Verification Rules for NBN Record Cleaner

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Revision	Date	Author	Comments
0	March 2013	H Dean	First draft – for review
1	June 2013	H Dean	Amended with comments from recording schemes
2	July 2013	H Dean	Update to new rule definition

Contents

1. Introduction

The NBN Record Cleaner is a tool designed to improve the quality of species records by applying a series of rules to check for errors in the data. The first set of checks *validates* the data against a set of in-built rules, such as checking spelling of species names or spotting incorrect dates (e.g. 31st February). The second set of checks *verifies* the data against a set of taxon specific rules which are developed and maintained by relevant experts.

This report details the methods for and results of creating verification rules for the following taxon groups: aculeate Hymenoptera (bees, wasps and ants), Isopods and Myriapods (centipedes, millipedes and woodlice), Coccinellidae (ladybirds), Orthoptera (grasshoppers, crickets and their allies), terrestrial Heteroptera (plant bugs, shieldbugs and their allies), Auchenorrhyncha (leaf hoppers and frog hoppers), Ephemeroptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddisflies), Carabidae (ground beetles), larger Brachycera (robberflies, soldierflies and their allies), Amphibia (amphibians) and Reptilia (reptiles). This work was co-ordinated by the Biological Records Centre (BRC) with 14 recording schemes providing the expertise (Section 2 provides a complete list).

The first part of the report (Section 3) details the methods employed to create the verification rules. The second part (Sections 4 to 13) provides a breakdown, per taxon group, of the results, including identification difficulty grading descriptions, a list of any sensitive species, essential and desirable attribute fields for species records, and a protocol for dealing with records which fail any of the rules. Two new rules have also been developed; one to verify a species record regardless of whether any of the other rules flag up the record and one which highlights rare species. Details of how the rules have been developed and protocols to follow should they highlight any records are provided in sections 4 to 13. The final section (Section 14) provides recommendations for the frequency of review of the rule files and other improvements.

2. Acknowledgements

The contacts below have provided the expertise to create the verification rules for their respective groups:

	Recording Scheme	Contact
	Biological Records Centre	Hannah Dean David Roy Colin Harrower http://www.brc.ac.uk/
	Bees, Wasps and Ants Recording Scheme	Mike Edwards http://www.bwars.com/
	Centipede Recording Scheme Millipede Recording Scheme Woodlice Recording Scheme	Paul Lee http://www.bmig.org.uk/
	UK Ladybird Survey	Peter Brown Helen Roy http://www.ladybird-survey.org/
	Orthopteroids of the British Isles Recording Scheme	Björn Beckmann Peter Sutton http://www.orthoptera.org.uk/
	Terrestrial Heteroptera Recording Scheme	Tristan Bantock Jim Flanagan http://www.britishbugs.org.uk/
	Auchenorrhyncha Recording Scheme for Britain and Ireland	Alan Stewart http://www.ledra.co.uk/
riverfly recording schemes	Ephemeroptera Recording Scheme Plecoptera Recording Scheme	Craig Macadam http://www.riverflies.org/riverfly-recording-schemes
	Trichoptera Recording Scheme	Ian Wallace http://www.riverflies.org/riverfly-recording-schemes
	Ground Beetle Recording Scheme	Mark Telfer
	Larger Brachycera Recording Scheme	Martin Harvey http://www.dipteristsforum.org.uk/
amphibian and reptile conservation	National Amphibian and Reptile Recording Scheme	John Wilkinson http://www.narrs.org.uk/

3. Method for Verification Rule Production

The following procedure was used to develop the verification rules for all recording schemes:

1. The first step was to ensure that the BRC held the most recent and up-to-date copy of the data for each Recording Scheme. Where new data were available from the Recording Schemes, it sent to the BRC and run through various validation and verification procedures before loading into the BRC database.
2. A species list, with recommended NBN taxon version key and name, was agreed between the BRC and the recording scheme. The number of species covered by the verification rules can be found in Table 3.1.
3. An R script was used to pull data from the BRC database and produce a document containing 5 maps and a phenogram for each species on a single page. The five maps contained the spatial distribution for each species, as predicted by 5 different methods, at a 10km square resolution. The phenogram showed the distribution of species records throughout the year. A brief description of each map method can be found in Table 3.2 and an example of the maps and phenogram can be found in Appendix 1.
4. The map and phenogram documents were sent to the Recording Schemes, who decided which map best described the distribution of the species.
5. The Recording Schemes also provided the ID difficulty gradings and definitions for each species.
6. The Recording Schemes also provided data to generate rules for the period of the year a species could be recorded in (using the phenogram as a guide) and the earliest and latest year a species may be recorded (if appropriate) without being highlighted as requiring further investigation.
7. In addition to providing data for creating the rules, the Recording Schemes also provided a list of species which are considered sensitive and a reason for why they are considered sensitive (output 7); the essential and desirable attribute fields of a species record (output 1) and the procedure that should be followed should any species records be highlighted by the rules in Record Cleaner (output 2).
8. The geographic distribution data, seasonal range data, year range data and identification difficulty data were then used by the BRC to create the rule files (outputs 4, 5, 6 and 3 respectively). The geographic rule files, seasonal range rule files and year range rule files were created via an automated process using a specially developed R script.
9. The Recording Schemes also provided information on rare species and on which species should have their records verified regardless of any of the rule results. These data were used to create a new rule: verify record. The definitions of rare species and the criteria for always verifying a record are provided in this report.

10. All the data and information provided by the Recording Scheme used to create the rule files have been collated into a single database. This combined with the automation of rule files by using the R script should allow the verification rules to be created, and updated quickly and easily in the future.

For more information about using the verification rule R scripts, please contact the BRC.

Table 3.1: Taxon groups and the number of species covered by the verification rules

Taxon Group	Number of Species
Aculeate Hymenoptera (bees, wasps and ants)	625
Myriapods and Isopods (centipedes, millipedes and woodlice)	188
Coccinellidae (ladybirds)	53
Orthoptera and allies (grasshoppers, crickets and allies)	78
Terrestrial Heteroptera (shieldbugs, plant bugs and allies)	490
Auchenorrhyncha (leafhoppers and froghoppers)	392
Riverflies (caddisflies, mayflies and stoneflies)	281
Carabidae (ground beetles)	369
Larger Brachycera (soldierflies and allies)	164
Amphibia and Reptilia (amphibians and reptiles)	33

Table 3.2: Name and description of map or diagram produced by the BRC for use by the Recording Schemes in determining the data to be used for generating the rule files. Also refer to Appendix 1.

Map/Diagram Name	Description
Observed Distribution	Observed distribution shows the 10km squares where the species has been recorded, taken from taxon occurrence data in the BRC database. The number in brackets shows how many 10km squares are occupied.
Neighbour Smoothed	Neighbour smoothed is based on the observed distribution but assumes that if a 10km square is occupied then the eight 10km squares surrounding the occupied square (the neighbouring squares) will also have the same species present. The dark green squares are the observed distribution and the light green squares are the neighbouring squares.
Frescalo Neighbourhood	Frescalo neighbourhood estimates the frequency of a species being found in a 10km square based on the frequency of the species being present in the neighbourhood. These are created using the Frescalo programme (Hill, 2012). The yellows are low frequency with red squares having a high frequency.

Map/Diagram Name	Description
Frescalo Adjusted	Frescalo adjusted estimates the frequency of the species being found in a 10km square based on the frequency of the species being present in the neighbourhood and on the recorder effort, so where a square has low recorder effort the frequency of species will be increased to compensate for this. Again, these are produced using the Frescalo programme (Hill, 2012). The yellows are low frequency with red squares having a high frequency.
Species Distribution Model	The species distribution model (Random Forest) uses environmental variables (geology, climate, habitat) and the species occurrence records to calculate the expected frequency of the species in any 10km square. The yellows are low frequency with red squares having a high frequency.
Phenogram	The phenogram is a histogram, which shows the number of records that have been recorded in each month.

4. Aculeate Hymenoptera (bees, wasps and ants)

4.1 Attribute fields for new records

4.1.1 Essential fields

The essential fields for bee, wasp and ant species records are detailed in Table 4.1.

Table 4.1: Essential fields for bee, wasp and ant species records

Field Name	Description
Species name	
Species number	Old-style BRC species code as shown on the BWARS web-site.
Grid reference	This can be obtained from the Ordnance Survey map or via various online sources and should be as accurate as practicable. 6-figure references are best if possible, e.g. SU822215.
Locality	The name by which you know the locality; it is best if this name, or part of it, appears on the 1:50000 O.S. map for the area.
Date of Record	Give in form dd/mm/yyyy, e.g. 02/07/2001 or as three separate entries DD MM YYYY. IT IS VITAL THAT EITHER OF THESE FORMATS IS USED. Use spaces (S), not zeros to show unknown details; unknown day can be shown as SS/07/2004, unknown months as SS/SS/2004. Please do not use spread dates, e.g. 14-21 July 2001, in submitted data. For this use an allocated date, this can be either 17/07/2001 or SS/07/2001 using a representative day or no day at all.
Collector	Name of the person who made the record.
Determiner	Name of the person who identified the species recorded.
Source of data	If the insect supporting the record is available for further inspection. This may well be necessary in some very difficult to identify species or for records outside the normally known range of the species. Record where this voucher is held, or the publication the record is taken from, including field notebooks!
Watsonian Vice-County name	This is used as a quick check for mis-read grid references. Do not worry about being very accurate where two counties adjoin. Maps of Watsonian V.C.s can be obtained from the Biological Records Centre and a link on the BWARS website.

