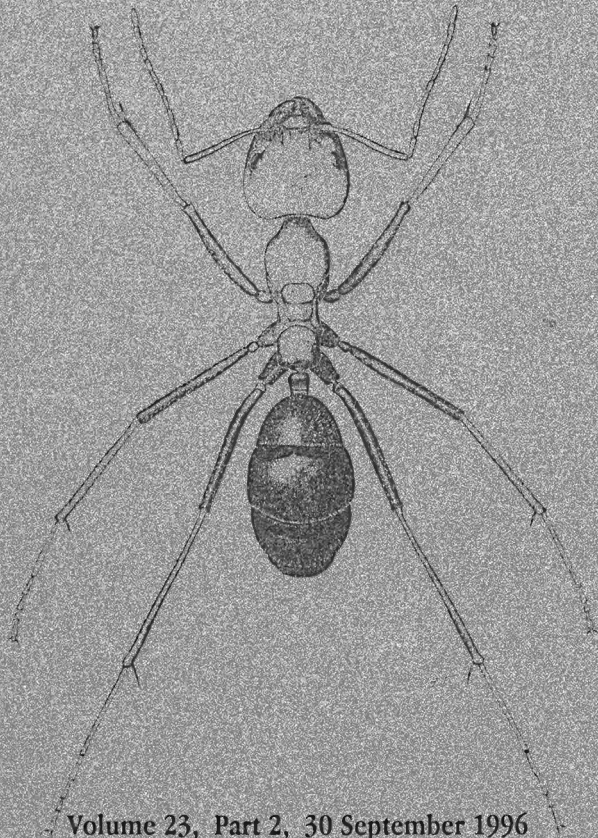


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**Cover:** This illustration shows a worker ant of the *Iridomyrmex purpureus* group. The ants of this complex are better known as Australia's ubiquitous meat ants. They form large colonies which live in broad flattened nests with multiple entrances and with the surface decorated with small pebbles. Illustration by Geoff Thompson.

## FLOWER VISITATION BY THE BUMBLE BEE *BOMBUS TERRESTRIS* (L.) (HYMENOPTERA: APIDAE) IN TASMANIA

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### Abstract

To date the bumble bee *Bombus terrestris* (L.), first detected in Tasmania in February 1992, is known to have visited 156 introduced and 14 native species of plants there.

### Introduction

The bumble bee *Bombus terrestris* (L.), first detected in Australia in a garden in Battery Point, Hobart in February 1992 (Semmens *et al.* 1993), has spread throughout most of Hobart, including the Eastern Shore and Collinssvale, down into the Huon Valley, at Franklin and Cygnet, into the Channel area south of Hobart; also to the west of Hobart to New Norfolk and Mt Field and to the north of Hobart to Kempton. It appears to be thriving in southern Tasmanian conditions. This species is one of 4 introduced into New Zealand from the United Kingdom in 1885-1906 for pollination purposes, particularly of red clover; it may have spread to Australia from New Zealand.

### Flower visitation

The flower visiting rate of *Bombus terrestris* is much higher than for other bees (Donovan and Macfarlane 1984). In Tasmania at least 170 plant species have been visited - 156 introduced and 14 native species (Table 1). This agrees with findings in New Zealand, where *Bombus terrestris* was reported to have visited at least 400 introduced and 19 native species (Donovan and Macfarlane 1984).

**Table 1.** Plant species visited by the bumble bee *Bombus terrestris* in Tasmania to July 1996.

Native Species	
<i>Acacia pravissima</i> (Ovens Wattle)	<i>Eucryphia lucida</i> (Leatherwood)
<i>Banksia marginata</i> (Banksia)	<i>Exocarpos cupressiformis</i> (Native Cherry)
<i>Callistemon pallidus</i> (Bottlebrush)	<i>Grevillea</i> sp. (Grevillea)
<i>Callistemon viridiflorus</i> (Green Bottlebrush)	<i>Melaleuca armillaris</i> (Bracelet Honey Myrtle)
<i>Correa nummularifolia</i> (Native Fuchsia)	<i>Melaleuca squamea</i> (Swamp Honey Myrtle)
<i>Epacris languinosa</i> (White Epacris)	<i>Oxylobium ellipticum</i> (Golden Rosemary)
<i>Eucalyptus ficifolia</i> (Red Flowering Gum)	<i>Westringia</i> sp. (Native Rosemary)
Introduced Species	
<i>Abelia schumannii</i> (Abelia)	<i>Aquilegia</i> sp. (Columbine, Granny's Bonnet)
<i>Acanthus</i> sp. (Bear's Breeches, Oyster Plant)	<i>Arbutus unedo</i> (Irish Strawberry)
<i>Acer psuedoplatanus</i> (Sycamore)	<i>Arctotis</i> sp. (African Daisy)
<i>Acontium napellus</i> (Monkshood)	<i>Asparagus officinalis</i> (Asparagus)
<i>Actinidia chinensis</i> (Kiwi Fruit)	<i>Aubrieta</i> sp. (Aubrieta)
<i>Agapanthus orientalis</i> (Agapanthus)	<i>Bellis</i> sp. (Daisy)
<i>Ajuga</i> sp. (Ajuga)	<i>Beta vulgaris</i> (Swiss Chard)
<i>Alcea rosea</i> (Hollyhock)	<i>Borago officinalis</i> (Borage)
<i>Allium schoenoprasum</i> (Chives)	<i>Brassica oleraceae</i> (Broccoli)
<i>Alstroemeria</i> sp. (Peruvian Lily)	<i>Brassica</i> sp. (Tatsoi)
<i>Antirrhinum majus</i> (Snapdragon)	<i>Buddleia</i> sp. (Buddleia)

### Introduced Species (cont.)

<i>Cakile maritima</i> (Sea Rocket)	<i>Lobelia</i> sp. (Lobelia)
<i>Ceanothus</i> sp. (Ceanothus)	<i>Lobularia maritana</i> (Sweet Alice)
<i>Centaurea cyanus</i> (Cornflower)	<i>Lonicera japonica</i> (Honeysuckle)
<i>Centranthus ruber</i> (Valerian, Kiss-me-quick)	<i>Lophomyrtus</i> sp. (Lophomyrtus)
<i>Cerastium tomentosum</i> (Snow-in-summer)	<i>Lupinus</i> sp. (Lupin)
<i>Chaenomeles</i> sp. (Japonica)	<i>Lycopersicon esculentum</i> (Tomato)
<i>Citrus aurantium</i> (Orange)	<i>Malus domestica</i> (Apple)
<i>Citrus limon</i> (Lemon)	<i>Malus ioensis</i> (Flowering Apple)
<i>Citrus paradisi</i> (Grapefruit)	<i>Matthiola</i> sp. (Stock)
<i>Citrus reticulata</i> (Mandarin)	<i>Meconopsis betonicifolia</i> (Blue Poppy)
<i>Clematis</i> sp. (Clematis)	<i>Melissa officinalis</i> (Balm, Lemon Balm)
<i>Coleonema</i> sp. (Golden Diosma)	<i>Mentha piperita</i> var <i>citrata</i> (Mint)
<i>Consolida</i> sp. (Larkspur)	<i>Monarda</i> sp. (Bergamot)
<i>Convolvulus</i> sp. (Convolvulus)	<i>Myosotis</i> sp. (Forget-me-not)
<i>Conyza</i> sp. (Erigeron)	<i>Myrtus communis</i> (European Myrtle)
<i>Coprosma</i> sp. (Coprosma)	<i>Myrtus ugni</i> (Chilean Guava)
<i>Corylus avellana</i> (Hazel)	<i>Nepeta cataria</i> (Catmint)
<i>Cosmos</i> sp. (Cosmos)	<i>Nothofagus</i> sp. (Beech)
<i>Cotoneaster horizontalis</i> (Cotoneaster)	<i>Origanum vulgare</i> (Oregano)
<i>Crocus</i> sp. (Crocus)	<i>Paeonia</i> sp. (Peony Rose)
<i>Cucurbita</i> sp. (Pumpkin)	<i>Papaver nudicaule</i> (Icelandic Poppy)
<i>Cytisus palmensis</i> (Tree Lucerne)	<i>Papaver orientale</i> (Oriental Poppy)
<i>Daboecia cantabrica alba</i> (Irish Heath)	<i>Passiflora</i> spp. (Passionfruit)
<i>Dahlia</i> sp. (Dahlia)	<i>Pelargonium</i> sp. (Pelargonium)
<i>Delphinium</i> sp. (Delphinium)	<i>Penstemon</i> sp. (Penstemon)
<i>Dianthus</i> sp. (Carnation)	<i>Petunia</i> sp. (Petunia)
<i>Digitalis purpurea</i> (Foxglove)	<i>Phaseolus coccineus</i> (Scarlet Runner Bean)
<i>Dimorphotheca</i> sp. (African Daisy)	<i>Philadelphus mexicanus</i> (Mock Orange)
<i>Echium fastuosum</i> (Pride of Madeira)	<i>Phragmites karka</i> (Bamboo)
<i>Erica</i> sp. (Erica)	<i>Pittosporum</i> sp. (Pittosporum)
<i>Escallonia</i> sp. (Escallonia)	<i>Plantago lanceolata</i> (Lamb Tongue, Plantain)
<i>Fortunella</i> sp. (Cumquat)	<i>Polemonium caeruleum</i> (Jacob's Ladder)
<i>Freesia refracta</i> (Freesia)	<i>Polygonatum</i> sp. (Solomon's Seal)
<i>Fuchsia</i> sp. (Fuchsia)	<i>Protea aurea</i> (Cream Protea)
<i>Fumaria muralis</i> (Fumitory)	<i>Prunus persica</i> (Peach)
<i>Gaillardia</i> sp. (Blanket Flower)	<i>Prunus</i> sp. (Cherry)
Genus unknown (Broom)	<i>Pseudofumaria alba</i> (Corydalis)
Genus unknown (Cactus)	<i>Pyracantha</i> sp. (Pyracantha)
Genus unknown (Orchid)	<i>Rhododendron</i> spp. (Rhododendron, Azalea)
<i>Geranium</i> sp. (Geranium)	<i>Ribes nigrum</i> (Blackcurrant)
<i>Gladiolus</i> sp. (Gladiolus)	<i>Ribes sanguineum</i> (Flowering Currant)
<i>Hebe</i> sp. (Hebe)	<i>Rosa</i> spp. (Roses)
<i>Hedera helix</i> (Ivy)	<i>Rosmarinus officinalis</i> (Rosemary)
<i>Hedychium</i> sp. (Ginger Lily)	<i>Rubus fruticosus</i> (Blackberry)
<i>Helianthus annuus</i> (Sunflower)	<i>Rubus idaeus</i> (Raspberry)
<i>Hydrangea macrophylla</i> (Hydrangea)	<i>Rubus ursinus</i> (Boysenberry)
<i>Hypericum perforatum</i> (St Johns Wort)	<i>Salvia officinalis</i> (Sage)
<i>Impatiens glandulifera</i> (Balsam)	<i>Salvia</i> sp. (Bog Sage)
<i>Jacaranda mimosifolia</i> (Jacaranda)	<i>Scabiosa columbaria</i> (Butterfly Blue)
<i>Jasmine</i> sp. (Jasmine)	<i>Schizanthus pinnatus</i> (Poor Man's Orchid)
<i>Kerria japonica</i> (Kerria)	<i>Senecio cruentus</i> (Cineraria)
<i>Laburnum</i> sp. (Laburnum)	<i>Solanum tuberosum</i> (Potato - "Pinkeye")
<i>Lampranthus</i> sp. (Pigface)	<i>Solidago canadensis</i> (Goldenrod)
<i>Lathyrus odoratus</i> (Sweet Pea)	<i>Symphandra hoffmannii</i>
<i>Lavandula alba</i> (English Lavender)	<i>Symphytum</i> sp. (Comfrey)
<i>Lavandula allardi</i> (French Lavender)	<i>Syringa</i> sp. (Lilac)
<i>Lavandula dentata</i> (French Lavender)	<i>Tagetes</i> sp. (French Marigold)
<i>Lavandula vera</i> (English Lavender)	<i>Taraxacum officinale</i> (Dandelion)
<i>Lavatera trimetris</i> (Mallow)	<i>Tecoma</i> sp. (Tecoma)
<i>Limonium</i> sp. (Statice)	<i>Tibouchina</i> sp. (Lasiandra)

### Introduced Species (cont.)

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<i>Trifolium repens</i> (White Clover)	<i>Vicia faba</i> (Broad Bean)
<i>Trifolium</i> sp. (Clover)	<i>Viola</i> sp. (Pansy)
<i>Tropaeolium</i> sp. (Nasturtium)	<i>Viola wittrockiana</i> (Pansy)
<i>Tulipa</i> sp. (Tulip)	<i>Virgilea</i> sp. (Virgilea)
<i>Ulex europaeas</i> (Gorse)	<i>Watsonia</i> sp. (Watsonia)
<i>Veronica</i> sp. (Veronica)	<i>Weigela</i> sp. (Weigela)
<i>Vicea</i> sp. (Vetch)	<i>Wistaria</i> sp. (Wisteria)

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### Acknowledgment

I thank Dennis Morris of the Tasmanian Herbarium for assistance in identification of the plants.

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NOTES ON THE FOODPLANT OF  
*DEUDORIX EPIRUS AGIMAR* FRUHSTORFER (LEPIDOPTERA:  
LYCAENIDAE)

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**Abstract**

This note records a name change and provides extra information for the foodplant of *Deudorix epirus agimar* Fruhstorfer, documented by De Baar and Johnson (1980).

**Discussion**

The foodplant for this lycaenid was identified as *Harpullia angustifolia* Radlk. (Sapindaceae) by the Queensland Herbarium and recorded as such by De Baar and Johnson (1980). This herbarium sample was then reassigned to *Harpullia ramiflora* Radlk (Reynolds 1981), previously only known from New Guinea. Leenhouts and Vente (1982) have listed *H. angustifolia* as a synonym of *H. ramiflora* and occurring in the Philippines, Moluccas (Halmaheira), New Guinea and Iron Range (northern Queensland). The name change for *H. angustifolia* is mentioned by Dunn and Dunn (1991) as De Baar pers. comm. (1990) without further explanation.

No further foodplant records have been gathered for *Deudorix epirus agimar* since De Baar and Johnson (1980), when two larvae were collected in rainforest along the upper Claudie Riv. near Tozer's Gap, northern Queensland. The fruit of *H. ramiflora* is eye catching as the capsules are red and contain two seeds covered in yellow aril. The trees are a small straggling species within the rainforest canopy.

