

Australian Museum

Report on the implementation of the
Science Research Strategy, 2007–2012

for the period: 1 May 2008 – 30 June 2009

nature culture **discover**



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Appendixes

- 1. Research Stocktake – a listing of research areas/projects for 1 May 2008 – 30 June 2009**
- 2. Research Grants – Funding from 1 July 2008 – 30 June 2009**
- 3. Publications – 1 July 2008 to 30 June 2009**

Abbreviations

ALA: Atlas of Living Australia

CHSI: Cultural Heritage and Science Initiatives Branch

CITES: Convention on International Trade in Endangered Species

EPBC Act: Environment Protection and Biodiversity Conservation Act

GBIF: Global Biodiversity Information Facility

IUCN: International Union for Conservation of Nature

PGA: Postgraduate Award recipient

RA: Research Associate

SF: Senior Fellow

VCF: Visiting Collections Fellow

VRF: Visiting Research Fellow

Glossary of Terms

Endemism, an organism being '*endemic*' means exclusively native to a place or biota.

A **geographic information system (GIS)** is an information system for capturing, storing, analysing, managing and presenting data which are spatially referenced.

Last Glacial Maximum refers to the time of maximum extent of the ice sheets during the last glaciation, or ice age, 20,000 years ago.

Ontogeny is the origin and development of an individual organism from embryo to adult.

Phylogeny is the evolutionary development and history of a species or higher taxonomic grouping of organisms. Also called *phylogenesis*.

Phylogeography is the study of the historical processes that may be responsible for the contemporary geographic distributions of genetic diversity.

Taxonomy/ Alpha Taxonomy is the science of finding, describing and categorising organisms,

thus giving rise to taxonomic groups or taxa (singular: *taxon*), which may then be named.

A **terrane** in geology is a fragment of crustal material formed on, or broken off from, one tectonic plate and 'sutured' to crust lying on another plate.

The Coral Triangle refers to the waters of Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands, Timor-Leste with an abundance of coral reefs.

Executive Summary

As this report demonstrates, research at the Australian Museum has continued its excellent record, both qualitatively and quantitatively, during 2008-09. Substantial progress has been made towards addressing all but one of the key research goals [Program 8 b)], with major contributions by staff, Senior Fellows, Research Associates, students and Visiting Fellows. The Museum does not have any research staff working in the area of 'Analysing dynamics of contemporary and recent reef systems' [Program 8 Key research goal b)].

Measures reported in the Museum's Annual Report (2008-09) quantify some of our achievements. In particular, we were awarded research grants totalling \$806,760 (up from the previous year total of \$698,760) with an average value of \$31,029 (compared with the previous year average of \$26,860). Staff were also involved in another 19 grant-funded projects where the funding was administered by another institution. These successes reflect a greater emphasis of effort in generating income to support our research that will need to be sustained as recurrent funding declines in real terms. During the financial year researchers produced 170 scientific publications – a 33% increase over the previous year.

These achievements are outstanding given the operational context for the year. We have had to do more with less. The number of full-time researchers continued to decline with one resignation and a failure to fill 4 advertised positions that were made vacant through resignations and retirements over recent years. Our research outputs are increasingly relying on short-term part-grant/part-salaried early career positions and non-salaried personnel with continuous erosion of core capability and diversity of expertise. While performance over the last year has been made possible through greater leveraging of resources, such as grants, the output of the Research & Collections Division will not be sustainable in the long run without staffing levels being maintained. We look forward to the current recruitment round being successful in helping to replace some of our lost research capacity.

During the year a significant number of our staff and biological collection specimens were relocated into the new Collections & Research Building with consequential relocations of geosciences staff and collections into refurbished spaces. This was a mammoth effort, particularly for collections staff. The launch of the new Museum website also required major inputs from research and collections staff to totally re-write major sections of web content and add new information.

The Museum's research priorities are a reflection of our geographic location – the vast majority of research projects undertaken have focussed on the environment and indigenous cultures of the Australasian region. However, the Australian continent, its fauna and our indigenous cultures have origins, components and connections in other parts of the world. For example, Australia was once part of Gondwana, and is now pushing up against the Asian plate. The ancestors of our animals arrived here from Gondwana, from the tropical oceans and lands to our north, and across the oceans to our east and west. Some of our species have been here for millions of years, have evolved greatly over that time, and are unique to Australia, whereas, others have broad distributions outside Australia and our region. Indigenous people came here from the north-west and more recent arrivals have come from everywhere. Thus, it should be no surprise that Australian Museum scientists must look beyond our immediate region. Science is as globalised as economics. The Museum's taxonomists undertake world-wide revisions of animal groups because to confine one's attention to our region alone will not provide a full or realistic understanding of the Australian species or their relationships. By the same token, overseas experts assist with the understanding of Australian biodiversity with their world-wide research.

Rather than attempting the impossible task of summarising succinctly the breadth and depth of scientific activity outlined in this report, this section highlights some projects from all programs that demonstrate one vital aspect of our research – relevance to contemporary societal issues. This is not to downplay the importance of basic biological and cultural research that underpins any advancement of knowledge; rather it is intended to focus on areas that showcase the obvious direct

value of our research activities and outcomes to a broader audience.

Species Discovery and Documentation:

Australasia's terrestrial and marine biodiversity remains relatively poorly described, particularly amongst invertebrate groups. This paucity of knowledge is a frustrating impediment to achieving environmental sustainability. In particular it constrains accurate and timely assessment of environmental impacts on biodiversity resulting directly from human activities and climate change, the development of cost-effective conservation and resource management measures and the detection of introduced pests. Using morphological and molecular approaches, Australian Museum researchers have made significant progress in documenting the diversity of key groups including amphipods, isopods, polychaete worms, land snails, spiders, beetles, moths, flies, ants, termites, fishes, frogs, skinks and geckos and in significant geographic areas such as the Pilbara bioregion of Western Australia, coral reefs, and in national reserve and indigenous protected areas. More than 80 new species were described in scientific papers during the year. Research also included studies of animal groups that leave good fossil records, including flies embedded in amber recently discovered in north Queensland, trilobites in China and conodonts (extinct eel-like animals) in the Australasian Province.

Conservation and Management:

The importance of biodiversity conservation was highlighted in 2008-09 by the release of discussion papers/draft strategies on this issue by both the NSW and the Australian Governments. In addition to providing substantial comment on these documents, Australian Museum researchers undertook a wide range of biological and ecological projects directed at addressing key aspects of concern. There were 26 research projects focused directly on human impacts on biodiversity during the year. These included studies on taxonomic groups with extremely limited distributions in areas at risk from extractive industries, connectivity of coral reef systems and populations, potential impacts of climate change on species distributions and ecological processes and the development of innovative tools for biodiversity assessment and

monitoring. Other research was focused on impacts of current management practices such as relocation of individuals of threatened species to 'safer' habitats and sandy beach nourishment. Geological research also contributed to the area of resource management with projects that identified rare mineral deposits in the Jenolan Caves and new mineral species from Broken Hill and added to our knowledge of volcanic processes relevant to understanding their geothermal potential.

Cultural Heritage and Diversity:

Increasing access to our cultural collections and the knowledge contained in them was a priority during 2008-09. Projects covered a broad range of topics relating to both tangible and intangible aspects of human cultures in direct response to NSW and national imperatives. Research included investigation of practices such as tattooing, trade in stone tools and artefacts as well as a suite of projects aimed at fostering greater engagement with creator communities. Activities in all of these areas were greatly assisted with the use of new technologies for analysis of collection specimens and for making collection material available electronically.

In addition to outlining the range of research undertaken to directly address the key research goals of the Science Research Strategy, 2007-2012 the report notes several areas of important research that do not strictly fit within this framework – in particular, research into human impacts on biodiversity that are not Sydney-centric or related to climate change. If the focus is to be constrained rigorously to these areas, our ability to participate in several national initiatives and take advantage of these potential funding sources may be hampered.

Dr Brian Lassig, Head of Research
30th July 2009

Structure of Report

1. The **narrative information** provided represents the collective achievements and activities of research scientists across the Research & Collections Division, and is not a report of individual performance. Rather than presenting a comprehensive description of all

research undertaken, the narrative aims to highlight key achievements and progress against each of the research programs and key research goals, as set out in the Science Research Strategy.

2. The qualitative narrative information is supplemented by **quantitative indicators** of performance, including **grant funding (Appendix 2)** and **publications (Appendix 3)**. NB: publications and grants are for the period 1 July 2008–30 June 2009.
3. The **table of research areas/projects (Appendix 1)** lists research undertaken in the reporting period in each of the research programs. It shows contributing staff for each project/area, including Senior Fellows.
4. Staff, Senior Fellows, Research Associates and Visiting Fellows and Postgraduate Award recipients who have contributed to a program are listed under each program and in Appendix 1.

Two researchers from across the three branches of the Division were nominated to coordinate the input for each research program:

Prog 1: Biota in Australasian marine environments

- Pat Hutchings (Research);
- Mark McGrouther (Collections)

Prog 2: Biota in Australian terrestrial and freshwater environments

- Dan Bickel (Research);
- Graham Milledge (Collections)

Prog 3: Genetic variation in key taxa of Australasian and Indo-Pacific biota

- Mark Eldridge (Research);
- Rebecca Johnson (CHSI)

Prog 4: Origin, evolution and biogeography of the biota of Indo-Pacific and Australasian region

- Chris Reid (Research);
- Ross Sadler (Collections)

Prog 5: Understanding human impacts on Australian biota

- Dan Faith (Research);
- Sandy Ingleby (Collections)

Prog 6: Investigating human cultures and communities over time.... in Australia and the Pacific

- Val Attenbrow (Research)
- Stan Florek (CHSI)

Prog 7: Linking intangible and tangible heritage

- Robin Torrence (Research);
- Dion Pieta (CHSI)

Prog 8: Investigating extant and extinct faunas and environmental systems in context of recent geological history ...

- Ross Pogson (Collections)
- Yong Yi Zhen (Collections)

This report does not include the research output of Lizard Island Research Station (LIRS) except where it has been undertaken by staff, Fellows and students of the Australian Museum.

The previous report was for the period to April 2008. This report covers slightly more than a 12-month period, from 1 May 2008 to 30 June 2009 to bring it into line with financial year reporting processes.

Program 1

Addressing knowledge gaps and problems in understanding the biota in Australasian marine environments.

Summary

The research undertaken primarily addressed issues such as documenting biodiversity, invasive species and other environmental impacts in marine environments.

This program recognises that a key requirement for conserving and managing marine environments is a better understanding of the organisms comprising marine biological communities. Species groups studied included adult and larval fishes, gastropod (snails or univalves) and nudibranch (sea slugs) molluscs, polychaetes (segmented marine worms), crustacean amphipods (scuds and beach hoppers) and isopods (sea slaters), and asteroids (sea stars).

Key Drivers

Research aligned with both State and Commonwealth initiatives designed to achieve an environmentally sustainable country with well managed marine ecosystems. Commonwealth Government, international and charitable research funding was awarded to undertake many of the projects.

Species groups studied drew on the specialist expertise of the research and collection staff to provide an improved understanding of current species diversity and distributions, and were used to inform marine planning. For example, amphipods, which are noted for their diverse ecological roles and as indicators of biogeographic and environmental change, were a key group investigated. Similarly, research on larval fish dispersal increased our understanding of the spatial scale at which marine populations operate, and is fundamental to management of them, both for fishery purposes and also for the design and operation of marine protected areas.

Many of these projects involve national and international collaborations to develop interdisciplinary teams. Some of the studies have

been collection-based, using existing collection data and also further building the collections.

Museum facilities which have been integral to research in this program include Lizard Island Research Station and the DNA and Scanning Electron Microscope laboratories.

Key research goal a) Understanding Australia's marine biodiversity, emphasising species with key ecological roles and high sensitivity to human impact.

Significant progress was made in understanding the diversity, phylogeny and distributions of a number of important species groups, resulting in new publications, identification keys and enhanced collections.

The Circum-Australian Amphipod Project (CAAP), in its third year of research, has completed an assessment of all shallow-water marine amphipod collections in natural history museums in Australia. New collections have been made from significant marine protected sites and Australian external territories, most recently collecting at Norfolk, Cocos (Keeling) and Christmas Islands. Through these collections the CAAP database provides a modern, comprehensive picture of Australia's near-shore amphipod fauna, recognising around 17% are unknown amphipod species. Research now focuses on describing these species to make this information available to the broader scientific community.

Three new picture-guided interactive identification systems to world fauna were developed for the Amphipod families Platyischnopidae, Megaluropidae and Paracalliopiidae. This group of taxa are abundant in soft-sediment marine coastal habitats. These identification systems will be made available to the Crustacea.net Website (www.crustacea.net).

A comprehensive study, 'Benthic Amphipoda (Crustacea: Peracarida) of the Great Barrier Reef, Australia', has been completed (Lowry and Myers, in press). It describes about 240 species from the Reef, nearly half of which are new to science. Interactive keys to the 240 species of Great Barrier Reef amphipods will form a CD supplement to the book.



The diversity of cirolanid isopods, one of the most abundant and speciose groups occurring in shallow marine areas, was examined. Many species play an important role in ecosystems as scavengers and may be pests of commercial fisheries. Field activities added to the collection of cirolanid isopods and other taxa, including undescribed species and provided new distributional information.

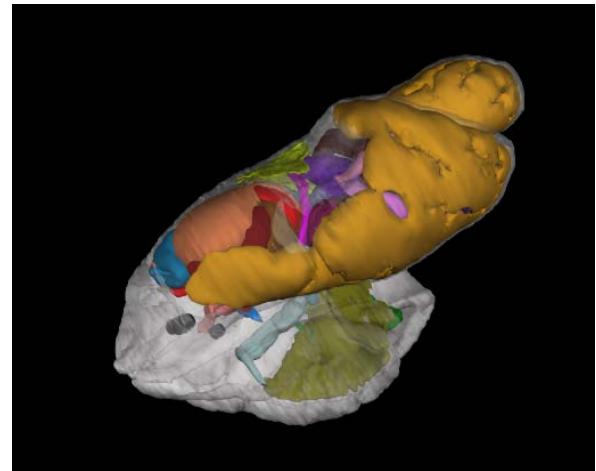
A recent publication incorporated a biodiversity survey of the isopod fauna from the Gulf of Mexico, a semi-enclosed basin that is similar to basins off northern Australia, such as the Arafura Sea. This study discovered that this basin has a diverse fauna at mid depths but below 2500m had declining diversity. Whether this pattern and its causes are seen in Australia marine faunas will be the subject of future research.

Numerous species of Sabellidae (Polychaeta), previously identified as introduced species, are being investigated by a postdoctoral researcher to determine if they are instead a suite of cryptic undescribed native species. Establishing their true status prior to undertaking remediation studies is critical.

The Museum has finalised a major phylogenetic study on the Sabellida using both morphological and molecular techniques. This represents the largest dataset ever assembled for this group and a new classification is proposed.

One researcher collaborated with colleagues from Spain to produce another paper documenting the diversity of the syllid polychaetes in Australia.

Researchers in the Malacology department, led by the inaugural Chadwick Biodiversity Fellow, used 3D reconstruction to record the anatomy of minute marine snails and identify a new species and genus of snail endemic to intertidal algae in NSW. The computer software enabled the researchers to build an anatomical model which showed that the new species is unique in Australia and is related to a group of deep-sea, polar taxa.



