This report was prepared by The Murray-Darling Freshwater Research Centre (MDFRC). The aim of the MDFRC is to provide the scientific knowledge necessary for the management and sustained utilisation of the Murray-Darling Basin water resources. The MDFRC is a joint venture between the Murray-Darling Basin Authority, La Trobe University and CSIRO (through its Division of Land and Water). Additional investment is provided through the Australian Government Department of the Environment, Water, Heritage and the Arts.

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Authors: Lyn Smith and John Hawking
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Client: Department of Environment, Water, Heritage and the Arts

Project Title: Colour Web Guide to the Identification of Invertebrates from Australian Inland waters

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1.0 Introduction

The online interactive guide Identification and Ecology of Australian Freshwater Invertebrates or more commonly referred to as the Bug Guide, has been developed in three sections; (1) the initial development of the database and the keys to the major groups and families, undertaken between 20 February 2003 and 31 January 2005, (2) the second part was the addition of the Hemiptera (bugs) and Crustacea (yabbies etc.) keys, undertaken between 20 May 2003 and 21 January 2004 and (3) the final part added the remaining orders of insects and the other non-insect groups, this contracted portion, was undertaken between 3 February 2006 and February 2009.

The Bug Guide is used by students through to ecologists; to identify aquatic invertebrates to family level and the more commonly used indicator taxa to generic level. This resource underpins environmental monitoring and assessment studies by aiding in the identification of the macroinvertebrates used as ecological indicators of river health. The Bug Guide is being adopted by agencies undertaking ecological assessments using AUSRIVAS Rapid Assessment Methods, particularly state departments conducting the Sustainable Rivers Audit, as well as community monitoring programs such as Waterwatch and Landcare.

The Bug Guide uses colour digital imagery of the animals and their body parts to enable easier identification. Information on life cycles, distribution and ecology is provided, as well as AUSRIVAS taxa codes and, SIGNAL pollution sensitivity ratings that are required for river health assessment. All relevant taxonomic references are provided along with sections containing downloadable taxonomic and educational resources.

2.0 Summaries of the major activities

2.1 Development of the guide

The Bug Guide project commenced in February 2003 and successive projects have seen it completed as a fully operational online guide. The first project established the database and developed keys to the major groups to the order level. In addition keys to the four major environmentally sensitive insect orders; Ephemeroptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddis flies), Odonata (dragonflies and damselflies) were further developed to the generic level, where possible. A second part was added to the initial project and this involved developing keys to the Hemiptera (bugs) at generic level and the malacostracan crustacean group, in particular the orders Amphipoda (sideswimmers), Isopoda (slaters) at family level and Decapoda (shrimps, prawns, crayfish, yabbies, crabs) at generic level. To support the taxonomic information on the home pages, ecology was also added for each of these groups.

The current contract involved finishing the Bug Guide to a standard that would be an efficient identification tool. This involved producing keys to the remaining insect orders - Diptera (true flies), Coleoptera (beetles), Lepidoptera (aquatic caterpillars), Mecoptera (scorpion flies), Megaloptera (alderflies, dobsonflies), Neuroptera (lacewings, spongeflies), as well as the major groups Arachnida (mites), Bivalvia (mussels), Cnidaria (hydra, jellyfish), Gastropoda (snails), Hirudinea (leeches) and Platyhelminthes (flatworms) to family level, where possible. Keys to dipteran subfamilies have also been created, where possible. General information is given for each of the major aquatic invertebrate groups. Ecological information has been provided to the family level, wherever available.

2.2 Guide resources

The introduction to the guide provides two tutorials to aid with navigation through the guide. The first tutorial introduces you to the guide and teaches you how to use this identification guide and the second tutorial helps with the identification of your bugs. These tutorials can be downloaded. Four taxonomic resources and 44 educational resources are available for teaching and training and are accessed via the homepage. They can also be downloaded as PDF or editable PowerPoint files.
2.2.1 Taxonomic resources

- CRCFE Identification Guides
- Key to Keys
- AUSRIVAS Taxacode
- Taxonomic changes