4.1.2 Desirable fields

The following are desirable fields for bee, wasp and ant species records:

- Flowers visited
- Pollen collected
- Prey/host
- Additional data

4.2 Procedure for dealing with records highlighted by Record Cleaner

A queried record should be refused on the first pass. Then:

1. If there is no reference specimen, possibly photo – decline record.
2. Re-check the determination against known reference specimens – we all have to do this at times, so even being given the nudge is valuable.
3. If the determination holds then submit to a third party with more experience. The BWARS Enquiry Secretary will forward requests for help to one of the team of verifiers if no-one is known to the recorder.
4. Re-submit, giving details of checking carried out. This needs to be flagged to make the process more valuable.

4.3 Verification rule sets

4.3.1 Identification difficulty rules

Each species of bee, wasp and ant was given an identification difficulty grade (Table 4.2)

Table 4.2: Identification difficulty grades and their definitions for bees, wasps and ants

ID Difficulty Grade	ID Difficulty Definition
1	Can be identified at sight in the field by anyone with a bit of experience. Species with which the beginner rapidly becomes familiar. Usually identifiable from a photo.
2	Can be identified in the field with care and experience. Needs a good view or the netting of a specimen to check, but the specimen can then be released. May be identifiable from a good photo, or series of photos.
3	Identification only accepted from known recorders or else needs confirmation from vice county recorder.
4	Species needs confirmation from national expert.
5	Voucher specimen required to be examined by national expert.

4.3.2 Spatial distribution rules

Frescalo adjusted distributions were used to create the spatial distribution rule files for bees, wasps and ants.

Post-1980 records only have been used in the creation of the rules.

4.3.3 Temporal rules – seasonal range

Rules have been created for species where there is a limited period within the year that a record would be acceptable. Where there is no rule file, records from any date within the year are acceptable.

4.3.4 Temporal rules – year range

No rules have been created for temporal year range as records from any year are considered acceptable.

4.3.5 Verify record rule

The 'verify record' rule has been used for species records where the species is new, establishing, spreading or rare. Rare species are defined as those with less than 500 records post-1980 and are on the current Red List.

4.4 Sensitive Records

There are no species of bees, wasps or ants that are considered sensitive.

5. Myriapods and Isopods (centipedes, millipedes and woodlice)

5.1 Attribute fields for new records

5.1.1 Essential fields

The following are essential fields for centipede, millipede and woodlouse species records:

- Taxon name
- Sex and stage of specimen named
- Location name that is recognisable from an OS map to enable cross checking with grid reference
- OS grid reference, ideally a six figure reference giving position at which taxon was found, not the centroid for the site
- Date on which taxon was observed or collected
- Name of recorder, i.e. person who observed or collected taxon
- Name of determiner, i.e. person who identified taxon

5.1.2 Desirable fields

The following are desirable fields for centipede, millipede and woodlouse species records:

- Habitat descriptor
- Microsite
- Altitude
- Slope and aspect
- Soil type
- Geology
- Collection method
- Quantity of each sex and stage
- Availability of voucher specimen
- Whether dissection of genitalia was used in identification
- Method for contacting recorder and / or determiner if not already known to the British Myriapod and Isopod Group (BMIG) to enable records to be followed up
- Watsonian vice county
- Other observation e.g. parasites, predators, prey, site management

5.2 Procedure for dealing with records highlighted by Record Cleaner

BMIG operates three recording schemes, each with a national organiser. A small number of counties have their own area recorder but coverage is very patchy. Therefore records which fall outside the verification rules should initially be referred to the relevant national organiser. The national organiser (Table 5.1) will be in the best position to decide if the record can be dealt with by an experienced local recorder or if they need to deal with it themselves.

Table 5.1: National organisers for the three BMIG recording schemes

Recording Scheme	National Organiser
Centipede Recording Scheme http://www.bmig.org.uk/page/centipede-recording-scheme	Tony Barber
Millipede Recording Scheme http://www.bmig.org.uk/page/millipede-recording-scheme	Paul Lee
Woodlice & Waterlice Recording Scheme http://www.bmig.org.uk/page/woodlice-waterlice-recording-scheme	Steve Gregory

5.3 Verification rule sets

5.3.1 Identification difficulty rules

Each species of centipede, millipede and woodlouse was given an identification difficulty grade (Table **5.2**).

Table 5.2: Identification difficulty grades and their definitions for centipedes, millipedes & woodlice

ID Difficulty Grade	ID Difficulty Definition
1	Can be identified in the field by anyone with a little experience. Species with which the beginner rapidly becomes familiar. May be identifiable from a good photo. Records accepted from most sources.
2	Can be identified in the field with care and experience but needs a good view or examination with a good quality lens. Beginners should take voucher specimens until they gain familiarity and experience. Records accepted from known competent recorders.
3	Voucher specimen needs checking under magnification and good lighting. Beginners should get specimens checked at first until they gain experience. Records accepted from known experienced recorders without further question unless the date, region or habitat was especially unusual. Voucher specimen should be retained.
4	Adult voucher specimens of either one or both sexes need careful dissection. Records accepted from known experienced recorders familiar with the species. Voucher specimen should be retained. If the recorder is not familiar with the species then a voucher specimen should be checked by an expert who is.

ID Difficulty Grade	ID Difficulty Definition
5	Adult voucher specimens of either one or both sexes need careful dissection and to be examined by national expert. Even the most experienced of recorders may need to seek a second opinion from an acknowledged expert. Specimen may need to be submitted to experts elsewhere in Europe for comparison with a wider range of material.

5.3.2 Spatial distribution rules

Post-1980 records only have been used in the production of the spatial distribution rules, with the exception of *Geophilus proximus*, where the only record dates to 1974.

A mixture of observed distributions and neighbour smoothed distributions has been used to create the spatial distribution rule files.

5.3.3 Temporal rules – seasonal range

Rules have been created for species where there is a limited period within the year that a record would be acceptable. In the majority of cases there is no rule file as records from any date within the year are acceptable.

5.3.4 Temporal rules – year range

Rules have been created for species for the earliest year that a record is considered acceptable. There are currently no rules for the latest year that a record is considered acceptable.

5.3.5 Verify record rule

This rule has been applied to rare species and to some species where taxonomic status is uncertain and more specimens are required. Rare species have been defined as those that occur in 15 or fewer hectads (10km square).

5.4 Sensitive Records

There are no species of centipedes, millipedes and woodlice that are considered sensitive.

6. Coccinellidae (ladybirds)

6.1 Attribute fields for new records

6.1.1 Essential fields

The following are essential fields for ladybird species records:

- Species name
- Locality
- GB grid reference (or post code if grid reference not known)
- Date of record
- Recorder

6.1.2 Desirable fields

The following are desirable fields for ladybird species records:

- Adult colour form
- Life stage
- Abundance
- Vice county
- Host plant associations
- Habitat
- Survey method
- Determiner
- Additional comments pertinent to the record

6.2 Procedure for dealing with records highlighted by Record Cleaner

Any records that are highlighted by the Record Cleaner rules should be referred to the UK Ladybird Survey scheme organisers (ladybird-survey@ceh.ac.uk).

6.3 Verification rule sets

6.3.1 Identification difficulty rules

Each species of ladybird was given an identification difficulty grade (Table 6.1).

Table 6.1: Identification difficulty grades and their definitions for ladybirds

ID Difficulty Grade	ID Difficulty Definition
1	Can be identified in the field by anyone with a bit of experience. Species with which the beginner rapidly becomes familiar. Usually identifiable from a photo.
2	Can be identified in the field with care and experience. May be identifiable from a good photo.
3	Identification only accepted from known recorders or else needs confirmation from vice county recorder or UK Ladybird Survey (UKLS).
4	Species needs confirmation from national expert / UKLS.
5	Voucher specimen required to be examined by national expert / UKLS.

6.3.2 Spatial distribution rules

All species records have been used to create the spatial distribution rules.

A mixture of observed distributions, neighbour smoothed distributions, Frescalo adjusted distributions (at frequencies between 0 and 0.2) and Frescalo neighbourhood distributions (at frequencies of 0.1 or 0.2) has been used to create the rules.

6.3.3 Temporal rules – seasonal range

No seasonal range rule files have been created for ladybird species as records from any month of the year are acceptable.

6.3.4 Temporal rules – year range

Rules have been created for ladybird species for the earliest year that a record is considered acceptable. There are currently no rules for the latest year that a record is considered acceptable.

6.3.5 Verify record rule

The 'verify record' rule has been used for species which are potential new arrivals or occasional visitors, species which were thought to be extinct from the UK, or rare. Rare species are defined as species with either under 100 records or under 50 hectads in the Ladybirds of Britain and Ireland atlas (Roy *et al*, 2011). This applies to 10 of the 46 species, plus vagrants.

6.4 Sensitive Records

There are no ladybird species that are considered sensitive.

7. Orthoptera and allies (grasshoppers, crickets and allies)

7.1 Attribute fields for new records

7.1.1 Essential fields

The following are essential fields for species records of grasshoppers, crickets and allies:

- Species name
- Grid reference
- Date
- Recorder

7.1.2 Desirable fields

The following are desirable fields for species records of grasshoppers, crickets and allies:

- Locality
- Vice county
- Determiner
- Comments
- Habitat
- Life stage
- Method
- Number of males
- Number of females

7.2 Procedure for dealing with records highlighted by Record Cleaner

Any records that are highlighted by the Record Cleaner rules should be referred to the recording scheme organiser (orthoptera@ceh.ac.uk), who will either verify it or contact the recorder for additional information.

7.3 Verification rule sets

7.3.1 Identification difficulty rules

Each species of grasshopper, cricket and ally was given an identification difficulty grade (Table 7.1).

Table 7.1: Identification difficulty grades and their definitions for grasshoppers, crickets and allies

ID Difficulty Grade	ID Difficulty Definition
1	Can be identified at sight in the field by anyone with a bit of experience. Species with which the beginner rapidly becomes familiar. Usually identifiable from a photo.
2	Can be identified in the field with care and experience. Needs a good view or the netting of a specimen to check, but the specimen can then be released. May be identifiable from a good photo, or series of photos.
3	Identification only accepted from known recorders or else needs confirmation from vice county recorder.
4	Species needs confirmation from national expert.
5	Voucher specimen required to be examined by national expert.

