A DATABASE OF THE FRESHWATER AND TERRESTRIAL CRUSTACEA OF INLAND SOUTH-WESTERN WESTERN AUSTRALIA.

ACCOMPANYING REPORT PREPARED FOR THE ENVIRONMENT FORESTS TASK FORCE OF ENVIRONMENT AUSTRALIA.

by

P Horwitz[1], D Jones[2] & S Judd[1]

[1] Department of Environmental Management, Edith Cowan University, 100, Joondalup Drive, Joondalup. WA. 6027.

[2] Department of Crustacea, Western Australian Museum, Francis Street, Perth. WA. 6000.

1. OVERVIEW

The Commonwealth and State (WA) Governments are together undertaking a comprehensive regional assessment as part of negotiating a Regional Forest Agreement for the forests of southwestern Australia. The assessment includes economic, social and ecological studies. It has been widely recognised that the assessment process needed some measure of the extent of existing data and databases for flora and fauna. Rather than assess each taxonomic group individually, key taxonomic groups could be chosen to depict biotic patterns across the landscape. The inland crustaceans are one such group.

This project aims to prepare a database of geographical records for all species of crustaceans from terrestrial and inland aquatic habitats in southwestern Australia (defined as those occurring above the high tide mark). By far the majority of these will be inland aquatic species.

The specific study region chosen included the three biogeographic regions of Swan Coastal Plain, Warren and Jarrah Forest defined in Thackway and Cresswell (1995). Some key studies which occurred just outside these regions could also be relevant to identify marginal occurrences of taxa. The primary purpose of the report was to collate records for all relevant material lodged in the Crustacean collection of the Western Australian Museum (WAM), and from 75 published sources.

This report is a companion to the database, prepared to the specifications outlined by the Commonwealth's Department of Environment, Sport and Territories, and it details the methodology used, the limitations of using the database, and gives recommendations for further work. The report also includes the full bibliography of published literature used to access records.

The database includes 4684 records with 34 fields. Primary fields give information about taxonomy, locality and date, while supplementary information, in respect to collection detail and the source of the data, was also included. Where sufficient locality information was available, decimal latitude and longitude coordinates, together with a degree of geographical precision, were included. The database facilitates the plotting of distributions of taxa at various taxonomic levels and on a regional basis. Some degree of historical analysis is also possible and the database contains valuable information about the specimens held by the WAM.

2. METHODS

2.1 Sources of Data

2.1.1 Collections

All registered and unregistered specimens of the WAM that fulfilled the following criteria were included in the database. Type specimens were taken from Jones (1986) and unpublished additions. A large collection of freshwater crayfish (only partially registered) by C. M. Austin formed part of the WAM collection. Most of the specimens in this collection were identified by P. Horwitz prior to its inclusion in the database. A collection of parastacids and other crustacean material belonging to P. Horwitz was also included. These separate collections are noted (see Section 2.3.33).

2.1.2 Literature

All published literature found to contain records of taxa that fulfilled the criteria below were included. Literature was not included where it was found to be an obvious duplication of material examined previously by the same author. Duplication of records occurs where material may have been re-examined and described by subsequent authors. No attempt is made to remove these duplications or duplications that occurred as a result of taxa being both registered specimens of the WAM and described in the literature. The unpublished theses of Austin (1979;1985) were included since they contain locality information that relates directly to material in the WAM collection. The unpublished report by Horwitz (1995) was included because it is one of the few major studies of the far southern part of the south-west of the state and because data from the report have been published elsewhere.

2.2 Criteria for Inclusion

2.2.1 Taxonomic

Records were included where taxonomic information was at the subclass level or lower. Nomenclature included in the Genus, Species and Subspecies fields is identical to that given on specimen/sample labels or in the literature. No attempt has been made to resolve synonymy since: (1) all taxa are not identified to the species level; (2) all names used are taxonomically valid even if included in synonymy;(3) synonymies will only be relevant at an analytical stage and (4) nomenclatures are likely to change in the future.

Higher order taxonomies were taken from the following established classificatory systems. Bowman & Abele (1982) for the Notostraca, Anostraca, Copepoda, Conchostraca, Branchiura, Ostracoda and Decapoda. The Syncarida and Amphipoda were adapted from Schramm (1986). The Thermosbaenacea were determined according to Poore and Humphreys (1992). For the Isopoda, Oniscoidea were classified according to Holdich *et al.*(1984), the Flabillifera and Asellota according to Bowman and Abele (1982). The position of the Phreatoicoidea follows two schemes, an unpublished family scheme of Knott, and Nicholls' (1943; 1944) scheme for genera. Higher order taxonomies were constructed in a separate database prior to their inclusion in the final database that accompanies this report. It follows that not all the groups above will necessarily be represented within the study area.

