Natural England Commissioned Report NECR174

A review of the stoneflies (Plecoptera) of Great Britain

Species Status No.20

First published 12 February 2015

www.gov.uk/natural-england

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

Decisions about the priority to be attached to the conservation of species should be based upon objective assessments of the degree of threat to species. The internationally-recognised approach to undertaking this is by assigning species to one of the IUCN threat categories using the IUCN guidelines.

This report was commissioned to update the national threat status of stoneflies. It covers all stoneflies, identifying those that are rare and/or under threat as well as non-threatened and non-native species. Reviews for other invertebrate groups will follow.

Natural England Project Manager - Jon Webb, **jon.webb@naturalengland.org.uk**

Contractor - Buglife (project management), Craig Macadam (author)

Keywords - stoneflies, Plecoptera, invertebrates, red list (IUCN), status reviews

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

ISBN 978-1-78354-159-1

CONTENTS

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.

1.4 References and Further Reading

AINSWORTH, A.M. , SMITH, J.H., BODDY, L., DENTINGER, B.T.M., JORDAN, M., PARFIITT, D., ROGERS, H.J. & SKEATES, S.J. 2013. Red List of Fungi for Great Britain: Boletaceae. A pilot conservation assessment based on national database records, fruit body morphology and DNA barcoding. *Species Status Assessment* No 14, ISSN 1473-0154, Joint Nature Conservation Committee, Peterborough.

ALEXANDER, K.N.A. 2014a. *A review of the scarce and threatened beetles of Britain. Buprestidae, Cantharidae, Cleridae, Dasytidae, Drilidae, Lampyridae, Lycidae, Lymexylidae, Malachiidae, Phloiophilidae and Trogossitidae* Species Status No.16 Natural England Commissioned Reports, Number 134.

ALEXANDER, K.N.A, DODD, S. & DENTON, J.S. 2014b. *A review of the scarce and threatened beetles of Britain.The darkling beetles and their allies. Aderidae, Anthicidae, Colydiidae, Melandryidae, Meloidae, Mordellidae, Mycetophagidae, Mycteridae, Oedemeridae, Pyrochroidae, Pythidae, Ripiphoridae, Salpingidae, Scraptiidae, Tenebrionidae & Tetratomidae (Tenebrionoidea less Ciidae).* Species Status No. 18. Natural England Commissioned Reports, Number 148.

CHEFFINGS, C. & FARRELL, L. (eds). 2005. The Vascular Plant Red Data List for Great Britain. *Species Status Assessment* No **7**, ISSN 1473-0154, Joint Nature Conservation Committee, Peterborough.

DAGUET, C., FRENCH, G. & TAYLOR, P. (eds.) 2008. The Odonata Red Data List for Great Britain. *Species Status Assessment* No 11, ISSN 1470-0154, Joint Nature Conservation Committee, Peterborough.

FALK, S.J. & CHANDLER, P.J. 2005. A review of the scarce and threatened flies of Great Britain. Part 2: Nematocera and Aschiza not dealt with by Falk (1991). *Species Status Assessment* No 2, ISSN 1473-0154, Joint Nature Conservation Committee, Peterborough.

FALK, S.J. & CROSSLEY, R. 2005. A review of the scarce and threatened flies of Great Britain. Part 3: Empidoidea. *Species Status Assessment* No 3, ISSN 1473-0154, Joint Nature Conservation Committee, Peterborough.

FOSTER, G.N. 2010. A review of the scarce and threatened Coleoptera of Great Britain Part (3): Water beetles of Great Britain. *Species Status* 1. Joint Nature Conservation Committee, Peterborough.

FOX, R., WARREN, M.S. and BRERETON, T.M. 2010. A new Red List of British Butterflies, *Species Status* 12; 1-32. Joint Nature Conservation Committee, Peterborough.

HYMAN, P.S. (revised PARSONS, M. S.) 1992. A review of the scarce and threatened Coleoptera of Great Britain. Part 1. UK Nature Conservation: 3. Joint Nature Conservation Committee, Peterborough.

IUCN. 1994. *IUCN Red List Categories and Criteria: Version 2.3*, IUCN Species Survival Commission. IUCN, Gland.

IUCN. 2001. *IUCN Red List Categories and Criteria: Version 3.1*. IUCN Species Survival Commission. IUCN, Gland and Cambridge.

IUCN. 2003. Guidelines for Application of IUCN Red List Criteria at Regional Levels: Version 3.0. IUCN Species Survival Commission IUCN, Gland and Cambridge.

IUCN. 2012a. *IUCN Red List Categories and Criteria*. Version 3.1. 2nd Edition, IUCN Species Survival Commission. IUCN, Gland.

IUCN. 2012b. Guidelines for Application of IUCN Red List Criteria at Regional and National Levels. Version 4.0, IUCN Species Survival Commission. IUCN, Gland.

IUCN. 2013. *Guidelines for Using the IUCN Red List Categories and Criteria*. Version 10, IUCN Species Survival Commission. IUCN, Gland.

PERRING, F.H. & FARRELL, L. 1977. *British Red Data Books: 1. Vascular Plants*. Society for Nature Conservation, Lincoln.

PERRING, F.H. & FARRELL, L. 1983. *British Red Data Books: 1. Vascular Plants, edn 2*. Royal Society for Nature Conservation, Lincoln.

SHIRT, D.B. 1987. *British Red Data Books: 2 Insects*. Nature Conservancy Council, Peterborough.

STEWART, N.F. & CHURCH, J.M. 1992. *Red Data Books of Britain and Ireland: Stoneworts*. Joint Nature Conservation Committee, Peterborough.

WIGGINTON, M.J. (ed.). 1999. *British Red Data Books.* 1. Vascular Plants. 3rd edition. Joint Nature Conservation Committee, Peterborough.

WOODS, R.G. & COPPINS, B.J. 2012. A Conservation Evaluation of British Lichens and Lichenicolous Fungi. *Species Status Assessment* No 13, ISSN 1473-0154, Joint Nature Conservation Committee, Peterborough.