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THE LIFE HISTORY OF  
*PHALACROGNATHUS MUELLERI* (MACLEAY)  
(COLEOPTERA: LUCANIDAE)

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### Abstract

The life history of *Phalacrognathus muelleri* (Macleay) is described and aspects of its biology discussed. The species is restricted to the wet tropics of northern Queensland where it breeds in rotting wood in rainforest. Larvae have been extracted from the wood of 27 tree species in 13 families. All larvae found were in wood attacked by white rot fungi. The final instar larva is described. Larva, pupa, and parasites are figured.

### Introduction

*Phalacrognathus muelleri* (Macleay) (Coleoptera: Lucanidae) is a well known but poorly documented species. It is variously known as the golden, rainbow, magnificent, Mueller's and king stag beetle, and is the largest Australian member of its family. It is illustrated as the centrepiece to colour plates in both the major textbooks on Australian insects, viz. Tillyard, 1926 and CSIRO, 1970. Since 1973 it has been the official symbol of the Entomological Society of Queensland. The history of the discovery of *P. muelleri* is an interesting story and we have included it here in some detail. The authors wish to thank Dr Geoff Monteith (Queensland Museum, Brisbane) for providing the information in the following two paragraphs.

*P. muelleri* was initially described as a new species of *Lamprima* in 1885 by Sir William Macleay in Sydney on the basis of a single female from "North Australia" sent to him from Victoria by Charles French Snr (Macleay, 1885a). French was later Government Entomologist in Victoria but at that time he was assistant to the redoubtable Victorian Colonial Botanist, Baron Ferdinand von Mueller. Macleay noted that French had asked him to name the beetle after von Mueller, a request ". . . to which it gives me great pleasure to comply . . .". Macleay speculated that the species "may well form the type of a new genus . . . but in the absence of a male specimen . . . it would be premature . . .". This prompted French, perhaps with a twinge of conscience, to immediately send Macleay the male specimen he had held back previously, and in the same year Macleay published a second paper (Macleay 1885b) erecting the new genus *Phalacrognathus*. Macleay described the male as "I think the most beautiful insect I have ever seen, not surpassed in brilliancy of metallic lustre by the most gorgeous of the Buprestidae".

Macleay exhibited the female specimen at the Linnean Society meeting in Sydney on 29 April 1885 where it "excited much attention" (Anon. 1885a) and he exhibited the male at the same venue on 30 September (Anon. 1885b). The origin of those specimens which French sent Macleay remains a

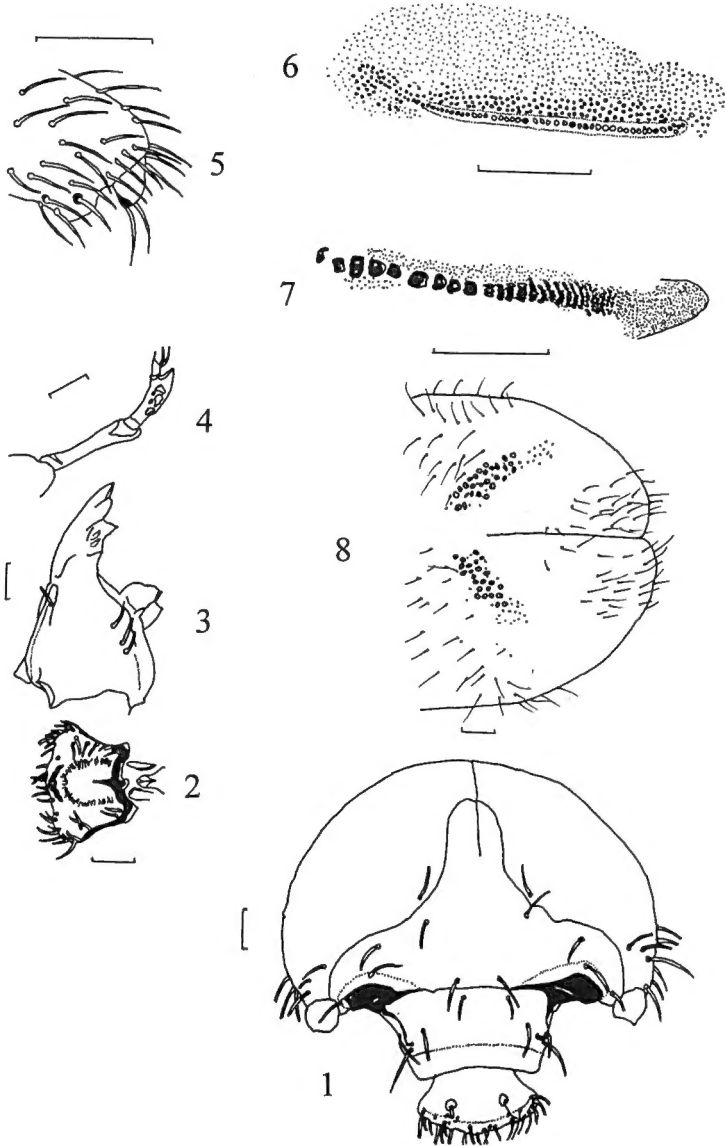
mystery. At that general time von Mueller was employing botanical collectors to work in north Queensland. One of these was William Sayer, who was also a cousin of Charles French. Another collector in north Queensland at that period was Walter Froggatt who, according to Musgrave (1932), sent insect specimens to both French and von Mueller. It is very likely that French's *Phalacrognathus* came from either Sayer or Froggatt. Contemporary entomologists were also curious about the origin of those exciting specimens. At the meeting of the Linnean Society of New South Wales in 1892 Mr A.S. Olliff enquired". . . as to the exact habitat of the splendid lucanid beetle . . . described by Sir William Macleay . . . about which the only information then available was that they came from North Australia?" Mr F.A. Skuse, then entomologist at the Australian Museum, replied that specimens had recently been received by the Museum from "Russell Scrub, Boar Pocket, near Cairns, Queensland" (Anon. 1892). This locality was a popular staging post at that time on the newly opened pack trail from Cairns to the Herberton tinfields via the Mulgrave River and presumably this is how the collector of those specimens would have accessed the area. Much is now submerged under the Tinaroo Dam at the north end of the Atherton Tableland (Toohey, 1994). The species was redescribed under the synonymic name of *Phalacrognathus westwoodi* by Shipp (1893) from a single male in the Oxford University Museum. This specimen had been purchased by Professor Westwood from the dealer Boucard in 1889 and came from the same uninformative locality as had French's specimens: "North Australia".

The few papers published on the biology of this species are largely the result of casual observation (Brooks 1970, Hancock 1970, Dodd 1971, Brunet 1981, Quick 1984). This paper provides detailed information on the biology and natural history of this the most beautiful of Australian beetles. Observations were made over a period of 14 years on a large number of specimens of all stages, taken in the wild or bred in captivity.

### Distribution and Abundance

*Phalacrognathus muelleri* is confined to the rainforests and adjacent wet sclerophyll forests of coastal north-eastern Queensland between Helenvale (15°43'S 145°14'E) near Cooktown and Pine Creek (19°15'S 146°28'E) at the southern end of the Paluma Range. It is referred to variously as very rare (Britton 1970) or extremely rare (Hawkeswood 1987). As pointed out by Wood and Hasenpusch (1990), this conclusion is likely a result of the species only occasionally coming to light, the most frequently used method of insect survey and collection in rainforests. Our study found *P. muelleri* to be common in virtually any rainforest block within its known distribution, although seemingly more abundant on the ranges and tablelands than at sea level. As the total area of rainforest within its distribution is an estimated





Figs 1-8. Third instar larva of *Phalacrognathus muelleri*. (1). Head capsule (mandibles removed); (2). epipharynx, ventral view; (3). left mandible, dorsal view; (4). antenna, inner surface; (5).apex of hind leg; (6). pars stridens on mesocoxa; (7).plectrum on metatrochanter; (8). raster on ventral side of abdominal sternite 10 . (Scale lines = 1 mm ).

7910 km<sup>2</sup> (Bell *et al* 1987), *P. muelleri* can certainly not be described as rare.

### Breeding Sites

*Phalacrognathus muelleri* breeds in rotting wood in both fallen and standing living or dead trees. Larvae may be found in suitable decayed wood with a minimum volume of approximately 10 litres (0.01 cubic metres). Although *P. muelleri* larvae prefer moderately moist conditions they have also been found in both dry and saturated substrates; waste wood left by logging operations is commonly used. Waste wood tends to be available for a relatively short time when compared to unlogged forests where food supply is continuous. In standing trees where there is an abundance of substrate, such as dead portions of a large, living tree, some individuals may complete their life-cycle without leaving the confines of the trunk. Adults feed on the same material as the larvae and supplement their diet with plant sap and fruits. Trees up to 1.5 m in diameter and containing up to 35 cubic metres of wood have been found as suitable. An indicator of this may be a fallen branch riddled with larvae. Such trees can support generations of beetles.

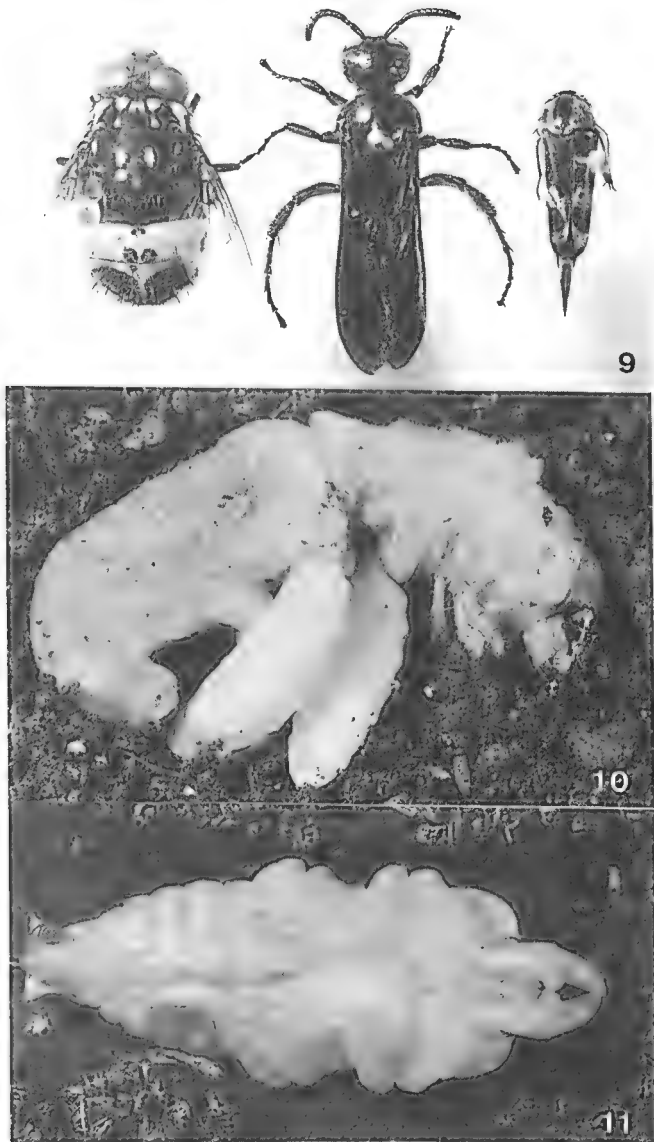
### Life History

#### *Oviposition and Egg*

Up to 50 eggs are laid by each female, either in wood pulp produced by the female as she excavates a tunnel with her mandibles and tibial spines or in pulp produced by older larvae. Substrate the consistency of balsa is suitable for oviposition. Although each egg is deposited singly, females have been observed to lay up to 30 eggs in close proximity. Captive females laid readily in whole pieces of substrate of suitable size but did not oviposit in artificially produced pulp from the same timber. Newly laid eggs are 2.9-3.7 mm long and 2.2-2.8 mm wide. The surface is smooth with distinct, fine, hexagonal microsculpture, and they are slightly longitudinally flattened in shape. Eggs take 10-14 days to hatch, each expanding to become almost spherical and approximately doubling in volume as they mature. Colour changes from translucent white to dark cream. The larva is visible within the egg just before emergence. The egg splits lengthwise on hatching but a seam or ridge is not visible beforehand.

#### *Larval Description and Behaviour*

Of the 18 genera of Lucanidae currently recognised in the Australian fauna (Moore and Cassis 1992), the larval stage has been described for very few. Alderson (1975a, 1975b) compared and partially described species of *Lamprima* Latreille, *Lissapterus* Deyrolle, *Lissotes* Westwood, *Syndesus* W.S. Macleay and *Ceratognathus* Westwood. Lawrence (1981) discussed larval Lucanidae in general and although he examined larvae of ten Australian genera (including *Phalacrognathus*), he did not include formal descriptions but did provide a partial larval key to genera and higher



**Figs 9-11.** (9). Parasites and ? hyperparasite of *P. muelleri* larvae (from left to right): *Amphibolia ignorata* Paramonov (Tachinidae); *Liacos insularis* (Smith) (Scoliidae); *Mordella elongatula* (Macleay) (Mordellidae); (10). Larva of *Liacos insularis* (Smith) attached to final instar *P. muelleri* larva; (11). Pupa of male *P. muelleri* showing lateral spines on apical abdominal segment.

categories. It is beyond the scope of this paper to discuss the larval relationships of *P. muelleri*. However, the following description of the final instar larva and illustrations of some characters used in the classification of lucanid larvae are provided:

**Head** (Fig. 1). Maximum width 7.2 - 12.0 mm. Colour light brown with posterior 2/3 of clypeus, antennae and labrum darker brown, anterior frontal angles and mandibles black. Frontal setae (pairs): 1 anterior angle, 1 anterior, 1 exterior, 2 posterior. Clypeus slightly convex with lateral seta and a short lateral tubercule. Labrum obtusely pointed apically. Left mandible (Fig. 3) with 3 apical teeth, right mandible with two, both mandibles with a shallow groove on outer side from base for about half the length. On the epipharynx (Fig. 2), haptomerum with 5 sensilla in a straight line, chaetoparia with 6-11 scattered setae towards outer margin, phobia semicircular, irregular, mostly made up of short blunt spines, epitorma narrow, about 1/3 length of phobia, pternotormae short, obtuse, two well sclerotized lateral and one medial nesia in the haplolachus. Oncylus of hypopharynx strong, triangular, apex acute. Antennae (Fig. 4) 4-segmented, first segment short almost completely fused to the second long, glabrous segment, third segment shorter with inner, irregular lateral and oval, subapical sensory patches, fourth segment short with two setae midway along inner margin, and one seta on subacute apex.