The different colours on this 3-D reconstruction distinguish the various internal organs of the snail. Image created by Rosemary Golding.

A Senior Fellow, has been working with colleagues at the Smithsonian Institution on the ontogeny, morphology, biology and relationships of deep-sea whalefishes (Cetomimidae). They have shown that the larvae, females, and males previously considered members of three separate families, are different life stages of this rare deep sea family (Johnson et al., 2009). The combination of extreme transformation from larval state to adult and the extraordinary differences between males and females is unparalleled in other families of vertebrates. The solution to the conundrum involved undertaking both detailed anatomical studies, particularly of rare intermediate specimens between larvae and adults, and DNA sequence analyses.

The Museum is collaborating with the CSIRO (Marine Labs) to produce illustrated keys for the 135 species of lanternfishes which are eaten by many marine groups, including Antarctic seals and penguins, oceanic birds and commercially important fishes, and usually dominate the catch of mid-water trawls in any ocean. The keys will include illustrations of each species including

taxonomically useful characters, plus additional data on distribution, maximum and maturation sizes, and end notes detailing new records and information.

Collaborative research has continued on the description of the larvae of the tropical snappers, Family Lutjanidae, with the dual goals of documenting their larval development, and ultimately using ontogenetic data for assessing relationships. A large proportion of lutjanid species live on coral reefs, and support artesinal, recreational and commercial fisheries throughout the world's warm waters.

The relationships of the Tripletail fishes (Lobotidae) using both adult and larval characters, were studies with collaborators at the International Institute for Species Exploration, Arizona State University. As a result, three families will be combined. In addition, the work has now expanded to include a reassessment of the fish suborder Acanthuroidei, and will result in a complete revision of the composition and phylogeny of this important group of largely tropical species, containing some of the most prominent and iconic coral-reef fish species. This represents a significant taxonomic contribution to understanding diversity and distributions in this important group.

A new report by Museum staff and colleagues described the beach-hoppers (family Talitridae) of NSW for the first time and mapped their distribution along the NSW coast. Beach-hoppers are extremely sensitive to human impact caused by grooming of beaches by councils and by off-road vehicles operating on beaches, both of which destroy their habitat. The unusually high diversity of beach-hoppers in NSW (7 genera and 16 species, half the species are new to science) is thought to be a result of the north/south transitional change from subtropical to temperate environments.

Starfish (Echinodermata: Asteroidea) are a distinctive group of invertebrates of great interest to the general public, they are often encountered intertidally and by divers. They are also ecologically and commercially significant, as evidenced by the examples of the impact of the

Crown-of-Thorns starfish on the Great Barrier Reef, and the introduction of the Northern Pacific Seastar. Research was undertaken on starfish in the Museum's collection and specimens recently collected, to develop tools (including a checklist, poster and key) to aid the identification of starfish of the Sydney region that can be delivered through the internet. In the past year taxonomic, geographic, ecological and reference information, distributional data from the Australian Museum and images from a variety of sources have been collected.

Key research goal b) Understanding the connectivity of marine populations.

Museum scientists have examined the geographic patterns of genetic variation and gene flow in intertidal gastropods and bivalves along the coasts of south-eastern Australia, and how these are changing in contemporary environments.

The researchers investigated morphological and molecular variation in an abundant group of intertidal snails, *Austrocochlea constricta*. Nuclear and mitochondrial DNA sequences from the group's three genetic species were collected. The most genetically divergent of these (*A. brevis*) is known only from southern Tasmania. As a cold-adapted species, it is at most risk among *Austrocochlea* species of extinction by range contraction caused by temperature increases.

DNA data collection has been completed for the estuarine snails *Tatea* and *Phallomedusa* and is underway for a number of other taxa including the mussels *Brachidontes australis* and *Xenostrobus* species and six gastropods. The genetics of the mussels are being studied in concert with historical records for the past 4 decades and contemporary surveys of their distribution in relation to climate change.

Museum studies have added at least three contrasting patterns of genetic variation among the Mollusca of south-eastern Australian coasts to the previously observed demarcation at Bass Strait. That demarcation is presumed to have been caused by land-bridge induced isolation at the Last Glacial Maximum. Much more work is required before population structures in the region will be well understood. It is already clear however that

management of these coasts must consider the differences between species in genetic patterns.

Research on larval fish dispersal increases our understanding of the spatial scale at which marine populations operate, and is fundamental to management of them both for fishery purposes, and also for the design and operation of marine protected areas. Dispersal processes are also important to understanding how invasive species spread

In collaboration with the University of Miami an innovative device – the DISC (Drifting In Situ Chamber) – was used to study orientation behaviour of fish larvae in the sea at Lizard Island. This research was supported by a Hermon Slade Grant and a Museum Visiting Research Fellowship.



Photo: the Drifting In Situ Chamber, by Lyle Vail.

Another study investigated the effects of changes to currents and temperature-related changes on the dispersal of fish larvae especially on the Great Barrier Reef (GBR). Changes in dispersal will influence the spatial scale and magnitude of population connectivity in reef fish populations. In addition, a paper on how to immediately apply information from research on population connectivity to management of coral reefs was published in collaboration with researchers from James Cook University and other institutions.

Key research goal c) Understanding the biodiversity of coral reefs.

Research on coral-reef biodiversity focused on the systematics of fishes, polychaete worms and crustacean amphipods. Museum scientists participated in a *CReefs* expedition to Ningaloo in Western Australia where an extensive collection of polychaetes was made. The collection will be analysed over the next 3 years and the diversity of this reefal system compared to two sites on the Great Barrier Reef using a recently awarded ABRS/*CReefs* grant.

One scientist has developed a method called ‘phylogenetic risk analysis’ which is a novel decision-support approach for biodiversity planning. The method has been applied to corals. Based on a phylogenetic ‘supertree’ for corals, it appears that there are many examples where entire clades (existing families and genera) fall into the IUCN (International Union for Conservation of Nature) threatened classes. Thus, loss of phylogenetic diversity or evolutionary history may be a concern. Application of phylogenetic risk analysis to the ‘supertree’ for corals, in combination with geographic distribution data from GBIF and other sources, indicated that worst case losses of phylogenetic diversity could be minimised through conservation efforts focussed in a portion of the Coral Triangle.

Research on the ontogeny of fish behaviour has shown that larval dispersal is a biophysical process in which behaviour plays a key role, unlike traditional assumptions that only currents need to be considered. The development of behaviour in larval fishes was applied to the construction of a biophysical dispersal model for fish larvae on the Great Barrier Reef that will be of great use to management of this World Heritage Area. This project was undertaken in collaboration with the Australian Maritime College, with Marine and Tropical Science Research Facility (MTSRF) support. The model is being tested in collaboration with a transgenerational marking project by James Cook University researchers.

Areas for potential further development – research that supports decision-making in regional marine planning and the establishment of marine

protected areas within both state and offshore waters.

Several studies undertaken in Program 1 demonstrate that further development in this area is occurring, such as the phylogenetic risk analysis of corals and the biophysical dispersal model described above.

Contributing Staff

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Program 2

Addressing knowledge gaps and problems in understanding the biota in Australian terrestrial and freshwater environments

This program recognises that a key requirement for conserving and managing terrestrial and freshwater environments is a better understanding of the organisms comprising these biological communities.

Contributions to this program encompassed a broad range of research methodologies and topics, from field-based ecological studies of interactions between species and their environment, to computer-based syntheses utilising over 200 years of accumulated taxonomic and collection data to analyse large scale patterns in biodiversity. In most cases projects in Program 2 have strong overlaps with other programs in the Research Strategy (esp. 3, 4, 5). Systematic studies, using morphological and genetic approaches, were the core strengths of this program. As part of this research, field work was conducted in localities throughout Australia and overseas. Visits were made to significant natural history collections in other museums, while the vital detailed work of sorting, databasing, identifying and examining specimens, as well as analysing data continued apace.

Key Drivers

It is not possible to measure human impact on biodiversity, or understand the significance of this loss unless there is knowledge of what species are present in the NSW and Australian environments, and what their relationships are to each other. Taxonomic and systematic research in this program provided keystone information required to identify, manage and ameliorate loss of biodiversity. This program also used taxonomic knowledge, collection-based distributional data and community/species-specific ecological and genetic data to assist land managers and policy makers in making informed conservation and management decisions, at both a landscape, and on a species-specific scale. Research also provided the rigorous and relevant framework required to identify potential and detect actual invasive species, as well

as providing baseline data to enable the ongoing impact of climate change to be monitored, modelled and predicted.

This program thus contributed to the achievement of a key goal of the NSW Government State Plan, *'Better environmental outcomes'*, as well as National Research Priorities, *'An environmentally sustainable Australia'* and *'Safeguarding Australia'*.

Most of the research in Program 2 involved collaboration between Museum staff and external (often international) researchers and/or institutions and was largely funded from external sources.

The majority of these projects were collection/specimen based, bringing together interdisciplinary teams including morphologists, ecologists, geneticists and information technologists and using key Museum research infrastructure (e.g., bioinformatics, GIS, SEM, DNA lab).

Key research goal a). Understanding the species and places of high biodiversity significance in Australia

Although there is a huge continuing need for alpha level taxonomy in Australia, the relationships between already described species and their environment is often lacking. Understanding these relationships has allowed researchers to open windows into evolutionary and ecological events in Australia's history, as well as begin to understand the impact of current climate change.

Regional faunal summaries and handbooks are very important. The Museum in collaboration with other institutions is producing an identification guide to the land snails of eastern Australia for a wide audience ranging from professional malacologists to amateur natural historians. The geographic coverage extends from the New South Wales/Victorian border to the islands of the Torres Strait and approximately 300km inland, and also includes a synoptic treatment of the unique Lord Howe Island and Norfolk Island land snail faunas.

In total, the guide features 796 species of land snail allocated to 295 genera within 44 families. As well as the many native species, the more commonly encountered introduced garden and agricultural

pests have also been included. Seventy-one genera and 308 species are described as new.



Plate from the soon to be published guide to the land snails of eastern Australia. Seventy-one genera and 308 species are described as new.

Major advances were made in the taxonomic understanding of many Australian terrestrial invertebrate taxa. For example, one scientist has undertaken a major study of hadrotarsine spiders in which 19 putative genera were identified from Australian material, of which two-thirds are undescribed. There will be an estimated 100+ species in this group, the majority currently undescribed.

Another researcher completed a revision of the leaf beetle subfamily Spilopyrinae ('fiery leaf beetles'), with the description of 14 new species, 8 from Australia. The species are large and spectacularly coloured, but rare in collections. Resolution of a taxonomic problem concerning the leaf beetle *Menippus fugitivus*, the first listed species of beetle under the Threatened Species Conservation Act (NSW 1995), led to the discovery of 3 new Australian species in this genus. The original listed species was a misidentification. The 6 Australian species were revised.

The Entomology department is currently undertaking taxonomic revisions of the Australian Lichen Moths (Lepidoptera: Arctiidae, Lithosiinae), and is currently working on *Asura*, a genus with 13 described species. The revision of these small orange and black diurnal moths will

result in several new species descriptions, and recognition of a couple of existing synonymies (that is, moths previously identified as separate species that are in fact the same species).

Studies of communities of organisms and their role in ecosystem assessment are another strong feature of this goal. The results of many of these studies will enable legislators and planners to make better decisions for conserving Australian habitats. Initiatives such as the Terrestrial Ecosystems Research Network (TERN) facilitate this process. Museum staff have helped to plan and progress the work of TERN. TERN approaches knowledge gaps related to the need to address the big national questions about Australia's terrestrial ecosystems and the services they provide by 'facilitating continental scale analyses and syntheses of datasets pertinent to that scale'.

Freshwater habitats are another area of research. One researcher has documented the risk from human use of freshwater to many freshwater isopods, especially members of the genus *Eophreaticus* in regions of Kakadu National Park where mining still occurs.

Key research goal b) Understanding the distribution, interaction and evolution of key species in arid Australia

Most projects listed under Goal 2b have substantial overlap with those in 2a. This reflects the biological reality that taxa from moister areas of Australia often have representatives in the arid zone.

The Museum participated in a pilot study for a multi-institutional 'biodiversity blitz' for recently established national reserve and indigenous protected areas. As part of a large 'Caring for our Country' grant, the Australian Biological Resources Study (ABRS) aims to survey and document the biodiversity present in recently established national reserve and indigenous protected areas. In May 2009, a pilot study was set up to survey the Charles Darwin Reserve in Western Australia. Two corporate sponsors, ABRS staff, volunteers and staff from the Earthwatch Institute, and staff from Western Australian Museum, University of New South Wales and Western Australian Herbarium participated in the survey, which was hosted by

Bush Heritage Australia. The Australian Museum's role in the project was to collect flying insects in the Reserve, and report on the moths. A preliminary report to the ABRS was submitted in June. Part of this project involves species discovery, so a revision of the moth genus *Diceratucha* (Oenosandridae) is currently underway using specimens collected during the field work, and those present in other institutions.

Australian Museum researchers have been studying terrestrial invertebrate biodiversity in the Pilbara bioregion of Western Australia. This area has been under pressure from mining, grazing and other human activities, and very little has been known about the terrestrial invertebrates. The Australian Museum has conducted surveys of terrestrial invertebrates in the Pilbara, and the material has been used to examine the distribution of invertebrate biodiversity in relation to climate, land use and other environmental factors.



Photo: Python Pool, Millstream-Chichester National Park, Pilbara Region, W.A., by Matthew Bulbert.

Another project underway investigating species in the arid regions of Australia is a survey of the land snails of the Kimberley Islands, Western Australia by a visiting research scientist.

Key research goal c) Other projects

A collaboration between the botanical consulting company Anne Clements Pty. Ltd. and the Museum is investigating the community of insects associated with fruit of the endangered Magenta

Lillipilly, *Syzygium paniculatum*, (Myrtaceae) from ornamental street trees and from remnant stands in natural bushland. This plant species shows very low rates of seedling recruitment in remnant populations, and it is hypothesised that insects damaging the fruit may have a detrimental impact on the long term survival of these populations. Several undescribed insect species are found feeding on the fruit of both wild and natural lillipilly, and on other species of *Syzygium*.

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Program 3

Increasing our understanding of the genetic variation in key taxa (species) of the Australasian and Indo-Pacific biota

The research reported for this program covers a broad range of taxa from Australia and the Indo-Pacific and comprised two distinct research goals as outlined below.

The collection and analysis of genetic information by Museum staff made significant contributions to many of the Museum's research projects in 2008/09. The use of such information is now a critical component of most evolutionary, biogeographic and biosystematic studies (including projects in Programs 1, 2 and 4). Genetic data are also very often central to the understanding of how species are responding to the environmental challenges associated with increasing human impacts. Such data can include details of the pattern of genetic diversity across the range of a species that determine, for example, what areas need to be managed to maintain the species' full evolutionary potential or how individuals can be translocated responsibly (also some projects in Program 5). Genetic information also assists in species identification. This may be necessary because only part of the animal is available (eg with forensic specimens) or because it is difficult to correlate different life history stages such as larvae, pupae and adults or because identity cannot be established only from morphology.