2. Introduction to this review

The stoneflies, or Plecoptera (from the Greek, "pleated wing"), are an ancient group of insects. One of the more "primitive" groups, they lack the pupal stage of the life cycle which occurs in more "advanced" groups, such as the butterflies and moths, beetles, and true flies. The first recognisable stonefly fossils are from the Permian period, about 250 million years ago.

Though stoneflies are often the unsung inhabitants of the freshwater world, their larvae can grow to over 30mm in length, which makes them, after crayfish and freshwater mussels, amongst the largest invertebrates found in freshwater. They have changed very little since the early Permian period over 250 million years ago. Approximately 2,500 species have been described worldwide, from all continents except Antarctica. Generally speaking, the greatest diversity of stoneflies tends to be in the temperate regions and in more mountainous parts of the tropics, as they prefer cool, well-oxygenated waters. In some areas they form a large portion of the biomass in a stream and at the best sites this may equal or exceed that of the mayflies or the caddisflies. Nevertheless, the group has attracted limited public or scientific interest, perhaps due to their inoffensive and often nocturnal lifestyle, and rather drab appearance.

Not all species are restricted to well-oxygenated upland waters. Several, with broad ecological preferences, can be found on the lower courses of rivers, whilst *Isoperla grammatica* is often found in southern chalkstreams and *Nemoura cinerea* and *Nemurella picteti* frequent marshes and springs. A few species, such as *Diura bicaudata* and *Siphonoperla torrentium*, may also be found on the shores of lakes, although the preference here is for rocky rather than muddy shores. Some species, such as *Protonemura* spp. and *Amphinemura* spp. and *Taeniopteryx nebulosa* have finger-like gills on the neck or legs to aid oxygen uptake, while the larger stoneflies (*Perla bipunctata* and *Dinocras cephalotes*) have filamentous gills on the thorax for the same purpose.

Due to their high oxygen requirements, the larvae are particularly sensitive to organic pollution and are one of the first groups to disappear when, for example, slurry pollution occurs. However, many species can tolerate quite severe heavy metal pollution, and healthy and diverse populations can be found living in outflows from abandoned lead mines.

2.1 Taxa considered in this review

All 33 species included in the Fauna Europaea checklist of Plecoptera (Stoneflies) of Britain (Fochetti, 2012) are included, with the addition of *Nemoura lacustris* which has been included following its discovery in a winterbourne in Dorset (Hammett, 2012) (Table 1). The Plecoptera Recording Scheme has, since its formation in 2001, 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**
Capniidae	*Capnia atra* Morton, 1896
Capniidae	*Capnia bifrons* (Newman, 1839)
Capniidae	*Capnia vidua anglica* Aubert, 1950
Chloroperlidae	*Chloroperla tripunctata* (Scopoli, 1763)
Chloroperlidae	*Siphonoperla torrentium* (Pictet, 1841)
Leuctridae	*Leuctra fusca* (Linnaeus, 1758)
Leuctridae	*Leuctra geniculata* Stephens, 1836
Leuctridae	*Leuctra hippopus* Kempny, 1899
Leuctridae	*Leuctra inermis* Kempny, 1899
Leuctridae	*Leuctra moselyi* Morton, 1929
Leuctridae	*Leuctra nigra* (Olivier, 1811)
Nemouridae	*Amphinemura standfussi* (Ris, 1902)
Nemouridae	*Amphinemura sulcicollis* (Stephens, 1836)
Nemouridae	*Nemoura avicularis* Morton, 1894
Nemouridae	*Nemoura cambrica* Stephens, 1836
Nemouridae	*Nemoura cinerea* (Retzius, 1783)
Nemouridae	*Nemoura dubitans* Morton, 1894
Nemouridae	*Nemoura erratica* Claassen, 1936
Nemouridae	*Nemoura lacustris* Pictet, 1865
Nemouridae	*Nemurella pictetii* Klapalek, 1900
Nemouridae	*Protonemura meyeri* (Pictet, 1841)
Nemouridae	*Protonemura montana* Kimmins, 1941
Nemouridae	*Protonemura praecox* (Morton, 1894)
Perlidae	*Dinocras cephalotes* (Curtis, 1827)
Perlidae	*Perla bipunctata* Pictet, 1833
Perlodidae	*Diura bicaudata* (Linnaeus, 1758)
Perlodidae	*Isogenus nubecula* Newman, 1833
Perlodidae	*Isoperla grammatica* (Poda, 1761)
Perlodidae	*Isoperla obscura* (Zetterstedt, 1840)
Perlodidae	*Perlodes mortoni* (Klapálek, 1906)
Taeniopterygidae	*Brachyptera putata* (Newman, 1838)
Taeniopterygidae	*Brachyptera risi* (Morton, 1896)
Taeniopterygidae	*Rhabdiopteryx acuminata* Klapálek, 1905
Taeniopterygidae	*Taeniopteryx nebulosa britannica* Hynes, 1957

Xanthoperla apicalis was previously included on the British checklist on the basis of three specimens which lack locality labels. Kimmins (1936) suggests that they may in fact be of Continental origin and were accidentally included with British specimens. Due to the doubt over the provenance of these specimens this species is no longer included on the British checklist.

Recent research (Zwick, 2011) has removed *Perlodes mortoni* (Klapálek, 1906) from synonomy with *P. microcephalus*. *P. mortoni* is currently thought to be endemic to the British

Isles. Further research is required to determine if *P. microcephalus* sensu stricto, which is found across continental Europe is also present.

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

2.1.1 Endemic species/sub-species

Despite a relatively small fauna, the Plecoptera display a high degree of endemism in the British Isles. Two species and two sub-species are considered endemic (Table 2). It is possible that further endemic sub-species may be encountered in the future, particularly in upland areas such as the Scottish highlands.

