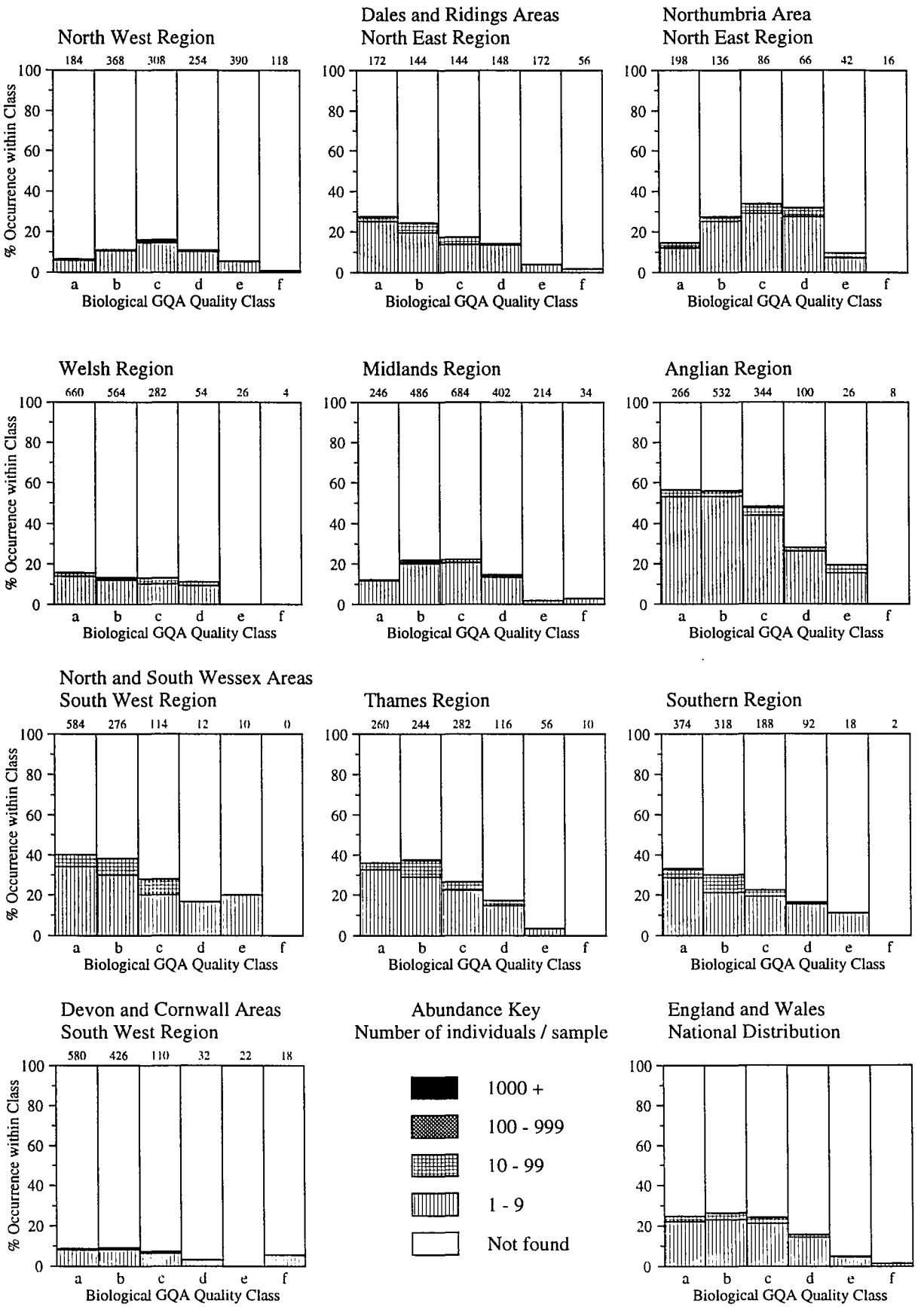


England and Wales
National Distribution



Regional Frequency Distributions by Class - River Sites 1995

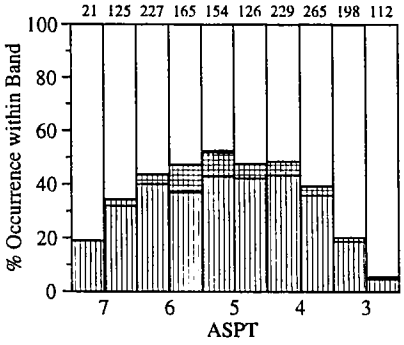
HALIPLIDAE



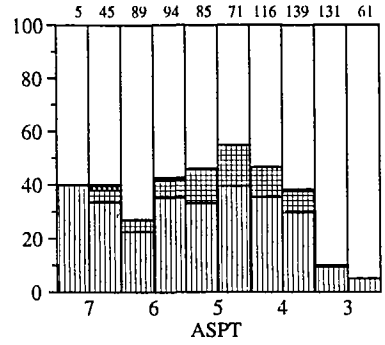
Regional Frequency Distributions by ASPT - River Sites 1995

DYTISCIDAE

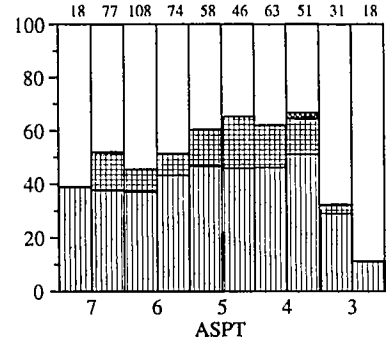
North West Region



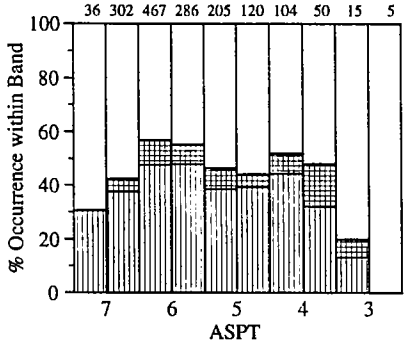
Dales and Ridings Areas
North East Region



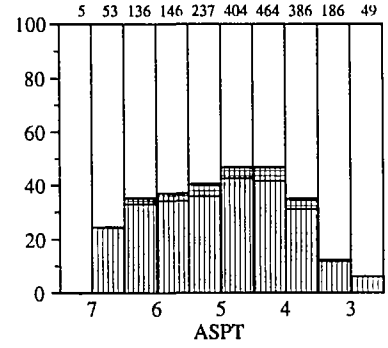
Northumbria Area
North East Region



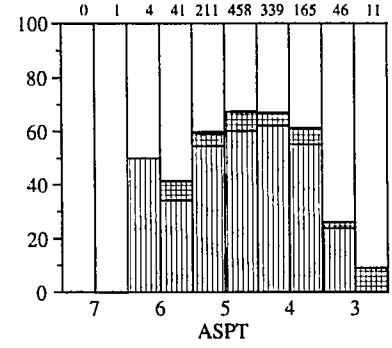
Welsh Region



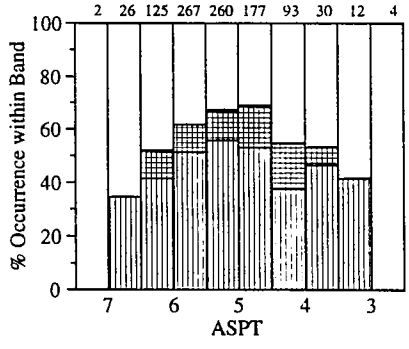
Midlands Region



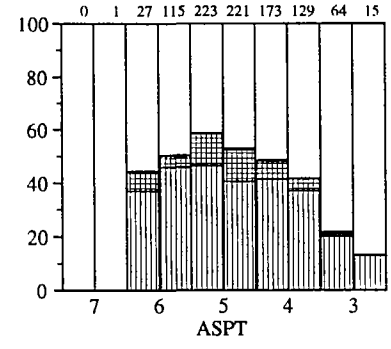
Anglian Region



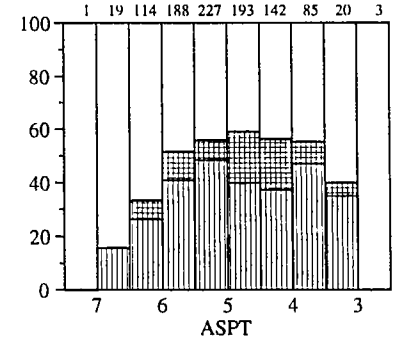
North and South Wessex Areas
South West Region



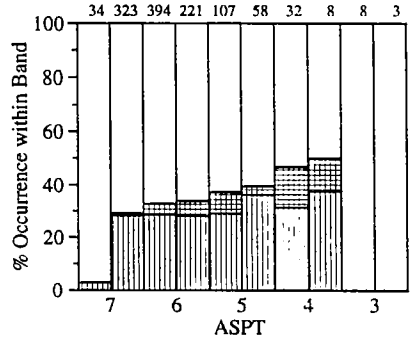
Thames Region



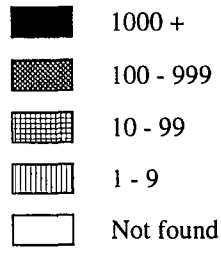
Southern Region



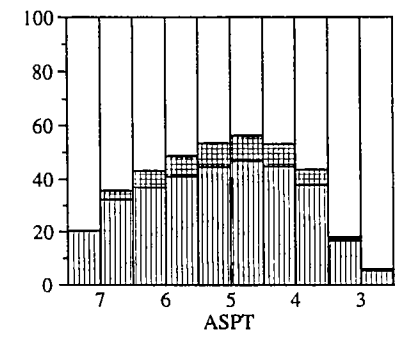
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



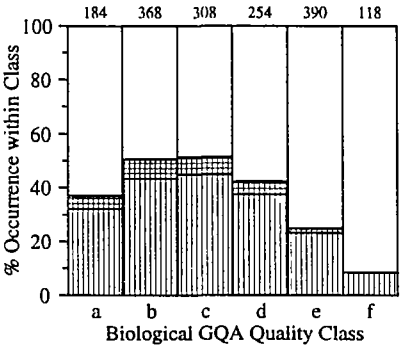
England and Wales
National Distribution



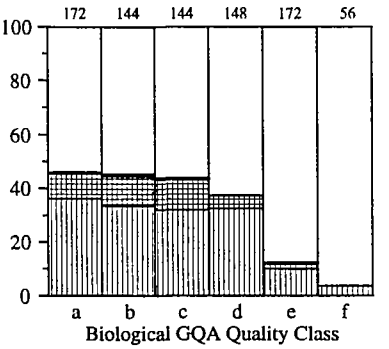
Regional Frequency Distributions by Class - River Sites 1995

DYTISCIDAE

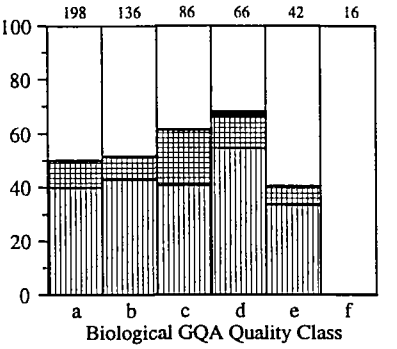
North West Region



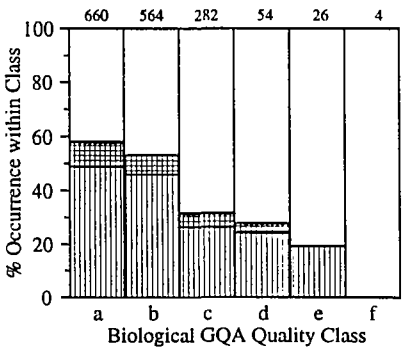
Dales and Ridings Areas
North East Region



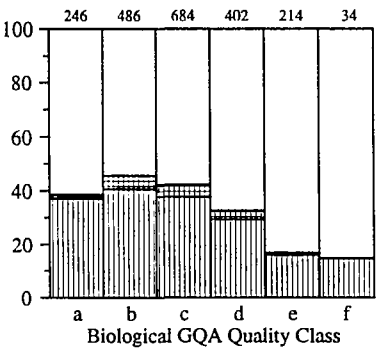
Northumbria Area
North East Region



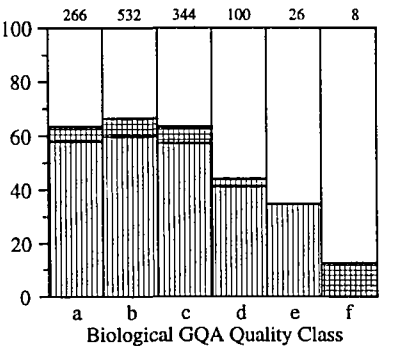
Welsh Region



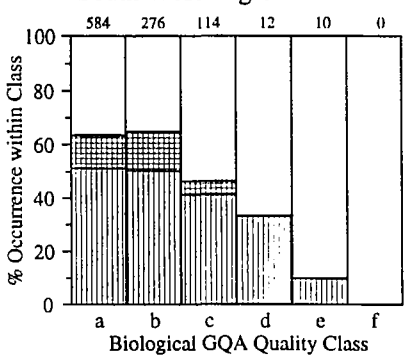
Midlands Region



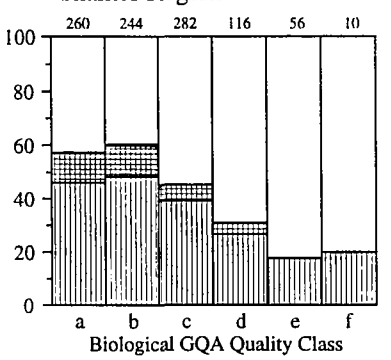
Anglian Region



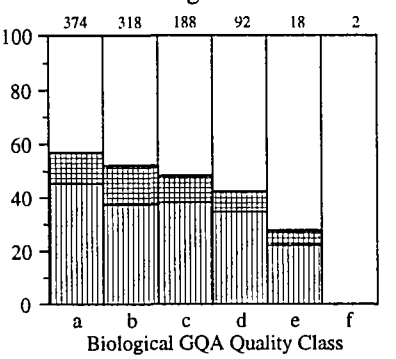
North and South Wessex Areas
South West Region



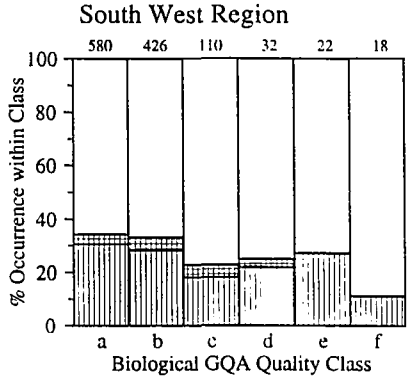
Thames Region



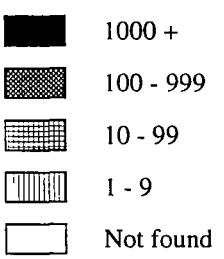
Southern Region



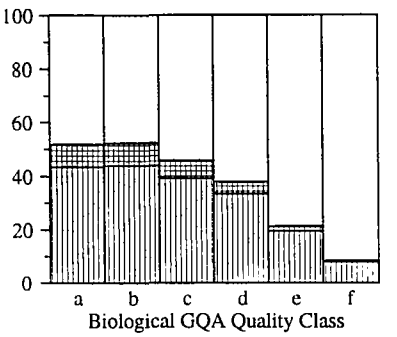
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



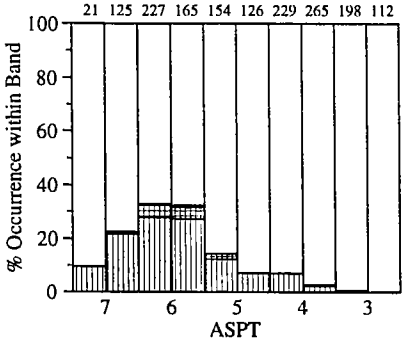
England and Wales
National Distribution



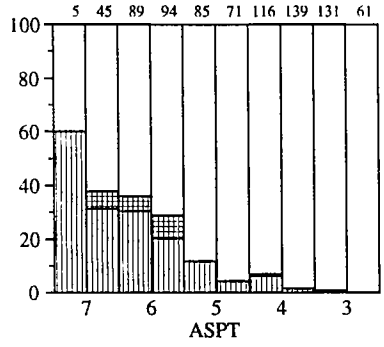
Regional Frequency Distributions by ASPT - River Sites 1995

GYRINIDAE

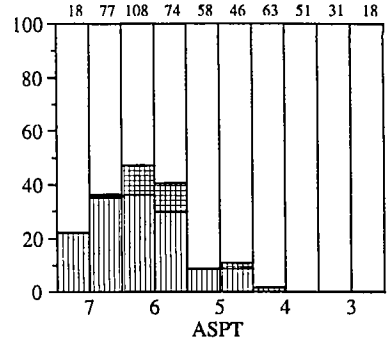
North West Region



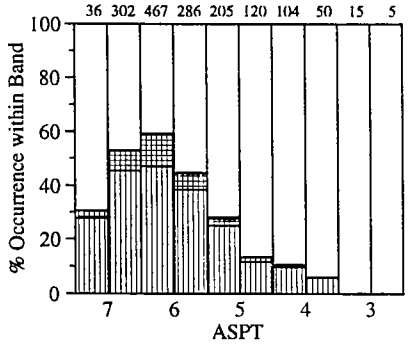
Dales and Ridings Areas
North East Region



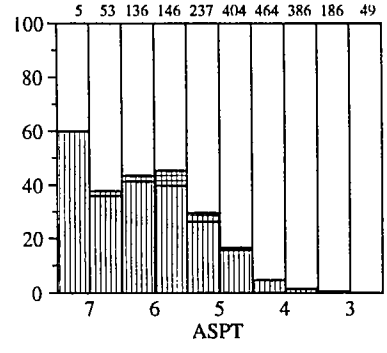
Northumbria Area
North East Region



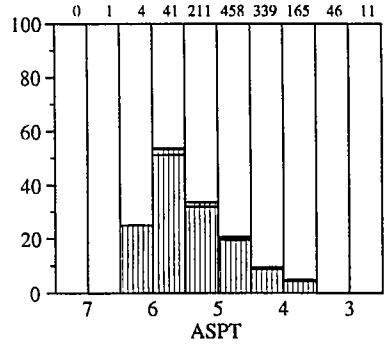
Welsh Region



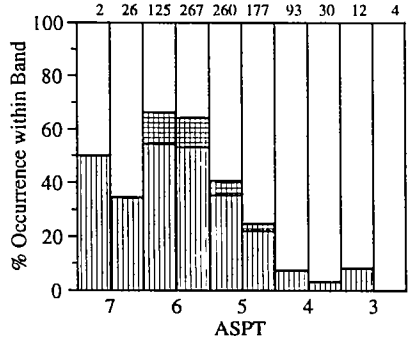
Midlands Region



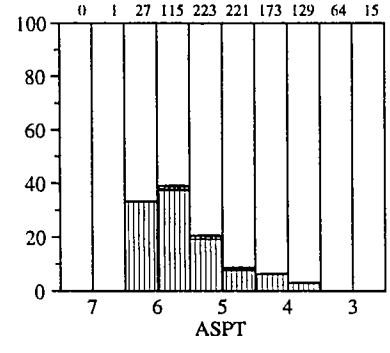
Anglian Region



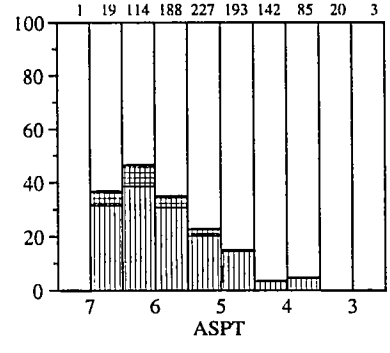
North and South Wessex Areas
South West Region



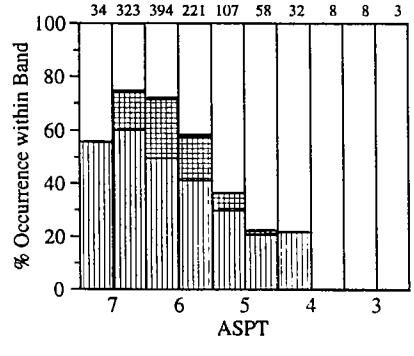
Thames Region



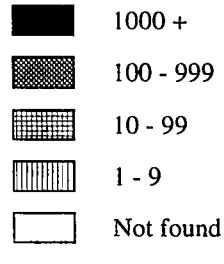
Southern Region



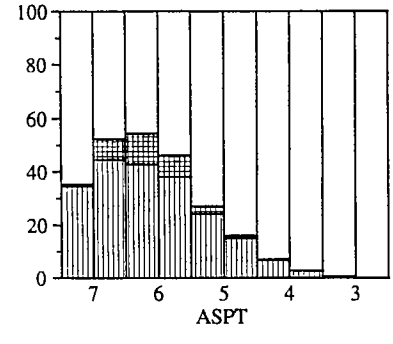
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

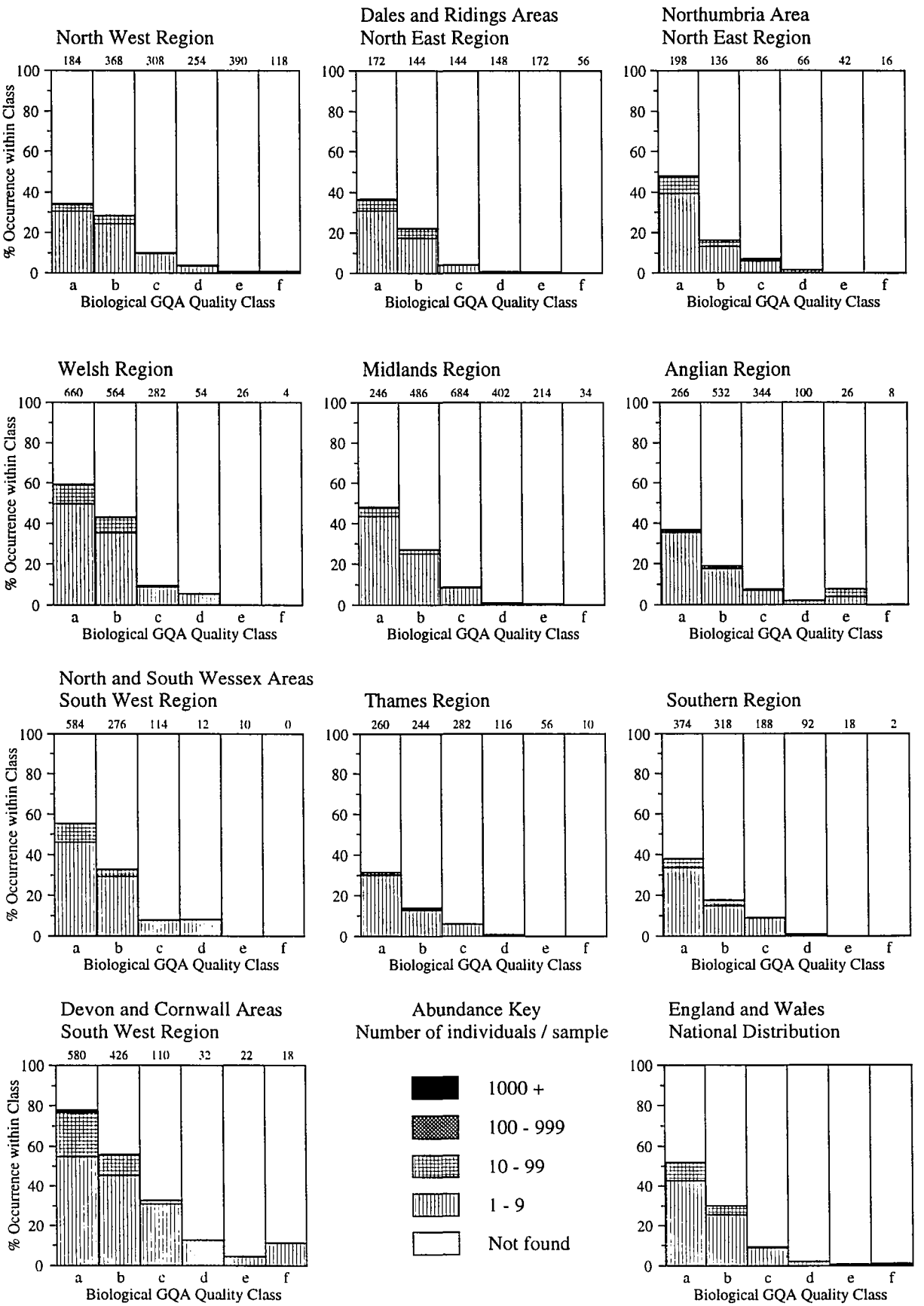


England and Wales
National Distribution



Regional Frequency Distributions by Class - River Sites 1995

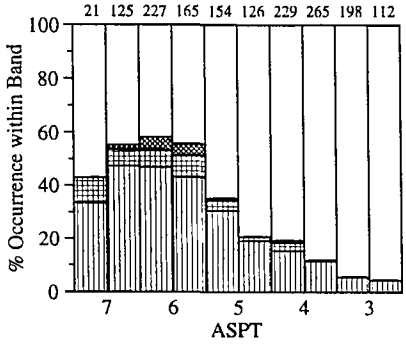
GYRINIDAE



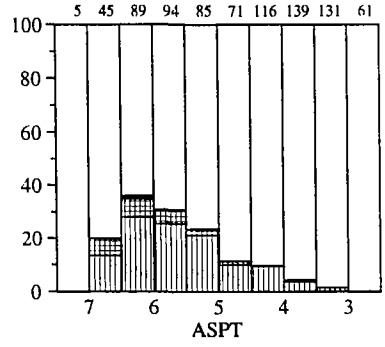
Regional Frequency Distributions by ASPT - River Sites 1995

