# Living with Insects

Family of Bess Beetles, *Mastichilus* sp.

- Facts and Figures
- Insect Origins and Evolution
- The Evolutionary Arms Race
- Regulation  of Insect Numbers
- Dispersal: a life force in insects
- Natural Ecosystems versus Agricultural Ecosystems
- Environmental Services provided by Insects
- Sustaining and encouraging insect diversity on your property
- A Cautionary Tale

# Exoskeleton

Cicada moulting

# Numbers of Insect Species

| INSECTS | World | | | Australia | | |
| --- | --- | --- | --- | --- | --- | --- |
| | Named | Estimate | % | Named | Estimate | % |
| | | | | | | |
| **TOTAL** | 900,000 | 5,000,000 | 18 | 62,000 | 205,000 | 30 |
| | | | | | | |
| **Beetles** | 380,000 | 1,100,000 | 3.4 | 23,000 | 90,000 | 26 |
| | | | | | | |
| **Butterflies & Moths** | 174,000 | 400,000 | 48 | 10,600 | 20,000 | 53 |
| | | | | | | |
| **Flies** | 160,000 | 600,000 | 26 | 7,500 | 30,000 | 25 |
| | | | | | | |
| **My Insect Guide Book** | | | | 500 | | |

# Beetles: a success story

Not the smallest
A flower beetle
*Arsipoda* sp 3 mm

One of Australia's largest
*Agrionome spinicollis*
30 mm long

| ERA | Events MYA | Insect evolution<br>A response to changing resources |
|---|---|---|
| **Ordovician**<br>**495 to 435 MYA** | 480 | First ancestral crustaceans, **hexapods**, arachnoids and plants colonise the land about 480 MYA.<br>Poor fossil record |
| **Silurian**<br>**435-412 MYA** | | Continuing evolution |

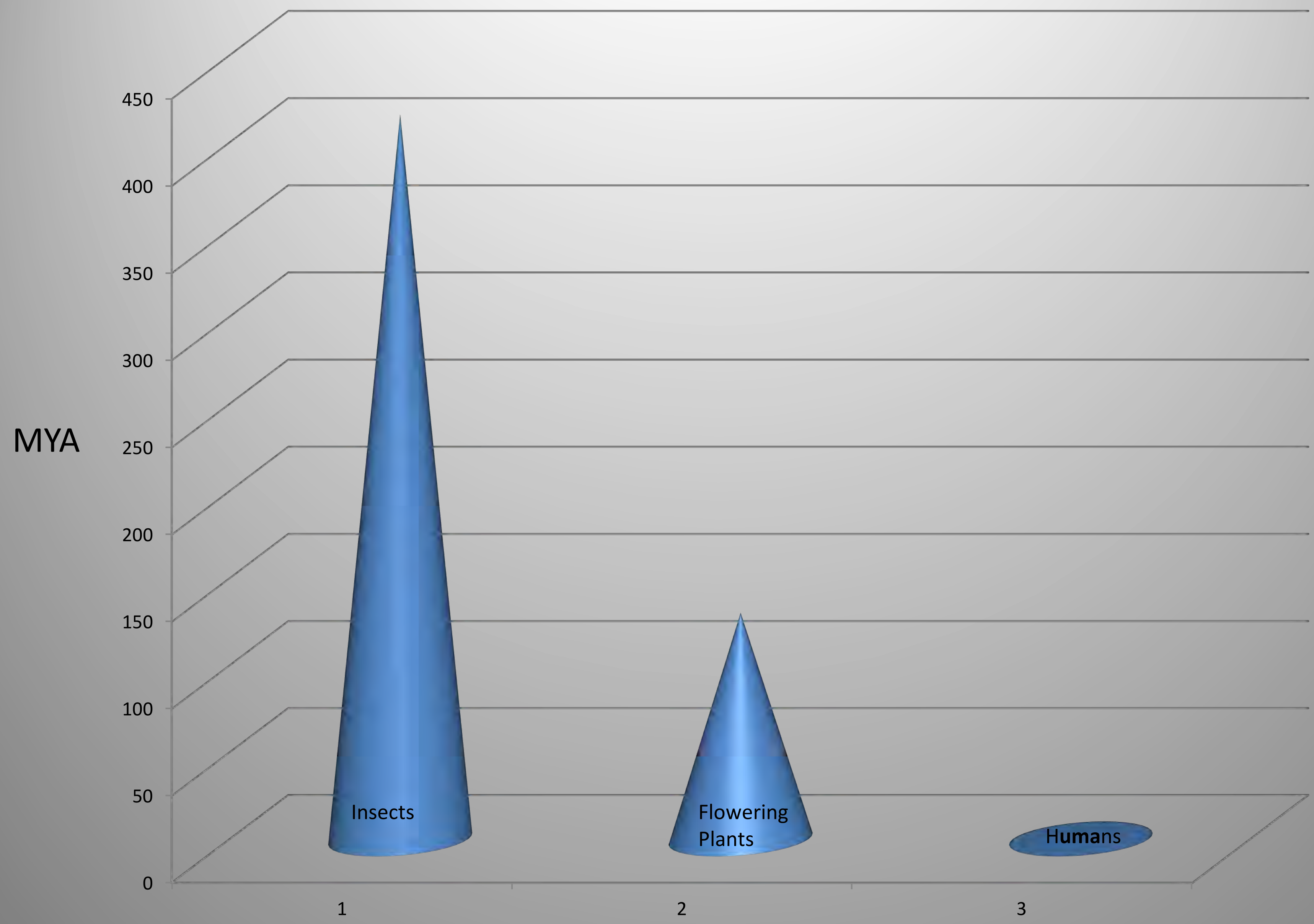
A modern *Remepedia.* Its ancesters in the early Ordovician gave rise to the hexapods and insects and to the crustacea