Key Drivers

The research undertaken involved collaborations with external researchers and institutions, nationally and internationally. This research was largely funded from external funding sources. Research addressed significant New South Wales issues such as the loss of biodiversity and the early identification of invasive species and the National Research Priorities '*An environmentally sustainable Australia*' and '*Safeguarding Australia*'. The Museum contributed to building international resources through its continued involvement in the International Barcode of Life project that aims to systematise genetic identifications by collecting sequence information from the same gene in all animals.

Genetic approaches to monitoring biodiversity and assisting resource-use planning for biodiversity conservation focussed primarily on Australian taxa. Studies drew on the Museum's expertise in particular species groups to demonstrate how genetic data can aid species identification, biodiversity conservation and provide baseline information on natural geographic boundaries to monitor changes in species distribution caused by climate change. Genetic research by its nature has a strong collections focus and can be used to enhance the value of the Museum's collection for understanding and solving emerging issues. Problems related to individual species or whole ecosystems have been addressed in this year's research, generally by bringing together interdisciplinary teams including morphologists and geneticists. The research for this program was mostly conducted in the Museum's Genetics Laboratory and was strongly supported by the Museum's frozen tissue collection.

Key research goal a) DNA Barcoding of taxonomic groups that are of economic, social or environmental concern.

The Museum has made considerable progress both experimentally and organisationally in its contribution to this research goal this year.

In September 2008 Australian Museum staff participated in a trip to Lizard Island with researchers from CSIRO and the International Barcode of Life research facility at the University of Guelph where additional Australian material was collected for the DNA barcoding effort.



Photo: Sally Reader, 2008.

On the experimental side, Australian museum researchers continued to develop DNA barcoding by testing the utility of different genes and how

useable they were for the purposes of identification using DNA. DNA barcoding was used to match larval fish to adults of the same fish species. It was also used to match frog larvae to the correct species of adult frog. DNA analyses continued in bird phylogenetics with Museum staff sequencing four different gene regions from around 100 bird species from five bird families (Columbidae, Rallidae, Alcedinidae, Cuclidae, and Burhinidae).

DNA barcoding of Australian termites is also underway. Specifically, DNA barcoding is currently being investigated using the 28S gene, and other variable markers in two species of Australian termites that are economically important due to their destructive nature.

Much of the Museum's contribution to barcoding will be by the provision of tissue specimens from vouchered and identified specimens to the central processing facility at the University of Guelph. In 2008/09, 188 tissue lots representing 147 species from the fish collection were sent to the University of Guelph to contribute to this barcoding effort.

Staff from the DNA laboratory attended a meeting held for 'International Barcode of Life Leading Laboratories' in San Diego in June 2008 where there was the opportunity to network with other Leading Laboratories and discuss the 'barcode standard' in detail. The Australian Museum also contributed to the development of the Australian Barcode of Life Network, which provides a forum through which researchers can share information about DNA barcoding activities, resources and opportunities in Australia and internationally.

The Museum's program in DNA-based identification of wildlife continues. In 2008/09 the DNA lab assisted with DNA-based identifications from multiple species of birds, fish, mammals, and reptiles for a number of agencies including NSW Department of Primary Industries, Australian Fisheries Management Authority, NZ Ministry of Agriculture and Forestry, Australian Customs and the Australian Quarantine Inspection Service.

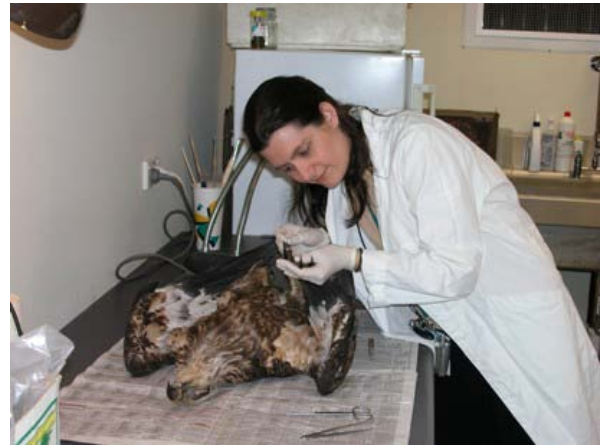


Photo: Rebecca Johnson takes a sample from a sea eagle.
Photo by Sue Lindsay.

These DNA-based identifications to species are often critical to court cases brought against perpetrators of wildlife-based crime by the Director of Public Prosecutions (under relevant legislation such as the EPBC Act 1999 and the Fisheries Management Act 1991), especially if DNA identifications reveal endangered or CITES listed species. Several cases that involved DNA-based identifications resulted in close to record penalties for wildlife crimes.

Key research goal b) Genetic approaches to monitoring biodiversity and assisting resource-use planning for biodiversity conservation.

Using its own resources and expertise, and in conjunction with external collaborators, the Museum has made substantial contributions toward this goal. Genetic analyses at both micro- and macro-levels have been conducted on a range of species including Australian birds, teleost fishes, insects, isopods, marsupials and molluscs.

Work continues in collaboration with NSW Department of Environment Climate Change. Staff conducted genetic analysis of several populations of the Bush Stone-curlew, which is endangered in southern Australia but which has large and healthy populations in northern

Australia. This work was undertaken to determine what geographical constraints existed on the release of captive bred Stone-curlews. The project continues to receive samples from casualties and dropped feathers of live birds from across the range to add to and strengthen the existing data. Although there is a low level of population structuring, this does not preclude release of the captive birds in the desired areas. This is now underway.

Genetic studies are also underway in collaboration with University of Sydney on the population genetics of the winter bronzing bug, *Thaumastocoris peregrinus*. This species is a major pest of eucalypt street trees in metropolitan Sydney, and has recently become a significant economic pest of eucalypt plantations of southern Africa and South America. Studies are underway to determine the endemic range of this species and this genetic analysis should enable inference of the population(s) that was the source of the original introduction.

The Museum continues to contribute to the ongoing search for an increased range of genetic markers and molecular biological approaches to support biodiversity research and conservation management. A particularly promising class of genes involve loci from the immune system related major histocompatibility complex (MHC). In collaboration with staff of the University of Sydney and the Sanger Centre (UK), Museum personnel have sequenced and characterised the MHC gene region of the model Australian marsupial, the tammar wallaby. As a consequence, a panel of MHC-linked microsatellite loci have been developed, with the majority proving effective in a variety of macropod species. These markers will be valuable tools in ongoing macropod genetic research.

The Museum is leading a long-term project on evolutionary and conservation genetics of marsupials. Molecular techniques continue to be used by Museum staff and their collaborators at University of Sydney and the Tasmanian Department of Primary Industries and Water to better understand the devastating Tasmanian devil facial tumour disease (DFTD). Although chromosomally distinct forms of the DFTD cancer have recently been discovered, genetic analysis has confirmed that these are derived from the original

DFTD strain and do not represent independent origins of the disease. In addition, an assessment of MHC diversity in Tasmanian devil populations has shown that devils from the north-west of Tasmania are more genetically diverse than those from eastern and central Tasmania, giving hope that a number of north-western devils may show some natural resistance to the disease.

Significant contributions have been made to phylogenetic studies of a species flock of freshwater Isopods (genus *Eophreaticus*) from Kakadu National Park. This work was recently published and continues with the addition of the nuclear gene 18S. This is important as the original work revealed deficiencies in the existing molecular data in its ability to distinguish species.

Genetic analysis of molluscs from the families Viviparidae, Planorbiidae and Hydrobiidae is being conducted by Museum staff and associates at the Justus Liebig University (Giessen, Germany), the Museum of Natural History (Berlin, Germany) and the University of Sydney. DNA sequences and morphological data are being used in these analyses.

Phylogeographic boundaries are discontinuities between the spatial distribution of members of different groups within a taxon. This discontinuity has immediate operational implications for conservation genetic management as populations on both sides of the boundary require management if the full evolutionary potential of the species is to be conserved. The concordance of boundaries in different species is particularly significant as it suggests that there may be a causal relationship to an historical and/or contemporary habitat or geographic barrier.

Museum staff in collaboration the University of Melbourne have commenced a phylogeographic study of the ecologically significant long-nosed potoroo, which is distributed throughout coastal south-eastern Australia. Preliminary results have revealed much higher than expected divergence at mitochondrial genes between northern and southern populations of this species. Significantly these data are concordant with previous studies by Museum staff on the brush-tailed rock-wallaby which also detected substantial divergence between northern and southern populations in south-eastern Australia, suggesting that a previously

unknown but significant phylogeographic boundary is present in southern NSW.

Considerable progress has also been made on an examination of the phylogeography of the short-eared rock-wallaby in collaboration with Adelaide University and the South Australian Museum. Samples from throughout the species range in the Kimberley and the Top End have been sequenced at multiple mitochondrial and nuclear genes revealing a complex series of highly divergent but geographically clustered lineages. These data suggest that multiple cryptic species are present within this taxon and that several major phylogeographic boundaries are present in north-western Australia

Museum staff have this year begun investigating the phylogeography of the estuarine snail genus *Phallomedusa* in south-eastern Australia. DNA sequence data for the mitochondrial COI gene have been collected from more than 90 specimens and for the 16S rRNA gene from 16 specimens. Two *Phallomedusa* species are recognised morphologically. *Phallomedusa austrina* was previously known only from north-western Tasmania but fieldwork for this study has discovered it in western Victoria and South Australia. The second species (*P. solida*) occurs in eastern and northern Tasmania, eastern Victoria and New South Wales and at a low frequency relative to *P. austrina* in South Australia. The two species are clearly genetically distinct. Within the morphospecies *P. solida* we observed two groups of variants that were even more highly divergent than the identified species. Indeed one of the two groups is apparently more closely related to *P. austrina* than it is to the other group. Both of these variants were common throughout the range of *P. solida*. Staff are currently developing a working

hypothesis to explain these complex and unexpected patterns of variation.

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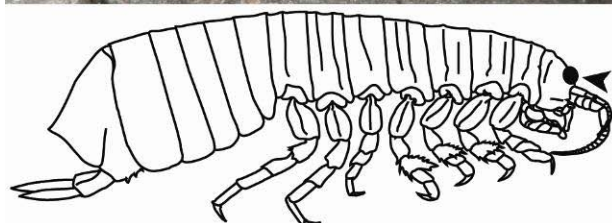
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Photographs and illustration by B. Wilson of a fossil of a freshwater Phreatoicidean from the Triassic (c. 240mya), collected from a shale quarry in Sydney.

Program 4

Origin, evolution and biogeography of the biota of the Indo-Pacific and Australasian region.

The Australian fauna is heterogeneous, some elements having survived little changed from Gondwanan times, some having recently crossed from south-east Asia (for example humans), but much of it as large radiations of species with unclear relationships to other land masses, effectively evolving *in situ*. Most of the Museum's zoologists are addressing this issue in their taxonomic research. The two key research goals of this program overlap, as it is frequently not possible to isolate the Australian fauna from its neighbours in systematic studies. Studies which could be included in both categories include research on marine worms, snails, freshwater isopods, spiders, beetles, flies, fish, lizards, birds and macropod mammals. A few of these projects are discussed below.

Key drivers

Biodiversity, its description, classification and status, is a key issue in New South Wales. Inherent to understanding the significance of the State's fauna is knowledge of its role in a broader context, both nationally and within the Pacific region. Our research under Program 4 helps to inform

environmental management policies, including those concerning climate change, for both the State and Federal legislative bodies. In recognition of this, several projects were funded by State or Federal agencies.

Research projects under Program 4 were commonly collaborative with overseas organisations or individuals. The research contributes to achieving an environmentally sustainable Australia, addressing national quarantine concerns and the enhancement of national collections. In particular, the Australian Museum's collections have been greatly augmented under Program 4, especially in material from remote parts of Australia and the western Pacific region.

Key research goal a) Understanding the origins of the Australian fauna

The marine fauna of Australia is of course part of an enormous network of oceans, yet marine fauna often display the same distribution patterns and enigmatic origins as their terrestrial counterparts. Sabellid marine worms have planktonic or free-drifting larvae, yet a classic morphological approach to their taxonomy has shown both a high degree of endemism in Australian waters (ie exclusively native to) and the presence of species which appear to be broadly distributed in the Indo-Pacific. These hypotheses were tested with molecular techniques. Approximately 20 species,

in 5 genera, were studied. Molecular analysis revealed cryptic taxa in south-east and north Australia only recognisable by molecular markers and not by morphological features.

On land, key questions for studying the Australian terrestrial and freshwater fauna are: is diversity driven by landscape and climate? is this diversity recent or ancient? is diversity congruent with patterns of diversity in other organisms? does the Australian fauna have a single origin or multiple origins?

Freshwater isopod crustaceans in this driest of continents are commonly isolated in remote aquifers and mound springs. All genera of the freshwater isopods Phreatoicidea were surveyed using Scanning Electron Microscopy. This database was used for systematics studies on the evolution of the group, showing their early diversification in several unrelated lineages. By inference from their nearest living relatives outside Australia, three groups were identified, of at least 180, 120 and 80 million years in age. Extraordinarily, a fossil was identified of a freshwater Phreatoicidean from the Triassic (c. 240mya), collected in Sydney shales, suggesting an even greater length of relative morphological stasis for this group. [See photo at the top of this program]

Spiders have also been in Australia for a long time, and have diversified in ways that are difficult to disentangle. Research at the Australian Museum has found up to 24 genera in one subfamily of comb-footed spiders (Hadrotarsinae), two thirds of which are new. There are at least 100 species found throughout Australia. Several genera have a wide distribution outside Australia and sorting the confused taxonomic history of the group means that this project will make a major contribution to the understanding of the world hadrotarsine fauna.

Work has also continued on the Australian forest spider fauna (Gray and Smith), including publication of a new subfamily of spiders (8 genera containing 33 species). Further research on Goblin Spiders (family Oonopidae) with colleagues from Queensland Museum and the West Australian Museum was undertaken, with discovery of a new genus and 22 new species). Clearly, understanding

the spider fauna of Australia is still at the exploratory stage. But progress was also made with use of spider diversity for community monitoring of environmental health.

Beetles dominate the terrestrial environments of Australia, therefore the study of the origins of this diversity is integral to understanding biodiversity itself. A large proportion of beetles feed on plants; one such group is the leaf-beetles with 35,000 species worldwide. Collaborative research continued with the University of the Balearic Islands (Spain), Institut de Biologia Evolutiva (Spain) and the Natural History Museum (UK) on the evolution of one subfamily of leaf-beetles (Chrysomelinae), with 3000 species, 750 of which are Australian. A novel method of sequencing and determining host plant from fragments in the beetles' guts was discovered. Comparison of beetle and host phylogenies based on DNA showed a general matching between beetle tribes and clades of plant orders, suggesting ancient co-evolution is at least a partial explanation for the diversity of this group. In another PhD study undertaken at the Australian Museum and University of Queensland, both the DNA and morphology of the speciose genera of the subfamily, Paropsis, with 80 species was analysed. Surprisingly many of the species were shown to be widespread in Australia, with little evidence of cryptic speciation and local endemism in this genus.

