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A review of the status of the mayflies (Ephemeroptera) of Great Britain

Ephemeroptera

Species Status No.28

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NATURAL ENGLAND

Foreword

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Background

Making good decisions to conserve species should primarily be based upon an objective process of determining the degree of threat to the survival of a species. The recognised international approach to undertaking this is by assigning the species to one of the IUCN threat categories.

This report was commissioned to update the threat status of mayflies from work originally undertaken in date 1990, using the IUCN methodology for assessing threat.

Reviews for other invertebrate groups will follow.

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Further information
This report can be downloaded from the Natural England website: **www.gov.uk/government/organisations/natural-england**. For information on Natural England publications contact the Natural England Enquiry Service on 0845 600 3078 or e-mail **enquiries@naturalengland.org.uk**.

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1. Introduction to the Species Status project

1.1 The Species Status project

The *Species Status* project is a new initiative, providing up-to-date assessments of the threat status of various invertebrate taxa using the internationally accepted guidelines developed by the International Union for Conservation of Nature (IUCN) (see IUCN, 2012a, b 2013). It is the successor to the JNCC's Species Status Assessment project (http://jncc.defra.gov.uk/page-3352) which ended in 2008. This publication is one in a series of reviews to be produced under the auspices of the new project.

Under the Species Status project, the UK's statutory nature conservation agencies will initiate, resource and publish Red Lists and other reviews of the status of selected taxonomic groups for Great Britain which will then be submitted to JNCC for accreditation (http://jncc.defra.gov.uk/page-1773). All publications will contain a clear audit trail of the assessments made. The approved threat statuses will be entered into the JNCC database of species conservation designations (http://jncc.defra.gov.uk/page-3408) and published by the agencies.

1.2 The Status Assessments

This review adopts the procedures recommended for the regional application of the IUCN threat assessment guidelines (http://www.iucnredlist.org/technical-documents/red-list-documents). Sections 3 and Appendix 2 provide further details. This is a two-step process, the first identifying the taxa threatened in the region of interest using information on the status of the taxa of interest in that region (IUCN2001), the second amending the assessments, where necessary, to take into account interaction with populations of the taxon in neighbouring regions (IUCN 2013). In addition, but as a separate exercise, the standard GB system of assessing rarity, based solely on distribution, is used alongside the IUCN system.

1.3 Species Status and Conservation Action

Sound decisions about the priority to attach to conservation action for any species should primarily be based upon objective assessments of the degree of threat to the survival of a species. This is conventionally done by assigning the species to one of the IUCN threat categories. However, the assessment of threats to survival should be separate and distinct from the subsequent process of deciding which species require action and what activities and resources should be allocated.

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2. Introduction to this review

The Ephemeroptera, commonly known as mayflies or up-wing flies, is an ancient order of insects dating back to the late Carboniferous period 300 million years ago. Mayflies can be seen emerging from the water, resting on nearby vegetation and most commonly "dancing" above head height, along the shores of many still waters and riverbanks. They can be identified by two large upright wings, two or three long tails and (in most species) two small hindwings. The word mayfly is misleading as this group of flies can appear throughout the year. The name comes from the habit of one species, *Ephemera danica*, which emerge as adults when the Mayflower or Hawthorn is in bloom. Over 3,000 species have been described from around the world and 51 of these species have been recorded from the British Isles.

2.1 Taxa considered in this review

All 51 species included in the Fauna Europaea checklist of Ephemeroptera (Mayflies) of Britain (Macadam, 2012) are included in this review. The Ephemeroptera Recording Scheme has, since its formation in 2000, collated information about these species from the following data sources:

- Historic records as published in the national journals (and in some cases also local journals).
- Published county reviews.
- Voucher specimens available through national and local museums.
- Modern records, arising from the recording activity of the Statutory Environment Agencies and the freshwater invertebrate recording community.

The area covered in this review is Great Britain (i.e. England, Scotland and Wales only). While Northern Ireland forms part of the United Kingdom, the recent trend has been for that area to work with the Irish Republic over whole Ireland reviews. The Isle of Man and the Channel Islands are also not included.

Table 1. Species covered by this review

FAMILY	**SPECIES**
Ameletidae	*Ameletus inopinatus* Eaton, 1887
Arthropleidae	*Arthroplea congener* Bengtsson, 1908
Baetidae	*Baetis atrebatinus* Eaton, 1870
Baetidae	*Baetis buceratus* Eaton, 1870
Baetidae	*Baetis digitatus* Bengtsson, 1912
Baetidae	*Baetis fuscatus* (Linnaeus, 1761)
Baetidae	*Baetis muticus* (Linnaeus, 1758)
Baetidae	*Baetis niger* (Linnaeus, 1761)
Baetidae	*Baetis rhodani* (Pictet, 1843)
Baetidae	*Baetis scambus* Eaton, 1870
Baetidae	*Baetis vernus* Curtis, 1834
Baetidae	*Centroptilum luteolum* (Müller, 1776)
Baetidae	*Cloeon dipterum* (Linnaeus, 1761)

Baetidae	*Cloeon simile* Eaton, 1870
Baetidae	*Procloeon bifidum* (Bengtsson, 1912)
Baetidae	*Procloeon pennulatum* (Eaton, 1870)
Caenidae	*Brachycercus harrisellus* Curtis, 1834
Caenidae	*Caenis beskidensis* Sowa, 1973
Caenidae	*Caenis horaria* (Linnaeus, 1758)
Caenidae	*Caenis luctuosa* (Burmeister, 1839)
Caenidae	*Caenis macrura* Stephens, 1835
Caenidae	*Caenis pseudorivulorum* Keffermüller, 1960
Caenidae	*Caenis pusilla* Navàs, 1913
Caenidae	*Caenis rivulorum* Eaton, 1884
Caenidae	*Caenis robusta* Eaton, 1884
Ephemerellidae	*Ephemerella notata* Eaton, 1887
Ephemerellidae	*Serratella ignita* (Poda, 1761)
Ephemeridae	*Ephemera danica* Müller, 1764
Ephemeridae	*Ephemera lineata* Eaton, 1870
Ephemeridae	*Ephemera vulgata* Linnaeus, 1758
Heptageniidae	*Ecdyonurus dispar* (Curtis, 1834)
Heptageniidae	*Ecdyonurus insignis* (Eaton, 1870)
Heptageniidae	*Ecdyonurus torrentis* Kimmins, 1942
Heptageniidae	*Ecdyonurus venosus* (Fabricius, 1775)
Heptageniidae	*Electrogena affinis* (Eaton, 1883)
Heptageniidae	*Electrogena lateralis* (Curtis, 1834)
Heptageniidae	*Heptagenia longicauda* (Stephens, 1835)
Heptageniidae	*Heptagenia sulphurea* (Müller, 1776)
Heptageniidae	*Kageronia fuscogrisea* (Retzius, 1783)
Heptageniidae	*Rhithrogena germanica* Eaton, 1885
Heptageniidae	*Rhithrogena semicolorata* (Curtis, 1834)
Leptophlebiidae	*Habrophlebia fusca* (Curtis, 1834)
Leptophlebiidae	*Leptophlebia marginata* (Linnaeus, 1767)
Leptophlebiidae	*Leptophlebia vespertina* (Linnaeus, 1758)
Leptophlebiidae	*Paraleptophlebia cincta* (Retzius, 1783)
Leptophlebiidae	*Paraleptophlebia submarginata* (Stephens, 1835)
Leptophlebiidae	*Paraleptophlebia werneri* Ulmer, 1920
Potamanthidae	*Potamanthus luteus* (Linnaeus, 1767)
Siphlonuridae	*Siphlonurus alternatus* (Say, 1824)
Siphlonuridae	*Siphlonurus armatus* (Eaton, 1870)
Siphlonuridae	*Siphlonurus lacustris* (Eaton, 1870)

It should be borne in mind that earlier reviews will have used earlier checklists, and that nomenclature may therefore be somewhat different.

2.2 Previous reviews

2.2.1 British Red Data Books: 2. Insects (1987)

Ephemeroptera were not included in the British Red Data Books: 2. Insects (Shirt, 1987) and a separate review of Ephemeroptera was subsequently undertaken (Bratton, 1990). This listed 5 of the total British fauna at that time (51 species), ie 9.8% (Table 2). Data sheets were given for Endangered (RDB1), Vulnerable (RDB2), Rare (RDB3) and Nationally Notable species. More recently, two species (*Baetis niger* and *Potamanthus luteus*) have been prioritised for conservation action through the UK Biodiversity Action Plan process using criteria such as international importance, rate of decline and other important issues. A review was undertaken in Ireland in 2012 (Kelly-Quinn & Regan, 2012) which gave red list status to six species (*Siphlonurus armatus* (CR); *Baetis atrebatinus* (EN); *Ephemerella notata* (EN); *Rhithrogena germanica* (VU); *Procloeon bifidum* (VU) and *Leptophlebia marginata* (VU)). A further two species were listed as Near Threatened (*Kageronia fuscogrisea* and *Ameletus inopinatus*) and two species listed as Data Deficient (*Baetis fuscatus* and *Ecdyonurus torrentis*).

Table 2. Red list categories for species reviewed by Bratton (1990)

Heptagenia longicauda	Category 1: Endangered
Potamanthus luteus	Category 2: Vulnerable
Ephemera lineata	Category 2: Vulnerable
Paraleptophlebia werneri	Category 3: Rare
Kageronia fuscogrisea	Nationally Notable

2.2.2 The new review

The present review has been undertaken to provide an up to date assessment of the status of mayfly species. The IUCN Guidelines (IUCN, 1994) have been revised and subsequently updated (IUCN, 2012a), and new information on distribution and trends is now available, making it necessary to revise the status of all mayfly species. It should be noted that the IUCN criteria for threat categories concentrate on imminent danger of extinction which hopefully applies to very few species, whilst the older, non-IUCN criteria for Nationally Rare and Nationally Scarce relate to a geographic distribution within Great Britain, without taking any account of trends, whether for increase or decline.