Table 2. British endemic Plecoptera species

Family	**Species**
Capniidae	*Capnia vidua anglica*
Perlodidae	*Perlodes mortoni*
Taeniopterygidae	*Brachyptera putata*
Taeniopterygidae	*Taeniopteryx nebulosa britannica*

2.2 Previous reviews

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

Plecoptera were not included in the British Red Data Books: 2. Insects (Shirt, 1987) and a separate review of Plecoptera was subsequently undertaken (Bratton, 1990). This listed 7 of the total British fauna at that time (34 species), ie 20.6% (Table 3). Data sheets were given for Extinct, Vulnerable (RDB2), Endemic (RDB5) and Nationally Notable species.

Table 3. Red list categories for species reviewed by Bratton (1990)

Species	**Red list categories**
Isoperla obscura	Extinct
Isogenus nubecula	Category 2: Vulnerable
Taeniopteryx nebulosa britannica	Category 5: Endemic
Brachyptera putata	Category 5: Endemic
Capnia vidua anglica	Category 5: Endemic
Rhabdiopteryx acuminata	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 stonefly species. The IUCN Guidelines have been revised (IUCN, 1994) and subsequently updated (IUCN, 2012a), and new information on distribution and trends is now available, making it necessary to revise the status of all stonefly 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 hierarchical relationship of the categories in Figure 2 (see Appendix 1). 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 4).

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 4).

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 4).

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)

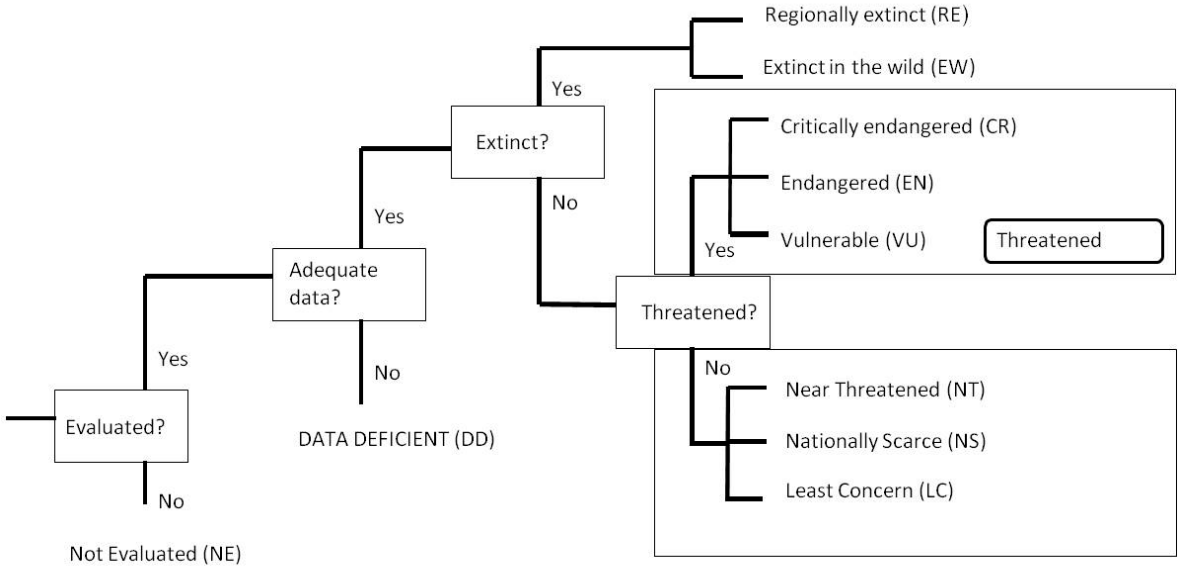

Figure adapted from IUCN (2001)

Figure 2. Hierarchical relationships of the categories

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 4.

Table 4. 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 <100km^2 or area of occupancy <10km^2 + two of the following: - severely fragmented or only a single location - continuing decline - extreme fluctuations	Extent of occurrence <5,000km^2 or area of occupancy <500km^2 + two of the following: - severely fragmented or no more than 5 locations - continuing decline - extreme fluctuations	Extent of occurrence 20,000km^2 or area of occupancy <2,000km^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. <20km^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 stoneflies.

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 recognize 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. However, no Plecoptera were assessed as Near Threatened in this review.

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 stoneflies (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 bulk of the data (c.38,000 records) was derived from the Plecoptera Recording Scheme supplemented with information from Statutory Agencies, such as Natural Resources Wales, Scottish Environment Protection Agency, etc. (c. 6,000 records); and Local Biological Record Centres from around the UK (c. 3,500 records). The majority of the records held by the Plecoptera Recording Scheme are from the Environment Agency and Scottish Environment Protection Agency, though these sources mainly cover riverine species, and common taxa predominate. 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 of the Environment Agency and Ian Milne 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. There are field observations by naturalists, but Plecoptera, mainly due to the need to preserve larvae in fluid and the need for microscopic examination, have been difficult to popularise amongst amateur recorders. 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 Plecoptera 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 1990-2011
- 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 IUCN criteria assess declines based on data from the last ten years, or three generations. It is extremely rare that any stonefly species has been comprehensively surveyed in the past ten years (or even over three generations). 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 CR, EN, VU and NT 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 Fochetti (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 Plecoptera species is relatively straightforward; however, a microscope is required to identify most to species level. With a little experience it is possible to identify about ten species with relative certainty in the field by taking into account the appearance, the habitat and the time of year. Family-level identification, of both larvae and adults, is easier and can be mastered with little effort.

The Freshwater Biological Association publishes a good, relatively cheap identification key to both adults and larvae, which includes information on their ecology. The key (Hynes, 1977) has been the subject of some minor revisions. 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 Plecoptera 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 the larvae over the past forty years means that the larval habit requirements of most species are 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, *Perla bipunctata* and *Dinocras cephalotes*, two of the larger stoneflies, take up to three years to reach maturity.

Stonefly eggs usually go through a period of rest, known as a diapause, before they hatch. Diapause varies in length from species to species and is also dependent on water temperature. Hatching times vary from a fortnight to two months, but in one species, *Amphinemura standfussi*, this may exceed three months. For *Capnia bifrons*, the period is much shorter as the eggs develop inside the female, and larvae emerge from the eggs only fifteen minutes after being laid.

