

THE BENEFITS OF USING BOTH ADULT AND LARVAL STONEFLIES (PLECOPTERA) IN ENVIRONMENTAL SURVEYS: AN EXAMPLE FROM NEW SOUTH WALES WITH A SUMMARY OF THE AUSTRALIAN STONEFLY FAUNA

GUNTHER THEISCHINGER¹, JAN MILLER¹, CHERYL TANG¹,
MARTIN KROGH¹ and ELIZABETH POPE²

¹*NSW Department of Environment, Climate Change and Water, PO Box 29, Lidcombe, NSW 1825*

²*Snowy Hydro Limited, PO Box 332, Cooma, NSW 2630*

Abstract

Freshwater environmental assessment and monitoring studies rely heavily on aquatic insect larvae because larvae are seen to directly reflect the aquatic environment they inhabit. However, the species-level taxonomy of most aquatic insects is based on the diagnostic characters found in adults. The uncertainty of correlating adult-based species with aquatic larvae means that aquatic life stages are rarely identified further than generic level, especially where there are sympatric congeners. However, Plecoptera adults are poor dispersers and generally remain near their site of emergence. Therefore, stonefly adults have the potential to provide more finely resolved species-level information about their nearby aquatic larval sites. Both adult and larval Plecoptera were collected during sampling for macroinvertebrates in a monitoring project in the Snowy Mountains, New South Wales. The results show that the collection and identification of adult stoneflies has potential for finer scale delimitation of riverine ecosystems than information provided by larvae alone. Also, adult stoneflies collected can provide information in related studies of taxonomy, ecology, biogeography, biodiversity, conservation and climate change. An updated check-list and an outline of taxonomic studies of Australian stoneflies, including all primary literature, are also presented.

Introduction

There has been a long standing division in the study of aquatic insects by ecologists and taxonomists. Whereas environmental and ecological studies are based almost exclusively on larvae, partially because larvae are seen to reflect directly the aquatic environment they inhabit, species-level taxonomy of aquatic insects is based on adults, because they present diagnostic characters such as wing venation and male genitalia. Aquatic entomologists would ideally like to identify larvae collected in surveys to species-level and thereby maximize biological and environmental information. However, in reality they frequently must settle for coarse level generic identifications, especially if the aquatic site hosts a number of sympatric, congeneric species.

Of all the entirely aquatic insect orders (Ephemeroptera, Odonata, Plecoptera, Megaloptera and Trichoptera), plecopteran adults are the poorest flyers, generally staying close to the emergence/breeding habitat and sometimes even occurring in aquatic kick-net samples. Numerous stonefly species are brachypterous, some even apterous, and adults of one North American species never emerge from the water. Adult stoneflies may be collected in the morning and during dull days as they emerge onto rocks protruding from the streams, or at other times by beating foliage along the stream margin (Theischinger 1991). Also, in winged species running, not flying is

commonly used to find food and mates. Since adults are often found in association with congeneric and probably conspecific larvae, it is likely that adults collected from vegetation, rocks and logs adjacent to a stream at a particular site have emerged from that water body.

In spite of the availability of several comprehensive keys to the larvae of the Victorian and New South Wales species (Hynes 1978, Yule 1997), species level identifications of larvae are difficult because of a lack of diagnostic characters, often made more uncertain because of the involvement of different larval instars. Moreover, the larvae of many species are still unknown.

The following study was based on surveys during 2009 for the program 'Snowy Hydro Cloud Seeding Trial: Further Studies on Aquatic Macroinvertebrates', in the Snowy Mountains of New South Wales, Australia. The monitoring team (the authors of this paper) were transported to sites mainly by helicopter. A decision was made to collect stonefly adults in addition to the normal aquatic samples, and thereby test if adults could provide significant additional information for such projects in the region.

I. The Snowy Hydro Cloud Seeding Trial Monitoring Program – Results for Plecoptera

Methods

Site locations

The sites were selected in 2007 for the Snowy Hydro Cloud Seeding Trial Monitoring Program, and aquatic larvae at the sites have been sampled annually since then. All sites are located within Kosciuszko National Park and include sites of varying altitude that are within the cloud seeding areas, plus control sites to the south of the seeding areas. The location of these sites is shown in Fig. 1.