HYDROPHILIDAE

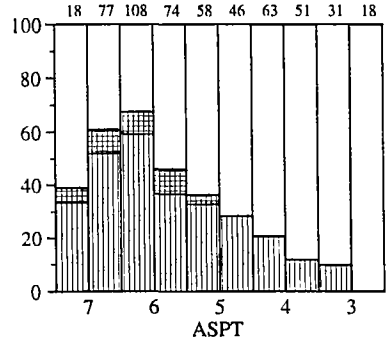
North West Region



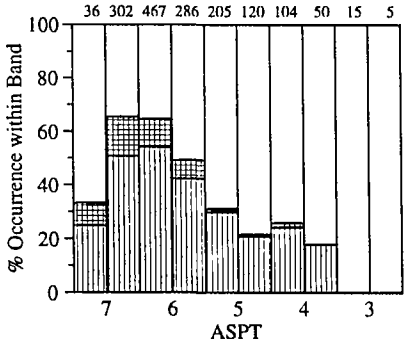
Dales and Ridings Areas
North East Region



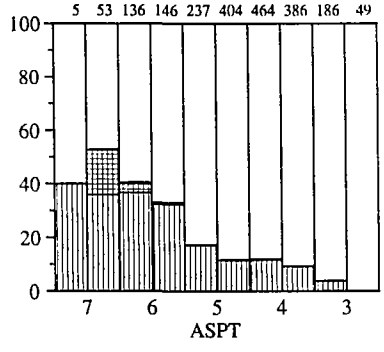
Northumbria Area
North East Region



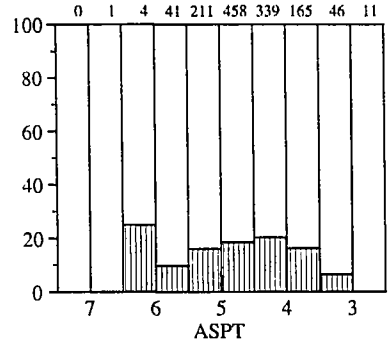
Welsh Region



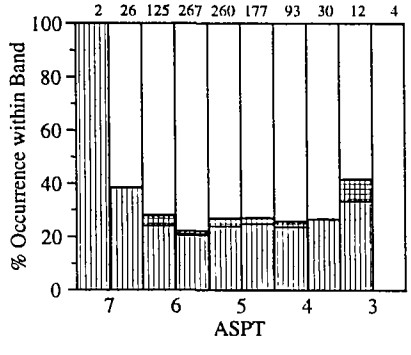
Midlands Region



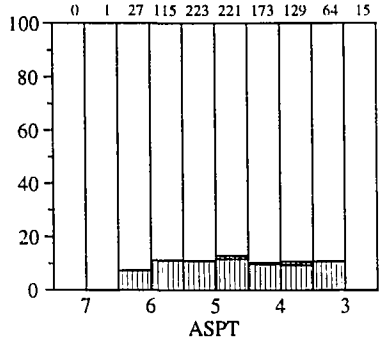
Anglian Region



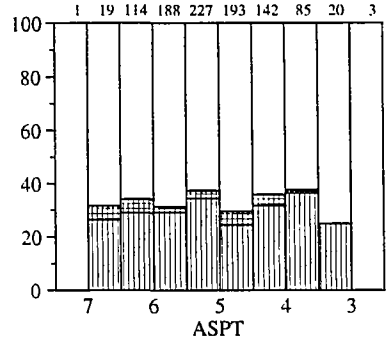
North and South Wessex Areas
South West Region



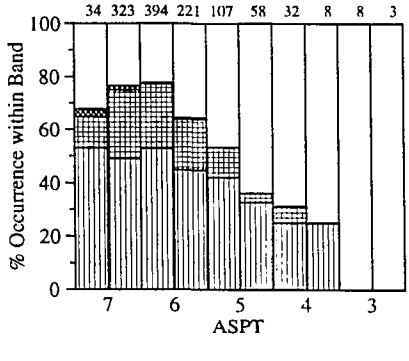
Thames Region



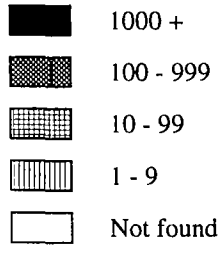
Southern Region



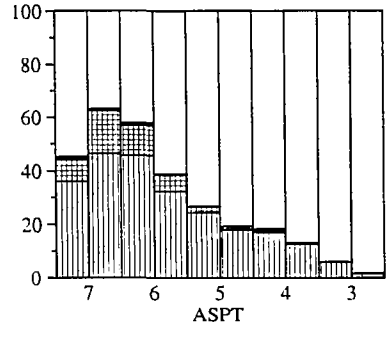
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



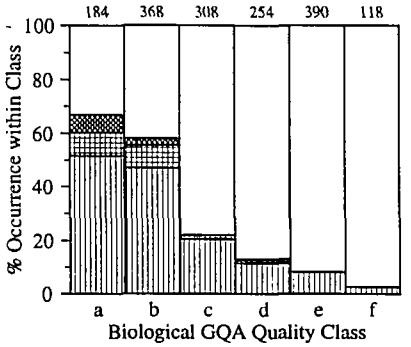
England and Wales
National Distribution



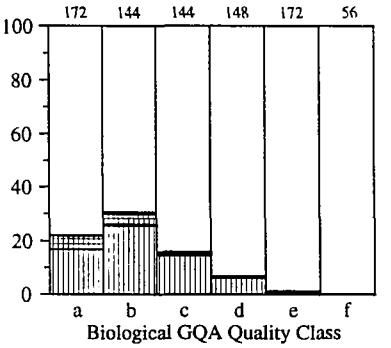
Regional Frequency Distributions by Class - River Sites 1995

HYDROPHILIDAE

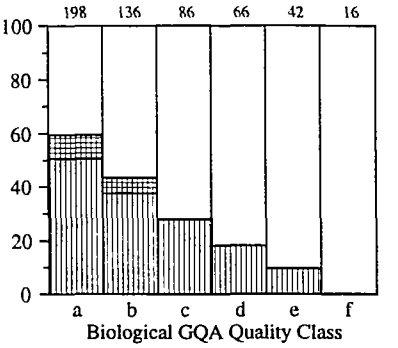
North West Region



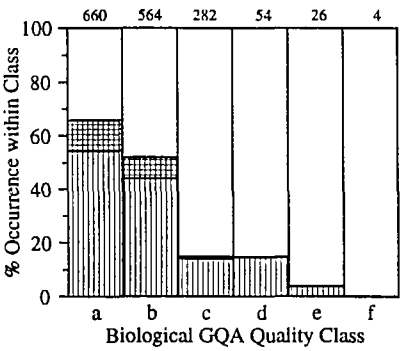
Dales and Ridings Areas
North East Region



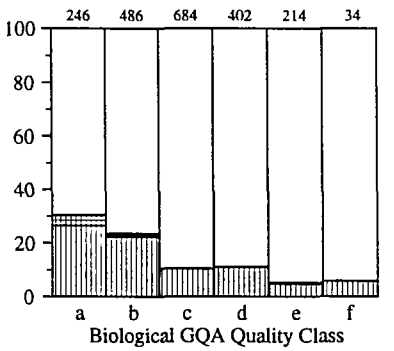
Northumbria Area
North East Region



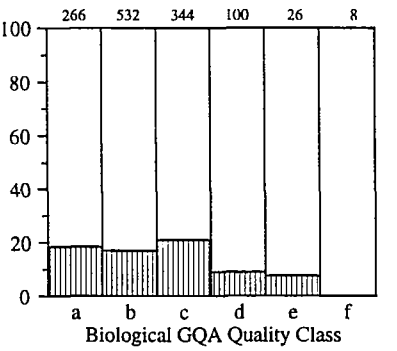
Welsh Region



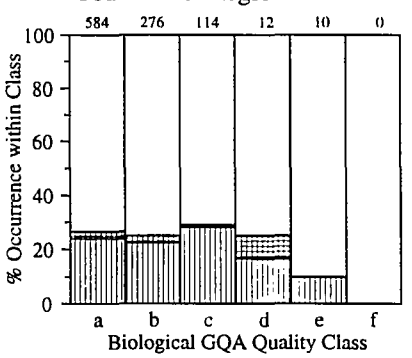
Midlands Region



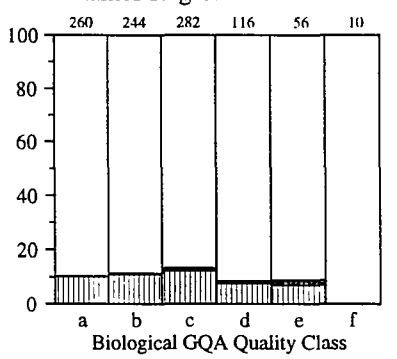
Anglian Region



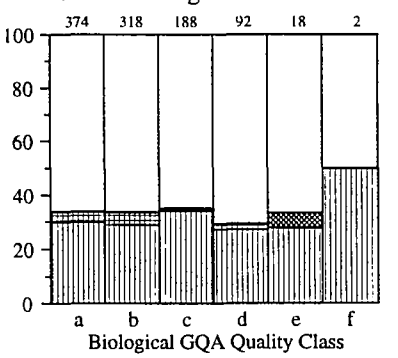
North and South Wessex Areas
South West Region



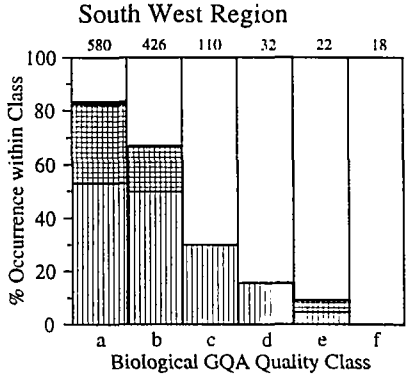
Thames Region



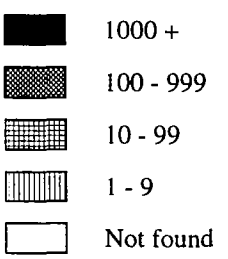
Southern Region



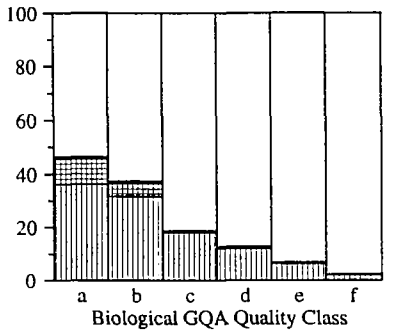
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



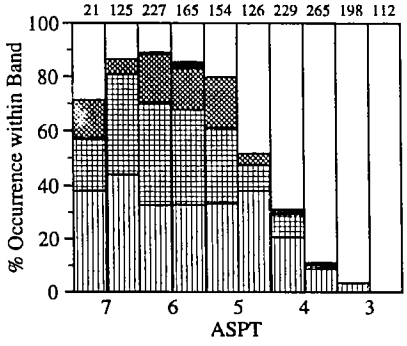
England and Wales
National Distribution



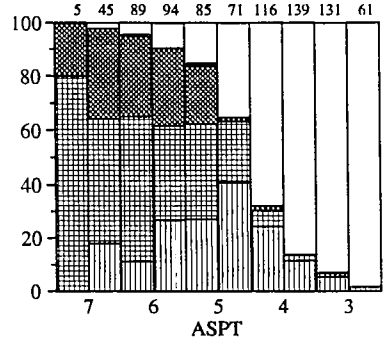
Regional Frequency Distributions by ASPT - River Sites 1995

ELMIDAE

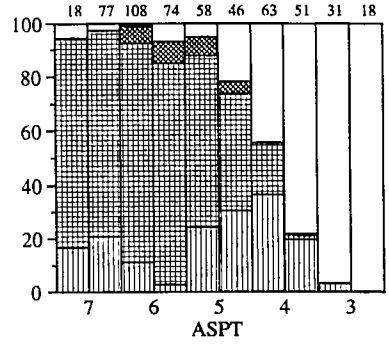
North West Region



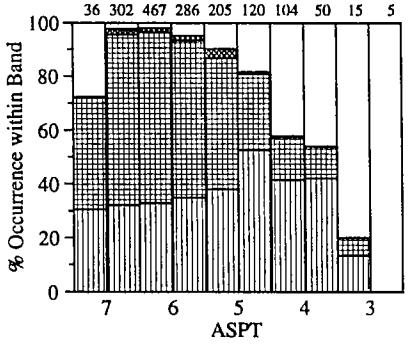
Dales and Ridings Areas
North East Region



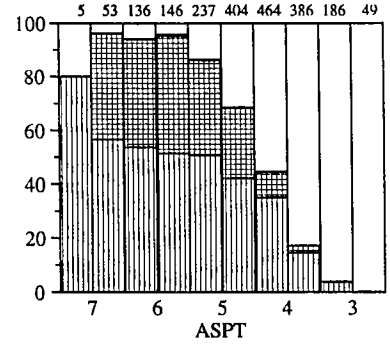
Northumbria Area
North East Region



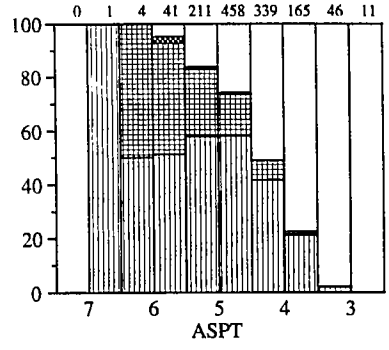
Welsh Region



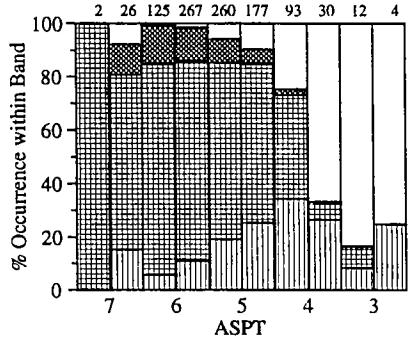
Midlands Region



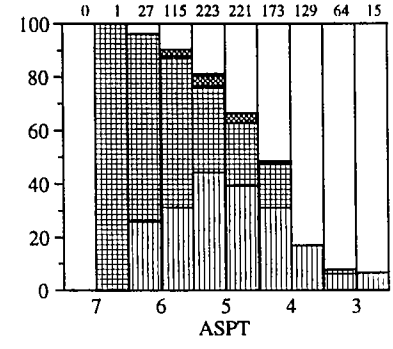
Anglian Region



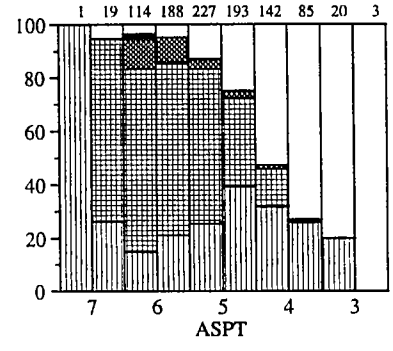
North and South Wessex Areas
South West Region



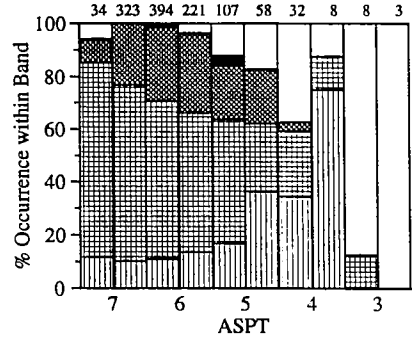
Thames Region



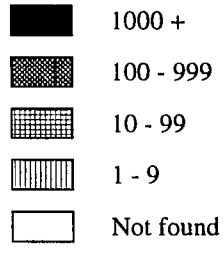
Southern Region



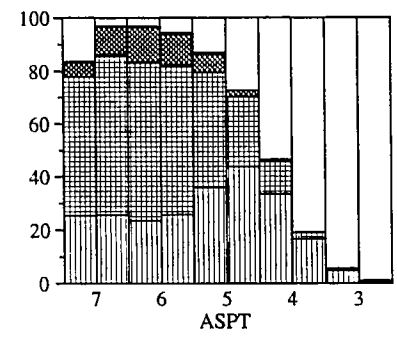
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



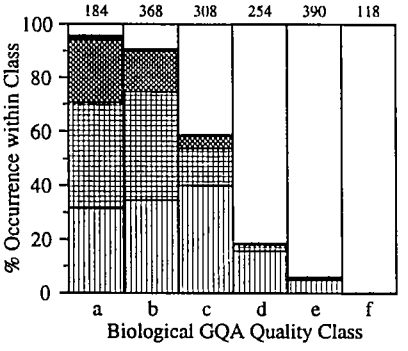
England and Wales
National Distribution



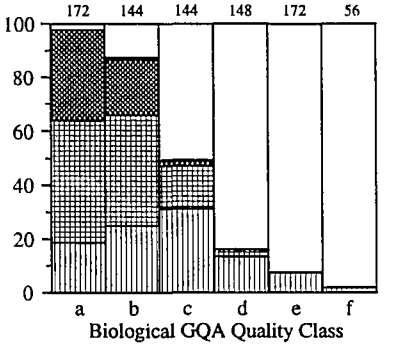
Regional Frequency Distributions by Class - River Sites 1995

ELMIDAE

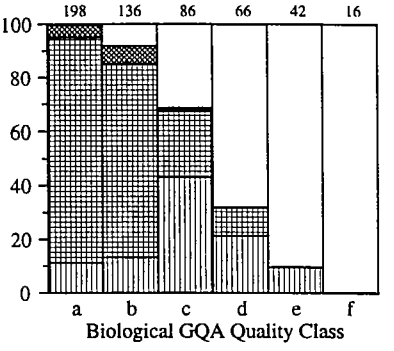
North West Region



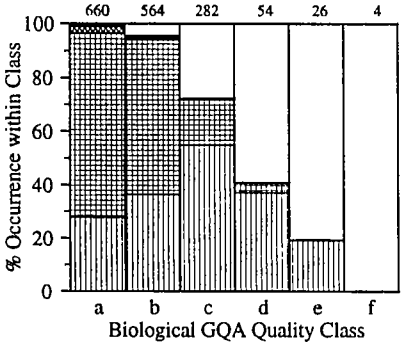
Dales and Ridings Areas
North East Region



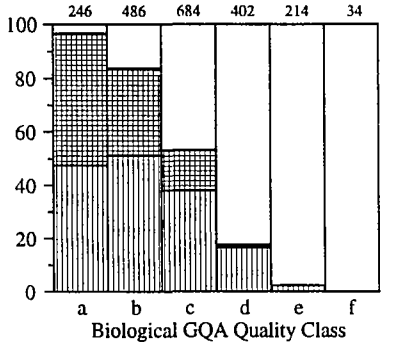
Northumbria Area
North East Region



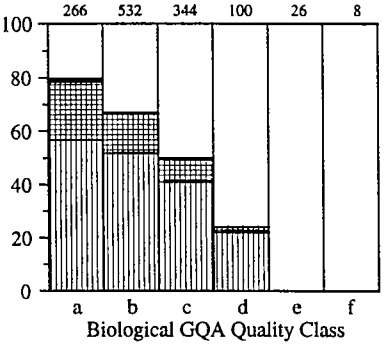
Welsh Region



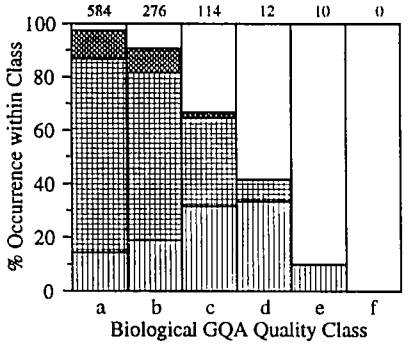
Midlands Region



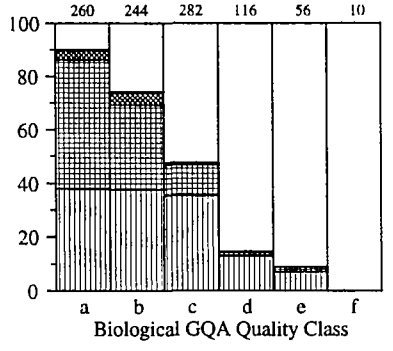
Anglian Region



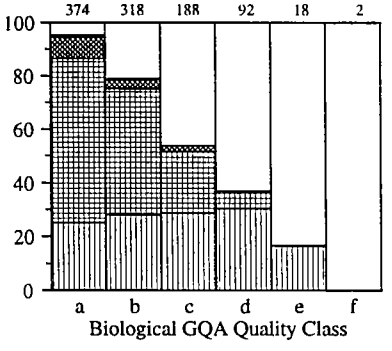
North and South Wessex Areas
South West Region



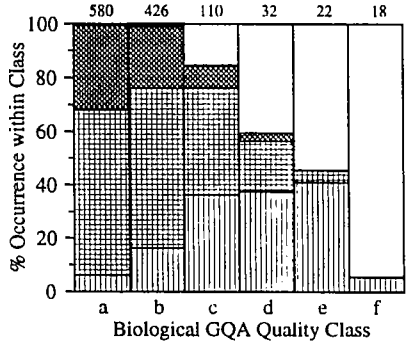
Thames Region



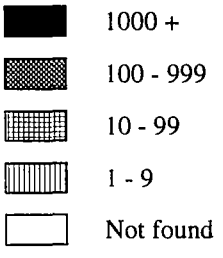
Southern Region



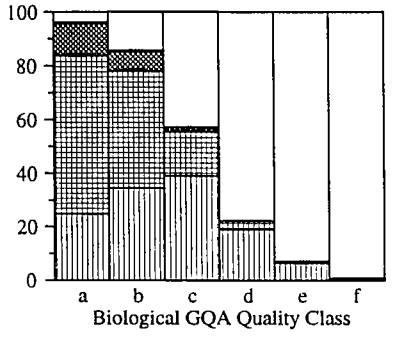
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



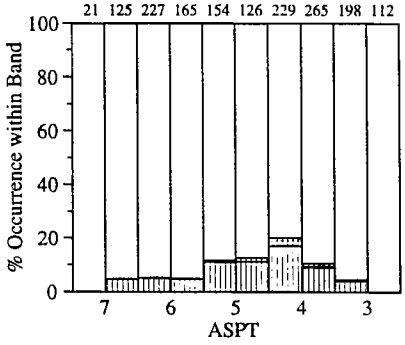
England and Wales
National Distribution



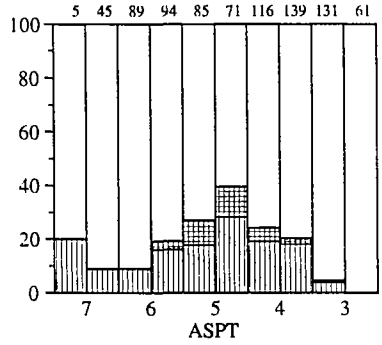
Regional Frequency Distributions by ASPT - River Sites 1995

SIALIDAE

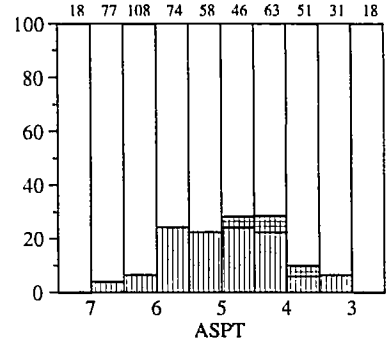
North West Region



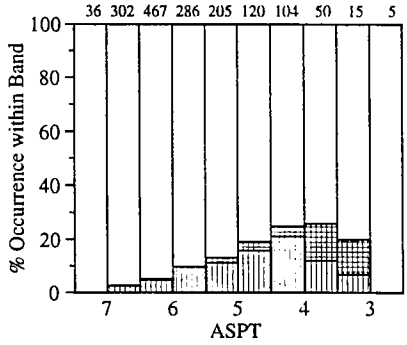
Dales and Ridings Areas
North East Region



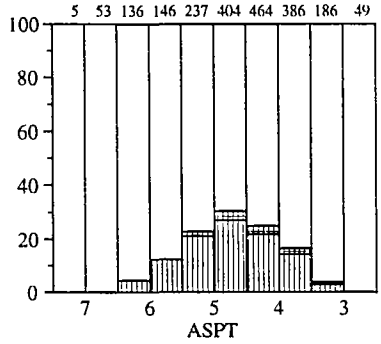
Northumbria Area
North East Region



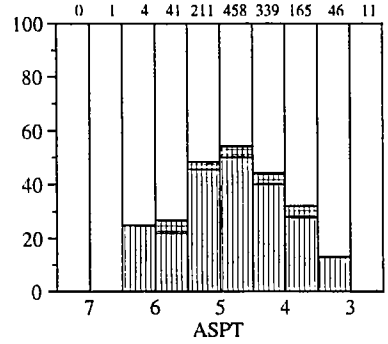
Welsh Region



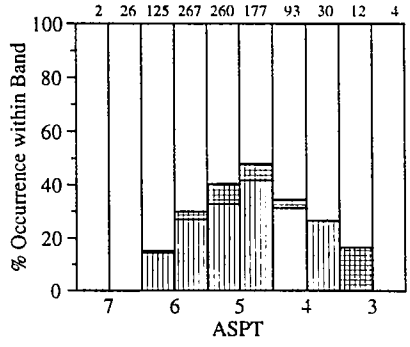
Midlands Region



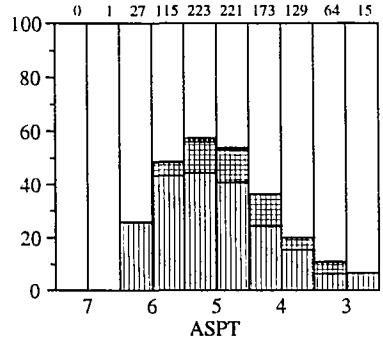
Anglian Region



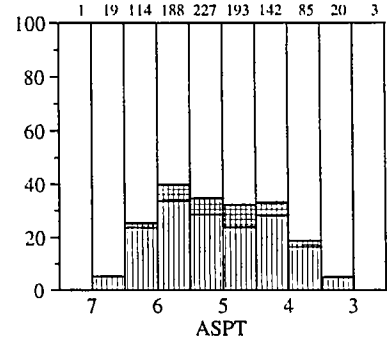
North and South Wessex Areas
South West Region