A typical larva looks similar to an underwater earwig, the group to which they are most closely related, except stoneflies have two long tails, called cerci, instead of pincers. Their bodies are shaped like slightly flattened cylinders and they have stout legs which are held out to the side. This shape helps to streamline the larva and allows it to cling very closely to the substrate so that it is within the boundary layer where the water velocity is much lower than further out in the water column. In water velocities too high for the larvae to cling on, they may burrow deep into crevices and gaps in the sediment - some larvae have even been found 50 cm down in river gravels.

Like the majority of aquatic invertebrates, stoneflies are primarily nocturnal in their habits. All stonefly larvae begin their life as herbivores or detritivores, eating diatoms, algae and detritus such as decaying leaves. Four families (the Leuctridae, Nemouridae, Taeniopterygidae and the Capnidae) stay with this diet until they are ready to emerge as adults. The remaining three families (Chloroperlidae, Perlidae and Perlodidae) switch over to an omnivorous diet, supplementing the vegetable matter with any other aquatic invertebrates they can catch, for example, small worms, shrimp, midge and mosquito larvae, caddisfly, mayfly and other stonefly larvae.

As they grow, the larvae undergo between ten and twenty moults. Immediately after each moult the larva expands as much as it can before the new skin hardens. During the last six or so moults the adult wings begin to develop underneath the skin and form two pairs of conspicuous wing-pads which project sideways and backwards from the top of the thorax. Just prior to emerging as an adult, the larva ceases feeding and spends a few days making the remaining internal changes before adult life can commence.

When suitable conditions occur, the larva crawls a short distance, usually only a few centimetres, out of the water and finds a suitable sheltered place where it grips tightly to a rock or piece of wood. The skin splits along the thorax and the adult stonefly pulls itself out. After the wings have been expanded and the skin has hardened the stonefly is ready to begin its adult life. The delicate larval skin, called a shuck or exuvium, is left where the insect emerged.

The flight season extends from mid February to early November with a peak of activity between April and July. A very small numbers of adults may be seen in flight in the winter

months. In most species the wings extend just beyond the tip of the abdomen. However in two British species, *Perlodes mortoni* and *Diura bicaudata*, the males are brachypterous, with wings between a third and a sixth of this length. Several other species become brachypterous at high altitudes, although in these cases brachyptery occurs in both males and females. This is thought to be an adaptation to the high wind speeds that can be encountered in these areas. Flight in these conditions would lead to a high risk of being blown away from the habitat into an unsuitable area.

Males and females locate each other by "drumming". While drumming the stonefly repeatedly strikes the end of the abdomen against the substrate to produce a species-specific signal of pulses and pauses. In some species, particularly the Leuctridae, males have prominences on the last few abdominal segments that are assumed to be of importance in drumming. There is also presumably some mechanism whereby the stoneflies can filter these messages out from the background noise that permeates their habitat, as the drumming is very quiet and streams can be surprisingly noisy places.

When mated, females mature the eggs over a few days and, when ready, produce an egg mass that is held below the base of the abdomen. Females of flying species can sometimes be seen coming down to the water surface in midstream, and with one touch of the abdomen the eggs are released. Flightless species, however, crawl down to the waters edge and swim or run over the surface to deposit the eggs. As the egg mass touches the water the cohesive substance holding the mass together dissolves and the eggs sink to the bottom. It is thought that each female is capable of producing two to three egg masses.

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 is extremely rare but have been used where available. The linear nature of river habitats however means the the IUCN ‘location’ concept can be used. This concept allows an ecologically distinct area, such as a river, where a single threatening event can rapidly affect all individuals in the populations to be treated 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. Stoneflies are frequently recorded by the Environment Agency 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 Plecoptera 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. *Diura bicaudata* is an example of a species known from 76 hectads since 1990 but which is widespread in upland areas 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 stonefly populations. Most stonefly 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 stonefly 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 stonefly species.

Abstraction from watercourses or the drawdown of reservoirs can have several potentially damaging effects for stonefly populations. In general, larvae are capable of reacting to a slowly receding water level by migrating to deeper water, stonefly 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 stonefly 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 stoneflies shelter is likely to lessen the chances of successful breeding. In addition, in lowland streams species such as *Taeniopteryx nebulosa* are known to cling to the surface of 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 stonefly larvae or, where it settles, bury them. Every effort should be made to prevent the release of silt into a watercourse.

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. Whilst many stonefly species are more tolerant 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 stonefly species.

Bankside grazing by livestock damages the vital turf layer of the adjacent land and leads 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 stoneflies, mayflies 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 stoneflies, 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 stonefly 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.

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 Plecoptera 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 David Pryce for collating many of the records for the scheme. Similarly, the efforts of Alice Hiley (EA) and Ian Milne (SEPA) in assisting with verification of records should be noted. During the preparation of this review the author sought the views of a range of specialists. In particular thanks are due to Michael Hammett, David Pryce and Louis Kitchen for information on some of the species and Ant Maddock (JNCC), Jon Webb, Ian Wallace, Margaret Palmer and Steven Falk (Buglife) for their help with the preparation of this review.

It is also important to acknowledge the support of many organisations, in particular Natural England, Natural Resources Wales, Environment Agency and Scottish Environment Protection Agency. This work was completed as part of the activities of Buglife – The Invertebrate Conservation Trust, and funded by Natural England.

Finally, it is important to acknowledge the considerable contribution made by contributors to the Scheme and those who share their data on the NBN Gateway.