**Thorax**. With a pair of dorsolateral sclerotized plates just behind head and a pair of ventral sclerotized plates in front of procoxa, meso- and metapleural lobes sclerotized above legs. Tibiotarsus, femur, and trochanter of each leg with ventral and lateral surfaces strongly granulate at base of each seta. Tarsungulus (Fig. 5) short, blunt, with an apical and a subapical seta. Pars stridens (Fig. 6) an area of confused microgranules, with a row of about 50-60 distinct larger granules along outer edge, increasing in size towards apical end. Plectrum (Fig. 7) consists of confused granules at apical end, grading to a single series of about 30 granular rows finally becoming oval, striated plates nearest coxa.

**Spiracles** C-shaped, thoracic largest, abdominal spiracles 4 and 5 smallest.

**Abdomen**. Dorsal surface of all abdominal segments with fields of short to long posteriorly directed setae, setae longest near the posterior margin of each segment. Raster (Fig. 8) present on ventral surface of segment 10 in the form of a V-shaped band of spinules, interrupted at apex. Upper anal lobe transverse, triangular, bare, crescent shaped on outside of lateral anal lobes.

Larvae live singly, but often in close proximity, within the decaying wood and may travel several metres through it as they develop. Excavated pulp is packed behind as the larva moves forward. Pieces of substrate are isolated by the mandibles and then grasped by the mandibles and legs and passed backwards. This action is achieved by arching the body upwards in the

**Table 1.** Host Tree Species for *P. muelleri* larvae

Family	Species	No. of Samples
Apocynaceae	<i>Alstonia scholaris</i> (L.) R. Br.	*
Cunoniaceae	<i>Ceratopetalum succirubrum</i> C.T. White	12
Cunoniaceae	<i>Caldcluvia australiensis</i> (Schltr.) Hoogl	7
Elaeocarpaceae	<i>Sloanea australiensis</i> (Beth.) F. Muell.	2
Elaeocarpaceae	<i>Sloanea</i> sp.	2
Flindersiaceae	<i>Flindersia pimenteliana</i> F. Muell.	3
Flindersiaceae	<i>Flindersia pubescens</i> F.M. Bail.	1
Lauraceae	<i>Beilschmiedia bancroftii</i> (F.M. Bail.) C.T. White	4
Lauraceae	<i>Beilschmiedia</i> spp.	3
Lauraceae	<i>Cryptocarya mackinnoniana</i> F. Muell.	1
Lauraceae	<i>Endiandra monothyra</i> B. Hyland <i>ssp. monothyra</i>	1
Meliaceae	<i>Dysoxylum</i> sp.	1
Meliaceae	<i>Synoum muelleri</i> C. DC.	*
Mimosaceae	<i>Acacia melanoxylon</i> R. Br.	1
Monimiaceae	<i>Daphnandra repandula</i> F. Muell.	1
Monimiaceae	<i>Doryphora aromatica</i> (F.M. Bail.) L.S. Smith	1
Moraceae	<i>Ficus</i> - 2 spp.	*
Moraceae	<i>Ficus</i> sp.	1
Myrtaceae	<i>Eucalyptus torelliana</i> F. Muell.	*
Myrtaceae	<i>Xanthostemon whitei</i> Gugerli	1
Proteaceae	<i>Cardwellia sublimis</i> F. Muell.	5
Proteaceae	3 Proteaceae spp.	3
Rutaceae	<i>Halfordia kendack</i> (Montr.) Guill.	1
Sapotaceae	<i>Palaquium (Lucuma) galactoxyla</i> (F. Muell.) H.J. Lam	*

\* Hancock (1970.)

**Table 2.** Fungi associated with *P. muelleri* larval development

Family	Species	No. of Samples
Ganodermataceae	<i>Ganoderma applanatum</i> (Pers.) Patouillard	4
Polyporaceae	<i>Nigrofomes melanoporus</i> (Mont.) Murr.	1
Polyporaceae	<i>Phellinus</i> nr. <i>glaucescens</i> (Petch) Ryvarden.	10
Polyporaceae	<i>Phellinus robustus</i> (P.Karst) Baird. & Galz.	1
Polyporaceae	<i>Phellinus</i> - 3 spp.	24
Polyporaceae	<i>Pycnoporus</i> sp.	2

centre, which draws the head under the body. Further movement is achieved by peristaltic movement in the folds of the surface of the thoracic segments. As the larva straightens, material is pressed into the rear wall of the cell. These arching and pressing movements are also used in the production of

oval ecdysal cells before moults. These cells are lined with faeces. Arching into a "C" shape the larva deposits a faecal pellet between the legs. The pellet is broken up with the aid of the mandibles and the larva then uses the flat anterior surface of the head to compress the faecal material on to the cell wall. Each ecdysal cell takes about 24 hours to construct. A few hours after completing the cell the larva moults, eating the cast skin before breaking out of the cell several hours later.

Each larva passes through three instars. From egg to adult takes a minimum of 12 months, with the larval stage a minimum of 11 months. Hancock (1970) reported the pupal stage lasting 4-5 weeks and observed length of time in this study was 3-5 weeks. Larvae that develop in 12 months produce small adults. Larger specimens take 2 to 3 years to develop. Specimens in poor quality substrate may take 4 years to develop and are usually small.

### *Larval Host Plants*

Like most members of the family Lucanidae, larvae of *P. muelleri* feed on decaying wood of various species of trees. Authors names of tree species mentioned here are given in Table 1. Two of the earliest records (Hancock 1970, Britton, 1970) of a suitable species were red cedar (*Toona australis*). Monteith (pers. comm.) felt that both these records were based on the opinion of the late George Brooks, an avid beetle collector based many years in Cairns, that a 'red-timbered log' from which he had taken *P. muelleri* specimens on several occasions was this species. Brooks (1970), about the same time, however, obtained an identification for the log in question which turned out to be *Synoum muelleri* C.DC. (Meliaceae). The record of *Synoum muelleri* cited by Brooks (1970), repeated by Hancock (1970), was later suggested to be a misidentification (J.G. Brooks, pers. comm. to D.L. Hancock) and requires confirmation. Other host records cited by Hancock (1970), apart from *Toona australis*, were supplied by R. Parrott (D.L. Hancock, pers. comm). *Toona* did not produce any specimens of *P. muelleri* in the current study, so should be removed from the host list. Hancock (1970) recorded four other species as hosts, namely *Palaquium* (as *Lucuma galactoxyla*), *Cerbera manghas*, and *Ficus* spp. (two species). It is likely that *Cerbera manghas* (Milky Pine) is in reality *Alstonia scholaris* as the former is primarily a sea level species, the latter being found on the Atherton Tablelands proper (Monteith, pers. comm.). Table 1 gives the tree species recorded in this study. The records of Hancock (1970) are also included except for the removal of *Toona* and the substitution of *Alstonia* for *Cerbera*. A large percentage of logs containing *P. muelleri* larvae have decayed to a point where species identification is not possible. Undoubtedly other tree species are also suitable. Timber samples from logs infested by *P. muelleri* larvae were identified by officers of the Queensland Forest Service. Leaf specimens from living trees were identified by Bernie Hyland of CSIRO, Atherton (5 species).

Host trees need to be infected with fungi to be suitable for *P. muelleri* larvae. It would appear that the tree species is less important than that suitable white rot must be present in the wood. In general, white rot is indicated by a pale discolouration of the wood, a result of the darker coloured lignin being removed. Colour ranges from white to pale brown and may include dark zone lines and "pockets". White rot tends to have a "stringy" texture. White rot chemistry is not uniform and we found that not all white rot wood is suitable substrate for *P. muelleri*. Fungal determinations are also rendered progressively more difficult as the substrate deteriorates. Table 2 gives fungal species recorded in this study as associated with *P. muelleri*.

### ***Pupation***

The pupal cell is constructed in a similar manner to the other ecdysal cells but takes up to a week to complete. In addition to the lining of faecal matter the cell walls are coated with an amber fluid. The anal segment of the abdomen is used as a "brush" in this process. The source and purpose of this coating is unknown.

The pupa has previously been illustrated. Hancock (1970) gives a line drawing and Brunet (1983) gives colour photographs of a pupa and newly emerged adult.

Hancock (1970) reported moult to pupa occurring approximately two weeks after completion of the pupal cell. The pupa can rotate in the pupal cell on its longitudinal axis using of a pair of lateral spines on the apical abdominal segment (Fig. 11). These spines grip the cell wall and the pupa rotates as it arches and twists sideways. The pupa changes position in the cell many times during development. As the legs begin to harden prior to adult emergence, the pupa rolls on to its back. When the legs become rigid the pupal skin around them is transparent. After then rolling back on to its legs the pupal skin is shed. This commences with the pupal skin splitting down the middle of the dorsal surface of the pronotum. The adult may remain within the pupal cell for up to 8 months before emergence.

### **Adult Morphology and Behaviour**

Males vary in length (measured from tips of mandibles to elytral apex) from 24-72 mm and females from 23-46 mm. As an expression of percentage of total length, male mandibles vary between 19 -32%, irrespective of beetle size. Two males have been recorded with asymmetric mandibles. No variation in mandibular development is apparent in females. A small percentage of non-teneral adults display a shift in colour to either increased red or green. Very rarely is either colour absent but several dark blue specimens have been recorded. Dodd (1971) also recorded rare examples that were very dark in colour.

In breeding large numbers of specimens of this species in this study, females were found to outnumber males by approximately 4%. Dodd (1971), however, stated that in the field males greatly outnumber females.

Adults break out of their pupal cells using the mandibles and legs. Males with well developed mandibles use the base of these for chewing, raking excavated material out with the tarsi. Upon emergence from the pupal cells adults disperse in search of food, mates and oviposition sites. Adults are known to live for up to 18 months in captivity. Light trapping records indicate peak activity at and just after dusk from September to April.

Adult feeding has been observed on *Eucalyptus* sp. blossom, on the fruit of *Calamus moti* Bailey (Arecaceae) (M. Walford-Huggins pers. comm.) and on sap flows associated with insect damage (E. Adams pers. comm.). Dodd (1971) noted that adults were taken on *Glochidion ferdinandi* (J. Muell.) F.M. Bail. (Euphorbiaceae) where hepialid or other wood borers had left a sap-exuding injury. Another apparently less favoured food plant is *Caesalpinia* sp. (Caesalpiniceae), a robust thorny leguminous creeper; in this case the beetle occurring on terminal shoots (Dodd 1971). All records except the first involved feeding during the day.

Oviposition occurs throughout the year in captivity and in the wild. Males have been recorded in the company of ovipositing females and mating has been observed on numerous occasions in captivity. Mating, together with conflict between males, also has been observed at feeding aggregations in captivity.

Adults being handled rarely fold in their legs and remain rigid; they usually claw with the tarsi and may attempt to bite. Males may adopt a threatening stance by rising up on the mid and hind pairs of legs, with forelegs outstretched and mandibles working like scissors.

Males use their mandibles as levers when in conflict with one another. Two protagonists approach each other with the mandibles lowered. Each beetle tries to pass beneath its opponent's body or legs, at which point the mandibles are raised in an attempt to dislodge the rival. On vertical surfaces combatants may be thrown into the air. On horizontal surfaces one may be rolled over and in the grappling that ensues tarsi are sometimes bitten off.

Males also have been observed using their mandibles to facilitate mating. If the female is in a position where she cannot be successfully approached, the male may use his mandibles to lever her into a better position. Where escape or concealment is attempted the male may use his mandibles to violently throw her about or carry her elsewhere.

#### **Relations with other beetles and parasites.**

Other lucanid species found in the same logs in close proximity to *P. muelleri* include *Lamprima latreillei* W.S. Macleay, *Rhyssonotus nebulosus*



(Kirby), *Prosopocoilus torresensis* (Deyrolle), *Figulus* sp., *Aegus jansoni* Boileau, *Syndesus cornutus* (Fabricius), and *Cacostomus squamosus* Newman. The first three species appear to be white rot associated but tend to utilise different niches. *L. latreillei* prefers drier sites and is more common in dead standing timber than in logs on the ground. *R. nebulosus* tends to be most common in sapwood and *P. torresensis* is less common with increasing elevation. Although they can be found in the same timber as *P. muelleri*, *A. jansoni* and *S. cornutus* are brown rot associated species. Brown rot is the result of fungal attack in which the cellulose has been destroyed leaving the dark coloured lignin. This is evidenced by zones of darker colour in the wood, dark brown to rust-red in colour. Brown rot does not have a "stringy" texture but tends to be powdery. *C. squamosus* is found in detritus in cracks in wood and under logs and is not clearly associated with either type of rot.

Larvae of the cetoniine *Schizorhina atropunctata* (Kirby) are commonly found with white rot-feeding lucanid larvae, feeding on their faeces and fragmented wood. Larvae of another cetoniine, *Lenosoma* sp. also have been found feeding on *P. muelleri* larval frass.

Larvae of *P. muelleri* are parasitised commonly by the fly *Amphibolia ignorata* Paramonov (Tachinidae) (Fig. 9). They are also parasitised by the wasp *Liacos insularis* (Smith) (Scoliidae) (Fig. 9): larvae attach to final-instar *P. muelleri* larvae and pupae (Fig. 10), the egg being laid on the underside, just behind the legs. *L. insularis* was only observed on the edge of rainforest. The beetle *Mordella elongatula* (Macleay) (Mordellidae) (Fig. 9), one specimen of which emerged from a pupal cell of *L. insularis*, is possibly a hyperparasite but this habit is not usual for mordellid beetles.

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THE LIFE HISTORY OF THE WESTERN AUSTRALIAN  
SKIPPER *MESODINA CYANOPHRACTA* LOWER  
(LEPIDOPTERA: HESPERIIDAE)

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### Abstract

The life history of *Mesodina cyanophracta* Lower is described and illustrated. The early stages of *M. cyanophracta* and *M. halyzia* (Hewitson) are compared.