3. The IUCN threat categories and selection criteria

3.1 Summary of the 2001 Threat Categories

A brief outline of the revised IUCN criteria and their application is given below, a full explanation being available (IUCN, 2001, 2013) and on the IUCN web site (http://www.iucnredlist.org/; www.iucn.org/). The definitions of the categories are given in Figure 1 and the criteria and categories in Appendix 2. The category *Extinct in the wild* has not been applied in this review. All categories refer to the status in the GB (not globally).

Taxa that are confidently assumed to be extinct in Great Britain are listed here as Regionally Extinct (RE) to indicate that populations no longer exist within Britain but do occur elsewhere in the world (IUCN 2003). Proving extinction beyond reasonable doubt is difficult for many organisms and especially invertebrates. Species not recorded in Britain since 1900 are typically assumed to now be extinct, while species not recorded since 1950 but known to be especially difficult to find 'on demand' have been 'tagged' here as Possibly Extinct (IUCN 2011). This category was used to identify those Critically Endangered species that are likely to be Extinct, but for which confirmation is still required. As the IUCN Guidelines point out, this is not a new criterion, but a qualifier that is appended to Critically Endangered taxa, such that relevant taxa are reported as Critically Endangered (Possibly Extinct), abbreviated as CR(PE).

REGIONALLY EXTINCT (RE)
A taxon is Extinct when there is no reasonable doubt that the last individual has died. In this review the last date for a record is set at fifty years before publication.

CRITICALLY ENDANGERED (CR)
A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered (see Table 3).

ENDANGERED (EN)
A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (see Table 3).

VULNERABLE (VU)
A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (see Table 3).

NEAR THREATENED (NT)
A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

LEAST CONCERN (LC)
A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

DATA DEFICIENT (DD)
A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate.

NOT EVALUATED (NE)
A taxon is Not Evaluated when it is has not yet been evaluated against the criteria.

Figure 1. Definitions of IUCN threat categories (from IUCN 2001 with a more specific definition for regional extinction)

Taxa listed as *Critically Endangered*, *Endangered* or *Vulnerable* are defined as Threatened (Red List) species. For each of these threat categories there is a set of five main criteria A-E, with a number of sub-criteria within A, B and C (and an additional sub-criterion in D for the *Vulnerable* category), and one of which qualifies a taxon for listing at that level of threat. The qualifying thresholds within the criteria A-E differ between threat categories and are summarised in Table 3.

Table 3. Summary of the thresholds for the IUCN Criteria

Criterion	**Main thresholds**		
	Critically Endangered	***Endangered***	***Vulnerable***
A. Rapid decline	>80% over 10 years or 3 generations in past or future	>50% over 10 years or 3 generations in past or future	>30% over 10 years or 3 generations in past or future
B. Small range + fragmented, declining or fluctuating	Extent of occurrence <100 km^2 or area of occupancy <10 km^2 + two of the following: - severely fragmented or only a single location - continuing decline - extreme fluctuations	Extent of occurrence <5,000 km^2 or area of occupancy <500 km^2 + two of the following: - severely fragmented or no more than 5 locations - continuing decline - extreme fluctuations	Extent of occurrence 20,000 km^2 or area of occupancy <2,000 km^2 + two of the following: - severely fragmented or no more than 10 locations - continuing decline - extreme fluctuations
C. Small population and declining	<250 mature individuals, population declining	<2,500 mature individuals, population declining	<10,000 mature individuals, population declining
D. Very small population	<50 mature individuals	<250 mature individuals	D1. <1,000 mature individuals
D2. Very small area of occupancy			D2. <20 km^2 or 5 or fewer locations
E. Quantifiable probability of extinction	>50% within 10 years or three generations	>20% within 20 years or five generations	>10% within 100 years

In the main, the assessment procedure relies on an objective assessment of the available evidence. In certain cases, however, subjective assessments are acceptable as, for example, in predicting future trends and judging the quality of the habitat and methods involving estimation, inference and projection are acceptable throughout. Inference and projection may be based on extrapolation of current or potential threats into the future (including their rate of change), or of factors related to population abundance or distribution (including dependence on other taxa), so long as these can be reasonably supported. Suspected or inferred patterns in the recent past, present or near future can be based on any of a series of related factors, and these factors should be specified as part of the documentation. Some threats need to be identified particularly early, and appropriate actions taken, because their effects are irreversible or nearly so (IUCN, 2001). Since the criteria have been designed for global application and for a wide range of organisms, it is hardly to be expected that each will be appropriate to every taxonomic group or taxon. Thus a taxon need not meet all the criteria A-E, but is allowed to qualify for a particular threat category on any single criterion. The criteria A, C, D1 and E are rarely appropriate for most mayflies.

The guidelines stipulate/advise that a precautionary approach should be adopted when assigning a taxon to a threat category, and this should be the arbiter in borderline cases. The threat assessment should be made on the basis of reasonable judgment, and it should be particularly noted that it is not the worse-case scenario which will determine the threat category to which the taxon will be assigned.

The categorization process is only be applied to wild populations inside their natural range (IUCN, 2001), with a long-term presence (since 1500 AD) in the GB. Taxa deemed to be ineligible for assessment at a regional level were placed in the category of '**Not Applicable (NA)**'. This category is typically used for introduced non-native species whether this results from accidental or deliberate importation. It may also be used for recent colonists (or attempted colonists) responding to the changing conditions available in Britain as a result of human activity and/or climate change.

In this Review, **Extent of occurrence** (EOO) is not applied to most species as an agreed methodology for its measurement in relation to these stonefly species is not available. There are some instances where the known EOO can be measured but these are the exception. They tend to be species known to occur on only one site where more work has been undertaken to ascertain their distribution.

Area of occupancy (AOO) is another measure that is difficult to apply to invertebrate records and populations as defined by the IUCN guidelines (IUCN, 2012a,b 2013).

"Area of occupancy is defined as the area within its 'extent of occurrence' which is occupied by a taxon, excluding cases of vagrancy. The measure reflects the fact that a taxon will not usually occur throughout the area of its extent of occurrence, which may contain unsuitable or unoccupied habitats. In some cases (e.g. irreplaceable colonial nesting sites, crucial feeding sites for migratory taxa) the area of occupancy is the smallest area essential at any stage to the survival of existing populations of a taxon. The size of the area of occupancy will be a function of the scale at which it is measured, and should be at a scale appropriate to relevant biological aspects of the taxon, the nature of threats and the available data. To avoid inconsistencies and bias in assessments caused by estimating area of occupancy at different scales, it may be necessary to standardize estimates by applying a scale-correction factor. It is difficult to give strict guidance on how standardization should be done because different types of taxa have different scale-area relationships." (IUCN, 2012a).

The IUCN have recommended a scale of 4 km^2 (a tetrad) as the reference scale (IUCN, 2013). This needs to be applied with caution and there will be instances where a different scaling is more applicable, or where attempting to apply any scale is extremely difficult. For common and widespread species applying this rule will lead to under-estimation of their true AOO and a degree of interpretation is required. This highlights the importance of peer review and shared expert opinion for making decisions on scale.

3.2 The two-stage process in relation to developing a Red List

The IUCN regional guidelines (IUCN, 2003) indicate that if a given taxon is known to migrate into or out of the region it should be assessed using a two stage approach. Populations in the region under review should firstly be assessed as if they were isolated taxa. They should then be reassessed and can be assigned a higher or a lower category if their status within the region is likely to be affected by emigration or immigration.

3.3 The use of Near Threatened, Nationally Rare and Nationally Scarce categories

The IUCN guidelines recognise a Near Threatened category to identify species that need to be kept under review to ensure that they have not become Threatened. This category is used for species where a potential threat, natural habitat dependency or range change demand frequent review of status.

This category would be best considered for those species that come close to qualifying as CR, EN or VU but not quite; i.e. meets many but not all of the criteria and sub-criteria. For those criteria that are not quite met, there should be sufficient evidence to show that the taxon is close to the relevant threatened thresholds. As such, it is up to the reviewers to provide evidence and methods for discerning this.

The Invertebrate Inter Agency Working Group and JNCC have defined the following for the use of B2bii which is commonly used in reviews. Continuing decline has to be demonstrated – and proven that it isn't an artefact of under-recording. If decline is demonstrated then the reviewer needs to consider whether or not B2a (and B2c if the data is present) is met:

- If 10 or less current localities then Critically Endangered, Endangered, Vulnerable is applicable.
- If 11 or 12 current localities then Near Threatened applies.
- If 13-15 and the taxon can be shown to be vulnerable to a specific and realistic threat, then Near Threatened applies.
- If more than 15 locations then Least Concern applies.

No Ephemeroptera were assessed as Near Threatened in this review because none met the threshold.

This review, as permitted under the IUCN guidelines, recognises a *Nationally Rare* category, defined as species recorded from 15 or fewer hectads of the Ordnance Survey national grid in Great Britain. It also recognises *Nationally Scarce* species, which are defined as species recorded in 16 to 100 hectads since 1990. This national set of definitions is referred to as the GB Rarity status within this document. Importantly, Nationally Rare and Nationaly Scarce are not categories of threat.

4. Methods and sources of information

4.1 Introduction

The most recent published list of scarce and threatened mayflies (Bratton, 1990) was based on the Red Data Book criteria used in the British Insects Red Data Book (Shirt, 1987) with the addition of the category RDB K (Insufficiently Known) after Wells, Pyle & Collins (1983). The original IUCN criteria for assigning threat status used in these publications had the categories Endangered, Vulnerable and Rare, which were defined rather loosely and without quantitative thresholds. The application of these categories was largely a matter of judgment, and it was not easy to apply them consistently within a taxonomic group or to make comparisons between groups of different organisms.