Craig R. Macadam
Buglife – The Invertebrate Conservation Trust
Balallan House
24 Allan Park
Stirling
FK8 2QG

8. Species listed by IUCN status category

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

Regionally Extinct

Perlodidae	*Isoperla obscura* (Zetterstedt)

Critically Endangered (Possibly Extinct)

Perlodidae	*Isogenus nubecula* (Newman)

Vulnerable

Taeniopterygidae	*Rhabdiopteryx acuminata* (Klapálek)

Data Deficient

Capniidae	*Capnia atra* (Morton)
	Capnia vidua anglica (Aubert)
Nemouridae	*Nemoura lacustris* (Pictet)
	Protonemura montana (Kimmins)

9. Species listed by GB Rarity Status category

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

Nationally Rare

Nemouridae	*Nemoura lacustris* (Pictet)
	Nemoura dubitans (Morton)
Perlodidae	*Isogenus nubecula* (Newman)
Taeniopterygidae	*Rhabdiopteryx acuminata* (Klapálek)

Nationally Scarce

Capniidae	*Capnia atra* Morton
	Capnia vidua anglica (Aubert)
Nemouridae	*Amphinemura standfussi* (Ris)
	Protonemura montana (Kimmins)
Taeniopterygidae	*Brachyptera putata* (Newman)

10. Criteria used for assigning species to threatened categories (see Appendix 2 for criteria and categories)

Table 5. Criteria used to assign extant species to GB IUCN categories with a level of threat VU or greater, not including Data Deficient (DD) or Regionally Extinct (RE) species

Scientific Name	**Status**	**Criteria used**
Perlodidae		
Isogenus nubecula (Newman)	Critically Endangered (Possibly Extinct)	B2a, bii, iv
Taeniopterygidae		
Rhabdiopteryx acuminata (Klapálek)	Vulnerable	D2

11. Taxonomic list of Threatened and Nationally Scarce Species

Table 6. Taxonomic list of Threatened and Nationally Scarce Species

Scientific name	**Bratton 1990**	**This review (GB Rarity status)**	**This review (IUCN status)**
Capniidae			
Capnia atra (Morton)		NS	DD
Capnia vidua anglica (Aubert)		NS	DD
Nemouridae			
Amphinemura standfussi (Ris)	-	NS	-
Nemoura dubitans (Morton)	NN[1]	NR	-
Nemoura lacustris (Pictet)	-	NR	DD
Protonemura montana (Kimmins)		NS	DD
Taeniopterygidae			
Brachyptera putata (Newman)	NN	NS	-
Rhabdiopteryx acuminata (Klapalek)	NN	NR	VU
Perlodidae			
Isogenus nubecula (Newman)	RDB2	NR	CR(PE)
Isoperla obscura (Zetterstedt)	Extinct	-	RE

[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 two 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 7. Downgraded Species

Scientific name	Number of post-1990 hectads	Rationale for exclusion
Capnia atra	3	Few modern records for this species however this is almost certainly due to under-recording. Further recording effort is required before the status of this species can be assessed, however this species is likely to occur in less than 100 hectads.
Capnia bifrons	30	This is a widespread species however its habit of living deep in the interstitial voids on the bed of rivers and streams until just before emergence means that it is often overlooked.
Capnia vidua anglica	2	There are few verified records for this species however this is almost certainly due to under-recording as it known to occur at high altitude sites in the Scottish Highlands. Further recording effort is required before the status of this species can be assessed, however this species is likely to occur in less than 100 hectads.
Diura bicaudata	76	This is a widespread upland species typically occurring at over 1000 metres. Very little routine surveying is undertaken at this altitude and it is therefore likely that this species is significantly under-recorded.
Protonemura montana	12	Difficulties with the separation of this species from *P. praecox* makes determining the status of this species in GB difficult, however this species is likely to occur in less than 100 hectads.

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.

ISOGENUS NUBECULA
CRITICALLY ENDANGERED B2a, bii, biv
(POSSIBLY EXTINCT)
Order PLECOPTERA
Family PERLODIDAE

Isogenus nubecula (Newman, 1833)

Identification
This species belongs to the family Perlodidae, of which just four other members are found in Britain. A key to the adults and nymphs of stoneflies is available from the Freshwater Biological Association (Hynes, 1977). Lillehammer (1988) also provides keys to adults and nymphs.

Adults have two long cerci (tails) and both the female and male are fully-winged. Females are 15-20mm long while males are slightly shorter at 14-19mm. They are separated from other Perlodidae species through examination of the sub-genital plate in the female and the tenth tergum in the male. Nymphs are 14-21mm long and are separated from the other Perlodidae by examination of the mouthparts.

Distribution
There are records from 8 hectads in Britain. It is reliably known from the River Dee, Flintshire, although there are a couple of unsubstantiated records from other sites which were discounted by Bratton (1990). A survey in the 1980s found nymphs along a 45 km stretch of the River Dee, between Newbridge and its confluence with the River Alyn (Alun), with the greatest abundance close to the site of the original discovery (Mills and Andrew, 1984). The range and abundance in the River Dee are thought to have increased between 1959 and 1982, but this is still the only river known to have supported a population of this species, despite searching in the tributaries of the Dee (Mills and Andrew, 1984) and much other sampling of river invertebrates by the Environment Agency and its predecessors.

In 1993 a survey of the middle reaches of the River Dee recorded *I. nubecula* at 5 sites between Overton Bridge and Wern (Davy-Bowker, 1995). A single specimen of *I. nubecula* was taken from the River Dee at Erbistock in 1995 during routine monitoring by the Environment Agency. Despite further surveys in 1997 (Tanner, 1997), 1998 (Milliband, 1998), 2003 (Davy-Bowker, 2003) and 2003/4 (Hammett and Wallace, 2005) no further specimens of *I. nubecula* have been found. Air-lift sampling of deeper water in the lower reaches of the River Dee was undertaken in 2007 (Davy-Bowker *et al*, 2007). These surveys did not however produce any records.

Habitat and ecology

Isogenus nubecula is found in large stony lowland rivers. The larvae are predatory, feeding mainly on Ephemeroptera and Chironomidae larvae (Brinck, 1949), although they may also eat some vegetation. Adults are reported as being on the wing between March and April (Bratton, 1990; Hynes, 1977) however sources from Europe suggest that the flight period might be later, occurring in May to July (Brinck, 1949; Lillehammer, 1988). The adults are thought not to feed, though they do drink water.