2.2.2 Educational resources

- Macroinvertebrate survey guide (schools)
- Guide to major groups
- Terminology Images
  - general macroinvertebrates
  - Insecta (insects)
  - Coleoptera (beetles)
  - Diptera (flies)
  - Ephemeroptera (mayflies)
  - Hemiptera (bugs)
  - Megaloptera (alderflies, dobsonflies)
  - Neuroptera (lacewings, spongeflies)
  - Odonata (damselflies, dragonflies)
  - Plecoptera (stoneflies)
  - Trichoptera (caddisflies)
  - Crustacea (crustaceans)
  - Malacostraca (malacostracans)
  - Amphipoda (side swimmers)
  - Decapoda (yabbies, crayfish, shrimps, prawns, crabs)
  - Isopoda (water slaters)
- Victorian Regional Resources (each including separate signal band, functional feeding group, trophic level, habitat and flow files)
  - Highlands
  - Forests A
  - Forests B
  - Cleared Hills and Coastal Plains
  - Murray and Western Plains

2.2.3 Key resources

To assist users in attaining an identification, a ‘Glossary’ (Figure 1) and ‘Terminology Images’ (Figure 2) can be accessed by clicking on navigation links at the top of the screen. These resources appear in pop-up windows so that the couplet and the resource can be viewed simultaneously.
To provide direct comparison of the corresponding couplet, a feature was added to displaying images of both opposing features at the same time. An enlargement facility was also added to double the image size for easier viewing (Figure 3.).
The following section describes how to use the Bug Guide and lists the major steps to follow in using the guide.

1. Launch the internet Explorer browser, type in: http://www.mdfrc.org.au and this will bring up the MDFRC website (Figure 4).
2. Click on the Bug Guide icon (stream with damselfly, beetle and yabby) which will take you to the Bug Guide homepage (Figure 5).
3. The educational and taxonomic resources are accessed from this homepage, including the ‘how to identify bugs’ tutorial.
4. First time users can click on ‘How to use this identification guide’, whereas returning users will generally click on ‘Identify your bug’ to enter the key.
5. This links to the ‘Major Groups’ page where the user has the choice of entering the ‘Key to Major Groups’ or navigating directly to a specific major group via a hyperlinked image.
6. From a major group page, the user can then either select to enter a ‘Key to Minor Groups’ or ‘Key to Orders’, depending upon the major group.

Figure 3. Couplet with enlarged images

2.3 Operation of the guide
Table 1), or select to navigate directly to a specific minor group or order via a hyperlinked image.

7. From an order page the user can then either select to enter a 'Key to Families', or select to navigate directly to a specific family via a hyperlink in the Taxonomic Checklist.

8. Once the family level is reached, the user must enter the 'Key to Genera' to proceed further, depending upon the family.

The taxonomic keys are dichotomous. This means that each key consists of a series of couplets where each couplet contains two opposing statements. By comparing the features of the animal being identified with the features listed in the two statements, the user selects the appropriate hyperlink to proceed through the key or the hyperlink that leads to a description page for the animal i.e. identification has been attained. Every labelled digital image can be enlarged by clicking on it and every image has its identification, at the current taxonomic level, in the hover text. This can be viewed by holding the mouse over the image. The enlarged images appear in new pop-up windows so that multiple images can be viewed simultaneously.

Figure 4. MDFRC homepage
2.3.1 Description Pages

Ecological and taxonomic information is provided for each taxonomic level reached at the end of the keys. Description pages (Figure 6) at major group, minor group, order and family levels include information on:

- Parent taxonomy
- Descriptive features
- Taxonomic checklist
- Distribution
- Sensitivity rating
- AUSRIVAS taxacodes
- Functional feeding Group
- Ecology
  - Instream habitat
  - Feeding ecology
  - Habit
  - Life history
- Information Sources (including lower taxonomic level key references, where the Bug Guide does not continue)

Description pages at subfamily and genus levels (Figure 7) do not include information on Sensitivity Rating, AUSRIVAS Taxacode or ecology. There are no sensitivity ratings or AUSRIVAS taxacodes allocated below family level, except for the Chironomidae subfamilies. Ecological information below the family level is not well known.
Table 1. Taxonomic resolution of the *Bug Guide*  
(shading indicates the level where the keys stop for that major group)