| Devonian 412-354 | 416 | **First fossil hexapods found (*Rhyniella*), wingless spore feeders resembling the modern springtails (Collembola). Bristle tails (Archeognatha) appeared later in this era and true insects have arrived.**<br>**Coexisted with mites, centipedes, scorpions and spiders.** |
| --- | --- | --- |

Reconstruction of *Rhyniella*

Modern springtail (*Hypogastrura* sp.

Modern bristle tail (*Qantelsella* sp.)



MYA
450
400
350
300
250
200
150
100
50
0
Insects
Flowering Plants
Humans
1
2
3

# Carboniferous 354-286 MYA

**Radiation of 'exopterygotes' (Palaeoptera & Neoptera) including large dragonflies, cockroaches and bugs etc and other groups now extinct. Insects ruled the air! Predators, sap-feeders and detritus feeders. Many have aquatic larvae. Their large size is attributed to the higher levels of oxygen in the atmosphere.**
**Forests of spore-bearing trees (Lycopods etc)**

Modern dragonfly, Royal Tigertail:
wing span 8 cm
Fossil dragonflies: wing span 60 cm

Modern wood cockroach
*Panesthia australis*

Cast skin of
Dragonfly nymph

| | | |
|---|---|---|
| **Permian 286-252 MYA** | | **Appearance of first endopterygotes, including beetles (Coleoptera) and sawflies (Hymenoptera) although ancestral cockroaches were still dominant.** |
| **Permian Triassic boundary** | 252 | **Mass extinctions (asteroid impact)** |

**METAMORPHOSIS**

< From this

Wood boring longicorn larvae

To this:

Soil dwelling
Christmas beetle larva

Modern sawfly *Perga affinis*

| | | |
|---|---|---|
| Triassic 252-201 MYA | | All insect Orders seen today appear.<br>Age of cycads |
| Jurassic 201-145 MYA | | Moths (Lepidoptera) and wasps (Hymenoptera) appear with more beetle radiations.<br>Range of fossil insects from Talbragar fish beds.<br>Birds & mammals appear and predate on insects.<br>Forests of conifers & cycads. Their wood and the nectar and spores in cones are food for herbivorous insects |

| | | |
|---|---|---|
| **Cretaceous 145-66 MYA** | | **Flowering plants (angiosperms) appear 130 MYA.**<br>**Insect herbivores, pollen and nectar feeders rapidly diversify on angiosperms.**<br>**Blood, carcass and dung feeders diversify.**<br>**Gondwana breakup starts** |
| **Cretaceous/Tertiary (Palaeogene) Boundary** | 66 | **Mass extinction event (meteorite?). ¾ of all species became extinct** |

Leaf beetles (Chrysomelidae) diversify on different Angiosperms. This is the modern Hop-bush leaf beetle, *Callidemum hypochalceum*

Modern native dung beetle, *Onthophagus australis*, in wombat dung

Burmese amber mid Cretaceous

# Cycad pollination by weevils

A modern rainforest cycad, *Lepidozamia hopei* (Daintree)

Modern cycads are pollinated by weevils that also breed In the female cones. Ancient cycads may have had the same dependence.