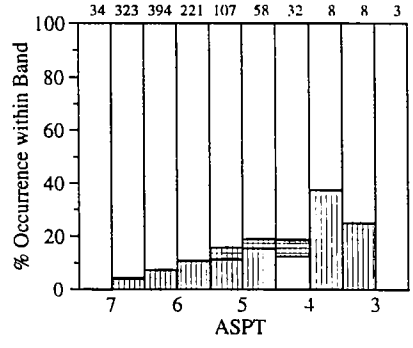
Thames Region



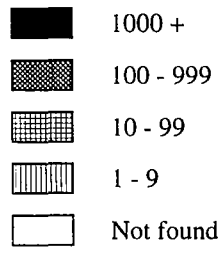
Southern Region



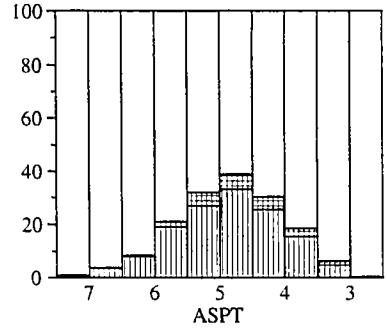
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

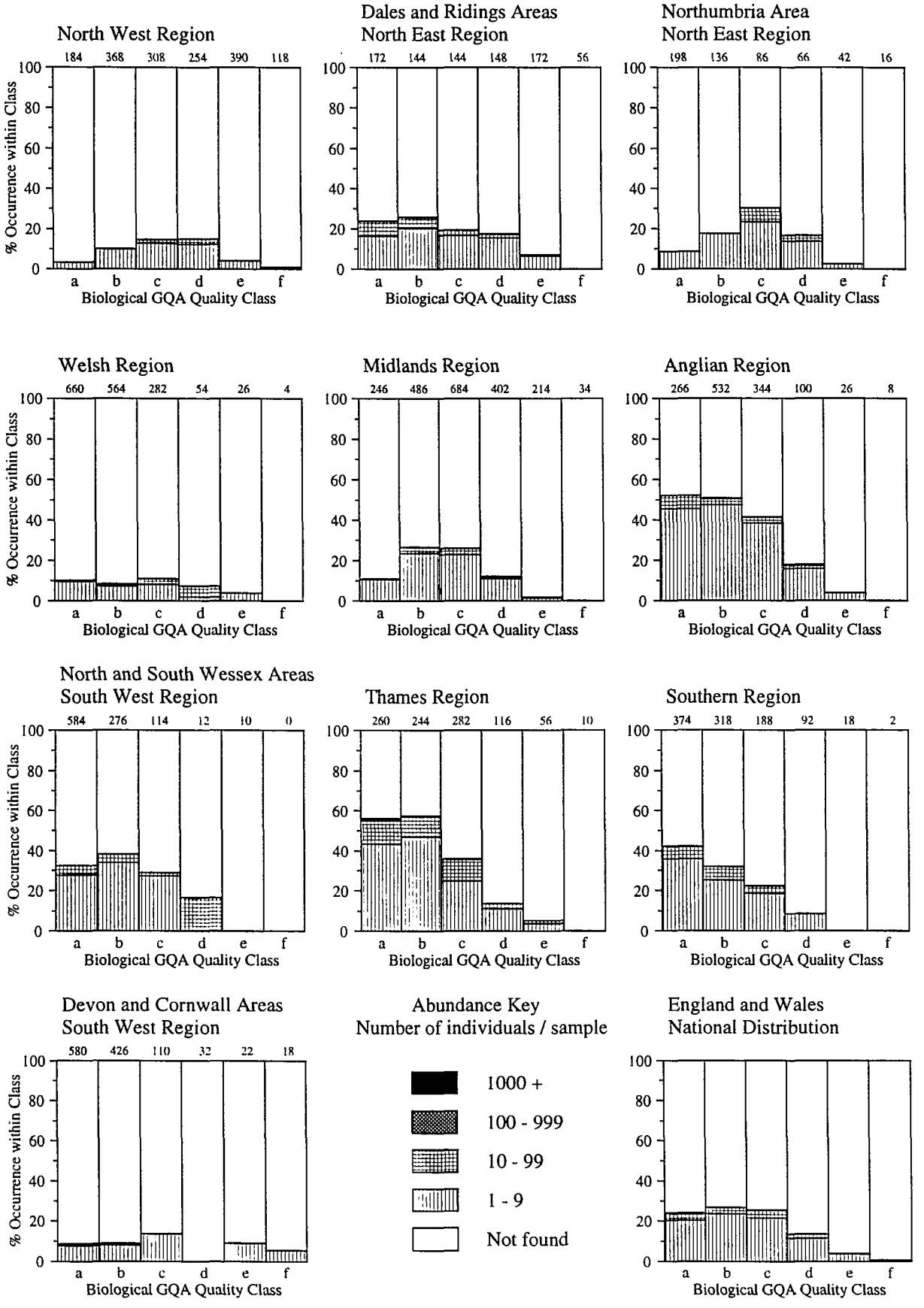


England and Wales
National Distribution



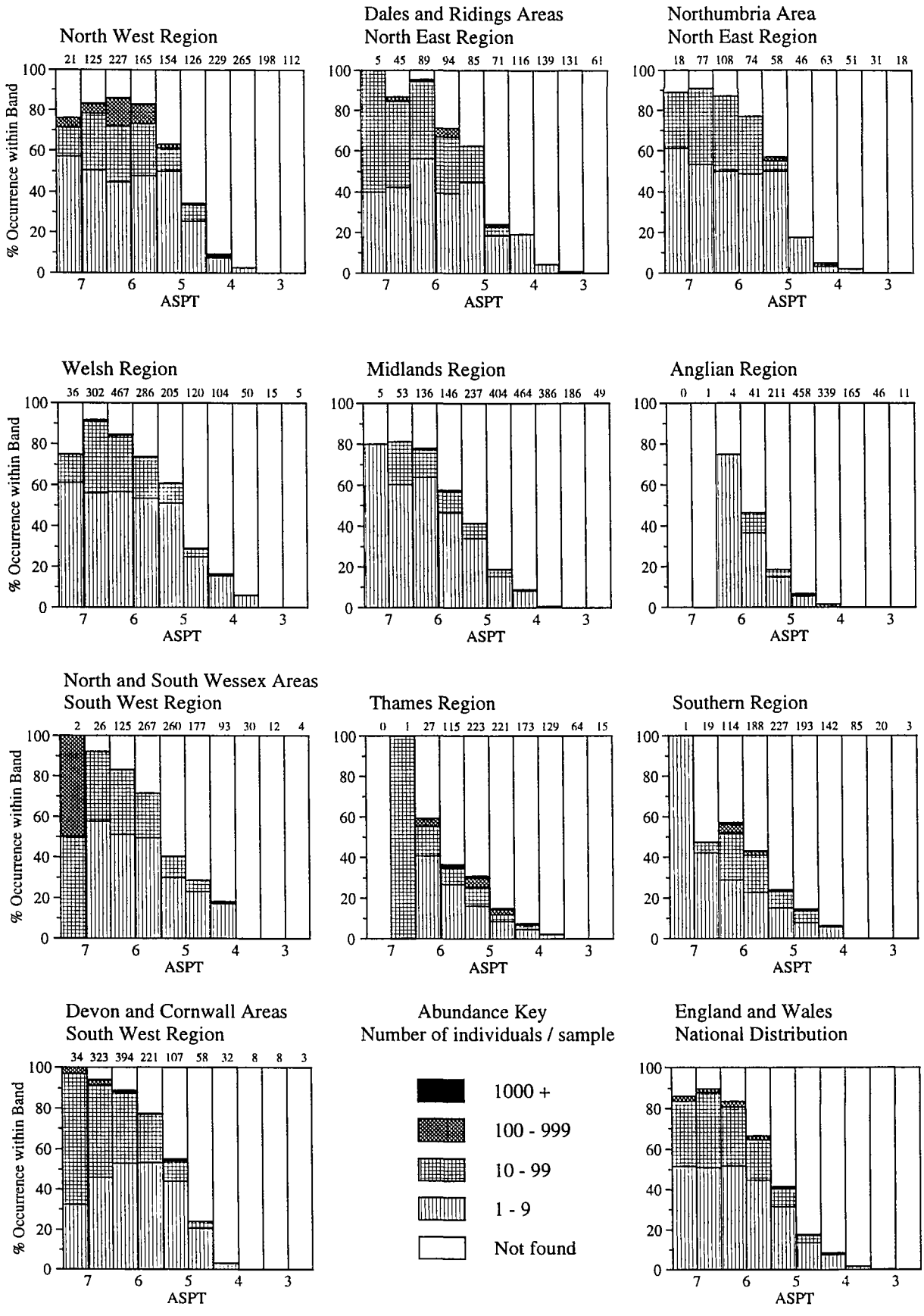
Regional Frequency Distributions by Class - River Sites 1995

SIALIDAE



Regional Frequency Distributions by ASPT - River Sites 1995

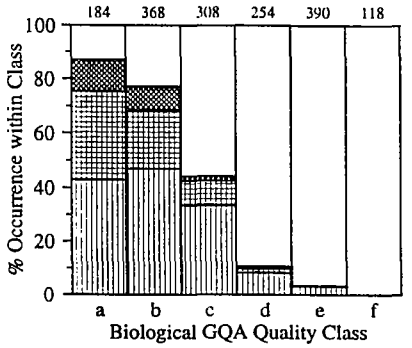
RHYACOPHILIDAE



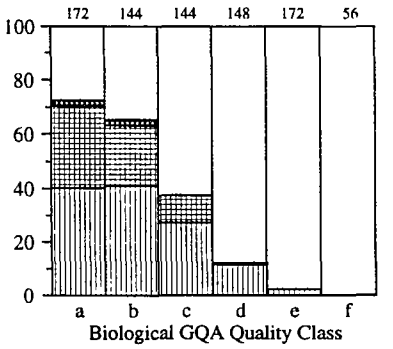
Regional Frequency Distributions by Class - River Sites 1995

RHYACOPHILIDAE

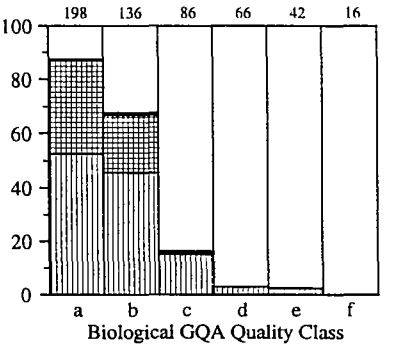
North West Region



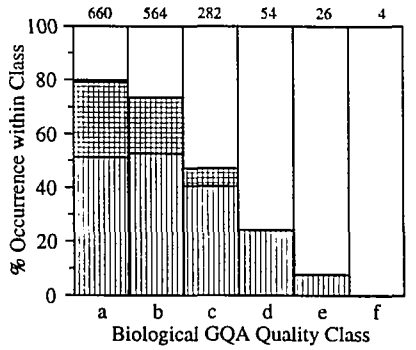
Dales and Ridings Areas
North East Region



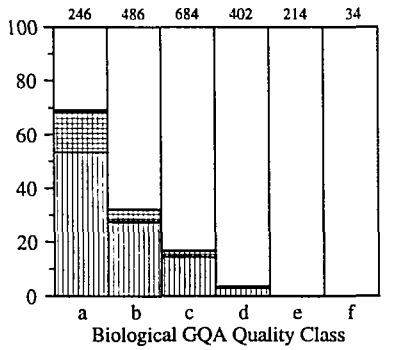
Northumbria Area
North East Region



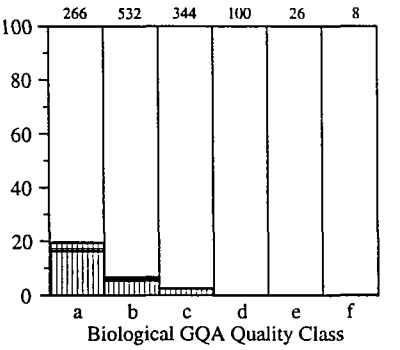
Welsh Region



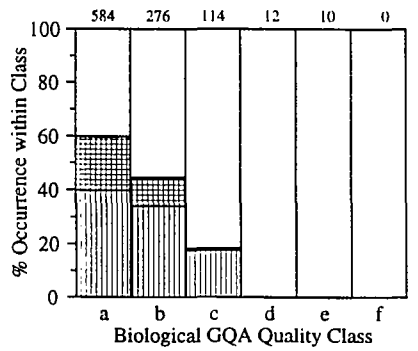
Midlands Region



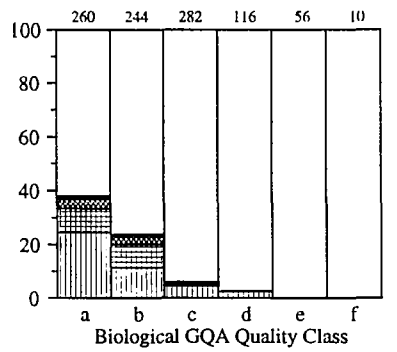
Anglian Region



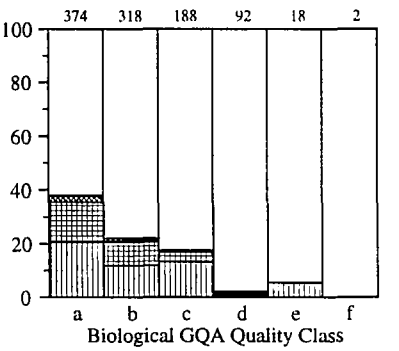
North and South Wessex Areas
South West Region



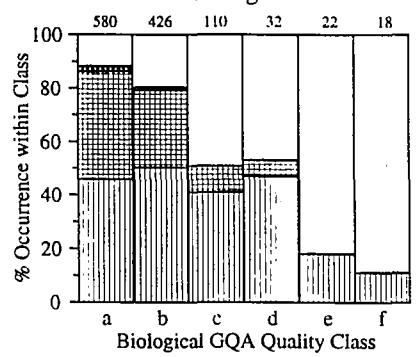
Thames Region



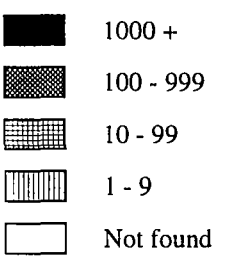
Southern Region



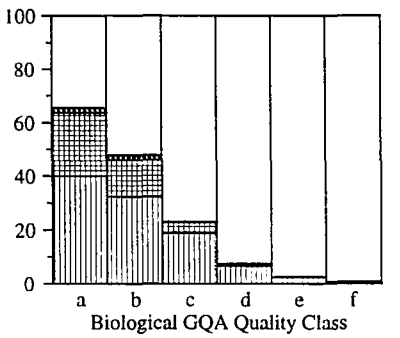
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



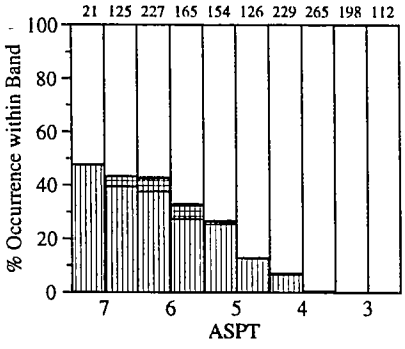
England and Wales
National Distribution



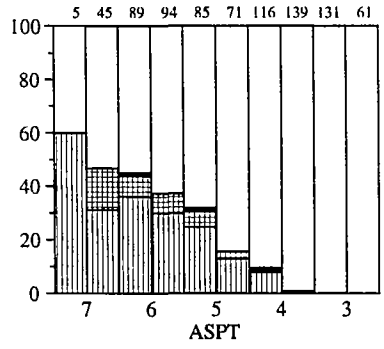
Regional Frequency Distributions by ASPT - River Sites 1995

POLYCENTROPIDAE

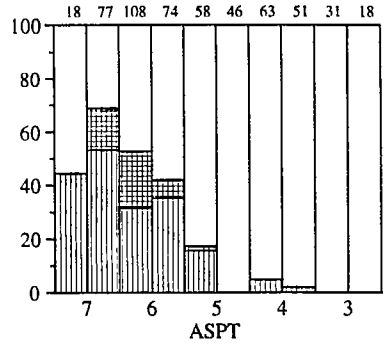
North West Region



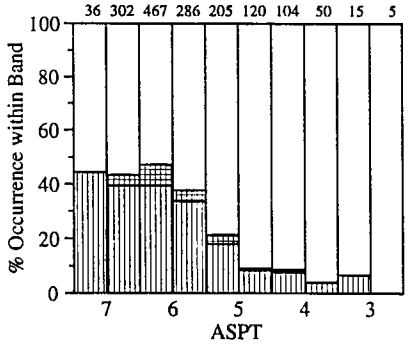
Dales and Ridings Areas
North East Region



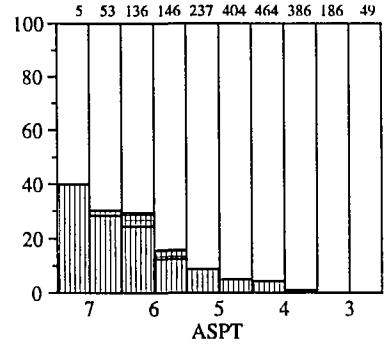
Northumbria Area
North East Region



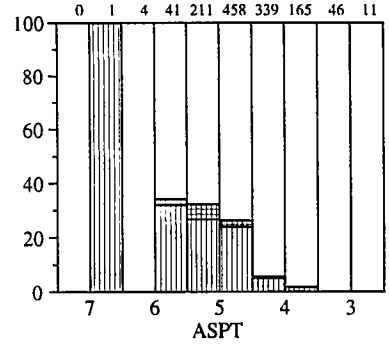
Welsh Region



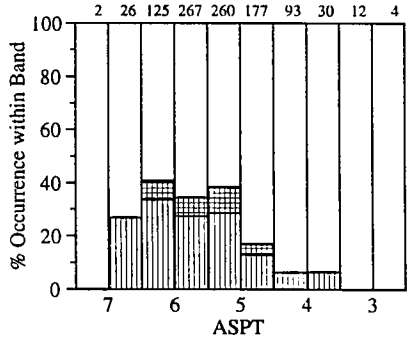
Midlands Region



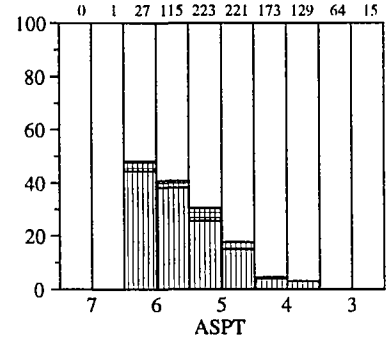
Anglian Region



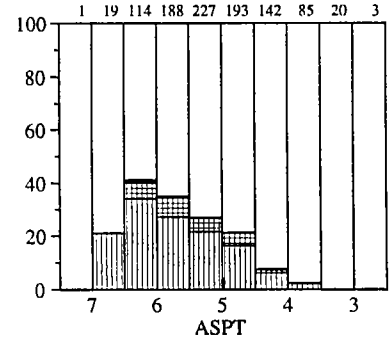
North and South Wessex Areas
South West Region



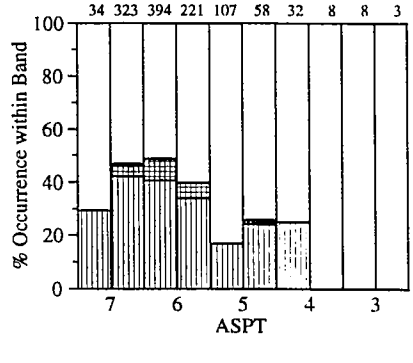
Thames Region



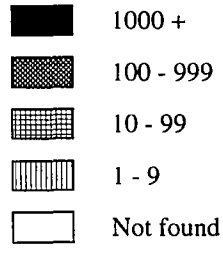
Southern Region



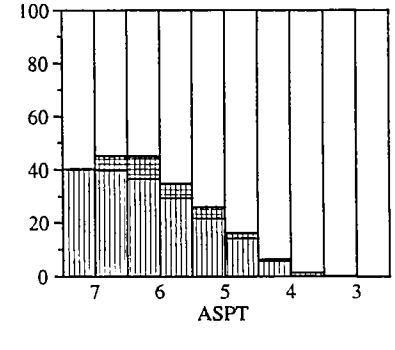
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



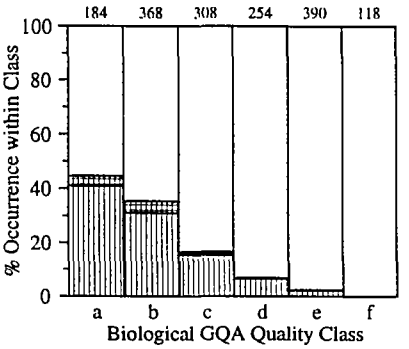
England and Wales
National Distribution



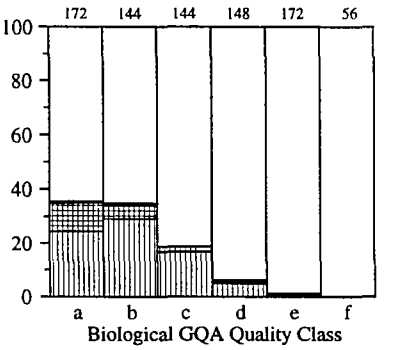
Regional Frequency Distributions by Class - River Sites 1995

POLYCENTROPIDAE

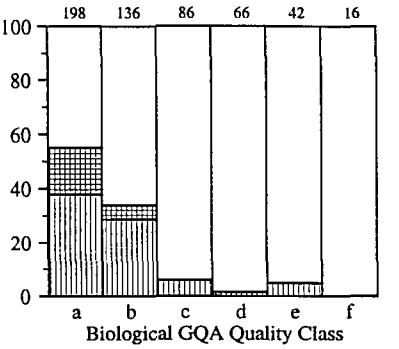
North West Region



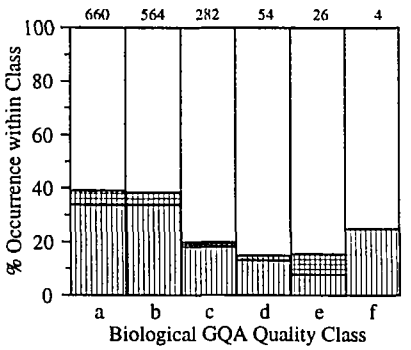
Dales and Ridings Areas
North East Region



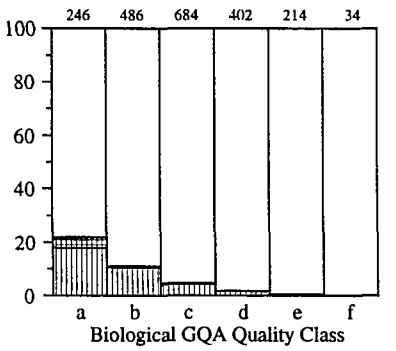
Northumbria Area
North East Region



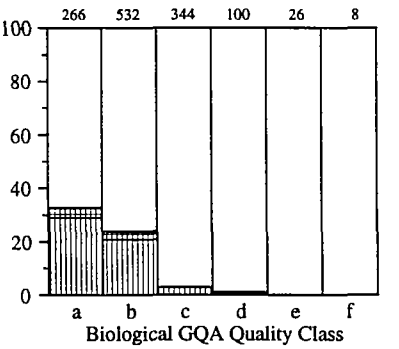
Welsh Region



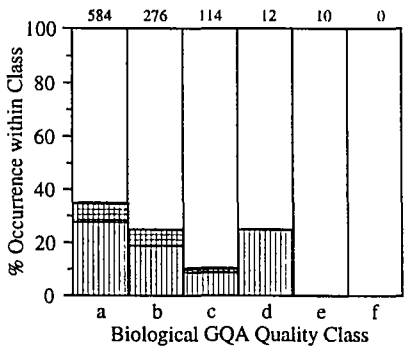
Midlands Region



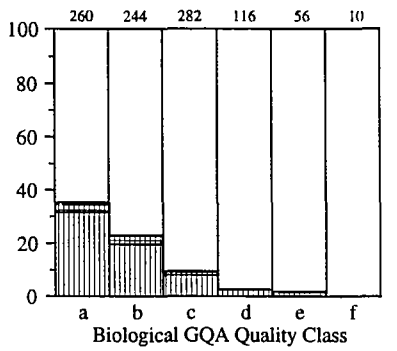
Anglian Region



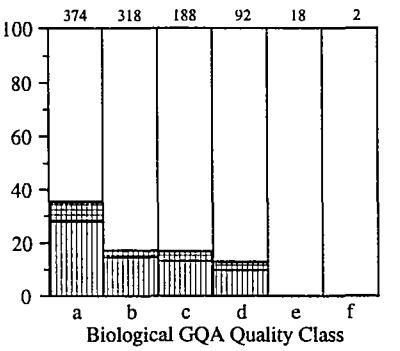
North and South Wessex Areas
South West Region



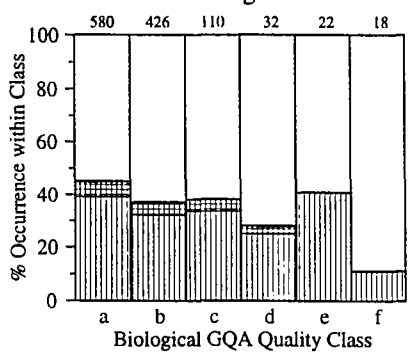
Thames Region



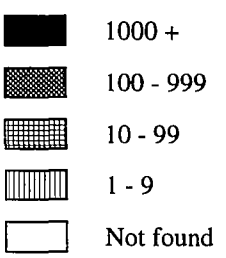
Southern Region



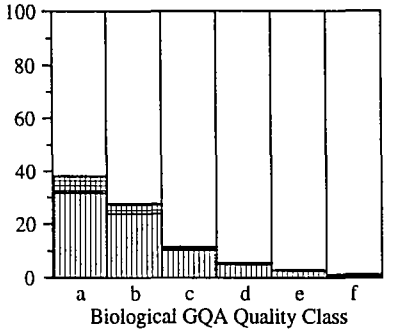
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