<table>
<thead>
<tr>
<th>Major Group</th>
<th>Minor Group</th>
<th>Order</th>
<th>Family</th>
<th>Genus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acarina</td>
<td>minor groups</td>
<td></td>
<td>Aeolosomatidae</td>
<td>Aeolosa</td>
</tr>
<tr>
<td>Aphanoneura</td>
<td></td>
<td></td>
<td>families</td>
<td></td>
</tr>
<tr>
<td>Bivalvia</td>
<td></td>
<td></td>
<td>families</td>
<td></td>
</tr>
<tr>
<td>Bryozoa</td>
<td></td>
<td></td>
<td>Hydrozoa</td>
<td>families</td>
</tr>
<tr>
<td>Nematoda</td>
<td></td>
<td></td>
<td>Tricladida</td>
<td>Temnocephalida</td>
</tr>
<tr>
<td>Nematomorpha</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nemertea</td>
<td></td>
<td></td>
<td>Dugesiida</td>
<td></td>
</tr>
<tr>
<td>Oligochaeta</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Platyhelminthes</td>
<td></td>
<td></td>
<td>Temnocephalida</td>
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</tr>
<tr>
<td>Polychaeta</td>
<td></td>
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<tr>
<td>Porifera</td>
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<td></td>
<td></td>
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<tr>
<td>Protozoa</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Rotifera</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tardigrada</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Figure 6 Description page (family level)
Figure 7. Description page (genus level)

A full listing of the information sources reviewed to create the description pages can be accessed by clicking on the navigation link at the top of the screen. This resource appears in a pop-up window (Figure 8.) so that the description page and the resource can be viewed simultaneously.
2.4 Evaluation of the usefulness of the guide

2.4.1 Testing of usefulness and user-friendliness completed

Testing of the usefulness and user-friendliness of the Bug Guide has been reported on previously (Hawking & Smith 2007) using the feedback from AUSRIVAS and Waterwatch users. Printed evaluation forms were completed at the Waterwatch Victoria Taxonomy training workshop (May 2007) and AUSRIVAS Taxonomy training day (November 2006). Electronic evaluation forms were sent to Waterwatch and AUSRIVAS contacts who then distributed them to their monitoring networks (May 2007).

Respondents ranged from those who were new to aquatic macroinvertebrate identification to those who are experienced in species level identifications. Reasons for not using the Bug Guide generally centred on not having computer access in the laboratory.

In summary, respondents found the keys and description pages easy to use with the language deemed to be a good mix of technical and simplified language. All respondents preferred the colour digital imagery to black and white line diagrams. The key resources within the Bug Guide were found to be useful by all respondents who used them.

The Bug Guide is well used by the wider community as proven by the 2008 website statistics (Table 2.2). However, all users must enter the homepage to start the identification keys and access downloadable resources and thus may not reflect exactly what resource is being accessed.

Waterwatch Victoria has been running taxonomy workshops focussing on the Bug Guide since 2004, resulting in a high profile among Waterwatch users. The first AUSRIVAS presentation was held in 2006. The Bug Guide with its ‘How to Identify Bugs’ tutorial is now included as a resource in the AUSRIVAS accreditation and training course and so the Bug Guide continues to be exposed to AUSRIVAS users.
Table 2. Summary of Bug Guide statistics for 2008

<table>
<thead>
<tr>
<th>Month</th>
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<th>Additional Resource Downloads</th>
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<tr>
<td>Jan-08</td>
<td>496</td>
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<td>564</td>
<td>1483</td>
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<td>1769</td>
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<tr>
<td>Apr-08</td>
<td>532</td>
<td>2368</td>
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<td>May-08</td>
<td>798</td>
<td>2811</td>
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<tr>
<td>Jun-08</td>
<td>799</td>
<td>3151</td>
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<tr>
<td>Jul-08</td>
<td>810</td>
<td>3270</td>
</tr>
<tr>
<td>Aug-08</td>
<td>756</td>
<td>2205</td>
</tr>
<tr>
<td>Sep-08</td>
<td>727</td>
<td>2011</td>
</tr>
<tr>
<td>Oct-08</td>
<td>925</td>
<td>2548</td>
</tr>
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<td>Nov-08</td>
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<td>2337</td>
</tr>
<tr>
<td>Dec-08</td>
<td>605</td>
<td>1099</td>
</tr>
</tbody>
</table>

2.5 Colour Web Key Guide available as a stand alone taxonomic resource on the web

The Colour Web Key Guide went live on 25 September 2006. It is hosted within the MDFRC website (http://www.mdfrc.org.au) by Gocreative, a local web developer and hosting company. The guide has an obvious hyperlink from the MDFRC homepage (Figure 4) to the Bug Guide homepage (Figure 5). The Colour Web Key Guide is now known as the Bug Guide due to the formatting restrictions of web addresses. The address for the Bug Guide is http://www.mdfrc.org.au/bugguide. Enquiries about the Bug Guide can be directed to Lyn Smith and John Hawking via bugsonline@mdfrc.org.au on the Contact Us page.