### Introduction

*Mesodina cyanophracta* Lower (Figs 7, 8) was recognised only recently as distinct from *M. halyzia* (Hewitson) (Edwards 1987). *M. cyanophracta* is restricted to south-western Australia where it occurs from 36 km west of Binu near Geraldton, south to Albany and inland to the Stirling Range; adults have been taken from late October to March (Common and Waterhouse 1981, Dunn and Dunn 1991). We have recent records from Condingup Peak, 65km east of Esperance (33°45'41"S 122°32'53"E), and from Mount Ragged in Cape Arid National Park (33°28'02"S 123°27'31"E). Around Perth the peak flying time is in November and the foodplant is *Patersonia occidentalis* R.Br. (Iridaceae) (Williams *et al.* 1993). The larval and pupal stages of *M. cyanophracta* have not been described in detail, although Common and Waterhouse (1981) and Edwards (1987) stated that the early stages are similar to *M. halyzia*.

### Life history

*Egg* (Figs 1, 9, 10). Diam. 1.75 mm, hemispherical, off white changing to pale green with maroon dorsal blotch, acentric to micropyle. Surface covered with a delicate lace-like ribbed structure.

*First instar larva* (Fig. 2). Length 3.5-4.0 mm. Head shiny black, surface faintly pitted and covered with variable pale setae; prothoracic plate shiny black; collar between head and prothoracic plate bright orange-red. Body tapered, yellowish, last segment pinkish; covered with variable white setae, some slightly clubbed; posterior setae long and slender.

*Mature larva* (Fig. 3). Length 20-26 mm. Head (Fig. 4) large and rounded, greyish black in colour, surface granulated and covered with variable pale setae. Body greyish-brown with short clubbed setae, posterior with long whitish setae. A narrow blackish dorsal line extends almost the length of the body. Medium-sized to mature larvae are covered with a white waxy powder which tends to obscure the skin coloration.

*Pupa* (Fig. 6). Length 18-22 mm, broad anterior tapering to posterior with small cremaster. Frons (Fig. 5) more or less smooth with small elliptical operculum pointed laterally. Colour somewhat variable; fresh pupae with

thorax and wing cases dull green, abdomen cream to yellow cream and frons grey-brown. As development progresses the pupae darken and some individuals turn almost black.

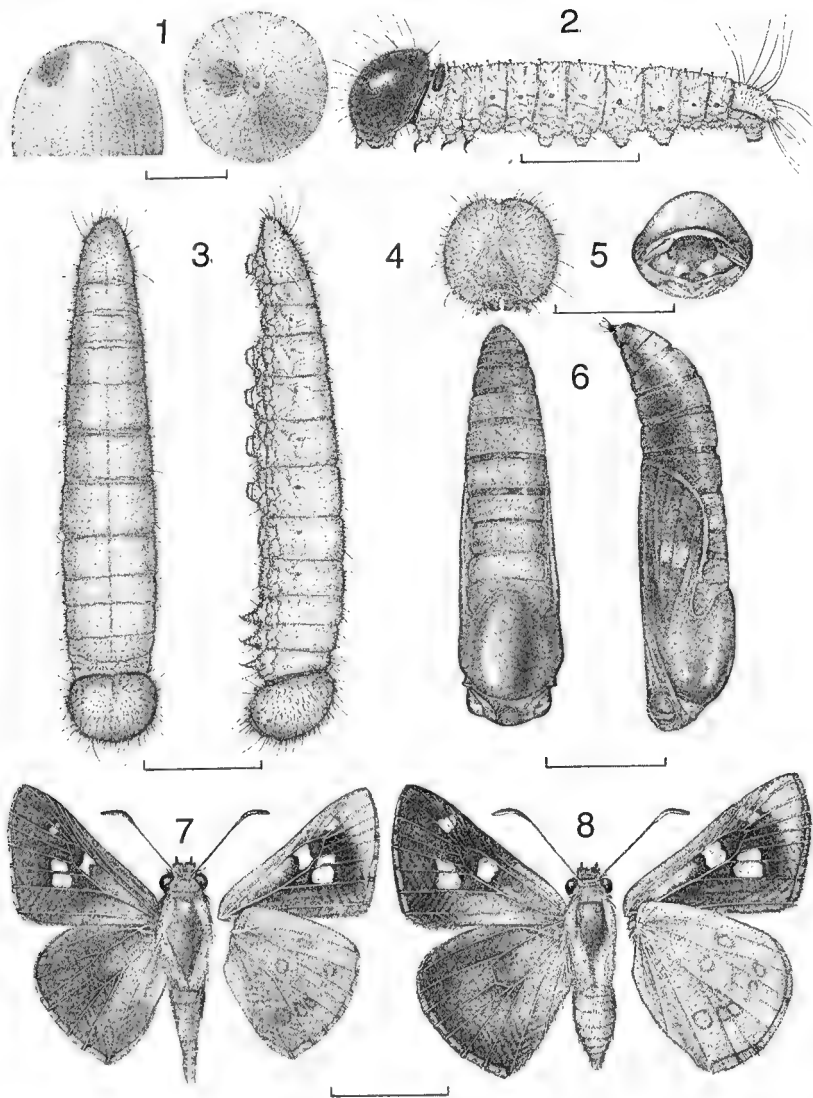
### Observations and Discussion

Eggs were found at Moore River National Park, 100 km north of Perth, in mid November 1993 and transferred to *P. occidentalis* plants suitably located for observation near Wanneroo. Larvae hatched after several days and consumed their egg casings before constructing shelters. Most individuals made shelters by drawing together the outer edges of a single leaf of the foodplant to form a partial tube, which was then sealed at the top. Others sewed together the extreme tips of two leaves to form a shelter. Early stage larvae invariably fed on the upper edges of the leaves in close proximity to their shelters.

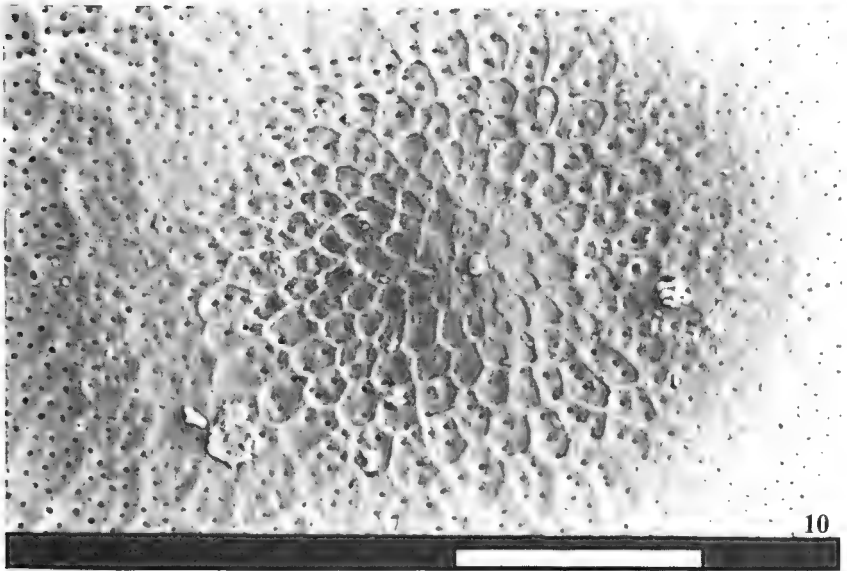
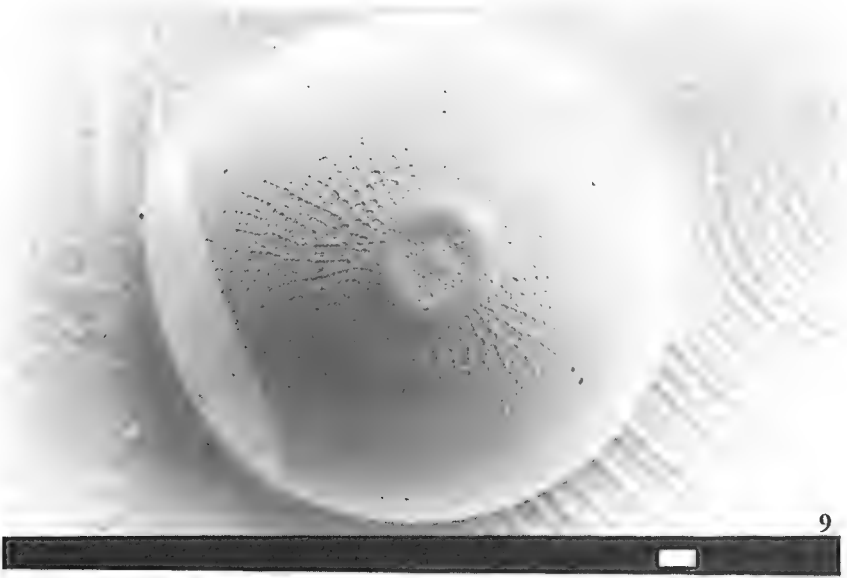
As larvae increased in size they abandoned their first shelters and constructed larger ones by sewing together three or four leaves of the foodplant to form a tent-like structure. These shelters were closed at the top and lined with silk with the entrance underneath. Larvae rested head downwards within the shelters and fed during the day, as do larvae of *M. halyzia* (Common and Waterhouse 1981). They produced distinctive feeding scars by cutting wedge-shaped sections out of the leaves; in some cases this resulted in leaves taking on a saw-toothed appearance. Larvae fed actively in November, December and again from May to October. They remained largely inactive during the hot dry summer months. Larvae pupated head downwards within their shelters. Before pupating they sealed the entrance with a horizontal pad of silk. Pupal duration was approximately 35 days.

Differences were found between the pupae of *M. cyanophracta* and *M. halyzia*. The most distinctive feature of *M. cyanophracta* is the comparatively small elliptical pupal cap (operculum), which is pointed laterally, unlike that of *M. halyzia* which is broadly elliptical, rounded laterally and with a more roughened sclerotized area on the upper frons. Mature larvae of *M. cyanophracta* also differ in colour from those of *M. halyzia* which are pale greenish in colour (Common and Waterhouse 1981). Scanning electron micrographs of the eggs of *M. cyanophracta* and *M. halyzia* (Figs 9-12) show subtle differences in their delicate lace-like ribbing. In *M. cyanophracta* the cross ribs are more prominent and the micropyle pattern more diffuse and complex than in *M. halyzia*. The delicate ribbed structure of *Mesodina* eggs is unique in the Trapezitinae (AFA pers. obs.).

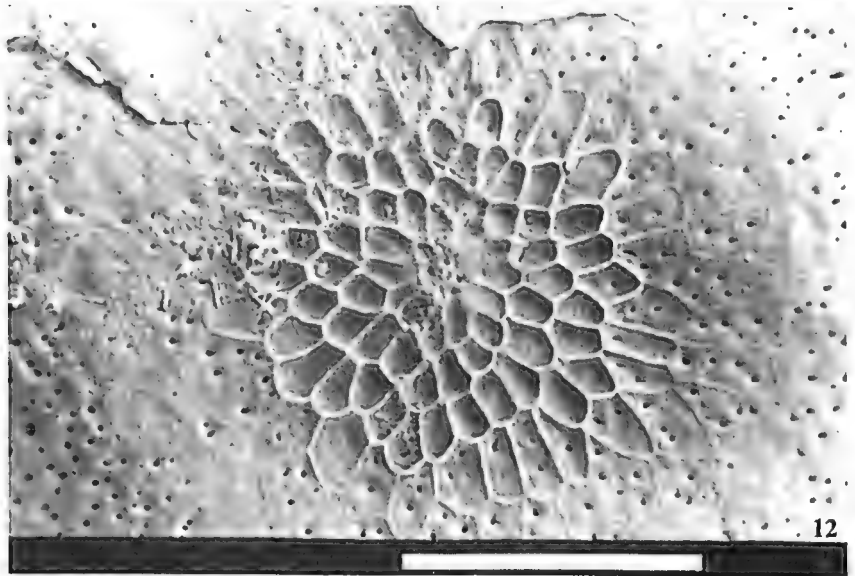
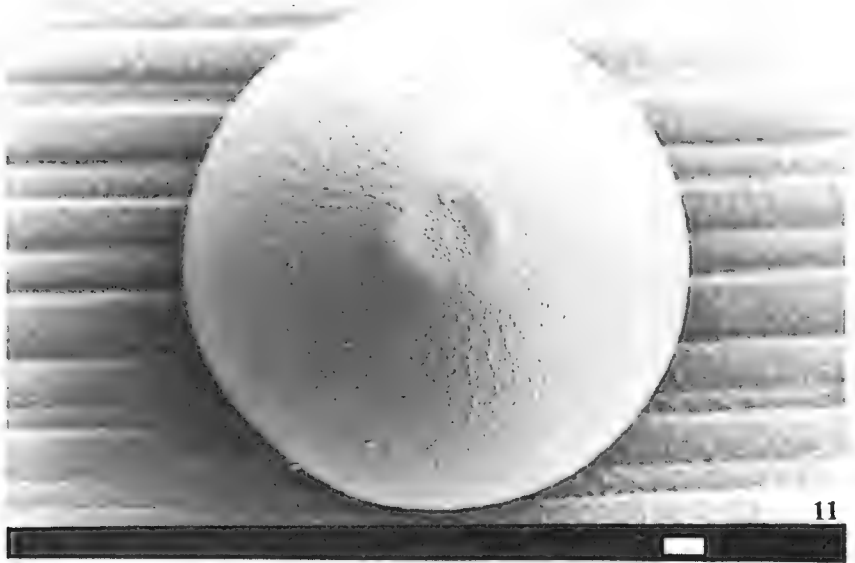
Observations over several years at Wanneroo indicate that female *M. cyanophracta* prefer to oviposit on young vigorously growing foodplants. They will often favour sites which have recently regenerated after fire, or select young *P. occidentalis* plants growing alongside tracks or firebreaks. Similar behaviour has been recorded for *Trapezites sciron sciron* Waterhouse & Lyell near Perth, where ovipositing females showed a distinct preference



**Figs 1-8.** Juvenile and adults of *Mesodina cyanophracta* Lower from Wanneroo, W.A. (1) egg; (2) 1st instar larva; (3) final instar larva; (4) final instar larval head; (5) frons of pupa and operculum; (6) pupa; (7) adult male, upperside and underside; (8) adult female, upperside and underside. Scale bars: (1, 2) = 1 mm, (3-6) = 5 mm, (7, 8) = 10 mm.



Figs 9-10. Scanning electron micrographs (SEM) of egg of *Mesodina cyanophracta* Lower from Wanneroo, W.A. (9) showing delicate lace-like ribbed structure, (10) detail of micropyle pattern. Scale bar = 100  $\mu$ m.