4.2 Data sources

The present review assessed the status of all species using the information sources described below and the system explained in Sections 3 and 6. During the process the views of other specialists were sought (see Acknowledgements). The Ephemeroptera Recording Scheme holds c. 210,000 records of Ephemeroptera from around the UK. The bulk of the data (c.175,000 records) are derived from the statutory environment agencies (Environment Agency, Natural Resources Wales and Scottish Environment Protection Agency). These records are supplemented with information from various Local Biological Records Centres (c. 8,900 records); Non-Governmental Organisations (c. 14,000 records); and from individuals who have contributed c. 9,500 records.

The records held by the Ephemeroptera Recording Scheme mainly cover riverine species, and common taxa predominate due to the large number of records from the Statutory Agencies. However, it is often amongst the Agency data that interesting records are found. Currently the general practice in the Agencies is for specimens of rare species, always taken as larvae, to be sent for external verification. Unfortunately this was not always done in the past and many records have no voucher specimens as support. Alice Hiley, Richard Chadd, Carole Fitzpatrick and France Attwood of the Environment Agency and Ian Milne and Ian Lorimer of the Scottish Environment Protection Agency have investigated many of these on the author's behalf, and those cited in this work are on the basis of identification by competent biologists and occurring in likely habitats; it is still very desirable to re-survey to try and confirm those records not backed by voucher specimens.

Other records are from various sources. Fly-fishers are a useful source of information on the distribution of Ephemeroptera, however the records are often unsubstantiated. The advent of digital photography has recently allowed more records from this source to be included in the recording scheme database. A start has been made in collating literature records from the main national entomological journals:- Entomologist, Entomologist's Monthly Magazine, Entomologist's Record and Journal of Variation, Entomologist's Gazette and the publications of the Society of British Entomology and its predecessors. The Ephemeroptera Recording Scheme data base is dynamic and the full details of some records cited in this report have still to be obtained for the scheme.

5. The assessments

5.1 The data table

The key outcome of this Review is the generation of a table which lists all of the taxa covered. The full table has been produced as a spreadsheet which accompanies this text. Appendix 1 provides an extract of the key data. The columns completed in the accompanying Excel table are as follows:

Species name

BRC number (identification code)

NBN taxon number (identification code)

Presence in:

- England
- Scotland
- Wales

Area of occupancy

Total number of hectads occupied for period up to and including 1989

Total number of hectads occupied from period from 1990-2014

Total number of dual hectads where species have been recorded from within the hectad in both date classes (see 5.2 below).

Proposed GB IUCN status

Qualifying criteria

Rationale

Current global IUCN status

Suggested GB Rarity status

Status in Shirt (1987)

Status in Bratton (1990)

Larval habitat key habitat / microhabitat

Adult habitat key habitat / microhabitat

Ecological account

Popular synonyms

5.2 Date classes

This Review uses 1990 as the **point of measurement** between old and recent date classes to assess decline as this was judged to be the date most applicable to the data concerned. It was judged that the adoption of a later date would have resulted in far too many species being found to have fewer than 100 hectads in the modern time period. This would obviously have seriously undermined the value of the assessments made. The use of this date has the consequence that Criterion B2b – continuing decline – has to rely heavily on estimation, inference and projection. The reviewer has needed therefore to assess whether reductions in the Area of Occupancy represent significant decline or lack of data. This will vary considerably between taxonomic groups and for different species within taxonomic groups depending on survey effort. Use of B2b for any taxon therefore demands justification by an explanation of confidence in the rate of decline.

Habitat decline values can be used as a proxy for population declines for species that are strongly associated with specific habitat types. However, it should be acknowledged that quantitative data on a species' habitats are also rarely available, and that the reviewer needs to work with very imperfect data.

Extinct is a difficult concept to apply to most invertebrates and an arbitrary cut-off has to be applied. Species not recorded in Britain since 1900 are typically assumed to now be extinct and have been recorded as Regionally Extinct (RE). In the case of species that, if they were present, should have been picked up by routine monitoring, this cut-off has been applied if a species has not been recorded since 1950. Species not recorded since 1950 but known to be especially difficult to find on demand have been tagged as Possibly (Regionally) Extinct (IUCN 2011). This was developed to identify those Critically Endangered species that are likely to be Extinct, but for which confirmation is still required.

6. Format of the species accounts

6.1 Information on the species accounts

Species accounts have been prepared for each of the threatened and near threatened species. Previous reviews have also included species accounts for Nationally Rare and Nationally Scarce taxa.

Information on each species is given in a standard form. The data sheets are designed to be largely self-contained in order to enable site managers to compile species-related information on site files; this accounts for some repetition between the species accounts. This section provides context for seven items of information on each of the data sheets.

6.2 The species name

Nomenclature is intended to be as up to date as possible and is based on Macadam (2012). Where the name differs from that used by Bratton (1990) the previous name is indicated, with citation of any relevant references. Information is also provided on any older names which have been used in the main identification literature.

6.3 Identification

The identification of the British Ephemeroptera species is relatively straightforward; however, a microscope is required to identify some to species level. With a little experience it is possible to identify the adults of about 18 species with relative certainty in the field by taking into account the appearance, the habitat and the time of year. Identification of larvae in the field is more challenging, nevertheless with experience nine species can be identified as larvae in the field. Family-level identification, of both larvae and adults, is easier and can be mastered with little effort.

The Freshwater Biological Association publishes good, relatively cheap identification keys to adults (Elliott and Humpesch, 1983) and larvae (Elliott and Humpesch, 2010), which also includes information on their ecology. It should be noted that the key to adults is now over 30 years old and no longer covers all species present in the UK. The Field Studies Council publish a combined pictorial key to both adults and larvae which includes all species (Macadam and Bennett, 2010). Where other works are available with additional keys for species they are listed in the species datasheets.

6.4 Distribution

Records held in the database of the Ephemeroptera Recording Scheme form the basis for determining the distribution of each species. In most cases these data can be accessed through the NBN Gateway (https://data.nbn.org.uk/) and therefore individual records have generally not been listed in this review. The exceptions are those species known from only a relatively small number of sites and where site information is considered essential to understanding habitat, ecology, status, threats and conservation.

International distribution is only referred to where a comment on the species' biogeography is considered useful.

6.5 Habitat and ecology

The concentration of study on larvae over the past forty years means that our knowledge of the larval habit requirements of most species is known. Whilst larval habitat is presumably the most important

determinant of a site's suitability, it is worth at least remembering that adult requirements for factors such as shelter, courtship and oviposition, whilst poorly known, will be important, and are worth studying when species conservation is being researched. This section aims to provide an overview of the habitat requirements of each species and the wider landscape context. Information on the life cycle and seasonal patterns is also included.

The majority of British species are univoltine, however some populations of *Ephemera* spp. can take two years to reach maturity. A number of species, particularly *Baetis* spp., can complete more than one generation per year.

Mayflies are unique as insects in that they have two winged adult forms. The nymph emerges from the water as a dull-coloured sub-imago (or dun) that seeks shelter in bankside vegetation and trees. After a period of a couple of hours or more, the sub-imago once again sheds its skin to transform into the brightly coloured imago (or spinner). It is not clear why mayflies have retained this unique step in their lifecycle, however it is thought that they may not be able to achieve the change from larva to sexually mature adult in one step.

The life cycle starts with the males forming a swarm above the water and the females flying into the swarm to mate. The male grabs a passing female with its elongated front legs and the pair mate in flight. After copulation, the male releases the female, which then descends to the surface of the water where she lays her eggs. Once mated she will fall, spent, onto the water surface to lie motionless, with her wings flat on the surface, where fish pick them off at their leisure. The male fly rarely returns to the water but instead he goes off to die on the nearby land.

The eggs fall to the bottom of the water where they stick to plants and stones. Females of *Baetis* spp. pull themselves under the water to attach their eggs directly to the bed before being drowned by the current. The eggs take anything between a few days to a number of weeks to hatch depending on water conditions and the species, and the resultant nymphs will spend various lengths of time, up to two years, foraging on the bottom before emerging as an adult fly.

When it is time to emerge, the larvae make their way to the surface where they pull themselves free of their larval shuck and emerge as a sub-imago. While they rest here to dry their newly exposed wings, they are at their most vulnerable to attack from fish. Some species exhibit great synchronicity in their hatching. One such species is *Rhithrogena germanica* which emerges in large numbers over short periods in early Spring.

6.6 Status

Status is largely based on range size and both short and long term trends, but association of a species with particular habitats under threat is also taken into account. Counts of hectads known to be occupied since 1990 were used to establish whether or not a species might be considered scarce. The IUCN guidelines (see Section 3 and Appendix 2) were then used to decide whether such species might also be considered under threat, and to assign a category. Detailed survey data are extremely rare but have been used where available. The linear nature of river habitats however means the IUCN 'location' concept is relatively easy to use. This concept defines an ecologically distinct area, such as a river, where a single threatening event can rapidly affect all individuals in the populations t as a single location or site when applying the IUCN criteria.

Only species which have been assessed as Critically Endangered, Endangered, Vulnerable or Near Threatened are provided with species accounts. The status of other species is summarised in Appendix 1.

Assessment of status can only be based on available records. Mayflies are frequently recorded by the Environment Agency, Natural Resources Wales and Scottish Environment Protection Agency as part of their routine regulatory monitoring activity. This monitoring is typically limited to a small number of sites on larger watercourses, resulting in species from habitats such as springs and seepages, marshes, ditches and upland streams being under-recorded. Therefore it has been necessary to make assumptions from the available records in order to arrive at the best estimate of the likely national distribution of each species.

The criteria are not rigid about the need for real data, but allow for expert opinion on some evidence – 'estimated, inferred, projected or suspected' are acceptable reasons – and so some species currently known from fewer than one hundred hectads have been excluded from Nationally Scarce status on this basis. It is appreciated that some species of Ephemeroptera are not yet recorded from more than one hundred hectads but are expected to be found to occur in more than one hundred when their distribution is better known. *Siphlonurus lacustris* is an example of a species known from 76 hectads since 1990 but which is widespread in Highland Scotland where recording effort is at its lowest. Where studies have been undertaken there are no indications of any decline in those areas, and under-recording is therefore presumed to be the cause for the low number of hectads. It appears reasonable to estimate its actual distribution is in excess of 100 hectads.