2.6 Colour Web Key Guide available as a CD by AUSRIVAS operators

A CD version of the Bug Guide can be generated online and downloaded through the MDFRC website publishing area. This is now available by requesting it via bugsonline@mdfrc.org.au on the Contact Us page. CDs will then be copied, labelled and sent out to recipients. It is envisaged that the CDs will be free to the public and monitoring agencies, but to date no arrangements have been made as to who will pay for the consumables, postage and staff time involved.

2.7 Improvements to the web guide completed

Progress toward this milestone has included;

- Editing the text of family level keys for all groups
- Editing the text of generic level keys for Ephemeroptera, Hemiptera, Trichoptera and Odonata
- Undescribed genera have been added, where applicable, to the generic keys of Ephemeroptera, and Trichoptera to make the Bug Guide more taxonomically correct
- New digital images have been added for the family level keys ofColeoptera and Diptera
- A simplified key to families of adult Coleoptera, has been included for trial
- Some digital images have been updated, where applicable, for the family and generic level keys of all insect orders
- Many line drawings from original sources have been scanned in to fill the image gaps where specimens have not been available for imagery in family level keys for all groups and generic level keys for Trichoptera
2.8 Communication activities

2.8.1 Conference and workshop presentations

The Bug Guide has been presented and workshopped at the following

- 4th National Waterwatch Conference Melbourne, 7-10 Feb 2005, with the title of the presentation “The ‘Colour Web Guide’ a ‘One Stop Shop’ for identification and ecology of freshwater invertebrates of Australian inland waters”
- Waterwatch Victoria Macroinvertebrate Training Workshop; May 2007, Ballarat. The guide was demonstrated and then used for the identification sessions
- Waterwatch Victoria Macroinvertebrate Training Workshop; 22-24 April 2008, Melbourne. The guide was demonstrated and then used for the identification sessions
- Waterwatch Victoria Macroinvertebrate Training Workshop; Sale 2006. The guide was demonstrated and then used for the identification sessions
- Waterwatch Victoria Macroinvertebrate Training Workshop; Bacchus Marsh, May 2007. The guide was demonstrated and then used for the identification sessions
- North East CMA Waterwatch Macroinvertebrate Volunteer Training Day, 6th Dec 2007, The guide was used in the session “Using the online Bug Guide”
- AUSRIVAS accreditation course, Canberra, November 2006, where the guide is the taxonomy resource used as part of the identification module in the course
- Invertebrate Taxonomic Workshop; Murray Darling Freshwater Research Centre, 10-11 Feb 2004.
- Invertebrate Taxonomic Workshop; La Trobe University, 10-11 Feb 2009

2.8.2 Conference proceedings

The Bug Guide has been published in the proceeding of the following conferences


2.8.3 Promotion of the project

The MDFRC is very supportive of the Bug Guide and is hosting the guide on their web, with the link a prominently displayed centre piece of home page (http://www.mdfrc.org.au/). The MDFRC has kindly agreed to host the guide into the future and add links; however, resources to update or provide CD versions of the guide will need to be externally sourced.

The Bug Guide has been promoted by the following activities;
• National Waterwatch Conferences, Canberra 27 Nov 2007, where as display on the “Online Bug Guide” was set up in the conference venue foyer as part of the trade display
• A flyer on the Bug Guide, containing information on the guide and the web address has been distributed at all conferences and workshops attended by the guide team (see above)
• Advertising articles have been placed in newsletters of various societies and institutions: i.e. Australian Society of Limnology, Waterwatch and MDFRC newsletters.

Through Waterwatch activities, the Bug Guide has been exposed to state and regional co-ordinators, secondary students and community volunteers. The AUSRIVAS training and accreditation course which delivers to environmental consulting and state water agencies, still utilises the Bug Guide in its online Macroinvertebrate module and Taxonomy accreditation day. Through the Taxonomic Workshops, the Bug Guide has been presented to university students and staff from research laboratories.