Figs 11-12. Scanning electron micrographs (SEM) of egg of *Mesodina halyzia* (Hewitson) from Catherine Hill Bay, N.S.W. (11) showing delicate lacc-like ribbed structure, (12) detail of micropyle pattern. Scale bar = 100 m.

for young vigorously growing *Lomandra caespitosa* (Benth.) foodplants (Williams *et al.* 1992). Larvae of *M. cyanophracta* are frequently attacked by a slender endoparasitic wasp, *Casinaria* sp. nr. *meridionalis* (Turner) (Ichneumonidae), that eventually kills them in the final instar (AFA identification - see Gauld 1984).

Voucher specimens pertinent to this paper are lodged in the Insect Collection of the Western Australian Department of Conservation and Land Management and in Andrew Atkins' private collection.

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## SEASONALITY OF CICADAS (HEMIPTERA) ON THE NORTHERN TABLELANDS OF NEW SOUTH WALES

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### **Abstract**

Seasonality records are provided for 16 cicada species at sites near Armidale NSW, observed over 4 summers (1990-91 to 1993-94). Cicadas were active at these sites from late October to late February. The greatest number of species was present during December and early January. There was a significant, positive correlation of species number with day length in all years. Neither temperature nor rainfall consistently correlated with species number.

### **Introduction**

A conspicuous feature of cicada biology is their predictable occurrence each year during summer. Though seasonality records are available for Australian species over their geographic range (Moulds 1990), there are no studies documenting seasonal patterns of occurrence on a regional basis. Regional differences in seasonality would be expected to occur as a consequence of regional climatic differences. This study was undertaken to document the seasonal activity of cicada species at sites near Armidale on the Northern Tablelands of New South Wales. Armidale experiences relatively mild summers (January average daily maximum, 27.1°C), and winters are cool to cold (July average daily maximum 12.4°C). The frost free period extends from November to March (30 y av.) (Bureau of Meteorology, unpubl. data). The Armidale climate is broadly representative of the New England Tablelands, a region extending from the township of Bendemeer (70 km south-west of Armidale) to Dorrigo (110 km east) and north to the Queensland border (Wallangarra).

### **Methods**

The following localities were used as sampling sites in this study: The University of New England campus (30°29'S, 151°39'E), the 'Pinnacle' (30°30'S, 151°30'E), Dangars Falls (30°41'S, 151°44'E) and 'The Devils Pinch' (30°20'S, 151°40'E). All sites are within 20 km of Armidale and vary from *ca* 1000 to 1200 m above sea level. Each was visited during the second and fourth weeks of each month from August to April of the summers 1990-91, 1991-92, 1992-93 and 1993-94. The cicada species present on each sampling date were identified by sight or by song pattern. Cicada songs are species specific (Young 1972, Ewart 1989) and can be readily learnt for a given locality. To assess the influence of climate on seasonal activity, fortnightly averages of climatic and regional variables (max. and min. temperature, rainfall and photoperiod) were obtained for Armidale for the study periods. Data from the four sampling localities were pooled and analysed (Pearson product-moment correlation) against climatic and regional variables for each year of the study.

**Table 1.** Seasonality records for cicada species at Armidale, New South Wales, during the period October to February of the years 1990/91 to 1993/94. Each month is scored twice to represent sampling in the second and fourth week.

Species	Year	Month									
		O	O	N	N	D	D	J	J	F	F
<i>Cicadetta waterhousei</i> (Distant)	90/91			*	*	*	*	*			
	91/92			*	*	*	*	*			
	92/93				*	*	*	*			
	93/94			*	*	*	*	*	*		
<i>Cicadetta labeculata</i> (Distant)	90/91			*	*	*	*	*	*	*	
	91/92				*	*	*	*	*	*	
	92/93				*	*	*	*	*	*	
	93/94				*	*	*	*	*	*	
<i>Cicadetta tristrigata</i> (Goding & Froggatt)	90/91				*	*	*				
	91/92				*	*	*	*	*		
	92/93				*	*	*	*	*		
	93/94				*	*	*	*	*		
<i>Cicadetta landsboroughi</i> (Distant)	90/91										
	91/92				*	*	*	*	*		
	92/93				*	*	*	*	*		
	93/94					*	*	*	*		
<i>Cicadetta puer</i> (Walker)	90/91			*	*	*	*	*	*	*	
	91/92			*	*	*	*	*	*	*	
	92/93		*	*	*	*	*	*	*	*	
	93/94		*	*	*	*	*	*	*	*	
<i>Urabunana marshalli</i> Distant	90/91			*	*	*	*	*	*		
	91/92				*	*	*	*			
	92/93				*	*	*	*	*		
	93/94			*	*	*	*	*	*		
<i>Urabunana wollombii</i> Coombs	90/91				*	*	*	*			
	91/92				*	*	*	*			
	92/93				*	*	*	*			
	93/94					*	*	*			
<i>Birrima varians</i> (Germar)	90/91			*	*	*	*	*	*	*	
	91/92			*	*	*	*	*	*	*	
	92/93			*	*	*	*	*	*	*	
	93/94			*	*	*	*	*	*	*	
<i>Pauropsalta corticinus</i> Ewart	90/91				*	*	*	*	*		
	91/92				*	*	*	*			
	92/93				*	*	*	*			
	93/94				*	*	*	*			

<i>Pauropsalta</i>	90/91	*	*	*	*	*	*	*	*
<i>collina</i> Ewart	91/92	*	*	*	*	*	*	*	*
	92/93	*	*	*	*	*	*	*	*
	93/94	*	*	*	*	*	*	*	*
<i>Notopsalta</i> sp.	90/91					*	*	*	
	91/92					*	*		
	92/93					*	*		
	93/94					*	*		
<i>Cystosoma</i>	90/91			*	*	*	*	*	
<i>saundersii</i>	91/92			*	*	*	*	*	
Westwood	92/93			*	*	*	*	*	
	93/94			*	*	*	*	*	
<i>Cyclochila</i>	90/91								
<i>australasiae</i>	91/92			*	*	*	*		
(Donovan)	92/93			*	*	*	*	*	
	93/94								
<i>Macrotristria</i>	90/91								
<i>angularis</i>	91/92								
(Germar)	92/93					*	*	*	*
	93/94								
<i>Psaltoda plaga</i>	90/91					*	*	*	*
(Walker)	91/92					*	*	*	*
	92/93					*	*	*	*
	93/94					*	*	*	*
<i>Psaltoda</i>	90/91					*	*	*	*
<i>moerens</i>	91/92					*	*	*	*
(Germar)	92/93					*	*	*	*
	93/94								

## Results

In general, cicadas were active at the study sites from late October to late February. Within this period, species appeared at differing times and were active for varying durations over the summer. Seasonality records are provided for 16 species of cicada for each year of the study (Table 1). Most adults were active from late November to late January. *Pauropsalta collina* Ewart (all years) and *Cicadetta puer* (Walker) (1992-93 only) were the most persistent species, occurring from late October to early February. Only *Psaltoda plaga* (Walker) occurred until the end of February and none was present by March. A species tentatively assigned to the genus *Notopsalta* was active for the shortest period, from late December to late January. All species were remarkably consistent from year to year in their times of appearance and persistence through the season. Not all species, however, were present in all study years. *Macrotristria angularis* (Germar) was present in 1992-93 only, whilst *Cyclochila australasiae* (Donovan) and *Cicadetta*

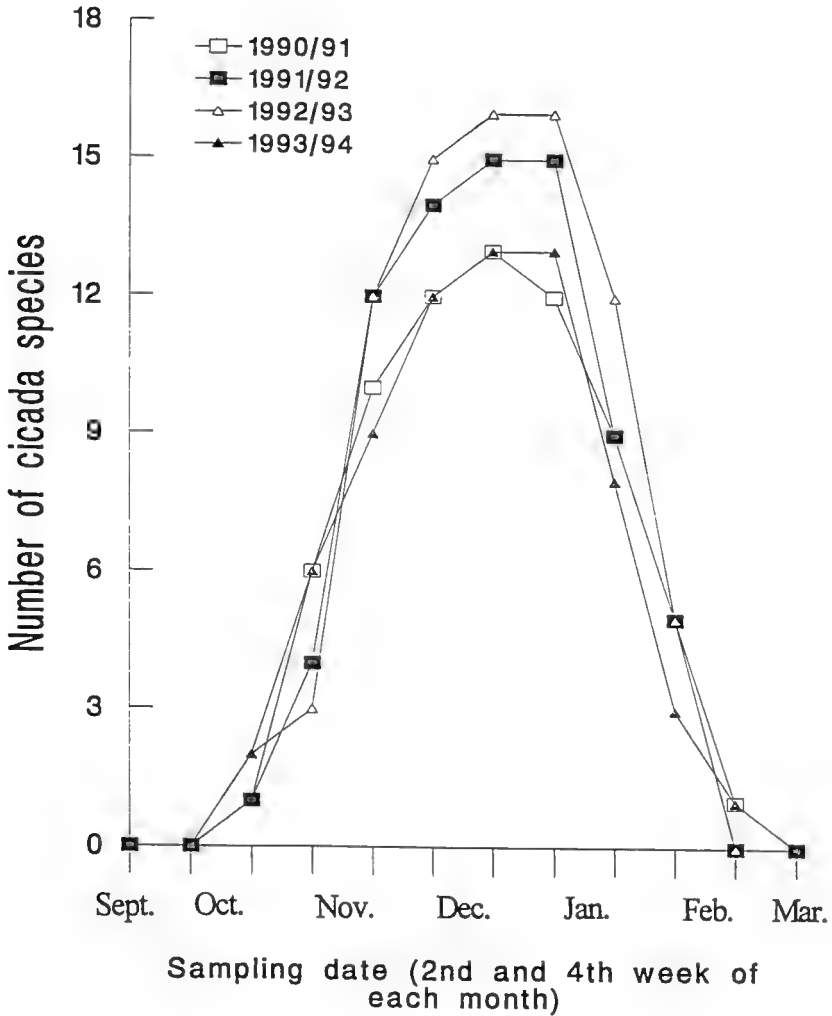


Fig. 1. Seasonal activity curve of cicada species at sites in the vicinity of Armidale, NSW during the period September to March of the years 1990-91, 1991-92, 1992-93 and 1993-94.

*landsboroughi* (Distant) were absent during 1990-91.

Figure 1 shows a plot of species number versus sampling date for each year of the study. Species number peaked during December to early January, and declined rapidly thereafter, with most species absent by late January. Pearson correlations and significance levels for species number against climatic and

**Table 2** Pearson correlations for species number against maximum and minimum temperature (°C), rainfall (mm) and photoperiod (hours of daylight).

Year		Max.	Min.	Rainfall	Photoperiod
1990-91	r	0.783	0.684	0.337	0.865
	t <sub>(12)</sub>	4.36	3.25	1.24	5.97
	P	< 0.01	< 0.01	> 0.2	< 0.01
1991-92	r	0.673	0.395	0.331	0.815
	t <sub>(12)</sub>	3.15	1.49	1.21	4.87
	P	< 0.01	> 0.1	> 0.2	< 0.01
1992-93	r	0.427	0.581	0.738	0.822
	t <sub>(12)</sub>	1.63	2.47	3.79	5.00
	P	> 0.1	< 0.05	< 0.01	< 0.01
1993-94	r	0.511	0.526	0.556	0.852
	t <sub>(12)</sub>	2.06	2.14	2.32	5.64
	P	> 0.05	> 0.05	< 0.05	< 0.01

regional variables are shown in Table 2. Species number was significantly and positively correlated with day length in all years and with average maximum daily temperature during 1990-91 and 1991-92 but not 1992-93 or 1993-94. Correlations of species number with average minimum daily temperature were significant during 1990-91 and 1992-93 only. Species number was significantly correlated with rainfall during 1992-93 and 1993-94 but not 1990-91 or 1991-92.

## Discussion

The seasonal activity of cicadas on the New England Tablelands appears to reflect dominant climatic conditions. The adverse (cool) season is spent below ground as immatures feeding on roots. The favourable (warm) season (as indicated by the frost free period) is relatively short, extending from November to March. The first adult cicadas appear during late October. The species per fortnight curve (Fig. 1) shows a rapid increase during November, peaking during December / January with a rapid decline in late January / February. Although significant correlations of species number with maximum or minimum daily temperature and rainfall occurred in some years, only photoperiod (hours of daylight) was significantly and positively correlated with species number in all years. Adult cicadas are strongly heliothermic. Adult reproductive behaviour is restricted to daylight hours in all species except the crepuscular *Cystosoma saundersii* Westwood. Clearly species are timing their seasonal appearance to coincide with the greatest duration of daylight hours. Such behaviour would enable individuals to maximise the time spent undertaking reproductive activities.

As adult cicadas are thought to be relatively short lived (usually about 2-4 weeks: Moulds 1990), variation observed in seasonal persistence between species may be a consequence of differences in the synchrony of adult emergence. Species present for several months (e.g. *P. collina*, *Birrima varians*) may have a staggered emergence, whereas shorter periods of seasonal activity (e.g. *Notopsalta* sp., *U. wollomombii*) may reflect greater synchrony in emergence.

The species activity curve presented here for cicadas on the New England Tablelands closely parallels activity patterns of other insect taxa at localities with short summers (Shapiro 1975, Wolda 1988). A short period of seasonal activity and a well defined seasonal peak appear to be typical of many insect faunas occupying either the higher latitudes or those occurring at altitude. Shapiro (1975) provides data on numbers of butterfly species in the Sierra Mountains (7000' altitude) of California largely restricted to a four month flight period. On average, cicadas on the New England Tablelands become active approximately one month later and disappear approximately one to two months earlier than would be expected when extracting seasonality data for the same species from Moulds (1990). Ewart (1989) provides seasonality records for *Pauropsalta* spp. from Queensland as extending from September to May.

### Acknowledgment

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SEASONAL ABUNDANCE, DISTRIBUTION, HOSTS  
AND TAXONOMIC PLACEMENT OF  
*DIPTEROPHAGUS DACI* DREW & ALLWOOD  
(STREPSIPTERA: DIPTEROPHAGIDAE)

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### Abstract

Nineteen species of dacine fruit flies are recorded as hosts of *Dipterophagus daci* Drew and Allwood, a strepsipteran parasite which has been reared only from Tephritidae. Aspects of the ecology of *D. daci* in northern Australia, in relation to the seasonal abundance of its two most abundant hosts, *Bactrocera aquilonis* (May) and *B. tenuifascia* (May), are reported. Monthly captures of the two hosts over a 12 month period indicated that their populations increased with the onset of higher temperatures, moisture levels and availability of host fruits. Numbers of *D. daci* peaked about one month after *B. aquilonis* and two months after *B. tenuifascia* and evidence indicated that the seasonal activity of *D. daci* was dependent upon the availability of its host and rainfall. Higher levels of parasitism occurred in *B. aquilonis* than in *B. tenuifascia* and rapid increase in host populations was probably one significant factor in the prevention of the parasite from causing a high level of parasitism during the period of high fruit fly population. The fruit flies and their parasites were more abundant in wet than dry habitats. *D. daci* is recorded for the first time from the Solomon Islands. The family Dipterophagidae is reinstated.