In conclusion, assessments of status can only be based on current knowledge, which is very unlikely to be comprehensive in the majority of cases, being based on the experience of a limited number of active recorders in each generation. The likely national distribution of each species and trends in population size must, therefore, be extrapolated from the available information so as to arrive at the best estimate of the likely national status of each species.

6.7 Threats

Loss of suitable habitat is undoubtedly the most immediate threat to mayfly populations. Most mayfly species rely on clean, aquatic habitats to complete their lifecycle. Insufficient areas of suitable water will result in unsuccessful larval development and declines in the population of mayfly species. Drainage and flood protection schemes that involve the straightening and widening of watercourses often result in shallower water that becomes warmer more quickly, proving dangerous to many mayfly species.

Abstraction from watercourses or the drawdown of reservoirs can have several potentially damaging effects for mayfly populations. In general, larvae are capable of reacting to a slowly receding water level by migrating to deeper water, mayfly eggs can, however, be stranded by excessive abstraction and this will affect the chances of them completing their development successfully.

The banks of a waterbody that is subject to excessive abstraction may dry out if this period of abstraction coincides with warm weather. The resultant dry soil becomes more susceptible to erosion either by wave action or by bankside damage. Receding water levels will also expose emergent and submerged vegetation and they will quickly wither and die. Many mayfly species develop in the small spaces between gravel and stones. Repeated water level fluctuations can lead to compaction of the bed and the loss of these important niches.

The importance of marginal and bankside vegetation should not be overlooked. Removal of the marginal vegetation in which adult mayflies shelter is likely to lessen the chances of successful breeding. In addition, species such as *Baetis niger* and *B. digitatus* are known to live amongst submerged vegetation. Any work that is likely to damage this vegetation should be carried out only on one bank, and preferably on only short stretches of, say 50 metres in each 200 metres in any year.

Waterway maintenance and engineering including dredging, bank protection and weed control can lead to bed disturbance, which temporarily increases the level of silt in the water. This silt can affect the respiration of mayfly larvae or, where it settles, bury them. Every effort should be made to prevent the release of silt into a watercourse.

Despite significant improvements in the past 20 years, pollution continues to impact on water quality. Sources of pollution include domestic and industrial sewage effluents, and run-off from agriculture and urban areas, with pesticides from farming posing the most acute risk to freshwater ecosystems. The impact of neonicotinoid pesticides is particularly worrying. Mayflies, caddisflies and true-flies are particularly sensitive to these pesticides and even at low concentrations there is considerable risk of widespread impact on freshwater invertebrate populations.

Acidification of freshwaters is mainly caused by the deposition of acidic sulphur and nitrogen compounds from the atmosphere in rainfall (‘acid rain’) or as dry deposition, derived from the burning of fossil fuels (mainly by power stations and vehicles). In fresh waters, acidification results in the loss of plant and animal species sensitive to, or intolerant of, the change in pH. Mayfly species are generally intolerant of lower pH values. The use of buffer strips alongside coniferous plantations and agricultural land can reduce the impacts of acidification on their populations.

Nutrient enrichment caused by sewage discharges, agricultural fertilisers, fish farms or even livestock defecating in the water can result in extensive mats of filamentous algae occurring. Healthy streams typically have little obvious signs of filamentous algae because aquatic invertebrates graze any growth. Extensive growths of algae are usually a symptom of elevated nutrient concentrations in a watercourse. As the algae begin to dominate the bed of the watercourse it may seriously deplete dissolved oxygen levels during the night, causing the loss of sensitive mayfly species.

Bankside grazing by livestock damages the vital turf layer of the adjacent land and can lead to erosion. This erosion causes silt to find its way into the water where it can smother the gravel on the bed. Where once invertebrates such as mayflies, stoneflies and caddis, which, in general, prefer gravel bottoms, were common-place, they would be replaced with water hog-louse (*Asellus* spp.), worms and midges. Individual patches of erosion should be stabilised using ‘soft’ methods like willow spilling, rather than ‘hard’ methods like rocks.

Buffer strips can be used to reduce the effects of agricultural run-off and acidification. As well as creating important refuges for adult mayflies, buffer strips can also help stabilise the bank and restrict livestock access, which will lead to less erosion. To be effective, buffer strips should be a minimum of 2 metres wide or more on steeper ground. Gaps should be avoided in buffer strips as this reduces their efficiency.

Light pollution is a growing threat to aquatic insect populations (Bruce-White and Shardlow, 2011). The steady increase in the intensity and distribution of lights in the countryside may have a potentially devastating effect on their populations. In some areas the intensity of artificial light means that day and night is merging into one and the cues for adult emergence may, as a result, disappear. In addition, the adults of some mayfly species are attracted to light. The inappropriate siting of bankside

lights may lure sufficient numbers of adult stoneflies away from the water to cause a permanent decline in their population.

It has also been shown that asphalt roads can act as an ecological trap for mayflies which are attracted to the horizontally polarised light reflected from their surface (Kriska et al., 1998). Solar panels are known to cause the same phenomenon (Horváth & Kriska, 2008) and the proliferation of this renewable energy source, particularly extensive solar farms, in recent years is a serious cause for concern. The siting of solar farms next to the River Thames or River Wye could attract sufficient numbers of mayflies away from the river and hence have a negative effect on their breeding success. Fortunately, there are relatively simple mitigation measures that can be undertaken to reduce the attractiveness of these panels (Horváth et al., 2010).

6.8 Published sources

Literature references that refer to the previous conservation status of the species in Britain, or that have contributed information to the Data Sheet, are cited here.

7. Acknowledgements

Much of this review is based on records supplied to the Ephemeroptera Recording Scheme. It is not possible to list every individual that has contributed to the recording scheme over the last decade. Special thanks must be made to Alice Hiley, Richard Chadd, Carole Fitzpatrick, Frances Attwood and Alex Pickwell (EA); Ian Milne and Ian Lorimer (SEPA); and Michelle Price (NRW) in assisting with the supply and verification of records. During the preparation of this review the author sought the views of a range of specialists. In particular thanks are due to Stuart Crofts, Louis Kitchen and Nick Everall for information on some of the species and Ant Maddock (JNCC), Jon Webb (Natural England), Ian Wallace (Liverpool Museum), and Margaret Palmer and Steven Falk (Buglife) for their help with the preparation of this review.

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8. Species listed by IUCN status category

In this list the species are given in taxonomic order within status categories.

Regionally Extinct

Arthropleidae	*Arthroplea congener* Bengtsson
Heptageniidae	*Heptagenia longicauda* Stephens

Endangered

Potamanthidae	*Potamanthus luteus* (Linnaeus)
Siphlonuridae	*Siphlonurus alternatus* (Say)
Siphlonuridae	*Siphlonurus armatus* (Eaton)

Vulnerable

Baetidae	*Baetis digitatus* Bengtsson
Ephemeridae	*Ephemera lineata* Eaton

Data Deficient

Baetidae	*Baetis fuscatus* (Linnaeus)
Caenidae	*Caenis beskidensis* Sowa
	Caenis macrura Stephens
	Caenis pseudorivulorum Keffermüller
	Caenis pusilla Navàs
Heptageniidae	*Electrogena affinis* (Eaton)

9. Species listed by GB Rarity Status category

In this list the species are given in taxonomic order within status categories.

Nationally Rare

Baetidae	*Baetis digitatus* Bengtsson
Caenidae	*Caenis beskidensis* Sowa
	Caenis pseudorivulorum Keffermüller
	Caenis pusilla Navàs
Heptageniidae	*Electrogena affinis* (Eaton)
Siphlonuridae	*Siphlonurus alternatus* (Say)
Siphlonuridae	*Siphlonurus armatus* (Eaton)

Nationally Scarce

Ameletidae	*Ameletus inopinatus* Eaton
Baetidae	*Baetis atrebatinus* Eaton
Caenidae	*Brachycercus harrisellus* Curtis
Ephemeridae	*Ephemera lineata* Eaton
Ephemerellidae	*Ephemerella notata* Eaton
Heptageniidae	*Kageronia fuscogrisea* (Retzius)
	Rhithrogena germanica Eaton
Leptophlebiidae	*Paraleptophlebia cincta* (Retzius)
	Paraleptophlebia werneri Ulmer
Potamanthidae	*Potamanthus luteus* (Linnaeus)

10. Criteria used for assigning species to threatened categories

(see Appendix 2 for criteria and categories)

Scientific name	**Status**	**Criteria used**
Baetidae		
Baetis digitatus Bengtsson	Vulnerable	B2a, bii, iv
Ephemeridae		
Ephemera lineata Eaton	Vulnerable	D2
Potamanthidae		
Potamanthus luteus (Linnaeus)	Endangered	B2a, bii, iv
Siphlonuridae		
Siphlonurus alternatus (Say)	Endangered	B2a, bii, iv
Siphlonurus armatus (Eaton)	Endangered	B2a, bii, iv

11. Taxonomic list of Threatened and Nationally Scarce Species

Nationally Rare	**Bratton (1990)**	**This review (GB Rarity status)**	**This review (IUCN status)**
Ameletidae			
Ameletus inopinatus Eaton		NS	
Arthropleidae			
Arthroplea congener Bengtsson			RE
Baetidae			
Baetis atrebatinus Eaton		NS	
Baetis digitatus Bengtsson		NR	VU
Baetis fuscatus (Linnaeus)			DD
Caenidae			
Brachycercus harrisellus Curtis		NS	
Caenis beskidensis Sowa		NR	DD
Caenis macrura Stephens			DD
Caenis pseudorivulorum Keffermüller		NR	DD
Caenis pusilla Navàs		NR	DD
Ephemerellidae			
Ephemerella notata Eaton		NS	
Ephemeridae			
Ephemera lineata Eaton	RDB2	NS	VU
Heptageniidae			
Electrogena affinis (Eaton)		NR	DD
Heptagenia longicauda Stephens	RDB1		RE
Kageronia fuscogrisea (Retzius)	NN[1]	NS	
Rhithrogena germanica Eaton		NS	
Leptophlebiidae			
Paraleptophlebia cincta (Retzius)		NS	
Paraleptophlebia werneri Ulmer	RDB3	NS	
Potamanthidae			
Potamanthus luteus (Linnaeus)	RDB2	NS	EN
Siphlonuridae			
Siphlonurus alternatus (Say)		NR	EN
Siphlonurus armatus (Eaton)		NR	EN