3.0 Maintenance requirements

To prevent the Bug Guide becoming outdated, a monthly maintenance schedule should be introduced. The following tasks are required, with more detail outlined in Appendix 1.

1. Taxonomic updates from new journal articles
2. Error corrections via feedback
3. Ecological additions from new journal articles
4. Additional scans for keys and description pages from new journal articles
5. Glossary requests via feedback
6. New specimens images as they become available at MDFRC
7. New habitat images as they become available at MDFRC

To maintain the Bug Guide as a valuable resource, a means of financing ongoing maintenance will need to be determined. MDFRC are prepared to host the Bug Guide on its web site, as is the present arrangement; however, financial assistance will be required to undertake an ongoing maintenance.

4.0 Offline CD

The option to request an offline CD version of the Bug Guide is available from the homepage. This CD version contains only the keys, key resources (glossary, terminology images, and information sources) and the tutorials (how to use this guide, how to identify bugs). The additional resources are not included so people are encouraged to return to the website where updates are made. To date the CDs have been provided free of charge. The consumable costs are low – blank CD and case, printed adhesive label, postage; but the MDFRC staff time cost is significant.

MDFRC is willing to provide this service; however, funding will need to be sourced from an external body to allow MDFRC to undertake this service.
## 5.0 Appendices
### Appendix 1 Detailed Maintenance Tasks

<table>
<thead>
<tr>
<th>Job</th>
<th>Tasks</th>
</tr>
</thead>
</table>
| **1. Taxonomic updates** | 1. Receive monthly email alerts re new papers from ISI Web of Knowledge – all databases  
2. Review, request, read, create hardcopy  
3. Update taxonomic list reference file  
4. Update taxonomic list online  
5. If required, edit keys, create new description pages  
6. Update ProCite reference database  
7. When required, edit reference file of name changes (M:\Projects\DEWHA\188-Bug Guide\Data\download resources\namechanges.xls)  
8. When required, edit reference file of key to keys (M:\Projects\Taxonomy\ProCite and References\key to keys)  
9. Create PDF files  
10. Post edited files to online *Bug Guide* |
| **2. Error corrections** | When errors in keys or description pages are noted via feedback  
1. Determine correction by returning to, or sourcing new, references and/or consultation with appropriate taxonomists, if required  
2. Edit online text  
3. Take any required new images using Leica Imaging Suite OR edit existing images in Photoshop  
4. Store original images in M:\Projects\Taxonomy\Images Invertebrate (whole animal images) or M:\Projects\DEWHA\188-Bug Guide\Images\key couplets high res files (couplet images)  
5. In Photoshop, edit all images for image quality and size, save for web  
6. Post new/edited image files to online *Bug Guide*  
7. Update hardcopy ‘remaining issues’ folders, if required |
| **3. Ecological additions** | Referring to literature obtained for Job 1 and progress lists of missing information  
1. Read relevant ecological papers  
2. Add to/edit description pages, where appropriate  
3. Update progress lists |
| **4. Additional scans for keys and description pages** | Referring to literature obtained for Job 1 and progress lists of missing images  
1. In Photoshop, scan images as required  
2. In Photoshop, edit image quality and size, add reference text, save for web  
3. Post new image files to online *Bug Guide* |
| **5. Fill glossary gaps** | When new meanings are requested via feedback  
1. Search reference books  
2. Find meanings of new terms  
3. Edit file in Dreamweaver  
4. Post edited files to online *Bug Guide* |
| **6. Include new specimens** | When new specimens become available at MDFRC and referring to progress lists of missing images  
1. Take required images using Leica Imaging Suite  
2. Store original images in M:\Projects\Taxonomy\Images Invertebrate (whole animal images) or M:\Projects\DEWHA\188-Bug Guide\Images\key couplets high res files (couplet images)  
3. In Photoshop, edit image quality and size, save for web  
4. Post new image files to online *Bug Guide* |
| **7. Include new habitat images** | When new images become available at MDFRC and referring to progress lists of missing images  
1. Store original images in M:\Projects\Taxonomy\Images River and lake  
2. In Photoshop, edit image quality and size, save for web  
3. Post new image files to online *Bug Guide* |