Hynes (1963) suggested that *I. nubecula* retreated to an area of deeper water during a period of mild pollution on the River Dee. At Bangor, larvae were only found towards the middle of the river where the flow was swift and deep. Mills and Andrew (1984) consider swift-flowing water, 25-30 cm in depth, over unstable cobbles and gravels to be the ideal habitat. Nymphs were not found amongst extensive growths of aquatic *Ranunculus*, or where the river becomes deeper with a substratum predominately of sand and silt. It was also suggested that the regulated flow of the River Dee, which has increased the minimum dry weather flow in the middle reaches to 6 cubic metres per second for 50% of the year, may be the factor creating suitable conditions for *I. nubecula* in this river alone.

In shallow water the larvae of this species can be collected by kick-sampling. 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. In deeper water air lift sampling can be employed to collect specimens from the river bed. Adults can be collected by examining bankside trees and other vegetation. Cast exuviae may be found on bankside structures such as bridges and walls.

Status

I. nubecula has been recorded from three hectads from 1990 onwards, however there have been no records since 1995. All of these modern records are from a single location - the River Dee in Wales. The IUCN criteria for Critically Endangered is therefore satisfied based upon a small and restricted number of locations. This species has been listed as Possibly Extinct due to the absence of recent records, despite extensive searches.

Threats

Water pollution is the most obvious threat to this species. Water quality in the River Dee is generally good, however pollution incidents, particularly those that occur above Bangor-on-Dee, may be detrimental to the survival of *Isogenus nubecula*. Davy-Bowker, et al. (2007) suggested that an increase in water temperature led to the River Dee becoming less suitable for this species. In particular, the potential effect of water releases from impoundments on the River Dee requires further investigation.

In lowland areas the riverbanks are sometimes unprotected from livestock on more heavily grazed pasture. The resulting disturbance of the riverbed, together with the potential eutrophication or pollution of the water, may lead to a deterioration of the habitat. Agricultural pollution also poses a serious threat, particularly slurry from factory farming and the leachate from silage clamps.

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 stonefly.

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.

Published sources

Bratton (1990); Brinck (1949); Brindle (1973); Davy-Bowker (1995); Davy-Bowker (2003); Davy-Bowker et al. (2007); Hammett and Wallace (2005); Hynes (1963); Lillehammer (1988); Macadam (2011); Millband (1998); Mills and Andrew (1984); Tanner (1997).

RHABDIOPTERYX ACUMINATA
VULNERABLE D2
Order PLECOPTERA
Family TAENIOPTERYGIDAE

Rhabdiopteryx acuminata Klapálek, 1905

Identification
This species belongs to the family Taeniopterygidae, of which just three other members are found in Britain. A key to the adults and nymphs of stoneflies is available from the Freshwater Biological Association (Hynes, 1977). Lillehammer (1988) also provides a key to both adults and nymphs including the use of head suture shape to separate nymphs of *R. acuminata* from those of *Brachyptera* spp.

Adults are typically fully winged however the cerci (tails) are reduced to short stumps of around only 5 segments. Females are 8-10mm long while males are slightly shorter at 8-9mm. They are separated from other Taeniopterygidae species through examination of the sub-genital plate in the female and the absence of a drumming lobe on the ninth sternum of the male. Nymphs are 7-10mm long and are separated from the other Taeniopterygidae by examination of the clothing hairs and head suture shape.

Distribution
There are records from 29 hectads in Britain, although eight records from Scotland are un-verified and may be mis-identified specimens of *Brachyptera* spp. There are five modern records from Northumberland and Yorkshire in England, and Monmouthshire and Montgomeryshire in Wales. Historic records are from Yorkshire, Cumbria, Radnorshire, Monmouthshire, Cardiganshire and Norfolk.

Habitat and ecology
In Yorkshire, this species is found in small calcareous streams. In the River Rye, it occurred where the river was about 15 metres wide with riffles about 30 cm deep between deeper pools. The river here tends to dry out in some years, as it flows over limestone. The bed is of rough stones and gravel with the mosses *Fontinalis* and *Hypnum* (Bratton, 1990). The descriptions of Pickering Beck and Jugger Howe Beck (Kimmins 1943) are similar, adult specimens being found in the numerous alders growing along their banks. Nymphs have also been recorded in three oligotrophic softwater rivers in Wales. In the River Wye, Morris and Brooker (1979) list *R. acuminata* among species colonising baskets of cobbles and coarse gravel in a riffle with a current velocity of approximately 0.5 metres per second, a typical salmon nursery area. The Rivers Rheidol and Ystwyth have similar water chemistry to the Wye, except that both suffered from metal pollution from disused mine workings (Brooker and Morris 1980). Adults are on the wing between March and May. Nymphs of this species mainly feed by shredding coarse particulate material such as leaves and other vegetation. They may also gather fine particulate material from the sediments or graze upon epilithic algae and biofilms on submerged stones (Moog, 1995).

In shallow water the larvae of this species can be collected by kick-sampling. 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. Cast exuviae may be found on bankside structures such as bridges and walls.

Status

R. acuminata has been recorded from five hectads from 1990 onwards. The IUCN criteria for Vulnerable is satisfied based upon a small and restricted number of locations (D2).

Threats

River pollution and water abstraction are probably the main threats. Sewage and agricultural practices leading to diffuse pollution are other frequent sources of river eutrophication which would be likely to eliminate oxygen-loving invertebrates such as stoneflies. Chronic eutrophication of rivers can lead to dense growths of algae at the expense of higher plants, which is likely to have serious implications for this species, as the nymphs are herbivorous. It is not clear how important the presence of trees is for the adult stages. They may feed on epiphytic lichens and algae or simply use riverside trees for shelter. In either case, removal of trees is likely to be harmful for this species.

Published sources

Bratton (1990); Brooker and Morris (1980); Hynes (1957); Hynes (1977); Kimmins (1943); Lillehammer (1988); Morris and Brooker (1979).

14. References

Bratton J.H. (1990). A review of the scarcer Ephemeroptera and Plecoptera of Great Britain. Nature Conservancy Council, Peterborough, UK. Research & survey in Nature Conservation no. 29:1-39.

Brinck, P. (1949). Studies on Swedish stoneflies (Plecoptera). Opuscula Entomologica, Supplementum XI: 1-250.