Sampling

In November 2009, kick-net samples were taken using the standard protocol AusRivas (edge/riffle) (Turak and Wadell 2001). Subsequent to this up to 10 minutes per site were spent walking in the water and sweeping emergent and trailing vegetation around the site for adult stoneflies, using an aerial insect net (diameter 18"). All the collected stonefly material was emptied into small plastic jars containing 70% ethanol, sorted in the lab and then identified using the guide of Theischinger and Cardale (1987). A list was prepared including, for each site, geographical coordinates (latitude and longitude in decimal degrees) and altitude, numbers of males and females of adults collected by adult sampling as well as adults and larvae collected by AusRivas kick-net sampling in both edge and riffle habitats. The results were compared with the 2008 sampling results obtained from identification (by consultants) of larvae only.

Analyses

The stonefly data were analysed to investigate whether they could provide information on species distribution, dispersal and habitat constraints. The location of specific stoneflies was compared with elevation and with known distribution and habitat requirements by the senior author, based on personal field experience and existing literature.

Stonefly assemblage data were also compared using the statistical software PrimerE. Multidimensional scaling (MDS) using the Bray-Curtis measure of similarity and presence/absence transformation was applied to the data. Species that were responsible for dissimilarities between sites were investigated using a simple Excel© spreadsheet and the sites were ordered by height above sea level to look for differences in species associations and elevation (shown in Table 2).

Results

Sampling

Stoneflies (adults and larvae) that were collected at 16 sites for 'Snowy Hydro Cloud Seeding Trial; Further Studies on Aquatic Macroinvertebrates' in November 2009 are shown in Table 1 below.

The following list provides the mostly confidently identified taxa that were collected in the 2009 sample:

Austroperlidae

Acruperla atra (Samal)
Austroheptura illiesi Hynes
Austroheptura sp.

Eustheniidae

Cosmioperla kuna (Theischinger)

Gripopterygidae

Gripopterygidae sp.
Dinotoperla brevipennis Kimmins
Dinotoperla christine McLellan
Dinotoperla eucumbene McLellan
Dinotoperla fontana Kimmins
Dinotoperla hirsuta McLellan
Dinotoperla thwaitesi Kimmins
Dinotoperla subserricauda Theischinger
Dinotoperla uniformis Kimmins
Dinotoperla sp.
Illiesoperla sp.
Leptoperla sp.

Leptoperla / Riekoperla sp.
Newmanoperla thoreyi (Banks)
Riekoperla alpina McLellan
Riekoperla hynesorum Theischinger
Riekoperla karki McLellan
Riekoperla reticulata (Kimmins)
Riekoperla rugosa (Kimmins)
Riekoperla tuberculata McLellan
Riekoperla sp.
Trinotoperla montana (Riek)
Trinotoperla nivata Kimmins
Trinotoperla sp.

Notonemouridae

Notonemouridae sp.
Austrocerca tasmanica (Tillyard)
?Austrocerca ?tasmanica
Austrocercella hynesi Illies
?Austrocercella ?hynesi
Austrocercella ?tillyardi

Table 1. Plecoptera collected at sites for the Snowy Hydro Cloud Seeding Trial in November 2009. Legend: ♂ = male adults, ♀ = female adults; L = larvae; Au = Austroperlidae, Eu = Eustheniidae, Gri = Gripopterygidae, No = Notonemouridae.

