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CONSULTING ECOLOGY

ECA
ECOLOGICAL
CONSULTANTS
ASSOCIATION
of NSW Inc

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Newsletter of the Ecological Consultants Association of NSW

ECA ECOLOGICAL CONSULTANTS ASSOCIATION of NSW Inc

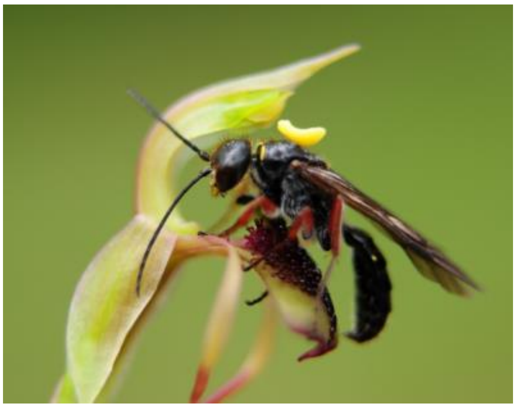
Russula. aff. rosacea **, one of the beautiful specimens observed on the Fungi Workshop (see page 17).** *Photo Courtesy of Mia Dalby-Ball.*

Golden-tipped Bats using a mop head for a roost (see page 4). *Photo Courtesy of Anne Williams*

VOLUME 35 August 2015

INSIDE THIS ISSUE!

A thynnine species attempts copulating and in trying to carry off the 'dummy female' collects the pollinia - fulfilling the purpose of the orchid's seductive processes (see page 25). *Photo Courtesy of Ray and Elma Kearney.*



Front Cover Photo: Scarlet Honeyeater *Photo Courtesy and Copyright of Natalie Parker.*

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Message from the President

Dear members,

Greetings from the President as we enter another year for the ECA. The past year has been very productive in terms of progress towards a stronger and long-term viable association that represents the Ecological Consulting community. With membership approaching 200, we are now a voice that is now being listened to and it is gratifying that we are called upon to be on committees and provide advice to several government and non-government organisations as "industry reps". This aspect of our association will be developed further in the coming months.

As usual, the 2015 ECA Conference was a great success with full attendance and an informative program. Many thanks to Isaac Mamott and Amy for organising everything, including the trivia competition – a good addition to the conference where trivia was not part of the day. In fact, over time, the conference programs have become more like a scientific meeting but still with a practical bent. Again, there were more attendees than our membership as people not yet members are attracted to what is presented. There is always a spike in membership applications post-conference as it is realised that the ECA can be considered seriously. This reflected in our newsletter which is full of short (and sometimes long) articles dealing with the problems of ecological consulting as well as scientific reports. One of the original aims of the newsletter was to provide a forum for short reports and observations no longer able to be published elsewhere. Publications such as the ECA Newsletter provide an important role to disseminating observational data to the scientific community.

As with any annual election of council members there are some losses and gains. This year two of our long-standing and productive members decided to retire – Deryk Engel (past secretary) and Paul Burcher (past treasurer). Hopefully they are not going to pasture but will still provide their experience and knowledge when needed. I wish them both well and will miss their constant banter. Kristy Peters also retired (temporarily I hope) but was able to establish the successful workshops run this past year. In compensation we now have on board Mia Dalby-Ball who will bring great knowledge and experience to the council.

Thanks to Belinda Pellow and Alison Hunt, we have progressed the Certification Scheme to a stage where it can be launched in the near future. We have sought legal advice concerning ECA responsibility and insurance, and are establishing a committee to assess applicants. Please spend time to look at the web site for more information and register an interest in becoming a Certified Practitioner. On a similar subject, there has been some confusion about the use of the ECA logo on individual reports. As it stood, this was not possible as it infers that the report was endorsed by the ECA. To avoid this confusion, a member's logo has been designed and will soon be available on request from Amy.

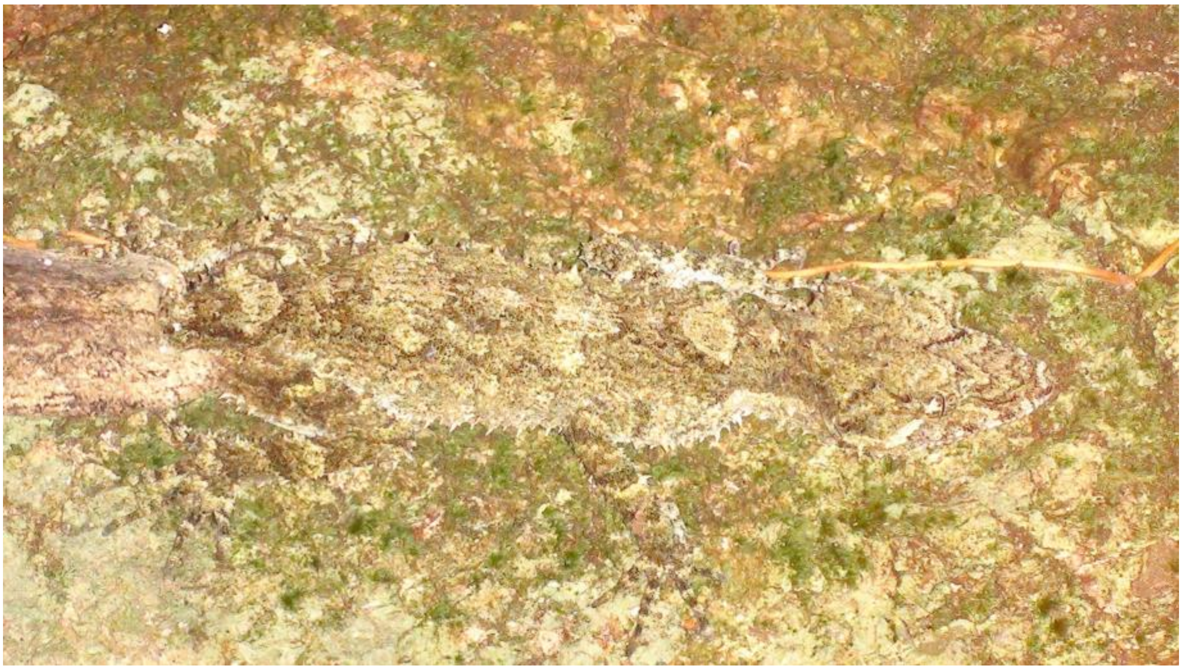
Finally, one concern that has surfaced during the last year is the revision of Biodiversity Regulations both here is NSW and Federally. I am constantly asked if the major mining companies that I am associated with try to weaken the regulations to ensure easier passage of development applications. I have to respond by stating that most weakening of regulations come from the regulators themselves who are slowly softening the criteria established for survey standards and impact assessments. Not only is this bad for conservation, but it could also result in less work for consultants, particularly regarding field surveys and assessment. The use of computer modelling and dependence upon existing data may make it easier for the regulators to steer developments through to success but at what cost. Biometrics may seem to be an ideal method of assessment, but it does neglect the fundamental basis of biodiversity assessment and turns its back on a long history of field assessment?

Martin Denny

ECA ECOLOGICAL CONSULTANTS ASSOCIATION of NSW Inc

MEMBER

The ECA Council meet every three months to discuss and deal with any current business of the association. The last meeting took place on the 15th of June and the next meeting is planned for the 28th of September 2015. Any member who wishes to view the minutes from any of the ECA council meetings may do so by contacting the Administration Assistant Amy Rowles admin@ecansw.org.au



Camouflage at its best. Northern Leaf-tail Gecko *Saltuarius cornutus*, Atherton Tablelands. *Photo Courtesy of Anne Williams*

PHOTO COMPETITION

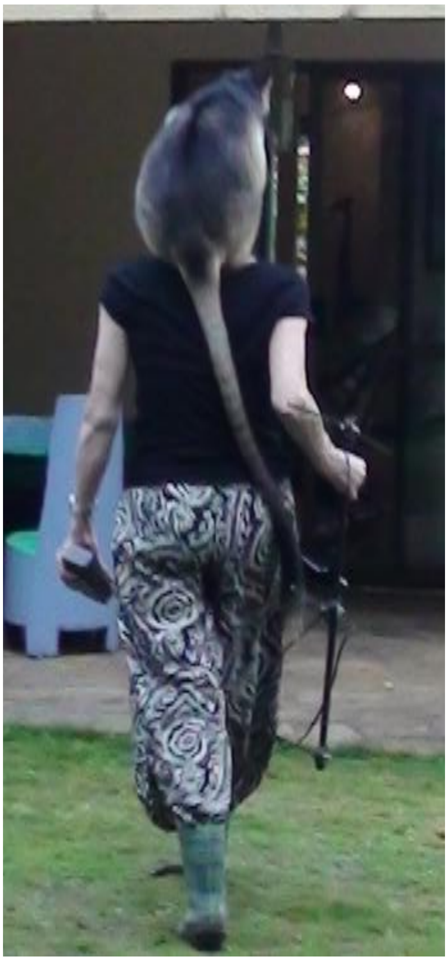
Congratulations! to ***Natalie Parker*** for winning the last photo competition with her photograph featured on the front cover of an Scarlet Honeyeater.

Thank you to everyone who entered our photo competition. All entries have been included in the ECA Photo Gallery on the back cover and central pages of the newsletter.

Email your favourite flora or fauna photo to admin@ecansw.org.au to enter a competition and have your photo on the cover of the next ECA newsletter. Win your choice of one year free membership or free entry into the next ECA annual conference. The winner will be selected by the ECA council. Runners up will be printed in the photo gallery

Photos entered in the competition may also be used on the ECA website

If a centaur is half human, half horse is this a Rooman. *Photo Courtesy of Anne Williams.*



We have had the pleasure of watching a pair of Yellow-faced Honeyeaters nest in a vine on the side of our water tank. Looking forward to spying on the chicks. *Photo courtesy of Amy Rowles*

Take a look at this Red Neck 'hangin out' in the park! Another new baiting technique perhaps! *Photo courtesy of Danny Wotherspoon.*

EUROKY

Euroky: ***ability of an organism to adapt to changes in the environment***

If you have any interesting observations or useful hints and information that you would like to share in the euroky column, please forward them to the newsletter editor or administration assistant to be included in the next edition.

A Golden-tipped Bat. Photos courtesy of Anne Williams

CAN'T FIND A SCRUBWREN NEST - THIS WILL DO!

Anne Williams

On my recent trip to Atherton Tablelands, North Queensland, I made this most interesting discovery. A colony of 7 juvenile Golden-tipped Bats *Kerivoula papuensis*, which included 5 females and 2 males, selected a cotton string mop as a roost site. They used this mop for at least 3 nights. Faecal droppings had been observed under the mop at various times for the previous month. In an interesting twist, when the bats moved on, the local scrubwrens began adding nesting material to the mop. This could be a cheap and easy method of providing artificial roost sites for the Golden -tipped Bat.

Colony of Golden-tipped Bats roosting in a mop head. Photos courtesy of Anne Williams.

NEW ONLINE SERVICE PUTS NSW BIODIVERSITY DATA AT YOUR FINGERTIPS

James Bibby
Senior Scientist, Biodiversity Information Systems
Office of Environment and Heritage

The NSW Office of Environment and Heritage has just launched the new BioNet Web Service; an open government initiative providing easy and direct access to information on species sightings held within the BioNet Atlas of NSW Wildlife. The new BioNet Web Service was developed with input from a range of stakeholders including ecological consultants, and provides users with the ability to define custom queries, automate the extraction of species sightings data across NSW and integrate this data with other sources for use in analyses and reports.

Over 90 data fields have be made available, including the full range of data currently available for download via the BioNet Atlas of NSW Wildlife. The service also adopts the existing BioNet Atlas security model, enabling scientific license holders to re-use their existing user name and password to authenticate themselves and access restricted data. As an environmental consultant in NSW, the survey data you contribute helps build and improve this important biodiversity asset for the state of NSW.

The BioNet Web Service has been designed with a range of users in mind; from organisations with a high level of IT capabilities seeking to integrate data into existing applications, through to users of Excel 2010 and 2013 who can now easily connect and extract data using Microsoft's free Power Query plugin for Excel. For more information on the service visit the data home page: https://data.bionet.nsw.gov.au

CHANGES MADE TO THE RURAL FIRE SERVICE 10/50 RULE

John Travers

Travers bushfire & ecology

The changes arising from a government review became law on September 4th 2015.

The government panel reviewing the 10/50 Rule completed its review of the 3,579 submissions made to the controversial 10/50 Rule. The government panel included the Department of Planning, The Office of Environment & Heritage and the Rural Fire Service.

The review began in October 2014 following community concerns about the apparent illicit clearing of native vegetation / habitat as a result of the introduction of the 10/50 Rule in August of 2014.

The original 10/50 Rule provided for an almost blanket approach to vegetation and habitat clearing up to 50 metres from a home, commercial premise or industrial building if that development was located in a mapped bushfire prone area.

The review determined that the 10/50 Rule would remain as it has been found to be a valid approach to the protection of the community in bushfire prone areas however thirty significant recommendations have been made as a result of the review which aims to protect the environment and important ecological values.

Key changes include;

1. Significant environmental interests are now given much tighter protection. The extent of these environmental interests are available on the website.
2. Where there has been a development consent issued and a bona-fide bushfire asset protection zone has been approved then no additional clearing will be possible. This will have a significant impact on illicit vegetation clearing and thus habitat clearing.
3. The definition of a tree has been amended to include multi-stemmed trees. This means you can no longer remove multi-stemmed trees beyond 10 metres.
4. The distance at which a tree may be removed has been clarified. You may only remove a tree if any part of the trunk that measures more than 30 centimetres in circumference (around the trunk) at a height of 1.3 metres above the ground, is within 10 metres of the external wall of the building.
5. The application of the rule on neighbours land has been clarified. For example if you are using the distance from a building on your neighbours land to use the 10/50 entitlement (and your buildings are not within 10 metres or 50 metres respectively), you must receive their written consent. Where the tree or vegetation is within 10 metres or 50 metres respectively of buildings on more than one adjoining parcel of land, you must receive written consent from each landowner who adjoins your land.
6. Clearing adjacent to farm sheds is now permitted under the 10/50 scheme.

The range of changes is explained on the website;

http://www.rfs.nsw.gov.au/news-and-media/general-news/1050-vegetation-clearing

CHANGES TO BIODIVERSITY LEGISLATION

John Travers

Travers bushfire & ecology

The NSW government is proposing changes to the biodiversity legislation in NSW. The exact changes are not known at the moment but we do know that OEH is delivering a paper on the changes to government at the end of this year. The changes involve the removal of the 7 part test / the species impact statement and replacement with another approach. Strong whispers also suggest that the current varied biometric formulae's used for biocertification, native vegetation assessment and biobanking will be reduced to one assessment method. In addition it is understood the Native Vegetation Act may be part of the changes.

A joint initiative has been ongoing with the *Ecological Consultants Association of NSW and the Royal Zoological Society of NSW*. The team working on this is Dr Stephen Ambrose, Dr Arthur White, Elizabeth Ashby and John Travers.

Background Information

These changes are likely to change the way ecological consultants undertake their work. It could be that the detailed surveys we now undertake may be reduced to an assessment against benchmarked vegetation communities and their insitu habitat.

As a result there is increasing concern within the ecological consultancy industry and the broader zoological community that the government appears to be weakening survey and assessment standards associated with biodiversity impact assessment. The ecological assessment of developments in NSW requires skilled and ethical persons who work within a code of practice and government legislation.

The weakening of these standards and the reasons for concern were summarised by Martin Denny, President of the Ecological Consultants Association of NSW (ECA NSW) in the February 2015 edition of Consulting Ecology, the official newsletter of the ECA NSW (see attachment). Briefly, there seems to be an increasing acceptance and reliance on existing online databases and modelling and less emphasis on field surveys that establish the actual biodiversity present or likely to be present. This seems to be the approach that government authorities are favouring for biodiversity impact assessments because it:

1. Removes the timing and durational constraints of field work and thus speeds up the assessment process and reduces financial costs;
2. Helps validate the use of government-established databases and predictive modelling software; and
3. Promotes the NSW BioBanking process.

The question that has been left out is whether it delivers a suitable conservation outcome. Moreover, it is a departure from the strong perspective held by DEC (OEH's predecessor) as recently as 10 years ago that, as a whole, there was insufficient field survey effort and design in many biodiversity impact assessments (which led DEC to develop its "*Threatened Biodiversity Survey Assessment Guidelines for Developments and Activities Working Draft November 2004*").

While there are significant merits in using online databases and ecological modelling software, these tools should not be used at the expense of reduced or compromised field survey design and effort. This is because most of the existing databases are not comprehensive or reliable enough, and they map habitats, habitat quality and species distributions at scales inappropriate for a site or development proposal under consideration.

Ecological consultants also believe that BioBanking as a mitigation or compensatory measure is not appropriate for all proposed development sites or forms of development, but the NSW Government, and many shire councils, appear to want that mathematical modelling process, or some form of it, as the default assessment mechanism.

The main concerns that the ECA NSW and RZS NSW have with the apparent weakening of standards are:

1. Insufficient information is being collected on the actual biodiversity values of many sites which, in turn, are likely to result in more (but unknown) significant impacts on biodiversity conservation from development and activities.
2. Computer models and databases of vegetation and habitat structure and quality are not good predictors of the presence of some fauna species or the structure of fauna communities.
3. Loss of field and data analytical skills that should be passed onto future generations of ecologists and ecological consultants.
4. Loss of first-hand knowledge of the relationships between species and their natural environment.
5. A significant reduction in employment opportunities for university graduates and other qualified people who seek a career in the ecological consultancy industry.

With these matters in mind, the ECA NSW has been working with OEH for some years to begin a certification scheme for consultants whom undertake survey and assessment works. Such a scheme is proposed to begin in early 2016. The ECA NSW will manage that scheme.

The joint working party is seeking meetings with OEH and this stage no final date has been set. We have received advice from OEH which explains the ECA/ RZS and others will be involved in the consultation in November of this year.

We will keep our membership informed when we know something more.

(Parts of the above were taken from an original letter penned by Dr Stephen Ambrose; and contributions from members of the joint working party and comments from the ECA Council and RZS).

Please see the letter sent to the ECA from OEH on the next page.

NSW GOVERNMENT | Office of Environment & Heritage

Our reference: DOC15/351887

Ms Elizabeth Ashby
e.ashby@keystone-ecological.com.au

Dear Ms Ashby

I refer to your email to my colleague Kate Wilson, Executive Director, Science, about the biodiversity reforms. Your email was referred to me and I have been asked to reply.

On 26 March 2015 the NSW Government announced that it will implement all of the Independent Biodiversity Legislation Review Panel's recommendations as an integrated package of reforms.

The government is now developing these reforms. The reforms will deliver a new Biodiversity Conservation Act to integrate and modernise NSW laws governing biodiversity conservation and the management of threatened species. The reforms will introduce new arrangements for managing the clearing of native vegetation under the *Local Land Services Act 2013* and the *Environmental Planning and Assessment Act 1979 (EP&A Act)*.