# Radiation of siphonate insects

*Buccinatormyia magnifica*
Zhangsolvidae fly in amber 125 MYA

Impression of Zhangsolvidae fly feeding on nectar at female cone of a Bennettitales 125 MYA ago in mid Cretaceous

Modern soldier fly
Stratiomyidae

Reconstruction of *Darwinus marcosi* (Oedemeridae) A false blister beetle.

**Pollen**
*Monosulcites* pollen: Cycadales 125 MYA

Modern false blister beetle
*Pseudolycus hilaris* feeding on flowers of
*Acacia parramattensis* ACT

# Flower visitors

Sawfly, *Neoeurys* sp visiting buttercup, *Ranunculus graniticola*

Flies on native white lily, *Diplarenna morea*

Pollen feeding katydid, *Zaprochilus australis*

Unidentified Potter wasp, Eumeninae

# Blood feeders

Biting flies on a lion in Namibia

Wallaby ked, *Ortholfersia macleayi*

Horse fly , *Scaptia maculiventris*, probing my shirt

Mosquito, *Culex* sp.

'No-see-um' biting midge, *Culicoides* sp

Snipe fly, *Spaniopsis* sp

| Cainozoic<br>65 MYA-present | | | Many modern insect genera detected in amber deposits in Baltic region & Burma. |
| --- | --- | --- | --- |
| | Palaeocene<br>65-55 MYA | | Butterflies and bees appear<br>Australia separates from Antarctica |
| | Eocene<br>55-33 MYA | | Fossil leaf deposits from mesic forests show insect feeding (Dalton) |
| | Oligocene<br>33-23 MYA | | Grassland expansion, grasshoppers diversify<br>Spread of eucalypts and diversification of their foliage feeding insects |

Dalton fossil leaf deposit in park

Gumleaf grasshopper, *Goniaea australasiae*

Eucalypt leaf beetle, *Apocera* sp.

Eucalypt leaf beetle, *Paropsisterna m-fuscum*

Cattle poisoning sawfly, *Lophyritoma interrupta*

Gumleaf skeletoniser, *Uraba lugens*

# The Evolutionary Arms Race

A major feature of insect/plant relations and insect/predator/parasite interactions is the coevolution of adaptations and counter adaptations to stay alive and reproduce.

1) Plant defence. Most plants produce different kinds of secondary chemical compounds to deter insect feeding. Insect herbivores develop digestive systems to break down these chemicals or divert them to other uses. This results in host specialisation and an inability to feed on other plant species

White lace lerp, *Cardiaspina albitextura*, restricted to leaves of Blakely's Red Gum

Gumtree scale, *Eriococcus confusus*, Found on stems of many eucalypts species

Acacia leaf beetle, *Calomela bartoni*, on Silver Wattle

Eucalypt leaf beetle, *Paropsisterna obliterata*, feeding on Snow Gum

Mistletoe day moth, *Comocrus behri* , in defensive posture

Shield Bug,  *Commius elegans*, feeding on Cherry Ballart  fruit

# 2) Insect defence against predators and parasites

## a) camouflage

Two looper caterpillars (Geometridae) on a eucalypt.
Daytime stance against bird predation.
NB Counter shading

Grasshopper, *Psednura pedestris*, on a Jointed Rush, its food plant

# b) Physical defences – bristles and hairs, stings, bites

Long-tailed Bombyx, *Trichiocercus sparshalli*

Raspy cricket, *Hadrogryllus* sp.

Bulldog ant, *Myrmecia gulosa*

Bee killer (Asassin Bug),
*Pristhesancus plagipennis*

Blue ant (female flower wasp), *Diamma bicolor,* quite a sting

# c) Chemical defences – anti-feedents and irritants

Stink bug nymph, *Amorbus* sp. (E-2-hexenal)

Jewel Beetle, *Cyrioides imperialis* (buprestin)

'Spitfires' sawfly larvae, *Perga affinis,* regurgitating eucalypt oils

Everted **osmeterium** of an orchard butterfly caterpillar, emitting a pungent chemical derived from citrus host plant

# The most distasteful of all!

Net-winged beetle, *Porrostoma rhipidium*, contains a distasteful pyrazine

Soldier beetle, *Chauliognathus lugubris,* secretes 8*Z*-dihydromatricaria acid from abdominal vesicles, possibly derived from the flowers it feeds on.
A soldier beetle from Burmese amber was shown with extruded vesicles 100 MYA (mid-Cretaceous)!