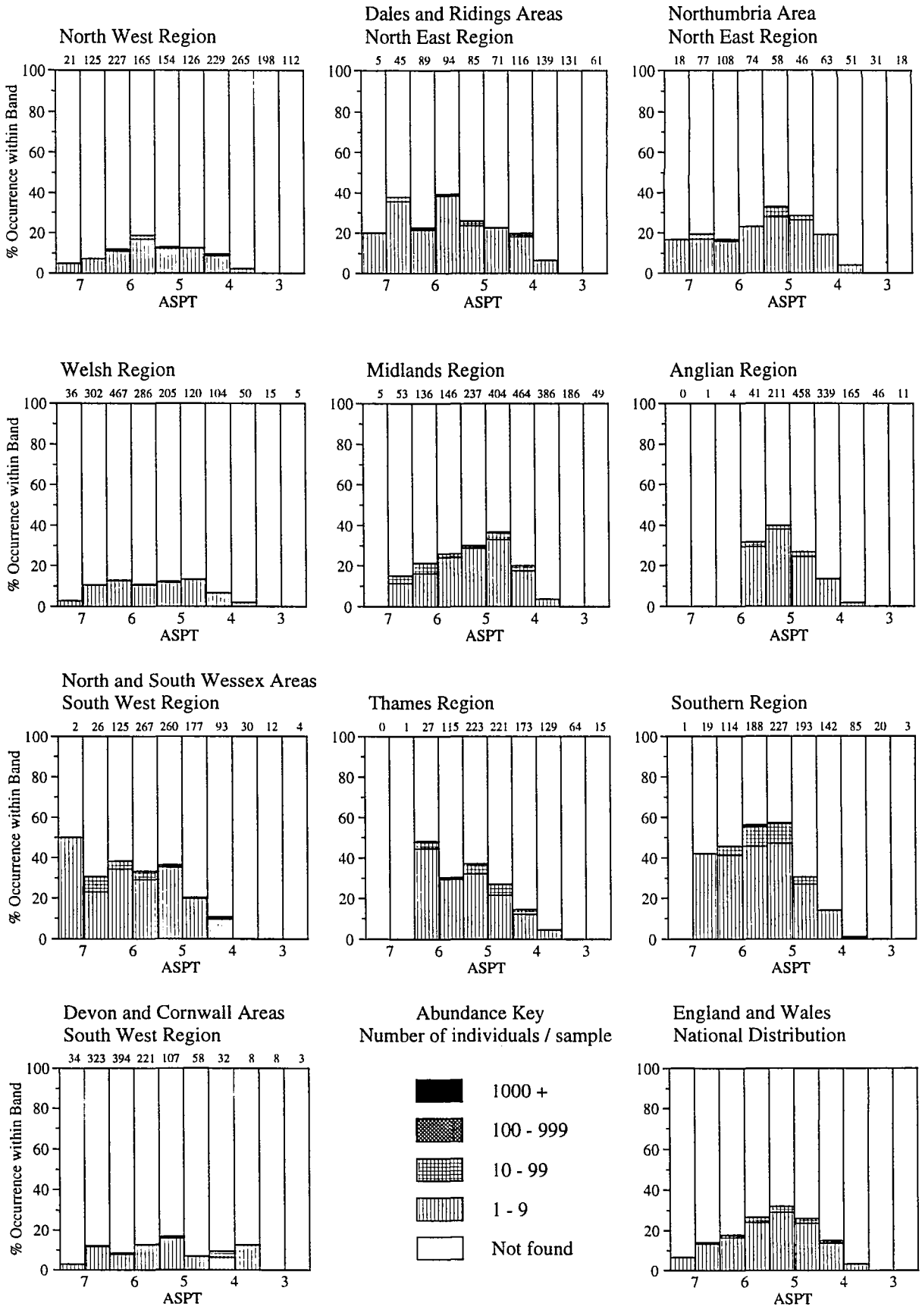


England and Wales
National Distribution



Regional Frequency Distributions by ASPT - River Sites 1995

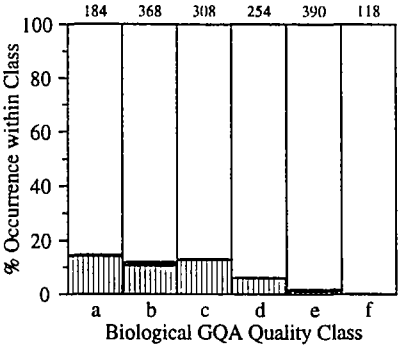
PSYCHOMYIIDAE



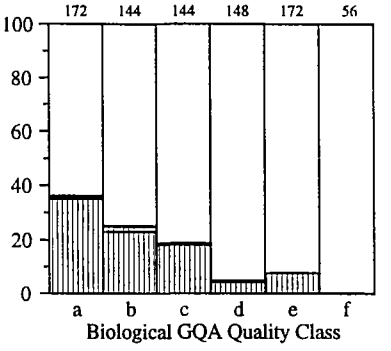
Regional Frequency Distributions by Class - River Sites 1995

PSYCHOMYIIDAE

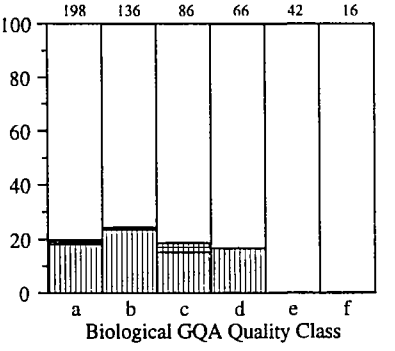
North West Region



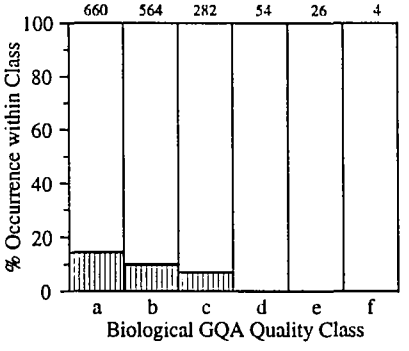
Dales and Ridings Areas
North East Region



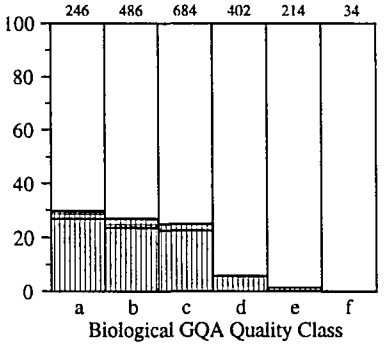
Northumbria Area
North East Region



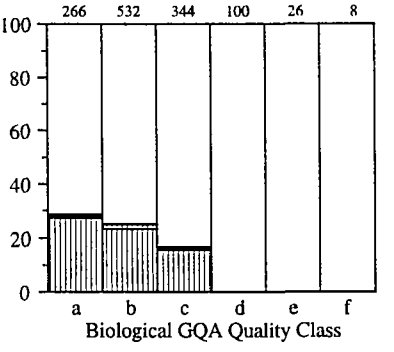
Welsh Region



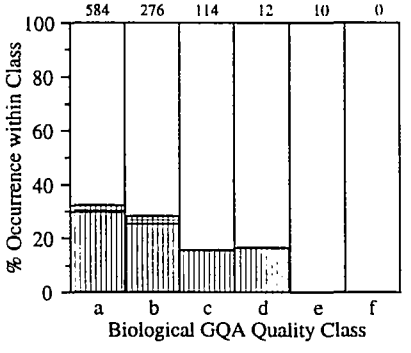
Midlands Region



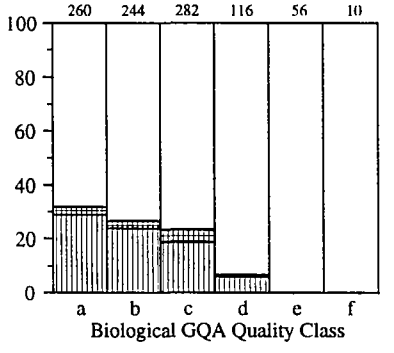
Anglian Region



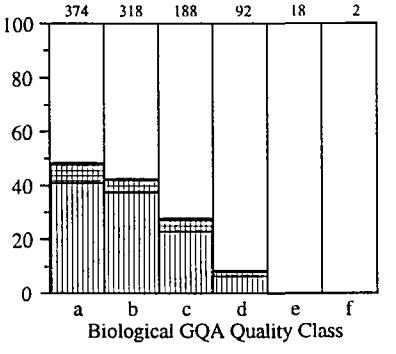
North and South Wessex Areas
South West Region



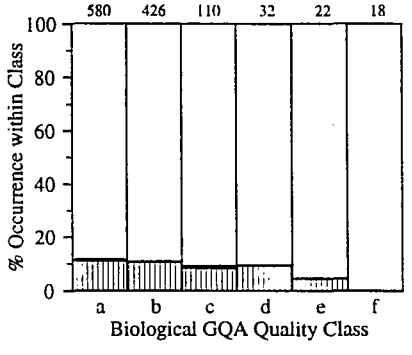
Thames Region



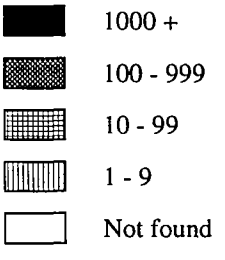
Southern Region



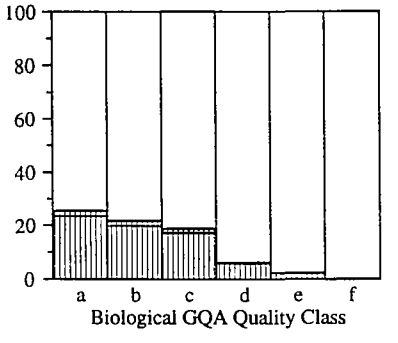
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

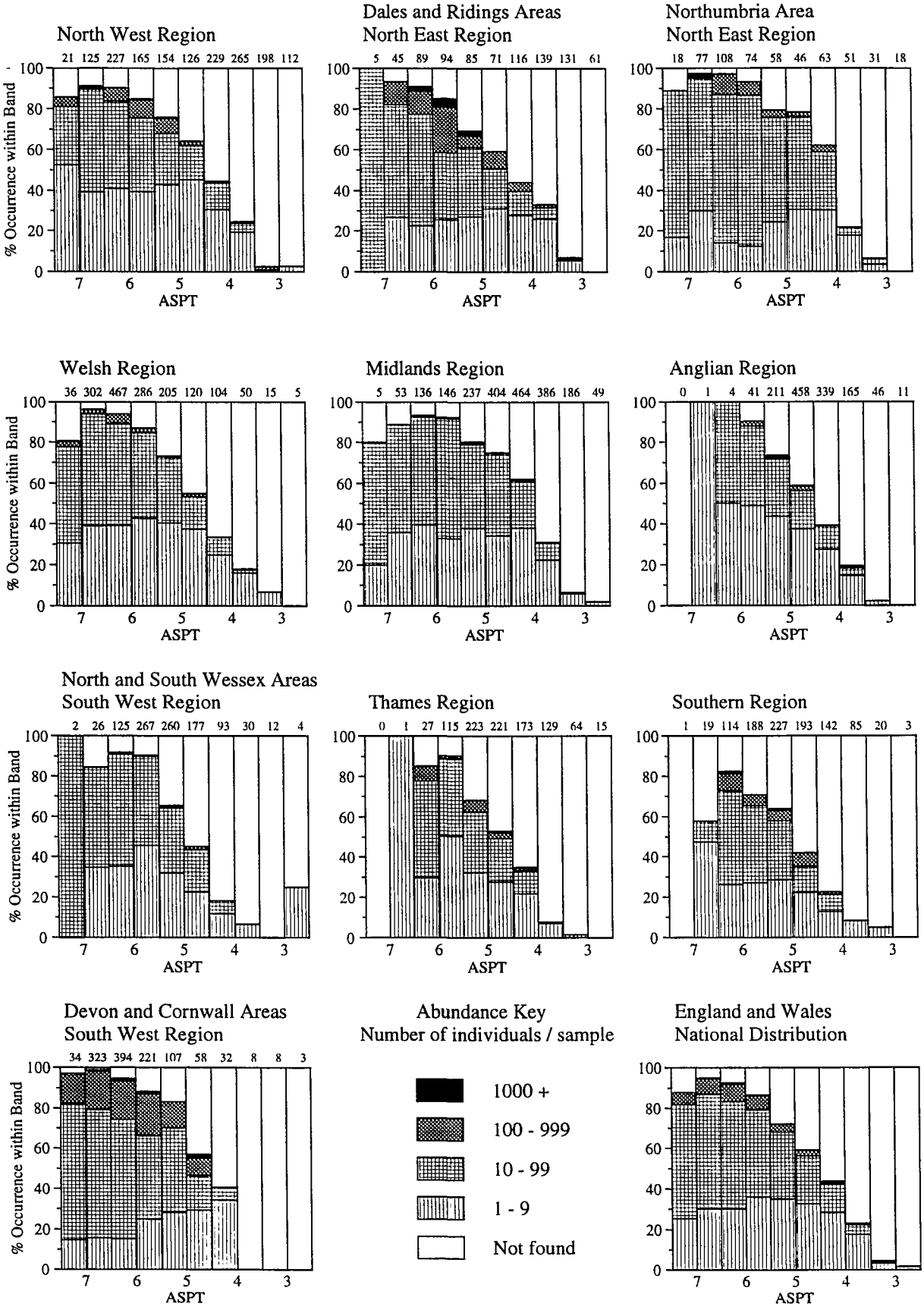


England and Wales
National Distribution



Regional Frequency Distributions by ASPT - River Sites 1995

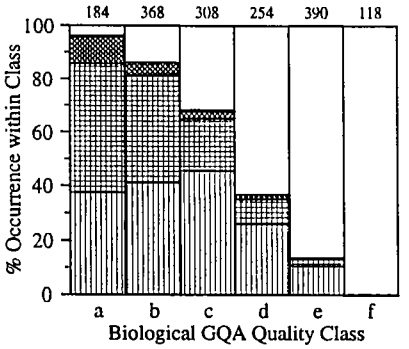
HYDROPSYCHIDAE



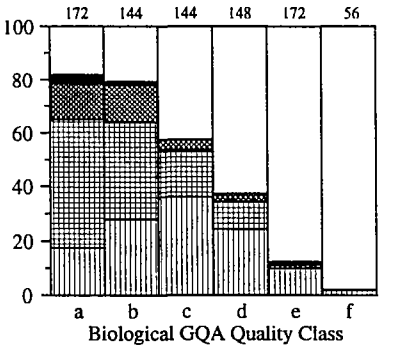
Regional Frequency Distributions by Class - River Sites 1995

HYDROPSYCHIDAE

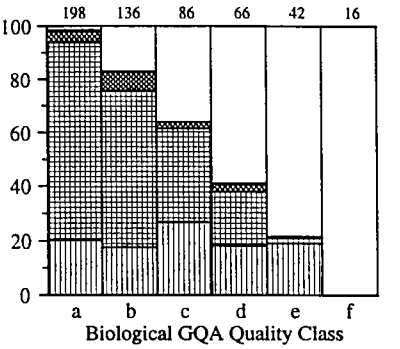
North West Region



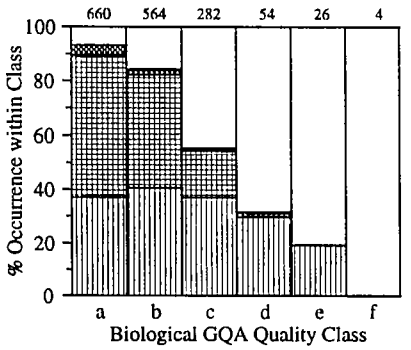
Dales and Ridings Areas
North East Region



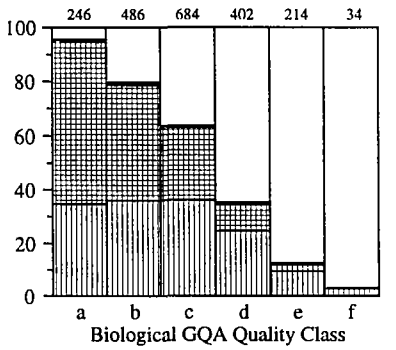
Northumbria Area
North East Region



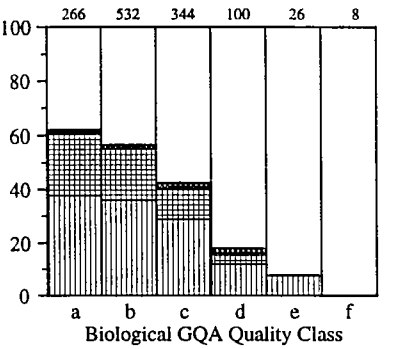
Welsh Region



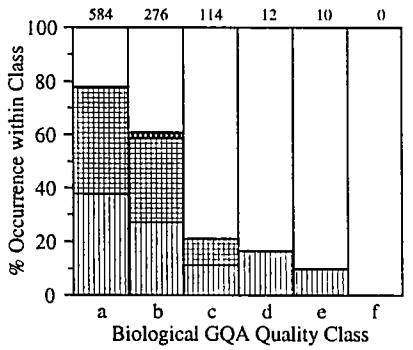
Midlands Region



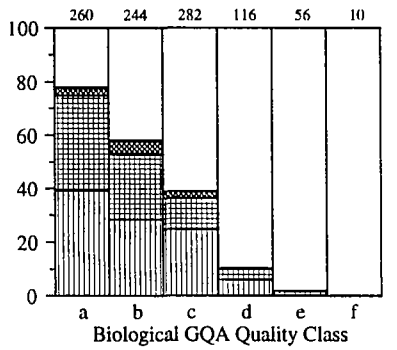
Anglian Region



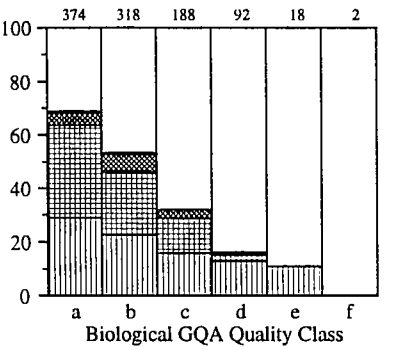
North and South Wessex Areas
South West Region



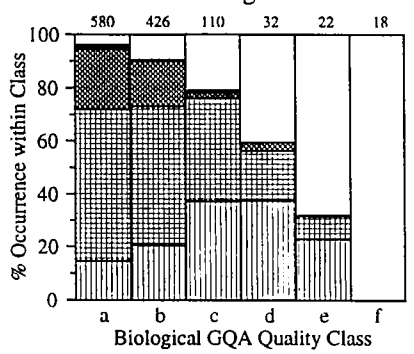
Thames Region



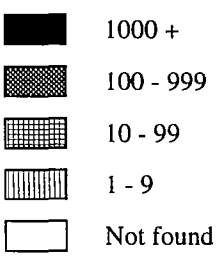
Southern Region



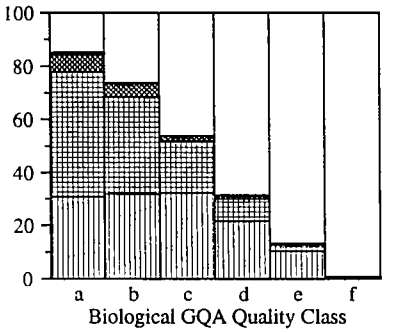
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



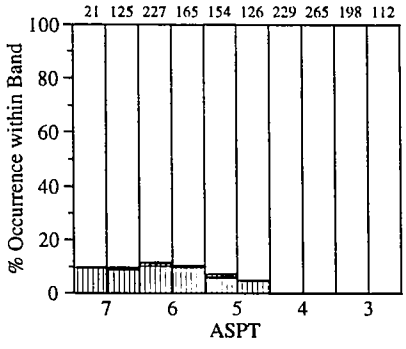
England and Wales
National Distribution



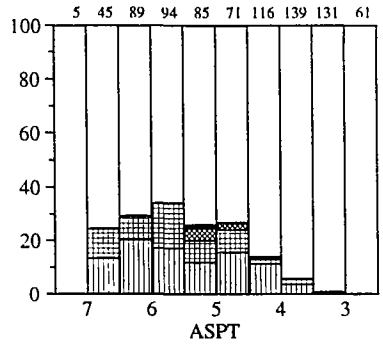
Regional Frequency Distributions by ASPT - River Sites 1995

HYDROPTILIDAE

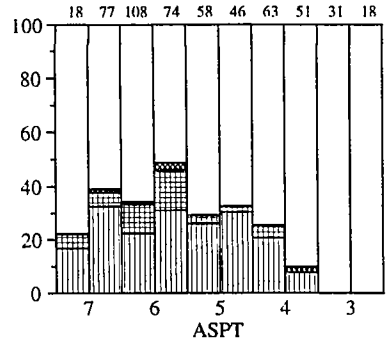
North West Region



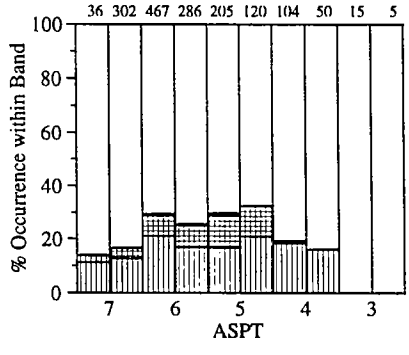
Dales and Ridings Areas
North East Region



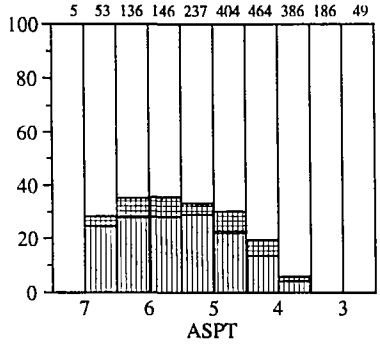
Northumbria Area
North East Region



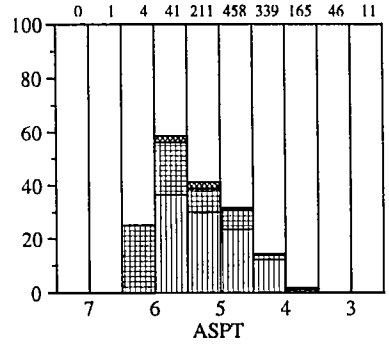
Welsh Region



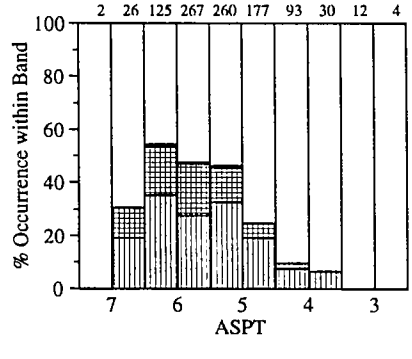
Midlands Region



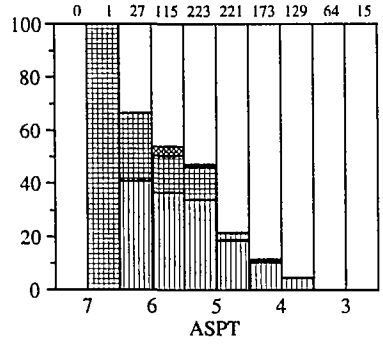
Anglian Region



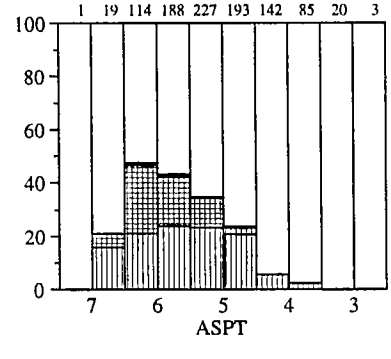
North and South Wessex Areas
South West Region



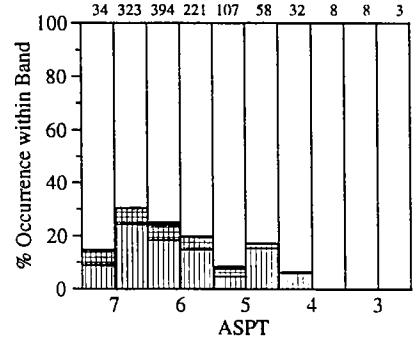
Thames Region



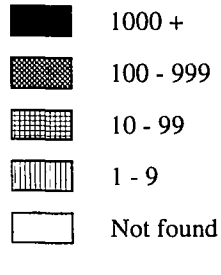
Southern Region



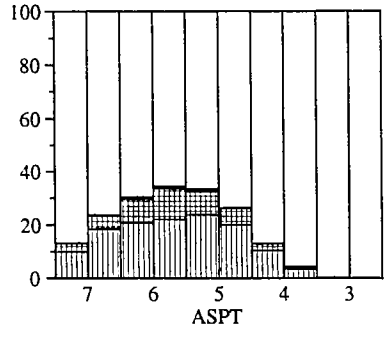
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