I anticipate that both the Ecological Consultants Association of NSW (ECA) and the Royal Zoological Society of NSW will have a keen interest in these reforms. In particular, the recommendations that relate to expanding the *NSW Biodiversity Offsets Policy for Major Projects* to all types of development (recommendation 13); adopting an single scientifically-based, transparent and independently reviewed method for assessing the biodiversity impacts of all development in NSW (recommendation 12); and maximising the use of accredited third parties to assess the biodiversity impacts of development applications under the EP&A Act (recommendation 10). As practitioners of biodiversity assessments, the government is particularly interested in ECA's views on these aspects of the reforms.

In its final report, the independent panel recognised that developing a single method for assessing the biodiversity impacts would build on the knowledge developed under the existing methods. These include the Environmental Outcomes Assessment Methodology, BioBanking Assessment Methodology, Biodiversity Certification Assessment Methodology, and Framework for Biodiversity Assessment.

The government will develop the reforms through a consultative approach with all interested stakeholders. The government intends to release a draft Bill for public comment from November 2015. As part of this process, OEH will be consulting with key stakeholders including the ECA. In the meantime, should you wish to discuss this further, Amanda Lawrence, Director Sustainable Development Policy, can be contacted on 9585 6938 or amanda.lawrence@environment.nsw.gov.au. More details on the reforms are also available on the Office of Environment and Heritage website at www.environment.nsw.gov.au.

Thank you for taking the time to write to OEH about this important issue.

Yours sincerely

P. Elton 9.9.15

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UPCOMING ECA EVENTS IN 2016

- **PROPOSED ECA WORKSHOPS 2016 / 2017**

  - **Business Development and Practices Workshop**
  - **Invertebrates**
  - **Orchid ID**
  - **Statistic for Ecological Consultants**

The dates and venues for these workshops are yet to be determined. You may register your interest in any of these workshops by emailing admin@ecansw.org.au.

Members may email any ideas for future ECA workshop topics or conference themes to Amy Rowles admin@ecansw.org.au

Non ECA Events

- **Ecological Society of Australia**

Date: 29th November - 3rd December 2015
Location: Adelaide
Details: http://www.ecolsoc.org.au

- **The Australasian Wildlife Management Society (AWMS) Conference 2015**

Date: 23-26th Nov 2015
Location: Perth
Theme: Wildlife Management in a Changing Environment
Details: www.awms.com.au/conference

- **The 17th Australasian Bat Society 2016 Conference and AGM**

Date: 29th March - 1st April 2016
Location: Hobart
Theme: Wildlife Management in a Changing Environment
Details: www.ausbats.org.au

- **Royal Zoological Society of NSW Annual Forum**

Date: 7th Nov 2015
Location: Australian Museum, Sydney
Theme: Zoology on the table: the science, sustainability and politics of eating animals
Details: www.rzsnsw.org.au

- **Australian Systematic Botany Society 2015 Conference**

Date: 29th November - 3rd December 2015
Location: Canberra
Theme: Building Our Botanical Capital
Details: www.asbs.org.au/cbr2015/

- **Australian Native Plants Society (Australia) Biennial Conference, 2015.**

Date: 15th-20th November, 2015
Location: Canberra
Theme: see program at website below
Details: anpsa.org.au/conference2015/

- **Royal Zoological Society of NSW Annual Forum**

Date: 7th Nov 2015
Location: Australian Museum
Theme: Zoology on the table: the science, sustainability and politics of eating animals
Details: www.rzsnsw.org.au

- **Australasian Society for Phycology and Aquatic Botany Conference**

Date: 4th-6th Nov 2015
Location: Hobart
Theme: see website below for details
Details: www.aspab.org

- **Rehabilitation of Mined Land Conference**

Date: 7th April 2016
Location: Singleton, NSW
Theme: the role of soil symbiotic microbes in a successful rehabilitation process, final voids in the Hunter, along with a broad range of presentations on the business of ecological rehabilitation of mined lands.
Details: www.tomfarrellinstitute.org

www.wildlifeschools.com.au

2015

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This event will count as 2 points per hour towards your Certified Environmental Practitioner CPD Log.

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Environment and Heritage

August 2015 ECA Membership Report

Amy Rowles
ECA administrative assistant

In total we have 182 members, comprised of 135 Practising Ecological Consultants, 5 Associate (Consultants), 21 Associate (Government Ecological/ Environment Officer), 9 Associate (Non-practicing), 2 Associate (Subscriber) and 10 Students. We have had 24 new members and four current applicants over the last six months. The new members are introduced below:

- Mathew Hansen
- Ian Colvin
- Kate Carroll
- Evelyn Craigie
- Chantel Benbow
- Daniel Clarke
- Shawn Hunt
- Samara Schulz
- James Rees
- Anna Douglas-Morris
- Ryan Sims
- Rachel Dryden
- Charlotte Mills
- Amelia Saul
- Rod Bennison
- Louise Tomlin
- Katherine Berthon
- Gus Porter
- Christopher Watson
- John Benson
- Alejandro Barreto
- Tony Steelcable
- Lucas McKinnon
- Jeremy Pepper

Definition of an Ecologist

http://www.urbandictionary.com/define.php?term=ecologist - link courtesy of Veronica Silver.

a cool person who does science, drinks beer, loves the outdoors, and is invariably hot and sexy

"You don't look like one of those pasty scientists that spends all day in the lab and never has any fun."
"That's because I'm an ECOLOGIST."

Recent Literature and New Publications

Recent Journal Articles / Literature

McDougall K., Walsh N. and Wright G. (2015) **Recovery of treeless subalpine vegetation in Kosciuszko National Park after the landscape-scale fire of 2003**. *Australian Journal of Botany* - http://dx.doi.org/10.1071/BT14319

Freestone M., Wills T. and Read J. (2015) **Post-fire succession during the long-term absence of fire in coastal heathland and a test of the chronosequence survey method.** *Australian Journal of Botany* - http://dx.doi.org/10.1071/BT14345

Quick G., Goldingay R., Parkyn J. and Newell D. (2015) **Population stability in the endangered Fleay's barred frog (*Mixophyes fleayi*) and a program for long-term monitoring.** *Australian Journal of Zoology* 63(3) 214-219 http://dx.doi.org/10.1071/ZO14106

Milner R., Starrs D., Hayes G. and Evans M. (2015) **Distribution and habitat preference of the broad-toothed rat (*Mastacomys fuscus*) in the Australian Capital Territory, Australia.** *Australian Mammalogy* 37(2) 125-131 http://dx.doi.org/10.1071/AM14031

Predavec M., Lunney D., Shannon I., Scotts D., Turbill John and Faulkner B. (2015) **Mapping the likelihood of koalas across New South Wales for use in Private Native Forestry: developing a simple, species distribution model that deals with opportunistic data.** *Australian Mammalogy* 37(2) 182-193 http://dx.doi.org/10.1071/AM15001

Goldingay R. (2015) **Temperature variation in nest boxes in eastern Australia.** *Australian Mammalogy* 37(2) 225-233 http://dx.doi.org/10.1071/AM14040

Lee J., Pedler L., Sarre S., Robertson J. and Joseph L. (2015) **Male sex-ratio bias in the endangered South Australian Glossy Black-Cockatoo *Calyptorhynchus lathami halmaturinus.*** *Emu* - http://dx.doi.org/10.1071/MU14107

Williams E. and Thomson B. (2015) **Improving population estimates of Glossy Black-Cockatoos (*Calyptorhynchus lathami*) using photo-identification.** *Emu* - http://dx.doi.org/10.1071/MU15041

Davis T. Harasti D. and Smith S. (2015) **Developing a habitat classification typology for subtidal habitats in a temperate estuary in New South Wales, Australia.** *Marine and Freshwater Research* - http://dx.doi.org/10.1071/MF15123

Klamt M., Davis J., Thompson R., Marchant R. and Grant T. (2015) **Trophic relationships of the platypus: insights from stable isotope and cheek pouch dietary analyses.** *Marine and Freshwater Research* - http://dx.doi.org/10.1071/MF15004

Thompson S., Thompson G. Sackman J., Spark J. and Brown T. (2015) **Using high-definition aerial photography to search in 3D for malleefowl mounds is a cost-effective alternative to ground searches.** *Pacific Conservation Biology* - http://dx.doi.org/10.1071/PC14919

Thompson S. and Thompson G. (2015) **Fauna-rescue programs can successfully relocate vertebrate fauna prior to and during vegetation-clearing programs.** *Pacific Conservation Biology* - http://dx.doi.org/10.1071/PC14922

Cashins S. Phillips A. and Skerratt L. (2015) **Using site-occupancy models to prepare for the spread of chytridiomyosis and identify factors affecting detectability of a cryptic susceptible species, the Tasmanian tree frog.** *Wildlife Research* - http://dx.doi.org/10.1071/WR14183

Wellbourne D., MacGregor C., Paull D. and Lindenmayer D. (2015) **The effectiveness and cost of camera traps for surveying small reptiles and critical weight range mammals: a comparison with labour-intensive complimentary methods.** *Wildlife Research* - http://dx.doi.org/10.1071/WR15054

Francis M., Spooner P. and Mathews A. (2015) **The influence of urban encroachment on squirrel gliders (*Petaurus norfolcensis*): effects of road density, light and noise pollution.** *Wildlife Research* 42(4) 324-333 http://dx.doi.org/10.1071/WR14182

HERE IS A SERIES OF ABSTRACTS ON THE EASTERN BEARDED DRAGON THAT MAY INTEREST YOU.

Wotherspoon, A. D. and Burgin, S. (2007) **Lizard testes volume measurements: are they always underpinned by the correct assumptions?** *European Journal of Anatomy* 11(3):163-167

http://eurjanat.com/data/pdf/eja.07030163.pdf

Two basic assumptions are frequently used in the measurement of testis volume: 1) they are highly conserved and thus measures are frequently restricted to a measure of a single testis/individual, and 2) a prolate spheroid provides an adequate measure of volume. Based on the measurement of museum and road kill *Pogona barbata* (Eastern bearded dragon), we showed these assumptions did not hold and recommend that when considering testis volume, researchers measure both testes and the formula used should be informed by careful consideration of their shape.

Wotherspoon, D. and Burgin, S. (2011) **The impact on native herpetofauna due to traffic collision at the interface between a suburban area and the Greater Blue Mountains World Heritage Area: an ecological disaster?** In: *Ecological Disasters*. Edited by: Lunney, D., Banks, P. and Dickman, C., Royal Zoological Society of New South Wales, Mosman.

http://publications.rzsnsw.org.au/doi/pdf/10.7882/AZ.2011.059

Abstract

Vehicle collision resulting in animal mortality is a common daily occurrence, although few studies have considered the impact on herpetofauna in urban areas. Over a 7 year period (2003 - 2010), 1.4 km of suburban streets of Falconbridge that interface with the Greater Blue Mountains World Heritage Area, west of Sydney, was surveyed on foot two to four days a week, typically soon after dawn. Over the period a total of 86 reptiles that represented 20 species: 38% of the lizard and 56% of snake species known from the area were collected as road kills due to collision with vehicles. This equated to approximately one individual per month that was collected across the 7 years. Representatives of six frog species were also identified as road kills (33% of the local frog fauna). In Faulconbridge, 20-30 km of 50 km/hr roadways interface with the national park and there are 26 towns within the World Heritage Area. Each of these towns has a network of streets that covers much more than just the perimeter of the town, and there are two major highways that bisect the World Heritage Area. Although an average death rate of one reptile per month may be considered negligible, the cumulative loss of reptiles due to vehicle collision in the region is an ecological disaster.

Danny Wotherspoon and Shelley Burgin (2011) **Allometric variation among juvenile, adult male and female eastern bearded dragons Pogona barbata (Cuvier, 1829), with comments on the behavioural implications.** *Zoology* Volume 114, Issue 1, February 2011, Pages 23–28

http://www.sciencedirect.com/science/article/pii/S0944200610000917

Abstract

The functional significance of allometric change in reptiles has received limited attention and the reason for such changes has been regarded as 'obscure'. In this paper we report data on the Australian *Pogona barbata,* the eastern bearded dragon, from across their range and review changes in allometric growth among juveniles, and adult males and females and consider the functional relevance of these changes. There were significant differences in the population for mass, tail length, tail width, rear leg length and jaw length. These differences were consistent with differences required in locomotor performance and thus habitat use, together with access to different preferred dietary components.

Danny Wotherspoon and Shelley Burgin (2015) **Testis abnormalities in a population of the iconic Australian species, the eastern bearded dragon *Pogona barbata*.** *Australian Zoologist*: 2015, Vol. 37, No. 3, pp. 369-380.

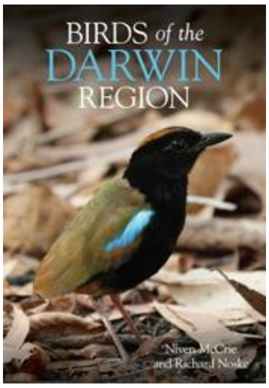
http://publications.rzsnsw.org.au/doi/abs/10.7882/AZ.2014.019?journalCode=azoo

Abstract

Testis volume is generally correlated with sperm production. Their size is, therefore, considered informative, and is widely used as a surrogate for reproductive ability in a range of species. Gonadal abnormalities that influence adult reproductive function as a result of endocrine disruption compounds (EDCs) have been reported. In response to the observation that the population of the bearded dragon *Pogona barbata* had crashed in peri-urban Western Sydney, we investigated the nature and extent of testis deformity. It was observed that individuals collected in Western Sydney since the introduction of unleaded petrol in 1985 have a high level of deformities that are consistent with disruption of the endocrine processes. While deformities, such as missing testes, extreme asymmetry between testes, and flattened testes were not associated with any single aspect of the reproductive cycle, and they were found across the range of the species, the problem was much greater in Western Sydney than elsewhere in the species' range. We suggest that the abnormalities in Western Sydney may, in part, be responsible for the crash in the local population of *P. barbata*.

Recent Book Releases

Information Source: CSIRO Publishing Website http://www.publish.csiro.au



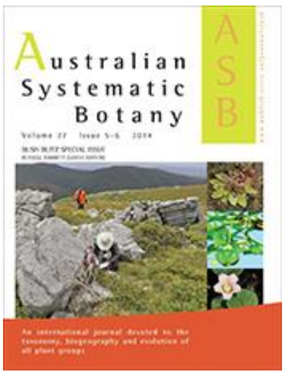
Title: Birds of the Darwin Region
Author: N. McCrie and R. Noske
RRP: $79.95
No. Pages:464
Publisher: CSIRO Publishing
Date: September 2015

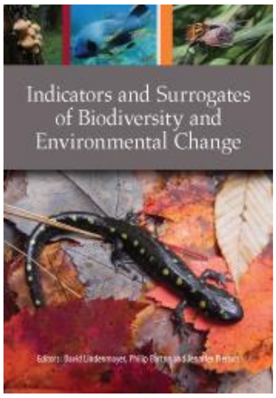
Title: Algae of Australia: Marine Benthic Algae of North-western Australia 1. Green and Brown Algae
Author: John Huisman
RRP: $150
No. Pages:328
Publisher: CSIRO Publishing / Australian Biological Resources Study (ABRS)
Date: July 2015

Title: Rodent Ecology, Behaviour and Management ; Wildlife Research Special Issue, Volume 42, Number 2.
Author: Ed. G. Singleton
RRP: $75
No. Pages:109
Publisher: CSIRO Publishing
Date: August 2015

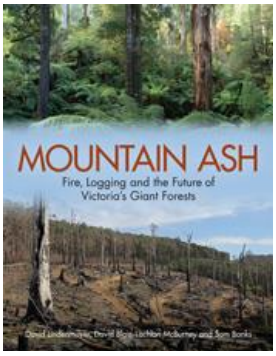
Title: Carbon Accounting and Savanna Fire Management
Author: B. Murphy, A. Edwards, M. Meyer and J. Russel--Smith
RRP: $120
No. Pages:368
Publisher: CSIRO Publishing
Date: June 2015

Title: Bush Blitz: Australian Systematic Botany Special Issue: Volume 27. Number 5 & 6
RRP: $125
No. Pages:157
Publisher: CSIRO Publishing
Date: September 2015

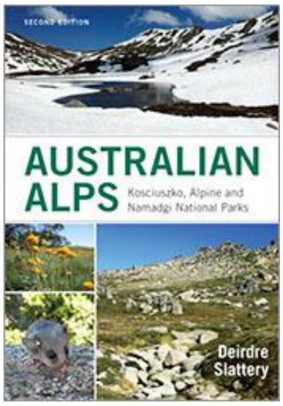




Title: Indicators and Surrogates of Biodiversity and Environmental Change
Author: Ed. D. Lindenmayer, P. Barton, J. Pierson
RRP: $79.95
No. Pages: 216
Publisher: CSIRO Publishing
Date: November 2015



Title: Mountain Ash: Fire, Logging and the Future of Victoria's Giant Forests
Author: D. Lindenmayer, D. Blair, L. McBurney and S. Banks
RRP: $59.95
No. Pages:200
Publisher: CSIRO Publishing
Date: November 2015



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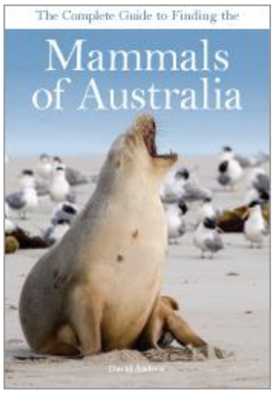
Author: D. Slattery
RRP: $45
No. Pages:320
Publisher: CSIRO Publishing
Date: December 2015



Title: The Complete Guide to Finding the Mammals of Australia
Author: D. Andrew
RRP: $49.95
No. Pages:432
Publisher: CSIRO Publishing
Date: December 2015

2015 UNIVERSITY LIAISON AND STUDENT GRANTS COMMITTEE SUMMARY

Toby Lambert
Environmental Property Services
ECA Research Grant Co-cordinator

ECA Research Grants

This year the ECA Council activated the Student Research Grants Program for the first time after adoption of the program in late 2014. The main purpose of the program is to contribute back to the scientific research community that provides vital information for the ecological consulting industry.

The grants program is also designed to improve links between the ecological consulting industry and the scientific community, while also directly supporting students at a time where research funding can be difficult to obtain.

Two grants of $2000 each were adopted by the ECA Council, being as follows:

<u>Ray Williams Mammal Research Grant</u>

In memory of our great friend and ecologist Ray Williams, this grant applies specifically to mammal research only.

<u>ECA Conservation Grant</u>

This grant is designed to be open to all ecological research related to flora and fauna, preferably in NSW where possible.

The application form was distributed to all universities in NSW for consideration, with applications due in March.

We had 18 applicants with a diverse range of projects and complexity, with the selection committee consisting of Toby Lambert, Deryk Engel and John Travers and with Amy Rowles providing administrative support.

Successful applicants were as follows:

<u>Ray Williams Mammal Research Grant</u>

- Charlotte Mills - PhD candidate from UNSW.

  'Is Woody shrub encroachment a legacy of native rodent declines'

<u>ECA Conservation Grant</u>

- Ryan Sims - Masters student at UNSW.