7.3.2 Spatial distribution rules

All species records have been used to create the spatial distribution rules.

A mixture of observed distributions and neighbour smoothed distributions has been used to create the rules.

7.3.3 Temporal rules – seasonal range

Rules have been created for species where there is a limited period within the year that a record would be acceptable. In the majority of cases there is no rule file as records from any date within the year are acceptable.

7.3.4 Temporal rules – year range

Rules have been created for species for the earliest year that a record is considered acceptable. There are currently no rules for the latest year that a record is considered acceptable.

7.3.5 Verify record rule

This rule has been created for species of grasshoppers, crickets and allies which are considered rare. Rare species have been defined as any species with less than 15 hectads since 1980, or declined below that number since then.

7.4 Sensitive Records

There are no species of grasshoppers, crickets and allies that are considered sensitive.

8. Terrestrial Heteroptera (shieldbugs, plant bugs and allies)

8.1 Attribute fields for new records

8.1.1 Essential fields

The essential fields for species records of shieldbugs, plant bugs and allies are detailed in Table 8.1.

Table 8.1: Essential fields for species records of shieldbugs, plant bugs and allies

Field Name	Description
Species name	A recognised species name with associated TVK from the NHM Species Inventory that provides unequivocal recognition of the taxon. Higher levels of taxonomic resolution (e.g. species-group or genus, especially where distinctions between closely-related species are problematic) are of little value even though this may be all that is possible with certain specimens (e.g. females of certain species). Very few members of this group have vernacular names (notable exceptions are the BAP Priority Species) that are widely accepted and recognised. All records should therefore use the scientific name.
Location/site name	Ideally this should be a name that appears on an Ordnance Survey map. May refer to a large area with a more precise location recorded as a sub-site or compartment in a separate field.
Grid-reference	An Ordnance Survey grid-reference to at least a 1km resolution (4-figure) but ideally to 100m resolution (6-figure). 10m resolution grid-references (8-figure) may be useful in certain rare circumstances (e.g. to locate an isolated patch of host plant) but recorders should avoid spurious precision. Hectad (10km) records are of little value except for national distribution mapping. Tetrad (2km) records may be acceptable as part of a survey operating at this scale. All grid references should be presented as a continuous string without spaces or separators, in the following sequence: 100km grid square, easting, northing (e.g. TQ123456). The 100km grid square should be given in letter rather than numeric format. Postcodes are not ideal but can usually be converted to grid-references if recorders are unfamiliar with the OS grid system.
Date	Single dates should ideally be provided in numeric dd/mm/yyyy format. Other formats (e.g. dd.mm.yy, dd-month-yyyy) can be accepted but require conversion to dd/mm/yyyy format before they can be incorporated into the database. Vague dates (e.g. 2010 or June 1990) should be avoided wherever possible, as should pre/post dates (e.g. pre-1960). There are circumstances when date can only be recorded as a range (e.g. 10-20 June 2005), for example records from traps (e.g. pitfall, Malaise) operated continuously over several days. In such cases, it is best to provide the start date in the date field and the full date range (start and end date) as text in the comments field.
Recorder name	Refers to the observer, recorder or collector. This is essential information to enable further investigation of the record if necessary and to establish 'ownership'. Ideally should be in the format <<*Surname, initials*>> to enable efficient sorting by surname. Given name(s) can be provided in full. Omit title. Avoid multiple names. A record without a recorder name can still be accepted in some circumstances (e.g. old records), especially for rare species.

8.1.2 Desirable fields

The desirable fields for species records of shieldbugs, plant bugs and allies are detailed in Table 8.2.

Table 8.2: Desirable fields for species records of shieldbugs, plant bugs and allies

Field Name	Description
Sex	Some species in this group are sexually dimorphic, males often being easier to identify compared to females. Thus, sex may be an important piece of information for assessing the reliability of a record. The two sexes tend to have temporally displaced phenologies, adult males tending to emerge earlier and die earlier than adult females. Gender information is therefore useful for gaining an understanding of seasonal phenologies. If both sexes have been recorded, this should ideally be reported as two separate records.
Stage	Adult or nymph. Although the nymphal stages of many heteropteran species cannot be identified to species with sufficient confidence, the nymphal stages of most species are more easily recongisable and are recorded frequently.
Abundance	Free text field to allow recorders to indicate abundance. No particular abundance scale adopted at the moment, but this may change in future. It is useful to know if the record refers to a single individual, a small number of individuals, or many. Use of zero to indicate presence (as in MapMate) should be avoided.
Vice County	Watsonian Vice-County. This information is very useful when verifying the locational information. Can be provided either as a name (e.g. East Suffolk) or a numeric code (25). BSBI on-line website can be used to establish the vice-county by entering a grid reference.
Habitat_Species	Free text to allow recorders to describe the immediate habitat, such as associated plant species.
Habitat_Locality	Free text to allow recorders to describe the habitat present at the location. There is no obvious habitat classification system that would be appropriate to use here (both simple to use and providing useful information).
Method	Field method used to collect the record. Regular methods include: sweep-netting; beating; direct observation; hand searching; suction/vacuum sampling; various trapping methods (pitfall, Malaise, water, light, flight interception, sticky).
Determiner	Name of the person who determined the record.
Comments	An open-text field used to capture any extra information of relevance, such as feeding behaviour

8.2 Procedure for dealing with records highlighted by Record Cleaner

Records highlighted by the rules in Record Cleaner should be sent to the recording scheme organiser or delegated national expert. The actions detailed in Table 8.3 will be applied and the record will be assigned one of the classifications detailed in Table 8.4.

Table 8.3: Actions to be taken by recording scheme organiser for records highlighted by rules

Problem highlighted by Record Cleaner	Action to be taken by Recording Scheme Organiser
Recorder known or suspected to be inexperienced in identifying Heteroptera	Accept only ID Category 1 records without further information. Suggest that recorder submits further evidence (e.g. photograph, specimen) for species in ID Category 2 or higher.
Geo-referencing incorrect (grid-reference format not valid, does not match site name or vice county, or grid square contains no land)	Check site name against 100km square. Use on-line facilities to check stated grid-reference against OS map and vice county. If plausible alternative grid-reference found, verify this with recorder. If no (or more than one) alternative grid-reference found, refer back to recorder for further detail or investigation.
Invalid date	Refer back to recorder
Stated date pre-dates 'Temporal Year Start'	Refer back to recorder, explaining that record pre-dates earliest known record for the species.
Stated date outside 'Acceptable Temporal Seasonal'	Refer back to recorder, explaining that record is outside the season defined in rule set for species.
Location outside known range or probability for species as defined by rule set	Check whether record lies outside Extent of Occurrence. If within EoO, critically assess likelihood of record based on location in relation to rest of species range, habitat (if stated), season, recorder expertise (if known) etc. If uncertain/doubtful, refer back to recorder. If outside EoO, assess whether record may be plausible extension of range based on known history of recent expansion. If uncertain/doubtful, refer back to recorder.
Recorder's known or suspected expertise does not match ID difficulty of species	Ask recorder how confident s/he is of identification, what method was used (e.g. +/- dissection), what characters were used, what identification key or other literature was used. Suggest they should seek another opinion or submit a specimen to an expert verifier.
Species in ID Category 4	Critically assess likelihood of record based on evidence (e.g. Location, season) and known competence of recorder. If uncertain/doubtful, request specimen is examined by an acknowledged expert.
Species in ID Category 5	Request that specimen is examined by an acknowledged expert.
Rare species	Check that all record details are plausible and that recorder's competence matches or exceeds ID difficulty category. If satisfied, accept record; otherwise call for further evidence and/or specimen.

Problem highlighted by Record Cleaner	Action to be taken by Recording Scheme Organiser
Flagged by 'Verify record' field in Record Cleaner	Such species will be either (a) already picked up by other Record Cleaner criteria or (b) newly-arrived species where it will be useful to monitor their future spread. All details of the record should be scrutinised to make sure that they are plausible.

Table 8.4: Definitions of record classification

Record Classification	Definition for the purposes of Auchenorrhyncha recording
Correct	Records where specimen or good quality photograph has been checked and identification confirmed by an expert verifier (may or may not have previously passed Record Cleaner test).
Considered correct	(a) Records that pass Record Cleaner but where neither a specimen nor a photograph has been checked by an expert verifier. (b) Records highlighted by Record Cleaner but where subsequent investigation (by expert assessment of evidence, correspondence with recorder or provision of photograph) satisfies the expert verifier that the record is correct.
Requires confirmation	Records highlighted by Record Cleaner, considered plausible by expert verifier, but still require some form of confirmation (e.g. specimen, photograph).
Considered incorrect	Records that fail Record Cleaner and either (a) expert assessment concludes that record is unlikely to be correct, or (b) requested extra evidence and/or specimen has not been forthcoming.
Incorrect	Records where a voucher specimen or photograph has been checked by an expert verifier and shown to be incorrect (may or may not be possible to provide an alternative confirmed identification).
Unchecked	Records that have not yet been processed by Record Cleaner.

8.3 Verification rule sets

8.3.1 Identification difficulty rules

Each species of shieldbug, plant bug and ally was given an identification difficulty grade (Table 8.5).

Table 8.5: Identification difficulty grades and their definitions for shieldbugs, plant bugs and allies

ID Difficulty Grade	ID Difficulty Definition
1	Can be identified in the field by anyone with a bit of experience. Species which beginners can rapidly learn to identify. Usually identifiable from a photo. Records acceptable from most sources.
2	Can be identified in the field with care and experience. Needs a good view or capture followed by examination with a good quality lens. Beginners should take voucher specimens until they gain familiarity and experience. May be identifiable from a good photo. Records acceptable from competent recorders.