Key research goal b) Understanding the biogeography and evolution of the Indo-Pacific

Starting with the marine environment, the Museum's research on larval development of fishes provides information that is the raw material for morphological assessment of relationships and evolution of Indo-Pacific fish species. Work continued on the tropical snappers (Lutjanidae), an important commercial group throughout the tropics, and in collaboration with Arizona State University, on the relationships of the tripletails (Lobotidae), with the first description of larval development of many fish species. Research continued with numerous collaborators on dispersal of coral reef fish larvae, fundamental to the understanding of species dispersal and biogeography of Indo-Pacific fishes.

Among many insect groups studied by staff of the Australian Museum, the flies and beetles are of particular interest for the Indo-Pacific region. Work continued on the Australasian Diptera fauna, particularly the predatory long-legged flies (Dolichopodidae). From New Caledonia 16 new species and a strange new monotypic genus (*Pouebo*) were described. 35 new species were described from Vanuatu and Fiji. A review of the biogeography of Diptera from the South-West Pacific was published, highlighting how little we know from this region.

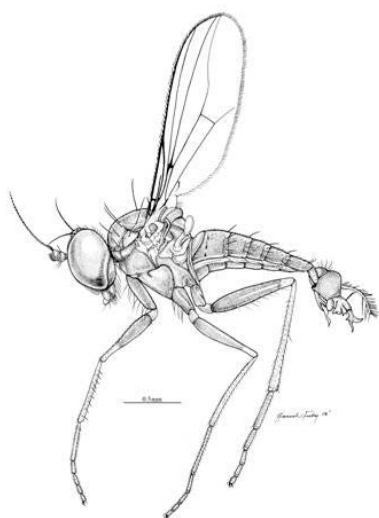


Fig. The new genus *Pouebo* from New Caledonia

The revision of the leaf-beetle subfamily Spilopyrinae ('fiery leaf-beetles') was completed. This enigmatic group, hitherto with only 23 species worldwide, is late Gondwanan in distribution. One new genus and 14 new species were discovered and described, 1 genus and 8 species from Australia, 3 from New Guinea and 3 from New Caledonia. Spilopyrinae species are large and spectacularly coloured, but rare in collections, so hopefully publication of these revisions and the associated website will stimulate more interest in this ancient group.

Species of Spilopyrinae



The Museum was also involved in a collaborative project with Kyoto University on the effect of El Niño droughts on rainforest beetles in Borneo. Drought opens up the canopy, radically affecting the beetle fauna. Work continued on the agricultural beetle pests of Solomon Islands, with the University of Queensland, Terracircle Inc., Solomon Islands Department of Agriculture and the Secretariat for the South Pacific. Most pests are widespread and well-known species, but a number are local to the Solomons and nearby archipelagos.

Research on the diverse New Caledonian lizard fauna continued, in collaboration with the New Caledonian government, led to the description of 5 new species. This island has the highest proportion of lizard endemism per unit area in the Pacific and one of the highest globally. A review of Marble-throated skinks in the genus *Marmorosphax*, showed high narrow-range endemism, with a suite of species restricted to specific massifs on the island, several only being found at high elevation. The latter are of particular conservation concern in the face of global warming, occupying only a very narrow environmental envelope which will retreat upwards in the face of increasing temperatures. Three new species were described. A new species of skink in the genus *Kanakysaurus* was also described from the region. This species is known only from several massifs in the territory, all of which are subject to development for extraction of nickel ore. A new species of the morphologically bizarre Chameleon geckos was also described.



Photo: *Kanakysaurus zebratus*, a new species of scincid lizard from New Caledonia by Ross Sadlier.

Described this year, *Kanakysaurus zebratus* takes its name from the highly banded pattern on the body (juvenile pictured above). This species is known from several massifs in the territory all of which are subject to development for extraction of nickel ore.

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Program 5

Understanding human impacts on the Australian biota.

Research was undertaken in twenty six research projects, including nineteen major ones, investigating human impacts on Australian biota. This research addressed three key research goals directed towards increasing understanding of our impacts on freshwater and estuarine ecosystems, effects of climate change on the Australian fauna, and human impacts in the Sydney region.

Key Drivers

Research was conducted in a number of areas identified as priorities at both the state and national levels. These priority areas include the loss of biodiversity (NSW Biodiversity Strategy 1999), climate change (NSW Biodiversity and Climate Change Adaptation Framework 2006-2008), invasive species (NSW State of the Environment Report) and better environmental outcomes for native vegetation, biodiversity, land, rivers and coastal waterways (NSW State Plan: A New Direction for NSW, November 2006). Research also linked to emerging opportunities through the National Collaborative Research Infrastructure Strategy which has identified biological collections as key research infrastructure, and provided funding through this program to develop an Atlas of Living Australia and the Terrestrial Ecosystems Research Network (TERN).

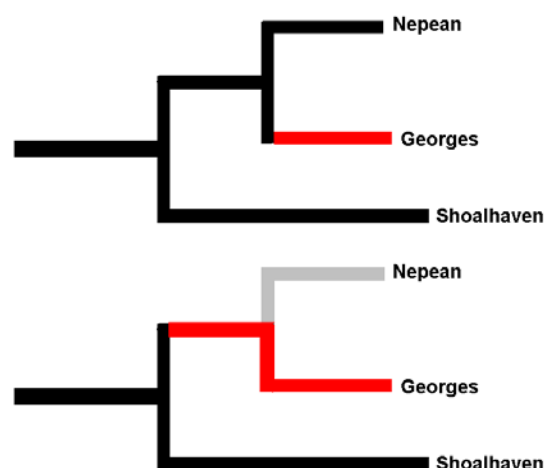
Research carried out as part of this program provided important data on the evolution, ecology and genetics of a diverse range of native and introduced species. This information will be invaluable in informing future conservation and management decisions related to human impacts on the Australian biota.

Key research goal a) Assessment of the vulnerability of Australia's freshwater and estuarine ecosystems to human impacts

Research extended results reported last year showing that the freshwater isopods from Kakadu National Park are at risk from water extraction by humans. This past year, a genetic

analysis of the freshwater isopod species (Crustacea; Isopoda) in the genus *Eophreatoicus* was completed, indicating many species in regions of Kakadu that may be exposed to risk from mining. Results were published in the widely-read journal *Molecular Phylogenetics and Evolution*.

Collaborative research examined innovative methods to assess possible impacts of mining on macroinvertebrate species in the Sydney water catchment region. The study demonstrated how conservation priorities could be set among localities by using the PD (phylogenetic diversity) measure. This approach allows assessments without identification of all variants to species, providing a general assessment approach, applicable to data from DNA barcoding and similar programs. The research was described in a chapter of a new book, 'Evolution in Action', published by Oxford University Press, which explores evolutionary approaches to solving real-world problems.



Top: the unique phylogenetic diversity contribution of the Georges River locality is shown in red.

Bottom: If the fauna at the Nepean locality are lost through human impacts, then the unique contribution – and conservation priority – of the Georges locality is greater.

Key research goal b) Investigating the effects of climate change on the Australian fauna.

Studies investigated the effects of changes to currents and temperature-related changes on the dispersal of fish larvae, especially on the Great Barrier Reef (GBR). These studies are important in understanding the effects of climate change on reef fish as changes in dispersal will influence the spatial scale and magnitude of population connectivity in reef fish populations.

In addition, a paper was published in the journal *Coral Reefs* describing how to immediately apply the knowledge gained from research on population connectivity to the management of coral reefs, in collaboration with researchers from James Cook University and other institutions.



Photo: Fish on the Great Barrier Reef, by J.Leis.

Collaborative research, notably with NSW DECC workers, led to the development of a family of practical, community-level methods that use museum collections data efficiently to provide a flexible, robust, biodiversity surrogates framework. Results were reported in a book chapter in a new book, 'Systematic Conservation Planning'. The collaborations also led to a publication in *Global Change Biology* reporting a new family of biodiversity 'representativeness indices' for rapid biodiversity assessments from regional to global scale. They allow land use or climate change impacts to reflect partial rather than just total biodiversity losses at localities, by incorporating estimated changes in average species abundance. The work also provides a potential way to assess genetic diversity patterns over large scales, by using a new genetic-diversity abundance-fraction curve, analogous to the well-known species-area curve. These research results are now feeding in to a new global program with NASA and others to monitor global changes in biodiversity (GEO BON).

Key research goal c) Understanding human impacts in the Sydney environs.

Coastal saltmarsh in the Sydney basin bioregion is an endangered ecological community with more than 80% of its extent having been destroyed for human development. The future of the habitat is precarious with the threat of sea-level rise

associated with global climate change. Museum records reveal that a salt-marsh dependent bird species, the White-fronted Chat, was once widely distributed in wetlands across the Sydney region, but now is restricted to only two isolated populations. Field studies this year have demonstrated that one of these populations now comprises only two females and eight males. Experimental work also demonstrated that this species is particularly vulnerable to human disturbance. Two grants awarded in May 2009 will enable gene flow between a number of potentially isolated populations to be measured, as well as the determination of reproductive success and adult survival in declining populations. The findings of this project will assist both in the recovery of the species and our general understanding of the extinction pathway.



Photo: White-fronted Chat, by Richard Major

Noisy Miners have been described as a 'reverse keystone' species, aggressively excluding many bird species from an ever-increasing range of human-dominated landscapes. Research to better understand the factors influencing the distribution of Noisy Miners showed that, contrary to popular expectation, there was no significant association between the abundance of Noisy Miners and the presence of hybrid grevilleas. However, there was a highly significant relationship between the abundance of Noisy Miners and the presence of eucalypts. The research, published in the journal *Emu*, counters the idea that hybrid grevilleas have played a causal role in the spread of Noisy Miners across many suburban areas of eastern Australia, and supports the hypothesis that it is the proliferation of lightly-treed open areas that favours the Noisy Miner.

‘Beach nourishment’ is increasingly being implemented to address problems of erosion. It is a process by which sand lost through erosion is replaced by transporting nourishment material from one area to the affected area. However, the ecological consequences of nourishment are poorly understood, especially in Australia. Research work in Botany Bay showed that the impact of the engineering operations on abundance of an intertidal amphipod was very large at the sites where nourishment material was taken from and to. However, recovery started within several weeks. As beach erosion is likely to increase in severity with rising sea levels and greater storm surges associated with climate change, management authorities will need a better understanding of the ecological effects of beach nourishment. This research was communicated in a journal supplement, *Marine Ecology – an Evolutionary Perspective*.

Discussion of goals under the broad theme of human impacts on biodiversity

It is clear that museums will play an increasingly unique and important role in addressing real world problems. The reason lies not just in our collections but also in the particular values and perspectives we promote – e.g. the intrinsic values of biodiversity, the importance of evolutionary history. Much of the research is integrative and multidisciplinary, and increasingly works through a ‘dialogue’ with other workers internationally focusing on the same problems. This means that, if the Museum wishes to pursue rapidly emerging opportunities, it may be unrealistic to focus only on the 3 key research goals stated in this section. After all, these current 3 goals would exclude all work on terrestrial and marine impacts, unless they involved climate change and/or Sydney.

Actual research outputs over the past year, and prospective new outputs, highlight the need for broader goals. We referred to research linked to emerging opportunities through The National Collaborative Research Infrastructure Strategy and Atlas of Living Australia (ALA) and the Terrestrial Ecosystems Research Network (TERN). Input was made this past year to the successful multi-million dollar proposal for TERN. Fresh collaborative arrangements (e.g. with CSIRO) have developed for key TERN/ALA tasks, including BioMaps and

other tools. This work covers terrestrial Australia, and so would not have been pursued except through departure from the 3 main goals. Other research output from the past year highlights this same point.

It is noteworthy also that, in addition to TERN/ALA, grant funding secured (e.g. from GBIF on the 2010 target; from the ARC Environmental Futures Network for biodiversity impacts research) linked to contexts outside of the 3 main goals.

These considerations highlight the need for new and/or additional goals – for example, relating to the development of the methods and tools for impacts monitoring, detection and conservation planning. Such a goal satisfies internal drivers relating to scientific excellence and to prospective funding, as well as external drivers at state, national and international scales.

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Program 6

Investigating human cultures and communities over time in the diverse and changing environments of Australia and the Pacific Region.

Many highly diverse human societies inhabit a wide range of different environments in the Australia and the Pacific region. Research on ethnographic objects and archaeological materials held in the Museum's anthropology collection from different parts of Australia and Papua New Guinea (PNG), as well as material collected during recent fieldwork in Russia and PNG have contributed significant new knowledge about the way these people lived in the recent and distant past. Over the millennia, these lands experienced numerous shifts in climate and associated environmental changes and research has revealed the way in which human groups have coped with and responded to the impacts of climate change and natural disasters, such as volcanic eruptions and tsunamis. New results have also been obtained about the history of indigenous people's practices as well as their relationships with their environment and with other communities, for example, the acquisition of raw materials, and long-distance trade and exchange of raw materials.

Key Drivers

Research in this Program has broadly contributed to a number of areas identified as priorities by the NSW Government, including:

- contributing to building harmonious communities and strengthening Aboriginal communities, under the State Plan;
- supporting and affirming Aboriginal people's culture and heritage under the Two Ways Together 2003-2012 policy; and
- contributing to the creation of a stronger multi-cultural society, which is relevant to policies set out in the Green Paper, Cultural Harmony: the Next Decade 2002-2012 and the White Paper Building on our Cultural Diversity: Ethnic Affairs Action Plan 2000.

Key research goal a) Understanding the history and diversity of Indigenous material culture

Many societies in the Pacific region decorate their bodies by tattooing and scarification. How old is this practice? Is this an indigenous trait or was it imported at the same time as distinctive pottery that bears marks resembling tattoos? To answer these questions, microscopic analysis of wear patterns and ancient residues was conducted on obsidian artefacts recovered from Australian Museum excavations in New Britain, PNG. These use traces were interpreted as being derived from cutting and piercing skin, based on similar patterns resulting from experiments using modern tools and chicken and pig skin. Results suggest that tattooing extends back at least 6000 years and is therefore an integral part of New Britain cultural practices.