  'Identifying alternate response models of endangered box gum grassy woodland following livestock exclusion'($1700)

- Amelia Saul - PhD candidate from USyd.

  'The relationship between the density of Lantana and its role as habitat for native reptiles: how does density affect the provision of ecosystem functions by alien species'($300)

The runner up which we also felt was deserving of some funding was Kyla Johnstone. She is a PhD candidate at USyd and her study is "***How an animal's personality influences its trapability and the consequences for wildlife management devices"***. John Travers decided to offer to independently fund her requested $1200. Thank you John.

Results of the research by successful applicants will be provided at the next ECA Annual Conference via either presentation or poster. An article for the ECA Newsletter *Consulting Ecology* is also required.

We have learnt some lessons for the next grant application process but all in all I think the process was objective and the funded projects are generally applicable to our industry. I am sure the members appreciate funds going to worthwhile causes.

If you or your colleagues have any queries in relation to these, or future grant opportunities in 2016, please contact Toby Lambert or Amy Rowles at the ECA.

RAINFOREST IDENTIFICATION WORKSHOP

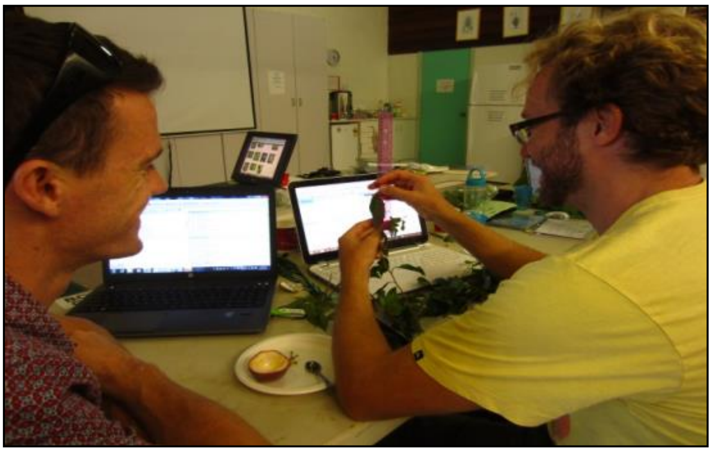
Elizabeth Norris
Eco Logical Australia

On the 16th March this year the ECA ran a Rainforest Identification Workshop, held at the North Coast Regional Botanic Garden in Coffs Harbour. Gwen Harden, one of Australia's leading rainforest experts presented the workshop. Gwen's career started as a botanist at the University of New England and then extended to the National Herbarium of New South Wales (at the Royal Botanic Gardens) from 1981 to 2001. While at the Herbarium she co-ordinated the *Flora of New South Wales* Project and was the editor of the 4-volume publication and subsequent revisions. Gwen, now retired, continues to update identification guides to rainforest species including the newly released LUCID key: *Rainforest Plants of Australia – Rockhampton to Victoria.* This Key represents the culmination of years of work on rainforest species identification and was produced in conjunction with Hugh and Nan Nicholson, Bill McDonald, Terry Tame and John Williams, and incorporates the well-known 'Red' and 'Green' Books.

Workshop attendees were generally from ecological consulting companies but also included staff from Coffs Harbour City Council and the North Coast Regional Botanic Gardens.

The morning consisted of an introduction to the LUCID key, including an introduction to the Front Page of USB, how to use the key, an explanation of the features used in the key and exploring the advanced functions of the key. This was then followed by time keying out a range of rainforest species collected from within the North Coast Regional Botanic Garden collections and from hinterland forests. Gwen provided a number of species, each with a unique number. Once a specimen was identified, it could then be cross-checked against the list to see if the identification was correct.

During the morning session attendees had the opportunity to meet with Alex Floyd, a long time



leading expert in rainforest plants spending 15 years as the officer-in-charge of the Forestry Research Centre in Coffs Harbour. He was also seconded to the NSW

National Parks and Wildlife Service because of his extensive knowledge where he undertook a review of the conservation status of NSW rainforest communities.

During the afternoon, time was spent walking through the Botanic Gardens to see a range of rainforest trees and shrubs including rare species. Discussions centered around specific features of each plant, their habit and habitat characteristics.

The LUCID key can be purchased direct from Gwen at www.rainforests.net.au for $80.

SHOREBIRD IDENTIFICATION AND ASSESSMENT

Amy Rowles

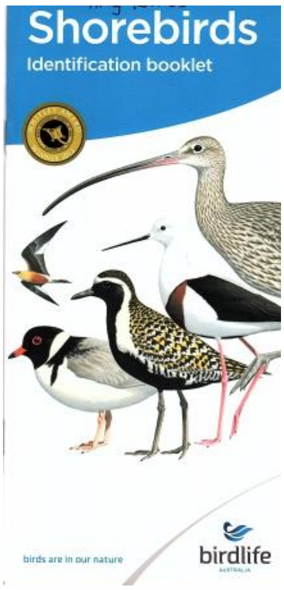
ECA Administrative Assistant and Biosis

The Shorebird Identification and Assessment Workshop was held on the 20th of April at the Hunter Wetlands Centre. Despite the dire weather conditions, with steady pouring rain, we had 24 people attend the workshop, which was presented by the very knowledgeable Phil Straw, director of Avifauna Research & Services. Phil is also vice chairman of the Australasian Wader Studies Group of BirdLife Australia.

We enjoyed the comforts of the dry conference room for the theory component of the workshop, focusing on identification, habitat use and assessment.

As luck would have it, there was a break in the heavy rain, allowing us a short trip into the field to observe a number of wader species at Kooragang. Despite getting rather wet, everyone really enjoyed the practical side of the workshop. 'Identification of wader species definitely requires a lot of practice'. Attendees were given a great little field guide by Birdlife.

Phil set up the scope on a group of waders for all to have a closer look. *Photo courtesy of Jenny Jolly.*



We held our workshop just in time - a few of the migratory shorebirds were still at Kooragang for us to see and this rain was to result in a major flooding event for the Hunter, with travel in the area very restricted by the following day.

A very big thankyou to Phil for sharing his knowledge on a very interesting group of birds.

FUNGI! THE FORGOTTEN KINGDOM WORKSHOP

Amy Rowles
ECA Administrative Assistant and Biosis

Ray Kearney and his wife Elma presented a well organised and enthusiastic workshop to 20 attendees, and are clearly passionate about their 'mushrooms'. The Kearney's have been studying the fungal community in the Lane Cove Bushland Park for many years.

The theory component of the workshop was held in the Cove Room at Lane Cove Council Chambers. Ray began by introducing Fungi and discussing the history of fungal listings in the State and National Legislation. Ray used a large collection of amazing photographs to introduce fungi species and discuss identification and classification. After looking at these detailed photos obviously taken with a macro lense, I was quite surprised when we went out into the field, how small many of the target fungi species from the listed community actually are. After morning tea, Ray continued to lecture on topics such as classification and taxonomy, as well as, conservation and management issues. Ray also illustrated examples of interdependency and associations between biological species (fungi, plants and animals). Ray concluded the lecture session with some information on the infestation of the Red Spider Mite in Lane Cove Bushland Park.

Students enjoyed a guided tour through the Lane Cove Bushland Reserve, with plenty of fungi specimens to observe.

I would like to thank Ray and Elma Kearney for presenting the workshop, generously donating their time for free, as well as contributing to this newsletter.

Ray Kearney, clearly enjoying the opportunity to share his knowledge with others. (*Photo courtesy of Amy Rowles*)

***Russula. aff. rosacea* which has a pale pink stem, distinguished from *Russula persanguinea* which has a pure white stem (stipe).**

This specimen has characteristics of *Ramaria gracilis*, a species of coral fungus in the family Gomphaceae

Deeply decurrent white lamellae - a characteristic of *Hygrocybe lanecovensis*

Left: Ray and Elma in the blue ponchos with the workshop participants. *Thanks to Ray and Elma Kearney for an ID for these fungi photos. Photos courtesy of Mia Dalby -Ball, Acacia Environmental Solutions.*

ECA CONFERENCE 2015

Amy Rowles
ECA Administrative Assistant and Biosis

This years conference was held at Doltone House, Pyrmont Point in Sydney and was well attended by 110 delegates, with 42 people staying on for the conference dinner and trivia quiz. The presentations were well received and enjoyed by delegates. A big thankyou to our eight presenters: James Shepherd, Dr Frank Lemckert, Dr Colin Driscoll, Paul Meek, Dr Colin Bower, Dr Brad Law, Phil Straw and Mia Dalby-Ball. Thankyou also to Isaac Mamott, who as conference co-ordinator put together a great conference program.

Once again the conference bookstall was popular. Thanks to Alison Hunt for organising the bookstall this year. Above: Mat Richardson keeping Alison company behind the desk. *Photo courtesy of Deryk Engel.*

Colin Bower presented on his pollination study of a critically endangered orchid on the NSW mid north coast, *Genoplesium littorale*, as part of a rezoning application. *Photo courtesy of Narawan Williams.*

Mia Dalby-Ball, last to present on the day, left us on a positive note discussing Saltmarsh restoration, creation and rehabilitation, including some success stories. *Photo Courtesy of Narawan Williams.*

Powerpoint presentations from the conference will be loaded onto the website soon.

The 2015 AGM was also held on the conference day, with the 2015-2016 council elected. Deryk Engel, Paul Burcher and Kristy Peters stood down, with all other councillors re-elected. Mia Dalby-Ball has joined council this year. The updated 'rules of the association' were voted on and accepted.

And of course - one of the most important components of a successful conference - *the food*, which thanks to Doltone House was top quality.

Please let me know if you have any suggestions for future conference or workshop topics.

Lunch by the water. *Photo courtesy of Narawan Williams.*

BIODIVERSITY IMPACT ASSESSMENT: THE GOOD, THE BAD AND THE UGLY OF EXPERIMENTAL DESIGN

Stephen Ambrose

Director, Ambrose Ecological Services Pty Ltd

INTRODUCTION

Large-scale and/or long-term biodiversity surveys associated with impact assessments are not that common. In the last issue of *Consulting Ecology*, ECA President, Martin Denny voiced strong concern that a weakening of regulatory standards for biodiversity assessments, together with increased costs of conducting field work has, in general, resulted in ecological consultants spending less survey time and effort in the field. Instead, they are becoming more reliant on electronic databases, software programs and other desktop tools to conduct their impact assessments.

I share Martin's concern. So when we have the opportunity to conduct comprehensive biodiversity surveys, the objectives of the survey should be clearly defined, an appropriate methodology should be employed, and there should be scientifically rigorous analysis and interpretation of the data. Sound familiar? Well it should be, all these principles relate to the basics of experimental scientific design. Surely, we all remember that topic as a core feature of our undergraduate university training. Yet, these principles seldom seem to be employed satisfactorily in biodiversity impact assessment, even when there is a need for them.

I appreciate that ecological consulting does not often fall into the category of "perfect" science, if at all. However, if field surveys are conducted, then they should be designed to provide meaningful answers in biodiversity impact assessment.

I describe below one project that seemingly represents "the good, the bad and the ugly" of biodiversity impact assessment. The "good" represents a decision by the proponent (a local council) to monitor the impacts of control-burning of two important bushland reserves on fauna populations. The "bad" is, despite the council's best intentions, the project aims are poorly-conceived. The "ugly" refers to the fact that the council appears to have ignored expert advice to help improve project outcomes.

CASE STUDY

A local council in Sydney's metropolitan area has developed bushfire management plans for reserves under its management. It recently called for tenders for a baseline vertebrate survey of two adjoining bushland reserves as a first step in the process of assessing the impacts of mosaic patch burning on their values as a biobank site. Collectively, these two reserves are 94 ha in area and, on average, about one hectare would be patch-burned in a given year. Control-burning would not occur every year at this reserve, the first two patches (both less than 0.5 ha in area) were burned earlier this year, but the next patch is not due to be control-burned until the 5th year, and the entire control-burn cycle of the forest's edges would take 37 years to complete if there are no wildfires. Although the 37-year cycle would result in most of the smaller reserve being fire-managed, control-burning would be restricted to the northern end of the larger reserve, and most of this latter reserve would be untouched.

The high mobility of vertebrates within the reserves, and between the reserves and habitat areas elsewhere in the locality, gives these species little value as measures of the reserves' overall biodiversity values and impacts of bushfire management.

Scientifically-rigorous terrestrial invertebrate surveys in fire-impacted and control areas would have been more appropriate for this project because:

1. the distributions and abundances of invertebrates are more finely patterned than those of vertebrates because of their specific habitat or resource requirements. These requirements make them more responsive to localised environmental changes;
2. invertebrates are numerous and diverse, but can be sampled relatively easily and often passively with traps. Invertebrate biodiversity is also richer and more diverse than that of vertebrates in the reserves, and so is a better measure of the overall fauna biodiversity of the reserves;
3. despite high diversity and small size they can be identified easily to at least family level or to a category of morphospecies with the broad range of taxonomic keys that are available; and

4. the richness and abundance of insect taxa (especially butterflies, beetles and ants) have been shown to correlate with other taxa and are often used as surrogate measures of changes in other trophic (food chain) levels (e.g. Oliver & Beattie 1996; Lawton *et al*. 1998; Andersen *et al*. 2004; Billeter *et al*. 2008; Vandewalle *et al*. 2010). Hence, they are good indicators of biodiversity changes in the local environment.

But the council chose to press ahead with a vertebrate survey despite this advice. The council has indicated that the fauna survey methodology developed for the two reserves is likely to be used by council officers to monitor bushfire management impacts on fauna populations in other reserves in the shire. They chose vertebrates as target fauna because they did not have any staff with the expertise to identify terrestrial invertebrates in future surveys.

This particular council puts a lot of resources into protecting and managing its bushland reserves. Consequently, its local government area is a leafy shire whose urban biodiversity is relatively rich and diverse and the council should be congratulated for its efforts to protect it. But this is clearly a wasted opportunity to follow correct scientific processes and gather meaningful information about the impacts of bushfire management on fauna populations. In turn, it could lead to mismanagement of these reserves as important habitat for fauna. Let's hope it does not happen in other reserves in the shire.

RECOMMENDATIONS

So where do we proceed from here? If you wish to refresh your memory about design theory and practice in ecological experiments, then it is worth reading Underwood (1990 & 2009), Hairston Snr (1996) and Gitzen *et al*. (2012). van der Ree *et al*. (2015) also provide an excellent overview of the challenges and design of biodiversity monitoring projects associated with road ecology, many of the issues in that tome being relevant to biodiversity impact assessment more broadly.

I have come across many fauna monitoring projects, conceived by a broad range of proponents, in recent times, which ask the wrong ecological questions, target the wrong biodiversity groups, and engage consultants to use inappropriate survey and assessment methods. I am sure that all of you, like me, could draw up a long list of biodiversity monitoring projects with which you are equally critical, and each person's list would be quite different. Therefore, we seem to have an endemic problem that needs resolving if we are to effectively assess biodiversity impacts and to put in place appropriate mitigation strategies.

It is clear that some of the blame for poorly-designed biodiversity monitoring lies with the expectations of the proponents of such projects. These proponents appear to have a poor or no understanding of experimental design, or have that knowledge and for one reason or another have decided not to use it in the workplace. As ecological consultants, we have an obligation to encourage appropriate field survey design, timing and effort in biodiversity impact assessment, and congratulate proponents when they accept that advice. But we also need to ensure that these proponents recognise good (and poor) experimental field survey designs, or at least have them accept the recommendations of appropriate expert advice. I believe that this is fundamental to our agreement to abide by the ECA's *Code of Business Practice, Professional Conduct and Ethics*.

We also need to encourage proponents to adequately and appropriately resource planned future biodiversity monitoring. For instance, in the case study described, if the council plans to monitor the impacts of control-burning of other bushland reserves on fauna populations, then they should employ an ecologist who has expertise in terrestrial invertebrate sampling and identification, or at least draw upon this expertise from elsewhere, rather than discounting the opportunity to perform good science and environmental management because they do not have the in-house expertise.

The ECA has had a proud history in recent years of running high-quality workshops and conferences, which have helped improve the knowledge and skills of members and others who we associate with professionally. In the interests of promoting effective biodiversity monitoring associated with impact assessments, I encourage the ECA to run a workshop on the design of ecological field experiments, for ecological consultants, environmental officers in local councils, and proponents of biodiversity projects in other levels of government.

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ORCHID POLLINATION BY SEXUAL TRICKERY

Ray & Elma Kearney

Members of the Sydney Fungal Studies Group Inc.

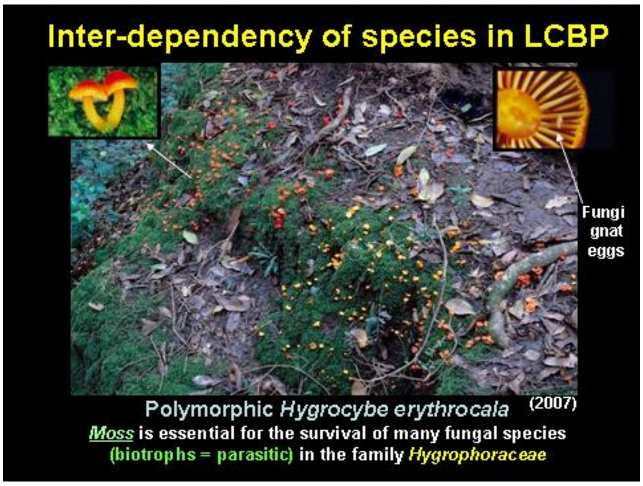
On fungal field studies it is common to see orchids and the inter-dependency of species at work for all to see. Because the seeds of orchids do not have the nutritional reserves to germinate, they require specific fungal hypha to enshroud the seed to provide the needed nourishment. Indeed some orchids (*Dipodium sp.*) have a parasitic relationship with certain fungi (e.g., *Russula sp.*) because they cannot obtain sufficient energy by photosynthesis for lack of chlorophyll. They are obligately myco-heterotrophic for *part of their life cycle.*

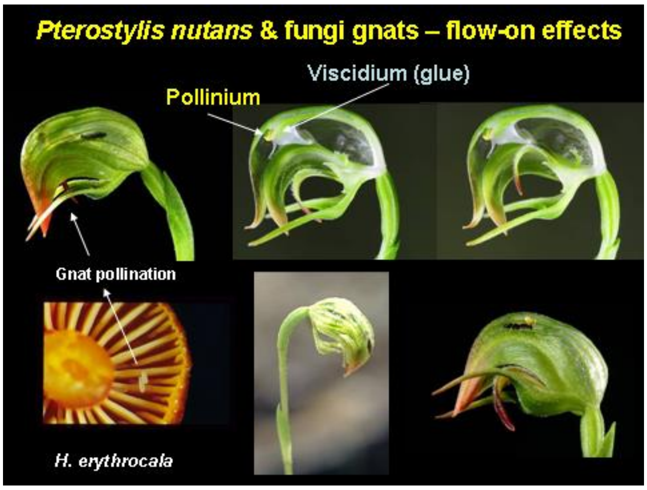
The fungal species is mycorrhizal with adjacent plant species (e.g., *Angophora sp.*). Such interdependency is vital to the health and well-being of such a biological community.