ID Difficulty Grade	ID Difficulty Definition
3	Species that require examination of external characters (including externally visible genitalia structures) under a microscope with good lighting, but where identification is then relatively straightforward. May apply to females of species in which identification of males is easier. Identification accepted from experienced recorders (unless season, region or habitat is unusual), but less experienced ones would be expected to provide a specimen.
4	Species that are difficult to identify, often requiring dissection (although identification may not be conclusive in females). All except very experienced recorders could be expected to provide a specimen, particularly if the record is outside the known season or geographic range of the species.
5	Species that can only be identified following critical assessment, usually involving dissection and microscopic examination of genitalia. A specimen should always be retained for confirmation. May require consultation of specialist literature or comparison with verified reference material. Identification needs confirmation by a national expert. Even experienced recorders should seek a second opinion.

8.3.2 Spatial distribution rules

A mixture of observed distributions, Frescalo adjusted distributions (mostly with a frequency cut-off at 0 or 0.1) and Species Distribution Model distributions (mostly with a frequency cut-off at 0 or 0.1) has been used to create the spatial distribution rulefiles.

All species records have been used in the production of the spatial distribution rules.

8.3.3 Temporal rules – seasonal range

Rules have been created for species where there is a limited period within the year that a record would be acceptable. Where no rule file exists, records from any date within the year are acceptable.

8.3.4 Temporal rules – year range

Rules have been created for species for the earliest acceptable date for a record. There are currently no rules for latest acceptable date.

8.3.5 Verify record rule

Species which are considered rare or are new arrivals should be verified by the scheme organiser regardless of the whether the rule passes or fails any other rules. In many cases the data for these species are scarce so no geographic or temporal rules can be created for them.

A species is regarded as 'rare' if:

- The species was designated Notable or Rare during the last status review (Kirby, 1992) and has not since undergone significant range expansion.
- The species has declined significantly in the period since the last review and would now probably qualify as Notable or Rare.

- The species is a recent arrival in Britain and still has a very restricted distribution (<30 hectads).

8.4 Sensitive Records

There are no species of shieldbugs, plant bugs or allies that are considered sensitive.

9. Auchenorrhyncha (leafhoppers and froghoppers)

9.1 Attribute fields for new records

9.1.1 Essential fields

The essential fields for leafhopper and froghopper records are detailed in Table 9.1.

Table 9.1: Essential fields for leafhopper and froghopper species records

Field Name	Description
Species name	A recognised species name with associated TVK from the NHM Species Inventory that provides unequivocal recognition of the taxon. Higher levels of taxonomic resolution (e.g. species-group or genus, especially where distinctions between closely-related species are problematic) are of little value even though this may be all that is possible with certain specimens (e.g. females of certain species). Very few members of this group have vernacular names (notable exceptions are the BAP Priority Species) that are widely accepted and recognised. All records should therefore use the scientific name.
Location/site name	Ideally this should be a name that appears on an Ordnance Survey map. May refer to a large area with a more precise location recorded as a sub-site or compartment in a separate field.
Grid-reference	An Ordnance Survey grid-reference to at least a 1km resolution (4-figure) but ideally to 100m resolution (6-figure). 10m resolution grid-references (8-figure) may be useful in certain rare circumstances (e.g. to locate an isolated patch of host plant) but recorders should avoid spurious precision. Hectad (10km) records are of little value except for national distribution mapping. Tetrad (2km) records may be acceptable as part of a survey operating at this scale. All grid references should be presented as a continuous string without spaces or separators, in the following sequence: 100km grid square, easting, northing (e.g. TQ123456). The 100km grid square should be given in letter rather than numeric format. Postcodes are not ideal but can usually be converted to grid-references if recorders are unfamiliar with the OS grid system.
Date	Single dates should ideally be provided in numeric dd/mm/yyyy format. Other formats (e.g. dd.mm.yy, dd-month-yyyy) can be accepted but require conversion to dd/mm/yyyy format before they can be incorporated into the database. Vague dates (e.g. 2010 or June 1990) should be avoided wherever possible, as should pre/post dates (e.g. pre-1960). There are circumstances when date can only be recorded as a range (e.g. 10-20 June 2005), for example records from traps (e.g. pitfall, Malaise) operated continuously over several days. In such cases, it is best to provide the start date in the date field and the full date range (start and end date) as text in the comments field.
Recorder name	Refers to the observer, recorder or collector. This is essential information to enable further investigation of the record if necessary and to establish 'ownership'. Ideally should be in the format <<*Surname, initials*>> to enable efficient sorting by surname. Given name(s) can be provided in full. Omit title. Avoid multiple names. A record without a recorder name can still be accepted in some circumstances (e.g. old records), especially for rare species.

Field Name	Description
Determiner name	Often the same person as the recorder but may be different if recorder is inexperienced and requires assistance. Guidelines are same as for recorder name.

9.1.2 Desirable fields

The desirable fields for leafhopper and froghopper records are detailed in Table 9.2.

Table 9.2: Desirable fields for leafhopper and froghopper species records

Field Name	Description
Sex/gender	Many species in this group are sexually dimorphic, males often being easier to identify compared to females. Thus, gender may be an important piece of information for assessing the reliability of a record. The two sexes tend to have temporally displaced phenologies, adult males tending to emerge earlier and die earlier than adult females. Gender information is therefore useful for gaining an understanding of seasonal phenologies. If both sexes have been recorded, this should ideally be reported as two separate records.
Stage	Adult or nymph. Historically, recorders have rarely reported nymphal stages except in the case of species with highly distinctive nymphs (e.g. *Ledra aurita*, *Cicadella viridis*). However, a key to the final-instar nymphs of all species is currently in preparation, so it can be expected that more records of nymphal stages will be submitted in future.
Abundance	Free text field to allow recorders to indicate abundance. No particular abundance scale adopted at the moment, but this may change in future. It is useful to know if the record refers to a single individual, a small number of individuals, or many. Use of zero to indicate presence (as in MapMate) should be avoided.
Vice County	Watsonian Vice-County. This information is very useful when verifying the locational information. Can be provided either as a name (e.g. East Suffolk) or a numeric code (25). BSBI on-line website can be used to establish the vice-county by entering a grid reference.
Habitat	Free text to allow recorders to describe the habitat. There is no obvious habitat classification system that would be appropriate to use here (both simple to use and providing useful information).
Method	Field method used to collect the record. Regular methods include: sweep-netting; beating; direct observation; hand searching; suction/vacuum sampling; various trapping methods (pitfall, Malaise, water, light, flight interception, sticky).
Comments	An open-text field used to capture any extra information of relevance.

9.2 Procedure for dealing with records highlighted by Record Cleaner

Records highlighted by the rules in Record Cleaner should be sent to the recording scheme organiser or delegated national expert. The actions detailed in Table 9.3 will be applied and the record will be assigned one of the classifications detailed in Table 9.4.

Table 9.3: Actions to be taken by recording scheme organiser for records highlighted by rules

Problem highlighted by Record Cleaner	Action to be taken by Recording Scheme Organiser
Recorder known or suspected to be inexperienced in identifying Auchenorrhyncha.	Accept only ID Category 1 records without further information. Suggest that recorder submits further evidence (e.g. photograph, specimen) for species in ID Category 2 or higher.
Recorder known or suspected not to have a microscope.	Suggest recorder gains access to a microscope for future recording. In the meantime, accept only records in ID Categories 1-2.
Geo-referencing incorrect (grid-reference format not valid, does not match site name or vice county, or grid square contains no land)	Check site name against 100km square. Use on-line facilities to check stated grid-reference against OS map and vice county. If plausible alternative grid-reference found, verify this with recorder. If no (or more than one) alternative grid-reference found, refer back to recorder for further detail or investigation.
Invalid date	Refer back to recorder
Stated date pre-dates 'Temporal Year Start'	Refer back to recorder, explaining that record pre-dates earliest known record for the species.
Stated date outside 'Acceptable Temporal Seasonal'	Refer back to recorder, explaining that record is outside the season defined in rule set for species.
Location outside known range or probability for species as defined by rule set	Check whether record lies outside Extent of Occurrence (EoO). If within EoO, critically assess likelihood of record based on location in relation to rest of species range, habitat (if stated), season, recorder expertise (if known) etc. If uncertain/ doubtful, refer back to recorder. If outside EoO, assess whether record may be plausible extension of range based on known history of recent expansion. If uncertain/doubtful, refer back to recorder.
Recorder's known or suspected expertise does not match ID difficulty of species	Ask recorder how confident s/he is of identification, what method was used (e.g. +/- dissection), what characters were used, what identification key or other literature was used. Suggest they should seek another opinion or submit a specimen to an expert verifier.
Species in ID Category 4	Critically assess likelihood of record based on evidence (e.g. Location, season) and known competence of recorder. If uncertain/doubtful, request specimen is examined by an acknowledged expert.
Species in ID Category 5	Request that specimen is examined by an acknowledged expert.
Rare species	Check that all record details are plausible and that recorder's competence matches or exceeds ID difficulty category. If satisfied, accept record; otherwise call for further evidence and/or specimen.

Problem highlighted by Record Cleaner	Action to be taken by Recording Scheme Organiser
Sensitive species (only 1 species: New Forest Cicada)	Scrutinise all available evidence. Inform Natural England.
Flagged by 'Verify record' field in Record Cleaner	Such species will be either (a) already picked up by other Record Cleaner criteria or (b) newly-arrived species where it will be useful to monitor their future spread. All details of the record should be scrutinised to make sure that they are plausible.