2.2.2 Geographic

Taxa were included where they occurred south of latitude 30°S, west of 118° 30'E, and west of a line drawn between the points where they coincide with the eastern and southern coasts of continental Western Australia. Within this region, records were confined to coastal areas, immediate off-shore islands and areas in the vicinity of forested regions. This area broadly encompasses the Darling Botanical District (Beard, 1981). Records from the agricultural wheatbelt of Western Australia were not included.

Some ecological studies present data that are grouped on the basis of an experimental treatment or as a result of replication. In many instances maps that appear in the final literature are too small to accurately determine localities for each of these sites. In such cases the data for a number of sites were grouped and given a broader locality description (eg. subcatchment). General latitudes and longitudes, which are accurate to 10 km or 50 km for all sites, were then calculated.

2.2.3 Dates

Multiple records were given to taxa which occurred at one locality but were collected on different dates. In literature detailing ecological studies, more than one record was included where the same taxa were collected as a result of sampling in distinctly different seasons and where such dates were explicitly stated in the literature. Records for which taxa were collected, or sampled over a range of dates in close succession, were given only one entry but the various dates of collection were noted (see Section 2.3.26).

2.2.4 Habitat

All known studies that detailed freshwater and terrestrial taxa were included. Papers by McKenzie (1978) and Bunn (1981), which deal with saline lakes, were included because they include some taxa and localities commonly found in other studies.

2.3 Fields

The following is a description of each of the 34 fields in the database. The field code, field type (character or numeric) and the field length are stated followed by detail of the criteria and methods relevant to each field. There are 12 fields which describe the taxonomy of each record (2.3.2 to 2.3.13) which need little further explanation. However, where a specific taxonomic field is not relevant, or a record is not identified to that level, it is indicated by a short dash (_). Where taxonomic detail remains unresolved it is indicated by a question mark (?). Standard abbreviations (aff. cf. nr. juv. sp. and spp.) are used in the manner that they appear in the literature or by collectors.

2.3.1 Record number-

(Code: recordnum. Type: Numeric Size: 5.) gives each record a unique identifying number.

2.3.2 Class

(Code: class. Type: Character. Size: 12.)

2.3.3 Subclass

(Code: subclass. Type: Character, Size: 14.)

2.3.4 Superorder

(Code: superorder. Type: Character. Size: 10.)

2.3.5 Order

(Code: order. Type: Character. Size: 13.)

2.3.6 Suborder

(Code: suborder. Type: Character. Size: 13.)

2.3.7 Infraorder

(Code: infraorder. Type: Character. Size: 12.)

2.3.8 Section

(Code: section. Type: Character. Size: 13.)

2.3.9 Superfamily

(Code: superfam. Type: Character. Size: 23.)

2.3.10 Family

(Code: family. Type: Character. Size: 29.)

2.3.11 Genus

(Code: genus. Type: Character Size: 17.)

2.3.12 Species

(Code: species. Type: Character Size: 21.)

2.3.13 Subspecies

(Code: subspecies. Type: Character. Size: 15.)

2.3.14 Location Code-

(Code: locatcode. Type: Character. Size: 7.) gives a code for locations as they are used in literature. Many ecological studies describe localities with four of five letter codes. This field facilitates quicker and easier cross reference to the literature and data entry.

2.3.15 Locality-

(Code: locality. Type: Character: Size 40.) gives general or specific localities dependent upon the type of information given in the literature or on the specimen label. Easily identifiable localities, and those for which latitudes and longitudes were provided, are included in this field. Where localities are described in general terms with additional information, this field is used to described the broader scale locality.

2.3.16 Locality detail-

(Code: locdetail. Type: Character. Size: 80.) complements the locality field and gives the detailed part of locality information if applicable.

2.3.17 Decimal latitude-

(Code: latdec. Type: Numeric. Size: 7.) values are given to 3 decimal places. These are extracted directly from several digital and printed WAM gazetteers or are computed from conventional degrees, minutes and seconds, or Australian Grid Map coordinates obtained from other sources (see Table 1).

2.3.18 Decimal longitude-

(Code: longdec. Type: Numeric. Size: 7.) values are given to 3 decimal places. Methodology as in 2.3.17.

2.3.19 Locality reliability

(Code: locatrel. Type: Numeric Size: 1.) assigns some degree of accuracy and reliability to each of the latitude and longitude coordinates. It also indicates where records could be made more accurate with further research. Details of categories and methodology are given in Table 1.