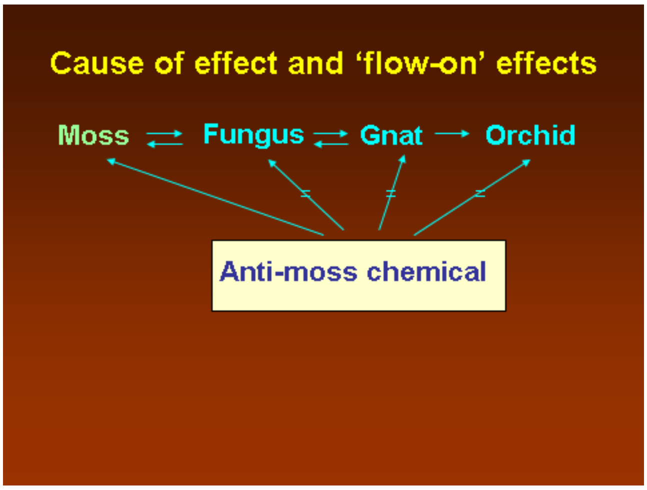
Compare seed size of acacia and duck orchid

At the top end of a flowering orchid, the essential business of pollination can be very complex but exquisitely beautiful and awe-inspiring of the many adaptations by orchids to pollinate when their flowers are not designed for self-pollination.

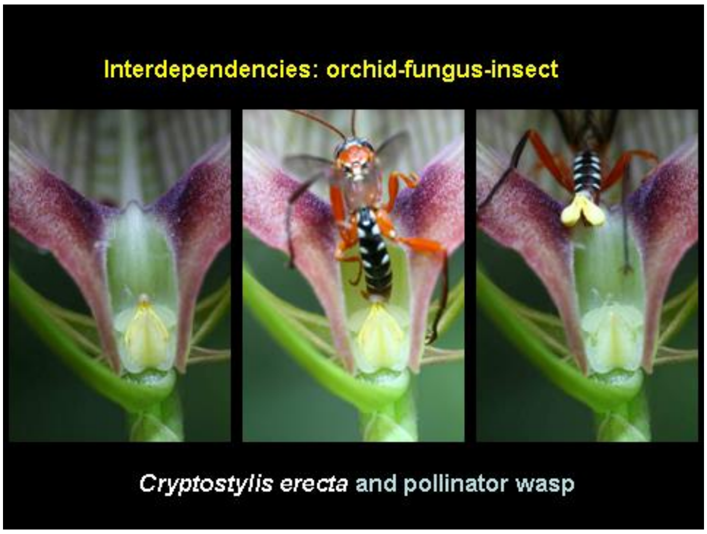
Fungi gnats are attracted to mushrooms by the fungal odour and lay their eggs from which hatch larvae to feed off the fungal tissue. After pupation, the fungi gnats seek out more fungi. By precise timing, some species of ground orchids (e.g., *Pterostylis sp*) come into flower during the fungal season of certain fungal species of which some depend upon bryophytes e.g., moss. Thus, damage to the moss can threaten certain species of fungi, the fungi gnats and ultimately the orchid which attracts the gnat (for pollination) by *mimicking* the odour of the fungus. The structure and function of the orchid flower is specifically designed to carefully capture the gnat which is directed along a pathway to swipe a glue-pad (viscidium) before it passes the pollinia on which the glue fastens with such strength to enable its passage on the top of the head or thorax outbound from the seductive orchid to be duped by another orchid.

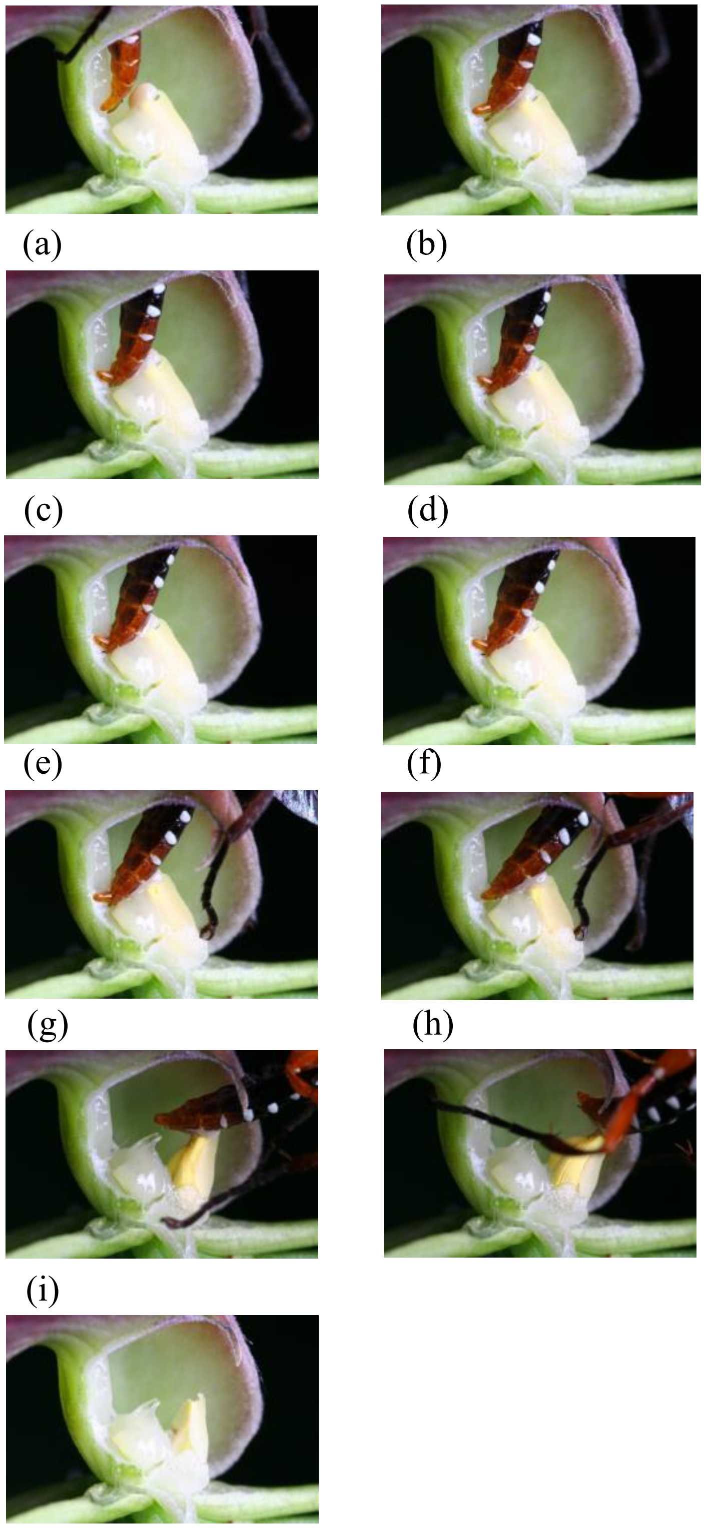






We pay tribute to citizen naturalist Edith Coleman who in 1928 was the first to record pseudocopulation by wasps (e.g., *Lissopimpla excelsa*) with certain species of ground orchids (e.g., *Cryptostylis erecta*). The male wasp hatches before the female with whom he seeks a mating partnership. However, the exquisite timing of the orchid allows it to seduce the male by emitting a pheromone that is identical to that of the female wasp. Thinking he is onto a winner, he zig-zags along the scent-plume. Its allure is overwhelming. He flies straight at it and grasps it - not to feed on nectar but to copulate with the 'dummy'! The male wasp's structure and anatomy is designed to match perfectly the 'dummy female', but most importantly the position of the 'knob of super-glue' attached to the pollinia is angled and positioned not to occlude the wasp's posterior. The delicate glue sac disrupts and sets immediately with such strength that when the wasp withdraws from its pseudocopulation that the pollinia remains attached to the anterior of the wasp's abdomen. The position of the pollinia allows for it to precisely pollinate the stigma of the next seductive *Cryptostylis erecta.* The same wasp species is involved in pollination of *Cryptostylis subulata* by pseudocopulation, but without hybridization of the two orchid species.





The above sequence was undertaken in the field with *Cryptostylis erecta* in which a 'window' was carefully cut to allow a lateral photo recording of the sequential steps of pseudocopulation including, mounting, penetration, ejaculation, fusion of viscidium-glue to abdomen (without occluding posterior), withdrawal, removal of pollinia (accompanied by tearing of pollinium sac to release pollen grains) and leaving an empty capsule.

In Australia, at least 250 species in some 10 genera have adopted the strategy, deceiving male insects – mostly wasps – into believing that they have found a female who in some species, are flightless. Most

Australian orchids that hoodwink unsuspecting males in this way are pollinated by a group of wasps known as thynnines. The female thynnine wasps are dumpy, flightless creatures that spend much of their adult lives underground, laying eggs on beetle larvae in the soil. But is the real female wasp, who emerges amorous, hungry and flightless from the ground really grateful to be collected by the male suitor or is she spitefully seductive?

Whilst waiting on a blade of grass she releases her seductive, alluring pheromone, he arrives, then they mate willingly and he then carries her off to feed on nectar. The literature infers that he, like a well tutored male, delivers her safely back to where she can return to the ground to lay eggs while he is free to go? The following photo sequence says otherwise!

Black Thynnine wasp species – *Phymatothynnus sp*

Black Thynnine wasp species – *Phymatothynnus sp*

Black Thynnine wasp species – *Phymatothynnus sp*

Black Thynnine wasp species – *Phymatothynnus sp*

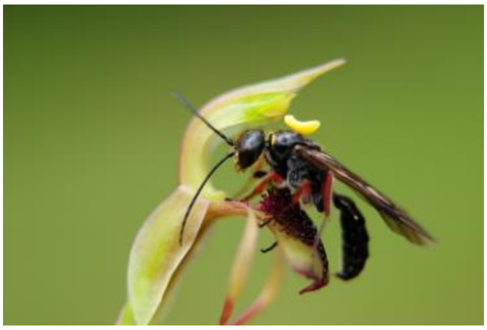
This male wasp species is reported to be involved in the pollination of species of *Caladenia*

ground orchids. Our photo sequence begins with the coupled male and flightless female landing on a long blade of grass in the field. Cardboard was placed behind to obtain contrast rather than result in a black background with a macro-flash unit. Upon landing, the female uncoupled sexually but immediately pierced the abdomen of the male with her large pincer mandibles and firmly grasped the posterior end and genitalia of the male. Nectar of the male's last supper flowed over the head of the female and some splashed on the blade of grass. The female continued to emasculate her suitor despite him trying to push her away with his hind legs. This assault would probably be fatal to the male and effectively render him impotent thereby restricting his genes to her progeny only. The intent of the female apparently is to ensure the male does not couple with another female! Other explanations are possible!

Species of the ground orchid in the genus Chiloglottis have been classified according to the kind and number of wasp pollinator species. On a fungal field study at Mt Wilson, the ground orchid *Chiloglottis reflexa* was in flower and its pheromone was attracting male thynnine wasps. Upon photographing them, we recorded for the first time the male wasp delivers a nuptial gift of nectar to the seductive orchid thinking he was feeding the female before grasping 'her' to fly off . Not realising 'she' is tethered, the male in frustration bumps his thorax on the viscidium glue which causes the pollinia to adhere - just what the orchid intended. The following sequence is one of many confirming the delivery of a nuptial gift of nectar to the 'head' of the orchid's female mimic.

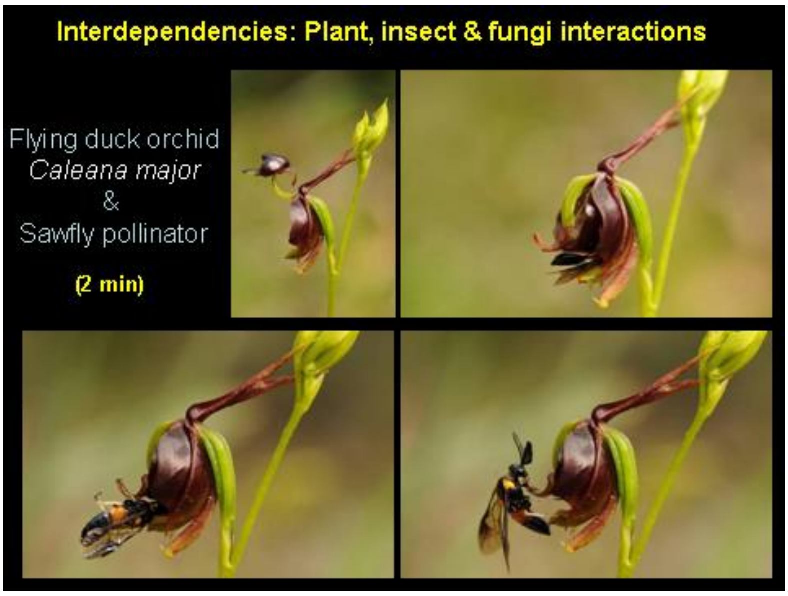
Male thynnine wasp approaches orchid

Wasp delivers a nuptial gift of nectar



A different thynnine species attempts copulating and in trying to carry off the 'dummy female' collects the pollinia - fulfilling the purpose of the orchid's seductive processes.

The flying duck orchid is pollinated by a species of male sawfly seduced by the orchid's alluring pheromone mimicking that of the female sawfly. The sawfly lands on the 'head' only to be thrown into the 'body' upside-down. The pressure on the sawfly is such that it can wriggle backwards, first collecting glue from the viscidium that adheres to the pollinia allowing the wasp to pollinate other orchids. (wasp here fails to remove pollinia). If the wasp has not exited within 20 minutes the 'head' raises to let it leave.



The living art of Nature's gallery allows our senses to be put in tune once more!

THE DREADED RED SPIDER MITE - *Tetranychus evansi* - IN SYDNEY AND WHAT IT MEANS TO BIOSECURITY AND NSW DEPT. PRIMARY INDUSTRY

Ray & Elma Kearney

This article is written to alert field biologists and bush regenerators, to the fact that the overseas Tomato Red Spider Mite has been introduced and caution needs to be taken to restrict spreading this potentially devastating pest whilst in areas known to be infested.

T. evansi originated from Brazil and spread to South and North America, Africa (end of 1980s) and Europe (Spain 1995). It had not been reported from countries in Oceania until October, 2013 when the NSW Department of Primary Industries (DPI) advised it has now entered Australia at Botany. The link below outlines the DPI 'Pest Alert' and describes this 'Tomato Red Spider Mite' which resembles two other species of spider mites. http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0008/486179/Pest-Alert-tomato-red-spider-mite.pdf

On 9th January, 2014, Ray and Elma noticed in bushland near Venteman's Reach, Lane Cove West that weeds (mainly nightshade –*Solanum americanum*) had been pulled up and placed in a stack on the ground. Their attention was drawn to an orange mass amid webbing on the exposed roots. Fig.1 shows the colony of red mites, unable to feed on sap of the pulled-up weeds, positioning themselves for dispersal by the wind. Voracious predatory larva yet to be identified, were recorded among them. This is unusual because, unlike other red mites, *T. evansi* accumulates toxins from host plants. The potential for biological control is currently being explored by us.

Photos were taken and forwarded to Lane Cove council who sent them to DPI. At the request of DPI, samples were sent by the authors and were confirmed by DPI expert entomologists at the Agricultural Institute, Orange, to be Tetranychus evansi Baker & Pritchard: Tetranychidae.

Fig. 1: *T. evansi* red mites among webbing

Further field studies by the authors revealed for the first time in Australia and overseas that the *T. evansi* red spider mite also parasitizes the common Kangaroo Apple shrub (*Solanum aviculare*). Fig. 2 records the characteristic webbing of *T. evansi* found on many Kangaroo Apple shrubs which inevitably die from the infestation. Several species of birds (vectors?) were recorded eating the red berries.

Fig. 2: *T. evansi* on *Solanum aviculare*

The mites are difficult to see individually without magnification and change colour during their lifecycle. Female mites are 0.5mm in size; orange-reddish and a broad oval shape. Males are 0.3 mm, light orange, more elongated and triangular in shape. Males are required for identification to a species level.

Females have a high reproductive rate:
~20 eggs/day (without mating) → high populations, under high temperatures and low humidity → causing important economic damage.

At 25°C, the lifecycle is completed in 13.5 days and the number of eggs laid can vary from approximately 80 eggs at low temperatures to 120–250 eggs at higher temperatures. The mites can remain undetected until major plant damage occurs and live on both sides of the leaves with a slight preference for the underside and for the vicinity of veins (Figs.3, 4).

Fig. 3: ***T. evansi*** **on** ***Solanum americanum*** **(nightshade)**

Fig. 4: ***T. evansi*** **red mites on** ***Solanum aviculare***

Eggs of *T. evansi* are rounded and deep to pale orange in colour. They are bright and clear when newly laid becoming rust red prior to hatching.

Our records demonstrate that the carved furrows in the plant tissue by the pest
28-dot ladybird beetle (Fig.5) and its larval instars (Fig.6) provide nesting for the mite's eggs (Fig.7). A *flea-beetle* species was found to behave similarly.

Ongoing field studies have noted red-mite infestations in Boronia Park, (Hunters Hill);
Fig. 4: ***T. evansi*** **red mites on** ***Solanum aviculare***
the Boreen and Batten Reserve (Lane Cove); Fairyland, Lane Cove National Park - added to other sightings in Sydney. To date, we have <u>not</u> been contacted by DPI for sites of located infestation. Minister of DPI claims *"It was technically not feasible to eradicate this pest"* which overseas is a highly destructive plant pest e.g., in Africa.
http://www.infonet-biovision.org/default/ct/74/pests

Figs. 5 & 6: 28-dot ladybird pest and its larva

The main hosts of *T.evansi* are plants in the *Solanaceae* family including weeds such as blackberry nightshade (*Solanum nigrum*), glossy night shade (*S. americanum*) and Kangaroo Apple (*S. aviculare*). Commodities affected by *T. evansi* include tomato, potato, eggplant, beans, citrus, cotton, tobacco and ornamentals such as roses. There is no currently registered *miticide* chemical for use against *T. evansi* in Australia.

Fig. 7: ***T. evansi*** **eggs (red) laid in furrows left by plant-eating 28-dot ladybirds and their larva**

Bush regenerators and field biologists should be aware of the signs of infestation and measures of containment. Affected weeds and shrubs should be carefully removed and incinerated. Professional advice should be sought for effective management and control of this potential threat to our agricultural industry. However, DPI – 'Biosecurity' claim they do not have the financial/human resources to eradicate this dreaded, newly arrived pest and shift responsibility to industry and local government for its management. Spraying infestations beside rivers is banned and also undesirable ecologically.