[1] NN = Nationally notable was used in the previous review (Bratton, 1990) to denote species that did not fall within the Red Data Book categories but were known from fewer than a hundred hectads

12. Downgraded species

There are nine species that occur in 100 hectads or less, but which the author believes should not be listed as Nationally Scarce. The rationale for these exclusions is given as follows:

Table 4. Rationale for not listing species occurring in 100 hectads or fewer

Scientific name	Number of post-1990 hectads	Rationale for exclusion
Baetis buceratus	84	This is a widespread species which is found in streams and rivers across England and Wales. There is no reason to believe that this species is not present in more than 100 hectads.
Baetis fuscatus	27	Due to problems with the separation of larvae of this species and *Baetis scambus* it is difficult to compile a complete distribution for this species. Whilst *B. fuscatus* is thought to be less common than *B. scambus* there are records from across the UK. It is therefore likely that this species occurs in more than 100 hectads.
Baetis niger	93	This is a widespread species which is found in streams and rivers throughout the UK. Whilst this species has suffered declines in recent years, there are many areas that have not been searched for this species. It is therefore likely that this species occurs in more than 100 hectads.
Caenis macrura	13	Due to problems with the separation of larvae of this species and *Caenis luctuosa* it is difficult to compile a complete distribution for this species. Whilst *C. macrura* is thought to be less common than *C. luctuosa* there are records from many parts of the the UK. It is therefore likely that this species occurs in more than 100 hectads.
Ecdyonurus dispar	80	Identification of the larvae of this species is difficult, however it is considered to be widespread and likely to occur in more than 100 hectads.
Ecdyonurus torrentis	34	Identification of the larvae of this species is difficult, however it is considered to be widespread and likely to occur in more than 100 hectads.

Leptophlebia marginata	98	This is a widespread species which is found in ponds, tarns and streams, typically in upland areas. Very little routine surveying is undertaken in these habitats in upland areas and it is therefore likely that this species is significantly under-recorded.
Leptophlebia vespertina	94	This is a widespread species which is found in ponds, tarns and streams, typically in upland areas. Very little routine surveying is undertaken in these habitats in upland areas and it is therefore likely that this species is significantly under-recorded.
Siphlonurus lacustris	76	This is a widespread species which is found in streams and rivers, typically in upland areas. Very little routine surveying is undertaken in these habitats in upland areas and it is therefore likely that this species is significantly under-recorded.

13. The data sheets

Data sheets for the species assessed as Critically Endangered, Endangered, Vulnerable or Near Threatened are given in this section. The data sheets are arranged in alphabetical order by scientific name. Where the species appeared in Bratton (1990) the information contained on the datasheet has been used, with new information inserted as appropriate.

BAETIS DIGITATUS

VULNERABLE B2a, bii, iv

Order EPHEMEROPTERA

Family BAETIDAE

Baetis digitatus Bengtsson, 1912

Nigrobaetis digitatus (Bengtsson, 1912)

Identification: This species belongs to the family Baetidae, of which there are 14 species found in Britain. Keys to the adults and nymphs are available from the Freshwater Biological Association (Elliott & Humpesch, 1983; Elliott & Humpesch, 2010) and from the Field Studies Council (Macadam & Bennett, 2010).

Nymphs of *Baetis digitatus* can be separated from the other narrow-bodied *Baetis* species by the dark band on their tails, and the presence of only six pairs of gills, features which they share with *B. niger*. Separation of *B. digitatus* and *B. niger* is by the shape of the last gill, the length of the black band on the tails and morphological differences in the mouthparts. Adults have two tails and small oval hindwings in common with other *Baetis* species. Separation of the adults is difficult and unreliable.

Distribution: The Ephemeroptera Recording Scheme has records from 21 hectads in Britain. There are recent records from Monmouthshire, Dorset and Hampshire. The first record of this species in the UK was made in the East Stoke millstream, which is fed by the River Frome (Crisp and Gledhill, 1970; Kimmins, 1972). It is also known from the River Teifi, Ceredigion (Jenkins, Wade and Pugh, 1984); the River Exe, Devon; River Test, Hampshire, River Wye, Herefordshire, River Lugg, Powys and a single watercourse in Perthshire, Scotland (Gunn and Wright, 1994).

Habitat and Ecology: Nymphs of this species typically crawl amongst macrophytes in riffle areas of rivers and streams. They will also swim in short, darting bursts swims amongst the substrate. They feed by scraping algae and biofilms from submerged stones and other structures, or by gathering or collecting fine particulate organic detritus from the sediment. There is one generation of this species per year which overwinters as half-grown nymphs. There is little or no growth over the winter months with the remainder of their growth taking part in the spring (Söderström, 1991). The flight period extends from May to October, with recent work showing that there may be two distinct peaks in the flight period – one in the spring and another in the autumn (Craig Macadam, unpublished). This may suggest that there are two separate cohorts - a slow growing winter cohort and a much faster growing summer cohort.

The larvae of this species can be collected by kick-sampling along suitable stretches of river. This is a standard technique employed by biologists to sample aquatic invertebrates and entails disturbing a section of the riverbed. Invertebrates are dislodged and collected in a water net held just downstream. Adults can be collected by examining bankside trees and other vegetation. Alternatively, they can be caught as they swarm near the water.

Status: *B. digitatus* has been recorded from 8 hectads from 1990 onwards. The IUCN criteria for Vulnerable is satisfied based upon an inferred reduction in population size of 43% and a restricted, and continuing decline in Area of Occupancy.

Threats: Water pollution is the most obvious threat to this species. In common with other Ephemeroptera, this species relies upon good water quality. Pollution events, whether persistent or catastrophic, could lead to the local extinction of this species. High levels of suspended silt are likely to be particularly damaging to this species, and other mayflies.

Any operations that affect the bed such as dredging, channel modifications or gravel removal could damage the habitat and should be avoided. Gross alterations to the aquatic vegetation structure, particularly weed cutting, may be detrimental to this species. Similarly, changes to the riparian habitat, whether through flood defence work or removal of bankside trees or inappropriate management of bankside vegetation may result in a loss of habitat for the adult insect. Maintenance work on riparian and marginal vegetation (e.g. strimming or pruning) should be carried out only on one bank, and preferably on only short stretches in any one year. It is important to maintain a varied structure and mixture of plant species in the marginal vegetation to increase the variety of places available for invertebrates to shelter and breed in.

It is also thought that this species could be affected by low flows. Abstraction; whether for irrigation, water supply or other purposes should be carefully considered where this species is present.

In 2012/13 a pair of Eurasian beavers established a lodge on the Lunan Burn - the sole Scottish location for *Baetis digitatus.* Since then Beavers have established a number of dams and significantly altered the hydrology of the watercourse. It is not clear what effect the presence of Beavers may be having on the *B. digitatus* population in this watercourse however the shift from riffle areas to more pools is likely to have a detrimental effect on the population here. A resurvey of this watercourse for *Baetis digitatus* is recommended to determine the full impact of the changes.

Published sources: Bratton (1990); Crisp and Gledhill (1970); Gunn and Wright (1994); Kimmins (1972); Jenkins, Wade and Pugh (1984)

EPHEMERA LINEATA

VULNERABLE D2

Order EPHEMEROPTERA

Family EPHEMERIDAE

Ephemera lineata Eaton, 1870

Identification: This species belongs to the family Ephemeridae, of which there are 3 species found in Britain. Keys to the adults and nymphs are available from the Freshwater Biological Association (Elliott & Humpesch, 1983; Elliott & Humpesch, 2010) and from the Field Studies Council (Macadam & Bennett, 2010).

Larvae and adults of *Ephemera lineata* can be separated from other *Ephemera* species by the markings on the upper surface of their abdomen. Adults have three tails and obvious hindwings.

Distribution: The Ephemeroptera Recording Scheme has records from 22 hectads in Britain. Historically, this species is known from the River Thames (Macan, 1953; Blair, 1927) and the Welsh River Wye (Harrisson, 1958). There are also records from the Kennet (Eaton, 1871) and Holy Brook (Eaton, 1883-88). The majority of modern records are from the River Thames. A single modern record from the River Wye indicates that this species still occurs there, albeit in low densities. Records from the River Welland, Rutland; River Ouse, East Sussex; and River Bourne, Kent are unverified, and the absence of a voucher specimens means that these records remain unsubstantiated.

Habitat and Ecology: Larvae of this species live in pools and margins of large rivers where they dig in to the substrate to form a tubular burrow. They use their gills and flex their abdomen to force the water through this burrow and the larvae feed by filtering or collecting fine particulate organic detritus from the water column. *Ephemera lineata* has a two-year life cycle, although some populations may have an annual life cycle. Adults are usually seen in July. Emergence of the adults probably takes place at dusk or dawn on the surface of the water or occasionally on a stick, stone or plant stem partially or entirely out of the water.

Status: *E. lineata* has been recorded from 17 hectads from 1990 onwards. These records are from two rivers: the River Thames (16 hectads) and the River Wye (1 hectad). In the River Thames the records cover a 166 kilometre stretch of the river from Newbridge, Oxfordshire to Ham in south east London. The river width was measured from aerial photography at the downstream location, giving a width of 75 metres, which when applied over the full 166 km stretch gives an Area of Occupancy in the River Thames of 12.45km^2. The only modern record from the River Wye is from Hay-on-Wye. The IUCN criteria for Vulnerable is satisfied based upon the Area of Occupancy being less than 20km^2. The AoO appears to be stable with no decline.