Table 9.4: Definitions of record classification

Record Classification	Definition for the purposes of Auchenorrhyncha recording
Correct	Records where specimen or good quality photograph has been checked and identification confirmed by an expert verifier (may or may not have previously passed Record Cleaner test).
Considered correct	(a) Records that pass Record Cleaner but where neither a specimen nor a photograph has been checked by an expert verifier. (b) Records highlighted by Record Cleaner but where subsequent investigation (by expert assessment of evidence, correspondence with recorder or provision of photograph) satisfies the expert verifier that the record is correct.
Requires confirmation	Records highlighted by Record Cleaner, considered plausible by expert verifier, but still require some form of confirmation (e.g. specimen, photograph).
Considered incorrect	Records that fail Record Cleaner and either (a) expert assessment concludes that record is unlikely to be correct, or (b) requested extra evidence and/or specimen has not been forthcoming.
Incorrect	Records where a voucher specimen or photograph has been checked by an expert verifier and shown to be incorrect (may or may not be possible to provide an alternative confirmed identification).
Unchecked	Records that have not yet been processed by Record Cleaner.

9.3 Verification rule sets

9.3.1 Identification difficulty rules

Each species of leafhopper and froghopper was given an identification difficulty grade (Table **9.5**).

Table 9.5: Identification difficulty grades and their definitions for leafhoppers and froghoppers

ID Difficulty Grade	ID Difficulty Definition
1	Can be identified in the field by anyone with a bit of experience. Species which beginners can rapidly learn to identify. Usually identifiable from a photo. Records acceptable from most sources.

ID Difficulty Grade	ID Difficulty Definition
2	Can be identified in the field with care and experience. Needs a good view or capture followed by examination with a good quality lens. Beginners should take voucher specimens until they gain familiarity and experience. May be identifiable from a good photo. Records acceptable from competent recorders.
3	Species that require examination of external characters (including externally visible genitalia structures) under a microscope with good lighting, but where identification is then relatively straightforward. May apply to females of species in which identification of males is easier. Identification accepted from experienced recorders (unless season, region or habitat is unusual), but less experienced ones would be expected to provide a specimen.
4	Species that are difficult to identify, often requiring dissection (although identification may not be conclusive in females). All except very experienced recorders could be expected to provide a specimen, particularly if the record is outside the known season or geographic range of the species.
5	Species that can only be identified following critical assessment, usually involving dissection and microscopic examination of genitalia. A specimen should always be retained for confirmation. May require consultation of specialist literature or comparison with verified reference material. Identification needs confirmation by a national expert. Even experienced recorders should seek a second opinion.

9.3.2 Spatial distribution rules

A mixture of observed distributions and Frescalo adjusted distributions (with a 0.3 frequency cut-off) has been used to create the spatial distribution rulefiles.

All species records have been used in the production of the spatial distribution rules.

9.3.3 Temporal rules – seasonal range

Rules have been created for species where there is a limited period within the year that a record would be acceptable. Where no rule file exists, records from any date within the year are acceptable.

9.3.4 Temporal rules – year range

Rules have been created for species for the earliest acceptable date for a record. There are currently no rules for latest acceptable date.

9.3.5 Verify record rule

Species which are considered very rare or are new arrivals should be verified by the scheme organiser regardless of the whether the rule passes or fails any other rules. In many cases the data for these species are scarce so no geographic or temporal rules can be created for them.

Rare species are defined as species that were Nationally Scarce or Red Data Book (RDB) K (thought to be RDB but insufficient data) when last reviewed in 1992 and their occurrence is still below 50 hectads.

9.4 Sensitive Records

There is one species of Auchenorrhyncha that is considered sensitive, detailed in Table 9.6.

Table 9.6: Species of Auchenorryhncha considered sensitive

Species name	Taxon version key	Reason for inclusion	Additional Criteria	Level of resolution considered sensitive
Cicadetta montana	NBNSYS0000010417	Vulnerable to collection if any populations still exist		Below 10km

10. Riverflies (caddisflies, mayflies and stoneflies)

10.1 Attribute fields for new records

The standard requirements are:

- Species
- Location
- Grid reference
- Date of collection or date range
- Recorder
- Determiner - if no determiner is cited it is presumed to be the recorder
- Life-cycle stage for the record should also be given: egg, larva, pupa or adult.

If the specimen has been collected as a larva and reared to the adult then the date and stage cited must be given as that of the larva but the reared adult referred to in the notes field.

The following also applies to the caddisfly (Trichoptera) species but not mayfly (Ephemeroptera) or stonefly (Plecoptera) species:

- Particular difficulty may arise if the record is of an empty pupal case or pupal shelter. It is important if the record has been made using that form it is distinguished clearly as being an old pupal case or shelter. These persist for an unpredictable time after the adult has emerged and are often identifiable to species, either by their shape or by the cast larval sclerites retained by the pupal grilles within the case. Using old cases can extend the time at which a record can be made of the immature stage and make the date range within Record Cleaner inoperable if cited just as larva or pupa.

10.2 Procedure for dealing with records highlighted by Record Cleaner

Records which fail the rules are sent to the recording scheme organiser.

The scheme organiser comments and approves and adds this to the available database with a comment why they have been approved.

Details of records that are retained for further evidence are returned with a request for permission to contact the record provider and a request for details of address of the same.

After discussion and agreement the record is submitted to the NBN. If the provider insists on the record being submitted despite the query then the scheme organiser will append a note as to their concerns to the record.

10.3 Verification rule sets

10.3.1 Identification difficulty rules

Each species of caddisfly, mayfly and stonefly was given an identification difficulty grade (Table 10.1).

Table 10.1: Identification difficulty grades and their definitions for caddisflies, mayflies & stoneflies

ID Difficulty Grade	ID Difficulty Definition
1	**Anyone can ID with rudimentary knowledge. Identifiable from photos**
2	Can be identified with experience. Identifiable by expert from photos
3	Needs microscope to ID. Records from recorders of known experience accepted
4	Record needs to be confirmed by national expert. Voucher specimens may be required
5	Voucher specimen required in all cases

An increasing number of species can be identified by photography as cameras improve their resolution. These are detailed in Table 10.3. Until recorders are familiar with a group they are expected to submit a voucher in the form of a photograph or specimen.

10.3.2 Spatial distribution rules

The neighbour smoothed distribution has been used to create the spatial distribution rulefiles for mayflies and stoneflies but a mixture of observed distribution, neighbour smoothed and Frescalo adjusted (with a 0.7 frequency cut-off) have been used for caddisflies.

Post-1980 records only have been used in the production of the spatial distribution rules, except for species where there are no valid post-1980 records. In this case, all records have been used.

10.3.3 Temporal rules – seasonal range

Rules have been created for species where there is a limited period within the year that a record would be acceptable. Where no rule file exists, records from any date within the year are acceptable.

10.3.4 Temporal rules – year range

Rules have been created for species where there is an earliest and/or latest acceptable date for a record. Where no rule file exists, species records from any date are considered acceptable.

10.3.5 Verify record rule

This rule has been created for species which are extremely rare or if it is a new species to the UK.

Rarity has not been used for mayflies or stoneflies. For caddisflies, rare species are generally those which occupy less than 15 hectads, although these have been reviewed by the scheme organiser and some species removed where they were considered to be of least concern.

10.4 Sensitive Records

There are no species of mayflies or stoneflies that are considered sensitive. There is one species of caddisfly that is considered sensitive, detailed in Table 10.2**.**

Table 10.2: Species of caddisfly considered sensitive

Species name	Taxon version key	Reason for inclusion	Additional Criteria	Level of resolution considered sensitive
Hagenella clathrata	NBNSYS0000008428	Habitat easily damaged		Below 10km

10.5 Additional Notes

Table 10.3 provides additional information about the acceptability of photographs for confirmation of a species record and other information which verifies a species record.

Table 10.3: Additional notes relating to the verification of riverfly species records

Species name	Taxon version key	Notes
Adicella reducta	NBNSYS0000008529	Photo good enough all stages
Agraylea multipunctata	NBNSYS0000008349	Photo good enough for larva
Agraylea sexmaculata	NBNSYS0000008350	Photo good enough for larva
Agrypnia crassicornis	NHMSYS0020442287	Photo good enough for adult and larva
Anabolia nervosa	NBNSYS0000008462	Photo good enough for adult and larva
Athripsodes albifrons	NBNSYS0000008510	Photo good enough for adult
Athripsodes aterrimus	NBNSYS0000008512	Photo good enough for larva
Athripsodes bilineatus	NBNSYS0000008513	Possible confusion with the rare interjectus form of albifrons and commutatus
Athripsodes cinereus	NBNSYS0000008514	Photo good enough for adult & larva
Brachycentrus subnubilus	NBNSYS0000008433	Photo good enough for all stages
Ceraclea annulicornis	NBNSYS0000008517	Photo good enough for larva
Ceraclea dissimilis	NBNSYS0000008518	Photo good enough for adult & larva
Ceraclea fulva	NBNSYS0000008519	Photo good enough for larva
Ceraclea nigronervosa	NBNSYS0000008520	Photo good enough for adult & larva
Ceraclea senilis	NBNSYS0000008521	Photo good enough for larva
Chaetopteryx villosa	NHMSYS0020704776	Photo good enough for adult & larva
Cheumatopsyche lepida	NBNSYS0000008412	Photo good enough for adult & larva
Chimarra marginata	NBNSYS0000008384	Photo good enough for adult & larva