# d) Mimicry: Models and Mimics

European wasp, *Vespa germanica*, a queen
ArchitpalModel with sting

**WARNING COLORATION**

Hairy flower wasp,
*Campsomeris gilesi* (Scoliidae)
Male no sting

Mimic: flower wasp *Catochelus* sp. sp. (mating)
Male no sting

Hover fly *Melangyna* sp feeding on pollen of Blackthorn, *Bursaria spinosa*
No sting

# More mimicry: by flies

Model: Potter wasp, *Euodynerus* sp
Female has sting

Mimic: Hover fly, *Sphiximorpha breviscapa*

Robber fly, *Daptolestes limbipennis*

# More mimicry: in beetles

Model: Net winged beetle,
*Porrostoma rhipidium*

Mimic: jewel beetle, *Castiarina erythroptera.*
Muellerian mimicry (toxic)

Mimic: bellid weevil, *Rhinotia haemoptera*
Batesian mimicry (non-toxic)

# More mimics of net-winged beetles

Unknown species of false click beetle
Eucnemidae

Snipe fly, *Pelecorhynchus fulvus*

# Ant mimics

Example of ant model: dolly ant, *Dolichoderus* sp

Batesian Mimic: a seed bug, *Daerlac cephalotes*

Muellerian Mimic: velvet ant, *Eupatomorpha* sp

# More ant mimicry: juvenile katydids

1st stage nymph of garden katydid
*Caedicia simplex*

Adult

# Regulation of Insect Numbers

- Most insect species have a huge capacity for increase each generation

An attractive Leaf Moth, *Gastrophora henricaria*

Its ugly caterpillar

If all its caterpillar offspring survived from ?1000+eggs, its eucalypt host plant could be entirely defoliated

# So what is regulating numbers ?

- Finding a specific food supply
- Quality of food
- Weather & Climate
- Predators and Parasites

Crab spider catching leaf beetle larva

Ichneumonid Wasp, *Stenorella victoriae*, Parasitising nest of resin bee

The more complex these interactions the more buffering and stability of populations.

The importance of density dependant factors

# Dispersal: a life force in insects

After emerging from the final immature stage (the pupa  or last instar nymph) most insects undergo a dispersal flight (or walk in the case of wingless species)

The implications of  this is that dispersing insects readily find new habitats and host plants, including one's garden.

Darkling beetle, *Lepispilus* sp

Grasshopper, *Urnisa guttulosa*

# Migration

Bogong Moth, *Agrotis infusa*

Spur-throated locust, *Austracris guttulosa*

Bush fly, *Musca vetutissima*

Caper white, *Belenois java*

# Natural ecosystems versus agricultural ecosystems

**Natural ecosystems**: typified by high species diversity and complex interactions Between and within plant and animal species across complex food webs = **stability**

Grassy Box Woodland Burra Reserve

# Impact of agriculture on grassy box woodland


# Agricultural landscapes. Low native species diversity, often with a preponderance of exotic species, prone to outbreaks of insect species, both native and exotic

Plague of wingless grasshopper, *Phaulacridium vittatum*, in pastures in the Braidwood area 1982-83

Plague of Christmas beetle, *Anoplognathus* spp
Yass area 2013



Plague of eucalypt weevil, *Gonipterus* sp., on manna gum, *Eucalyptus viminalis*, Monaro 2012

# Yellow swarming fly, *Chloromerus striatifrons*
March 2015

# Environmental Services provided by Insects

## 1 Breakdown of fallen leaves

Case-bearing leaf beetle larvae, *Cadmus aurantiacus*,
Feeding on fallen eucalyptus leaf

Concealer moth larva feeding
on fallen eucalypt leaves

Unidentified ghost moth larva (Hepialidae)

Example of an adult concealer moth
*Crepidosceles*? sp. (Oecophoridae)

# 2) Wood

Stage 1: cambial tunnelling by the larvae of the eucalypt borer, *Phoracantha semipunctata* and allied species

# Stage 2: cambium & dead wood chewers

Under bark cockroach, *Laxta friedmanni*

Darkling beetle, *Promethis* sp

Darkling beetle, *Lepispilus* sp.

Bess beetles, *Mastichilus* sp.