Brindle, A. (1973). *Isogenus nubecula* Newman in Flintshire (Plecoptera:Perlodidae). Entomologist's Record and Journal of Variation, 85:50-53.

Brooker, M.P. and Morris, D.L. (1980). A survey of the macro-invertebrate riffle fauna of the rivers Ystwyth and Rheidol, Wales. Freshwater Biology, 10: 459-474.

Bruce-White, C. and Shardlow, M. (2011). A Review of the Impact of Artificial Light on Invertebrates. Buglife – The Invertebrate Conservation Trust.

Davy-Bowker, J. (1995). Records of *Isogenus nubecula* Newman (Plecopt., Perlodidae) from the Welsh River Dee. Entomologist's Monthly Magazine. 131: 69-70.

Davy-Bowker, J. (2003). A survey of the Welsh River Dee for the rare stonefly *Isogenus nubecula* Newman in February 2003. A report by the Centre for Ecology & Hydrology, (Dorset) (Unpublished).

Davy-Bowker, J., Neale, M., Hammett, M.J. & Hull, M. (2007). An airlift study of the Welsh River Dee for the rare stonefly *Isogenus nubecula* Newman in January 2007. Bangor, Countryside Council for Wales, 10pp. (CCW Contract Science Report No. 793, CEH Report No. C02871/2007/1, Contract No. FC 73-01-580A) (Unpublished).

Fochetti, R. (2012). Fauna Europaea: Plecoptera. Fauna Europaea version 2.5, http://www.faunaeur.org

Hammett, M.J. & Wallace, I.D. (2005). A survey for the stonefly *Isogenus nubecula* (Newman) on the Welsh River Dee and its tributaries (December 2003 to April 2004). Countryside Council for Wales (Bangor), Contract Science Report No. 717.

Hammett, M.J. (2012). *Nemoura lacustris* Pictet, 1865 (Plecoptera: Nemouridae) - an addition to the British list. Entomologist's monthly magazine, 148(1772): 43-45.

Hynes, H.B.N. (1957). The British Taeniopterygidae (Plecoptera). Transactions of the Royal Entomological Society of London, 109: 233-243.

Hynes, H.B.N. (1963). *Isogenus nubecula* Newman in Britain (Plecoptera: Perlodidae). Proceedings of the Royal Entomological Society London (A). 38: 12-14.

Hynes, H.B.N. (1977). A key to the adults and nymphs of the British stoneflies (Plecoptera) with notes on their ecology and distribution. Scientific Publications of the Freshwater Biological Association, No. 17.

Hynes, H.B.N. (1977). A key to the adults and nymphs of the British stoneflies (Plecoptera) with notes on their ecology and distribution. Scientific Publications of the Freshwater Biological Association, No. 17.

IUCN. (1994). IUCN Red List categories and Criteria. Version 2.3, IUCN Species Survival Commission. IUCN, Gland.

IUCN. (2001). IUCN Red List categories and Criteria. Version 3.1, IUCN Species Survival Commission. IUCN, Gland & Cambridge.

IUCN. (2003). Guidelines for Application of IUCN Red List Criteria at Regional levels. Version 3.0, IUCN Species Survival Commission. IUCN, Gland.

IUCN. (2012a). IUCN Red List Categories and Criteria. Version 3.1. 2nd Edition, IUCN Species Survival Commission. IUCN, Gland.

Kimmins, D.E. (1936). Synonymic notes on the genera Chloroperla, Isopteryx and Isoperla (Plecoptera), with a list of the British species of Chloroperla. Journal of the Society for British Entomology, 1: 121-124.

Kimmins, D.E. (1943). *Rhabdiopteryx anglica*, a new British species of Plecoptera. Proceedings of the Royal Entomological Society of London, Series B, 12: 42-44.

Lillehammer, A. (1988). Stoneflies (Plecoptera) of Fennoscandia and Denmark. Fauna Entomologica Scandinavica, 21: 1-165.

Macadam, C.R. (2011). Species Dossier: *Isogenus nubecula*. Buglife – The Invertebrate Conservation Trust http://www.buglife.org.uk

Mace, G.M. and Lande, R. (1991). Assessing extinction threats: toward a re-evaluation of IUCN threatened species categories. Conservation Biology, 5(2): 148-157.

Millband, H. (1998). The status of the rare stonefly, *Isogenus nubecula*, in the middle Dee. A report by the Environment Agency, Welsh Region.

Mills, M.J. & Andrew, D. (1984). *Isogenus nubecula* Newman (Plecoptera: Perlodidae) in the Welsh River Dee. Entomologist's Gazette, 35: 45-51.

Moog, O. (1995). Functional-Feeding Guilds - Family/Genus Level. Fauna Aquatica Austriaca, Lieferungen 1995. Wasserwirtschaftskataster, Bundesministerium Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Wien.

Morris, D.L. and Brooker, M.P. (1979). The vertical distribution of macro-invertebrates in the substratum of the upper reaches of the River Wye, Wales. Freshwater Biology, 9: 573-583.

Shirt, D.B. (ed.) (1987). *British Red Data Books: 2.Insects*. Nature Conservancy Council, Peterborough.

Tanner, J.M. (1997). A survey of the Welsh River Dee for the rare stonefly *Isogenus nubecula*. A report by the Environment Agency, Welsh Region.

Wells, S., Pyle, R.M. and Collins, N.M. (1983). IUCN Invertebrate Red Data Book. IUCN, Gland. 632pp.

Zwick, P. (2011). Polymorphism and taxonomic problems in the *Perlodes microcephalus* group (Plecoptera: Perlodidae); *Perlodes mortoni* removed from synonymy. Illiesia, 7(26): 291-296.

Appendix 1. A complete listing of all species reviewed

Table A.