Threats: Water pollution is the most obvious threat to this species. Water quality in the River Thames is generally good however localised or acute pollution incidents such as those caused by pesticide spillage may be detrimental to the survival of this species.

Any operations that affect the bed material such as dredging, channel modifications or gravel removal could damage the habitat and should be avoided. Similarly, changes to the riparian habitat, whether through flood defence work or removal of bankside trees may result in a loss of habitat for the adult mayfly. Maintenance work on riparian and marginal vegetation (e.g. strimming or pruning) should be carried out only on one bank, and preferably on only short stretches in any one year. It is important to maintain a varied structure and mixture of plant species in the marginal vegetation to increase the variety of places available for invertebrates to shelter and breed in.

As the adults of this species are potentially attracted to light, the positioning of bankside lights, such as road lights, may also have a deleterious effect on populations.

This species is also likely to be attracted to surfaces that reflect horizontally polarized light. It has been shown that asphalt roads can act as an ecological trap for mayflies which are attracted to the horizontally polarised light reflected from their surface (Kriska et al., 1998). Solar panels are known to cause the same phenomenon (Horváth & Kriska, 2008) and the proliferation of this renewable energy source, particularly extensive solar farms, in recent years is a serious cause for concern. The siting of solar farms next to the River Thames or River Wye could attract sufficient numbers of mayflies away from the river and hence have a negative effect on their breeding success. Fortunately, there are relatively simple mitigation measures that can be undertaken to reduce the attractiveness of these panels (Horváth et al., 2010).

Published sources: Bratton (1990); Macan (1953); Blair (1927); Harrisson (1958); Eaton (1870; 1883-88)

POTAMANTHUS LUTEUS

ENDANGERED B2a, bii, iv

Order EPHEMEROPTERA

Family POTAMANTHIDAE

Identification: This species is the sole UK member of the family Potamanthidae. Keys to the adults and nymphs are available from the Freshwater Biological Association (Elliott & Humpesch, 1983; Elliott & Humpesch, 2010) and from the Field Studies Council (Macadam & Bennett, 2010).

Potamanthus luteus has very distinctive yellowish larvae, with branched feathery gills. The only other species with similar feathery gills are the *Ephemera*, however in *Ephemera* species the gills are held over the back of the body while in *Potamanthus* they extend outwards from the body. In addition, in *Ephemera* species the mandibles are large and project past the front of the head.

Adults of *Potamanthus luteus* are also distinctive. The sub-imago is bright yellow, a characteristic which is shared with only two other species: *Heptagenia sulphurea* and *H. longicauda*. *P. luteus* can be separated from the *Heptagenia* species by the number of tails present. In *Heptagenia* there are only two tails while in *P. luteus* there are three.

Distribution: The Ephemeroptera Recording Scheme has records from 35 hectads in Britain. *Potamanthus luteus* has always been a rare mayfly in Britain, with few river systems holding populations of this species. In the nineteenth century there were only two records of this species: in 1835 in the “metropolitan district” (Stephens, 1835) and from the Thames in 1878 (McLachlan, 1878). During the twentieth century, *P. luteus* has been recorded from the River Wye (Macan, 1970; Brooker and Morris, 1980) and River Usk (Macan, 1970; Brooker and Morris, 1980); Hammett (2009), with an erroneous record from the River Itchin (Lucas, 1906) and unconfirmed records from the Chichester Canal (Brooker and Morris, 1980) and New Reservoir at Colne in Lancashire (Bainbridge, 1933). A record from Aylesbeare and Harpford Common in 1978 is also unconfirmed. No suitable habitat was found during a visit to the site in 2005 and it is likely that this record is incorrect (Macadam, 2011). Two records from a pond at Fford-fawr are intriguing. The pond in question is situated in a meander of the River Wye downstream of Glasbury. These records relate to larval specimens collected during the National Pond Survey in the early 1990s. No specimens were found during a visit to the pond in spring 2010, and it is unlikely that the pond could now support *P.*

luteus. During the same visit specimens were found in the nearby River Wye and it is likely that larvae found in the pond were part of an adventive population resulting from opportunistic egg-laying or an earlier flood event. Records of adults from sites where larvae have not been found have not been included in this review.

Recent specimens taken during routine Environment Agency monitoring of the River Teme at Knightsford Bridge were the first verified records of *P. luteus* from the River Severn catchment. The site was visited in 2010 and despite unfavourable river conditions, two larvae of *P. luteus* were found. The continued presence of *P. luteus* at this site would suggest that a small population of this species may be persisting at this site. Further records have subsequently been made at other locations in the Severn catchment from around Kidderminster. These records from the River Severn represent an important expansion to the range of this species, nevertheless it remains restricted to only two river systems in the UK.

Habitat and Ecology: Nymphs of this species typically live in silt trapped amongst stones on the bed of the river and can be found in side channels and pools following flood events. They are good swimmers and they feed by gathering fine particles from the bed. There is one generation a year which overwinters as larvae in the UK, however in north western Italy it overwinters in the egg stage or possibly as very small larvae (Fenoglio, et al., 2008).

Larvae in the River Wye are found under loose stones, preferring mobile sections of shingle or a mixture of larger stones with loose shingle such as those found downstream of bridges or at the confluence of tributaries (Hammett, 2009).

The adults are short-lived, with peak emergence typically in July. The flight period however extends from late May to late October in some years. Emergence typically takes place at dusk and the adults usually emerge from the surface of the water, however the nymphs may also climb up stones or plant stems to emerge partially or entirely out of the water (Hammett, 2009). Adults are positively phototactic and are readily attracted to bankside lights (Bratton, 1990). Verrier (1948) suggests that adults can migrate as far as 3 kilometres upstream following emergence, while Hammett (2009) suggests that this migration might be as far as 12km and that they can fly overland to adjacent river valleys.

Surveys on the River Wye have shown that the population density can fluctuate markedly with some locations suffering significant declines before recovering in subsequent years (Hammett, 2009).

The larvae of this species can be collected by kick-sampling along suitable stretches of river. This is a standard technique employed by biologists to sample aquatic invertebrates and entails disturbing a section of the riverbed. Invertebrates are dislodged and collected in a water net held just downstream. Adults fly at dusk and are positively phototactic; they can therefore be attracted to light. Moth traps operated on the banks of a river during June and July are likely to produce specimens if the species is present. Adults can also be swept from bankside vegetation or beaten from nearby trees. Alternatively, they can be caught as they swarm near the water.

The Countryside Commission for Wales (now Natural Resources Wales) published a Common Standards Monitoring methodology for monitoring the River Wye population of *P. luteus* (Hammett, 2009).

Status: *P. luteus* has been recorded from 29 hectads from 1990 onwards. These records are from two rivers: the River Wye and the River Severn. In 1995 this species was present in 152 kilometres of the River Wye from Llanstephan upstream of Hay-on-Wye to Whitebrook downstream of Monmouth. During the following decade the species was lost from 27 kilometres of the upper River Wye and is now only found reliably downstream of Whitney. The river width was measured from aerial photography at the downstream location, giving a width of 60 metres, which when applied to the stretches where this species occurs/occurred gives a previous Area of Occupancy of 9.12km^2 and a current AoO of 7.5km^2 representing a decline in AoO of 1.52 km^2 over the past 20 years. Countering this slightly are the new records from the River Severn catchment. These records are from a single site on the River Teme and a 7 kilometre stretch of the River Severn near Kidderminster. The IUCN criteria for Endangered is satisfied based upon a restricted Area of Occupancy, three locations and a continuing decline.

Threats: Recent localised declines on the River Wye are likely to have been caused by dredging operations and sheep dip pollution (Hammett, 2009). In common with other Ephemeroptera, this species relies upon good water quality. Pollution events, whether persistent or catastrophic, could lead to the local extinction of this species. High levels of suspended silt are likely to be particularly damaging to this species, and other mayflies.

Any operations that affect the bed material such as dredging, channel modifications or gravel removal could damage the habitat and should be avoided. Similarly, changes to the structure and management of marginal and riparian vegetation such as the removal of bankside trees may result in a loss of habitat for the adult mayfly. Maintenance work on riparian and marginal vegetation (e.g. strimming or pruning) should be carried out only on one bank, and preferably on only short stretches in any one year. It is important to maintain a varied structure and mixture of plant species in the marginal vegetation to increase the variety of places available for invertebrates to shelter and breed in.

Adults of this species are attracted to light, and therefore the positioning of bankside lights, such as road lights, may also have a deleterious effect on populations.

This species is also likely to be attracted to surfaces that reflect horizontally polarized light. It has been shown that asphalt roads can act as an ecological trap for mayflies which are attracted to the horizontally polarised light reflected from their surface (Kriska et al., 1998). Solar panels are known to cause the same phenomenon (Horváth & Kriska, 2008) and the proliferation of this renewable energy source, particularly extensive solar farms, in recent years is a serious cause for concern. The siting of solar farms next to the River Wye or River Severn could attract sufficient numbers of mayflies away from the river and hence have a negative effect on their breeding success. Fortunately, there are relatively simple mitigation measures that can be undertaken to reduce the attractiveness of these panels (Horváth et al., 2010).

It is also thought that this species could be affected by low flows. Abstraction; whether for irrigation, water supply or other purposes should be carefully considered where this species is present.

Published sources: Bratton (1990); Brooker and Morris (1980); Hammett (2009); Stephens (1835); Macadam (2011); Macan (1970); McLachlan (1878)

SIPHLONURUS ALTERNATUS

ENDANGERED B2a, bii, iv

Order EPHEMEROPTERA

Family SIPHLONURIDAE

Siphlonurus alternatus (Say, 1824)

Siphlonurus linnaeanus (Eaton, 1871)

Siphlonurella linnaeana (Eaton, 1871)

Identification: This species belongs to the family Siphlonuridae, of which there are 3 species found in Britain. Keys to the adults and nymphs are available from the Freshwater Biological Association (Elliott & Humpesch, 1983; Elliott & Humpesch, 2010) and from the Field Studies Council (Macadam & Bennett, 2010). Macan (1951) provides additional information. In older literature this species is referred to as *S. linneanus*.