Table 1. Summary of categories used to classify locality reliability

CATE-GORY	NAME	DESCRIPTION	EXAMPLES	UPGRADE POSSIBLE?	PREDICTED ACCURACY
1	Precise A	Lats and longs or AMG reference given by author.	Specimen in a vial with a label that includes degrees and minutes or a published paper that includes lats and longs or AMG. Assumed to be accurate.	NO	1 km
2	Precise B	Lats and longs determinable from data, from detailed maps within published papers or determined from maps at a scale of 1:50000 or 1:25000. Localities specific enough to allow determination by gazetteer.	Detailed diagram within a published paper showing locations of sites. Road junctions, stream confluences, distances on known roads from major towns or landmarks subsequently plotted on appropriate scale maps. Landmarks, lakes or other distinct or detailed localities determinable by gazetteer.	NO	1 km
3	Specific A	Specific localities, given by collectors or detailed in literature, which cover a large area or where sites are grouped. Lats and longs determinable by gazetteer or by 1:100000 map or from other records. Additional detail given.	Published paper or records state localities as suburbs, catchments, national parks or small creeks. Additional detail included such as north-west corner, street names or points up or down stream from river crossings or confluences.	YES. to 2	10 km
4	Specific B	Specific localities, given by collectors or detailed in literature, which cover a large area or where sites are grouped. Lats and longs determinable from gazetteer or from 1:100000 maps or from other records. No additional detail given.	Published paper or record stated as suburbs, catchments, national parks or small creeks without additional detail.	NO	10 km
5	Detailed	General locality detail present but more specific information given by collector or author. Lats and longs obtained from gazetteer, from 1:100000 maps or from other records.	Published paper gives a general locality description but also refers to a distance and direction from a known point or locality, or refers to junction of roads or mile pegs.	YES to 4 or 2	50 km
6	General	Only general locality information given.	Locality given as a town or large geographical feature such as an extensive range of hills, catchment or district. Specimen label may say, for example, "Near Walpole".	NO	50 km
7	Determinable	Locality too general but can be upgraded.	Locality given as being between two towns. Location or feature unknown at this stage.	YES to 6, 4 or 2	NA
8	Indeterminate	Bad locality data. Illegible or misspelt labels. Information could refer to more than one locality or geographic scale far too broad.	Locality given as large river system or other large geological feature *ie.* "Blackwood River" or "South-west Western Australia".	NO	NA

2.3.20 Collector species discrimination-

(Code: colspecnum. Type: Character. Size: 5.) gives any species numbers or letters detailed by collectors or authors. More than one species of any specified taxonomic level may have been collected at any given locality. This category preserves any discrimination between taxa made by a collector or author.

2.3.21 Site-

(Code: site. Type: Character. Size: 10.) gives site numbers or codes given in ecological papers or on vial labels. This field differs from location code (2.3.14) in that many sites may occur at one locality.

2.3.22 Source-

(Code: source. Type: Character. Size: 50.) documents the collector of a specimen record or the author of a paper from which a record was obtained. Collectors are given when the literature reference number (2.3.23) is zero (0). All other entries are authors which are listed in Section 5.

2.3.23 Literature reference number-

(Code: litrefnum. Type: Numeric Size: 2.) gives a number (1-75) to each published paper cited This facilitates extraction of information in respect to any individual author or paper. Each published paper from which records were drawn was numbered sequentially. Literature reference numbers precede each article, which are listed alphabetically by author, in Section 5. A literature reference of zero (0) indicates a record obtained from a specimen and not from literature.

2.3.24 Year-

(Code: year. Type: Numeric. Size: 4.) gives the year of publication of a paper or the year of collection of a specimen (if known) depending upon the source of the record.

2.3.25 Exact date of collection-

(Code: exacdate. Type: Date. Size: 8.) gives the exact date of collection of an individual record (if known) whether it is part of collection or is given by an author in the literature.

2.3.26 Approximate date of collection-

(Code: recordnum Type: Character Size: 22.) gives the approximate date of collection of an individual record (if known) whether it is part of collection or it is given by an author in the literature. Approximate dates include records where only part of the date is known (eg. month and year), or where sampling or collecting occurred over a period of time or on a number of dates.

2.3 27 Lodgement-

(Code: lodged. Type: Character. Size: 4.) gives the name of the institution where specimens are lodged. As well as indicating those specimens/samples which were part of the WAM collection, this field gives details of those specimens/samples described in the literature that are lodged elsewhere. Standard abbreviations are used (see Jones, 1986).

2.3.28 Registration number-

(Code: regnumber. Type: Character. Size: 16.) gives the registration number of specimens/samples lodged with the institutions detailed in the previous section.

2.3.29 Type-

(Code: type. Type: Character. Size: 1.) details the type of specimen/sample, if applicable, of those lodged with institutions (H = Holotype; P = Paratype; A = Allotype; S = Syntype; N = Neotype).