Species name	Taxon version key	Notes
Crunoecia irrorata	NBNSYS0000008434	Photo good enough for adult & larva
Diplectrona felix	NBNSYS0000008422	Photo good enough for adult & larva
Drusus annulatus	NBNSYS0000008442	Photo good enough for adult & larva
Ecclisopteryx guttulata	NBNSYS0000008443	Photo good enough for larva
Ecnomus tenellus	NBNSYS0000008397	Photo good enough for larva
Enoicyla pusilla	NBNSYS0000008445	Photo good enough for adult & larva
Ernodes articularis	NBNSYS0000008504	Photo good enough for larva
Erotesis baltica	NBNSYS0000008530	Photo good enough for larva
Glyphotaelius pellucidus	NBNSYS0000008463	Photo good enough for adult larvae & egg
Goera pilosa	NHMSYS0020704791	Photo good enough for adult
Hagenella clathrata	NBNSYS0000008428	Photograph rather than taking specimen but essential as voucher
Halesus digitatus	NBNSYS0000008446	Photo good enough for adult
Halesus radiatus	NBNSYS0000008447	Photo good enough for adult
Hydropsyche angustipennis	NBNSYS0000008413	Photo good enough for larva
Hydropsyche contubernalis	NBNSYS0000008415	Photo good enough for larva
Hydropsyche fulvipes	NBNSYS0000008417	Photo good enough for larva
Hydropsyche instabilis	NBNSYS0000008418	Photo good enough for larva
Hydropsyche pellucidula	NBNSYS0000008419	Photo good enough for larva
Hydropsyche siltalai	NBNSYS0000008421	Photo good enough for larva
Hydroptila angulata	NBNSYS0000008352	Immature record acceptable if reared out
Hydroptila cornuta	NBNSYS0000008353	Immature record acceptable if reared out
Hydroptila forcipata	NBNSYS0000008354	Immature record acceptable if reared out
Hydroptila lotensis	NBNSYS0000008355	Immature record acceptable if reared out
Hydroptila martini	NBNSYS0000008356	Immature record acceptable if reared out
Hydroptila occulta	NBNSYS0000008357	Immature record acceptable if reared out
Hydroptila pulchricornis	NBNSYS0000008358	Immature record acceptable if reared out
Hydroptila simulans	NBNSYS0000008359	Immature record acceptable if reared out
Hydroptila sparsa	NBNSYS0000008360	Immature record acceptable if reared out
Hydroptila sylvestris	NBNSYS0000008361	Immature record acceptable if reared out
Hydroptila tigurina	NBNSYS0000008362	Immature record acceptable if reared out
Hydroptila tineoides	NBNSYS0000008363	Immature record acceptable if reared out
Hydroptila valesiaca	NBNSYS0000008364	Immature record acceptable if reared out
Hydroptila vectis	NBNSYS0000008365	Immature record acceptable if reared out
Ithytrichia clavata	NBNSYS0000008375	Immature record acceptable if reared out
Ithytrichia lamellaris	NBNSYS0000008376	Immature record acceptable if reared out
Lasiocephala basalis	NBNSYS0000008435	Photo good enough for larva
Leptocerus interruptus	NHMSYS0020442420	Photo good enough for adult

Species name	Taxon version key	Notes
Limnephilus affinis	NBNSYS0000008466	Immature record acceptable if reared out. Photo good enough for adult
Limnephilus auricula	NBNSYS0000008467	Photo good enough for adult
Limnephilus bipunctatus	NBNSYS0000008469	Photo good enough for adult
Limnephilus borealis	NBNSYS0000008470	Photo good enough for adult
Limnephilus centralis	NBNSYS0000008471	Photo good enough for adult & larva
Limnephilus coenosus	NBNSYS0000008472	Photo good enough for adult & larva
Limnephilus elegans	NBNSYS0000008474	Photo good enough for adult
Limnephilus flavicornis	NHMSYS0020704807	Photo good enough for adult
Limnephilus griseus	NBNSYS0000008479	Photo good enough for adult
Limnephilus incisus	NBNSYS0000008482	Immature record acceptable if reared out. Photo good enough for adult
Limnephilus lunatus	NBNSYS0000008483	Photo good enough for adult
Limnephilus marmoratus	NBNSYS0000008485	Photo good enough for adult
Limnephilus rhombicus	NBNSYS0000008489	Photo good enough for adult
Limnephilus sparsus	NBNSYS0000008490	Photo good enough for adult
Limnephilus stigma	NBNSYS0000008491	Photo good enough for adult
Limnephilus subcentralis	NBNSYS0000008492	Photo good enough for adult
Limnephilus vittatus	NHMSYS0020704808	Photo good enough for adult & larva
Lype reducta	NBNSYS0000008386	Identification key for larvae needs revision
Mystacides longicornis	NBNSYS0000008526	Photo good enough for adult and larva
Nemotaulius punctatolineatus	NBNSYS0000008495	Photo good enough for adult larva & egg
Neureclipsis bimaculata	NBNSYS0000008405	Photo good enough for adult
Notidobia ciliaris	NBNSYS0000008505	Photo good enough for adult
Odontocerum albicorne	NBNSYS0000008507	Photo good enough for adult larva & pupa
Oecetis notata	NBNSYS0000008537	Photo good enough for adult and larva
Oecetis ochracea	NBNSYS0000008538	Photo good enough for adult and larva
Oecetis testacea	NBNSYS0000008539	Photo good enough for adult and larva
Oligotricha striata	NBNSYS0000008429	Photo good enough for adult and larva
Orthotrichia angustella	NBNSYS0000008377	Immature record acceptable if reared out
Orthotrichia costalis	NBNSYS0000008378	Immature record acceptable if reared out
Orthotrichia tragetti	NBNSYS0000008379	Immature record acceptable if reared out
Oxyethira distinctella	NBNSYS0000008366	Immature record acceptable if reared out
Oxyethira falcata	NBNSYS0000008367	Immature record acceptable if reared out
Oxyethira frici	NBNSYS0000008369	Immature record acceptable if reared out
Oxyethira mirabilis	NBNSYS0000008370	Immature record acceptable if reared out
Oxyethira sagittifera	NBNSYS0000008371	Immature record acceptable if reared out
Oxyethira simplex	NBNSYS0000008372	Immature record acceptable if reared out

Species name	Taxon version key	Notes
Oxyethira tristella	NBNSYS0000008373	Immature record acceptable if reared out
Philopotamus montanus	NBNSYS0000008380	Photo good enough for adult and larva
Psychomyia pusilla	NHMSYS0020704831	Photo good enough for larva
Rhadicoleptus alpestris	NBNSYS0000008497	Photo good enough for adult and larva
Sericostoma personatum	NBNSYS0000008506	Photo good enough for adult and larva
Tinodes waeneri	NBNSYS0000008396	Photo good enough for adult and larva
Triaenodes bicolor	NBNSYS0000008531	Photo good enough for adult and larva
Tricholeiochiton fagesii	NBNSYS0000008374	Photo good enough for larva
Trichostegia minor	NBNSYS0000008432	Photo good enough for adult, larva and egg
Wormaldia mediana	NBNSYS0000008381	Immature record acceptable if reared out
Wormaldia subnigra	NBNSYS0000008383	Immature record acceptable if reared out

11. Carabidae (ground beetles)

11.1 Attribute fields for new records

11.1.1 Essential fields

The essential fields for ground beetle species records are detailed in Table 11.1.

Table 11.1: Essential fields for ground beetle species records

Field Name	Description
Species	Species name
Recorder	Name of person who found the beetle
Determiner	Name of person who identified the species
Complier	Name of the person who entered the data/filled out the card
Locality	The name by which you know the locality
Vice county	Watsonian Vice-County
Grid reference	6 figure OS grid reference or GPS coordinates
Dates	Start date and end date
Source	Field, museum, literature (more details should be provided for museum and literature sources)

11.1.2 Desirable fields

The desirable fields for ground beetle species records are detailed in Table 11.2.

Table 11.2: Desirable fields for ground beetle species records

Attribute Class	Attribute Values
Living or dead	Living, Dead, Not recorded
Life-stage	Egg, Larva, Pupa, Adult, Not recorded
Sex	Male, Female, Not recorded
Specimen?	Not collected, Specimen(s) collected, Specimen(s) collected and retained, Not recorded
Genitalia	Genitalia dissected, Not dissected, Not recorded
Photographed?	Photographed, Not photographed, Not recorded
Date of determination	Start date, end date, datetype (allowing for date ranges, vague dates, etc, as with dates of recording)

11.2 Procedure for dealing with records highlighted by Record Cleaner

Records that fall outside the verification rules should be labelled as “requiring confirmation”. Other records should be presumed correct and no further verification is required.

For records requiring confirmation, the current procedure should be for these records to be passed to Mark Telfer, the Ground Beetle Recording Scheme organiser, for consideration. Mark will try to decide whether the record is best accepted or rejected which may require examination of specimen(s), or photographs, or communication with the recorder and/or determiner and/or compiler to check whether the record may have failed the verification process due to an error of data entry or other error, rather than an error of identification.

11.3 Verification rule sets

11.3.1 Identification difficulty rules

Each species of ground beetle was given an identification difficulty grade (Table 11.3).

Table 11.3: Identification difficulty grades and their definitions for ground beetles

ID Difficulty Grade	ID Difficulty Definition
1	Distinctive and rarely misidentified by any mature person of sound mind. Almost always identifiable from a field photograph.
2	Fairly distinctive and can be accurately identified using available guides, even on first encounter. Usually identifiable from a field photograph.
3	Less distinctive; reliably accurate identification comes with experience. (Includes species which are distinctive if dissected but otherwise less distinctive). A field photograph will usually not show enough to allow confident identification.
4	Difficult to identify, or poorly covered by available guides. Worth getting a second opinion and/or comparing to a reliable reference collection. For most of these species, a field photograph will not be sufficient to allow confident identification.
5	Identifications always require confirmation from a designated expert. For most of these species, a field photograph will not be sufficient to allow confident identification.

11.3.2 Spatial distribution rules

All species records have been used for creation of the geographic rules for ground beetles. A mixture of neighbour smoothed distributions and observed distributions have been used to create the rules.

11.3.3 Temporal rules – seasonal range

Rules have been created for species where there is a limited period within the year that a record would be acceptable. Where no rule file exists, records from any date within the year are acceptable.

11.3.4 Temporal rules – year range

Rules have been created for species where there is an acceptable and/or latest acceptable date for a record. Where no rule exists, any date is considerable acceptable for the species record.

11.3.5 Verify record rule

This rule has not been used for ground beetles.