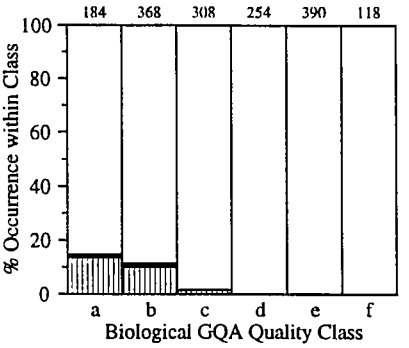
England and Wales
National Distribution



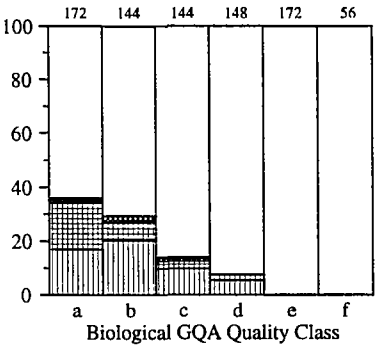
Regional Frequency Distributions by Class - River Sites 1995

HYDROPTILIDAE

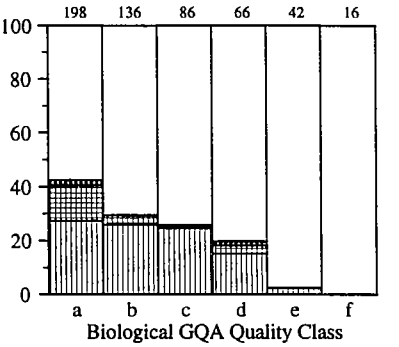
North West Region



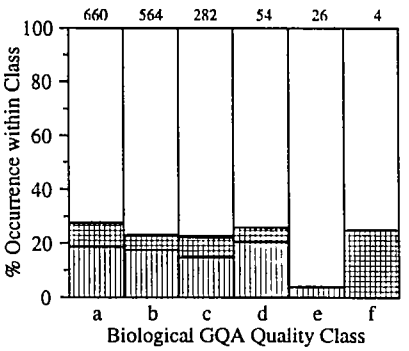
Dales and Ridings Areas
North East Region



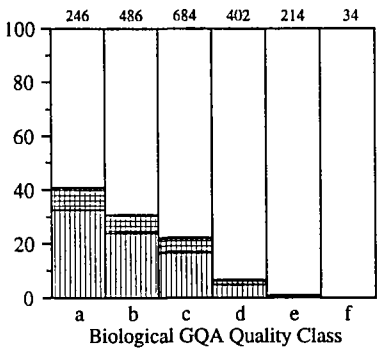
Northumbria Area
North East Region



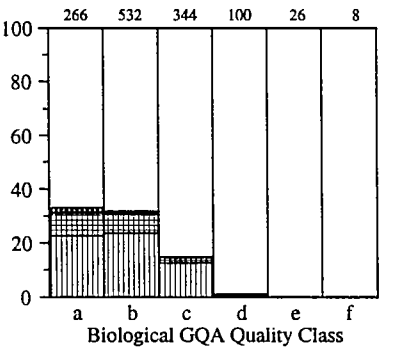
Welsh Region



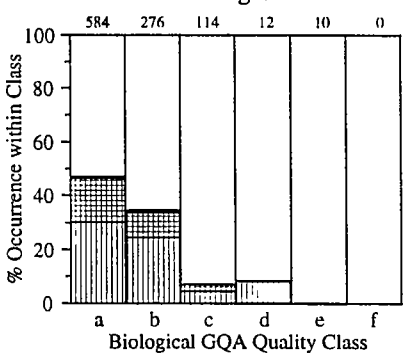
Midlands Region



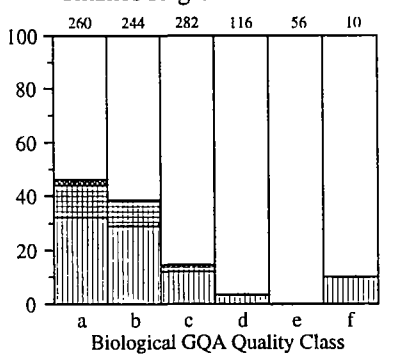
Anglian Region



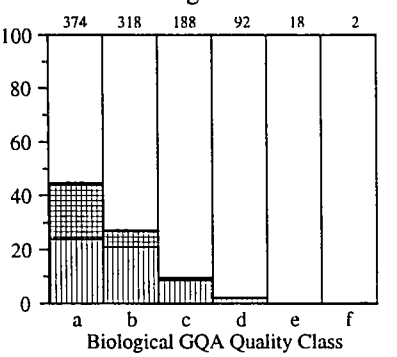
North and South Wessex Areas
South West Region



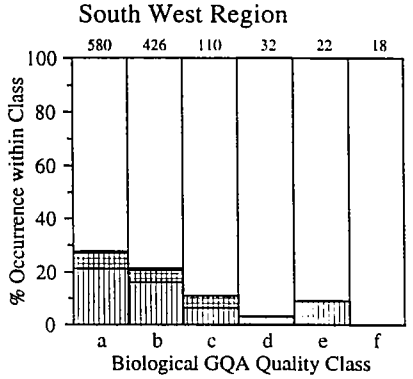
Thames Region



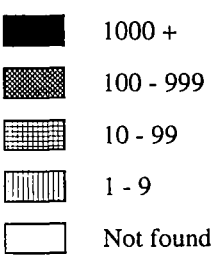
Southern Region



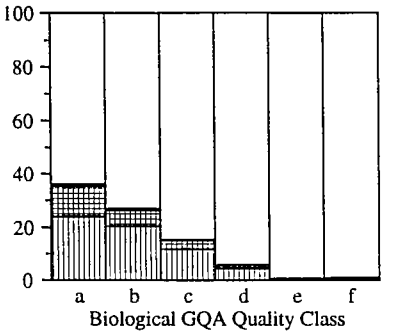
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

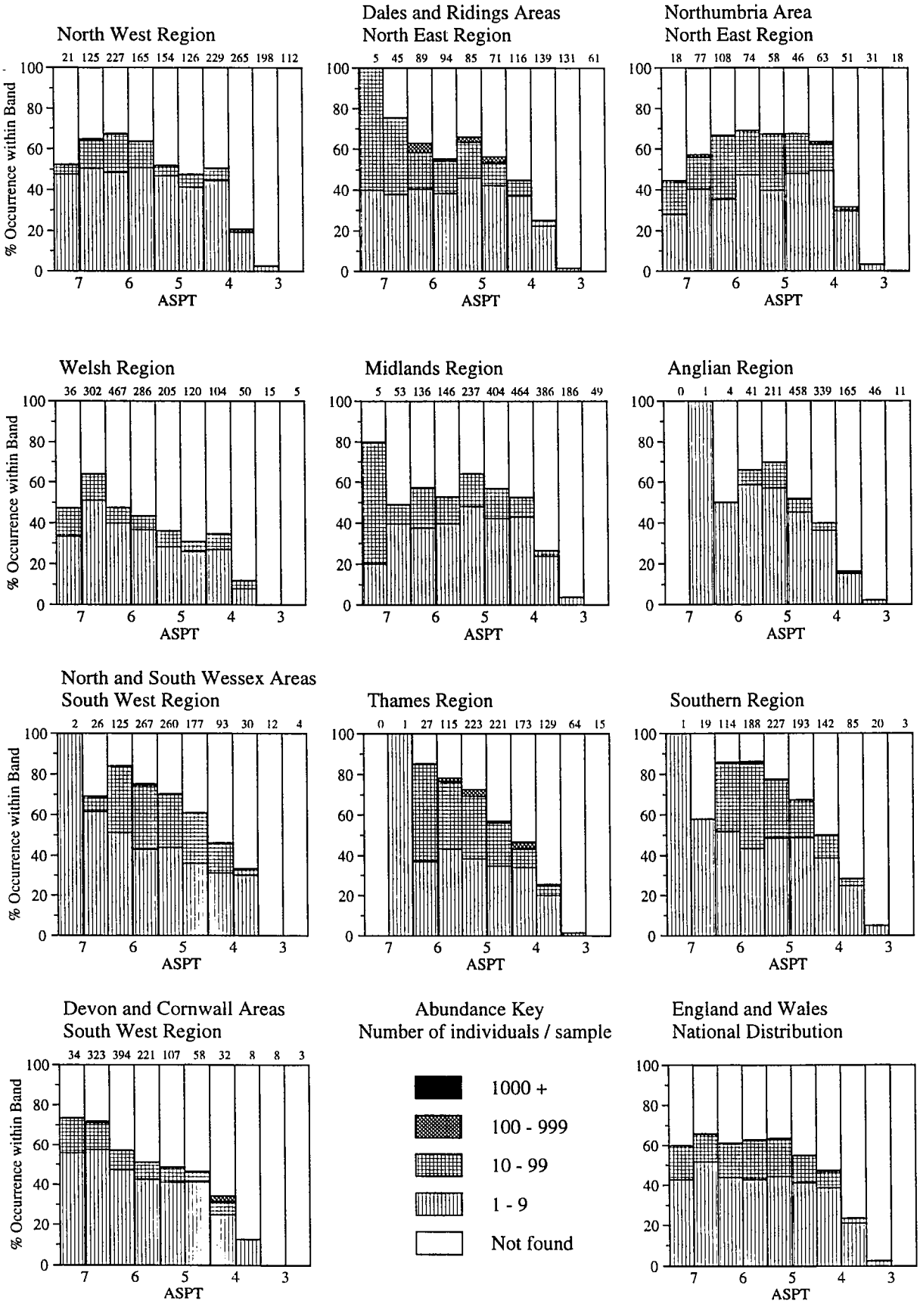


England and Wales
National Distribution



Regional Frequency Distributions by ASPT - River Sites 1995

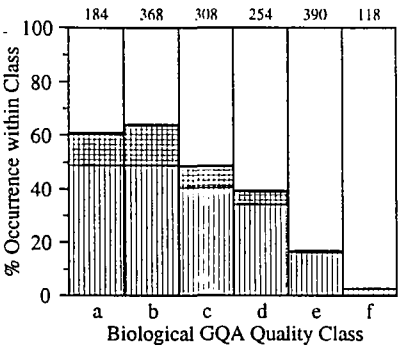
LIMNEPHILIDAE



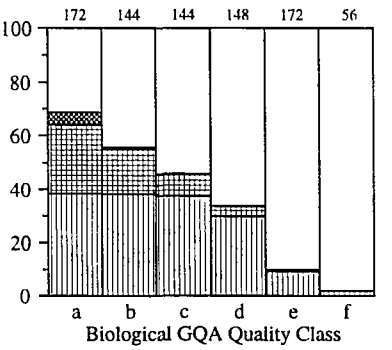
Regional Frequency Distributions by Class - River Sites 1995

LIMNEPHILIDAE

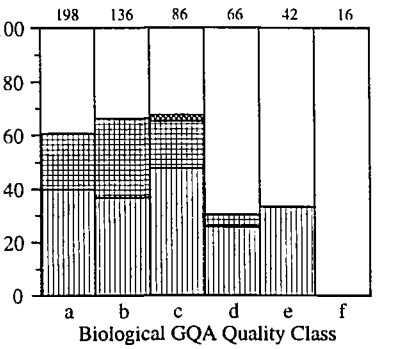
North West Region



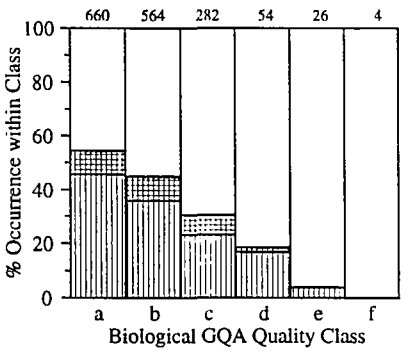
Dales and Ridings Areas
North East Region



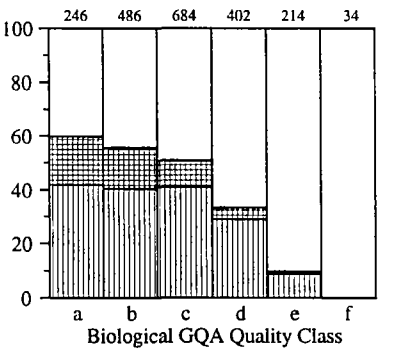
Northumbria Area
North East Region



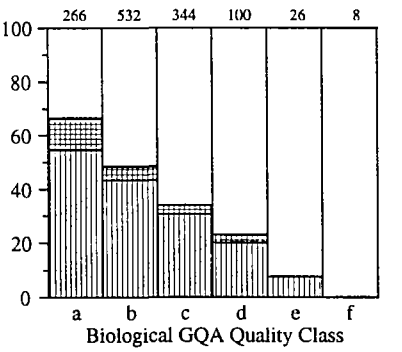
Welsh Region



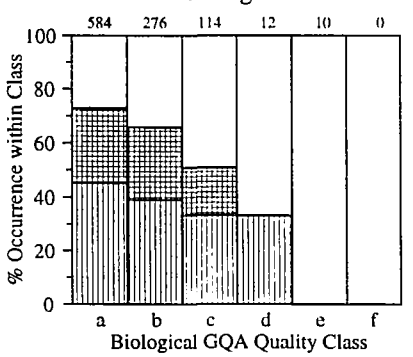
Midlands Region



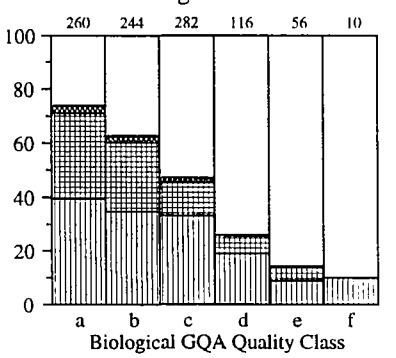
Anglian Region



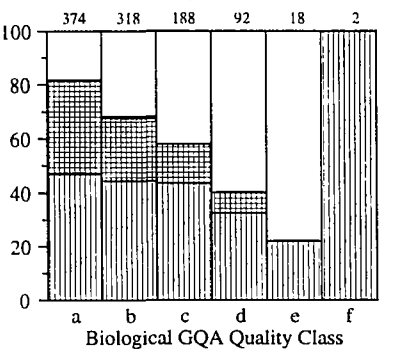
North and South Wessex Areas
South West Region



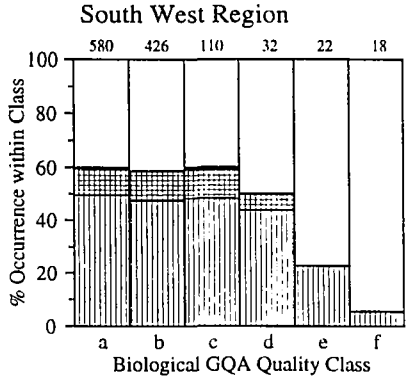
Thames Region



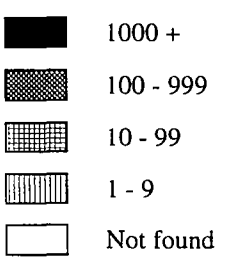
Southern Region



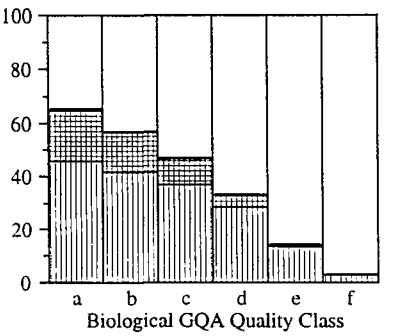
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



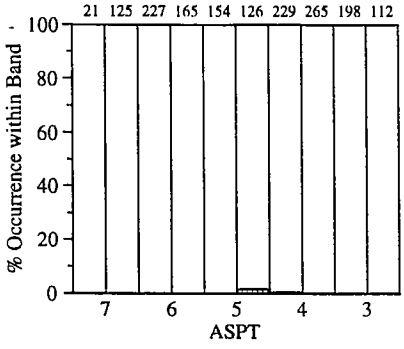
England and Wales
National Distribution



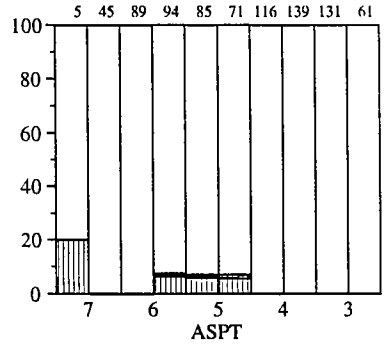
Regional Frequency Distributions by ASPT - River Sites 1995

MOLANNIDAE

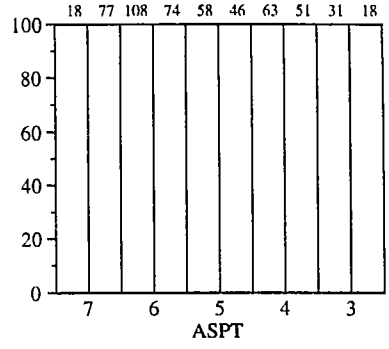
North West Region



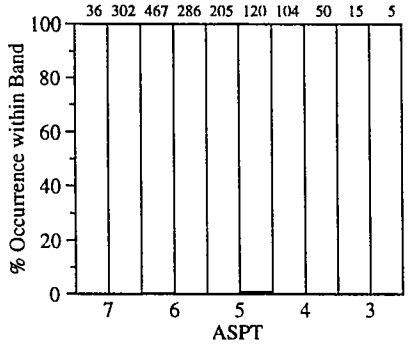
Dales and Ridings Areas
North East Region



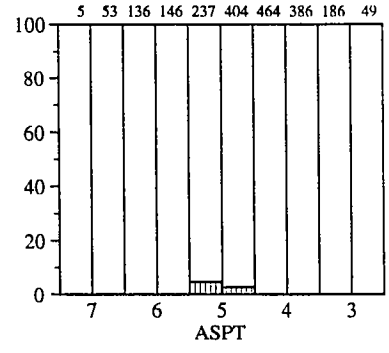
Northumbria Area
North East Region



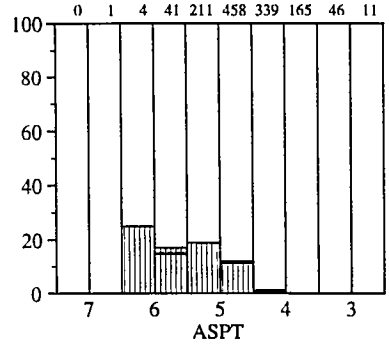
Welsh Region



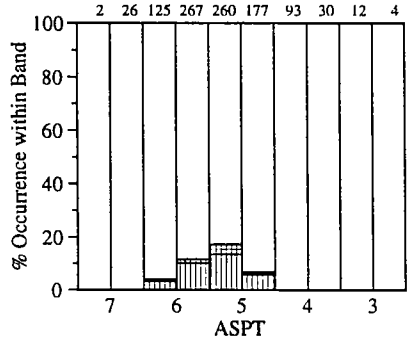
Midlands Region



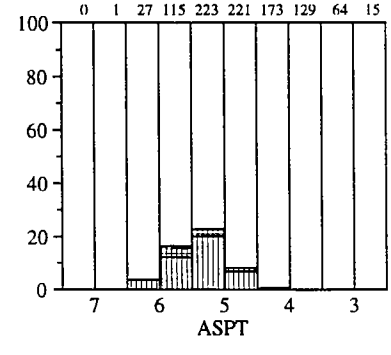
Anglian Region



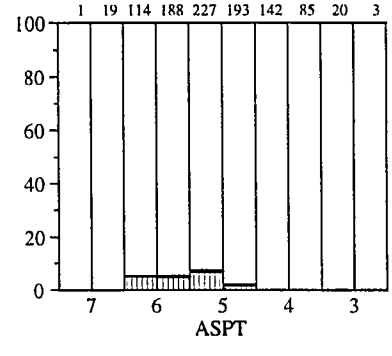
North and South Wessex Areas
South West Region



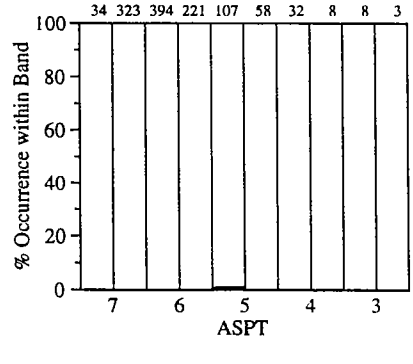
Thames Region



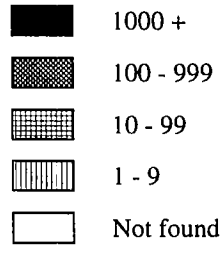
Southern Region



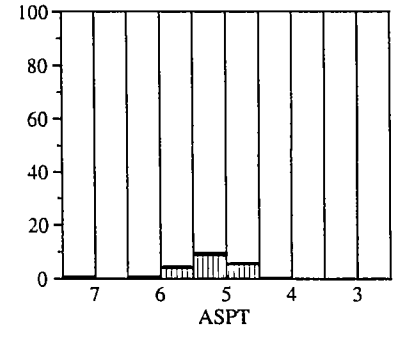
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

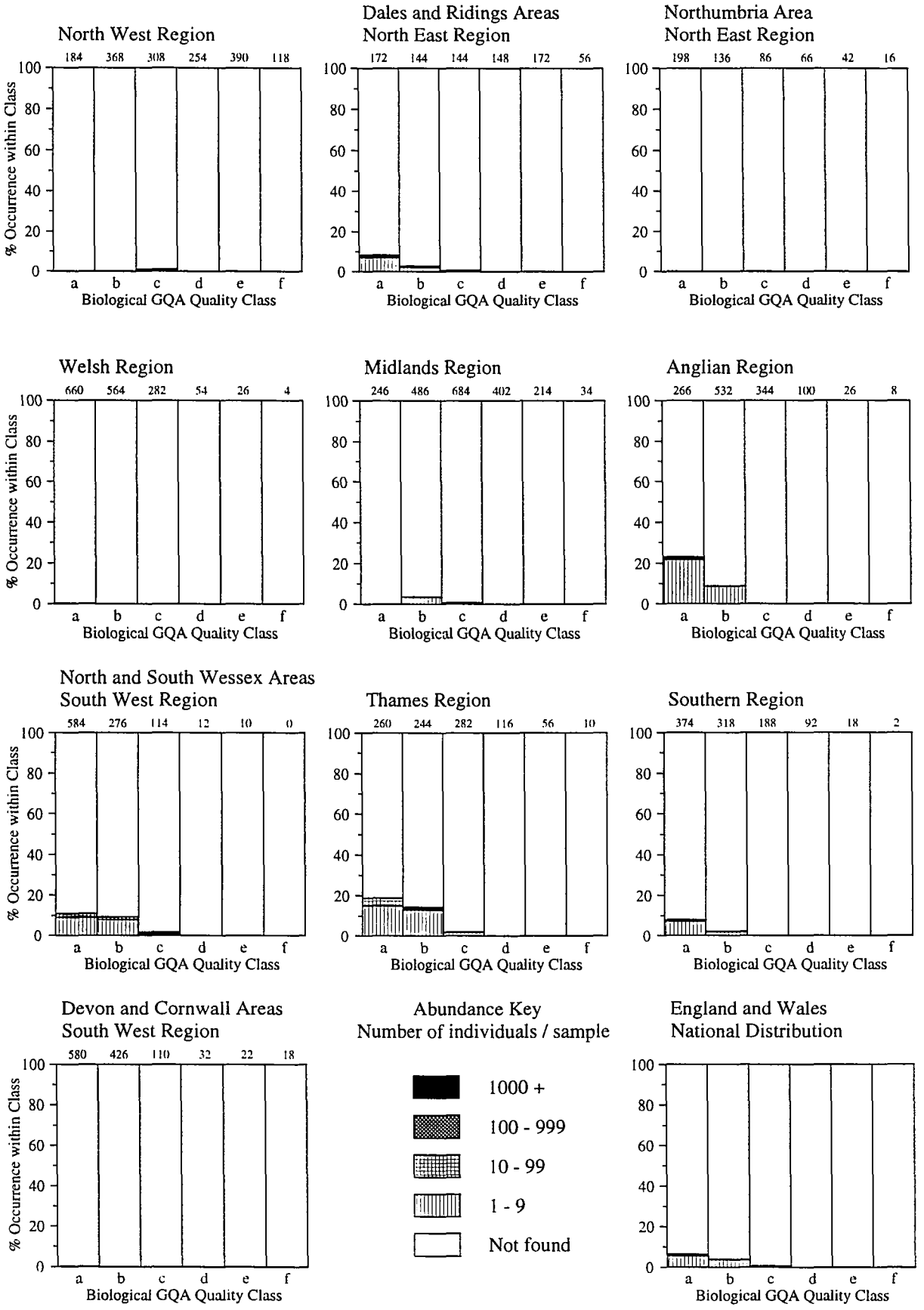


England and Wales
National Distribution



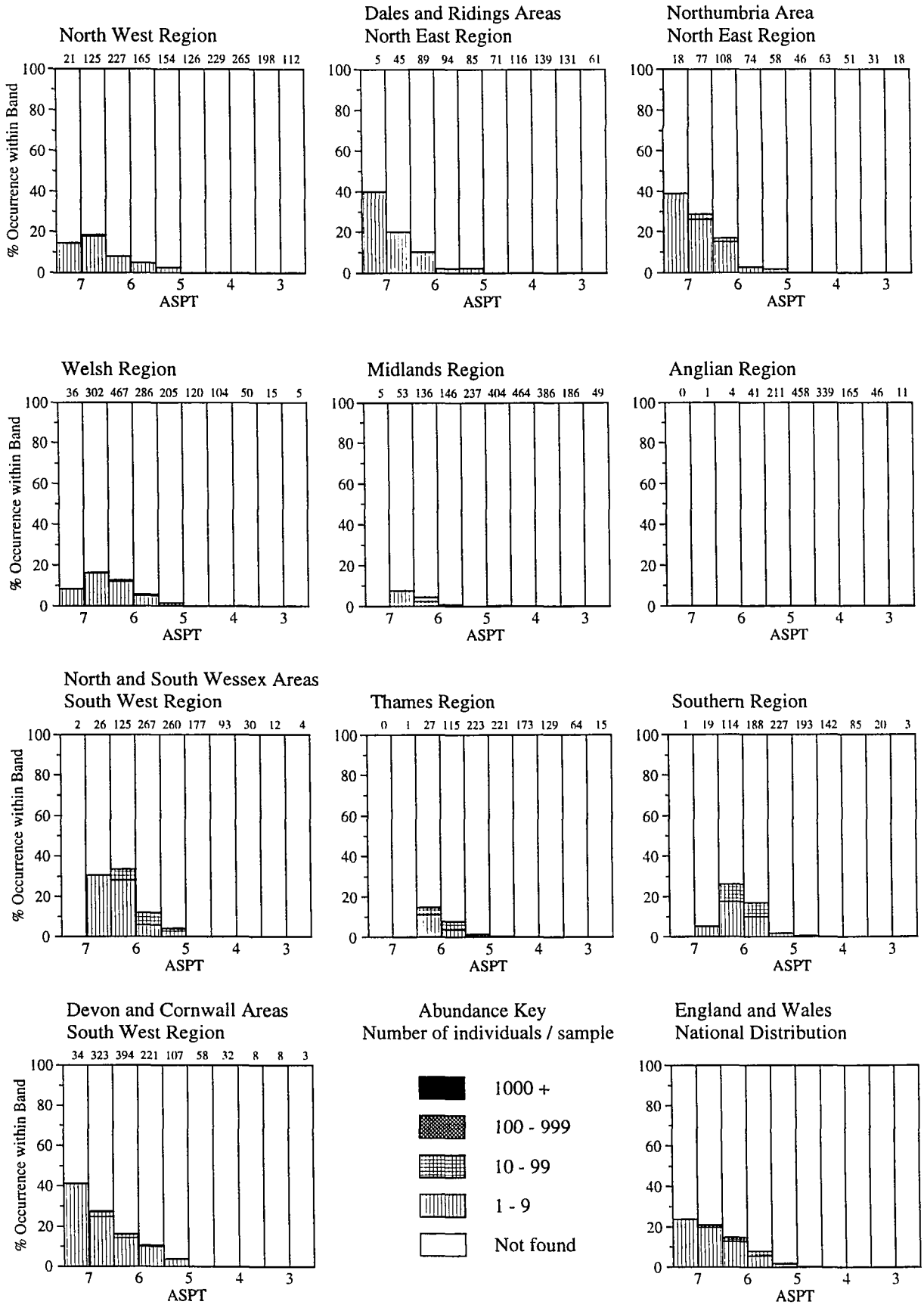
Regional Frequency Distributions by Class - River Sites 1995