2.3.30 Females-

(Code: females. Type: Numeric. Size: 2.) gives the number of females in registered or unregistered specimens if it is stated in the literature or on specimen/sample labels.

2.3.31 Males-

(Code: males. Type: Numeric. Size: 2.) gives the number of males in registered or unregistered specimens if it is stated in the literature or on specimen/sample labels.

2.3.32 Determination

(Code: determine. Type: Character. Size: 17) gives the name of a person or person (where stated) who made the taxonomic determination of the specimens/samples lodged at the WAM.

2.3.33 Collection code-

(Code: collector. Type: Character. Size: 2.) indicates those specimens which were part of extensive collections of C. M. Austin (AU) and P. Horwitz (PH).

2.3.34 Notes-

(Code: notes. Type: Character. Size: 85.) gives any other information from literature of specimen labels that may be pertinent to the further refinement of any other fields.

3. DISCUSSION

3.1 Use

The database can be used to extract records at any of the 12 taxonomic levels for which there are fields. The distribution of these selected taxa may be plotted using the decimal latitudes and longitudes provided. This allows for distributional analysis over a range of taxonomic levels. The occurrence of taxa within a certain region may be examined by prescribing decimal latitude and longitude values between which records must fall. By using a combination of the date fields (2.3.24 & 2.3.25) it is possible to examine the historical occurrence of some species. It should be noted that synonymy may be a problem in this respect because some species have been redescribed.

As well as these three principal uses, the database provides valuable information about the specimens held by the WAM and where and when some of the more significant collections took place.

3.2 Taxonomic reliability

There are a number of limitations inherent with data assimilation of this kind. Firstly, the records need to be classified according to their taxonomic reliability. This would greatly enhance the database and allow for analysis of both reliable taxa and precise localities. This task would involve review of all records, reference to the original literature and possibly correspondence with authors. Specimens have been identified by a range of workers with varying skills. The literature and specimen collections also give information at various taxonomic levels. The more common and easily identified taxa may be more readily represented than new or rarer taxa.

We recommend that use of this database should be restricted to personnel who are capable and confident in their ability to interpret the sources of identified in this report.

3.3 Sources of error

Phonetic spellings. Some names were commonly misspelt. Where an obvious error of one or two incorrect letters was detected, names were changed to their correct spelling. Some localities have changed in spelling (eg. Bulls Brook - Bullsbrook). Modern interpretations of these spellings were made but it is possible that some places referred to may now be called something completely different and that some interpretations were erroneous. Many names of lakes are also very similar (eg. Lake Jandabup -Yangebup Lake). Possible sources of error may have occurred at the original detailing, or later interpretation, of labels of specimens from such places.

Gazetteers. Latitudes and longitudes obtained from gazetteers were, assumed to be correct and not checked. However, where two localities have the same name, or more than one set of latitudes and longitudes were given, they were verified and the most appropriate pair was selected. In addition, only those localities within the area defined in Section 2.2.2 were searched. Those localities obtained from the gazetteers which matched localities for which latitudes and long were given by authors or collectors were cross-checked.

3.4 Database Development

The following four sections detail areas of further investigation which will greatly enhance the usefulness of the crustacean database. Collectively, the amount of work required to complete them would be about equal to that taken to construct the database to its current state. We recommend that consideration be given to funding this extended work in the near future.

3.4.1 Taxonomic precision

A scheme for taxonomic reliability and the subsequent grading of records was partially developed during the construction of this database, but time constraints prevented its full implementation. However, we regard this, and the resolution of synonymies (or at least indicating where they occur in the database), as important, achievable refinements in the future. The analysis of the distribution of records following the implementation of such a scheme would assist in the identification of erroneous records.

3.4.2 Geographical accuracy

More time could be spent on upgrading locality reliability (eg. locality reliability categories 3, 5 and 7), thereby making more use of data that is of broad geographical resolution or unreliable. This would take considerable time and involve referring to maps of a scale of 1:50000. However, it could be easily accomplished as all relevant information is contained in the database. It should be possible to classify records by geographical region, catchment or subcatchment to show gaps in sampling and regions of endemism.

3.4.3 Private collections and unpublished data

Many researchers hold private collections or have unpublished data on the distributions of Crustacea in the south-west. Having established the database it is now possible to gain access to the private collections of individual researchers (subject to their approval). Further research and the chance to access such collections or obtain unpublished data is likely to greatly enhance the amount of information contained in the database. In addition, individual authors could be approached for more information to make some records more useful or reliable.

3.4.4 Updating

Some researchers, contacted during the development of this database, have indicated that they have relevant papers in press or in preparation. It is important that the database be regularly updated to incorporate such new information, particularly as very few studies have concentrated on Crustacea of the forested regions of south-west Australia.

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