### Introduction

Most species of Strepsiptera occur in the Palaeotropical region of the world which incorporates the tropics and subtropics (Kinzelbach 1978). Little is known about the biology and ecology of these insects and no information has been reported on the seasonal abundance of species or levels of parasitism achieved in nature. The most comprehensive biological study was on a strepsipterous parasite of *Antestia* spp. (Pentatomidae) by Kirkpatrick (1937). Brief accounts of general biology and life histories have been reported by Perkins (1905), Ogloblin (1939), Bohart (1941) and Riek (1970), while Raatikainen and Heikinheimo (1974) studied the flying times of strepsipteran males at different latitudes in Finland.

Fruit flies (Tephritidae: Dacinae) are endemic to northern and eastern Australia. Considerable research has been undertaken on the ecology of Dacinae in endemic tropical and subtropical rainforest habitats and in cultivated orchards (Fitt 1981, Drew and Hooper 1983, Fletcher 1987). The influence of hymenopterous parasites and various predators was investigated by Drew (1987) in rainforest habitats. Major reductions in fly populations were due to fruit-eating vertebrates and hymenopterous parasites had only a minor effect.

*Dipterophagus daci* Drew and Allwood is unique in being the only strepsipteran species so far described which is a parasite of Diptera. It is most abundant in the Northern Territory where it parasitises a number of fruit fly species. Because of the economic importance of fruit flies to Australia, including some of the hosts of *D. daci*, data have been collected on host

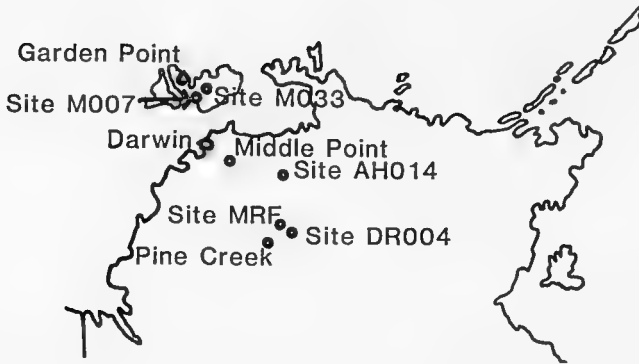


Fig. 1. Location of trapping sites and meteorological stations used in this study.

records, seasonal abundance and geographic distribution of the parasite in its endemic habitats. Percent parasitism levels have been calculated also.

#### Taxonomic note

The family Dipterophagidae was established for *D. daci* based on a combination of male, female and first stage larval characters (Drew and Allwood 1985). Kathirithamby (1989) treated it as a subfamily of Halictophagidae on the basis of a number of characters that *D. daci* and known halictophagids have in common. However, other families of Strepsiptera also possess some of these characters and families such as Bohartillidae were separated on the basis of one of these characters (number of antennal segments).

Kathirithamby (1989, 1992) noted that most species placed in the Halictophagidae are parasites of Hemiptera and that all (except *D. daci*) had males with seven antennal segments and lateral flabella on more than one segment (except in the Tridactylophaginae which has one lateral flabellum and parasitises Orthoptera) and females with abdominal segments 1-5 with one genital aperture each and the cephalothorax flattened. A measurement of the 7th antennal segment of *D. daci* was given (Kathirithamby 1989, p. 78) but this species has only six such segments. Also it was stated that the female of *D. daci* possessed genital pores on abdominal segments 4-6 (Kathirithamby 1989, pp 76, 78) or 3-6 (Kathirithamby 1992, p. 166). However, this species has genital pores on abdominal sterna 3-5 (Drew and Allwood 1985).

The following combination of characters is unique to *D. daci*: male with six antennal segments and a lateral flabellum on segment 3 only; female with a bell-shaped (rounded) cephalothorax and genital openings on abdominal sterna 3-5. These characters, plus the host, render it very distinct from all true halictophagids and the family Dipterophagidae is reinstated.



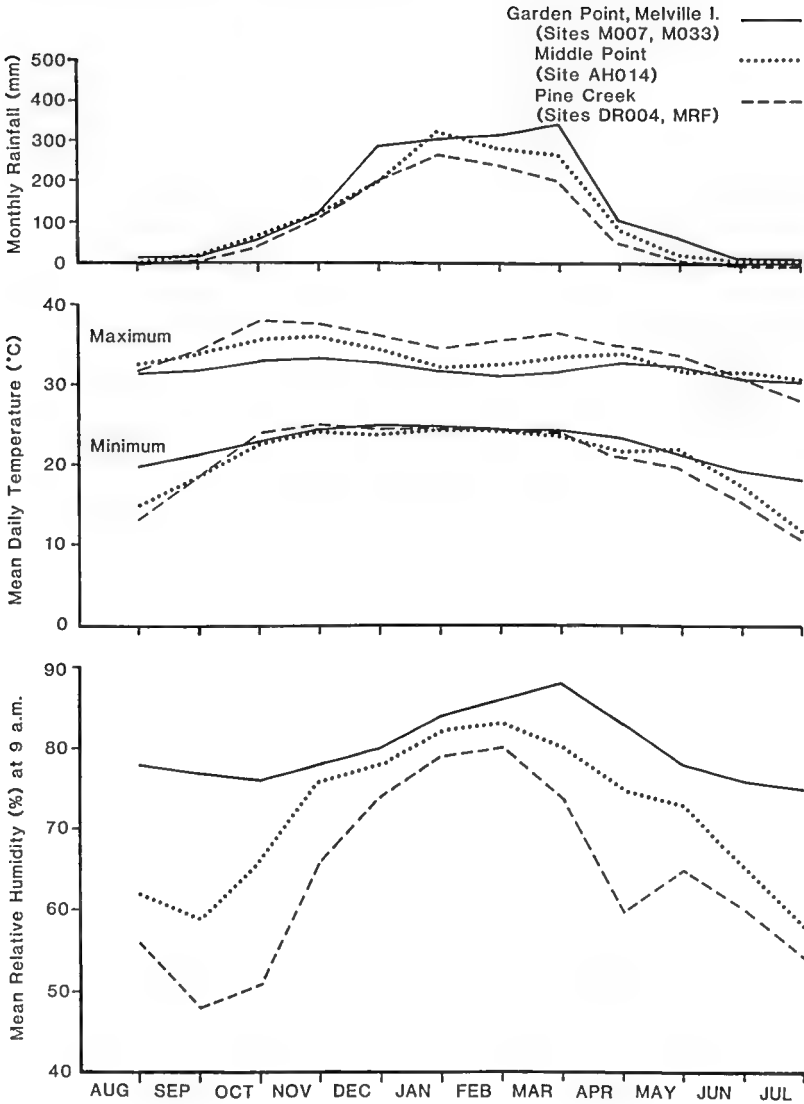
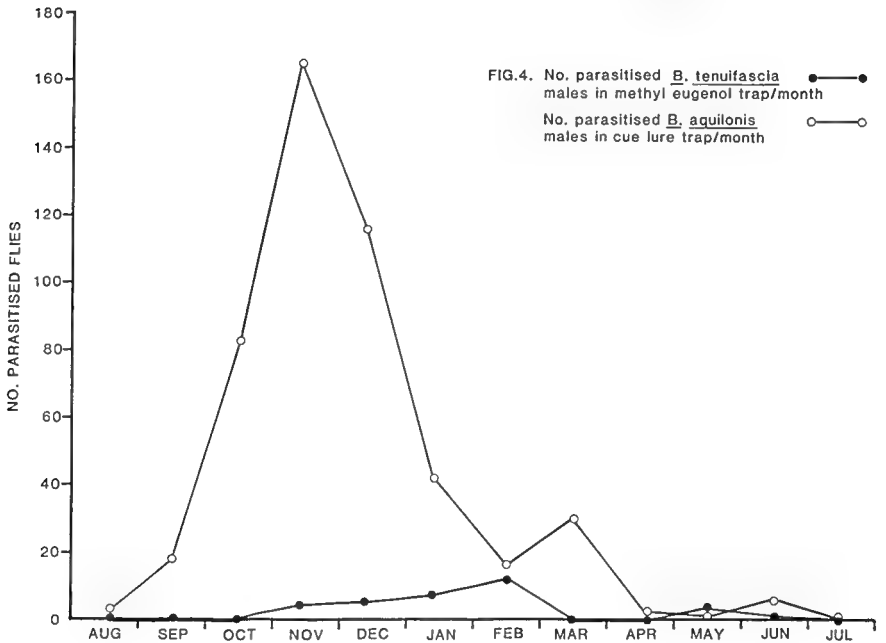
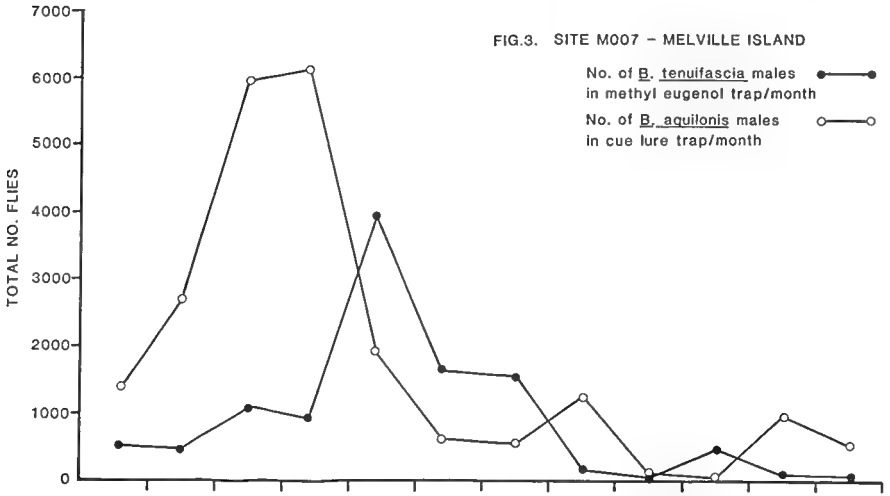


Fig. 2. Meteorological data (monthly rainfall, mean maximum and minimum daily temperatures and mean relative humidities at 9 am) at weather stations that represent trapping sites.



**Figs. 3 and 4.** (3). Number of male *Bactrocera aquilonis* and *B. tenuifascia* per trap month at site M007 on Melville Island; (4). Number of male *Bactrocera aquilonis* and *B. tenuifascia* per trap month parasitised by *Dipterophagus daci* at site M007 on Melville Island.

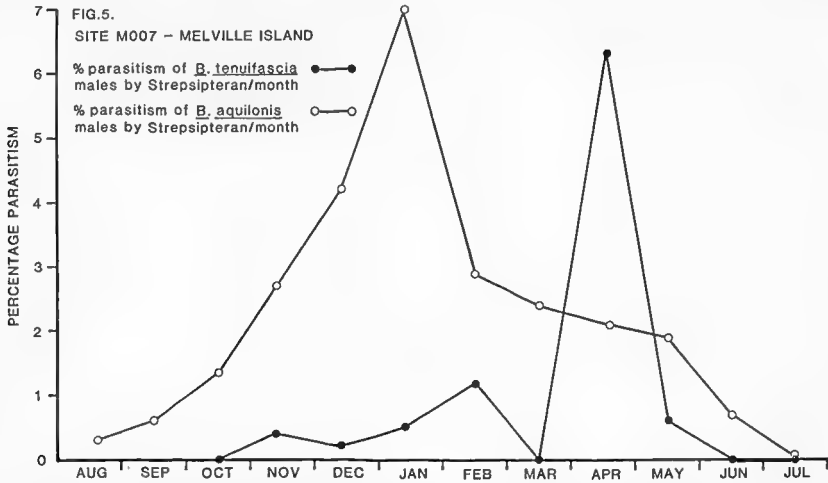


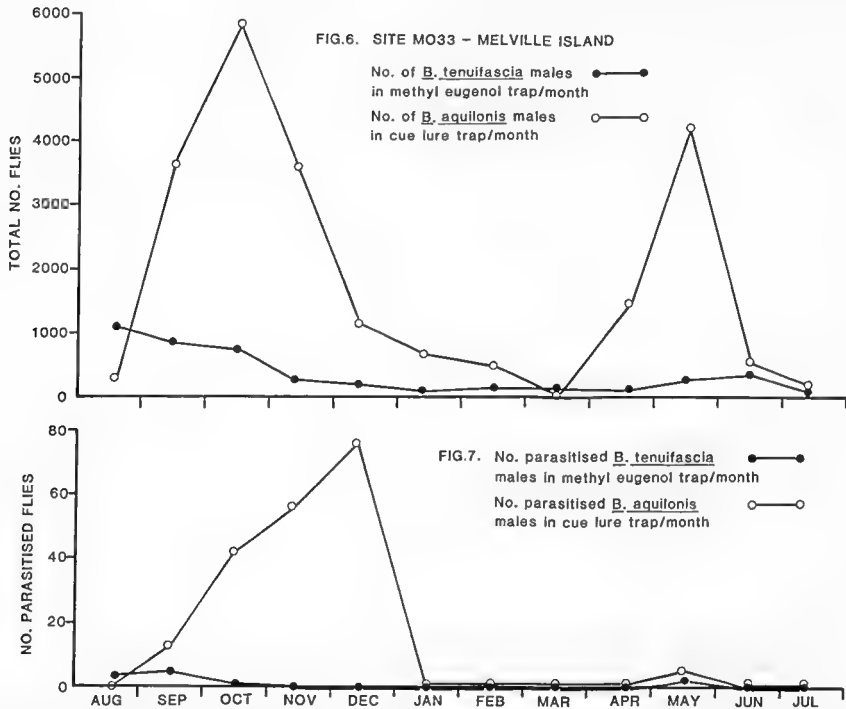
Fig. 5. Percent of male *Bactrocera aquilonis* and *B. tenuifascia* per trap month parasitised by *Dipterophagus daci* at site M007 on Melville Island.