MOLANNIDAE



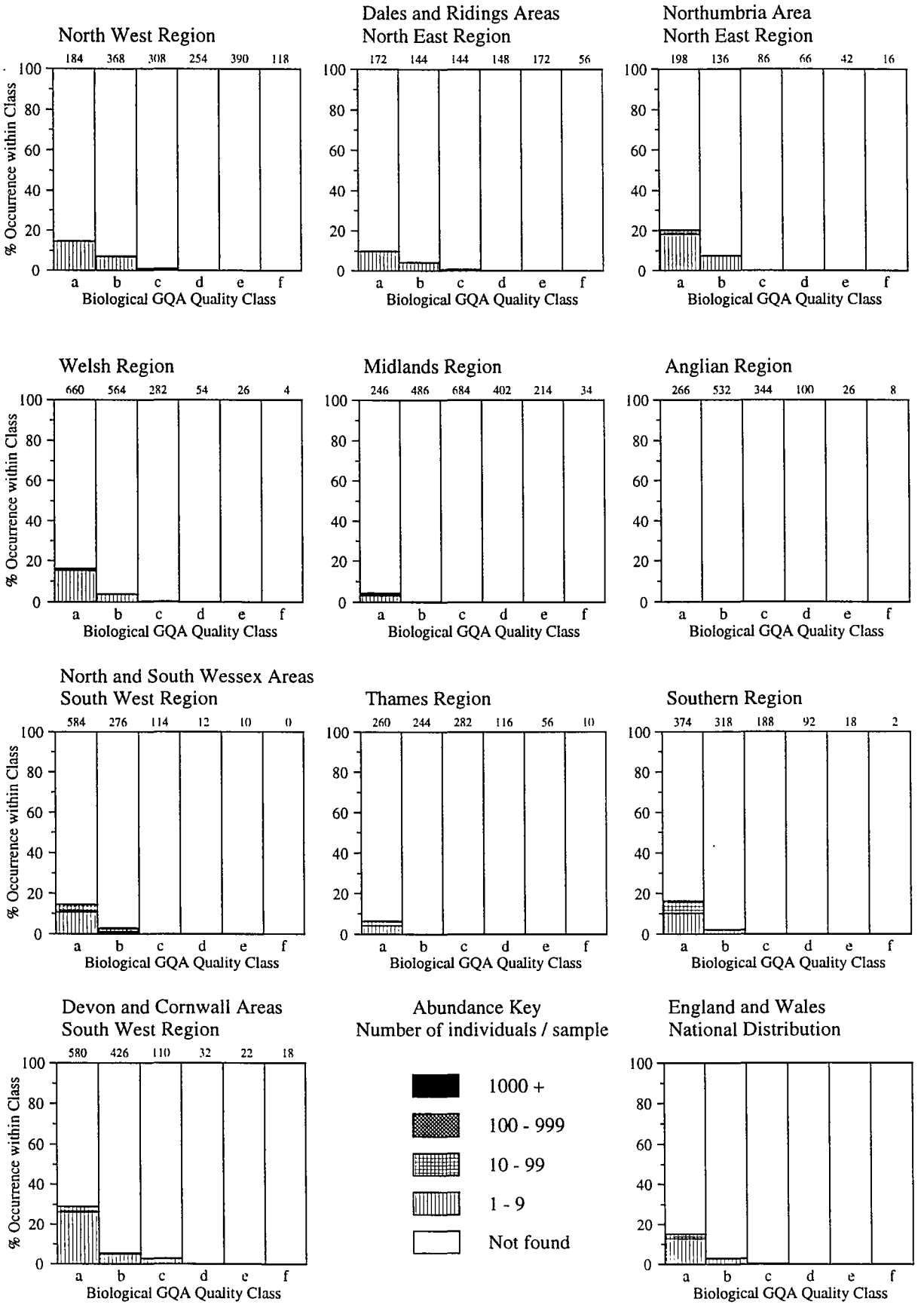
Regional Frequency Distributions by ASPT - River Sites 1995

ODONTOCERIDAE



Regional Frequency Distributions by Class - River Sites 1995

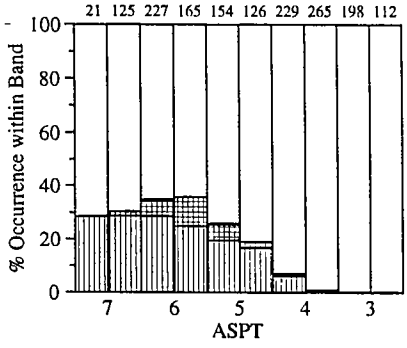
ODONTOCERIDAE



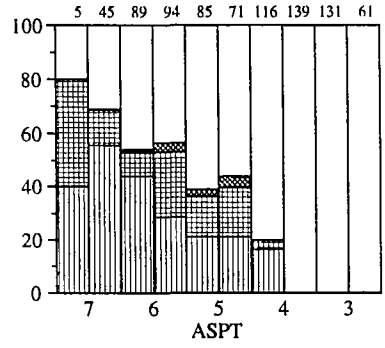
Regional Frequency Distributions by ASPT - River Sites 1995

LEPTOCERIDAE

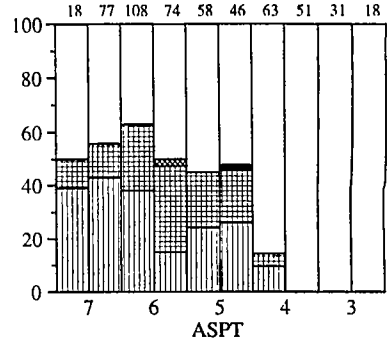
North West Region



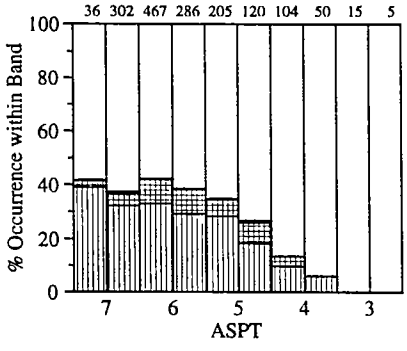
Dales and Ridings Areas
North East Region



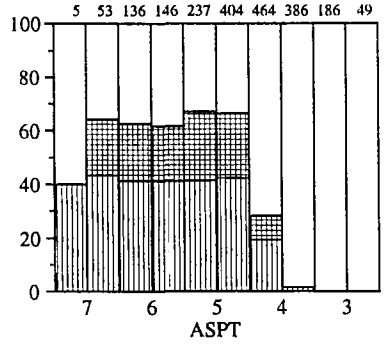
Northumbria Area
North East Region



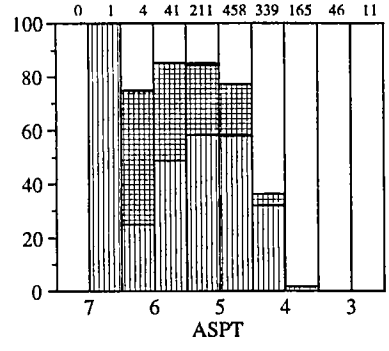
Welsh Region



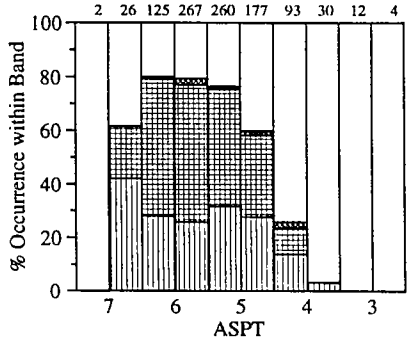
Midlands Region



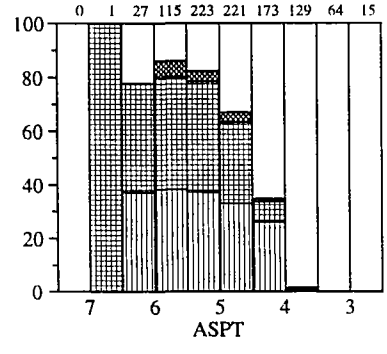
Anglian Region



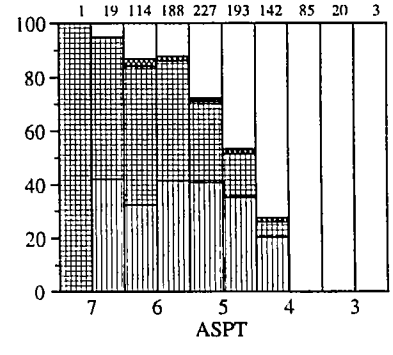
North and South Wessex Areas
South West Region



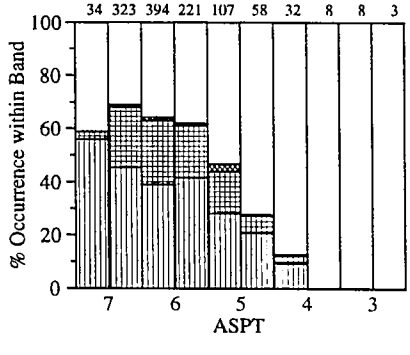
Thames Region



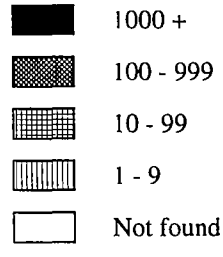
Southern Region



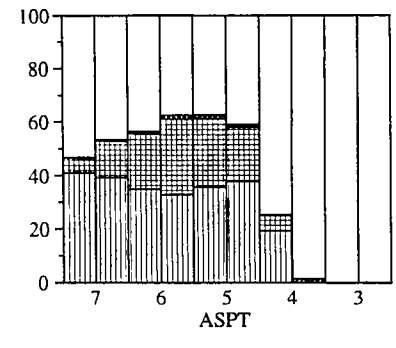
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



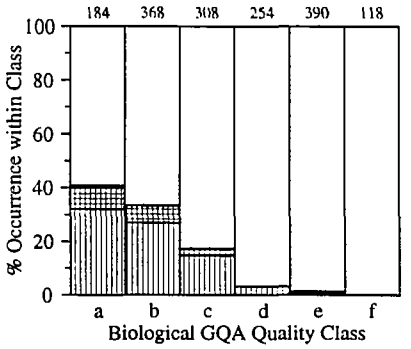
England and Wales
National Distribution



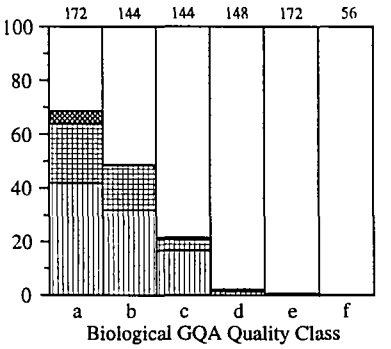
Regional Frequency Distributions by Class - River Sites 1995

LEPTOCERIDAE

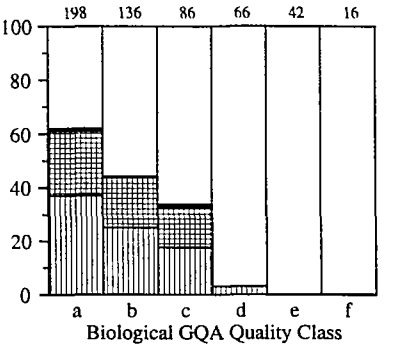
North West Region



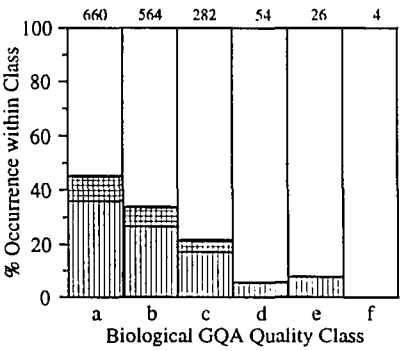
Dales and Ridings Areas
North East Region



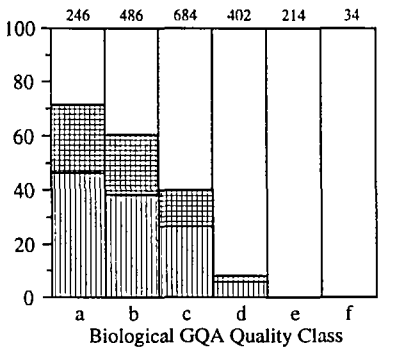
Northumbria Area
North East Region



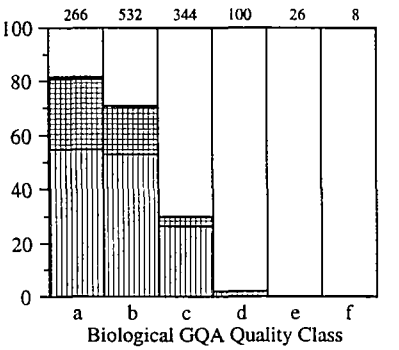
Welsh Region



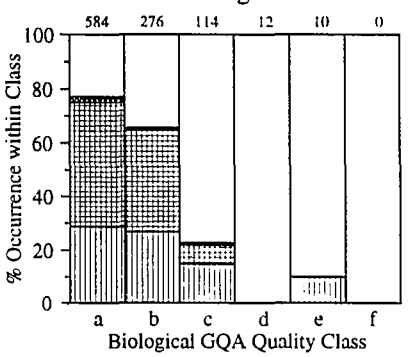
Midlands Region



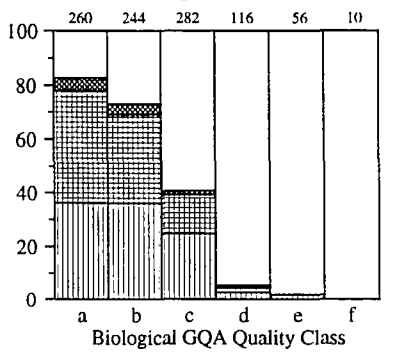
Anglian Region



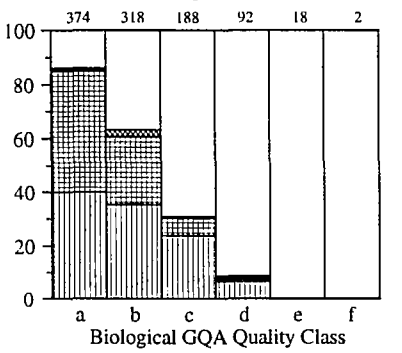
North and South Wessex Areas
South West Region



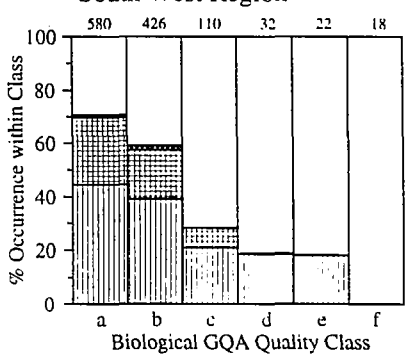
Thames Region



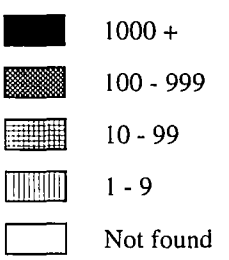
Southern Region



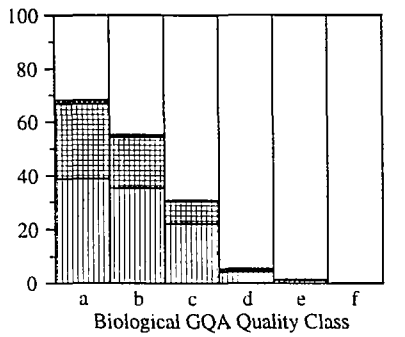
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



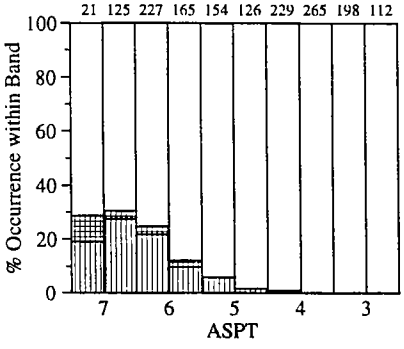
England and Wales
National Distribution



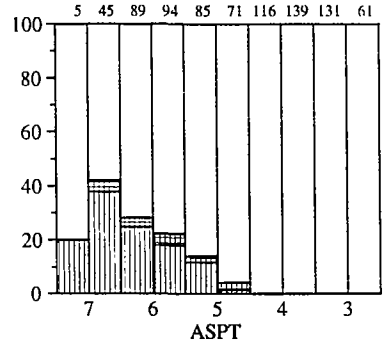
Regional Frequency Distributions by ASPT - River Sites 1995

GOERIDAE

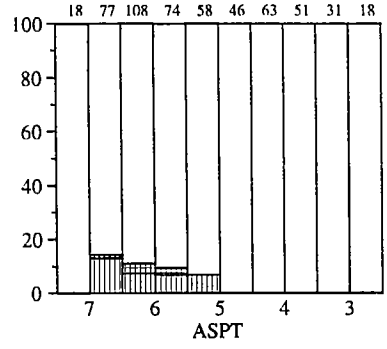
North West Region



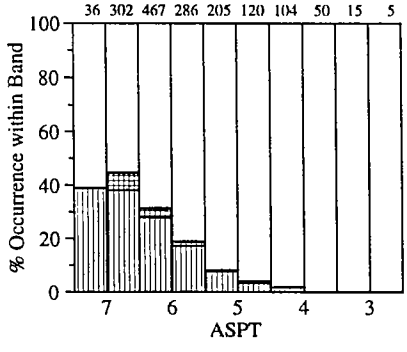
Dales and Ridings Areas
North East Region



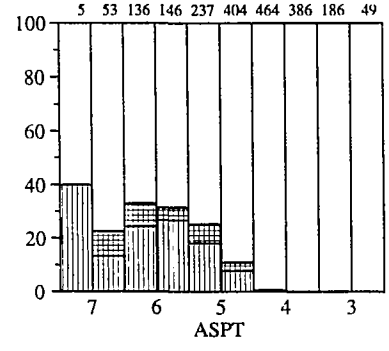
Northumbria Area
North East Region



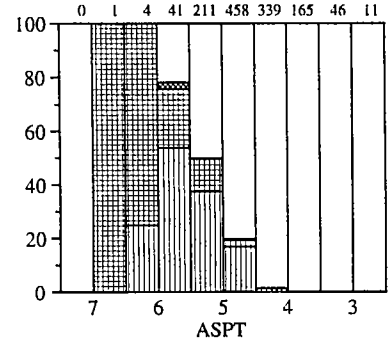
Welsh Region



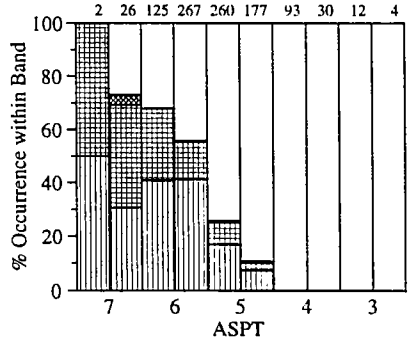
Midlands Region



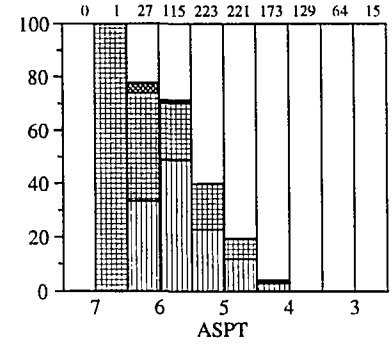
Anglian Region



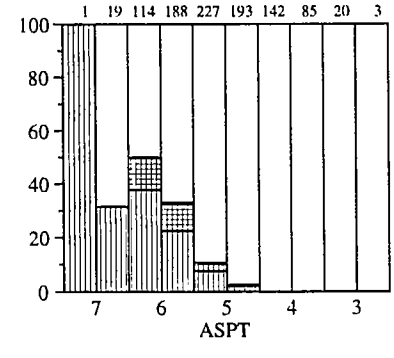
North and South Wessex Areas
South West Region



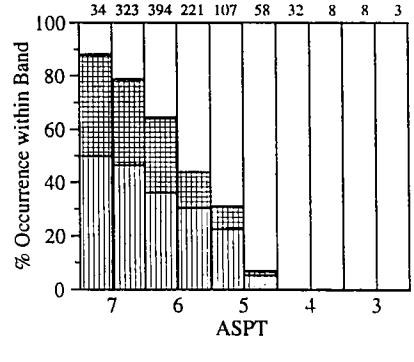
Thames Region



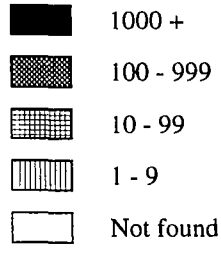
Southern Region



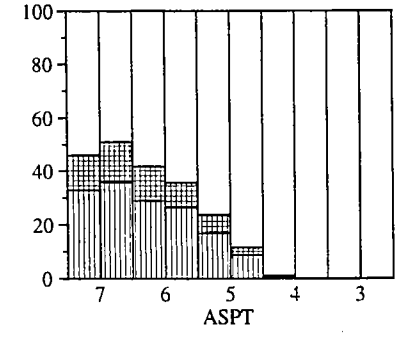
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