Species name	GB IUCN status (2013)	Qualifying criteria	Rationale	GB status (2014)	Global IUCN status (2010)	Presence in England	Presence in Scotland	Presence in Wales	AoO (hectads) <1989	AoO (hectads) 1990-2011	Dual hectads
Amphinemura standfussi	LC		Widespread though localised species, recent increase in number of records.	NS	None	E	S	W	37	56	2
Amphinemura sulcicollis	LC		Widespread species, recent increase in number of records.		None	E	S	W	133	448	58
Brachyptera putata	LC		Endemic species, thought now to be restricted to rivers in Highland Scotland, where it is relatively widespread. Previously recorded from the River Usk in Wales and the River Wye on English/Welsh border.	NS	None		S	W?	34	63	15
Brachyptera risi	LC		Widespread species, recent increase in number of records.		None	E	S	W	75	423	45
Capnia atra	DD		Few modern records for this species however this is almost certainly due to under-recording. Further recording effort is required before the status of this species can be assessed, however this species is likely to occur in less than 100 hectads.	NS	None	E	S		3	3	0

Capnia bifrons	LC		This is a widespread species however its habitat of living deep in the interstitial voids on the bed of rivers and streams until just before emergence means that it is often overlooked. Probably under-recorded and likely to occur in more than 100 hectads.		None	E	S	W	29	30	2
Capnia vidua anglica	DD		There are few verified records for this species however this is almost certainly due to under-recording as it known to occur at high altitude sites in the Scottish Highlands. Further recording effort is required before the status of this species can be assessed, however this species is likely to occur in less than 100 hectads.	NS	None	E	S	W	16	2	0
Chloroperla tripunctata	LC		Widespread species, recent increase in number of records.		None	E	S	W	54	174	15
Dinocras cephalotes	LC		Widespread species, recent increase in number of records.		None	E	S	W	147	272	103
Diura bicaudata	LC		This is a widespread upland species typically occurring at over 1000 metres. Very little routine surveying is undertaken at this altitude and it is therefore likely that this species is significantly under-recorded and occurs in more than 100 hectads.		None	E	S	W	39	76	12
Isogenus nubecula	CR(PE)	B2a, bii, biv	Last record is from 1995. Despite extensive surveys in the areas where this species has been previously recorded it has not been found since.	NR	None			W	8	3	3

Isoperla grammatica	LC	Widespread species, recent increase in number of records.	None	E	S	W	306	760	250
Isoperla obscura	RE	The last record of this species is from 1920. Widespread sampling of suitable watercourses by the Environment Agency and its predecessor organisations has not resulted in any further records.	None	E			4	0	0
Leuctra fusca	LC	Widespread species, recent increase in number of records.	None	E	S	W	99	433	36
Leuctra geniculata	LC	Widespread species, recent increase in number of records.	None	E	S	W	134	361	98
Euleuctra hippopus	LC	Widespread species, recent increase in number of records.	None	E	S	W	81	423	40
Leuctra inermis	LC	Widespread species, recent increase in number of records.	None	E	S	W	52	377	23
Leuctra moselyi	LC	This is a widespread species however it is superficially similar to *L. hippopus*. Many biologist do not separate these species and the recording scheme has many records listed as *Leuctra hippopus/moselyi*.	None	E	S	W	39	149	5
Leuctra nigra	LC	Widespread species, recent increase in number of records.	None	E	S	W	59	197	13
Nemoura avicularis	LC	Widespread species, recent increase in number of records.	None	E	S	W	63	218	29
Nemoura cambrica	LC	Widespread species, recent increase in number of records.	None	E	S	W	48	184	7
Nemoura cinerea	LC	Widespread species, recent increase in number of records.	None	E	S	W	122	282	26

Nemoura dubitans	LC	This species lives in seepages flowing through marshes. Whilst this is an often overlooked and undersurveyed habitat this species appears to be genuinely rare with only 14 modern records.	NR	None	E			13	14	2
Nemoura erratica	LC	Widespread species, recent increase in number of records.		None	E	S	W	68	126	22
Nemoura lacustris	DD	Discovered in 2011 and therefore too early to assign a threat category.	NR	None	E			0	1	0
Nemurella pictetii	LC	Widespread species, recent increase in number of records.		None	E	S	W	70	229	33
Perla bipunctata	LC	Widespread species, recent increase in number of records.		None	E	S	W	47	156	16
Perlodes mortoni	LC	Widespread species, recent increase in number of records.		None	E	S	W	143	434	98
Protonemura meyeri	LC	Widespread species, recent increase in number of records.		None	E	S	W	93	330	41
Protonemura montana	DD	Difficulties with the separation of this species from *P. praecox* makes determining the status of this species in GB difficult, however this species is likely to occur in less than 100 hectads.	NS	None	E	S	W	18	12	1
Protonemura praecox	LC	Difficulties with the separation of this species from *P. montana* makes determining the status of this species in GB difficult. It is however thought to be widely distributed and therefore the Least Concern category has been applied.		None	E	S	W	38	83	4

Rhabdiopteryx acuminata	VU	D2	This species has a highly restricted distribution.	NR	None	E		W	16	5	0
Siphonoperla torrentium	LC		Widespread species, recent increase in number of records.		None	E	S	W	82	488	36
Taeniopteryx nebulosa britannica	LC		Widespread species, recent increase in number of records.		None	E	S	W	109	176	46

Appendix 2. IUCN Criteria and Categories

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

Use any of the criteria A–E	**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 (up to a maximum of 100 years) where the time period must include both the past and the 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)	< 100km²	< 5,000km²	< 20,000km²
B2. Area of occupancy (AOO)	< 10km²	< 500km²	< 2,000km²

AND at least 2 of the following:

(a) Severely fragmented, **OR**

Number of locations	= 1	≤ 5	≤ 10

(b) Continuing decline 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 either C1 or C2:			
C1. An estimated continuing decline of at least: (up to a max. of 100 years in future)	25% in 3 years or 1 generation	20% in 5 years or 2 generations	10% in 10 years or 3 generations
C2. A continuing decline **AND** (a) and/or (b):			
(a i) Number of mature individuals in each subpopulation: **or**	< 50	< 250	< 1,000
(a ii) % 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
			AND/OR
VU D2. 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 < 20km² 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 (100 years max.)	≥ 20% in 20 years or 5 generations (100 years max.)	≥ 10% in 100 years

INDEX