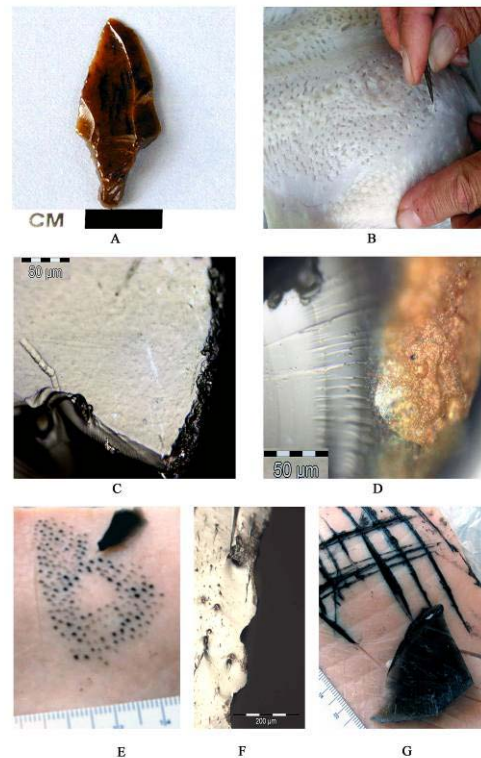
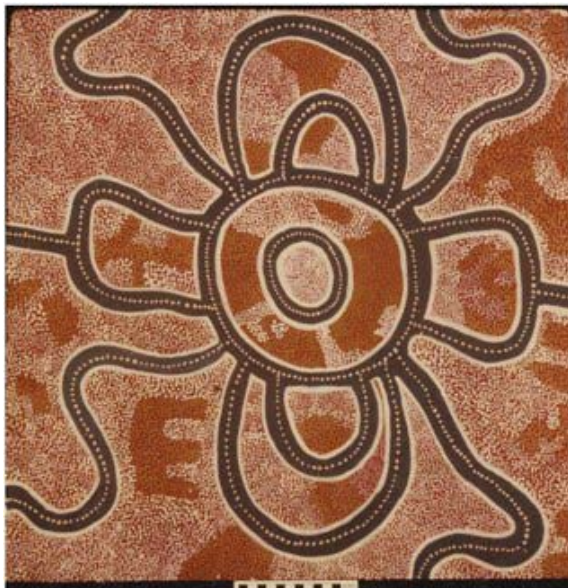


Photo: Experimental work using modern obsidian tools and pigskin to replicate ancient tattooing

The recently completed documentation of the historically significant Papunya Permanent Collection of 94 paintings held in the Museum's anthropology collection, includes oral histories and informants views collected in the 1980s. This information about the paintings contributes greatly to the history of the Western Desert art movement which originated in Papunya in the 1970s some 250 km west of Alice Springs.



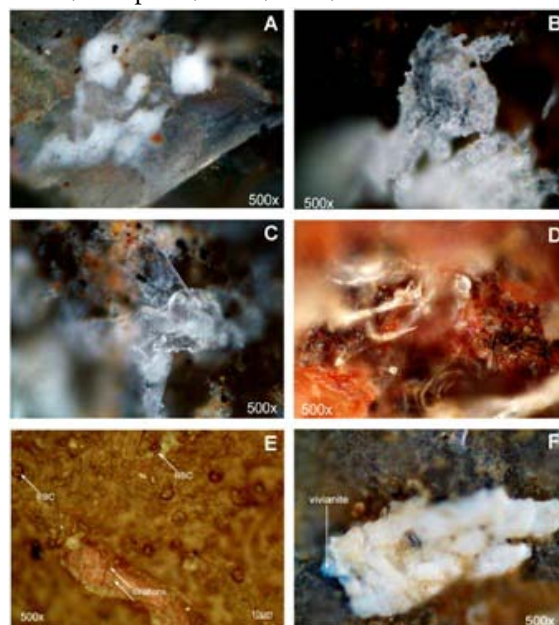
Spider Dreaming (c. 1971), north-west of Vaughan Springs Station, Central Australia, © Artist David Corby Tjapaltjarri. Part of the Australian Museum Papunya Permanent Collection.

A new project investigating the history of artefacts acquired by the Australian Museum prior to 1850, many of which were subsequently exchanged for other items in the early 1900s, is tracing their origins, their methods of acquisition and present provenance.

Key research goal b) Tracking the history of human interaction with the natural environment

In south-eastern Australia during the Holocene (the past 10,000 years) small stone tools known as backed artefacts were introduced into the Aboriginal tool kit. Between 3500 and 1500 years ago they were left in large numbers in numerous archaeological sites, after which their use declined or was abandoned. These tools were not observed at the time of British colonisation and thus their use is not known. Recent microscopic examination of these tools from a number of Sydney Basin Aboriginal sites employing an integrated use-wear

and residue approach has shown that they were used for a range of functions such as cutting, scraping, incising, drilling and thrusting/throwing. They were used on a range of materials including wood, soft plant, bone, flesh, feathers and skin.



Examples of animal residues on backed artefacts from Upper Mangrove Creek, NSW Central Coast © Gail Robertson.

Although the reason(s) for their proliferation is not yet known, a number of explanatory models are being explored. These focus on heightened foraging risk and/or social re-organisation brought about by a change in climate to a regime which was cooler and drier than any other time during the Holocene combined with intensified El Niño-Southern Oscillation conditions.

Significant art-works by contemporary western NSW Aboriginal artist Badger Bates were the focus of an exhibition in the Museum's Indigenous Australians Gallery. The lino-prints, acquired during anthropological research, portray the relationship between Barkindji people and the Darling River.

Key research goal c) Understanding the origin and functions of social exchange

Application of the novel analytical techniques, Portable Raman (Spectroscopy) and XRF (X-ray Fluorescence), is helping rewrite the ancient history of trade and exchange in Papua New Guinea (PNG) and south-eastern Australia.

Two papers published this year challenged long held views about the development of social complexity in PNG. Using a suite of geochemical methods, experimental studies that replicated methods of stone tool manufacture and use, and microscopic use-wear analysis, the research focused on large obsidian artefacts and elaborately carved stone mortars and pestles between 6000 and 3000 years old.



A highly decorated stone mortar with bird head and wings illustrates one of the styles shared across mainland New Guinea and the adjacent island of New Britain.

Results demonstrate that these elaborate objects were probably made by skilled specialists and circulated through ceremonial trading systems, possibly involving high status individuals. The spatial distribution of these ‘valuables’ shows that at this early date social networks stretched from West Papua to Bougainville, a distance of over 2000 km. The existence of prestige objects and widespread interaction provides a picture of relatively complex societies in this pre-pottery period.

To further understand these wide-scale social networks, a collaborative team is experimenting with new techniques using non-destructive methods to analyze large, fragile artefacts housed in foreign museums. A pilot study using Raman spectroscopy matched the chemical composition of an obsidian artefact now housed in the Pitt-Rivers Museum, Oxford, with its geological source in West New Britain. Portable Raman spectroscopy and XRF, which can operate within museum storerooms, provide further research opportunities as they eliminate the need for transport of valuable objects.

Portable XRF (PXRF) is integral to research into the way raw materials and Aboriginal stone hatchet (axe) heads were moved or exchanged in late

Holocene south-eastern NSW, where no comprehensive sourcing studies have yet been done. Artefacts held in the Museum’s archaeological collection form the basis of the study. Australian museum policies and Aboriginal communities do not endorse destructive sampling of archaeological materials, and PXRF has been adopted as it enables non-destructive quantitative compositional analysis of whole artefacts.

A pilot study on a small sample of ground-edge hatchet heads, to explore the potential of the PXRF technique, showed that several different raw material sources were used.



Photo: Hafted ground-edge hatchet given by an Aboriginal person to a six year old girl in Manly in the 1830s, used in PXRF project.

Planned research will employ PXRF on a larger sample of basalt ground-edged hatchet heads from a number of different geographic areas as well as rock samples from likely basalt sources. The results will help develop an understanding of past human behaviour in relation to the changing dynamics of exchange systems and mobility patterns in south-east NSW.

Key research goal d) Other research into human cultures

Radiocarbon ages on marine shell are central to debates concerning chronological changes in the Holocene archaeological record, refining sea-level curves, and reconstructing the geomorphological development of coastal environments. However, conventional radiocarbon ages require ‘correcting’ to offset the marine reservoir effect caused by the up-welling of deep oceanic waters, which have higher radiocarbon concentrations, and their mixing with surface waters in which the radiocarbon-dated shellfish live.

For south-east Australia, previously recommended correction values were based on only one living specimen. To obtain a more accurate correction value, additional shells samples were analysed from several locations along the south-east Australian coast. The results highlighted significant differences with north-east Australian open marine environments and indicated a new correction value for the south-east region.

These results will directly enhance research in Australian archaeology, coastal geomorphology and palaeo-environmental studies by providing more secure characterisation of local marine reservoir conditions and greater precision in dating chronological changes.

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Program 7

Linking intangible and tangible heritage

Productive collaborations between Museum staff, Indigenous communities and university scholars have brought the ethnographic collections back to life this year by making new connections among the static objects, their makers, local histories, and traditional knowledge.

Techniques for harnessing the capabilities of digital media and the worldwide web have returned information about the artefacts to descendant groups in Papua New Guinea, Vanuatu, Fiji, and the Solomon Islands.

Social networking websites were built to maintain the relevance of the collections through eliciting new data and stimulating debate about objects, their roles and meanings.

Field studies have recorded how repatriation of knowledge about the ethnographic collections has inspired and aided cultural revitalisation among Pacific groups.

Key Drivers

The research in this program has encouraged a wide variety of collaborations, methods and theoretical approaches. The research responded in direct ways to a number of key priorities at state, national and international levels, for instance:

- NSW Two Ways Together Policy (supporting Indigenous Australian culture and heritage);
- The Green and White papers on cultural diversity;
- the National Research Priority of '*Frontier Technologies*'; and
- the international research issue of the loss of cultural diversity in the Australian-Pacific region.

This has included projects which were collection-based, and which enhanced our understanding of objects in the ethnographic collections. Work with Indigenous communities led to the development a documentary film, 'Nelokompne Rises Again', a

collaboration with communities in Erromango, and to important new acquisitions.

Key research goal a) Investigating the history of creativity in human cultures and communities in Australia and the Pacific region.

Contrary to popular assumptions, ethnographic collections are not the straightforward products of intrepid explorers and dedicated researchers. Award winning research in 2008 by the Australian Museum and the University of Sydney has uncovered the creative ways in which communities from the south coast of Papua New Guinea used the trade in ethnographic artefacts to achieve their own goals when negotiating with European explorers, traders, missionaries, and colonial government officials. The study shows that opportunities for collecting ethnographic material were often determined by the needs of the Papuan communities, rather than the wishes of the outsiders. Analyses of objects that found their way into museum collections in Australia and Europe – notably grass skirts – together with research on historic photographs, diaries, and government reports have provided new insights into how local people made deliberate choices in the kinds of objects they offered up for sale. Down the line, their preferences have heavily influenced the nature and quantities of objects that now comprise ethnographic collections around the world. For instance, the research found that shell objects, highly valued within local ceremonial systems, are very rare within museum collections, whereas items of personal ornamentation that were easy to replace are plentiful. The study also shows that chronological changes in trade goods can be accounted for as much by differences in social and economic situations of the artefact makers as by the particular tastes of western consumers.

Key research goal b) Understanding knowledges and social imperatives which produce and shape material culture.

Using museum collections to understand how contemporary communities conceive of and use material culture is a highly innovative approach for Anthropology. The introduction of specially designed equipment for visual repatriation of objects from the Museum's ethnographic collections to the Solomon Islands National

Museum provided an opportunity to record how various sectors of the community interact with both modern technology and, what are for many people today, ancient objects.

The Intangible Cultural Heritage Field Kit houses a DVD player and tape recorder within a sturdy waterproof box. On one level its function is to enable staff at the Solomon Islands National Museum to collect information from communities about artefacts collected long ago and now housed in the Australian Museum. Informants view the slides and videos of Museum material and can then record additional information. On another level, however, the project introduces state-of-the-art technology to a wide range of Solomon Islanders.



A first field test of the Intangible Cultural Heritage Field Kit over 10 days in Honiara with museum staff, school children, villagers, and public servants demonstrated the tantalising research possibilities, but further grant funds are necessary to move the project further.

Photo: Paul Monahan

Key research goal c) Understanding the collecting process.

To ensure that the objects are representative of the cultures under study, research on ethnographic artefacts must consider the local circumstances framing the context in which they were obtained as well as the biases of the collectors. Recapturing past cultural contexts is not always possible since many objects were purchased during the early years of the Museum, before the value of this information was fully appreciated.

New technology provides a useful way to enhance collections for future researchers. For example,

recordings and films of interviews with the original collector fill in the social background to the events in which the objects were acquired. This approach, used recently in connection with an extensive new donation of objects from the Southern Highlands of Papua New Guinea, has markedly improved the research potential of the collection.

Ethnographic collections are composed of objects acquired through donations, collecting trips and purchases from dealers and auctions. Sale and auction catalogues from Britain during the peak period of museum expansion in the late 19th and early 20th centuries provide a rich source of data about the quantities and variety of objects in circulation. Focusing on items from British Papua, the research team developed approaches to expose the wide range of creative responses to market opportunities adopted by the Indigenous makers of the artefacts. These include clear choices in what was offered or refused for sale as well as strategies for attracting commerce through creating objects that dazzled European eyes. Changes through time in the composition of the catalogues have also provided innovative insights into social processes during the colonial period.

Key research goal d) Engaging with creator communities to better understand the significance of our collections.



Photo: Erromango Cultural Association with Umponielongi community members and Collection Officer, Yvonne Carrillo-Huffman with a collection of contemporary barkcloths acquired by the Museum, by Russell Lovo. May 2008.

Anthropology researchers and collection managers at the Museum have a long and successful history

of collaborating with descendant communities to share knowledge about historical practices enshrined within the ethnographic collections. This information has often been instrumental for regenerating cultural practices or stimulating innovative designs and uses among modern groups.

Recent research in Vanuatu and West Papua examined the diverse ways that people revived and recreated traditional practices for making and decorating bark cloth as part of conscious efforts to reinvigorate contemporary culture and assert local identity. The products of this work include a documentary film, 'Nelokompne Rises Again' made in collaboration with communities in Erromango. It gives a voice to local views about how the loss of traditional dress affected them and provides an opportunity to showcase the contemporary importance and meaning of bark cloth. Material produced as part of the cultural revival and acquired this year ensures that the ethnographic collections preserve recent as well as past artistic achievements.

Personal interaction with the Museum's collections or through visual repatriation of objects during staff visits to communities is invaluable, but limited by cost and distance.

This digital system is experimenting with information acquisition associated with a digital collection of museum artefacts. Implemented as a Web 2.0 application, it enables high-quality digital images, 3-dimensional imaging, and comprehensive data records from the current Museum database to be accessed using new associative navigation and an attractive interface. Four hundred objects are being loaded as the first test of the system. The next step will be to add a social media component, where community members, researchers, and others can add comments, discuss objects and upload their own stories, images and videos. Ongoing research will investigate issues regarding user-generated content, intellectual property and traditional knowledge.

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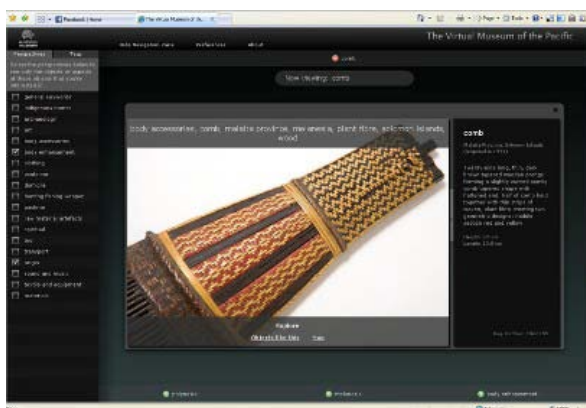
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'Virtual Museum of the Pacific'.



A new collaborative project with Wollongong University will considerably broaden outreach to a global audience by developing the computer software necessary to create a 'Virtual Museum of the Pacific'.

Program 8

Investigating extant and extinct faunas and environmental systems in the context of recent geological history to better forecast future changes.

Interdisciplinary research projects with both geological and palaeobiological components have contributed to this program, providing information on the origins of Australian and South-East Asian environments as well as climate change. They include research on insects frozen in time in Cape York fossil amber, the trilobite record of China, Ordovician biogeography and biostratigraphy of eastern Gondwana as revealed by conodont (extinct eel-like organisms) studies, and Jenolan Caves minerals resulting from unique sedimentary processes and biological interactions.