Immature nymphs of *Siphlonurus alternatus* are superficially similar to *Cloeon* species however the abdominal segments are drawn out to form large spines. *S. alternatus* can be separated from other *Siphlonurus* species by the number of pairs of double gills present. Adults have two tails and obvious hindwings. Identification of adults of *S. alternatus* is based on the coloration of the femur and/or examination of the male genitalia.

Distribution: There are records of this species from 6 hectads in Britain. *S. alternatus* was first recorded in Britain from the River Tummel, Perthshire in 1913 (Mosely 1931). There are also two historic records from Dumfries and Galloway (Macan, 1951). Macan (1979) mentions a record from the River Severn however gives no other details. This record almost certainly relates to a specimen collected from the River Severn near Kidderminster in 1975. The only verified modern records are from the River Dove catchment in the Peak District. There is however a number of other unverified records of this species. Many of these closely overlap with the range of other *Siphlonurus* species and in the absence of a voucher specimen these records remain unsubstantiated.

Habitat and Ecology: Nymphs of this species typically live in deep pools in rivers and streams, but can also be found in calcareous lakes (Kimmins, 1932, Bratton, 1990). The large nymphs are good swimmers and typically swim in short, darting bursts. They feed by gathering or collecting fine particulate organic detritus from the sediment. There is one generation a year, which usually overwinters as eggs and emerges between May and August (Elliott & Humpesch, 1983). Emergence of the adults typically takes place during daylight hours and males of this species can be found swarming at dawn and dusk over light patches on the bed of the waterbody or floating plants such water-lilies (Savolainen, 1978).

The larvae of this species can be collected by kick-sampling along suitable stretches of river. This is a standard technique employed by biologists to sample aquatic invertebrates and entails disturbing a section of the riverbed. Invertebrates are dislodged and collected in a water net held just downstream. Adults can be collected by examining bankside trees and other vegetation. Alternatively, they can be caught as they swarm near the water.

Status: Bratton (1990) noted that a lack of records of this species from the mainland British Isles did not necessarily indicate a Notable species however the paucity of records in the intervening period points to this being an incredibly rare species. There are only two modern records and there is no reason to suggest that under-recording is responsible for the low number of records. The IUCN criteria for Endangered is therefore satisfied based upon the low number of sites and a continuing decline in Area of Occupancy.

Threats: Water pollution is the most obvious threat to this species. In common with other Ephemeroptera, this species relies upon good water quality. Pollution events, whether persistent or catastrophic, could lead to the local extinction of this species. High levels of suspended silt are likely to be particularly damaging to this species, and other mayflies.

Any operations that affect the bed such as dredging, channel modifications or gravel removal could damage the habitat and should be avoided. Gross alterations to the aquatic vegetation structure, particularly weed cutting, may be detrimental to this species. Similarly, changes to the riparian habitat, whether through flood defence work or removal of bankside trees or inappropriate management of bankside vegetation may result in a loss of habitat for the adult insect. Maintenance work on riparian and marginal vegetation (e.g. strimming or pruning) should be carried out only on one bank, and preferably on only short stretches in any one year. It is important to maintain a varied structure and mixture of plant species in the marginal vegetation to increase the variety of places available for invertebrates to shelter and breed in.

This species is likely to be affected by low flows. Abstraction; whether for irrigation, water supply or other purposes should be carefully considered where this species is present.

Published sources: Bratton (1990); Kimmins (1932); Mosely (1931); Macan (1951; 1979)

SIPHLONURUS ARMATUS

ENDANGERED B2a, bii, iv

Order EPHEMEROPTERA

Family SIPHLONURIDAE

Siphlonurus armatus Eaton, 1870

Identification: This species belongs to the family Siphlonuridae, of which there are 3 species found in Britain. Keys to the adults and nymphs are available from the Freshwater Biological Association (Elliott & Humpesch, 1983; Elliott & Humpesch, 2010) and from the Field Studies Council (Macadam & Bennett, 2010). Macan (1951) provides additional information.

Immature nymphs of *Siphlonurus armatus* are superficially similar to *Cloeon* species however the abdominal segments are drawn out to form large spines. *S. armatus* can be separated from other *Siphlonurus* species by the number of pairs of double gills present, the shape of the ninth abdominal segment, and morphological differences in the mouthparts. Adults have two tails and obvious hindwings. Identification of adults of *S. armatus* is based on the shape of the ninth abdominal segment and/or examination of the male genitalia.

Distribution: The Ephemeroptera Recording Scheme has records from 10 hectads in Britain. There are recent records from the Peak District and Hertfordshire. There are also a number of other unverified records of this species. Many of these closely overlap with the range of other *Siphlonurus* species and in the absence of a voucher specimen these records remain unsubstantiated. Confirmed historical records are from East and West Sussex (Gillies, 1990); Hertfordshire (Eaton, 1870) , Cumbria (Macan, 1951) and Yorkshire (Percival and Whitehead, 1927).

Habitat and Ecology: Nymphs of this species typically live in the pools and margins of rivers and streams, or in standing waters. The large nymphs are good swimmers and typically swim in short, darting bursts. They feed by gathering or collecting fine particulate organic detritus from the sediment. There is probably one generation a year, which overwinters as eggs (Landa, 1968) and emerges between May and August (Elliott and Humpesch, 1989). Emergence of the adults typically takes place during daylight hours and males of this species can be found swarming at dawn and dusk.

The larvae of this species can be collected by kick-sampling along suitable stretches of river. This is a standard technique employed by biologists to sample aquatic invertebrates and entails disturbing a section of the riverbed. Invertebrates are dislodged and collected in a water net held just downstream. Adults can be collected by examining bankside trees and other vegetation. Alternatively, they can be caught as they swarm near the water.

Status: *S. armatus* has been reliably recorded from four hectads since 1990. The IUCN criteria for Endangered is therefore satisfied based upon the low number of sites and a continuing decline in Area of Occupancy.

Threats: Water pollution is the most obvious threat to this species. In common with other Ephemeroptera, this species relies upon good water quality. Pollution events, whether persistent or catastrophic, could lead to the local extinction of this species. High levels of suspended silt are likely to be particularly damaging to this species, and other mayflies.

Any operations that affect the bed such as dredging, channel modifications or gravel removal could damage the habitat and should be avoided. Gross alterations to the aquatic vegetation structure, particularly weed cutting, may be detrimental to this species. Similarly, changes to the riparian habitat, whether through flood defence work or removal of bankside trees or inappropriate management of bankside vegetation may result in a loss of habitat for the adult insect. Maintenance work on riparian and marginal vegetation (e.g. strimming or pruning) should be carried out only on one bank, and preferably on only short stretches in any one year. It is important to maintain a varied structure and mixture of plant species in the marginal vegetation to increase the variety of places available for invertebrates to shelter and breed in.

The processes of natural succession mean that ponds where this species occurs will accumulate silt and detritus over time. Dredging of these sediments could cause the loss of this species from the site. The creation of new ponds on a site rather than dredging or deepening an existing pond is a far better management option. If dredging is deemed necessary then only one third of the pond should be dredged at any time, thus allowing invertebrates to re-colonise the dredged area. The remaining areas of the pond can then be cleared in rotation over the next two/three years. It is important to avoid the introduction of any non-native plant species, particularly New Zealand pigmyweed (*Crassula helmsii*), Canadian Pondweed (*Elodea canadensis*) and Parrot's Feather (*Myriophyllum aquaticum*) during any maintenance work.

Maintenance work on riparian and marginal vegetation (e.g. strimming or pruning) should be carried out only on one bank, and preferably on only short stretches in any one year. It is important to maintain a varied structure and mixture of plant species in the marginal vegetation to increase the variety of places available for invertebrates to shelter and breed in.

Published sources: Gillies, (1990); Eaton (1870); Macan, (1951); Percival and Whitehead (1927)

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Appendix 1: A complete listing of all species reviewed

Species Name	GB IUCN Status (2015)	Qualifying Crieria	Rationale	GB Status (2015)	Global IUCN status (2010)	Presence in England	Presence in Scotland	Presence in Wales	AoO(hectads) <1990	AoO(hectads) 1990-2011	Dual hectads
Ameletus inopinatus	LC		This species is widely present across suitable upland areas in Scotland and the Peak District. Current research (Taubmann et al., 2011) predicts that the range of this species will contract by over 50% by 2080, by which time the remaining populations will be found in the Scottish Highlands.	NS	None	E	S	W	30	29	1
Arthroplea congener	RE		Last/only record is from 1920. Distinctive larvae that should have turned up in routine monitoring samples if the species was present.		None	E			1	0	0
Baetis atrebatinus	LC		There are modern records from only 20 hectads. This species has always had a restricted distribution in the UK.	NS	None	E		W	22	20	11
Baetis buceratus	LC		This is a widespread species which is found in streams and rivers across England and Wales. There is no reason to believe that this species is not present in more than 100 hectads.		None	E			63	84	19
Baetis digitatus	VU	B2a,b(iv)	This species has always had a restricted distribution, however it has suffered a 43% decline in area of occupancy since 1990.	NR	None	E	S		14	8	1