We decided out of interest to record the interdependency of species involved with this Red Mite and *Solanum aviculare* as this association was new to science although the Mite's association with *other* species of *Solanum* is very well documented overseas. The 'Red Mite' interest with a focus on the Kangaroo Apple shrub has given us the opportunity to record several new observations and new species. The following is one:

A new parasitoid female wasp in the subfamily *Tetrastichinae* of the family *Eulophidae* was recorded inserting its ovipositor in eggs of the 28 -dot ladybird beetle. As the wasp moved from egg to egg, withdrawing its ovipositor, droplets of fluid from the egg appeared. (Figs 8, 9) This fluid subsequently provided substrate for a fungal mold which remained on the shell until the larvae of the wasp hatched. (Figs. 9, 10)

Fig. 8 parasitoid wasp withdrawing ovipositor from ladybird egg

Fig. 9 Fungal mold on eggs 'stung' by wasp

Fig. 10 Wasp larva hatching from ladybird eggs

Other observations by us include a new species of *Uga* wasp parasitizing the late stage instar of the 28-dot ladybird. Research is now being undertaken in collaboration with Australian and overseas entomologists - similarly, for a new species of *Strepsipteran*.

Photographs are copyright to Ray & Elma Kearney

MOSQUITO-BORNE DISEASES IN AUSTRALIA: RESERVOIR HOSTS AND VECTOR SPECIES

Stephen Ambrose

Director, Ambrose Ecological Services Pty Ltd

INTRODUCTION

Ecological consultants and other environmental professionals are often placed at increased risk of contracting diseases as a result of conducting fieldwork in environments where host reservoirs and vectors for viral and bacterial pathogens occur. Ambrose (2014 & 2015) examined the roles of Australian ticks and mites, respectively, as vectors of pathogens that can infect humans. The present report identifies mosquito-borne diseases in Australia that can affect humans; the environments, locations and host species that are pathogenic reservoirs for these diseases; and the mosquito vectors.

MOSQUITO TAXONOMY

Mosquitoes belong to the family Culicidae in the Order Diptera (true flies) and Suborder Nematocera (thread-horned flies). The general morphology of an adult and larval mosquitoes, showing body parts referred to in this report are shown in Figures 1 and 2, respectively.

Reinert *et al*. (2009) stated that there were 111 mosquito genera worldwide, totalling 3,517 species. However, this has since been revised to at least 3,542 species in 112 genera (Mosquito Taxonomic Inventory http://mosquito-taxonomic-inventory.info/, accessed 23 May 2015).

Mosquitoes are grouped into the following divisions within two-subfamilies, the Anophelinae (Grassi, 1900) and Culicinae (Meigen, 1818):

Subfamily Anophelinae (at least 485 species in three genera)

Genus *Anopheles* (Meigen, 1818) (472 recognised species and 50 unnamed members of species complexes);
Genus *Bironella* (Theobald, 1905) (eight species); and
Genus *Chagasia* (Cruz, 1906) (five species).

Description in the Mosquito Taxonomic Inventory:

Adult anophelines are easily recognised by their appearance. Most species stand with the body inclined at an angle of 30-45° to the surface and have dark and pale spots of scales on the veins of the wings. Some species have the wing veins entirely covered with dark scales. The maxillary palpi of both sexes are about as long as the proboscis (except in *Bironella*). The palpi of females sometimes have semi-erect scales that give them a rather shaggy appearance. The scutellum is evenly rounded in *Anopheles* and *Bironella* and tri-lobed in *Chagasia*. The abdominal sterna, and usually the terga, are completely or nearly devoid of scales. Anopheline larvae lack a respiratory siphon, the head is longer than wide and pairs of palmate setae are normally present on some or all of abdominal segments I-VII.

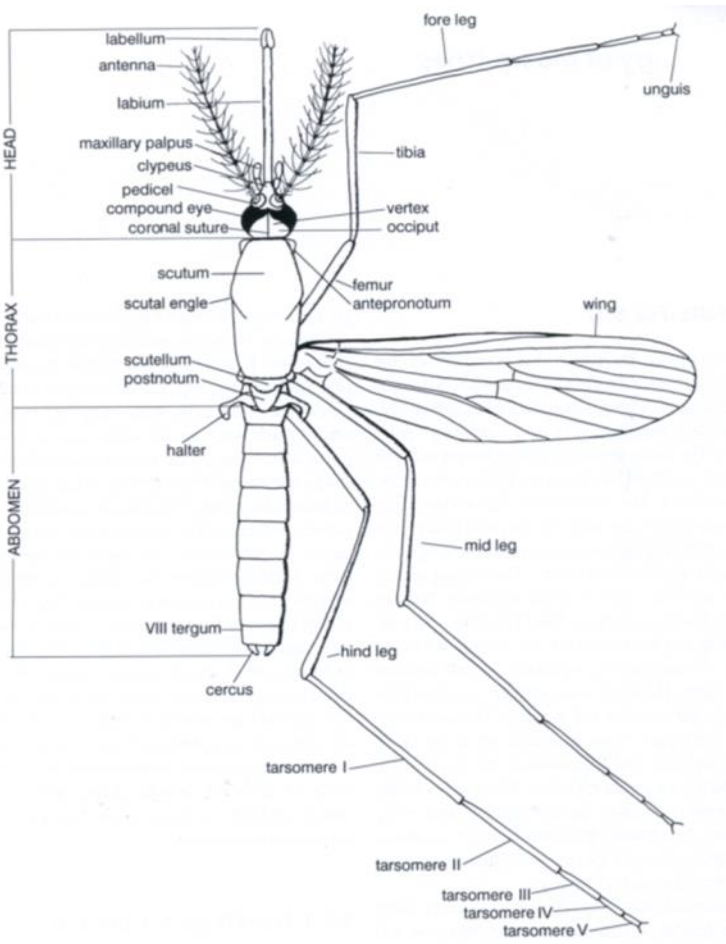
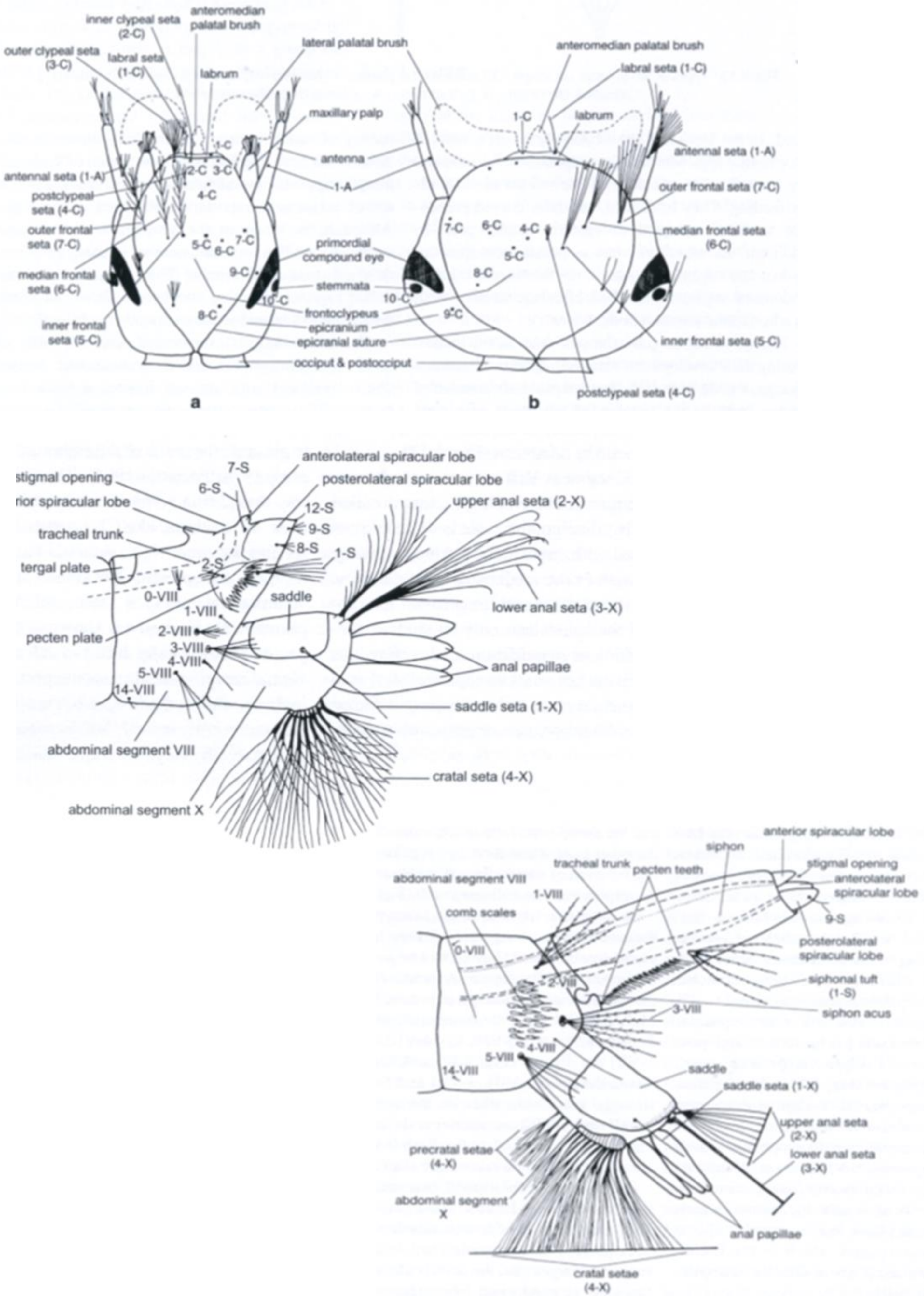


Figure 1. General morpohology of a female culicine mosquito(adapted from Marshall 1938)

Figure 2. Head (top diagrams) and abdomen (bottom diagrams) of anopheline (left) and culicine (right) larvae (from Becker *et al*. 2010).



Subfamily Culicinae (3,061 species in 109 genera)

Tribe Aedeomyiini (Theobald 1901) (one genus, seven species);
Tribe Aedini (Neveu-Lemaire 1902) (81 genera, 1254 species);
Tribe Culicini (Meigen 1818) (four genera, 796 species);
Tribe Culisetini (Belkin, 1962) (one genus, 37 species);
Tribe Ficalbiini (Belkin, 1962) (two genera, 53 species);
Tribe Hodgesiini (Belkin, 1962) (one genus, 11 species);
Tribe Mansoniini (Belkin, 1962) (two genera, 82 species);
Tribe Orthopodomyiini (Belkin, Heinermann & Pages, 1970) (one genus, 36 species);
Tribe Sabethini (Blanchard, 1905) (14 genera, 429 species);
Tribe Toxorhynchitini (Lahille, 1901) (one genus, 89 species); and
Tribe Uranotaeniini (Lahille, 1904) (one genus, 267 species).

Description in the Mosquito Taxonomic Inventory:

Culicine females have maxillary palpi that are usually much shorter than the proboscis. Males have long palpi with numerous long setae, but they are not swollen apically like those of anophelines. The scutellum has three lobes with setae confined to each lobe. The wing veins are usually entirely dark-scaled, but speckles or patches of white or yellow scales are present in some species. The abdominal terga and sterna are densely covered with scales, which distinguishes them immediately from almost all anophelines. Adult culicines stand with the body parallel to the surface on which they are resting. All culicine larvae have a respiratory siphon, the dorsal and ventral abdominal setae arise separately and usually without basal sclerites, and the mouth brushes are composed of numerous, usually slender filaments.

GENERAL MOSQUITO BIOLOGY

Mosquitoes breed in standing water. Their lifecycles are characterised by egg, larva, pupa and adult stages. The eggs, which are laid in or near water, hatch into larvae within a few days. In many cases, the eggs adhere to each other to form raft-like structures, but also can be laid singly. The larvae feed on microscopic plant life, moult several times as they grow, pupate, then develop into free-flying adults. For many of Australia's mosquito species, the egg to adult stage is between seven and 10 days.

Only adult females feed on blood and must do so before they can lay eggs. Males usually feed on plant saps and nectar.

Mosquitoes are generally grouped ecologically according to the habitat preferences of the larvae. These groups are the permanent pool group, transient water group, floodwater group, and artificial container and tree-hole group.

Larvae of species in the permanent pool group are generally found in fresh, still water exposed to sunlight and containing an abundance of vegetation at the air-water interface. Typical habitats include shallow margins of permanent ponds and lakes and are characteristic breeding sites of many *Anopheles*, *Culex* and *Mansonia* species. Eggs are laid on the surface of the water, and the sites are usually sheltered from wave action and have abundant vegetation that protects larvae and/or provide anchor points for egg attachment. These mosquitoes generally breed continuously and pass through many generations per year. The adults fly only short distances, remaining within several hundred metres of their breeding site.
The transient water group consists of mainly of *Culiseta* species and and few *Culex* species. Their habits are similar to those in the permanent pool group. Typical breeding sites include roadside ditches, canals. Ground pools, clogged streams and irrigated land. These mosquitoes also only fly short distances from their breeding site.

The floodwater group includes *Aedes* and *Ochlerotatus* species. These mosquitoes deposit their eggs singly on damp soil in grassy or woodland depressions or along vegetated shorelines that are flooded intermittently. Eggs remain dormant and viable on the soil for some time until the area is flooded. Typically, large numbers hatch simultaneously. The larvae develop synchronously, and adults begin to appear as early as seven days after flooding. Some species produce only a single brood per year, while many others produce multiple generations. Mosquitoes in this group can fly up to several kilometres from their breeding sites.

The artificial container and tree-hole group also contains *Aedes* and *Ochlerotatus* species. Adults lay eggs singly on the inside wall of a container, at or above the waterline. Following a period of dessication, the eggs hatch after being submerged in water. These mosquitoes overwinter in the eggs stage. Breeding sites include natural cavities holding water, such as tree-holes, and artificial containers containing leafy sediment or decaying leaves. Adults generally do not fly more than several hundred metres from their breeding site.

MOSQUITO-BORNE DISEASES IN AUSTRALIA

Overview

There are more than 300 species of mosquitoes in Australia, but there are a few species that are known to carry pathogens that are harmful to humans. These species, descriptions of their life stages, distributions, life cycles, seasonality, host species and pathogens carried are presented later in this report. Apart from *Anopheles* species, all the mosquitoes that are known to be of concern to human health in Australia are culicines.

Nearly all mosquito-borne diseases that are transmitted to humans in Australia are viral. Viruses that replicate in arthropods and which are transmitted to vertebrates are called arboviruses. The arthropod becomes infected by feeding on the blood of an infected vertebrate during viraemia (virus circulation in the peripheral blood vessels) and, after proliferation in the vector, the virus can be transmiited to another vertebrate host (horizontal transmission). Arboviruses can also be transferred between arthropod generations through transovarial transmission (vertical transmission). Therefore some arboviruses are capable of overwintering in the egg stage of their mosquito host (Becker *et al*. 2010).

Francki *et al*. (1991) and Karabatsos (1985) list more than 300 and 500 species of arboviruses, respectively, worldwide. Approximately 100 arboviruses infect humans and 40 infect livestock (Monath 1988). Most harmful viruses that are transmitted to humans by mosquitoes belong to three genera: *Alphavirus* (Family Togaviridae), *Flavivirus* (Family Flaviviridae) and Bunyavirus (Family *Bunyaviridae*) (Murphy *et al.* 1995, Eldridge & Edman 2000).

Malaria, caused by protozoans (*Plasmodium* spp.), is the most widespread mosquito-borne disease in humans. It affects more than 100 tropical countries, and there are at least 300 million humans infected and one million deaths annually (WHO 2008). Human malaria is caused principally by four species (*Plasmodium falciparum*, *P. vivax*, *P. ovale* and *P. malariae*), which are transmitted solely by anopheline mosquitoes.

Lymphatic filarial diseases, caused by filarial nematodes, affect an estimated 120 million people in 80 countries throughout the tropics and subtropics of Asia, Africa, the western Pacific, and parts of the Caribbean and South America. Mosquitoes deposit filarial parasites into the human body with repeated bites. These larvae worms live in the human lymph system where they grow into adults and live in the body for between 6 – 8 years, mating and producing millions of larvae. About 90% of the infections are caused by Bancroft's Filaria *Wuchereria bancrofti* (Family Ochocercidae), but in Asia the disease can also be caused by Malayan Filaria *Brugia malayi* and *B. timori* (Becker et al. 2010). The human disease is not known to occur naturally in Australia; cases of infection reported in Australia are very rare and appear to be imported from Asia. Therefore, filariasis is not discussed further in this report.

Alphaviruses

Overview

The main alphaviruses of concern in Australia are:

- Ross River Virus; and
- Barmah Forest Virus.

Two other alphaviruses, the Chikungunya and Sindbis Viruses, are currently very rare in Australia, and recent reported cases are likely to have been imports from neighbouring regions. However, there have been recent extensive outbreaks of the Chikungunya Virus elsewhere, including in Papua New Guinea, and on Indian Ocean and Pacific islands. Therefore, the Australian Government warns that there is a high risk of this virus emerging in Australia (Australian Health Department website http://www.health.gov.au/internet/main/publishing.nsf/Content/cdi3702f; accessed 24 May 2015).

Ross River Virus

The Ross River Virus is found throughout Australia, the Solomon Islands and New Guinea and is the most prevalent arbovirus in the region. Areas under intense irrigation and localities close to saltmarshes are most productive for mosquito populations and hence tend to result in the highest number of human cases of the disease. Outbreaks occur when local conditions of rainfall, tides and temperature promote vector abundance (Department of Medical Entomology, University of Sydney website http://medent.usyd.edu.au/fact/ross%20river&20%barmah%20forest.htm; accessed 24 May 2015).

It was first isolated from passerines, but mammals (especially macropods) are considered major hosts for

enzootic transmission (Eldridge & Edman 2000).
Across most of Australia, the peak incidence of the disease is through the summer and autumn moths, particularly from January through to March, when the mosquito vectors are most prevalent.

Barmah Forest Virus

The Barmah Forest Virus occurs only in mainland Australia, but is the second-most prevalent arbovirus in the country. It was discovered in 1974 in mosquitoes in Barmah Forest in northern Victoria (Victorian Department of Health website http://ideas/health.vic.gov.au/diseases/ross-river-and-barmah-forest-virus.asp; accessed 24 May 2015). The virus has gradually spread from the tropical northern areas of Australia to the coastal regions of NSW, Qld and WA. Across most of Australia, people are most likely to be infected in summer and autumn, but the highest incidence of the disease in south-western WA is in spring (Hueston *et al.* 2013).

The virus is hosted mainly by marsupials (especially possums, kangaroos and wallabies) and humans (Barmah Forest Virus Fact Sheet, http://access.health.qld.gov.au/hid/InfectionsandParasites/ViralInfections/barmahForestVirus.fs.pdf; accessed 24 May 2014).

Flaviviruses

Overview

The main flaviviruses of concern in Australia are:

- Dengue Virus;
- Japanese Encephalitis Virus;
- Murray Valley Encephalitis Virus; and
- Kunjin Virus.