# 3) Decomposers of rotting plant material and its conversion to humus


Unidentified native earwig feeding in compost


Larva of compost fly *Exaireta spinigera*


Adult fly

Cockchafer larva in cell in humus
(Scarabaeidae)

False Wireworm (Tenebrionidae)

Some colourful beetles whose larvae feed in compost and humus

Spotted chafer, *Polystigma punctata*

Fiddle beetle, *Eupoecila australasiae*

Cowboy Beetle, *Chondropyga dorsalis*

Golden Stag beetle, *Lamprima aur*ata, Female

# 4) Disposal of Dung

## a) Dung shredders

Rove beetles, *Anotylus* sp. shredding a ball of wombat dung

Flies, *Lamprogaster excelsa* and *Euprosopia* sp. shredding wombat dung

## b) Dung buriers

Native dung beetle, *Onthophagus australis*, under kangaroo dung

Native dung beetle, *Onthophagus granulatus*, in cattle dung.

Introduced dung beetle , *Onitis alexis* In cattle dung

Accidentally introduced dung beetle, *Aphodius fimetarius,* dispersing

# 5) Cadaver Breakdown

1st stage is liquifaction by fly larvae

Greenbottle *Chrysomya* sp

Flesh Fly Sarcophaga sp

Blowfly *Calliphora stygia*

# 2nd stage following desiccation

Carcass beetle, *Ptomaphila lacrymosa*

Larvae

Bacon beetle larva , *Dermestes* sp.

# Nectar & Pollen – a source of energy for predators & parasites - Beetles

Ladybird larvae feed on aphids

Clerid larvae feed on the larvae of cambium-boring beetles

Larvae of soldier beetles are generalist soil predators

Flower beetle larvae feed on grasshopper egg-pods

# Wasps

Sand wasps stock their nest with caterpillars

Spider wasps stock their nests with wolf spiders and huntsman

Mud wasps stock their nests with caterpillars

Potter wasps also stock their nests with caterpillars


Flower wasps parasitise scarab larvae


Gasterupid wasps parasitise bee larvae in nests


Orchid dupe wasp parasitises noctuid moth larvae


Ichneumonid wasp parasitises wood boring moth larvae

# Flies

< Blowfly - larvae feed on cadavers

Bristle fly >
Larvae parasitise scarab larvae

Bee fly - larvae parasitise grasshopper eggs

Horse fly – larvae are generalist predators in soil

# Flower visitors & Pollination

Brown blowfly, *Calliphora augur*, feeding on pollen of pink flannel flower

MYTH: Bees are the commonest visitors to the flowers of native plants of Australia

**Flies** & **beetles** are the most frequent visitors, especially in the cooler and more arid areas

Dance fly, *Hilara* sp., feeding on pollen of Snow Daisy *Celmesia* sp. Alpine areas

Chequered beetle, *Eleale* sp., feeding on pollen of Blackthorn, *Bursaria spinosa*

## MYTH: Insects primary purpose in visiting flowers  is to ensure cross pollination

- Insects are not altruistic, they visit flowers for their resources. Most  feed on nectar and pollen as an energy and growth resource

- Others additionally harvest pollen and nectar to nourish their offspring (bees).

- Flowers have evolved specific features to attract insects in general or specific species.

- Some insects have evolved mouthparts adapted to sweep up and collect pollen, and to imbibe and sometimes store nectar.

Bee fly, *Stauristichus* sp., imbibing nectar of Burgan through a sucking proboscis

Day-flying moth, *Hecatesia fenestrata*, Imbibing nectar from a rice flower, *Pimelea* sp

Jewel beetle, Castiarina lapping up nectar from a tea-tree flower cup

Horse fly, *Dasybasis*, sweeping up pollen from a billy buttons, *Craspedia* sp.

# MYTH: wattles, *Acacia* spp., are pollinated by bees

NO, they are mostly pollinated by small beetles in a range of species and the common hover fly that are active in early spring before bees emerge.
They also pollinate the summer- flowering Acacias.
Acacia flowers are rich in pollen but lack nectar although they may be scented

Flower weevil, *Ancyttalia* sp

Chrysomelid*, Diandichus ?analis*

Chrysomelid, *Peltochema* sp

Hide beetle *Eurhopalus* sp

Early spore-feeding mandibulate insects were pre-adapted to feed on pollen once the flowering plants appeared in the late Cretaceous era but some may have used the flowers as food.