Baetis fuscatus	DD		Due to problems with the separation of larvae of this species and *Baetis scambus* it is difficult to compile a complete distribution for this species. Whilst *B. fuscatus* is thought to be less common than *B. scambus* there are records from across the UK. It is therefore likely that this species occurs in more than 100 hectads.		None	E	S		21	27	5
Baetis muticus	LC		Widespread species with recent increase in area of occupancy.		None	E	S	W	357	469	193
Baetis niger	LC		This is a widespread species which is found in streams and rivers throughout the UK. Whilst this species has suffered declines in recent years, there are many areas that have not been searched for this species. It is therefore likely that this species occurs in more than 100 hectads.		None	E	S	W	113	93	19
Baetis rhodani	LC		Widespread species found in most running water habitats.		None	E	S	W	825	1307	637
Baetis scambus	LC		Widespread species with recent slight increase in area of occupancy.		None	E	S	W	77	145	17
Baetis vernus	LC		Widespread species with recent slight increase in area of occupancy.		None	E	S	W	299	332	141
Brachycercus harrisellus	LC		Widespread though very localised species showing a recent slight increase in number of hectads recorded.	NS	None	E	S		26	28	11
Caenis beskidensis	DD		Discovered in 1984 and too early to assign a threat category as a thorough review of specimens within this species group is required.	NR	None			W	0	1	0
Caenis horaria	LC		Widespread species with marked increase in the number of hectads where this species has been recorded.		None	E	S	W	159	364	96

Caenis luctuosa	LC		Widespread species with recent increase in the number of hectads where this species has been recorded.		None	E	S	W	78	142	21
Caenis macrura	DD		Due to problems with the separation of larvae of this species and Caenis luctuosa it is difficult to compile a complete distribution for this species. Whilst C. macrura is thought to be less common than C. luctuosa there are records from many parts of the the UK. It is therefore likely that this species occurs in more than 100 hectads.		None	E	?		10	13	0
Caenis pseudorivulorum	DD		Discovered in 1994 and too early to assign a threat category as a thorough review of specimens within this species group is required.	NR	None	E			0	1	0
Caenis pusilla	DD		This species is known from the River Wye and the River Frome and it may occur elsewhere however status unclear due to lack of records.	NR	None	E		W	0	0	0
Caenis rivulorum	LC		Widespread species with recent increase in number of hectads recorded.		None	E	S	W	265	464	117
Caenis robusta	LC		Widespread species with recent increase in number of hectads recorded.		None	E	S	W	97	121	29
Centroptilum luteolum	LC		Widespread species with recent increase in number of hectads recorded.		None	E	S	W	339	380	127
Cloeon dipterum	LC		Widespread species found in stillwaters and slow-flowing watercourses.		None	E	S	W	342	715	258
Cloeon simile	LC		Widespread and common species with recent increase in number of hectads recorded.		None	E	S	W	77	135	26
Ecdyonurus dispar	LC		Some difficulties in identification of larvae however this species is considered to be widespread and likely to occur in more than 100 hectads.		None	E	S	W	64	80	9

Ecdyonurus torrentis	LC		Some difficulties in identification of larvae however this species is considered to be widespread and likely to occur in more than 100 hectads.		None	E	S	?	10	34	1
Ecdyonurus venosus	LC		Widespread species with recent increase in number of hectads recorded.		None	E	S	W	59	148	19
Edyonurus insignis	LC		Widespread species with recent increase in number of hectads recorded.		None	E	S	?	59	134	12
Electrogena affinis	DD		Discovered in 1988 and too early to assign a threat category.	NR	None	E			0	5	0
Electrogena lateralis	LC		Widespread species with recent increase in number of hectads recorded.		None	E	S	W	72	176	17
Ephemera danica	LC		Widespread species with recent increase in number of hectads recorded.		None	E	S	W	330	554	236
Ephemera lineata	VU	D2	Despite a recent increase in Area of Occupancy this species is still restricted to only two river catchments. In the River Wye it remains restricted to 1 hectad however in the River Thames there has been a recent increase in the number of hectads recorded.	NS	None	E			3	17	1
Ephemera vulgata	LC		Widespread species in England with recent increase in number of hectads recorded.		None	E			51	139	20
Ephemerella notata	LC		Widespread though localised species showing a recent slight increase in Area of Occupany.	NS	None	E	S		43	50	8
Habrophlebia fusca	LC		Widespread species with recent increase in number of hectads recorded.		None	E	S	W	293	475	173
Heptagenia longicauda	RE		Last record is from 1930. Despite extensive surveys in the areas where this species has been previously recorded it has not been found.		None	E			4	0	0
Heptagenia sulphurea	LC		Widespread species which is increasing its range upstream in river systems.		None	E	S	W	168	380	87

Kageronia fuscogrisea	LC		Despite being widespread in Ireland, this species still has a restricted range in mainland UK.	NS	None	E	S		10	33	6
Leptophlebia marginata	LC		Widespread species found in both running and standing water, typically in upland areas. It is thought to occur in more than 100 hectads.		None	E	S	W	72	98	7
Leptophlebia vespertina	LC		Widespread species found in both running and standing water, typically in upland areas. It is thought to occur in more than 100 hectads.		None	E	S	W	45	94	11
Paraleptophlebia cincta	LC		Widespread though localised species showing a recent slight increase in Area of Occupancy.	NS	None	E	S	W	25	41	4
Paraleptophlebia submarginata	LC		Widespread species with recent increase in number of hectads recorded.		None	E	S	W	254	424	129
Paraleptophlebia werneri	LC		Localised species which typically inhabitats winterbournes and other temporary streams. There has been a recent increase in the number of hectads recorded.	NS	None	E			2	22	0
Potamanthus luteus	EN	B2a, bii, iv	Species found predominately in the River Wye, however has recently been found in the River Severn catchment. This species has suffered a decline in AoO of over 17% in the last 20 years however an increase in recording masks this trend.	NS	None	E		W	13	29	7
Procloeon bifidum	LC		Widespread but localised species showing a recent decline in number of hectads where it has been recorded. There is no reason to suggest that this is due to a decrease in recording effort. Nevertheless it continues to occur in more than 100 hectads.		None	E	S	W	127	113	24
Procloeon pennulatum	LC		Widespread but localised species which has shown a recent increase in the number of hectads where it has been recorded.		None	E	S	W	82	149	23

Rhithrogena germanica	LC		Difficulties with the identification of larvae has meant that historically there were few records of this species. A public survey focused on the adult stage has shown that this species has a widespread but very localised distribution.	NS	None	E	S	W	1	59	0
Rhithrogena semicolorata	LC		Widespread species with recent increase in number of hectads recorded.		None	E	S	W	64	375	24
Serratella ignita	LC		Widespread species with recent increase in number of hectads recorded.		None	E	S	W	611	966	419
Siphlonurus alternatus	EN	B2ab(ii-iv)	An incredibly rare species with only 2 substantiated modern records, representing a 50% decline in Area of Occupancy.	NR	None	E	S		4	2	0
Siphlonurus armatus	EN	B2ab(ii-iv)	Very local species, which has shown a 67% decline in the number of hectads where it has been recorded.	NR	None	E			9	3	2
Siphlonurus lacustris	LC		Widespread but localised species which has shown a recent increase in the number of hectads where it has been recorded. It is thought to occur in more than 100 hectads.		None	E	S	W	44	76	5

Appendix 2: IUCN Criteria and Categories

Summary of the five criteria (A–E) used to evaluate if a taxon belongs in a threatened category (Critically Endangered, Endangered or Vulnerable)

	Critically Endangered	Endangered	Vulnerable
A. Population reduction			
A1	≥ 90%	≥ 70%	≥ 50%
A2, A3 & A4	≥ 80%	≥ 50%	≥ 30%

A1. Population reduction observed, estimated, inferred, or suspected in the past where the causes of the reduction are clearly reversible **AND** understood **AND** have ceased, based on and specifying any of the following:

(a) direct observation

(b) an index of abundance appropriate to the taxon

(c) a decline in area of occupancy (AOO), extent of occurrence (EOO) and/or habitat quality

(d) actual or potential levels of exploitation

(e) effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.

A2. Population reduction observed, estimated, inferred, or suspected in the past where the causes of reduction may not have ceased **OR** may not be understood **OR** may not be reversible, based on (a) to (e) under A1.

A3. Population reduction projected or suspected to be met in the future (up to a maximum of 100 years) based on (b) to (e) under A1.

A4. An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a maximum of 100 years in future), and where the causes of reduction may not have ceased **OR** may not be understood **OR** may not be reversible, based on (a) to (e) under A1.

B. Geographic range in the form of either B1 (extent of occurrence) AND/OR B2 (area of occupancy)			
B1. Extent of occurrence (EOO)	< 100 km²	< 5,000 km²	< 20,000 km²
B2. Area of occupancy (AOO)	< 10 km²	< 500 km²	< 2,000 km²

AND at least 2 of the following:

(a) Severely fragmented, **OR**

Number of locations	= 1	≤ 5	≤ 10

(b) Continuing decline observed, estimated, inferred or projected in any of: **(i)** extent of occurrence; **(ii)** area of occupancy; **(iii)** area, extent and/or quality of habitat; **(iv)** number of locations or subpopulations; **(v)** number of mature individuals.

(c) Extreme fluctuations in any of: **(i)** extent of occurrence; **(ii)** area of occupancy; **(iii)** number of locations or subpopulations; **(iv)** number of mature individuals.

C. Small population size and decline			
Number of mature individuals	< 250	< 2,500	< 10,000
AND at least one of C1 or C2:			
C1. An observed, estimated or projected continuing decline of at least (up to a maximum of 100 years in future):	25% in 3 years or 1 generation (whichever is longer)	20% in 5 years or 2 generations (whichever is longer)	10% in 10 years or 3 generations (whichever is longer)
(up to a max. of 100 years in future)			
C2. An observed, estimated, inferred or projected continuing decline **AND** at least 1 of the following 3 conditions:			
(a i) Number of mature individuals in each subpopulation:	≤ 50	≤ 250	≤ 1,000
or			
(a ii) % of mature individuals in one subpopulation =	90–100%	95–100%	100%
(b) Extreme fluctuations in the number of mature individuals.			

D. Very small or restricted population			
Either:			
Number of mature individuals	< 50	< 250	**D1.** < 1,000
D2. *Only applies to the VU category*. Restricted area of occupancy or number of locations with a plausible future threat that could drive the taxon to CR or EX in a very short time.			**D2.** typically: AOO < 20 km² or number of locations ≤ 5
E. Quantitative Analysis			
Indicating the probability of extinction in the wild to be:	≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)	≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)	≥ 10% in 100 years

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