Dengue Virus

The Dengue Virus is found in tropical and subtropical regions of the world, predominantly in urban and sem-urban areas. The global incidence of dengue has and Dengue Fever has grown markedly in recent decades as a result of a marked increase in international travel (Becker *et al*. 2010). WHO (2008) assessed that 2.5 billion people, across 100 countries in Africa, Asia, the Western Pacific region, the Caribbean, Central and South America and the Eastern Mediterranean, live with the risk of Dengue Virus infection. Small outbreaks of Dengue Fever have been recorded in northern Qld each year since the early 1990s. It is believed that Dengue Fever is imported into Australia by people who have been infected while travelling overseas. The principal vector for the Dengue Virus worldwide is the Yellow Fever Mosquito / Dengue Mosquito *Stegomyia* (*Aedes) aegypti*, a species that also occurs in Australia, and is the likely cause of the isolated outbreaks in northern Qld (Australian Department of Health website http://worldaidsday.org.au/internet/main/publishing.nsf/Content/cdi3701f; accessed 24 May 2015).

Japanese Encephalitis Virus

Japanese Encephalitis Virus is the leading cause of viral encephalitis in Asia, with up to 70,000 cases reported annually (Campbell *et al*. 2011). Case-fatality rates range from 0.3% to 60% and depend on the population and age. Rare outbreaks in the Western Pacific have also occurred. Residents of rural areas in endemic locations are at highest risk; Japanese encephalitis does not usually occur in urban areas.

Countries which have had major epidemics in the past, but which have controlled the disease primarily by vaccination, include China, Republic of Korea, Japan, Taiwan and Thailand. Other countries that still have periodic epidemics include Vietnam, Cambodia, Myanmar, India, Nepal, and Malaysia. Japanese encephalitis has been reported on the Torres Strait Islands and two fatal cases were reported in mainland northern Australia in 1998. There were reported cases in Kachin State, Myanmar in 2013. The spread of the virus in Australia is of particular concern to Australian health officials due to the unplanned introduction of the Frosty Mosquito *Culex gelidus* (Theobald, 1901), a potential vector of the virus, from Asia. However, the current presence on mainland Australia is minimal.

Human, cattle and horses are dead-end hosts as the disease manifests as fatal encephalitis. The pig acts as an amplifying host and thus has a very important role in the epidemiology of the disease. Infection in pigs is asymptomatic, except in pregnant sows, when abortion and fetal abnormalities are common.

Murray Valley Encephalitis Virus

The Murray Valley Encephalitis Virus was first isolated from patients who died from encephalitis during an outbreak of disease in the Murray Valley in Victoria and South Australia in 1951. The only Australia-wide outbreak of infection was in 1974, although most cases occurred in south-eastern Australia. Since then almost all cases have been infected in northern and central Australia, with regular viral activity and human cases in the Kimberley region of Western Australia and the northern two thirds of the Northern Territory. Infections have also occurred further south in the Pilbara, Gascoyne, Midwest, and Murchison areas of Western Australia (particularly in 2000 and 2011), in central Australia and in Queensland. There is also an occasional risk to south-eastern Australia, with cases reported in NSW in 2008 and 2011, and in South Australia in 2011. The virus has also been detected occasionally in horses, however, the implications for human health are unclear. There was evidence of widespread virus activity in sentinel chickens and in horses in some areas of the southern states in 2011 (Knox *et al.* 2012).

Murray Valley Encephalitis Virus activity in Australia is divided broadly into two categories:

- **enzootic activity** (Kimberley region of Western Australia and northern Northern Territory) - annual virus activity as indicated by sentinel chicken programs, with one or two human cases on average each year, vectors and predisposing environmental conditions relatively well defined, and generally small human population centres.

- **epizootic activity** (including south-eastern Australia and southern Western Australia) **-** rare activity, with vectors, hosts and predisposing environmental conditions less well-defined and/ or larger or more numerous centres of human population which are likely to have low levels of immunity, and where prevailing conditions may indicate potential for a large outbreak.

The risk of infection is related to the presence of the principal vector, the Common Banded Mosquito *Culex sitiens (annulostris)*, which is found throughout Australia (except for Tasmania) and breeds in freshwater environments. In northern Australia it is active year-round, with the number of mosquitoes greatest in the wet and post wet season. In southern regions, *C. sitiens* tends to be a high-summer species associated with natural wetlands and irrigation waters, emerging during mid-to-late spring as the weather warms, peaking in abundance in mid-to late-summer, and disappearing before winter.

The primary hosts of the virus are thought to be waterbirds such as herons and egrets, which act as reservoirs or amplifiers for infection. The Rufous Night Heron *(Nycticorax caledonicus)* is considered a particularly important host. The principal virus cycle exists between these birds and the mosquito vectors. Native placental mammals, marsupials such as macropods (kangaroos and related species), and domesticated animals such as fowl, horses, pigs and cattle may be infected, but their role in natural transmission cycles is uncertain.

Kunjin Virus

The Kunjin Virus is closely related to the Murray River Encephalitis Virus and causes similar symptoms. It is a subtype of the West Nile Virus and is endemic to Oceania (Scherret *et al*. 2001). Although only a small number of cases of Kunjin are reported annually, the virus is known to occur in many parts of Australia, particularly near wetlands and rivers in tropical northern regions.

The main mosquito associated with the spread of Kunjin virus is the Common Banded Mosquito. Wading birds, such as herons, are associated with spread of the virus to mosquitoes. The virus cannot be spread directly from person to person.

Rarer Flaviviruses

(Information from the Department of Medical Entomology, University of Sydney website http://medent.usyd.edu.au/arbovirus/viruses.htm; accessed 24 May 2015).

Edge Hill Virus. A single case of presumptive infection has been described, with symptoms including myalgia, arthralgia and muscle fatigue. *Ochlerotatus vigilax* has yielded most of the Edge Hill Virus isolates in south-east Australia, but it has also been isolated from several other mosquito species. The vertebrate hosts may be wallabies and bandicoots, however studies are limited.

Kokobera Virus. Only three cases of illness associated with Kokobera infection have been reported and all were from south-eastern Australia. Symptoms included mild fever, aches and pains in the joints, and severe headaches and lethargy. Symptoms were still being reported by the patients five months after onset. *Culex sitiens* appears to be the principal vector.

Stratford Virus. There have been very few documented symptomatic patients, only three described and symptoms include fever, arthritis and lethargy. The virus has mostly been isolated from *Ochlerotatus vigilax*, although recent isolates from the Sydney metropolitan area include *O. notoscriptus* and *O. procax*.

Bunyaviruses

(Information from the Department of Medical Entomology, University of Sydney website http://medent.usyd.edu.au/arbovirus/viruses.htm; accessed 24 May 2015).

suggestive of Trubanaman. Most isolates in south-eastern Australia have come from *Anopheles annulipes*.

Symptoms of Infection by Main Arboviruses in Australia

The following information is from "Arboviruses" (School of Biological Sciences, University of Qld website http://www.biology.uq.edu.au/arboviruses#barmah; accessed 24 May 2015) unless specified otherwise:

Classical dengue	Severe. Often symptoms appear without warning. Fever lasts five to seven days; may fluctuate in severity. Symptoms include an intense headache, rash and retro-orbital pain. Muscular movement causes considerable pain. Often causes diarrhoea. Not fatal.
Haemorrhagic Fever	Similar to classical dengue initially. Body temperature increases after about four days. Extensive internal bleeding (due to haemorrhaging) occurs throughout the body causing the skin to become mottled blue and red. Patients bleed through the nose and gums and blood appears in the urine. Vomiting expels dead (black) blood cells. Blood pressure drops occur.
Ross River Virus & Barmah Forest Virus	These viruses are grouped together as symptoms are similar. Symptoms may persist for 6 weeks to a year or longer. The first sign of infection is given by symptoms of a mild viral illness. This often persists longer than most viruses, but advanced symptoms differ quite dramatically from person to person. Infections can produce polyarthritis, true arthralgia, decreased mobility, swollen joints, a rash, fatigue, headaches, hot and cold sensations, muscle pain and dizziness. Symptoms usually become more severe with increasing age of the patient. Not fatal.
Japanese Encephalitis	Symptoms are often mild or absent. However, typical viral fever symptoms develop in some patients, including vomiting, nausea and fatigue. The subsequent affect on the brain is more significant. More than half of those that develop symptoms either do not survive or suffer severe brain damage and/or paralysis.
Murray Valley Encephalitis	Causes Australian Encephalitis. Typical fever symptoms like Japanese Encephalitis, often with a severe initial fever that may include seizures. Can cause permanent brain damage in some people and is fatal in about one third of clinical cases.
Kunjin	Generally begins with typical viral symptoms and often causes lethargy and can affect behaviour. May cause encephalitis (swelling in the brain), but outcomes are generally less severe than in Murray Valley Encephalitis and Japanese Encephalitis.

Gan Gan Virus. Known mainly from south-eastern Australia and has been recorded, albeit rarely, causing a mild illness. Three patients with suspected disease from Gan Gan were noted with fever, malaise, myalgia, polyarthralgia/ployarthritis and rash. Mosquitoes such as *Ochlerotatus vigilax* and *Culex sitiens* have been found infected with the virus. Nothing is known on the reservoir hosts.

Trubanaman Virus. Antibodies to Trubanaman have been found in humans, and two patients with symptoms similar to that of Gan Gan had serology

Malaria

Malaria formerly occurred sporadically in northern Australia. An outbreak of malaria, caused by *Plasmodium falciparum*, occurred at Fitzroy Crossing, Western Australia in 1934, resulting in the death of 165 people, but the disease was declared eradicated from Australia in 1981. Currently, about 700-800 malaria cases are imported into Australia annually, but very few cases of locally transmitted cases occur (Becker et al. 2010).

AUSTRALIAN MOSQUITO VECTORS OF THE ALPHAVIRUSES

Overview

The Ross River and Barmah Forest viruses have been isolated from many mosquito species in Australia. Those species that commonly infect humans are:

Tribe Aedini

- Southern Saltmarsh Mosquito *Ochlerotatus camptorhynchus* (Thomson, 1868);
- Floodwater Mosquito *Ochlerotatus normanensis* (Taylor, 1915)
- Striped Mosquito *Ochlerotatus notoscriptus* (Skuse, 1889);
- Salt Marsh Mosquito *Ochlerotatus* (*Aedes*) *vigilax* (Skuse, 1889); and
- *Ochlerotatus* (*Aedes*) *theobaldi* (Taylor, 1914).

Tribe Culicini

- Common Banded Mosquito *Culex sitiens (annulirostris)* (Skuse, 1889).

Tribe Mansoniini

- *Coquillettidia linealis* (Skuse, 1889)

Additionally, *Stegomyia* (*Aedes*) species may transmit the Ross River Virus from human to human (Eldridge & Edman 2000).

The Yellow Fever Mosquito / Dengue Mosquito *Stegomyia* (*Aedes) aegypti* (Linnaeus, 1762), Asian Tiger Mosquito *Aedes albopictus* (Skuse, 1894) and the Salt Marsh Mosquito are the principal vectors of the Chikungunya Virus, but it has also been isolated from the Striped Mosquito and *Ochlerotatus procax* (Skuse, 1889) in Australia.

The Sindbis Virus has also been isolated from many mosquitoes, but most notably from the Common Banded Mosquito.

AUSTRALIAN MOSQUITO VECTORS OF FLAVIRUSES

The principal vectors of the Dengue Virus in Australia appear to be:

- Yellow Fever/Dengue Fever Mosquito;
- *Aedes scutellaris* (Walker, 1859); and
- *Aedes katherinensis* (Woodhill, 1949)

Although the other flaviviruses have also been isolated from many mosquito species, the Salt Marsh Mosquito appears to be the principal vector for the Edge Hill and Stratford Viruses, although the latter virus has also been isolated recently in Sydney from the Striped Mosquito and *Ochlerotatus procax*.

The Common Banded Mosquito appears to be the principal vector of the Kokobera and Murray River Encephalitis Virus. This mosquito species and the Saltmarsh Culex *Culex sitiens* (Wiedemann, 1828) are also thought to be responsible for Japanese Encephalitis in the Torres Strait. However, the Japanese Encephalitis Virus has also been isolated from *Culex tritaeniorhynchus* (Giles 1901), the Frosty Mosquito, *Anopheles vagus* (Doenitz, 1902) and *Anopheles annularis* (van der Wulpe, 1884) in Indonesia, all of which have the potential to be carried by winds to Australia's northern coastline.

MOSQUITO VECTORS OF MALARIA

There are more than 400 *Anopheles* species worldwide and about 40 of these species are important vectors of human malaria. *Anopheles farauti* (Laveran, 1902) is believed to have been an important vector in the spread of malaria in northern Australia, with *Anopheles amictus* (Edwards, 1921), *Anopheles bancroftii* (Giles, 1902) and *Anopheles hilli* (Woodhill & Lee, 1924) probably also playing a role (Becker *et al.* 2010).

PROFILES OF MAJOR MOSQUITO VECTORS IN AUSTRALIA

Recorded distributions of the main mosquito species that transfer viruses and blood parasites to and/or between humans in Australia (Atlas of Living Australia http://www.ala.org.au/; accessed 24 May 2015) are shown in Figure 3.

A useful key to the identification of major mosquito species in south-eastern Australia, which also contains photographs of adult and larval phases, can be accessed online (Department of Medical Entomology website, University of Sydney http://medent.usyd.edu.au/mosqkey/mosquito_key.htm). A more comprehensive collection of colour photographs of mosquito species of south-eastern Australia is provided by Russell (1996). However, it should be noted that both these sources of information have not been updated in the light of recent taxonomic revisions.

Figure 3 **Distributions of Australian mosquito species of medical importance (from Atlas of Living Australia)**

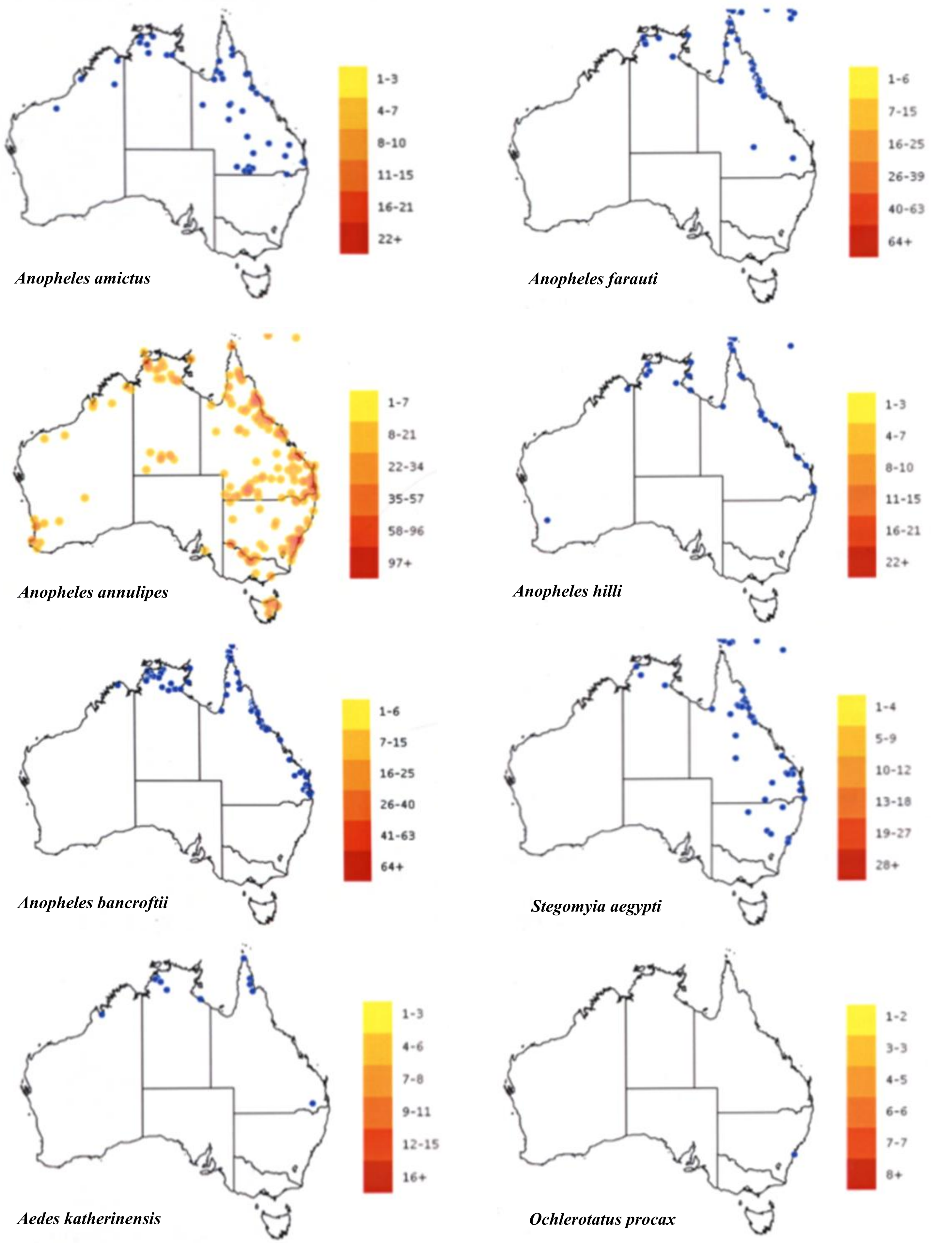
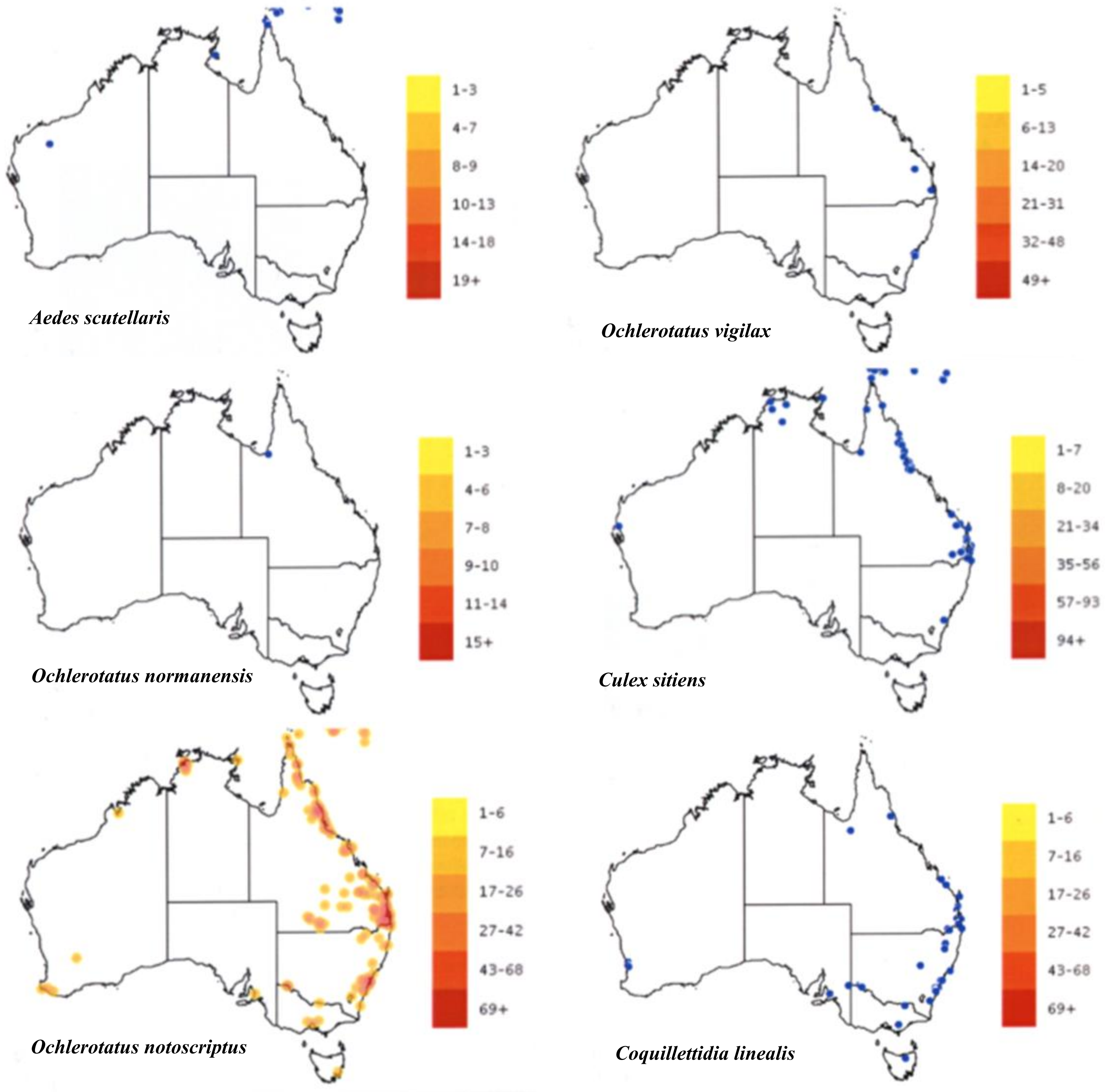


Figure 3 Continued. Distributions of Australian mosquito species of medical importance (from Atlas of Living Australia)



An excellent online information resource about mosquitoes worldwide is the Walter Reed Biosystematics Unit website http://www.wrbu.org/index.html, which has been created and is managed by the Smithsonian Institute. This site has links to the latest scientific literature about mosquitoes, identification keys to mosquito genera and species, maps of global distributions of each species, and some of the best quality photographs that I have come across on the internet of the adult, pupal and larval stages of many of the world's mosquito species.