Location data	Family	Species	♂	♀	L
SNO2 24/11/2009 Snowy River above Blue Lake 36.42066 S 148.33132 E Elev. 1670 m asl. Edge/Riffle Coll: G. Theisinger	Eu	<i>Cosmioperla kuna</i>			1
	Gri	<i>Dinotoperla hirsuta</i>	1		
	Gri	<i>Riekoperla hynesorum</i>	11	12	
	Gri	<i>Riekoperla reticulata</i>	3	2	
	Gri	<i>Riekoperla</i> sp.			72
	Gri	<i>Trinotoperla</i> sp.			1
	No	? <i>Austrocercera ?tasmanica</i>		1	
	No	<i>Austrocercella hynesi</i>	2	3	
No	sp.			6	
SNO3 24/11/2009 Snowy River above Spencers Creek 36.40060 S 148.34314 E Elev. 1650 m asl. Edge/Riffle Coll: G. Theisinger	Eu	<i>Cosmioperla kuna</i>			1
	Gri	<i>Riekoperla hynesorum</i>	16	18	
	Gri	<i>Riekoperla reticulata</i>	2	10	
	Gri	<i>Riekoperla</i> sp.			63
	Gri	<i>Trinotoperla</i> sp.			1
	No	? <i>Austrocercella ?hynesi</i>		4	
	No	<i>Austrocercella ?tillyardi</i>		2	
No	sp.			1	
SNO4 23/11/2009 Kosciusko Creek above Snowy River 36.44278 S 148.30067 E Elev. 1830 m asl. Edge/Riffle Coll: G. Theisinger	Eu	<i>Cosmioperla kuna</i>			15
	Gri	<i>Leptoperla</i> sp.		1	
	Gri	<i>Riekoperla hynesorum</i>	7	2	
	Gri	<i>Riekoperla reticulata</i>	1	2	
	Gri	<i>Riekoperla</i> sp.		3	24
	No	<i>Austrocercella hynesi</i>	1	1	
No	sp.			2	
SNO7 23/11/2009 Snowy River above Club Lake Creek 36.43138 S 148.31946 E Elev. 1730 m asl. Edge/Riffle Coll: G. Theisinger	Eu	<i>Cosmioperla kuna</i>			1
	Gri	<i>Leptoperla</i> sp.			1
	Gri	<i>Riekoperla hynesorum</i>	5	4	
	Gri	<i>Riekoperla reticulata</i>	3	3	
	Gri	<i>Riekoperla</i> sp.			46
	No	<i>Austrocercella hynesi</i>	1	4	
	No	<i>Austrocercella ?tillyardi</i>		1	
GEE1 24/11/2009 Geehi River above Gehi Reservoir 36.25792 S 148.32545 E Elev. 1230 m asl. Edge/Riffle Coll: G. Theisinger	Au	<i>Austroheptura</i> sp.			3
	Eu	<i>Cosmioperla kuna</i>			4
	Gri	<i>Dinotoperla fontana</i>	7	10	
	Gri	<i>Dinotoperla thwaitesi</i>	11	5	
	Gri	<i>Dinotoperla</i> sp.			8
	Gri	<i>Trinotoperla montana</i>	2		
	Gri	<i>Trinotoperla nivata</i>		1	
	Gri	<i>Trinotoperla</i> sp.			14
	Gri	<i>Illiesoperla</i> sp.			1
No	sp.			9	