**Materials and Methods**

The work was carried out in a region across the north of the Northern Territory. Two sites were selected on Melville Island and three on the mainland (Fig. 1). Taracumbi Falls (Site M033) and the site 7 km N of Paru Village are both wet habitats on Melville Island, about 40 km apart. The site at Moline Rock Falls (Site MRF) ca 70 km NE of Pine Creek is a wet habitat. The site near the Wildman River (West Branch) ca 100 km E of Darwin (Site AH014) and that ca 70 km NE of Pine Creek (Site DR004) are classed as dry habitats. The wet sites are characterised by the presence of surface water for the whole year and situated in or near monsoonal rainforest. The dry sites are devoid of surface water for part of the year and are situated in open eucalypt woodland.

The climate of the study area is classified as semi-arid tropical (Williams *et al.* 1985). It is characterised by having a distinct “wet” season during December to April and a “dry” season for the remainder of the year. Mean daily maximum and minimum temperatures, mean relative humidities at 9 am and monthly rainfall data were obtained from weather stations at Garden Point (Melville Island), Middle Point and Pine Creek, selected because of their proximity to the trapping locations (Fig. 2).

Fruit fly populations were monitored at ca 100 localities representative of the endemic vegetation. This was part of a broad surveillance strategy for exotic fruit flies carried out under the auspices of the North Australian Quarantine Survey. At each locality two Steiner type fruit fly traps were set, one



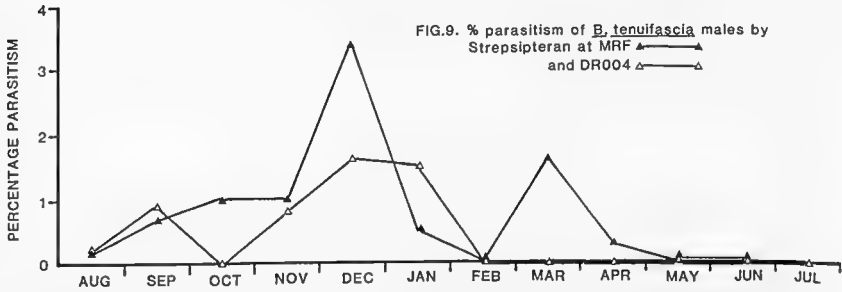
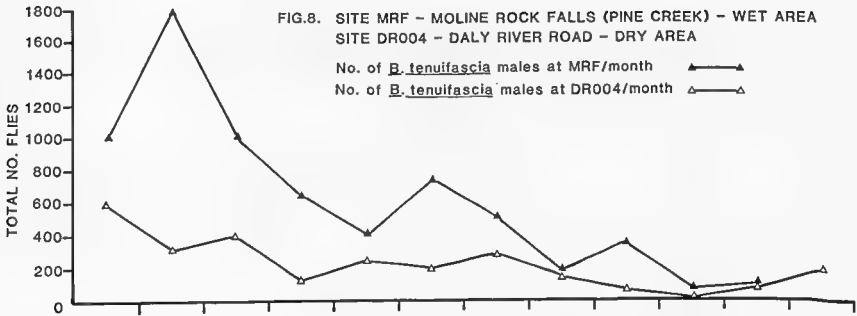
Figs. 6 and 7. (6). Number of male *Bactrocera aquilonis* and *B. tenuifascia* per trap month at site M033 on Melville Island; (7). Number of male *Bactrocera aquilonis* and *B. tenuifascia* per trap month parasitised by *Dipterophagus daci* at site M033 on Melville Island.

containing methyl eugenol (4 ml + 2 ml 50% w/v malathion e. c.), the other containing cue lure (4 ml + 2 ml 50% w/v malathion e. c.). This study was carried out for one year from August 1977. All traps were cleared of flies at *ca* one-month intervals at which time the lure plus insecticide baits were changed. The trapped flies (all males) were identified, counted and examined under a stereo microscope for presence of strepsipteran parasites. At five localities, selected as wet or dry habitats, the number and percentage of parasitised flies were calculated for two species, *Bactrocera aquilonis* (May) and *B. tenuifascia* (May).

## Results

### Seasonal abundance

Data are presented for *B. aquilonis* from three sites (M007, M033, AH014) and for *B. tenuifascia* from five sites (M007, M033, MRF, DR004, AH014). At each site flies were present for the entire one year trapping period. Data



**Figs. 8 and 9.** (8). Number of male *Bactrocera tenuifascia* per trap month at sites MRF and DR004 in the Northern Territory; (9). Percent of male *Bactrocera tenuifascia* per trap month parasitised by *Dipterophagus daci* at sites MRF and DR004 in the Northern Territory.

for *B. aquilonis* from MRF and DR004 have not been presented but support conclusions drawn from the other data.

At site M007 the numbers of *B. aquilonis* increased from August to reach a peak (ca 6000 trapped flies per month) in mid-October and early November, then declined to mid-January after which they remained at a low level (Fig. 3). At site M033 *B. aquilonis* had two population peaks, in mid-October (ca 6000) and mid-May (ca 4000), the latter being for a shorter period (Fig. 6). The fruit fly population at M033 showed similar rates of increase and decline in mid-October to that at M007. At site AH014 *B. aquilonis* also had two peaks, one in mid-November and the other in mid-May (each ca 1500).

At site M007 the numbers of *B. tenuifascia* increased from mid-September to reach a peak (ca 4000) in early December, then declined to mid-March after which they remained at a low level (Fig. 3). At site M033 the numbers of *B. tenuifascia* were low, with a maximum of 1100 in mid-August before declining to ca 100 in mid-November, after which they remained at approximately the same level for the remainder of the study period (Fig. 6). At site MRF the numbers of *B. tenuifascia* increased from August to reach a

peak (ca 1800) in mid-September, then entered a slow decline to June (Fig. 8). At sites DR004 (Fig. 8) and AH014 (Fig. 10) *B. tenuifascia* reached peaks in mid-August (ca 600 and 4000 respectively), after which they entered a slow decline.

Flies parasitised by *D. daci* generally were restricted to shorter periods of the year. At site M007 the number of parasitised *B. aquilonis* increased in mid-September to reach a peak (ca 165) in mid-November, then declined to mid-February (Fig. 4). Parasites were present for ca 10 months. At the peak of activity of *B. aquilonis* (October-November), the level of parasitism was 2.6% and this reached a peak of 7% in mid-January when the fly population had declined (Fig. 5). Concurrently, the number of parasitised *B. tenuifascia* increased slowly from mid-October to reach a peak in mid-February (ca 15), then declined to mid-March (Fig. 4). Parasites were present for 5 months. At the peak of activity of *B. tenuifascia* (early December), the level of parasitism was 0.25% and this peaked at 6.5% in mid-April when the fly population had declined markedly (Fig. 5).

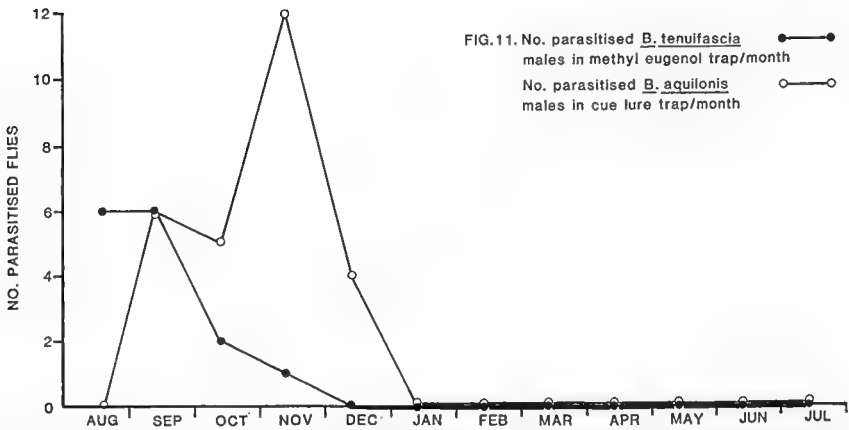
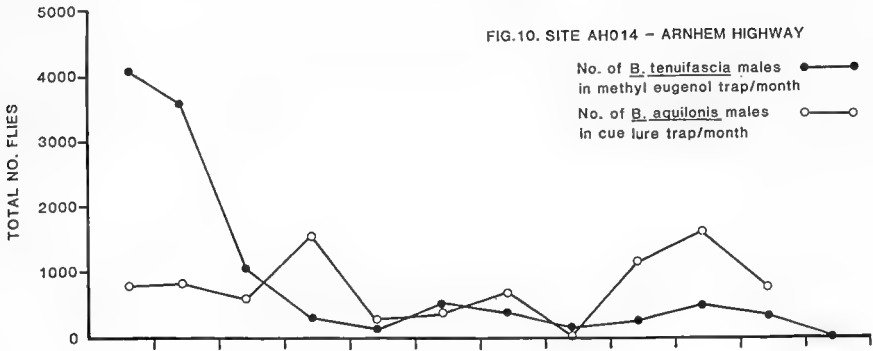
At site M033 the number of parasitised *B. aquilonis* increased from mid-August to peak at mid-December (ca 80 flies and 7% parasitism) (Fig. 7). During the second peak of *B. aquilonis* in mid-May there was almost no parasite activity (ca 0.1% parasitism) (Fig. 7). At this site the number of parasitised *B. tenuifascia* was at a very low level but followed the population trend of the host species (Fig. 7).

At site MRF the level of parasitism in *B. tenuifascia* was 0.7% at the peak of the fly population, increasing to ca 3.5% in mid-December when the fly numbers had declined to a low level (Fig. 9). At site DR004 the level of parasitism in *B. tenuifascia* was ca 0.25% at the peak of the fly population, increasing to ca 1.5% in mid-December when the fly population was well into its decline (Fig. 9).

At site AH014 the number of parasitised *B. aquilonis* reached a peak in mid-November (Fig. 11). The level of parasitism was ca 0.8% during the peak of the fly population in mid-November and 1.3% in December when the host population was low. There was no parasite activity for eight months from mid-January (Fig. 11). At this site the period of parasite activity in *B. tenuifascia* was only four months, from mid-August to mid-December (Fig. 11). The level of parasitism in this fly species was ca 0.15% at the peak of its population in mid-August and 0.4% in mid-November when the fly population had declined.

#### *Geographic distribution*

*D. daci* is known in Australia from Melville Island, coastal and subcoastal areas of both the Northern Territory and Cape York Peninsula, some Torres Strait islands and Townsville (northern Qld), Mt Glorious, Palmwoods and



**Figs. 10-11.** (10). Number of male *Bactrocera aquilonis* and *B. tenuifascia* per trap month at site AH014 in the Northern Territory; (11) Number of male *Bactrocera aquilonis* and *B. tenuifascia* per trap month parasitised by *Dipterophagus daci* at site AH014 in the Northern Territory.

Redland Bay (SE Qld) (Drew and Allwood 1985, Drew unpublished data). It occurs also on Guadalcanal, Solomon Islands (new record).

*Host records*

*D. daci* has been recorded from 19 dacine hosts: *Bactrocera aquilonis* (May), *B. cacuminata* (Hering), *B. decurtans* (May), *B. mayi* (Hardy), *B. neohumeralis* (Hardy), *B. peninsularis* (Drew & Hancock), *B. tenuifascia* (May), *B. tryoni* (Froggatt), *Dacus bellulus* Drew & Hancock (Drew and Allwood 1985), plus *B. abscondita* (Drew & Hancock), *B. aeruginosa* (Drew & Hancock), *B. breviaculeus* (Hardy), *B. frauenfeldi* (Schiner), *B. jarvisi* (Tryon), *B. musae* (Tryon), *B. perkinsi* (Drew & Hancock), *Dacus aequalis* Coquillett (new records from Australia), *B. froggatti* (Bezzi) and *B. umbrosa* (Fabricius) (new records from Solomon Islands). *B. aquilonis*, *B. musae*, *B. neohumeralis* and *B. tryoni* are major pest species in Australia.

## Discussion

The seasonal activity of dacine fruit flies is dependent upon temperature, rainfall and the state of development of the host fruit (Bateman 1968, Drew and Hooper 1983). Drew and Hooper (1983) also demonstrated that male lure trap catches provided an accurate assessment of the seasonal changes in dacine populations.

Both *B. aquilonis* and *B. tenuifascia* were trapped throughout the year at all sites but their populations increased in the August-December period prior to the onset of the wet season. This was probably due to increasing temperature and relative humidity and increased wild host fruit production, as found for *B. cacuminata* (Hering) by Drew and Hooper (1983). The major wild host fruits of *B. aquilonis* are *Glycosmis trifoliata* (Blume) Sprengel, *Micromelum minutum* (Forster f.) Wight and Arn. and various species of *Syzygium* (Smith *et al* 1988). Their peak fruiting period is October-November, immediately prior to the onset of the wet season. Second peaks in populations of *B. aquilonis* occurred from March-May at sites M033 and AH014, coinciding with the fruiting period of *Terminalia ferdinandiana* Exell (March-June). Populations of *B. tenuifascia* also reflected the availability of its major hosts; *Planchonella pohlmaniana* (F. Muell.) fruits April-November while *P. arnhemica* (F. Muell.) *P. Royen* fruits June-November (Fitt 1981).

Rainfall is probably more important later because of its influence on the survival of pupae and emerging adults (Bateman 1972). The populations of *B. aquilonis* were higher than those of *B. tenuifascia* at all study sites. Populations of *B. aquilonis* were 3-4 times larger in the wet habitats (M007 and M033) than in the dry habitat (AH014). Similarly, populations of *B. tenuifascia* were usually higher in the wet habitats but this difference was not as consistent as in *B. aquilonis*.

The increase in parasite activity followed that of the host flies. However, there was a one month lag period for the parasite in *B. aquilonis* and a two month lag period in *B. tenuifascia*. The activity of the parasites coincided with the onset of the wet season and even when there was a second *B. aquilonis* population peak at M033, in the dry season, the parasites were virtually absent. There was a shorter period of parasite activity and a lower % peak parasitism level in both host species in the dry habitats. The level of parasitism in *B. tenuifascia* was consistently lower than that in *B. aquilonis*, indicating that the latter species is a better host for the parasite.

The seasonal activity of *D. daci* was dependent upon the availability of its hosts and rainfall. However, in spite of the availability of large fruit fly populations, the parasite was not efficient in inducing high rates of parasitism. There were very low percentages of parasitism when the fly populations were at their peaks and higher levels only when the fly populations declined markedly. This may be explained by the fact that *Bactrocera* species are *r* selected species, undergoing rapid increases in



population when host fruits are available and environmental conditions permit (Bateman 1972, Drew and Hooper 1983). The rapid population increases of the host species appear too large for the rate of increase of the parasite. Although no evidence exists, low levels of parasitism by *D. daci* may be explained by low survival rates of triungulins, small numbers of triungulins actually coming in contact with fruit fly adults, or male dacines being less favoured as hosts than females.