Profiles of each species presented on the following pages are reproduced from Whelan (2010) and Becker *et al.* (2010), unless stated otherwise.

Spear Mosquito *Anopheles annulipes*

Global distribution: Australia and New Guinea.

Description: The female is a medium-sized mosquito that has a dark and speckled grey appearance; proboscis generally dark above and often with variable pale area below on apical half (in northern Australia the apical half of the proboscis may be all pale), palps as long as proboscis and palps with broad white apical bands on terminal three segments; scutum a greyish colour with scattering of broad white scales, sides of thorax with some darker coloured areas but only a few pale scales; wings with all veins having patches of dark and pale scales; hind legs with femur, tibia and first tarsus spotted and banded with pale scales, tarsi 2-4 with apical pale band and tarsus 5 is usually all dark; abdominal tergites and sternites hairy but with no scales except for some pale scattered on terminal few segments.

The larvae are very variable in colour. They have no siphon. The head is as long as it is broad. The inner clypeal hairs on the front of the head are wide apart, and the outer clypeals are branched. This species can be similar in appearance to *Anopheles.meraukensis* in respect of the outer clypeal hairs, but can be differentiated by the air scoop on the last abdominal segment. In *Anopheles annulipes* the median plate of the scoop is broad and has no lateral projections. It rests parallel to the surface of the water and feeds on particles on top of water by filtering with a series of brushes near its mouth.

Biology: Breeds in all kinds of temporary and permanent fresh water ground pools, stream and vegetated swamp edges and amongst floating algae or vegetation away from banks of streams and swamps. It also occurs in rock pools and large open artificial containers such as drums and disused swimming pools, and is sometimes found in slightly brackish water. Eggs are laid singly on the water and float by means of floats on each side.

Like all *Anopheles* species, the adult stands on its head to bite. Bites by night, particularly dusk and dawn and will enter houses. Bites people readily but will also feed on cattle. Resting places in hollow stumps, drums, banks of streams and stormwater pipes. This species is abundant in northern Australia from February to April near extensive paperbark and freshwater reed swamps, but rarely becomes an appreciable human pest, and never very numerous in coastal situations. Flight range is approximately 2 km from breeding areas.

Medical Importance: This species has the ability to transmit malaria (which is not endemic to Australia). Ross River Virus has been isolated from *Anopheles annulipes*, but its vector status remains unknown.

Anopheles amictus

Global Distribution: Australia.

Description: A pdf of Woodhill & Lee (1944), which describes this species is accessible online (http://www.mosquitocatalog.org/files/pdfs/142300-0.PDF).

Biology: Breeds in brackish water, although it may occasionally occur in freshwater bodies in inland parts of its range. Females usually feed on the blood of animals within 3 to 4 hours of sunset, and readily bite humans. Adults can be found throughout the year, but recorded peaks in activity are in April-May and November-January.

Medical Importance: Ross River Virus has been isolated from this species in Northern Queensland but is unlikely to be an important vector in south eastern Australia due to its low numbers.

Anopheles bancroftii

Global Distribution: Irian Jaya, Admiralty Islands and northern Australia.

Description: A large black mosquito with bushy black palps and a black proboscis. Wings are mostly dark with few small white patches on the front edge. The top of the abdomen is black. The underside of abdomen has a central row of pale scale patches. Palps are as long as the proboscis.

The larva is dark in colour, often with some irregular white patches. Has no siphon. The antennae have a conspicuous branched hair at mid length, with bushy branched outer clypeals on the apical section of the front of the head. Feeds parallel to the surface of the water by drawing in particles on the surface with a series of brushes near its mouth.

Biology: Larvae are found in shaded freshwater swamps, waterholes and stream margins. Sometimes found in slightly brackish reed swamps where reeds shade the water. Paperbark trees and the areas of spike rush reeds such as *Eleocharis sphacelata* are often good indicators of suitable breeding places.

The adult stands almost vertically on its head when biting. It bites principally at night, but readily attacks people by day in shaded areas near its breeding grounds. It also attacks other mammals readily including cattle. The flight range of 2 to 4 km from the breeding areas. This species is usually more numerous in the late wet season and early dry season.

Medical Importance: Capable of carrying malaria, and is a suspected vector in the Northern Territory, but usually not long lived enough to be an effective vector. A vector of filariasis in New Guinea.

Australian Malaria Mosquito *Anopheles farauti*

Global Distribution: Occurs from the Moluccas, New Guinea, Solomon Islands to Vanuatu as a number of sibling species. In Australia it occurs in North Queensland, Top End of the Northern Territory north of Katherine including occasionally in Katherine, very rarely in Ngukurr, and very rarely in the north east coastal area of Western Australia.

Description: A speckled grey mosquito with extensively spotted wings and with palps as long as proboscis. There are three narrow black bands on the apical half of the palps, with the two most basal of these dark bands separated by a narrow white band. The proboscis is dark, and the abdomen is all dark, with no pale scales on the under-surface.

Anopheles farauti is actually part of a complex of different but morphologically indistinguishable species (known as 'sibling' species) with *Anopheles punctulatus*. This species can be confused with *Anopheles annulipes* but is easily separated by the characteristic paired narrow black bands on the apical section of the palps. A small to medium species.

Like all *Anopheles* larvae, it has no siphon. Head is as long as it is broad. This species can be easily distinguished from *Anopheles hilli* as it has larger inter segmental plates. Larva feeds and rests horizontal to the surface of the water.

Biology: *Anopheles farauti* occurs in many kinds of permanent and semi-permanent fresh and brackish water sites. It is usually in sunlit locations and uncommon in deep shade. The freshwater subspecies breeds in the margins of shallow vegetated freshwater swamps and streams. The brackish water breeding subspecies is found in open brackish pools or swamps near the coast, often in association with *Anopheles hilli, Culex sitiens* or *Culex annulirostris*.

Adults bite people and other mammals and birds readily. It stands at an angle to the skin to bite. Flight range approximately 2 km. It is normally most numerous in the late wet season and early dry season.

Medical Importance: The group is widely distributed across northern Australia and is a major vector of malaria in Papua New Guinea, but the relative efficiency of the different sibling species in Australia is unknown.

Salt Water Anopheles Mosquito *Anopheles hilli*

Global Distribution: Australia and southern part of Irian Jaya. Common across Northern Australia from north west Western Australia, coastally and subcoastally in the Northern Territory to coastal east Queensland, and down to the New South Wales border. Has been found in inland areas of the Northern Territory, occasionally to Katherine, rarely to Larrimah, a few times in Tennant Creek, and one record from Alice Springs at Ilparpa swamp.

Adult Female: A speckled grey mosquito with extremely spotted wings. The palps are as long as the proboscis. There are two dark bands and two wide white bands on the apical half of the palps. The proboscis is dark. There are wide white bands across the joints of the tarsi, on the hind legs. The abdomen is pale on top, with a mottling of scattered pale scales on the underside.

Larva: Does not have a siphon, and are generally pale in colour, with relatively narrow inter- segmental plates. All clypeal hairs are long with the outer ones frayed. Rests horizontally to surface of the water, feeds by filtering particulate matter from the surface of the water.

Biology: Found in natural and artificial coastal ground pools, coastal swamp margins and tidally influenced flood plains in sunlit to partly shaded sites, and with or without ground vegetation present. Breeds almost exclusively in brackish to salt water, and often in typical *Aedes vigilax* salt marsh breeding sites. This species is most numerous at the end of the wet season.

Adults Bite people, cattle and horses. It is most active after sunset for the first two hours of the night and will enter houses. Fed females can be found inside houses. Flight range is approximately 4 km, with very high numbers often found close to brackish swamps in the late dry season. Like other *Anopheles*, it stands at an angle to bite.

Medical Importance: *Anopheles hilli* is capable of carrying malaria. It was a secondary vector in malaria outbreaks in Queensland, and is a suspected vector in the Northern Territory.

Yellow Fever Mosquito / Dengue Mosquito *Stegomyia* (*Aedes*) *aegypti*

Global Distribution: Occurs in the tropical, subtropical and warm temperate regions of both hemispheres. Its range is mainly limited by the 10 ºC cold-month isotherms where breeding can occur all year round. Some populations may extend their summer range north of this line, but they are not able to survive during the winter months, thus preventing permanent populations being established.

Adult Female: A medium-sized dark species with contrasting silvery-white ornamentation on the head, scutum, legs and abdomen. It is easily recognised and distinguished from other members of the genus by the white scutal markings which form the typical "lyre-shaped" pattern. The proboscis is dark scaled, the palps 1/5th the length of the proboscis with white scales on the apical half, the clypeus with lateral white scales, and the pedicel with large patches of white scales at the sides. The vertex has a median line of broad white scales from the interocular space to the back of the occiput, and white scales also on the sides, separated by patches of dark scales. Erect scales are restricted to the occiput, and all are pale. The scutum is predominantly covered with narrow dark brown scales, with a distinctive pattern of light scales. The scutellum has broad white scales on all the lobes and a few broad dark scales at the apex at the mid lobe. The post-pronotum has a patch of broad white scales on all the lobes and some dark and pale narrow scales in the upper part. The paratergite has broad white scales. The post-spiracular area is without scales, but there are patches of broad white scales on the propleuron, and subspiracular and hypostigmal areas. The coxae have patches of white scales, and all femora have white knee spots, the fore and mid femora with a narrow white longitudinal stripe on the anterior surface. All the tibiae are dark anteriorly, the fore and mid tarsi have a white basal band on tarsomeres I and II, the hind tarsus has a broad white band on tarsomeres I-IV, and tarsomere V is all white. The claws of the fore and mid tarsi have a sub-basal tooth, and the claws of the hind tarsi are simple. The wing veins are all dark-scaled, except for a small spot of white scales at the base of the costa. Tergum I has white scales laterally and a median pale patch, terga II-IV have basal white bands and basolateral white spots separate from the bands, and tergum VII has lateral white spots only. Sterna II -IV are largely pale-scaled, V and VI have predominantly dark scales, and VII is dark except for a small lateral patch.

Adult Male: The palps are as long as the proboscis with white basal rings on palpomeres II-V. The last two segments are slender and upturned with only a few short setae. The posterior margin of tergum IX is deeply concave in the middle, and the lateral lobes are prominent with three apical setae. The gonocoxite is slightly more than twice as long as wide, with scales restricted to the lateral and ventral surfaces. The gonostylus markedly narrows apically and is curved, with a pointed apical spine. The claspettes are large, lobe-like, appressed to and occupy most of the mesal surface of the gonocoxite, with numerous setae and several stronger setae, three or four of which are bent at the tip. The paraproct has an inwardly directed mesal arm, and the aedeagus is strongly serrated.

Larva: The antennae are about half as long as the head and without spicules. The antennal seta is small and single, and inserted slightly beyond the middle of the antennal shaft. The post-clypeal and median frontal setae are displaced far forward toward the anterior margin of the head. The post-clypeal seta is situated slightly forward of the median frontal seta, and is well-developed with 4-7 branches. The frontal setae are long and single, and the outer frontal seta very rarely has two branches. At the base of the meso- and metathoracic setae there is a long stout spine which is pointed and hooked at the tip. The comb consists of a single irregular row of 6-12 scales, and each comb scale has a long median spine and strong smaller spines at the base forming a "triffid" appearance. The siphon is moderately pigmented, the siphonal index is about 1.8-2.5 mm, and the acus is not developed. The pectin has 8-22 teeth (usually 10-16), evenly spaced or sometimes the distal-most tooth is detached apically, and each tooth has 1-4 lateral denticles. The siphonal tuft has three or four branches, usually inserted close to the distal pectin tooth and just beyond the middle of the siphon. The saddle reaches far down the lateral sides of the anal segment, the saddle seta usually has two short branches. The ventral brush has 8-10 tufts of cratal setae, and the precratal setae are absent. The anal papillae are about 2.5-3 times the length of the saddle, sausage-like, and rounded apically.

Biology: In subtropical climates the species is almost always found in the close vicinity of human settlements. The larvae occur in a wide variety water bodies, including uncovered small water containers, pots, uncovered cisterns, water tanks and pooled water in broken bottles and discarded tyres. If vegetation surrounds human settlements, the larvae may breed in tree-holes, leaf axils, bamboo stumps or coconut shells after heavy rainfall. The water needs to be mostly clean or have only a moderate content of organic matter. The larvae spend a lot of time under water feeding on the floor of the aqueous substrate. The eggs are resistant to desiccation and are deposited close to the waterline. At 27-30 ºC, eggs will hatch two days after deposition, pupation occurs after eight days and adults emerge 9-10 days after the eggs have been laid. The females feed predominantly during the day in shaded places and only occasionally during the night in lit rooms. Human blood seems to be preferred to that of domestic animals, but the blood feeding interval is only 2-4 days. The adults are commonly found resting indoors. They do not migrate over long distances, and rarely fly more than several hundred metres from their breeding sites.

Medical Importance: A major vector of the Yellow Fever and Dengue Viruses outside Australia. A possible vector of the Dengue Virus in north-eastern Australia.

Aedes katherinensis

Global Distribution: Northern coastal and sub-coastal Australia.

Description: Adults of *Aedes katherinensis* are very similar to *Aedes albopictus*. Both species have bold black shiny scales and distinct silver white scales on the palpi, the scutum is black with distinguishing white stripe around the perimeter, and a silver stripe down the center of the scutum beginning at the dorsal surface of the head and continuing along the thorax.

Biology: Similar to that of *Aedes scutellaris*. Larvae of both species in Australia can be found in the same body of water and their identities cannot be separated based on morphological characteristics.

Medical Importance: A vector of the Dengue Virus.

Aedes scutellaris

Global Distribution: Found throughout Papua New Guinea, Tonga, South-east Asia, south Pacific, Torres Strait Islands and the Cape York Peninsula.

Description: Very similar in appearance to *Aedes albopictus*. The larvae of the two species are impossible to separate on morphological features.

Adult Female: A single silvery-white line of tight scales begins between the eyes and continues down the dorsal side of the thorax. The proboscis is dark colored, the upper surface of the end segment of the palps is covered in silvery scales, and the labium does not feature a light line on its underside. The compound eyes are distinctly separated from one another. The scutum, the dorsal portion of an insect's thoracic segment, is black alongside the characteristic white midline. On the side of the thorax, the scutellum, and the abdomen there are numerous spots covered in white-silvery scales. The same coloured scales also occur on the tarsus, particularly on the hind legs that are commonly suspended in the air. The base of tarsomere I through IV has a ring of white scales, creating the appearance of white and black rings. On the forelegs and middle legs, only the first three tarsomeres have the ring of white scales whereas tarsomere V on the hind legs is completely white. The femur of each leg is also black with white scales on the end of the knee. The femurs of the middle legs do not feature a silver line on the base of the upper side, whereas, the femurs on the hind legs have short white lines on base of the upper side. The tibias are black on the base and have no white scales. The terga on segments II through VI of the abdomen are dark and have an almost triangular silvery-white marking on the base that is not aligned with the silvery bands of scales on the ventral side of the abdomen. The triangular marking and the silvery band are only aligned on abdominal segment VII. The transparent wings have white spots at the base of the costas.

Adult Male: The males are roughly 20% smaller than the females, but they are morphologically very similar. However, as in all mosquito species, the antennae of the males in comparison to the females are noticeably bushier and contain auditory receptors to detect the characteristic whine of the female. The maxillary palps of the males are also longer than their proboscises whereas the females' maxillary palps are much shorter. In addition, the tarsus of the hind legs of the males is more silvery. Tarsomere IV is roughly three-quarters silver in the males whereas the females' is only about 60% silver.

Biology: An autogenous, semi-domestic container-breeding mosquito. Commonly breeds in clean water and sometimes polluted water. It has been collected from tree-holes, ground pools, coconut husks, shells, fallen coconut fronds, leaf axils, cocoa pods, pools in lava holes and crab holes. It will also breed in water in artificial containers such as water tanks, canoes, tins, bottles, cement drains and wells. Eggs are laid at or just above the water line, and are far less resistant to desiccation than those of *Ochlerotatus vigilax*.

The adult is a diurnal host-seeking species, and will attack readily during the day in shaded areas, but not in direct sunlight. This species has a preference for humans and will bite both indoors and outdoors. Adults may be found in houses, forests, bushes or in coconut plantations.

In dispersal experiments, the species has been observed to fly between 455 and 727 m. The majority of adults disperse less than 100 m during their lifetime. Moderate breezes do not prevent feeding, but strong ones do. Dispersal of this species varies depending on availability of shelter, food and suitable breeding sites.

Medical Importance: A vector of the Dengue Virus. It has also been infected with filarial worms in the laboratory.

Southern Saltmarsh Mosquito (*Ochlerotatus camptorhynchus*)

Global Distribution: Australia where it is found in southern coastal areas.