Key drivers

Many projects in Program 8 have involved national and international collaborations. The conodont project is providing better Ordovician stratigraphic correlation for reconstruction of past biogeography and biodiversity, a significant international issue. The Cape York fossil amber project, which received Australian Research Council funding, will address National Research Priorities in relation to an *Environmentally Sustainable Australia* by providing new information on changes in Australia's climate and fill in gaps about the biodiversity of Australia's recent past.

Research projects have contributed new material to the Museum's collections and provided new knowledge about the existing collections (eg. the Jenolan Caves minerals project, the conodont project and studies on gemstones). Research has used the Museum's infrastructure including SEM, optical microscopy and X-Ray diffraction.

Key research goal a) Studying animal groups that leave good fossil records to help forecast future change.

A new find of amber (fossilised tree resin) from the remote northern part of Cape York Peninsula, Queensland, is being investigated jointly by the

Australian Museum, University of NSW, Queensland Museum and the original discoverers, funded by a 3-year ARC Discovery Grant.



A perfectly preserved midge in a sample of amber.

Amber has been known since ancient times from the Baltic Sea, but also occurs in Lebanon, the Dominican Republic, Burma, and Mexico. Australian amber deposits were previously unknown, until pieces were found washed up on remote Cape York Peninsula beaches. Some scientists were sceptical that this amber was of Australian origin, but thanks to the persistence of its discoverer, subsequent testing revealed its chemical 'signature' to be unique among the world's ambers. Amber is special because insects, flowers, pollen etc. are perfectly preserved within it. The insects are preserved down to the finest hairs in transparent amber, providing a window into the past, a unique view of the most fragile ancient life not found in other types of fossilisation. Approximately 250 specimens collected so far are being described and compared to modern counterparts. A paper has been published describing the first species, a long-legged fly, *Chaetogonopteron bethnorrisae*, in a genus that currently has some 20 Australian species. Cape York amber is probably derived from a kauri tree (genus *Agathis*) which still grows in eastern Australian rainforests, but the age and precise location of the deposits are still unknown. An attempt in September 2008 to reach the coastal beaches was unsuccessful because of inclement weather. This unique material is revealing new information about the origin and development of Australia's environment.

Other work is focussing on the trilobite record of China and the Ordovician biogeography and biostratigraphy of eastern Gondwana. After nearly eight years of persistent, hard work as co-editors and author of two chapters, the book 'Trilobite Record of China' (402 pages) was published at the end of 2008. This book deals with 1677 trilobite genera recorded in the Palaeozoic of China, and after a critical revision, 1317 of them are considered as valid. Based on updated data of their temporal and spatial distribution, the Cambrian and Ordovician biogeography of China is reviewed. Furthermore, the familial and generic biodiversity changes through the 46 Palaeozoic stages and 71 Cambro-Ordovician time intervals (defined by biozones) in China are depicted, and the fundamental trends in the history of trilobite diversification and macroevolution through the Palaeozoic of China are revealed. The book provides the most complete and consistent data for the trilobite records in China and the biodiversity analysis of the group, and is a valuable reference book for the study of trilobites, in particular the GIS global data analysis, palaeobiogeography and biostratigraphy.

The main focus of a study on Ordovician biogeography and biostratigraphy of eastern Gondwana in 2008-9 was the recognition of a new conodont Family, Serratognathidae. Detailed taxonomic studies of *Serratognathus* faunas from Western Australia and South China suggest that this bizarre conodont group is restricted stratigraphically to the lower Floian¹ (upper P. proteus to lower P. elegans biozones) of eastern Gondwana and peri-Gondwana plates and terranes², including Australia, China, and parts of South-East Asia. It is a characteristic component of the earliest development (early Floian) of the Ordovician conodont 'Australasian Province'. Occurrence of *S. bilobatus* in northern and western Australia implies strong biogeographic linkages to

¹ The **Floian** is the name now given to the second half of the Early Ordovician Epoch.

² A **terrane** is a fragment of crustal material formed on, or broken off from, one tectonic plate and 'sutured' to crust lying on another plate.

North China via intervening terranes (Sibumasu and Indochina).

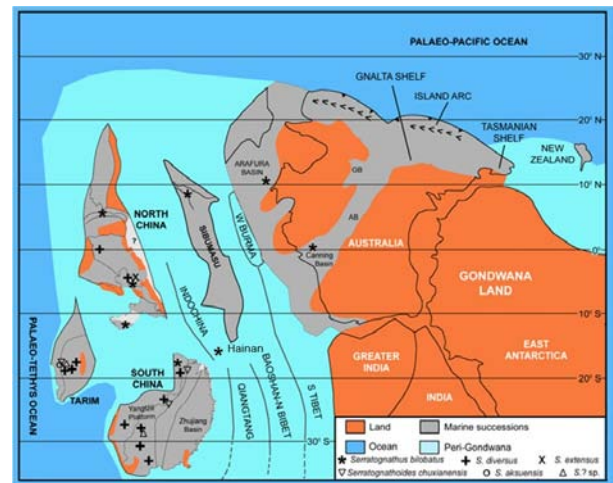


Image: Biogeographic distribution of six species of Serratognathidae in eastern Gondwana.

Key research goal c) Sedimentary Mineralogy



Photo: Jenolan Caves entrance.

The first report of ardealite from eastern Australia was a result of investigations of the mineralogy, sulphur/oxygen isotope chemistry, and structure of sulfate and phosphate cave formations at Jenolan Caves, NSW.

The mineralogy, sulphur/oxygen isotope chemistry, and structure of sulfate and phosphate cave formations at Jenolan Caves NSW have been investigated by a team from the Australian Museum, Sydney University and ANSTO. This has revealed gypsum (calcium sulfate) and unusual mineral species (ardealite, calcium sulphate-phosphate and crandallite, calcium aluminium

phosphate) of geologically recent origin, growing on clay-rich cave sediments. This is the first report of ardealite from eastern Australia, in formations called 'potatoes' in Lucas and Chifley Caves.

Two different sets of gypsum (calcium sulphate) were found, one resulted from chemical reactions between leached bat guano and reef limestone, and the other from chemical breakdown of pyrite (iron sulphide) and its interaction with the limestone. The guano deposits are from the Large Bentwing Bat, *Miniopterus Schreibersi*, which has thus contributed significantly to this interdisciplinary geological/biological study. X-ray and SEM equipment at the Museum and University of Technology were used, and sulphur/oxygen stable isotope analysis was carried out at CSIRO and the University of Barcelona. With additional field collecting, sample analysis and detailed cave mapping during 2008, the project was completed and a publication 'Sulfate and phosphate-sulfate speleothems at Jenolan Caves, New South Wales', was submitted to the *Australian Journal of Earth Sciences* in May 2009. The project data has given Jenolan Caves management and guides useful information for their cave tours and tourist promotion, and has highlighted fragile cave environments for future monitoring.

Other Research

A wide range of other research was also undertaken in collaboration with Research Associates, Senior Fellows and Australian and international institutions and researchers.

Research on a new mineral species from Broken Hill, NSW, was undertaken and mineral group nomenclature was revised for the International Mineralogical Association. Comparative studies of zeolite minerals from Australasia are underway. The internal mineral inclusions of Australian and South-East Asian diamonds are being studied to better understand the genesis of these gems.

Gemstone deposits along eastern Australian, New Zealand and Asian-Russian Pacific margins are being investigated for potential exploration and economic benefits; many are alluvial concentrates derived from eroded sources. Sapphire, ruby, zircon and diamond studies have involved

international collaborations, including world-leading gem corundum studies.

East Australian volcanic landscape studies have elucidated geomorphic developments since continental break-up along the Tasman and Southern Seas. Age-dating using several techniques involved collaborative work with many institutions. Studies on the youngest volcanism involved climatic effects and hazards.

Australia's origins are being studied through investigations of deep rocks and minerals brought up in volcanic eruptions. They shed light on thermal changes and structure under the continent during its evolution and provide information about geothermal potential (eg. for energy generation and use in industrial processes).

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Program 1. Addressing knowledge gaps and problems in understanding the biota in Australasian marine environments.

Key research goals	Research area that addresses goal	Name of Researcher(s)	Major/Minor contribution to goal
a) Understanding Australia's marine biodiversity, emphasising species with key ecological roles and high sensitivity to human impact	Research Area = Taxonomy. Project title = Taxonomy of Australian Cirrolanidae (Crustacea: Isopoda) from Australian Museum collections	S Keable	Minor
	Research Areas = Taxonomy; Biodiversity Assessment; Biogeography; Ecology. Project title = Targeted collecting, checklist and guide to starfish (Echinodermata: Asteroidea) of the Sydney region	S Keable, H Stoddart, R Springthorpe, A Murray, K Attwood	Minor
	Defining evolutionary stability in south-eastern Australia: (1) Phylogeographic studies of marine and estuarine mollusca	D Colgan	Major - relevant 5 b) also
	Systematics of Cerapus and related genera (Crustacea: Amphipoda)	J Lowry and P Berents	Minor
	Taxonomy of fish larvae occurring in NSW	A Hay & J Leis	Major
	Larval-fish systematics - Families Lutjanidae, Leiognathidae & Polynemidae	J Leis	Major (also applies to C below)
	Larval-fish and adult systematics - Lobotes, Haplogeny and Datnioides	J Leis	Major (also applies to C below)
	Arafura Sea Isopoda Asellota	GDF Wilson	Major
	Biodiversity of Algal Substrates	GDF Wilson, AJK Millar (Royal Botanic Gardens Sydney)	Major
	Structure of Deep-sea Invertebrate Assemblages, especially Isopoda	GDF Wilson	Major
	Systematics of Ampharetids	P Hutchings, D Garner	Minor
	Systematics, toxinology, ecology and biogeography of laticaudid sea snakes	H Cogger (SF)	Major
	Reviews of various fish taxa (gobies, clinids)	D Hoese (SF)	Major
	Review of the Acoetidae polychaetes of Australasian region	A Murray & P Hutchings	Minor
	Web-based catalogue of the marine molluscs of NSW	D Beechey (SF)	Major
	Circum-Australian Amphipoda	J Lowry & L Hughes	Major
	Great Barrier Reef Amphipoda	J Lowry	Major
	Systematics and phylogeny of Sabellida	P Hutchings, M Capa	Major
	Biology and taxonomy of nudibranchs	W Rudman (SF)	Major
	Phylogenetic diversity and conservation	D Faith	Major
	Taxonomy of NSW species of <i>Merelina</i> (Rissoidae)	A Miller	Minor
	Circum-Australian Amphipoda	J Lowry & L Hughes	Major
	Biology and taxonomy of lanternfishes (family Myctophidae)	J Paxton (SF)	Major (also applies to b)
	Taxonomy of Australian Sabellid genera	M Capa & A Murray	Minor

Program 1. Addressing knowledge gaps and problems in understanding the biota in Australasian marine environments.
Cont.

<i>Key research goals</i>	<i>Research area that addresses goal</i>	<i>Name of Researcher(s)</i>	<i>Major/Minor contribution to goal</i>
b) Understanding the connectivity of marine populations.	Defining evolutionary stability in south-eastern Australia: (1) Measures of gene flow in marine and estuarine Mollusca, and investigations of shell elemental compositions as an indicator of provenance	D Colgan	Major - relevant to 5 b) also
	Larval-fish ecology - behaviour in relation to dispersal	J Leis	Major
	Larval-fish ecology- biophysical dispersal model for GBR	J Leis	Major
	Larval-fish ecology - effects of climate change on connectivity in coral reef systems and comparing connectivity in temperate and tropical oceans	J Leis	Major (also applies to c, below)
	Larval-fish ecology - Connectivity and biodiversity in coral reef systems	J Leis	Major (also applies to c, below)
	Larval-fish ecology - OWNFOR project on larval-fish orientation	J Leis	Major (also applies to c, below)
	Ontogeny, biology and evolution of deep-sea whalefishes (family Cetomimidae)	J Paxton (SF)	Major (also applies to a, above)
c) Understanding the biodiversity of coral reefs.	Larval-fish ecology - effects of climate change on Connectivity in coral reef systems	J Leis	Major (also applies to b, above)
	Larval-fish ecology - Connectivity and biodiversity in coral reef systems	J Leis	Major (also applies to b, above)
	Larval-fish ecology - OWNFOR project on larval-fish orientation	J Leis	Major (also applies to b, above)
	Larval-fish systematics - Family Lutjanidae	J Leis	Major (also applies to a, above)
	Larval-fish and adult systematics - Lobotes, Hapalogenys and Datnioides	J Leis	Major (also applies to a, above)
	Phylogenetic diversity and conservation	D Faith	Major
	Bioerosion of coral substrates	P Hutchings	Minor
Other research on biota in Aust marine environments	Reproductive anatomy of the Isopoda	GDF Wilson	Minor

Program 2. Addressing knowledge gaps and problems in understanding the biota in Australian terrestrial and freshwater environments.

<i>Key research goals</i>	<i>Research area that addresses goal</i>	<i>Name of Researcher(s)</i>	<i>Major/ Minor contribution to goal</i>
a) Understanding the species and places of high biodiversity significance in Australia.	Revision of Spilopyrinae (fiery leaf-beetles)	C Reid	major
	Morphological and Molecular Investigations of the Systematics and Phylogeography of the Speciose Landsnail Genus Gyrocochlea (Mollusca: Charopidae)	D Colgan, J Stanisc	Major
	Evolutionary and conservation genetics of marsupials	M Eldridge	Major
	The systematics of Australian comb-footed spiders in the subfamily Hadrotarsinae (Araneae: Theridiidae)	H Smith	major
	Investigations of Australian web-building spiders	H Smith, J Gollan	minor
	Australasian forest spider fauna	H Smith	minor (on hold at present)
	Systematics of spiders in wet forests of SE Aust.	G Milledge	minor
	Revision of Australian Lichen Moths (Lepidoptera: Arctiidae, Lithosiinae).	D Britton	Major
	Revisions of Australian Dolichopodidae -various genera	D Bickel	Major
	Revisions of Australian Empididae - Hilarini- Dance flies	D Bickel	Major
	Diversity and conservation of rainforest dependent lizards in eastern Australia	R Sadler	major
	Genetic and evolutionary connectivity of Australian ecosystems	L Christidis	major (also b), below, & 3b, 5b)
	Developing online tools for modelling biodiversity distribution in terrestrial environments for conservation planning	P Flemons, A Ranipeta, M Elliott, M Ashcroft, J Gollan	major
	Morphological and molecular systematics of the funnel-web spiders	M Gray (SF)	Major
	Systematics of the Australasian Badumniae	M Gray (SF)	Major
	Ecology and sustainability of estuaries and sandy beaches	A Jones (SF)	Major
	Response of terrestrial invertebrates to riparian habitat rehabilitation in the Hunter Valley	J Gollan	major
	Distribution patterns of terrestrial arthropods in Pilbara	J Gollan, M Ashcroft	Major
	Deep sea biodiversity ARC Linkage	P Hutchings et al	major
	Phylogeny and phylogeography of Planorbidae (Pulmonata)	W Ponder (SF)	Major
	Phylogeny and phylogeography of Australian Viviparidae (Caenogastropoda)	W Ponder (SF)	Major
	Arid-zone artesian spring biota - faunal composition, endemism and conservation	W Ponder (SF), E Jefferys, R Fensham	Major

Program 2. Addressing knowledge gaps and problems in understanding the biota in Australian terrestrial and freshwater environments. Cont.