11.4 Sensitive Records

There are no species of ground beetles that are considered sensitive.

12. Larger Brachycera (soldierflies and allies)

12.1 Attribute fields for new records

12.1.1 Essential fields

The essential fields for Larger Brachycera species records are detailed in Table 12.1.

Table 12.1: Essential fields for Larger Brachycera species records

Field Name	Description
Taxon	A name for the taxon determination that has been made. This name should ideally match an existing taxon in the NHM species inventory (only exception being where a determination specifies a taxon not previously recorded in Britain). For the Larger Brachycera recording scheme only taxa at species level are required. No aggregate taxa are currently defined in the NHM inventory, but at least one is required (for *Tabanus bovinus/sudeticus*), and the recording scheme will take that up with NHM. No default value is offered for this field.
Quantity	A measure of how many individuals of this taxon were seen. Ideally an exact number, but also allow recording of "Present, but no count made". The scheme would prefer not to allow number ranges or estimates such as "over 100". The Larger Brachycera scheme does not require 'negative' or absence records (i.e. records of a species being searched for and not found). No default value.
Sex	Although not essential to record for all taxa, this is essential for some taxa, where there are differing identification criteria for males and females, and record validation may depend on knowing which sex was recorded. Default value: "not recorded".
Stage	Default will be adult, but for some species in the scheme larval or pupal records may be made, and it is essential that these are recorded as such. Default value: "adult".
Location Name	Although this is less important than an accurate grid reference, it is a useful cross-check for the grid reference, and may enable extra information to be given such as the compartment within a nature reserve or SSSI. The recording scheme prefers names to be given in the format "Overall site name or nearest town: sub-site: compartment", e.g.: Homefield Wood SSSI: compartment 2: pond. No default value.
Grid Reference	Preferably to six-figures (100 metre square) precision for widespread species, and to eight-figures (10 metre square) for rarer species. Ideally the grid reference should indicate a centroid for the habitat patch in which the record was made. No default value.
Date	Preferably a single day, but date ranges need to be catered for as well, e.g. for malaise-trapped material, or for literature records than cannot be assigned to a day, which means that a "Date To" field is also required. No default value required, although arguably a default to today's date might be helpful.
Date to	See previous comments under Date. Default value is to be equal to the Date.

Field Name	Description
Recorder	Name of person who saw the organism and made a record of it. The scheme preference is for the format "First-name + Middle-initial/s + Surname", not least because this provides a more friendly, approachable format when listing recorder names. The Recorder can be a list of more than one person, but lists of more than three people should be avoided.
Determiner	Name of person who takes responsibility for the taxon name that has been attached to the record. Should refer to just one person. Default value: the recorder name.
Comment	Free text field for additional information about the record. No default value.

12.1.2 Desirable fields

The desirable fields for Larger Brachycera species records are detailed in Table 12.2.

Table 12.2: Desirable fields for Larger Brachycera species records

Field Name	Description
Type of grid reference	The scheme preference is for the grid reference to indicate the centroid of the patch of habitat in which the taxon was found, but ideally it would be good to record whether this is what the grid reference actually refers to, or whether it is simply a reference to a square in which the record was made, or a more approximate reference to a larger site. However, providing these details may be considered onerous by the general user, and this issue is probably best dealt with through guidance to recorders rather than by adding extra data fields.
Confidence	Recorder's assessment of how confident they are that the identification is correct.
Method	e.g. "Field record", "Sweeping", "Malaise trap" etc.
Reference	Source for records that are taken from literature or museum collections.
Confirmer	The name of a person (usually an expert) who has agreed with the determiner's determination. But this information can be stored in the Comments field.
Vice-county	This information is needed by the recording scheme, but can be auto-generated either at the point of data entry or subsequently.

12.2 Procedure for dealing with records highlighted by Record Cleaner

Currently the Larger Brachycera recording scheme is relatively small, with contributed records in the low thousands per year. Verification is largely carried out by one person, the scheme organiser. Recently an advisory panel has been established, consisting of dipterists who are specialists in individual families within the Larger Brachycera group, and it is anticipated that in future this panel will be able to advise on verification problems, although responsibility for the final decision remains with the scheme organiser.

Where the record cleaning rule sets are being applied, the verification process will take these as its starting point:

- Records passing automated checks: these are very likely to be verified in batches ("Considered correct"), although where they are from recorders new to the scheme they will be subject to closer inspection to ensure that no unwitting errors are creeping in.
- Records failing automated checks: action here depends on which check/s produce the fail, and who the recorders are. It is expected that as new records accumulate there will be numerous occasions on which species are recorded in 10km squares from which they were previously unknown, and these records are likely to be verified unless from inexperienced recorders, where supporting evidence will be sought. Where records fail checks based on difficulty of ID these are likely to be verified if from experienced recorders and in categories 1-3, otherwise supporting evidence will be sought. All records of species in categories 4 and 5 will need supporting evidence (often including voucher specimens) unless they are from recorders with a proven high level of expertise. For records of some species in category 4, and all in category 5, advice will be sought from the scheme's advisory panel.

"Supporting evidence" can include: descriptive notes, a photograph (preferably close-up and well-focused), a second opinion (preferably from an experienced dipterist), a voucher specimen (the strongest evidence, which will be required for some species and circumstances). In addition to the scheme advisory panel, the scheme organiser may also seek advice from other dipterists (e.g. county recorder where they exist) as required.

The scheme organiser aims to provide feedback on verification decisions to all recorders who submit data. Records that cannot be verified will be retained, but clearly flagged as "Requires confirmation", "Considered incorrect" or "Incorrect", as appropriate.

12.3 Verification rule sets

12.3.1 Identification difficulty rules

Each species of Larger Brachycera was given an identification difficulty grade (Table 12.3).

Table 12.3: Identification difficulty grades and their definitions for Larger Brachycera

ID Difficulty Grade	ID Difficulty Definition
1	Can be identified at sight in the field by anyone with a bit of experience. Species with which the beginner rapidly becomes familiar. Usually identifiable from a photo.
2	Can be identified in the field with care and experience. Needs a good view or the netting of a specimen to check, but the specimen can then be released. Beginners need to take specimens until they gain familiarity and experience. May be identifiable from a good photo or series of photos.

ID Difficulty Grade	ID Difficulty Definition
3	Specimen needs checking under magnification and good lighting. Records accepted from experienced recorders without further question (unless the date, region or habitat was especially unusual). Beginners should get specimens checked at first until they gain experience. Usually not identifiable from a photo - unless you are lucky and get exactly the right features!
4	Voucher specimen should be retained. Confirmation would be required in the majority of cases, e.g. specimen having been checked by an acknowledged expert.
5	Even the most expert of recorders would seek a second opinion. Specimen may need to be passed on to further experts for comparison with a wider range of material.

12.3.2 Spatial distribution rules

A mixture of observed distributions and Frescalo adjusted distributions (with 0.6 frequency cut-off) has been used to create the spatial rule files.

Post-1980 records have been used for creation of the geographic rules for the Larger Brachycera.

12.3.3 Temporal rules – seasonal range

Rules have been created for species where there is a limited period within the year that a record would be acceptable. Where no rule file exists, records from any date within the year are acceptable.

12.3.4 Temporal rules – year range

There are a very limited number of species for which there is an earliest and/or latest acceptable date for a record. For records of all other species any date is considered acceptable.

12.3.5 Verify record rule

Table 12.4 contains the rationale for flagging species that always require verification.

Table 12.4: Rationale for always verifying a species record

Species name	Taxon version key	Rationale
Xylophagus junki	NBNSYS0000007848	Rarity: only known in Britain from one specimen in 1913.
Ptiolina nigra	NBNSYS0100004993	Taxonomy: “A thorough review of the Palaearctic *Ptiolina* is needed because there are problems in delimiting some species and it seems likely that others will be recognised”; “The ecological range [of *P. nigra*] suggests that more than one species may be involved” (Stubbs and Drake 2001)

Species name	Taxon version key	Rationale
Ptiolina obscura	NBNSYS0000007854	Taxonomy: "A thorough review of the Palaearctic *Ptiolina* is needed because there are problems in delimiting some species and it seems likely that others will be recognised" (Stubbs and Drake 2001)
Hybomitra solstitialis	NBNSYS0000148975	Rarity/taxonomy: has been the subject of much taxonomic confusion over the years ("Most literature records of solstitialis are in error and refer to other species", Stubbs and Drake *in prep*.), and remained unrecorded after 1934 until its rediscovery in 2008.
Tabanus bovinus	NBNSYS0000007888	Taxonomy/rarity: "there has been much confusion over the characterisation of *bovinus* because it is so variable. Females still cannot be reliably separated from the paler forms of *sudeticus*" (Stubbs and Drake 2001). Few confirmed records and many misidentifications exist.
Solva varia	NBNSYS0000007845	Unconfirmed from Britain: the only evidence for this species being in Britain dates from about 1830 and their provenance is open to doubt.
Clitellaria ephippium	NBNSYS0000007803	Unconfirmed from Britain: a single unconfirmed record from Kent in the 19th century.
Oxycera fallenii	NBNSYS0000007810	Rarity: known from Ireland for many years but possibly restricted to one site; first found in Britain in 1997 but still known from only one site.
Oxycera leonina	NBNSYS0000007812	Rarity: first recorded in Britain in 1989 and still known from only two sites.
Stratiomys chamaeleon	NBNSYS0000007839	Rarity: a habitat specialist known from one area in each of England, Wales and Scotland.
Villa venusta	NBNSYS0100005964	Rarity: no record since 1958, may be extinct; hard to identify.
Neoitamus cothurnatus	NBNSYS0000007903	Rarity: known from one site in England up to 1921, not seen again until discovered at one site in Wales in 1997.
Neomochtherus pallipes	NBNSYS0100004212	Rarity: just one record in Britain so far, 1990.
Dasypogon diadema	NBNSYS0000007913	Unconfirmed from Britain: reported in the 19th century but interpreted as an introduction.
Choerades gilvus	NBNSYS0100002378	Unconfirmed from Britain: recorded from 1938 to 1951 but interpreted as an temporary colonisation.
Oxycera varipes	NBNSYS0000033213	Unconfirmed from Britain: was added to British list (and Red Data list) in error, no confirmed record.