Others with siphonate mouthparts that were feeding on exudates from gymnosperm cones were pre-adapted to feed on nectar-producing flowers that appeared at the start of the Paleogene

Flower beetle , *Dicranolaius villosus*, feeding on copper wire daisy petals of *Podolepis jaceoides*

Many species aggregate on flowers for mating as well as feeding and their stays may be brief

Tumbling flower beetles, *Mordella* sp. on Blackthorn, *Bursaria spinosa*

# Meadows of Flat weed, *Hypochaeris radicata*

Day flying moth, *Asterovora* sp
imbibing nectar

Reed bee, *Exoneura* sp.
harvesting pollen

# Sustaining and encouraging insect diversity on your property

1 Where are the insects breeding ?

2 Retain and restore native vegetation. Encourage natural regeneration

3 Retain or plant a range of forbs, grasses, shrubs and trees from different plant families as food for plant-feeding larvae and adults. They will find them!

4 Try and have flowers present all year round through choice of species. Most species flower in spring. Incorporate summer and winter flowering species to provide continuity of pollen and nectar sources

5 Don't be too hooked on local native plants. But don't pick potentially invasive species e.g. some wattles and heaths

6 Don't abandon your exotic plants. There are several that attract native insects ie orchard butterfly on citrus, pollinators visiting flowers of herbs

6 Retain or place rocks and old eucalypt and wattle logs around and allow the latter to decay. Retain standing dead trees with bark on. Beware of termites.

7 Retain or establish patches of deep natural litter in suitable locations, i.e. around logs

# Native insects and exotic flowers

Hairy flower wasps, *Scolia* spp., feeding on nectar from chinese chives

# Bess beetles under stump

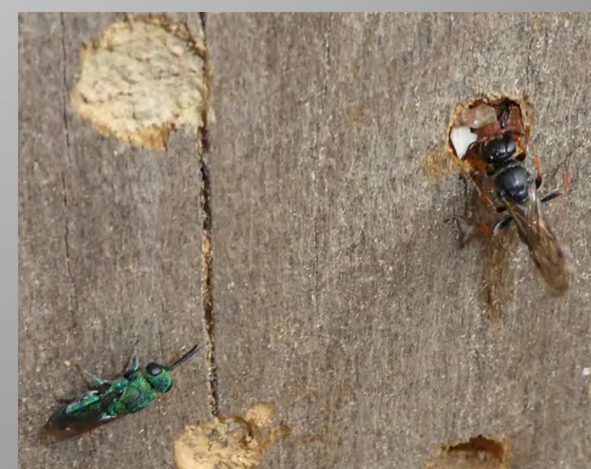
MYTH: bee houses will attract large numbers of native bees for nesting year after year

1. Many native bees are ground nesters except for resin, leaf cutter, masked, blue banded and carpenter bees
2. Holes are often occupied by native wasps but this is not a bad outcome
3. Parasitic wasps and cuckoo bees are also attracted to the nesting holes of host bees and wasps and the majority of nesters could be parasitised: that's the balance of nature
4. Artificial nesting holes are not reused unless cleaned out of nesting material each year
5. Large bee houses simply have too many holes for the number of local hole- requiring insects
6. Small numbers of holes dispersed in posts, dead stumps, billets, packets of bamboo, clay-filled concrete blocks etc. are a better option (No treated timber)

oles occupied by mason wasp, *Pison* spp.

Digger wasp, *Isodontia* sp.

Masked bee, *Hylaeus* sp



Cuckoo wasp, *Chrysis* sp. & mason wasp, *Pison* sp

# A Cautionary Tale


Keys Matchstick,
*Keyacris scurra*

Heath morabine, *Heide amalculi,* Scotts NR Bungendore

# Kearney & Hoffman Survey of Southeast NSW 2019

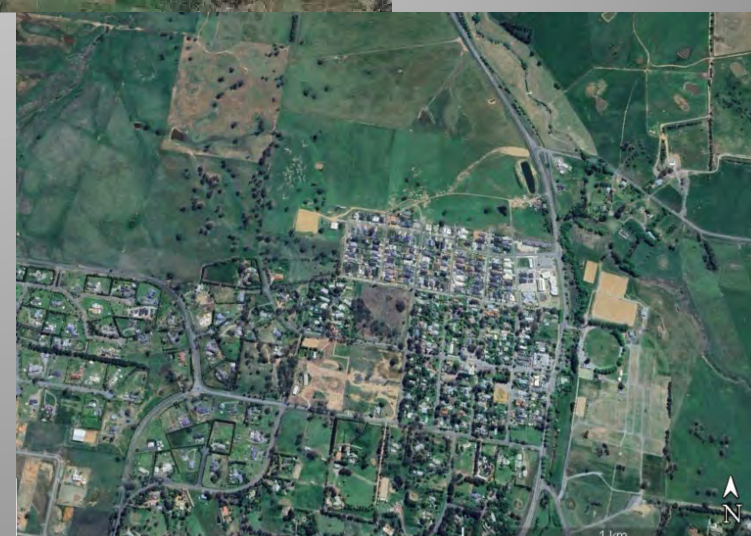
| | Sites visited | Cemeteries | | Other Sites | |
|---|---|---|---|---|---|
| | 93 (102) | 25 | | 68 | |
| With Keyacris | 26 | 3 | | 23 | |
| % | 28 | 12 | | 34 | |
| | | Existing | New | Existing | New |
| | | 23 | 2 | 39 | 29 |
| With Keyacris | | 3 | 0 | 11 | 14 |
| % | | 13 | 0 | 28 | 48 |
| | | | | | |