Key research goals	Research area that addresses goal	Name of Researcher(s)	Major/ Minor contribution to goal
a) Understanding the species and places of high biodiversity significance in Australia. Cont.	Australasian freshwater mollusc fauna - composition, distribution, conservation	W Ponder (SF)	Major
	Taxonomy, behaviour and ecology of Diptera	D McAlpine (SF)	Major
	Taxonomy and systematics of cicadas	M Moulds (SF)	Major
	Population biology of endangered frogs	G Pyke (SF)	Major
	Evolutionary genetics and DNA barcoding of Australian termites	N Lo	Major
	Molecular phylogenetics of burrowing cockroaches (Geoscapheinae, Panesthiinae)	N Lo	Major
	Taxonomy and systematics of Psocoptera	C Smithers (SF)	Major
	Terrestrial Isopods of Sydney; new species in the family Armadillidae	T. Lee, GDF Wilson	Major
	Conservation planning for key biodiversity regions, including Papua New Guinea and Eastern Australia	D Faith	Major
	Kimberley Islands Landsnails (from 4/08)	F.Koehler, W.Ponder (SF)	Minor
	Survey of land snail diversity on the Kimberley Islands, WA	F Köhler	Major
b) Understanding the distribution, interaction and evolution of key species in arid Australia.	A species flock of <i>Eophreatoicus</i> from Kakadu Nat. Park	GDF Wilson, C Humphrey (ERISS), D Colgan, R Johnson, K Gray	Major
	Revision of Sagrinae (kangaroo beetles)	C Reid	major
	Evolutionary and conservation genetics of marsupials	M Eldridge	minor
	Systematics of Australian mantid fauna	G Milledge	minor
	Genetic and evolutionary connectivity of Australian ecosystems (ARC Linkage and Environmental Futures Network)	L Christidis	major (also a), above & 3b,5b)
	Phylogeny and phylogeography of hydrobiids associated with arid-zone artesian springs	W Ponder (SF)	Major
	Evolutionary genetics and DNA barcoding of Australian termites	N Lo	Major
	Molecular phylogenetics of burrowing cockroaches (Geoscapheinae, Panesthiinae)	N Lo	Major
	Effects of day to day temperature fluctuations on pitfall-trapped invertebrates	J Gollan, M Ashcroft	minor
Other projects addressing knowledge gaps in biota in Aust terrestrial and freshwater environments	Insect damage to fruit of endangered Lillipillies <i>Syzgium</i> sp. and an endangered Quassia sp.	D Britton, A Clements, P. Juniper	Major
	Eastern Australian landsnails book	O.Griffiths (RA), M.Shea, J.Stanisic, D.Potter	Major

Program 2. Addressing knowledge gaps and problems in understanding the biota in Australian terrestrial and freshwater environments. Cont.

<i>Key research goals</i>	<i>Research area that addresses goal</i>	<i>Name of Researcher(s)</i>	<i>Major/ Minor contribution to goal</i>
Other projects cont.	Integrating museum biological collections, environmental layers, and other data, to produce more effective biodiversity models and predictions, including those for climate change impacts	D Faith	Major
	Identifying taxonomic and spatial gaps and biases in the collections of the Australian Museum and other Australian Museums.	P.Flemons, J. Gollan, M.Ashcroft, M.Elliott, L Wilkie, G Gowing	Major

Program 3. Increasing our understanding of the genetic variation in key taxa (species) of the Australasian and Indo-Pacific biota.

Key research goals	Research area that addresses goal	Name of Researcher(s)	Major/ Minor contribution to goal
a) DNA Barcoding of taxonomic groups that are of economic, social or environmental concern.	A species flock of <i>Eophreataicus</i> from Kakadu Nat. Park	GDF Wilson, C Humphrey (ERISS), D Colgan, R Johnson, K Gray	Major
	Forensic DNA-based identification of wildlife	R Johnson, K Gray, R Mason	Major
	A DNA library for the New Caledonian lizard fauna	R Sadlier	Major
	DNA barcoding of Australian fauna	R Johnson, K Gray, R Mason, M McGrouther, D Bickel	Major
	DNA barcoding of larval frogs	J Rowley	Major
	DNA barcoding of Larval fishes	J Leis, R Johnson	Minor
	DNA barcoding of Australian termites	N Lo, A King	Major
b) Genetic approaches to monitoring biodiversity and assisting resource-use planning for biodiversity conservation.	Evolutionary and conservation genetics of marsupials	M Eldridge	Major
	Characterisation of the marsupial MHC	M Eldridge	Major
	A species flock of <i>Eophreataicus</i> from Kakadu Nat. Park	GDF Wilson, C Humphrey (ERISS), D Colgan, R Johnson, K Gray	minor
	Analysis of the population genetic structure of the Bush Stone Curlew (<i>Burhinus grallarius</i>)	W Boles, R Johnson, R Mason, C Price (DECC)	Major
	Phylogenetic analysis of molluscs from the families Viviparidae, Planorbiidae, Hydrobiidae	W Ponder (SF), R Mason, K Gray, R Johnson	minor
	The phylogeography of <i>Phallomedusa solida</i>	Don Colgan, Rosemary Golding	major
	Molecular Systematics of the Christmas Island Shrew	M Eldridge, R Johnson, P Meek (UNE, Armidale)	Major
	Phylogenetic diversity and conservation	D Faith	Major
	Population genetic structure of the white fronted chat	R Major, R Johnson	Major
	Morphological and molecular systematics of the funnel-web spiders	M Gray (SF)	minor

Program 4. Origin, evolution and biogeography of the biota of the Indo-Pacific and Australasian region.

<i>Key research goals</i>	<i>Research area that addresses goal</i>	<i>Name of Researcher(s)</i>	<i>Major/ Minor contribution to goal</i>
a) Understanding the origins of the Australian fauna.	Conodont Biostratigraphy and reconstruction of palaeogeography, palaeoclimate and ecosystems in the Ordovician world	Y Y Zhen	major
	Revision of Spilopyrinae (fiery leaf-beetles)	C Reid	major
	Revision of Sagrinae (kangaroo beetles)	C Reid	major
	Understanding gastropod phylogeny, particularly the basal Pulmonate and basal Heterobranchia, that are particularly characteristic of Australian waters	D Colgan, C Lydeard, B Dayrat, W Ponder (SF)	Major - see goal b of this program and Program 5, research goals a and c
	Molecular systematics of New Guinean macropodids	M Eldridge	Major
	The systematics of Australian comb-footed spiders in the subfamily Hadrotarsinae (Araneae: Theridiidae)	H Smith	major
	Australasian forest spider fauna	H Smith	minor (on hold at present)
	Systematics of Australian mantid fauna	G Milledge	minor
	Systematics of spiders in wet forests of SE Aust.	G Milledge	minor
	Cape York Amber fauna -insect inclusions -origins	D Bickel	Major
	Systematics of Australian Agamid Lizards	R Sadler	Minor
	Systematics of the Egernia striolata group	R Sadler	Minor
	Evolutionary genetics and DNA barcoding of Australian termites	N Lo	Major
	Molecular phylogenetics of burrowing cockroaches (Geoscapheinae, Panesthiinae)	N Lo	Major
	Systematics of the Gondwanan group, Phreatoicidea (Isopoda; freshwater)	GDF Wilson	Major
	Systematics and biogeography of Australo-Pacific avifauna	W Boles	Major (also b), below)
	Insect plant linkages in eastern Australia: A new phylogenetic framework for estimating local, regional, and global biodiversity	D Faith	major
	Description and systematics of Australian Tertiary avifauna	W Boles	Major
	Survey of land snail diversity on the Kimberley Islands, WA	F Köhler	Major
b) Understanding the biogeography and evolution of the Indo-Pacific fauna.	Understanding heterobranch (a major gastropod clade) phylogeny, particularly the basal pulmonate and basal Heterobranchia, that are particularly characteristic of Australian waters	D Colgan, C Lydeard, W Ponder (SF)	Major - see goal a of this program and Program 5, research goals a and c
	Revision of Spilopyrinae (fiery leaf-beetles)	C Reid	minor
	Molecular systematics of New Guinean macropods	M Eldridge	Major

Program 4. Origin, evolution and biogeography of the biota of the Indo-Pacific and Australasian region.

<i>Key research goals</i>	<i>Research area that addresses goal</i>	<i>Name of Researcher(s)</i>	<i>Major/ Minor contribution to goal</i>
b) Understanding the biogeography and evolution of the Indo-Pacific fauna.	Molecular sytematics of the Christmas Island shrew	M Eldridge, R Johnson	Minor
	Systematics and biogeography of Australo-Pacific avifauna	W Boles	Major (also a), above)
	Larval-fish ecology - behaviour in relation to dispersal	J Leis	major
	Larval-fish systematics - Family Lutjanidae	J Leis	major
	Larval-fish and adult systematics - Lobotes, Hapalogenys and Datnioides	J Leis	major
	Reviews of various Indo-Pacific fish species	D Hoese (SF)	minor
	Taxonomic studies of signal flies (New Caledonia, PNG, Australia)	D McAlpine (SF)	Minor
	Fiji Arthropod survey - Co-PI	D Bickel	Major
	Dolichopodidae (Diptera) of Fiji and mid-Pacific	D Bickel	Major
	Dolichopodidae (Diptera) of New Caledonia	D Bickel	Major
	Systematics and biology of New Caledonian Lizards	R Sadlier	Major
	Systematics and phylogeny of sabellida	Pat Hutchings	major
	Caenogastropod phylogeny	W Ponder (SF), D Colgan, R Golding, E Strong, J Healy	major
	Phylogeny and phylography of hydrobiid gastropods in the Australasian region	D Colgan, W Ponder (SF), M Haase	major
	Crustacean phylogeny, relationships within the Arthropoda	GDF Wilson	minor
	Phylogeny of the Isopoda and the Peracarida	GDF Wilson	minor
	Molecular phylogenetics of burrowing cockroaches (Geoscapheinae, Panesthiinae)	N Lo	Major
	Amphibian diversity and conservation in South-East Asia	J Rowley	Major
	Comparative morphometrics in three large lizard or lizard-like ecological analogues - NZ tuatara, Australian agamid, Fijian iguanid	H Cogger (SF)	Minor
	Guide to the reptiles and amphibians of the Western Pacific	H Cogger (SF), R Sadlier	minor
Other research on origin, evolution and biogeography of the region	A Conservation Assessment of the New Caledonian Lizard Fauna. A WEB based assessment of the conservation status of the New Caledonian lizard fauna funded by the territory national government	R Sadlier	Major
	Phylogenetic diversity and conservation	D Faith	Major

Program 5. Understanding human impacts on the Australian biota.

Key research goals	Research area that addresses goal	Name of Researcher(s)	Major/ Minor contribution to goal
a) Assessment of the vulnerability of Australia's freshwater and estuarine ecosystems to human impacts.	Understanding gastropod phylogeny, particularly the basal Pulmonate and basal Heterobranchia, that are particularly characteristic of Australian waters	D Colgan, C Lydeard, W Ponder (SF)	Minor - Major relevance to program 4.
	A species flock of <i>Eophreataicus</i> from Kakadu National Park	GDF Wilson, C Humphrey (ERISS)	Major
	Overview of integrative tools and methods in assessing ecological integrity in estuarine and coastal systems worldwide	P Hutchings, A Borja, S Bricker, D Dauer, A Forbes, R Kenchington, J Marques, P Qian	major
	Reviews of various freshwater fish species	D Hoese (SF)	Minor
b) Investigating the effects of climate change on the Australian fauna.	Defining evolutionary stability in south-eastern Australia: (1) Phylogeographic studies of marine and estuarine mollusca	D Colgan	Major - relevant to 1 a) also
	Defining evolutionary stability in south-eastern Australia: (1) Measures of gene flow in marine and estuarine Mollusca, and investigations of shell elemental compositions as an indicator of provenance	D Colgan	Major - relevant to 1 b) also
	Australasian forest spider fauna	H Smith	minor (on hold at present)
	Ecology of Australian White Ibis (also included in[c])	R Major, J Martin, K French	Major
	Larval-fish ecology - effects of climate change on Connectivity in coral reef systems	J Leis	major
	Genetic and evolutionary connectivity of Australian ecosystems (ARC Linkage and Environmental Futures Network)	L Christidis	major (also 2a, 2b, 3b)
	Vulnerability of climate on benthic invertebrates of the GBR	P Hutchings, S Ah Yong, M Byrne, R Przeslawski, G Wörheide	major
	Assessing impact of ocean acidification on coral reefs	P Hutchings, S Dove	major
	Development of online tools for exploration of the potential effects of climate change on biodiversity distribution.	P. Flemons, A. Ranipeta, M. Ashcroft	major
	Fine scale climate surfaces for improved capacity to predict biodiversity distributions at regional scales	M. Ashcroft, J Gollan, P Flemons	major
c) Understanding Human Impacts in the Sydney environs.	Bird-habitat relationships in urban areas	R Major, H Parsons, K French	Major
	Ecology of Australian White Ibis (also included in[b])	R Major, H Parsons, K French	Major
	Historical Changes in the Birds of Sydney	R Major, H Parsons	Major

Program 5. Understanding human impacts on the Australian biota.**Cont.**

<i>Key research goals</i>	<i>Research area that addresses goal</i>	<i>Name of Researcher(s)</i>	<i>Major/ Minor contribution to goal</i>
c) Understanding Human Impacts in the Sydney environs. Cont.	Assessment of Hill-topping sites for Butterflies in the Hawkesbury-Nepean CMA	D Britton, S Ginn, L Holme	Major
	Human Climate and Fire Nexus in the Sydney Basin	V Attenbrow with S Mooney, UNSW	Major
	Ecology of a recently discovered exotic bee in Australia	J Gollan, M Ashcroft, M Batley	Major
	Forensic DNA-based identification of wildlife	R Johnson, K Gray, R Mason	Minor
Other - Human Impacts on Australian Biota	The role of eucalypt plantations in biodiversity conservation.	R Major, T Hsu, K French	Minor
	Conservation planning for key biodiversity regions, including Papua New Guinea and Eastern Australia	D Faith	Major
	Impacts on invertebrates in the Pilbara	J Gollan, M Ashcroft	Minor
	Invasive species analysis of port surveys	P Hutchings & M Bishop	Major
	Phylogenetic diversity and conservation	D Faith	Minor

Program 6. Investigating the history of human cultures and communities in the diverse and changing environments of Australia and the Pacific region.