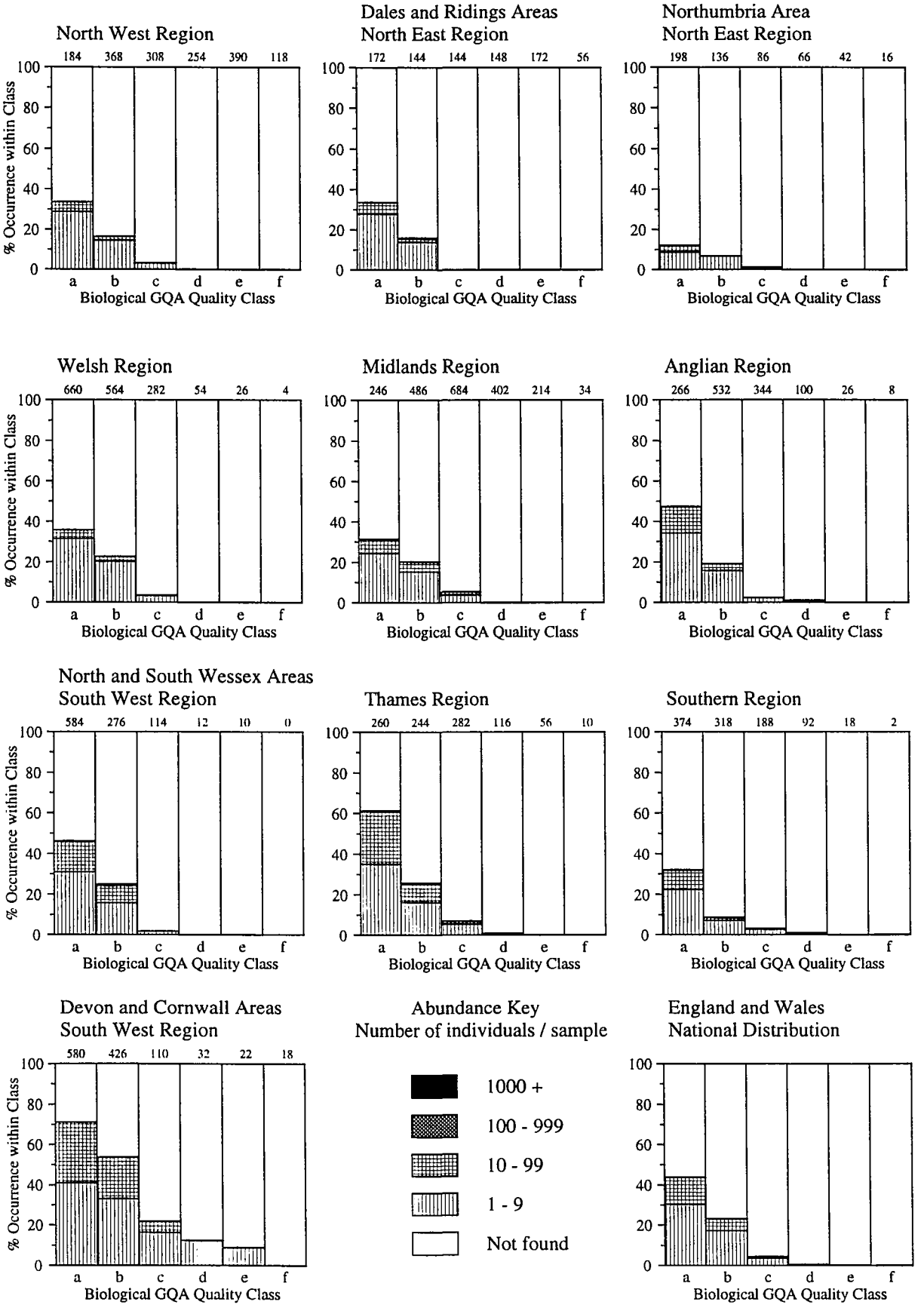


England and Wales
National Distribution



Regional Frequency Distributions by Class - River Sites 1995

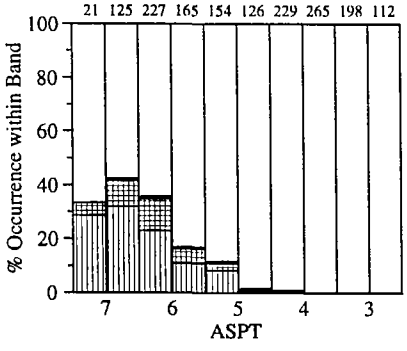
GOERIDAE



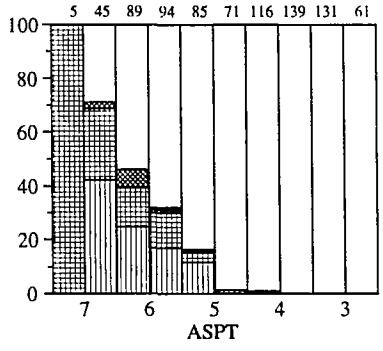
Regional Frequency Distributions by ASPT - River Sites 1995

LEPIDOSTOMATIDAE

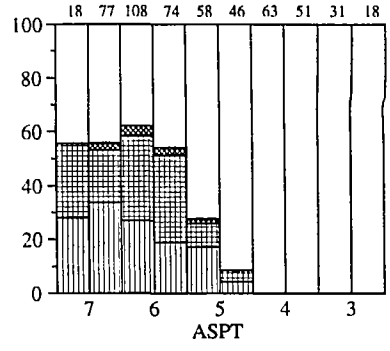
North West Region



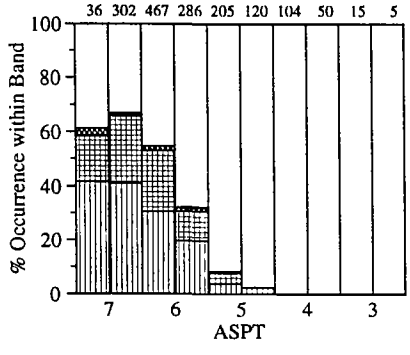
Dales and Ridings Areas
North East Region



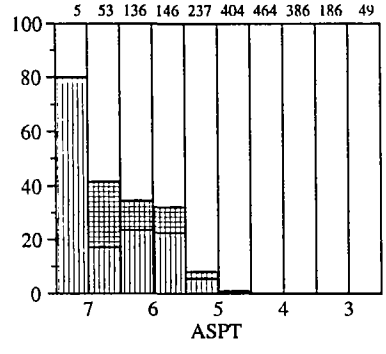
Northumbria Area
North East Region



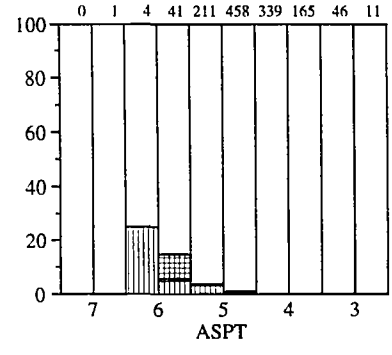
Welsh Region



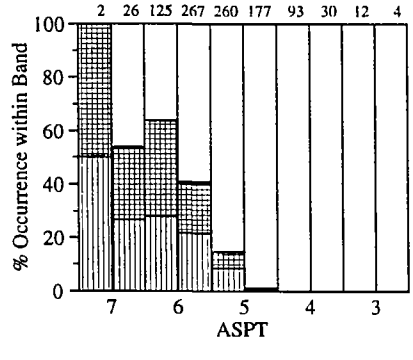
Midlands Region



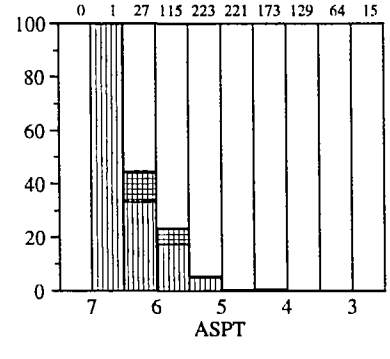
Anglian Region



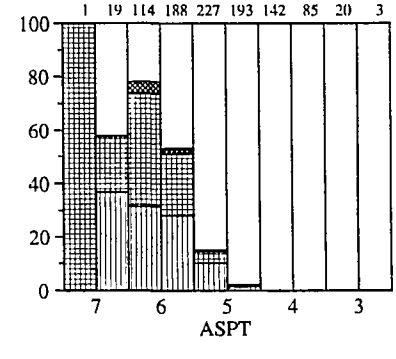
North and South Wessex Areas
South West Region



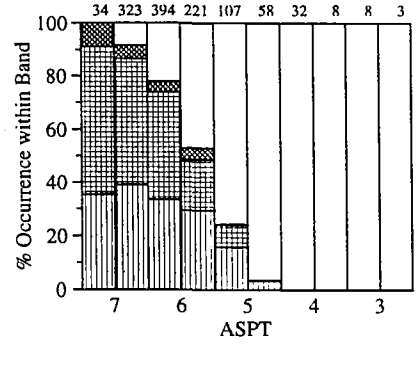
Thames Region



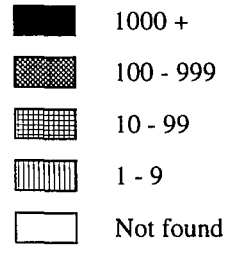
Southern Region



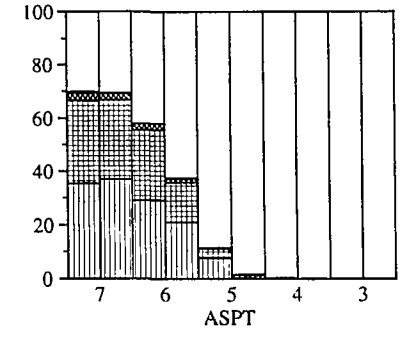
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample



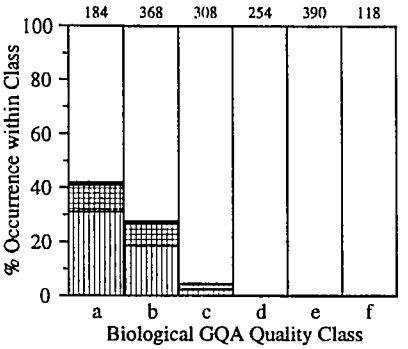
England and Wales
National Distribution



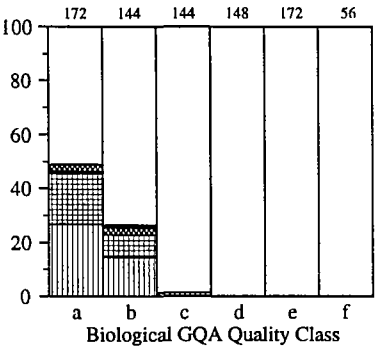
Regional Frequency Distributions by Class - River Sites 1995

LEPIDOSTOMATIDAE

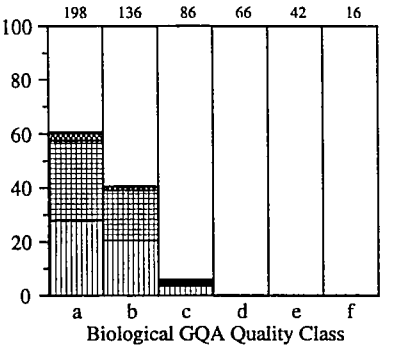
North West Region



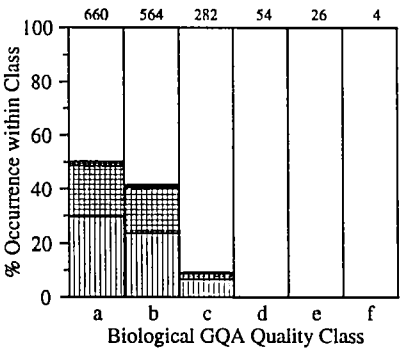
Dales and Ridings Areas
North East Region



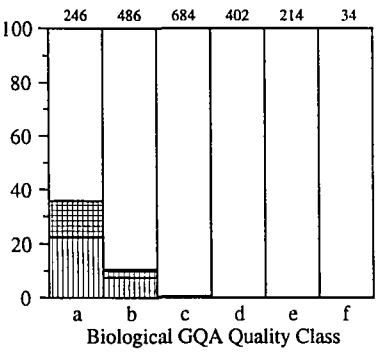
Northumbria Area
North East Region



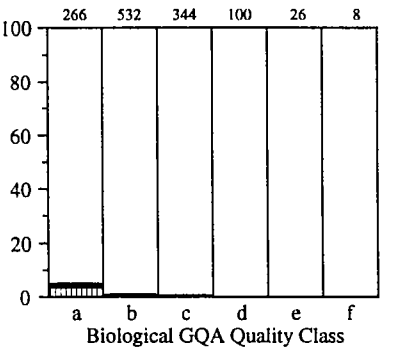
Welsh Region



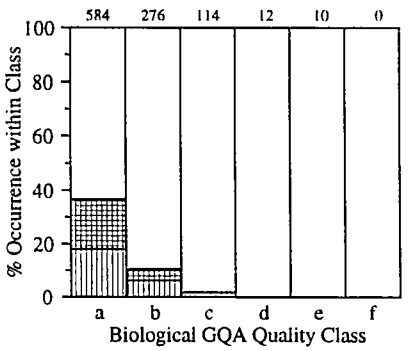
Midlands Region



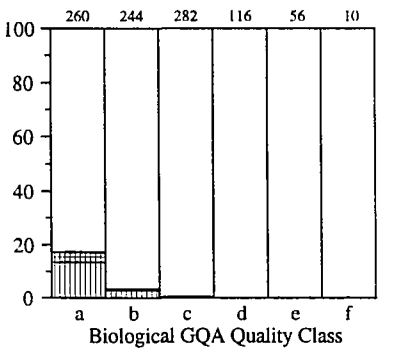
Anglian Region



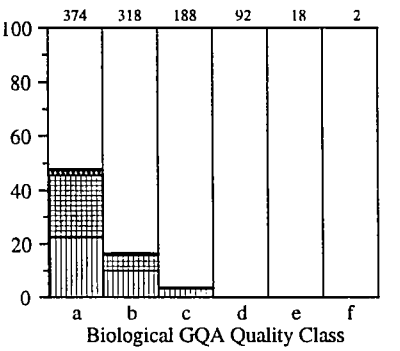
North and South Wessex Areas
South West Region



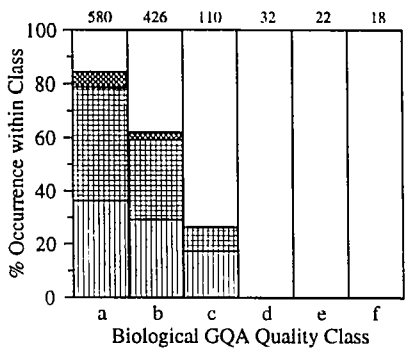
Thames Region



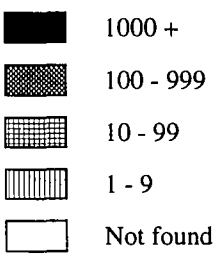
Southern Region



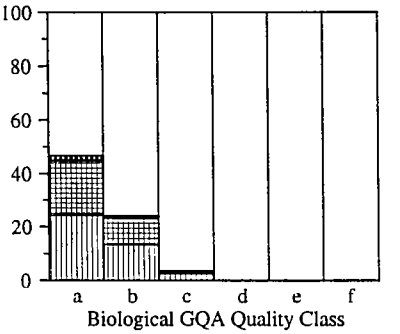
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

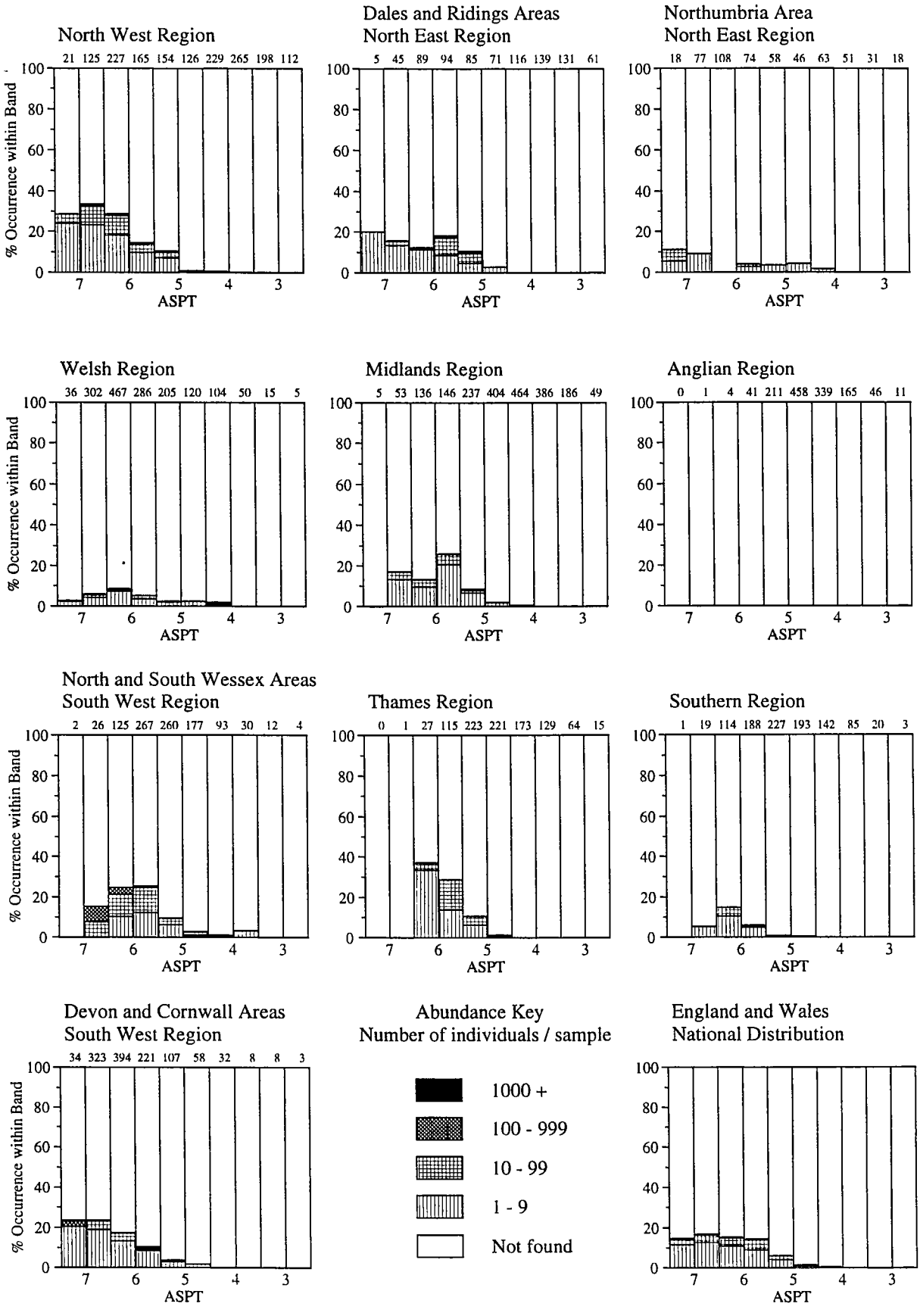


England and Wales
National Distribution



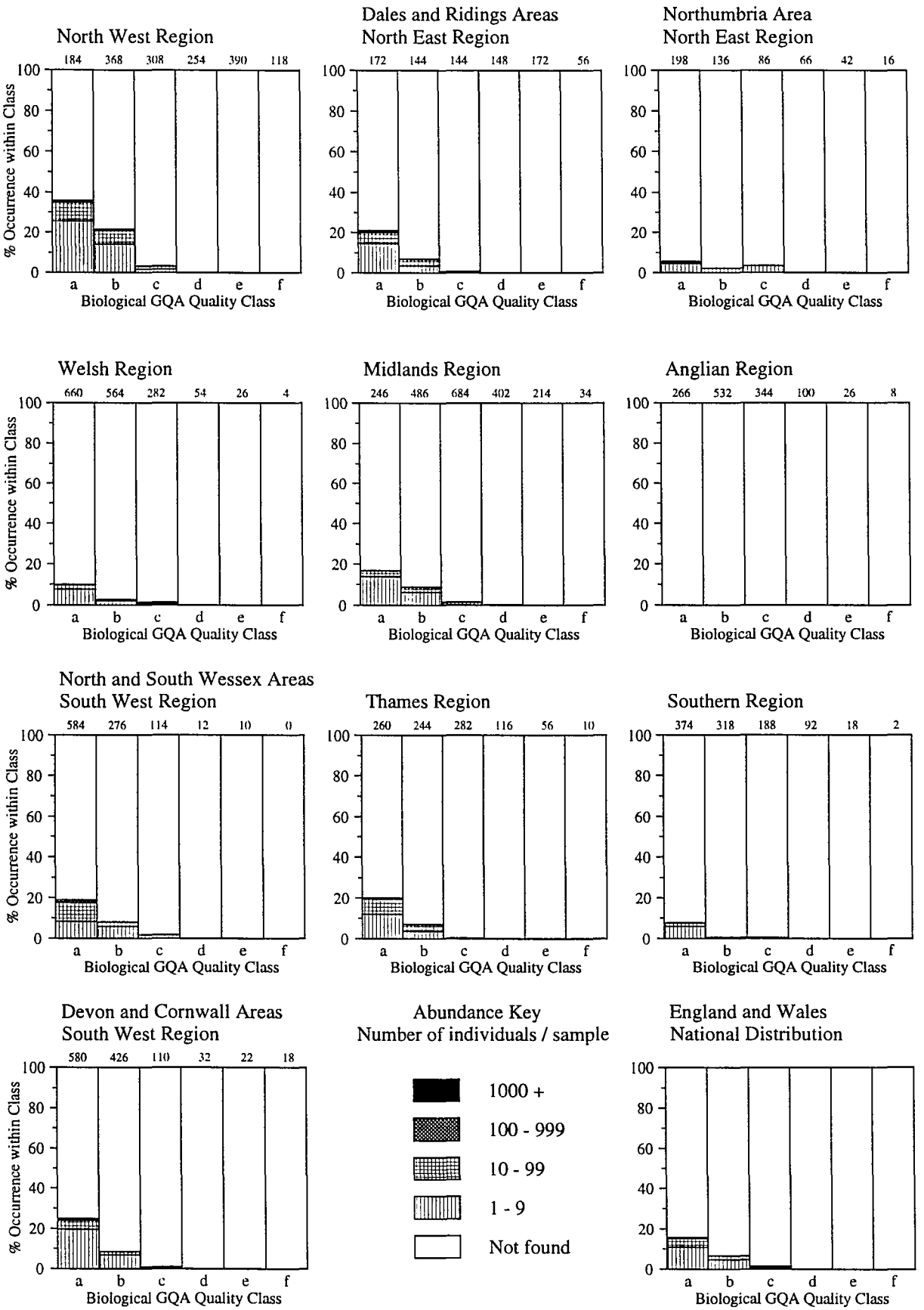
Regional Frequency Distributions by ASPT - River Sites 1995

BRACHYCENTRIDAE



Regional Frequency Distributions by Class - River Sites 1995

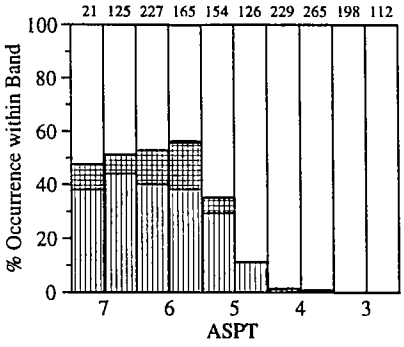
BRACHYCENTRIDAE



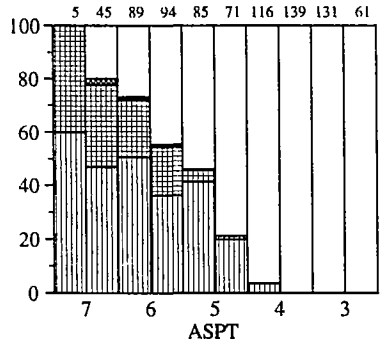
Regional Frequency Distributions by ASPT - River Sites 1995

SERICOSTOMATIDAE

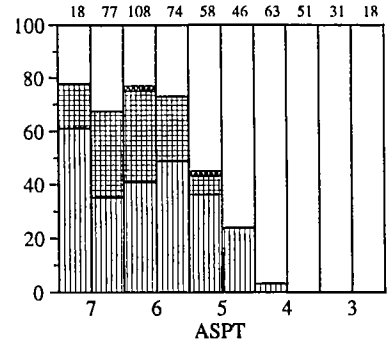
North West Region



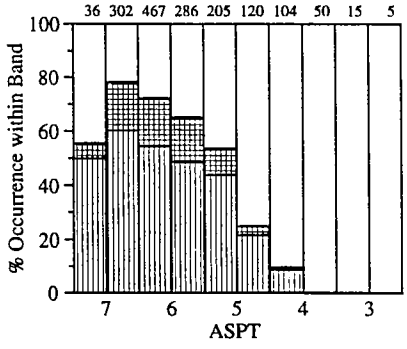
Dales and Ridings Areas
North East Region



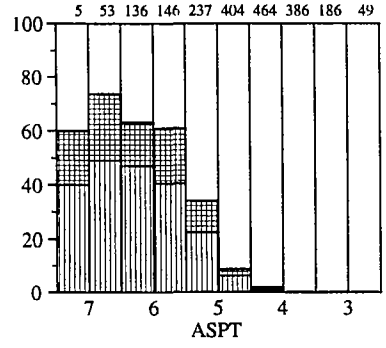
Northumbria Area
North East Region



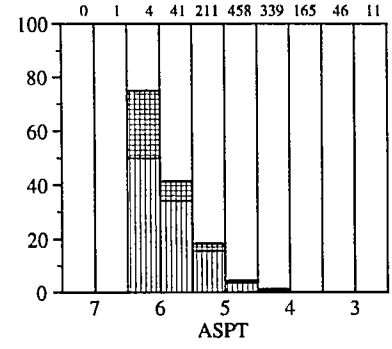
Welsh Region



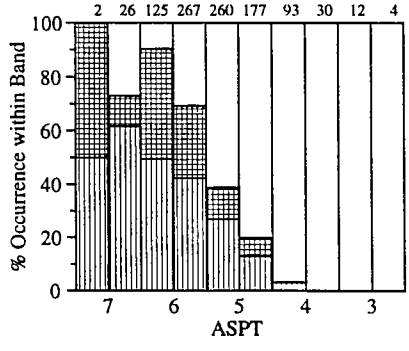
Midlands Region



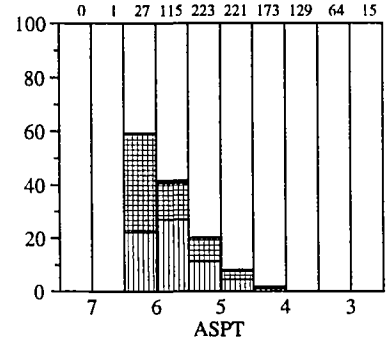
Anglian Region



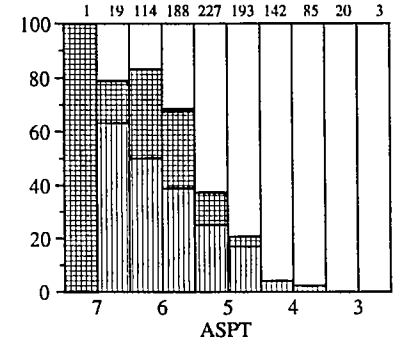
North and South Wessex Areas
South West Region



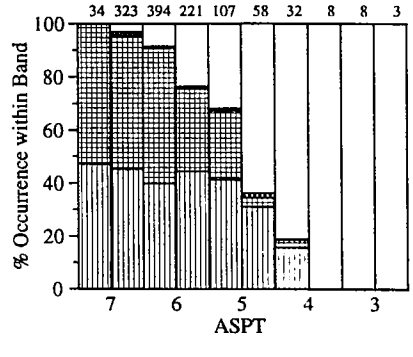
Thames Region



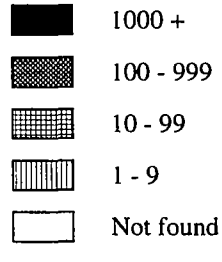
Southern Region



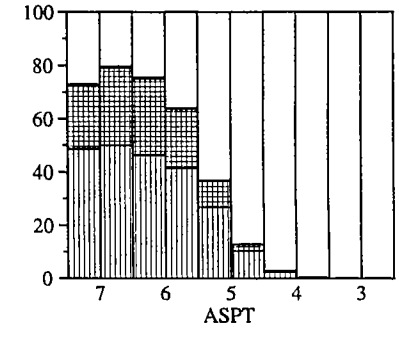
Devon and Cornwall Areas
South West Region