## Summary of Conservation Assessment

- *Keyacris scurra* Key's Matchstick Grasshopper was found to be eligible for listing as Endangered
- The main reasons for this species being eligible are
- i) inferred restricted geographical range (AOO = 124 km2)
- ii) severe fragmentation
- iii) historical and inferred ongoing decline in abundance, habitat availability and quality
- iv) ongoing threats (and poorly understood management requirements)
- This species is now locally extinct at many previously known locations.


Almost 100% loss of local open grassy box woodland Keyacris habitat

Remnant GBW



# Mowing


Hall Cemetery


Dalton Cemetery

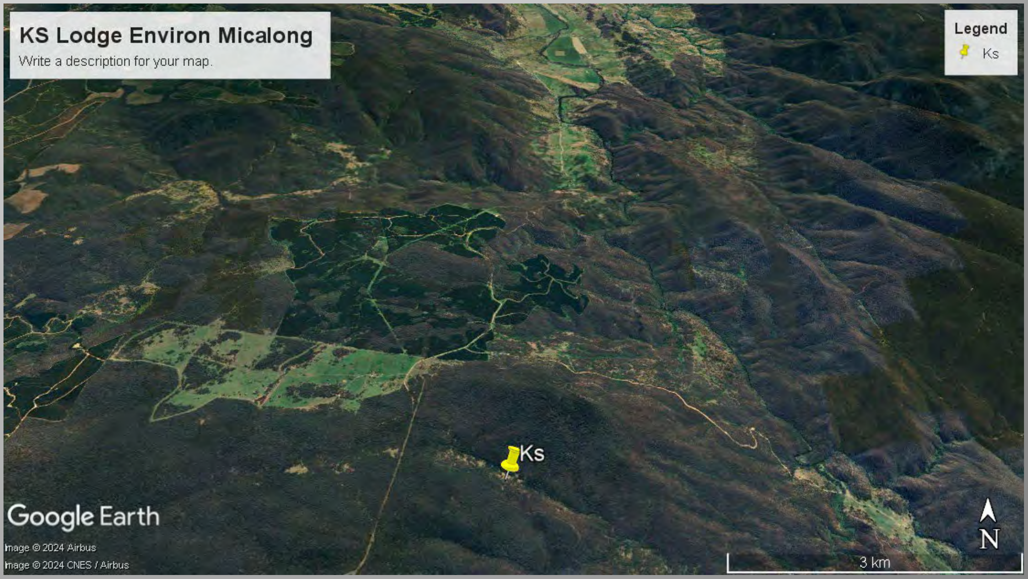

Dalton Cemetery