Key research goals	Research area that addresses goal	Name of Researcher(s)	Major/ Minor contribution to goal
a) Understanding the history and diversity of Indigenous material culture	Evolution of Technology and Tool Use in 10,000 years of Aboriginal Prehistory	V Attenbrow, P Hiscock (ANU), G Robertson (ANU, UQ)	Major
	Geographical diversity in the distribution of Holocene Sydney Basin backed artefacts	V Attenbrow, B Asmussen, P Hiscock (ANU), M Ashcroft	Minor
	History and documentation of the Papunya Permanent Collection	K Khan (SF)	Major
	Impact of natural disasters on cultural change with special reference to West New Britain, Papua New Guinea	R Torrence, V Neall (Massey Uni), B. Boyd (Southern Cross Uni), C. Lentfer (Uni QLD), C. Petrie (Cambridge Uni), C. McKee (Mineral Resources, PNG)	Major
	Indigenous agency and museum collections	R Torrence, A Clarke (Uni of Sydney), J Philp (U Syd), E Lilje (PhD student, U Syd)	Major
	In the Beginning: Early Anthropology Collections at the Australian Museum	S. Florek	Minor
	Residue analysis of mortars and pestles from Papua New Guinea	R Torrence, H Barton (Uni of Leicester), P Swadling (ANU)	Minor
	Roth collection from the Gulf region	K Khan (SF)	Minor
	Stone tools and potters of New Britain, PNG	J Specht (SF)	Minor
	Tracing the diversity of stone tools assemblages in West New Britain, Papua New Guinea	R Torrence, N Kononenko (U Syd), P Rath (U Syd, PhD student)	Major
b) Tracking the history of human interaction with the natural environment incl. effects of urbanisation, industrialisation, tourism, environmental changes and disasters.	Evolution of Technology and Tool Use in 10,000 years of Aboriginal Prehistory	V Attenbrow, P Hiscock (ANU), Gail Robertson (ANU, UQ)	Major
	Exploring the changing relationship of Barkindji people to the Darling River as expressed through contemporary art making and its content.	L Gibson [Till 30 June 2008]	Minor
	Human Climate and Fire Nexus in the Sydney Basin	V Attenbrow, S Mooney, UNSW	Major

Program 6. Investigating the history of human cultures and communities in the diverse and changing environments of Australia and the Pacific region. Cont.

<i>Key research goals</i>	<i>Research area that addresses goal</i>	<i>Name of Researcher(s)</i>	<i>Major/ Minor contribution to goal</i>
b) Tracking the history of human interaction with the natural environment incl. effects of urbanisation, industrialisation, tourism, environmental changes and disasters. Cont.	Late Holocene mega-tsunamis and the coastal archaeological record of NSW	V Attenbrow, I Hutchinson (S Fraser Uni, Canada)	Major
	Port Jackson Tools and Technology - Accessing stone materials	V Attenbrow, T Corkill (MusAssoc)	Minor
	Prehistoric obsidian exchange in Melanesia	R Torrence, G Summerhayes (Uni of Otago), P Rath (PhD student, USyd)	Major
c) Understanding the origin and functions of social exchange	Aboriginal trade and exchange in eastern NSW: Non-destructive provenancing (PXRF) of basalt ground edged axes	V Attenbrow, P Grave (UNE)	Major
	Ancient obsidian exchange in Far East Russia	R Torrence, T Doelman (Uni of Sydney), N. Klujev, I. Sleptsov, V. Popov (Russian Acad of Sci)	Major
	Application of Laser Ramon technique to characterisation of obsidian	R Torrence, E Carter (Uni of Sydney), S Kelloway (Uni of Sydney, PhD student)	Major
	Stone tools and potters of New Britain, PNG	J Specht (SF)	Minor
Other research into human cultures	Marine Carbon Reservoir Variability along the NSW South Coast	V Attenbrow, I Loch, S Ulm (UQld), G Jacobsen (ANSTO)	Minor

Program 7. Linking intangible and tangible heritage.

Key research goals	Research area that addresses goal	Name of Researcher(s)	Major/ Minor contribution to goal
a) Investigating the history of creativity in human cultures and communities in Australia and the Pacific	Indigenous agency and museum collections	R Torrence, A Clarke (Uni of Sydney), J. Philp (Uni of Sydney), E Lilje (PhD student, Uni of Sydney)	Major
b) Understanding the roles of material culture and traditional knowledge in Indigenous cultures.	Shearston Project	Y. Carrillo-Huffman, E Aholelei, F Mahoney	Major
	Fiji Tabua Project	P Monaghan	Major
	Solomon Islands Intangible Cultural Heritage Field Kit Project	P Monaghan	Major
	Fiji pottery	M Van Olffen	Major
c) Understanding the collecting process.	Indigenous agency and museum collections	R Torrence, A Clarke (Uni of Sydney), J. Philp (Uni of Sydney), E Lilje (PhD student, Uni of Sydney)	Major
d) Engaging with creator communities to better understand the significance of our collections.	Fiji Tabua Project	P Monaghan	Major
	Solomon Islands Intangible Cultural Heritage Field Kit Project	P Monaghan	Major
	Understanding Balinese paintings: collections, narrative, aesthetics and society	V Daniel, S Florek, D Peita	Minor
	Virtual Museum	V Daniel, M. van Olffen, P Dadswell, D. Peita	Major
	Indigenous agency and museum collections	R Torrence, A Clarke (Uni of Sydney), J. Philp (Uni of Sydney), E Lilje (PhD student, Uni of Sydney)	Minor
	Erromango and Sentani, barkcloth dynamics: revival and identity	Y. Carrillo-Huffman	Major

Program 8. Investigating extant and extinct faunas and environmental systems in the context of recent geological history to better forecast future changes

<i>Key research goals</i>	<i>Research area that addresses goal</i>	<i>Name of Researcher(s)</i>	<i>Major/ Minor contribution to goal</i>
a) Studying animal groups that leave good fossil records to help forecast future change	Conodont Biostratigraphy and reconstruction of palaeogeography, palaeoclimate and ecosystems in the Ordovician world	Y Y Zhen, I. Percival(Geol. Surv. NSW), B. Webby (Macquarie Uni), R. Nicoll (ANU), C. Burrett (Uni of Tas),Y.Zhang (Nanjing Inst. Geol. & Palaeo), Z.Zhou (Nanjing Inst. Geol. & Palae)	major
	Cape York Amber fauna - insect inclusions	D Bickel	Major
	Devonian fossil fish	A Ritchie (SF), Z Johanson, Natural History Museum London; R Carr, Ohio USA	major
b) Analysing dynamics of contemporary and recent reef systems.			
c) Sedimentary Mineralogy	Distribution,origin, and mineralogy of Australian limestone cave formations (speleothems) and sediments in a former continental shelf reef system, featuring Jenolan Caves NSW, with implications for palaeoclimate, cave conservation, environmental management and tourism in a World Heritage area.	R Pogson, D Colchester, A Osborne (USyd), B England	major
Other Geosciences Research	Triggers for volcanism, Australasia/Antarctica	L Sutherland (SF), R Pogson, I Graham	major
	Gemstone origins, Australia/Pacific margins	L Sutherland (SF), G Webb, L Barron, I Graham, K Zaw (U Tas)	major
	Post-Gondwana geochronology, eastern Australia	L Sutherland (SF)	
	Landscape evolution, central NSW	L Sutherland (SF), R Pogson, L Barron	major
	Description and systematics of Australian Tertiary avifauna	W Boles	minor
	Cretaceous-Cenozoic mass extinction event	L Sutherland (SF)	minor
	Eastern Australian zeolites - distribution and origins	R Pogson, L Sutherland, I Graham, D Colchester, B England	
	New Australian mineral species	R Pogson, I Graham, D Colchester	

Grant funded projects administered by Australian Museum, 1 July 2008 – 30 June 2009

Principal Investigator(s)	Title of project	Granting body	Amount awarded 08/ 09	Total value of grant	Years funds	Research Strategy Program
D Britton	Biodiversity Blitz on Charles Darwin Reserve - Pilot	Dept of the Environment, Water, Heritage and the Arts (ABRS)	6,000	6,000	2009	2
D Colgan	Monitoring the response of NSW bivalves to changed environments	NSW Environmental Trust - Research Grant	17,800	17,800	2009	5
D Colgan, J Stanisc	Morphological and molecular investigations of the systematics and biogeography of the speciose landsnail genus <i>Gyrocochlea</i> (Mollusca: Charopidae)	Australian Biological Resource Study (ABRS)	32,000	92,000	2006-09	4
M Eldridge, R Johnston, P Meek	Investigation of the Taxonomy of the Christmas Island Shrew	Dept of Environment, Water, Heritage and the Arts (DEWHA)	7,009	7,009	2008-09	2, 3, 4
P Flemons, L Kelly, J Tann	Atlas of Living Australia (ALA) User Needs Analysis	Atlas of Living Australia (CSIRO)	66,229	66,229	2008-09	2
P Flemons	Digital Stories for Taxonomic Databases Working Group (2008/09 project)	Global Biodiversity Information Facility	5,500	5,500	2008-2009	2
P Flemons	BioMaps Strategic Directions	Rio Tinto	70,000	70,000	2009	2
J Gollan, M Ashcroft	Piloting Fine-Scale Climate Data Collection in the Hunter Valley (GER Pilot)	Dept of Environment and Climate Change, NSW	10,000	10,000	2009-10	2, 5
R Golding, W Ponder	Exploring the diversity and biogeography of Australasian mangrove snails	James N Kirby Foundation	15,600	15,600	2009-10	1,3, 5
R Golding	Chadwich Biodiversity Fellowship: position co-funded by the Australian Museum Foundation	Australian Museum Foundation	23,000	23,000	2008-2009	1,5
P Hutchings	Systematics and Phylogeny of Sabellida: Polychaeta	Australian Biological Resource Study (ABRS)	41,750	150,000	2008-11	2, 3
P Hutchings, M Capa, C Glasby, C Watson, V Wei, K Gibb	Polychaete fauna of coral reefs:morphological and molecular characterisation and keys to species	Australian Biological Resource Study (ABRS)	90,000	270,000	2009-2012	2, 3
S Keable	Identification and Data Capture for Arafura Sea Polychaeta and Arafura Sea Invertebrata	Ocean Biogeographic Information System (OBIS)	10,500	10,500	2008-2009	1

Principal Investigator(s)	Title of project	Granting body	Amount awarded 08/09	Total value of grant	Years funds	Research Strategy Program
J Leis / C Paris, C Guignad	How Baby Fish Find a Home: orientation by reef-fish larvae in the pelagic environment.	Hermon Slade Foundation	23,000	59,000	2007-10	1
J Lowry	Kimberley Amphipod Data - extension of the the Circum Amphipoda Australia Project	Dept of Environment, Water, Heritage and the Arts - Natural Heritage Trust	30,000	30,000	2009	1
J Lowry	Tasmanian Amphipod Data - extension of the the Circum Amphipoda Australia Project	Dept of Environment, Water, Heritage and the Arts - Natural Heritage Trust	28,182	28,182	2009	1
H Smith, I Agnarsson, G Anderson, M Harvey	The systematics of Australian comb-footed spiders in the subfamily Hadrotarsinae (Araneae: Theridiidae)	Dept of the Environment, Water, Heritage and the Arts (ABRS)	60,000	180,000	2007-10	2,4
J Rowley	Amphibian Conservation in Indo-Burma	ADM Capital Foundation (Hong Kong)	25,000	55,000	2008-10	4
J Rowley, R Sadlier	Amphibian Conservation in Vietnam	Ocean Park Conservation Fund, Hong Kong	11,613	23,226	2009	4
D Britton	Biodiversity Blitz on Charles Darwin Reserve - Pilot	Dept of the Environment, Water, Heritage and the Arts (ABRS)	6,000	6,000	2009	2

Grant funded projects administered by another research institution

Principal Investigator(s)	Title of project	Granting body	Amount awarded 08/09	Total value of grant	Years funds	Research Strategy Program
L Hughes, A Beattie, D Faith , R Kitching	A new phylogenetic framework for estimating local, regional and global biodiversity	Australian Research Council - DP	127,000	404,000	2006-08	2
S Dove, W Leggat, D Yellowless, J Lough, P Hutchings , K Caldeira	Assessing the risk of ocean acidification for the Great Barrier Reef	Australian Research Council - LP	125,560	476,950	2007-09	1
R Beaman, P Flemons , R Guralnick, A Hill, A Stewart	BiogeoBIF: A system for increasing the georeferencing quantity and quality of all GBIF-mediated occurrence records.	The University of Florida	8,989 to AM	60,000	2009	2
K Belov, M Eldridge , S Beck	Characterisation of the tammar wallaby MHC	Australian Research Council - DP	70,000	220,000	2006-09	2, 3
J Marshall, S Collin, R McCauley, K Fritsches, N Hart, B Degnan, S Degnan, M Norman, J Hooper, P Hutchings et al	Deep Downunder: designing a deep-sea exploration and discovery capability for Australia	Australian Research Council - LP	362,000	1,093,000	2007-09	1
P Hiscock, V Attenbrow	Evolution of technology and tool use in 10,000 years of Aboriginal History	Australian Research Council - DP	44,000	139,000	2007-2009	7
D Faith , S Ferrier, C Brown, J Soberon, T Peterson, D Yeates, C Slatyer, J West, V Savolainen	GBIF for 2010	Global Biodiversity Information Facility (GBIF)	0	30,000 euro	2007-10	2, 4, 5
P Flemons	OZCAM Cache Upgrades	Australian Biological Resource Study (ABRS)	12,727		2008-09	
S Hand, M Archer, D Bickel	Precious time-capsule: discovery of fossil-rich amber from Australia	Australian Research Council - DP	90,000	245,000	2008-10	2, 4, 5, 8
A Clarke, J Philp, R Torrence	Producers and Collectors: Uncovering the Role of Indigenous Agency in the Formation of Museum Collections	Australian Research Council - LP	34,650	103,950	2007-11	6

Principal Investigator(s)	Title of project	Granting body	Amount awarded 08/09	Total value of grant	Years funds	Research Strategy Program
J Leis, G Jones, T Hughes	Resilience and connectivity: Development and test of realistic larval-fish dispersal models for the Great Barrier Reef	Marine and Tropical Science Research Facility (MTSRF),	72,560 (to AM)	492,000	2007-10	1, 5
A Lawson, P Eklund, B Bunt, V Daniel	Search, Navigation and Annotation of Digital Museum Collections Using Concept-Lattices: A Case Study of the Australian Museum's Vanuatu Collections" (Wollongong Concept Lattices)	University of Wollongong (URC) Partnership Grant Scheme	3760 (to AM)	12,000	2007-08	
A Lawson, L Christidis (until April 2009); V Daniel; P Eklund, B Bunt	The application of concept lattices to digital museum collection management and access	Australian Research Council - LP	91,407	246,239	2008-11	7
A Vickers, L Christidis; P Monaghan, V Daniel, D Pieta (from April 09), P Worsley, S Diamond	Understanding Balinese paintings: collections, narrative, aesthetics and society	Australian Research Council - LP	78,330	227,738	2009-11	7
S Ulm, V Attenbrow, I Loch, G Jacobsen	Marine Carbon Reservoir Variability along the NSW Coast	AINSE	12,000	12,000	2008-09	6
L Hughes, A Beattie, D Faith, R Kitching	A new phylogenetic framework for estimating local, regional and global biodiversity	Australian Research Council - DP	127,000	404,000	2006-08	2
S Dove, W Leggat, D Yellowless, J Lough, P Hutchings, K Caldeira	Assessing the risk of ocean acidification for the Great Barrier Reef	Australian Research Council - LP	125,560	476,950	2007-09	1

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