Location data	Family	Species	♂	♀	L
DCK1 25/11/2009 Dicky Cooper Creek near Schlinks Hut 36.27524 S 148.38231 E Elev. 1770 m asl. Edge/Rifle Coll: G. Theisinger	Au	<i>Austroheptura illiesi</i>		1	
	Au	<i>Austroheptura sp.</i>			14
	Eu	<i>Cosmioperla kuna</i>		1	15
	Gri	<i>Dinotoperla hirsuta</i>	3	2	
	Gri	<i>Dinotoperla sp.</i>			1
	Gri	<i>Riekoperla hynesorum</i>	26	29	
	Gri	<i>Riekoperla karki</i>	3	1	
	Gri	<i>Riekoperla reticulata</i>	20	19	
	Gri	<i>sp.</i>			40
	No	<i>Austrocerca tasmanica</i>	1		
	No	<i>Austrocerella ?tillyardi</i>		1	
No	<i>sp.</i>		1	2	
DCK2 25/11/2009 Dicky Cooper Creek 36.25829 S 148.36209 E Elev. 1504 m asl. Edge/Riffle Coll: G. Theisinger	Au	<i>Austroheptura sp.</i>			4
	Eu	<i>Cosmioperla kuna</i>			4
	Gri	<i>Dinotoperla eucumbene</i>	1		
	Gri	<i>Dinotoperla fontana</i>	5	3	
	Gri	<i>Dinotoperla thwaitesi</i>	20	8	
	Gri	<i>Dinotoperla sp.</i>			4
	Gri	<i>Leptoperla/Riekoperla sp.</i>			1
	Gri	<i>Riekoperla alpina</i>	7	7	
	Gri	<i>Riekoperla karki</i>	2		
	Gri	<i>Riekoperla rugosa</i>	1	4	
	Gri	<i>Trinotoperla montana</i>	1	2	
	Gri	<i>Trinotoperla sp.</i>			13
	No	<i>sp.</i>			21
TUM1 23/11/2009 Tumut River above Bogong Creek 36.08654 S 148.38524 E Elev. 1400 m asl. Edge/Riffle Coll: G. Theisinger	Eu	<i>Cosmioperla kuna</i>			8
	Gri	<i>Dinotoperla brevipennis</i>	3	8	
	Gri	<i>Dinotoperla fontana</i>	16	12	
	Gri	<i>Dinotoperla hirsuta</i>	35	32	
	Gri	<i>Dinotoperla thwaitesi</i>	9	9	
	Gri	<i>Dinotoperla sp.</i>		1	4
	Gri	<i>Riekoperla sp.</i>		1	
	Gri	<i>Trinotoperla nivata</i>		2	
	Gri	<i>Trinotoperla sp.</i>			6
	No	<i>sp.</i>			35
TUM2 23/11/2009 Tumut River below Bogong Creek 36.07212 S 148.38107 E Elev. 1360 m asl. Edge/Riffle Coll: G. Theisinger	Eu	<i>Cosmioperla kuna</i>			8
	Gri	<i>Dinotoperla brevipennis</i>	3	4	
	Gri	<i>Dinotoperla Fontana</i>	2	13	
	Gri	<i>Dinotoperla hirsute</i>	9	8	
	Gri	<i>Dinotoperla thwaitesi</i>	4	11	
	Gri	<i>Dinotoperla uniformis</i>	1		
	Gri	<i>Dinotoperla sp.</i>			3
	Gri	<i>Riekoperla tuberculata</i>	1		
	Gri	<i>Trinotoperla montana</i>		1	
	Gri	<i>Trinotoperla nivata</i>	3	2	
	Gri	<i>Trinotoperla sp.</i>			13
	No	<i>sp.</i>			4

Location data	Family	Species	♂	♀	L
TUM3 23/11/2009 Tumut River at Round Mountain 36.04476 S 148.39330 E Elev. 1310 m asl. Edge/Riffle Coll: G. Theischinger	Eu	<i>Cosmioperla kuna</i>			8
	Gri	<i>Dinotoperla brevipennis</i>		2	
	Gri	<i>Dinotoperla Fontana</i>	9	17	
	Gri	<i>Dinotoperla hirsute</i>	4	11	
	Gri	<i>Dinotoperla thwaitesi</i>	8	8	
	Gri	<i>Dinotoperla</i> sp.			2
	Gri	<i>Trinotoperla montana</i>		3	
	Gri	<i>Trinotoperla nivata</i>	1	1	
	Gri	<i>Trinotoperla</i> sp.			5
	No	sp.			18
DB1 23/11/2009 Doubtful Creek at McCallister 36.16371 S 148.43515 E Elev. 1676 m asl. Edge/Riffle Coll: G. Theischinger	Au	<i>Austroheptura</i> sp.			2
	Eu	<i>Cosmioperla kuna</i>			10
	Gri	<i>Dinotoperla Fontana</i>		1	
	Gri	<i>Dinotoperla hirsute</i>	12	22	
	Gri	<i>Dinotoperla</i> sp.			4
	Gri	<i>Leptoperla</i> sp.		1	
	Gri	<i>Riekoperla hynesorum</i>	4	4	
	Gri	<i>Riekoperla karki</i>	2	2	
	Gri	<i>Riekoperla</i> sp.			3
	No	<i>Austrocercia tasmanica</i>	1		
	No	sp.			10
DB2 23/11/2009 Doubtful Creek at Cesjacks 36.14505 S 148.44429 Elev. 1650 m asl. Edge/Riffle Coll: G. Theischinger	Eu	<i>Cosmioperla kuna</i>			2
	Gri	<i>Dinotoperla hirsute</i>	4	6	
	Gri	<i>Dinotoperla thwaitesi</i>		1	
	Gri	<i>Dinotoperla</i> sp.			1
	Gri	<i>Riekoperla</i> sp.		1	1
	No	sp.			8
DB3 23/11/2009 Doubtful Creek at Grey Mares Trail 36.11081 S 148.43168 E Elev. 1540 m asl. Edge/Riffle Coll: G. Theischinger	Eu	<i>Cosmioperla kuna</i>			2
	Gri	<i>Dinotoperla Fontana</i>		1	
	Gri	<i>Dinotoperla hirsute</i>		1	
	Gri	<i>Dinotoperla</i> sp.			1
	Gri	<i>Riekoperla karki</i>	3	1	
	Gri	<i>Riekoperla tuberculata</i>		1	
	Gri	<i>Riekoperla</i> sp.			2
	Gri	<i>Trinotoperla</i> sp.			1
	No	sp.			14
TIN 24/11/2009 Tin Mine Creek at Hut 36.70461 S 148.23559 E Elev. 1290 m asl. Edge/Riffle Coll: G. Theischinger	Au	<i>Acruperla atra</i>		1	
	Gri	<i>Dinotoperla brevipennis</i>	1	3	
	Gri	<i>Dinotoperla</i> sp.			5
	Gri	<i>Riekoperla</i> sp.		1	
	No	sp.			4