Species name	Taxon version key	Rationale
Haematopota italica	NHMSYS0020734197	Potential addition: not yet known from Britain but might occur, and is keyed in Stubbs and Drake 2001.
Tabanus spodopterus	NHMSYS0020734206	Unconfirmed from Britain: one record in 1929 is regarded as dubious.
Haematopota sp. A	NHMSYS0020734199	Taxonomy: this taxon is based on a single female specimen that cannot be assigned to any known species.
Haematopota sp. B	NHMSYS0020734200	Taxonomy: this taxon is based on a single female specimen that cannot be assigned to any known species.

12.4 Sensitive Records

There are no species within the Larger Brachycera group that are considered sensitive.

13. Amphibia and Reptilia (amphibians and reptiles)

13.1 Attribute fields for new records

13.1.1 Essential fields

The following are essential fields for amphibian and reptile species records:

- Recorder
- Location (grid reference)
- Species
- Date of record

13.1.2 Desirable fields

The following are desirable fields for amphibian and reptile species records:

- Site name
- Grid reference accuracy (e.g. from GPS)
- Date precision
- Time of sighting (24 hr)
- Number of animals/eggs/spawn clumps etc.
- Sex
- Age/stage (egg/tadpole/hatchling/metamorph/juvenile/immature/adult)
- Slough? (for reptiles only)
- Weather/temperature details
- Surrounding habitat/s

13.2 Procedure for dealing with records highlighted by Record Cleaner

Work is currently in progress to set up a network of verifiers. Until this is in operation all records highlighted by the verification rules should be referred to the Scheme Organiser.

13.3 Verification rule sets

13.3.1 Identification difficulty rules

Each species of amphibian and reptile was given an identification difficulty grade (Table **13.1**).

Table 13.1: Identification difficulty grades and their definitions for amphibians and reptiles

ID Difficulty Grade	ID Difficulty Definition
1	Easy to identify, unlikely to be confused with other species.
2	Possibility for confusion with similar species, refer to identification guide.
3	Can be mis-identified and/or local non-native. Refer to identification guide and known distribution.
4	Hard to separate species, may need close examination and expert confirmation.
5	Identity requires expert confirmation from (at least) photograph or other evidence.

13.3.2 Spatial distribution rules

Due to the patchy distribution data for amphibian and reptile species, a mixture of all the different types of distributions have been used in the creation of the spatial rule files. Less than half of the species have a spatial rule file due to the lack of data currently available.

All species records have been used for creation of the geographic rules for amphibians and reptiles.

13.3.3 Temporal rules – seasonal range

Rules have been created for species where there is a limited period within the year that a record would be acceptable. Where no rule file exists, records from any date within the year are acceptable.

13.3.4 Temporal rules – year range

There are a very limited number of species for which there is an earliest acceptable date for a record. For records of all other species any date is considered acceptable.

13.3.5 Verify record rule

All records for species which are uncommon non-natives should always be verified. The only native species this rule applies to is *Pelophylax esculentus* which is a very rare native species but also has non-native populations. Rare species are also flagged and applies to native species with very restricted distribution.

13.4 Sensitive Records

There are eleven species of amphibians and reptiles that are considered sensitive, detailed in Table 13.2**.**

Table 13.2: Species of amphibians and reptiles that are considered sensitive

Species name	Taxon version key	Reason for inclusion	Additional Criteria	Level of resolution considered sensitive
Bombina bombina	NHMSYS0000080162	Potential target for collectors		Below 10km

Species name	Taxon version key	Reason for inclusion	Additional Criteria	Level of resolution considered sensitive
Bombina variegata	NHMSYS0000080163	Potential target for collectors		Below 10km
Hyla arborea	NHMSYS0000080165	Potential target for collectors		Below 10km
Lithobates catesbeianus	NHMSYS0020194859	Possible impact from disease		Below 10km
Natrix tessellata	NHMSYS0000080232	Potential target for collectors		Below 10km
Pelophylax lessonae	NHMSYS0020194823	Reintroduction – site kept secret		Below 10km
Podarcis sicula	NHMSYS0000375719	Potential target for collectors		Below 10km
Salamandra salamandra	NHMSYS0000080153	Potential target for collectors		Below 10km
Triturus carnifex	NHMSYS0000080155	Possible impact from disease / hydridization		Below 10km
Triturus marmoratus	NHMSYS0000376071	Potential target for collectors / possible impact from hybridization		Below 10km
Xenopus laevis	NHMSYS0000080166	Possible impact from disease		Below 10km

14. Recommendations

14.1 Updating of Rule Sets

Rule sets should be reviewed within the first year of implementation to allow changes to made where too many records are being flagged for verification or where some records are not getting flagged when they should. This is probably most important for the spatial rules where the rules are based on modelled data rather than the observed.

The automation of the creation of verification rules should make it much easier to recreate rule files where changes are made. The R scripts that are used to create the rule files are currently held by the BRC so any changes have to be made by the BRC. In future it would be preferable if the scheme organisers/verifiers could update the rules manually, possibly via an online portal.

14.2 Distinguishing between Life Stages

Where there are distinctive life stages for a species (e.g. larvae and adult stages), the verification rules would be more powerful if they could be split and used separately.

For example, larvae and adults of the same species may be found at different times of the year, so using one seasonal rule for larvae and a different seasonal rule for adults would allow a greater number of species records to be automatically verified. At present a limited seasonal range has to be used to prevent adult records being verified during the larval seasonal period and prevent larvae records being verified during the adult seasonal period.

The identification difficulty of larvae and adults may also be different, so the harder identification difficulty grading has to be used to prevent records from being automatically verified when they need checking by an expert. By splitting identification difficulty into two rules for larvae and adults, this would allow a greater number of species to be automatically verified.

15. References

Hill, M.O. (2012) Local frequency as a key to interpreting species occurrence data when recording effort is not known. *Methods in Ecology and Evolution*, **3**, 195-205

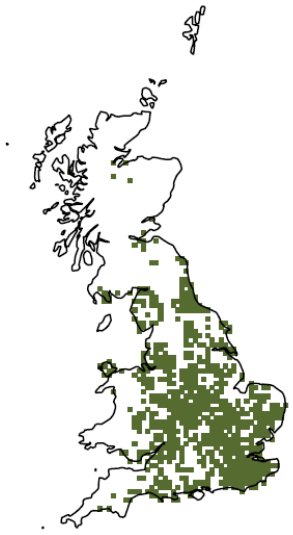
Kirby, P. (1992) *A review of the scarce and threatened Hemiptera of Great Britain*, Joint Nature Conservation Committee, ISBN 1 873701 02 0, 267pp

Roy, H., Brown, P., Frost, R. and Poland, R. (2011) *Ladybirds (Coccinellidae) of Britain and Ireland*, FSC Publications, Telford, 198pp

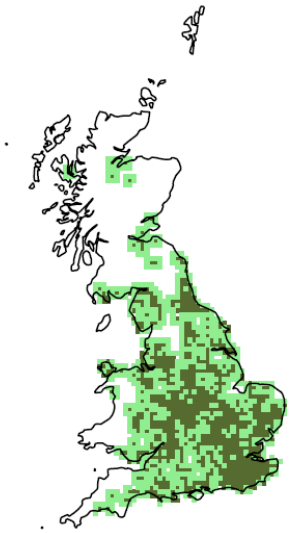
Stubbs, A. and Drake, C.M. (2001) *British Soldierflies and their Allies: A Field Guide to the Larger British Brachycera*, British Entomological & Natural History Society, 528pp

Appendix 1 – Example Maps and Phenogram

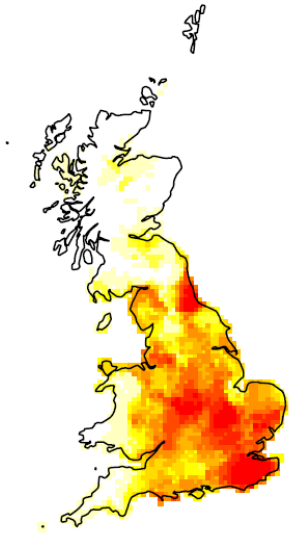
(a) Observed Distribution (n = 745)



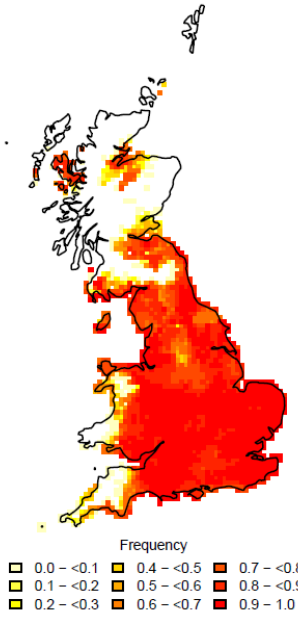
(b) Neighbour Smoothed



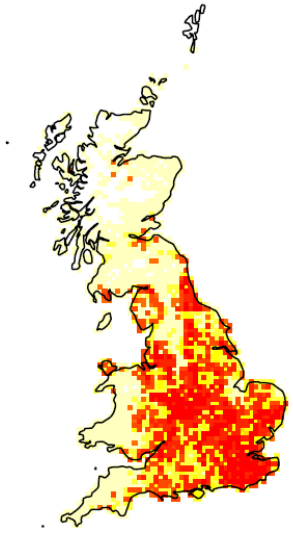
(c) Frescalo Neighbourhood



(d) Frescalo Adjusted



(e) Species Distribution Model



(f) Phenogram