Keyacris


Dalton Cemetery
Current mowed area


Dalton Cemetery
Old mowe d area

# Newly discovered populations

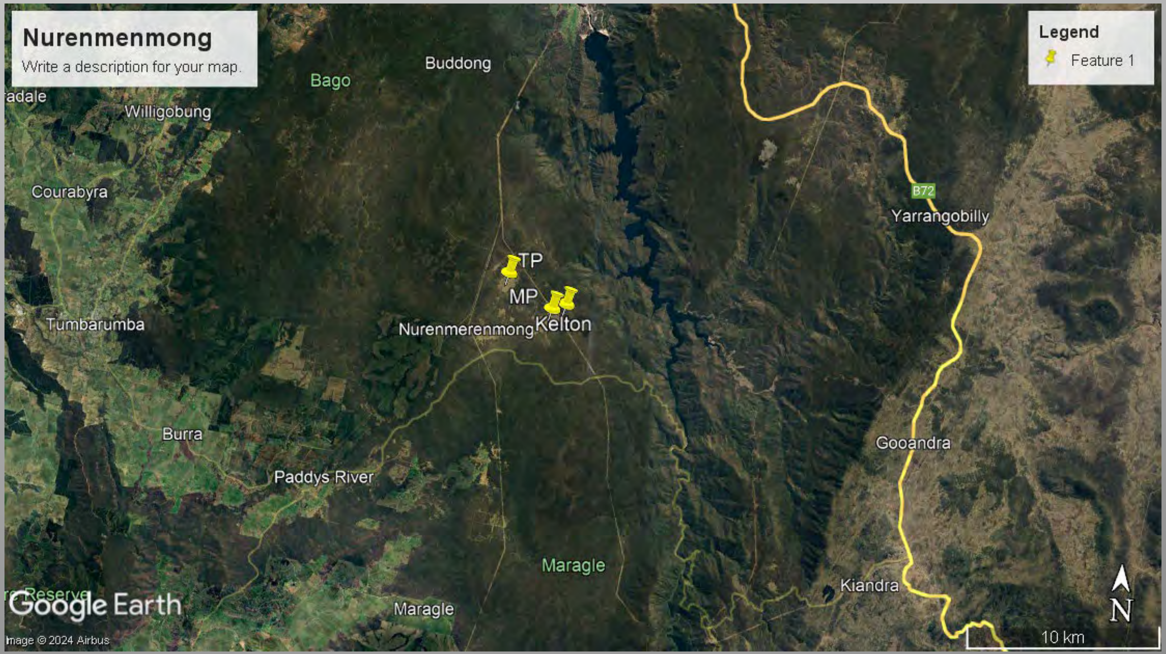

Isolated grassland clearing




Micalong State Forest

# High Altitude

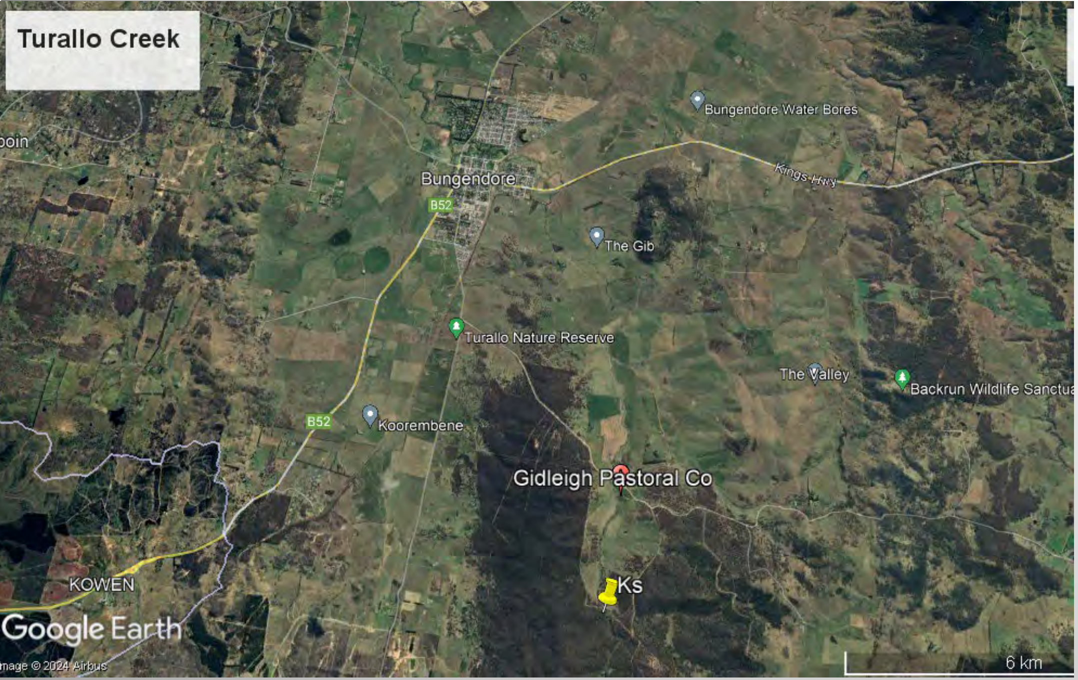

Tomneys Plain 1100m




Themeda grassy woodlands surrounding Smiths TSR

Smiths TSR (Bungonia)
Pig Damage

# ?Atypical Habitat





Upper Turallo Creek

Chrysocephalum semipapposum

# Tiny populations can survive

Tuggeranong Hill NR 250 m2

Mulligans Flat NR
20X population increase between spring 2023 and autumn 2024

# GONE?

*Laxabilla smaragdina*
Not seen in the native grasslands of Southern Tablelands for more than 30 years