There was no apparent effect on the external appearance of the host and on the size and colour of the testes, similar to *Corioxenos antestiae* Blair parasitising *Antestia* spp. (Pentatomidae) in Africa (Kirkpatrick 1937). However, in *Antestia* the styloipised females never produced mature eggs and the styloipised males were incapable of fertilising eggs even when they copulated. Even if *D. daci* has a similar effect on its fruit fly host species, it seems that it will never have a marked influence on population reduction. Kirkpatrick (1937) suggested that the combination of an egg parasite and a strepsipteran may have a better chance of inducing larger population reductions in *Antestia*.

Gregarious parasitism, recorded by Drew and Allwood (1985), occurs with larger numbers of parasites per host than that reported by Kirkpatrick (1937). We have observed the fungus infection in the empty male pupal cases recorded by Kirkpatrick (1937) and Bohart (1941). One female parasite collected at Palmwoods, SE Qld, had over 3000 triungulin larvae indicating that they have a very large reproductive rate. This is probably essential as the triungulins must be exposed to severe environmental stresses between emerging from the female and finding a host.

*Dipterophagus daci* has now been recorded in 19 dacine host species and more frequently in Cape York Peninsula than SE Queensland. There is no evidence to suggest that it is going through a southward expansion of its distribution. It predominates in the northern tropics and it is probable that recordings in SE Qld are related to increased collections of flies for other ecological studies and bait spray trials.

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Mrs M.C. Romig, QDPI, prepared the figures. The specimens were collected during the North Australian Quarantine Survey and in Solomon Islands by the RFFP and ACIAR projects. The study was partly funded by the Australian Biological Resources Study. This support is gratefully acknowledged.

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NOTES ON THE LIFE HISTORY OF  
*NACADUBA KURAVA FELSINA* WATERHOUSE & LYELL  
(LEPIDOPTERA: LYCAENIDAE)

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### Abstract

Notes are given on the life history of *Nacaduba kurava felsina* Waterhouse & Lyell and the food plant *Embelia curvinervia* (Myrsinaceae) recorded.

### Introduction

The white line blue *Nacaduba kurava felsina* is known to occur in the Northern Territory from Darwin south to Mataranka (Common and Waterhouse 1981, Dunn and Dunn 1991). The life history of the eastern subspecies *N. kurava parma* Waterhouse & Lyell has been described (Common and Waterhouse 1981) but, apart from one record of a larva feeding on the young foliage of a rainforest tree growing on the banks of the Katherine River (Common and Waterhouse 1981), little is known of the life history of *N. k. felsina*.

During the past two years adults were prevalent in early June at Ooloo Crossing on the Daly River. Eggs and early instar larvae were discovered in late May 1994 and reared on cuttings of the host plant.

### Life History

*Host Plant:* *Embelia curvinervia* (Family Myrsinaceae) (Reynolds 1991).

The descriptions of the immature stages of *N.k. parma* given in Common and Waterhouse (1981) are similar to those of *N. k. felsina*, with variation occurring in colouring and markings as noted below.

*Egg* (Fig. 1): Small, white, mandarin shaped; dense clockwise and anticlockwise series of ridges and pits radiating from micropylar depression; ridges intersect at coarse erect spines; 0.55 mm diameter x 0.25 mm high.



Fig. 1. *Nacaduba kurava felsina*, eggs.

*First instar larva:* Olive green with purple dorsal lines from head to last abdominal segment. Dorsal lines give early instar larva the appearance of

being purple but on closer examination base colouring can be seen. Head pale brown.

*Final instar larva:* Olive green or purple, strongly humped above and prominently segmented with purple middorsal and subdorsal lines; head pale brown. Size 9-12 mm (n=40).

*Pupa:* Covered with very short erect hairs and black spots; head and thorax brown with pinkish brown abdomen; black spotted middorsal line present from head to mesothorax; first abdominal segment with two conspicuous dorsolateral black spots; attached by anal hooks and central girdle. Average size 9 mm x 3.5 mm.

### Discussion

The host plant is known from several sites in the Northern Territory and near the Claudie River, Cape York Peninsula (Reynolds 1991). In the Northern Territory it and associated butterfly colonies have been found at Ooloo Crossing on the Daly River, the Adelaide River bridge on the Daly River road and at the Marrakai Road jungle, 50 km south of Darwin. The host plant is a rambling woody vine which appears to grow near permanent water.

Eggs generally are laid singly on new growth or flowers of the host plant. Larvae at first were collected from new growth of the host plant in late May and from the flowers a fortnight later. Larvae appeared to prefer flowers but these are short-lived. During this period larval growth is rapid, reaching final instar in 11 to 14 days. Pupal duration was 6 to 11 days.

Larvae occur throughout the year but are more numerous from May to July, indicating a preference for the dry season (winter). Their appearance at other times depends upon the presence of new growth or flowers on the host plant.

Adult females flutter around the host plant and rest on twigs or branches of the vine. Adult males are territorial, settling head downwards on twigs or small branches higher up in the canopy adjacent to the host plant.

### Acknowledgments

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**LEPIDOPTERA BREEDING RECORDS FROM  
ALPHITONIA SPECIES (RHAMNACEAE)  
AT PALUMA, NORTH QUEENSLAND**

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**Abstract**

Fourteen species of Lepidoptera (12 previously unrecorded) feeding upon three species of *Alphitonia* (Rhamnaceae) from the Paluma area, North Queensland, are documented.

**Introduction**

Three species of *Alphitonia* grow in the Paluma area (19°00'S 146°12'E, altitude 892 m, 80 km north-west of Townsville, North Queensland). *A. petriei* C.T.White & Braid is a pioneer tree, common along disturbed and undisturbed rainforest margins. *A. whitei* Braid is more shade tolerant and grows in small gaps and the understorey, while *A. excelsa* (A. Curn. ex Fenzl) Reissek ex Benth. occurs in dry sclerophyll communities. To date 11 Lepidoptera species have been recorded as herbivores of *Alphitonia* species. All but one are from *A. excelsa*. These are: *Bucculatrix* sp. (Bucculatricidae), which is a leaf-miner in early stages but later feeds exposed on the leaf surface; *Carmenta chrysophanes* (Meyrick) (Sesiidae), larvae of which bore the inner bark; *Casbia rectoria* Walker (Geometridae), a leaf feeder; the leaf-miner *Leucoptera* sp. (Lyonetiidae); *Opodiphthera austrophela* (Walker) (Saturniidae), another leaf feeder (Common 1990); plus 5 species of Lycaenidae which feed on the leaves or flower buds (Common and Waterhouse 1981). The recorded distributions of *C. chrysophanes* and *C. rectoria* cover the Paluma area. The remaining species, *Aenetus mirabilis* (Rothschild) (Hepialidae), has a stem-boring larva on an unspecified species of *Alphitonia* (Common 1990) but its described location at the edge of rainforest and its geographical range suggest its host is probably *A. petriei*.

At Paluma I observed and reared specimens of 7 lepidopteran families comprising 14 species. These are listed below by family (Table 1). All are folivores and all except one are new records. These are also the first confirmed records from *A. petriei* and *A. whitei*. Voucher specimens of both plants and insects are deposited at the Department of Zoology, James Cook University of North Queensland.

**Acknowledgments**

Thanks go to Ted Edwards (CSIRO Division of Entomology, Canberra) for identifying the geometrids, *E. ?postvittana*, *S. janetta*, *O. mendosa* and *E. epidela*, and to an anonymous reviewer for constructive criticism which improved the manuscript.

**Table 1.** Lepidoptera observed feeding on *Alphitonia* species and reared to maturity.

SPECIES	FAMILY	HOST PLANT	MONTH(S) OBSERVED
<i>Casbia rectaria</i> Walker	Geometridae	<i>A. petriei</i> *	Feb-Aug;
		<i>A. excelsa</i> †	Oct-Nov
		<i>A. whitei</i>	
<i>C. calliorma</i> Turner	Geometridae	<i>A. whitei</i>	Feb-May
		<i>A. petriei</i>	
<i>C. didymosticta</i> Turner	Geometridae	<i>A. petriei</i>	Jun; Aug
<i>C. scardamiata</i> (Warren)	Geometridae	<i>A. petriei</i>	Apr; May; July
<i>Ectropis rufobrunnea</i> Warren	Geometridae	<i>A. petriei</i>	Aug; Dec
<i>Epiphyas ?postvittana</i> (Walker)	Tortricidae	<i>A. petriei</i>	Aug-Oct
		<i>A. excelsa</i>	
<i>Syntherata janetta</i> (White)	Saturniidae	<i>A. excelsa</i>	Feb; Dec
<i>Opodiphthera eucalypti</i> (Scott)	Saturniidae	<i>A. excelsa</i>	Mar
<i>Olene mendosa</i> Hübner	Lymantriidae	<i>A. petriei</i>	Apr
<i>Euproctis ?epidela</i> Turner	Lymantriidae	<i>A. excelsa</i>	Feb; Aug
<i>Orgyia papuana</i> Riotte	Lymantriidae	<i>A. petriei</i>	Mar
<i>Mecytha fasciata</i> (Walker)	Zygaenidae	<i>A. excelsa</i>	Dec
<i>Anaxidia lozogramma</i> Turner	Limacodidae	<i>A. petriei</i>	Dec
<i>Danis hymetus</i> (C.& R. Felder)	Lycaenidae	<i>A. petriei</i>	Feb-June

\* where >1 species of *Alphitonia* hosted a herbivore, they are listed in order of relative frequency of use

† previously recorded host plant

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## SMOKE FLIES (DIPTERA: PLATYPEZIDAE) AND THE SYDNEY BUSHFIRES

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### Abstract

Swarms of the smoke fly *Microsania australis* Collart were found at a smoking log in Royal National Park, New South Wales, three weeks after the area was burnt by severe bushfires. The attraction of *Microsania* to smoke for mating assembly is discussed.

### Introduction

In early January 1994, bushfires burnt large regions of eastern New South Wales, including some Sydney suburbs. The bushfires were severe in Royal National Park, a large area of natural bushland south of metropolitan Sydney. More than 80% of the park was burnt, including most of the northern half. On January 29, three weeks after the fires, I visited the Park. The landscape was open and desolate, with the dense mallee heathland reduced to a thick grey ashbed and a few charred sticks. In the dry sclerophyll woodland many trees were dead and fallen and standing trees were badly seared.

The bushfires took a heavy toll of fauna, including insects. A few ants from surviving underground colonies were foraging, otherwise there was no observable ground fauna. Native cockroaches, beetles and centipedes had been baked in place under sandstone slabs. I saw few flying insects during a ten kilometre walk through burnt heath and woodland. Near the Curra Moors track roadhead I noticed smoke issuing from a log. This was unusual since the fires had been "out" for almost three weeks and it had rained during that time. A large fallen *Angophora costata* trunk and its stump were both smoldering and the log was almost entirely burnt out. Swarms of tiny flies were present in smoke from both the log and stump, with some 150-200 individuals in each swarm. Of 68 individuals taken in a sweep, there were 66 males and 2 females of *Microsania australis* Collart (Platypezidae), confirmed by the genitalic figure in Collart (1938).

*Microsania* Zetterstedt is a cosmopolitan genus with four described Australian species (Chandler 1994). They are commonly known as "smoke flies" because they form mating swarms in woodsmoke. Indeed, collectors suggest lighting smoky fires with green wood to attract them. Kessel (1960a, b) notes that *Microsania* is attracted to cold smoke used by bee-keepers and even to shirts previously worn in woodsmoke.

### Discussion

Although *Microsania australis* is attracted to woodsmoke, its concentration in large numbers in such a devastated landscape raises questions:

1. Where did they come from? Nothing is known of the immature stages of *Microsania* (Kessel 1987) but other platypezid genera have fungus-feeding larvae. Nevertheless, the intensity of the bushfires would have destroyed most larvae within the main burn. The nearest source of unburnt or slightly

burnt bushland was Bola Creek, 3-4 km to the west.

2. When did they arrive? The main bushfire would have been too hot and turbulent to attract the flies. I suspect *M. australis* came into the area after the main blaze was extinguished but while logs were still smoldering. As fires died out, the smoke flies probably gathered at remaining smoke, and the smoldering trunk was possibly the last source over a wide area.

The sex ratio of the *M. australis* sample (66 ♂♂, 2 ♀♀) is typical of an aerial mating swarm (Downes 1969). In many insects, aerial swarming is initiated by environmental cues such as light intensity and relative humidity. However it seems that *Microsania* spp. use smoke in two ways: as an aggregating "scent" to concentrate dispersed individuals of both sexes and as a swarm marker, the actual smoke plume delimiting the swarm boundary (individuals rarely leave the plume and follow as it shifts).

Kessel (1989) suggested that attraction to smoke was a positive response to concentrate individuals in areas recently burnt by forest fires, and that *Microsania* bred in fungi specifically associated with fire-scarred wood. However, this hypothesis has yet to be documented, as larvae and their hosts are unknown. If this were the case, one would expect *Microsania* to be co-adapted with fire-ecology vegetation, such as the eucalypt forests of Australia or chaparral of California. However, smoke flies also occur in northwestern Europe and Central African rainforest where natural fires are exceedingly rare. In these moist regions they often appear in large numbers around smoky fires (e.g. Chandler 1978). Therefore, although *Microsania* is distinctly attracted to smoke for mating, it must have other means of aggregation and swarming in the absence of fire. Possibly they are attracted to certain plant aromatics which also facilitate aggregation.

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A NEW RECORD OF *NESOLYCAENA CAESIA*  
D'APICE & MILLER (LEPIDOPTERA: LYCAENIDAE)  
FROM NORTH-EASTERN WESTERN AUSTRALIA

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**Abstract**

*Nesolycaena caesia* d'Apice and Miller is recorded from near Kununurra, Western Australia.

A single female *Nesolycaena caesia* d'Apice and Miller was taken at a roadside soak, 1 km N of Amalia Gorge (15°57'S 128°01'E), via Kununurra, Western Australia, in April 1995. d'Apice and Miller (1992) recorded this butterfly from three localities near Kalumburu in the eastern Kimberley Region of Western Australia. This record extends the known eastward distribution of this butterfly by approximately 250 km.

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