Abundance Key
Number of individuals / sample

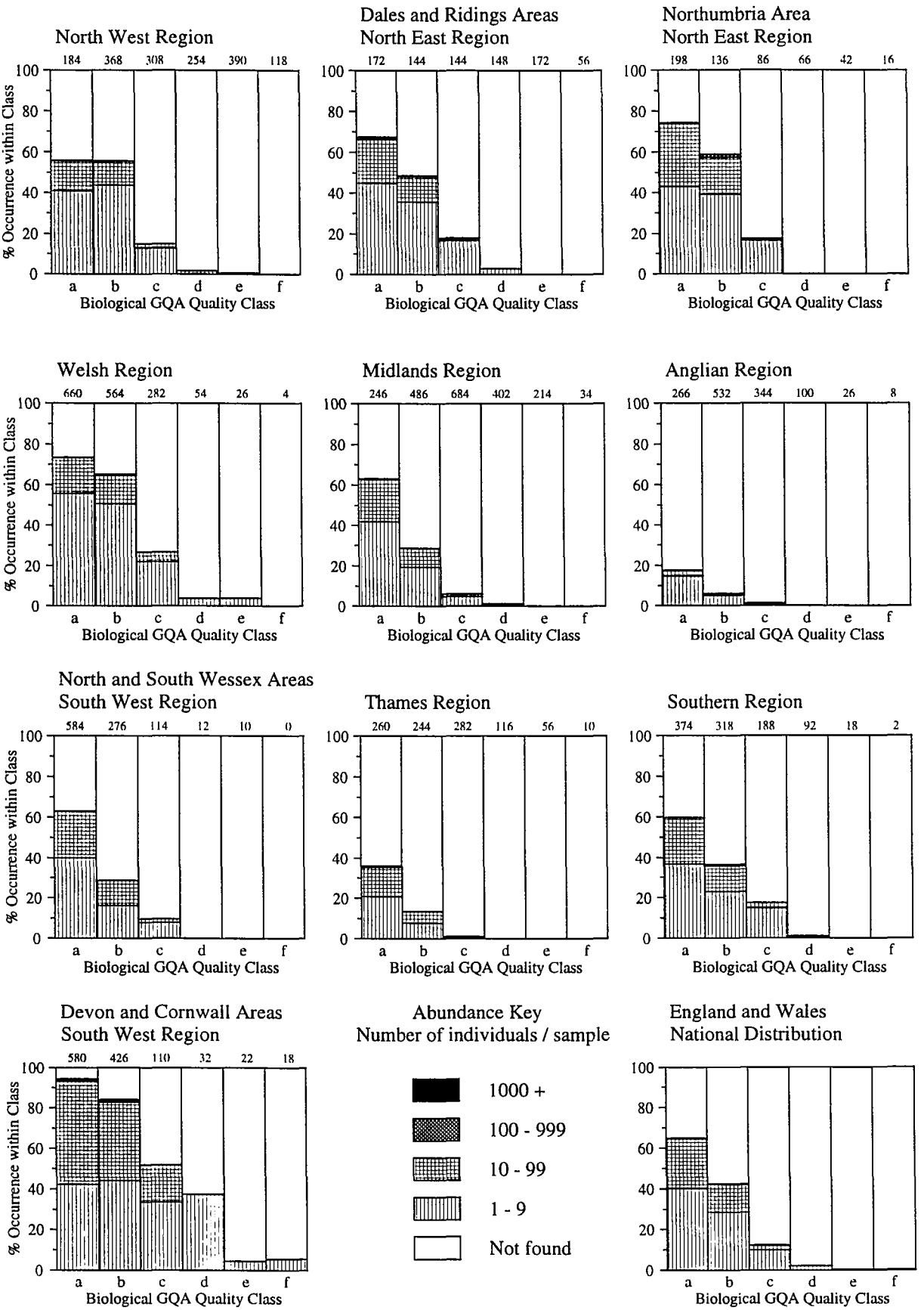


England and Wales
National Distribution



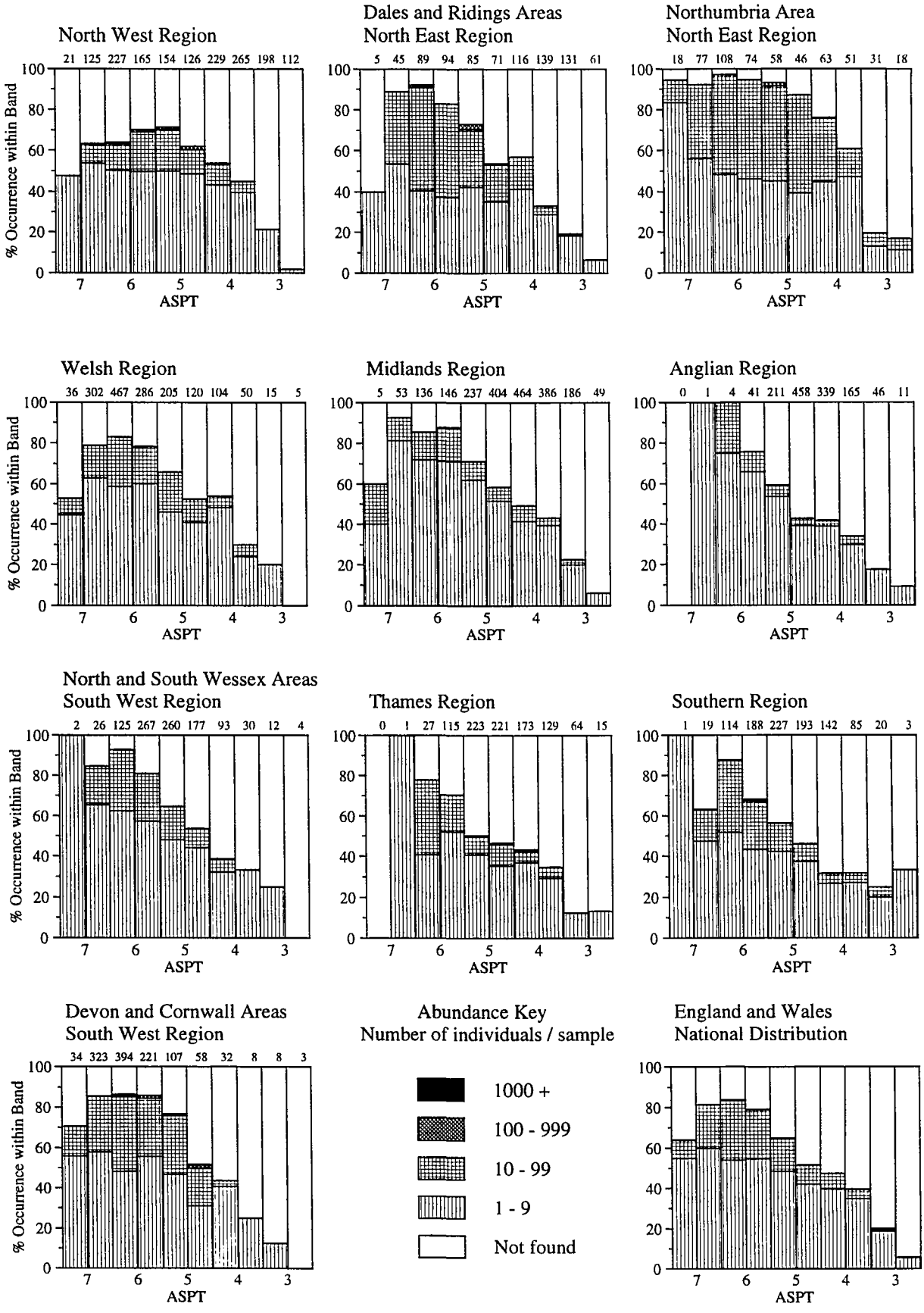
Regional Frequency Distributions by Class - River Sites 1995

SERICOSTOMATIDAE



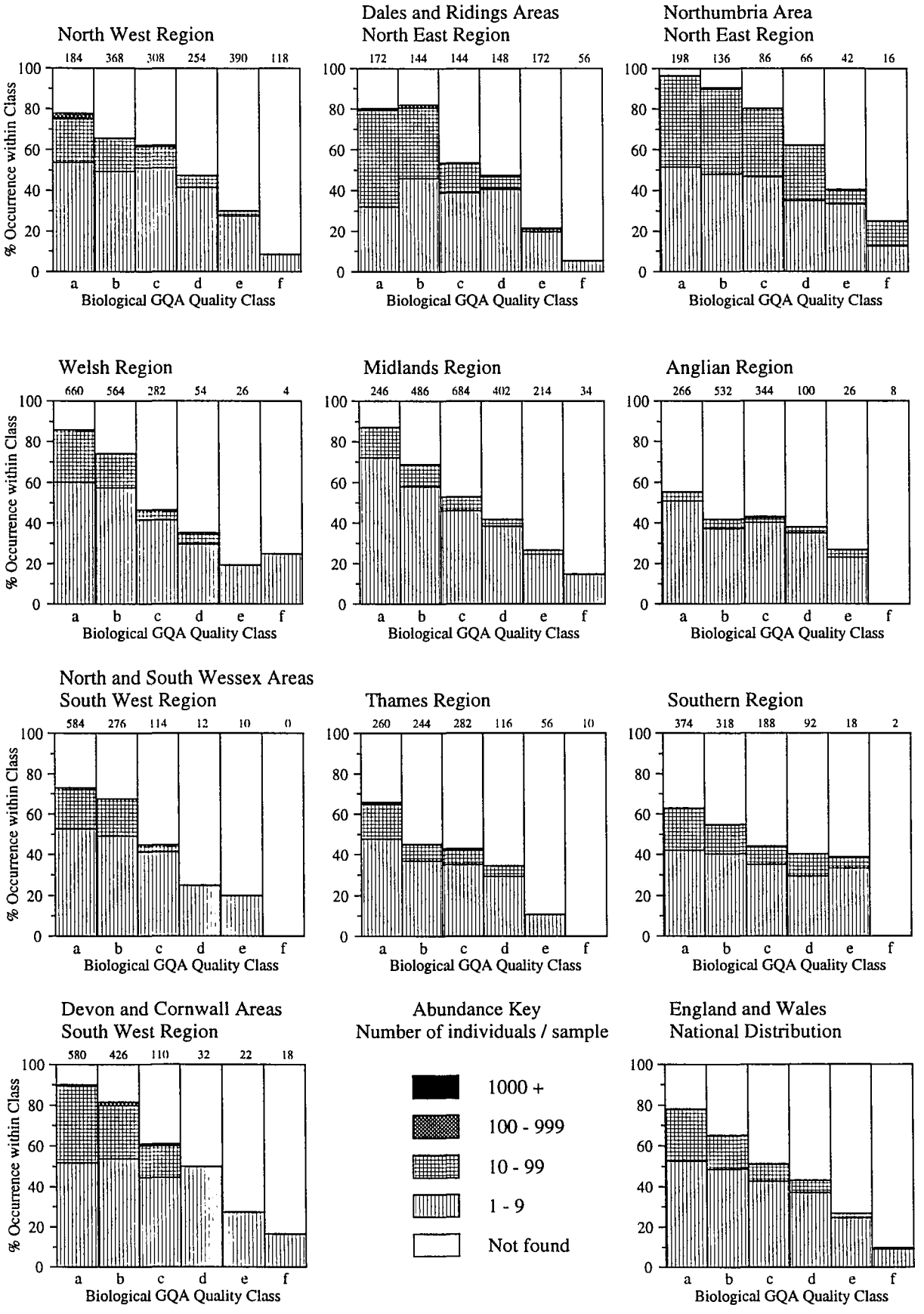
Regional Frequency Distributions by ASPT - River Sites 1995

TIPULIDAE



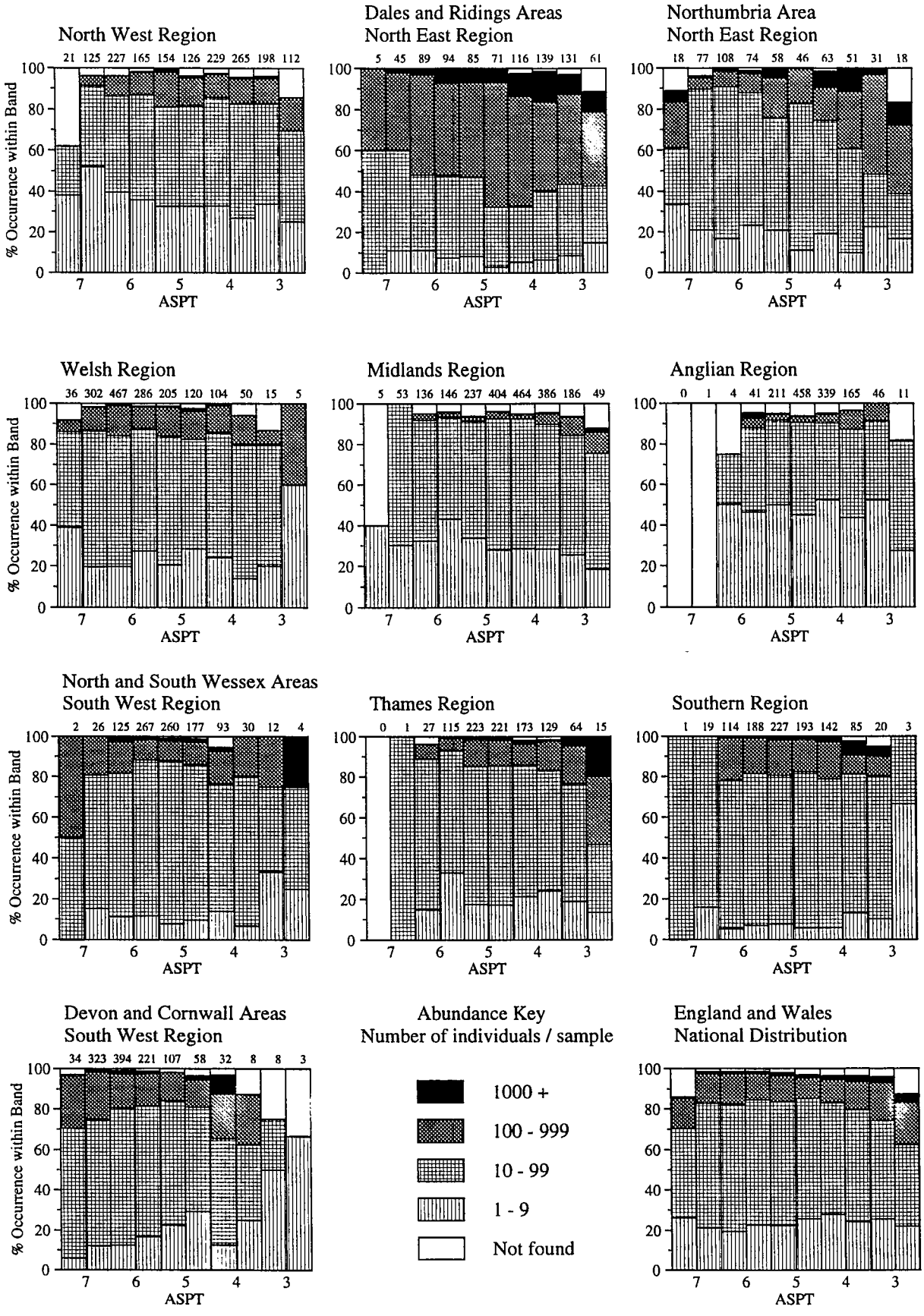
Regional Frequency Distributions by Class - River Sites 1995

TIPULIDAE



Regional Frequency Distributions by ASPT - River Sites 1995

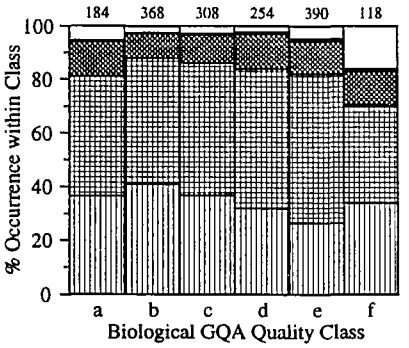
CHIRONOMIDAE



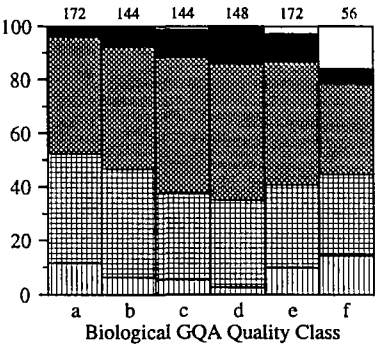
Regional Frequency Distributions by Class - River Sites 1995

CHIRONOMIDAE

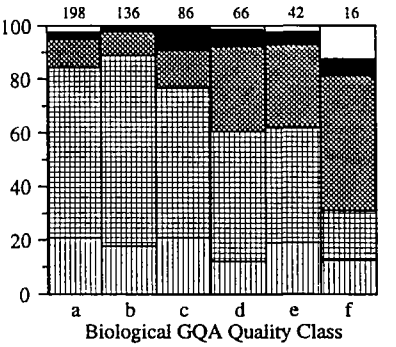
North West Region



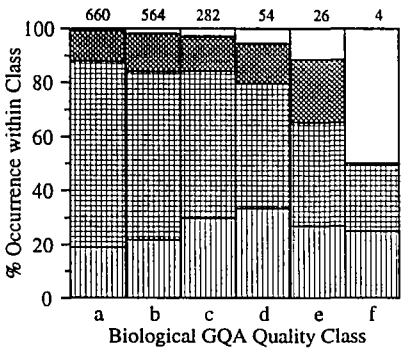
Dales and Ridings Areas
North East Region



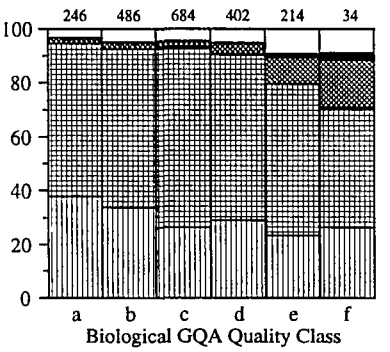
Northumbria Area
North East Region



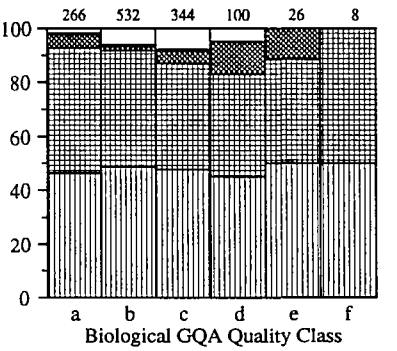
Welsh Region



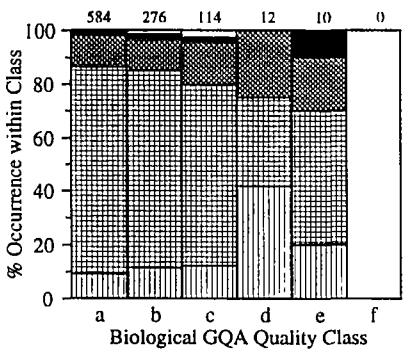
Midlands Region



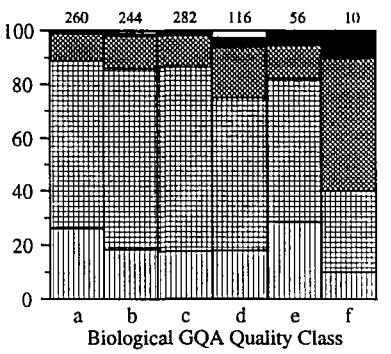
Anglian Region



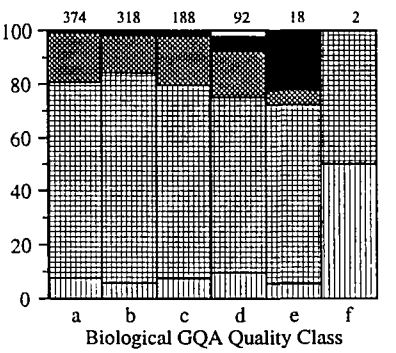
North and South Wessex Areas
South West Region



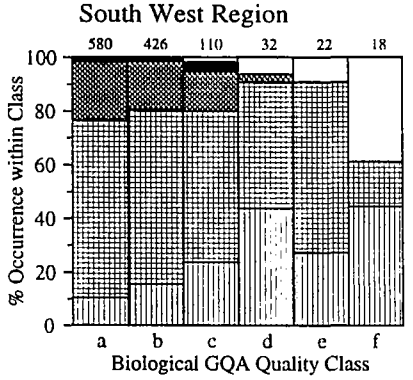
Thames Region



Southern Region



Devon and Cornwall Areas
South West Region



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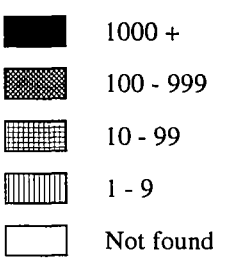
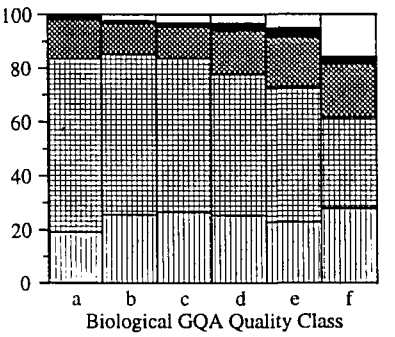
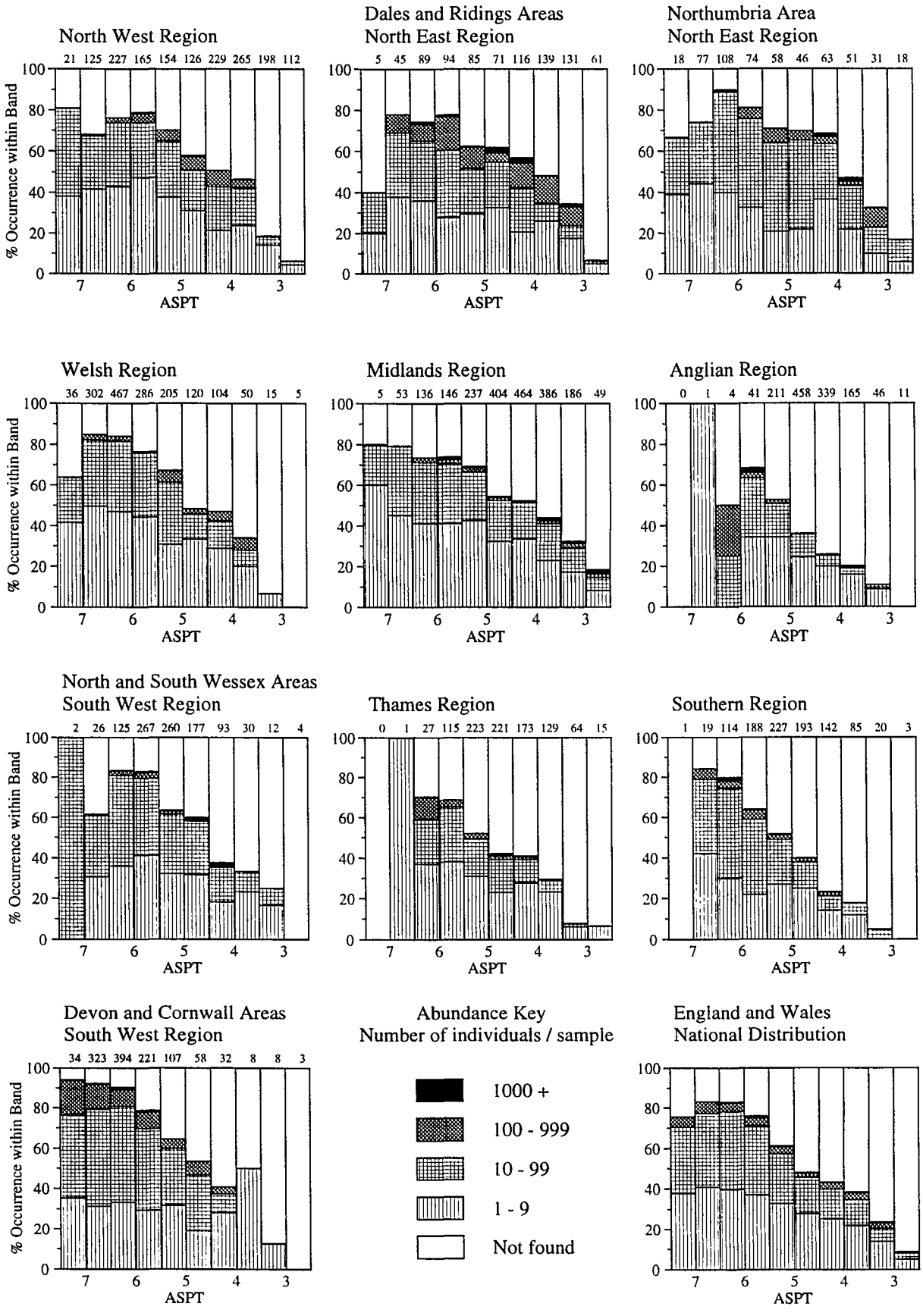


England and Wales
National Distribution



Regional Frequency Distributions by ASPT - River Sites 1995

SIMULIIDAE



Regional Frequency Distributions by Class - River Sites 1995

SIMULIIDAE