Description: A medium sized mosquito of darkish appearance but with banded legs; proboscis extensively mottled, particularly on underside; scutum with no obvious pattern amongst the narrow golden scales although there a few paler patches at mid-length and particularly at the rear; wings completely dark scaled; hind legs with pale basal bands on tarsi, and femur, tibia and first tarsus mottled with pale scales; abdominal tergites with pale basal bands often convex or triangular in the midline, sternites pale scaled with median black (and sometimes apical lateral) patches.

Biology: Breeds mainly in brackish swamps and marshes in open country. It is typically a coastal species, but occurs in inland riverine areas with brackish influence. Adults may be active throughout the year and may disperse widely from their larval habitats. They are extremely aggressive biters and readily attack humans and birds during the day, at dusk and after sunset. The species is a major pest in coastal areas.

Medical Importance: Vector for the transmission of the Ross River Virus (Russell 1996).

Floodwater Mosquito *Ochlerotatus normanensis*

Global Distribution: Australia.

Biology: Larvae are usually found in temporary ground pools and swampy areas resulting from heavy rain, fully or partially exposed to the sun. Frequently, the larvae of this species are found with those of *Anopheles annulipes*, *Ochlerotatus alternans*, *O. vigilax*, *O. vittiger* and *Culex sitiens (annulirostris)*. The pools may occur in natural depressions, dry water courses, or man-made excavations, including country road gutters and hoof prints. The water may be clear or muddy, and sometimes slightly polluted by animal droppings. Females readily bite humans during the day. It is a common species in northern Australia where it is a major pest mosquito.

Medical Importance: Vector of the Murray Valley and Ross River Viruses (Russell 1996).

Striped Mosquito *Ochlerotatus notoscriptus*

Global Distribution: South West Pacific Australia and New Zealand. Found Australia-wide.

Description: A small to medium-sized black mosquito with a conspicuous lyre shaped pattern and fine white lines on the top of the thorax. The proboscis has a white band around the middle, and the palps are very short compared with the proboscis. The abdomen tapers towards the apex. Tarsi of all legs have distinct wide white basal bands.

A dark grey larva with a light brown head and short siphon. The relatively long larvae have a sinuous movement, and the dorsal and ventral pairs of the anal papillae are pointed at the ends and unequal in length. There is a distinctive row of spines at the apex of the saddle.

Larvae often forage at the bottom of receptacles but hang down at the water surface when obtaining oxygen through their siphon.

Biology: The natural breeding places are tree holes, rock pools and fallen palm fronds. This mosquito is domestic in settled areas and breeds in all types of artificial rain filled receptacles such as boats, tyres, tins, drums, domestic water tanks, roof gutters, pot plant drip trays and plant striking containers, particularly where there is rotting vegetable matter. Eggs are laid singly just above the water line and can withstand considerable periods of drying until they are flooded.

Females readily attack humans by day in shaded areas, but also feed during the evening. Stands with its body horizontal to the skin when biting. The adults are capable of flying 2-3 km but domestic pest situations are usually from sources within 200 m of the pest problem. Overwintering takes place in the larval stage. It is one of the major domestic pest species in south-eastern Australia.

Medical Importance: A significant vector of the Barmah Forest Virus, Ross River Virus and heartworm in dogs (Russell 1996). It is a very good vector of heartworm of dogs.

Ochlerotatus procax

Global Distribution: Australia (Qld, NSW & Vic).

Biology: A common species in coastal regions and breeds in bushland ground-pools. Can be a minor pest close to its breeding areaThe ecology of larval habitats of freshwater *Ochlerotatus* species is poorly described in Australia. Although *O. procax* may be recorded in seasonally high abundance from local government light-trap surveillance, little is known of the characteristics of larval development, survival or chemical susceptibility for this species. Adults disperse less than 100 m from their breeding habitat.

Medical Importance: Likely to be a significant vector of Ross River and Barmah Forest Viruses.

Ochlerotatus (*Aedes*) *theobaldi*

Global Distribution: Australia. NSW (throughout western areas, occasionally on coast), Vic (north/northwest river and western areas), SA (upper Murray), (also Qld particularly west of the Divide) areas.

Description: A medium-sized mosquito of mottled dark appearance; proboscis dark scaled but with extensive pale area on the underside; scutum generally covered with golden and dark narrow scales but with some larger pale towards rear; wings with extensive mottling of broad pale scales; hind legs with femur, tibia and first tarsus mottled, all tarsi banded (although fifth may be all dark); abdominal tergites dark with pale lateral patches and basal bands which may not be complete and there may be some mottling on terminal segments, sternites pale scaled with some dark scales in mottling or apical bands or lateral patches.

Adult females of *Ochlerotatus. theobaldi* can be confused with *O. eidsvoldensis* which have the tergal bands produced into a median triangle; other species with mottled proboscis, wings and legs such as *O. flavifrons* (blotch on wing membrane), and *O. vigilax* (fewer pale scales on wing, and scales are narrow like the dark ones not broad) can be readily separated; *O. normanensis* can appear similar but generally has darker proboscis.

Biology: Adults may become active in spring and be apparent throughout the year in warmer areas providing natural flooding or irrigation promotes an egg hatch; day-biting is usually apparent as the species readily attacks humans and other animals but they will bite also in the evening and at night.

Medical Importance: May be a major pest following extensive rain or flooding in western areas of its range and can disperse for many kilometres when there are major larval populations. The species has been shown to be able to carry Murray Valley Encephalitis Virus in laboratory studies and Ross River Virus has been isolated from collections in the Murray valley, but there is no information as to any role in transmission of human disease.

Salt Marsh Mosquito *Ochlerotatus (Aedes) vigilax*

Global Distribution: Found in the Oriental region and the South West Pacific area including Australia, Timor, Solomons, New Guinea, New Caledonia, Fiji and Vanuatu. Found coastally in Australia from New South Wales, Qld, NT and WA to Mandurah south of Perth. Found in Victoria inland at Mildura. In the NT it is seasonally common across the Top End and subcoastally to inland, commonly to Katherine, occasionally to Tennant Creek, and rarely in Alice Springs (usually after monsoon or cyclones weather systems and associated north-west winds).

Description: *Ochlerotatus vigilax* is a small, dark, robust mosquito with a pointed abdomen. The proboscis is pale scaled on the basal 2/3 on the underside. There are basal white bands on each segment on top of the abdomen with lateral white patches. The tarsi have basal white bands on each segment, and these are particularly noticeable on the hind legs. Stands with its body horizontal to the skin when biting.

The larvae are moderate size and relatively dark, with a short siphon, and short, pointed anal papillae. The major head hairs are single. Generally larvae feed on the substrate at the bottom of pools and tend to congregate around sheltered areas of vegetation. If the larvae are disturbed they rapidly move to the bottom of the pool.

Biology: Commonly breeds in brackish to salt water swamps and temporary pools that are filled after the highest tides of the month and after rain. These areas are usually sunlit so their development is rapid, with four days as larvae and two days as pupae. The breeding areas are often associated with salt water couch grass (*Sporobolus)* or various marsh grasses (*Xerochloa*) or salt tolerant succulents (*Tecticornia* and *Halosarcia*) and reeds such as *Shoenoplectus, Eleocharis* and *Typha* sp. Will breed in flooded grass areas above high tide limit where there is some salt influence from the soil or seaspray. Larvae are seldom found under a heavy mangrove cover with daily tide movement, but are often associated with *Avicennia* mangroves and *Shoenoplectus* reeds in brackish swamps reached by high tides.

In some cases, increased breeding has occurred when sand dunes or mangrove boundaries have been altered and the natural drainage of sea water has been blocked. Only complete reclamation by filling or the exclusion of salt water by tide gates and bund walls will remove these breeding areas. The eggs are laid singly in the moist mud, usually at the base of vegetation and are laid at the edges of the depressions as the water recedes. These eggs can resist periods of dryness for up to 12 months until the area is flooded again.

The larvae go through four stages in the water and then turn into pupae which are much rounder and look like very small crayfish without legs. The adult mosquito hatches from the pupa as it rests at the surface of the water. The adult mosquito then rests on the surface of the water until the wings are sufficiently hardened to fly. The period from egg to adult is usually only 6 days. The larvae will grow in a range of salinities from slightly brackish to twice sea water. They are also found in freshwater when the breeding grounds are flooded by rains. Eggs are generally not laid at the edges of fresh water pools or freshwater swamps.

Only the females feed on blood, which is needed for the development of their eggs. Both males and females feed on plant juices or nectar. After the adults emerge they mate and then remain at their breeding site for two days while the females develop their first batch of eggs while harbouring at the breeding site. They do not require a blood meal for this first batch of eggs. Mass dispersal of newly emerged females may take place to points up to 40 km or more from the breeding sites, but are generally in highest numbers from 1–5 km from extensive breeding sites.

After strong prevailing winds from coastal breeding sites, large numbers of *Ochlerotatus vigilax* have been found far inland. The adults shelter in vegetation during the day, especially in mangroves and dense forest near their breeding sites, but also in dense vegetation such as mango trees and shade trees in suburban areas.

The female mosquito will bite by day or night and will bite people, other mammals and birds. Peaks flying and biting times are just after sunset and before sunrise.

Plagues of *Ochlerotatus vigilax* in coastal areas of northern Australia occur from the mid and late dry season to the early wet season, starting 9-10 days after the highest monthly tides or the first flooding rains. Numbers reduce rapidly after the wet season rains seasonally flood the extensive salt marsh breeding areas to allow predator fish access, as well as markedly reducing egg laying sites.

Medical Importance: Regarded as the principal vector of Ross River Virus and Barmah Forest Virus in the late dry to early wet season, and is a potential vector of the Murray Valley Encephalitis Virus. It is capable of carrying heartworm of dogs. It is a vector of filariasis in New Caledonia.

Common Banded Mosquito *Culex sitiens (annulirostris)*

Global Distribution: Widespread throughout coastal South East Asia and adjacent tropical area of the Oriental region. Also Micronesia, South Pacific and Australasia, including Timor and New Guinea. In Australia it is recorded from coastal areas from as far south as Perth and north in WA, up to the NT and across to Qld and down to NSW as far south as Batemans Bay.

Description: A medium sized mosquito with a square tipped abdomen and a narrow white band on the middle third of the proboscis, with the white band shorter when viewed from above compared with from below. The wings are all dark scaled. The femora of the hind legs are mottled and the tarsi of the hind leg have narrow basal bands of white scales. There are basal straight white bands on the top of the abdomen on each segment and uninterrupted apical black bands on the segments under the abdomen.

Larva is pale with a long siphon with 6 groups of hairs along each side underneath the siphon. Antennae on the head have the bottom 2/3 white and the tip of the antennae dark. Has pointed pale transparent anal papillae at the hind end of the abdomen. Larvae hang down from the surface of the water when obtaining air. Feed among submerged vegetation.

Biology: Breeds in natural freshwater swamps, pools, streams that have vegetation, but will also breed in many artificial situations such as stormwater drains, grassy edges of sewerage ponds and disused swimming pools. May breed in large numbers in low lying grassy areas where the water lays for 1-3 weeks.

It has been found in brackish water in salt marshes, although is not usually found in areas exceeding one third salt water. This species may breed in large numbers in the dry season in vegetated sewage lagoons and stormwater drains. Eggs are laid in rafts on the water surface and can contain up to 200 eggs.

The adult commonly bites people, birds and other animals after sundown and in the early part of the night. It is the chief non-domestic mosquito pest in Australia and the most common biting mosquito species. It can fly from 4 to 10 km from its breeding place, but generally is in higher numbers within 2km of productive breeding sites.

Medical Importance: The confirmed and major vector of Murray Valley Encephalitis Virus in Australia, and is capable of carrying Kunjin Virus, Ross River Virus, Barmah Forest Virus and other viruses. It is probably the major vector of Ross River Virus from January to April. It can transmit heartworm of dogs and is capable of carrying human filariasis in New Guinea.

The Golden Mosquito *Coquillettidia linealis*

Global Distribution: The islands of New Guinea, New Caledonia and Vanuatu. Occurs widely in Australia. In Queensland it occurs mainly in tropical coastal areas but is also recorded inland as far as Charleville, and south to near Sanford and Bunya near Brisbane. Found also in the Northern Territory, North West Western Australia and coastal and sub coastal northern New South Wales. It is found widely and common in the Top End of the Northern Territory coastally to sub coastally from Port Keats in the west to Borroloola in the east, and south to Katherine and Mataranka.

Description: A medium-sized mosquito with a bright gold/ orange thorax and abdomen. The legs are dark, and have purple reflections. A pale/white larva with tip of siphon dark and modified for piercing plants. A very sluggish swimmer. Larvae are attached to aquatic plants and rarely seen.

Biology: Breeding habitats are permanent and semi-permanent swamps with aquatic vegetation. Larvae attach to underwater roots or stems of plants. It is most frequently associated with the semi-aquatic reeds *Eleocharis* sp and *Typha* sp, and the water lilies *Nymphaea sp*. Pandanus, grasses and sedges may be suitable habitats in some localities.

The adult bites mainly at night, but also in the daytime in shade. It bites people, domestic animals and birds, and may travel up to 4 km from the breeding places. It is attracted to light and is seasonally numerous.

REDUCING THE RISK OF INFECTION

The NSW Dept. of Health offers the following relevant advice for avoiding mosquito bites during fieldwork (http://www.health.nsw.gov.au/Infectious/factsheets/Pages/mosquito.aspx):

- Use an effective repellent on exposed skin areas. Re-apply repellent every few hours, according to the instructions, as protection wears off from perspiration, particularly on hot nights or during exercise.

- ☐ The best mosquito repellents contain Diethyl Toluamide (DEET) or Picaridin. Botanical-based products (e.g. Eucalyptus, Citronella etc) provide only limited periods of protection.
- ☐ Topical repellents are not recommended for use on children below the age of 3 months.
- ☐ Note that prolonged or excessive use of repellents can be dangerous, particularly on babies and young children. Avoid putting repellent near eyes and mouth, spread sparingly over the skin, and rinse off once you are indoors.
- ☐ Provide mosquito netting, where necessary—both indoors and outdoors.
- ☐ Cover up as much as possible with loose fitting clothing and sensible footwear. Avoid tight clothes.
- ☐ Cover your clothes with repellent as mosquitoes can bite through material, but be careful, some repellents stain clothes.
- ☐ Use mosquito coils outdoors and vapourising mats indoors. Note, however, that devices that use light to attract and electrocute insects have not been proved to be effective in reducing mosquito numbers.

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Advertising Opportunities with the ECA

Website:

- $200 for a banner
- $300 for company name with some detail and a link
- $500 for company name within box, logo, details and web link

All website packages run for one financial year and include a small ad in any newsletter produced during the financial year.

Newsletter:

- $100 for a third of a page
- $250 for a half page
- $500 for a full page
- $1 / insert / pamphlet

Advertising is available to service providers of the Ecological Consulting industry. The ECA will not advertise a consultant or their consulting business.

If you wish to advertise, please contact the ECA administrative assistant on admin@ecansw.org.au.

"Non-ECA promotional material presented in the ECA Newsletter does not necessarily represent the views of the ECA or its members."

As the story goes, some prominent scientists and engineers were invited to a party, and this is how they replied. (http://www.smex.net.au/Other/Humour03.php - link courtesy of Deryk Engel)

- Ampere was worried he wasn't current.
- Audobon said he'd have to wing it.
- Boyle said he was under too much pressure.
- Darwin waited to see what evolved.
- Descartes said he'd think about it.
- Dr Jekyll declined -- he hadn't been feeling himself lately.
- Edison thought it would be illuminating.
- Einstein thought it would be relatively easy to attend.
- Gauss was asked to attend because of his magnetic personality.
- Hertz said in the future he planned to attend with greater frequency.
- Morse's reply: "I'll be there on the dot. Can't stop now, must dash."
- Newton planned to drop in.
- Ohm resisted the idea.
- Pavlov was drooling at the thought.
- Pierre and Marie Curie were radiating enthusiasm.
- Volta was electrified
- Archimedes was buoyant at the thought.
- Watt reckoned it would be a good way to let off steam.
- Wilbur Wright accepted, provided he and Orville could get a flight.
- Bell tried to telephone, but the line was busy.
- da Vinci was on a date with his friend, Mona Lisa.
- Geiger counted on being there.
- Nobel prized his invitation.
- Diesel got really heated up from the pressure he was under.
- Faraday's response was filtered through parallel contacts.
- Van de Graff generated a highly charged reply.

Contributions to the Newsletter, Volume 36

Contributions to the next newsletter should be forwarded to the administration assistant Amy Rowles **admin@ecansw.org.au** by the

15th of January 2016.

- Articles may be emailed in WORD, with photos included or referenced in an attached file as a jpg.
- Please keep file size to a minimum, however there is no limit on article size (within reason)
- Ensure all photos are owned by you, or you have permission from the owner
- Ensure that any data presented is yours and you have permission from your client to refer to a specific site (if not please generalise the location).
- All articles will be reviewed by the editorial committee, and we reserve the right to request amendments to submitted articles or not to publish.
- Please avoid inflammatory comments about specific persons or entity

The following contributions are welcome and encouraged:

◊ Relevant articles
◊ Anecdotal ecological observations
◊ Hints and information
◊ Upcoming events
◊ Recent literature
◊ New publications (including reviews)
◊ Photographs

If you have 2nd hand ecological equipment that you would like to sell or would like to purchase you can place an ad in this newsletter. Free for members or $40 for non-members. Contact admin@ecansw.org.au.

ECA Photo Gallery

Photo Competition Entries

Above: Silvereye *(photo courtesy of Natalie Parker)*

Top Left: Eastern Grey Kangaroos in the frost.
Middle Left: Northern Leaf-tail Gecko *Saltuarius cornutus*

Middle Right: The Chameleon Gecko, *Carphodactylus laevis*, from the rainforests of north Queensland. **Centre**: Paper Wasps. (*Photos Courtesy of Narawan Williams)*

Top Centre: Orange-eyed Tree Frog, Atherton Tablelands, QLD (*Photo courtesy of Anne Williams)*.

Below: Barrington Tops National Park *(photo courtesy of Natalie Parker)*

Left: *Rainbow Lorikeets 'hugging' (photo courtesy of Tim Johnson).*

***Below**: Paranyctimene raptor*, Green Tube-nosed Bat, western province PNG *(photo courtesy of Adam Greenhalgh)*

ECA Photo Gallery

Photo Competition Entries

Right: *Hibiscus menzeliae* in Kakadu National Park (*Photo courtesy of Belinda Pellow*)

Left: Koalas and Rainbow Lorikeet, Blackbutt Reserve.

Centre Left: Green Tree Snake.

Centre Right: Eastern Spinebill.

Bottom Left: Juvenile Tawny Frogmouth.

(*Photos courtesy of Natalie Parker)*

Below: Spotted Pardalote *Pardalotus punctatus* **(***Photo courtesy of De-Anne Attard)*

Below Centre: *Cryptostylis erecta. (Photo courtesy of Chantelle Doyle).*

Below Right: One of five Echidnas in a group, August, in the Hunter Valley *(Photo courtesy of Amy Rowles).*