Location data	Family	Species	♂	♀	L
MURR 24/11/2009 Upper Murray at Cowambat 36.79249 S 148.16801 E Elev. 1160 m asl. Edge/Riffle Coll: G. Theischinger	Eu	<i>Cosmioperla kuna</i>			1
	Gri	<i>Dinotoperla subserricauda</i>	1		
	Gri	<i>Dinotoperla thwaitesi</i>	3		
	Gri	<i>Dinotoperla</i> sp.			13
	Gri	<i>Illiesoperla</i> sp.			3
	Gri	<i>Newmanoperla thoreyi</i>	1		
	Gri	<i>Riekoperla karki</i>	1		
	Gri	<i>Riekoperla rugosa</i>	1	1	
ING 24/11/2009 Ingeegoodbee River above access road 36.73327 S 148.26489 E Elev. 1140 m asl. Edge/Riffle Coll: G. Theischinger	Gri	<i>Dinotoperla brevipennis</i>	3		
	Gri	<i>Dinotoperla christinae</i>			1
	Gri	<i>Dinotoperla fontana</i>		1	
	Gri	<i>Dinotoperla</i> sp.			1
	Gri	<i>Riekoperla rugosa</i>	2		
	Gri	<i>Riekoperla</i> sp.			1
	No	sp.			14

Analyses

The MDS plots of site Stonefly assemblage similarities indicated that site differences were better defined using species level adult stonefly data (shown in Fig. 3) rather than the genus/family level larval data (Fig. 2). The plot of stonefly larvae could not differentiate between sites TUM2 and TUM3, SNO2 and SNO3, and DB2, TIN and ING.

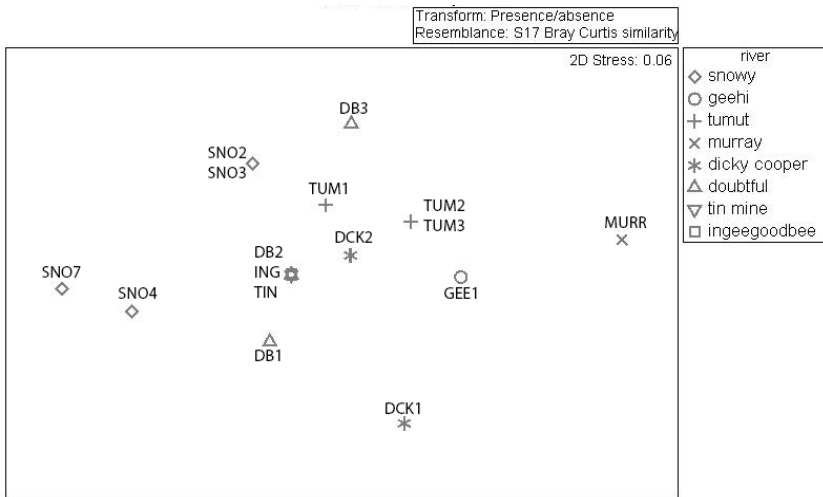


Fig. 2. MDS plot of Stonefly larvae assemblages for the study sites.

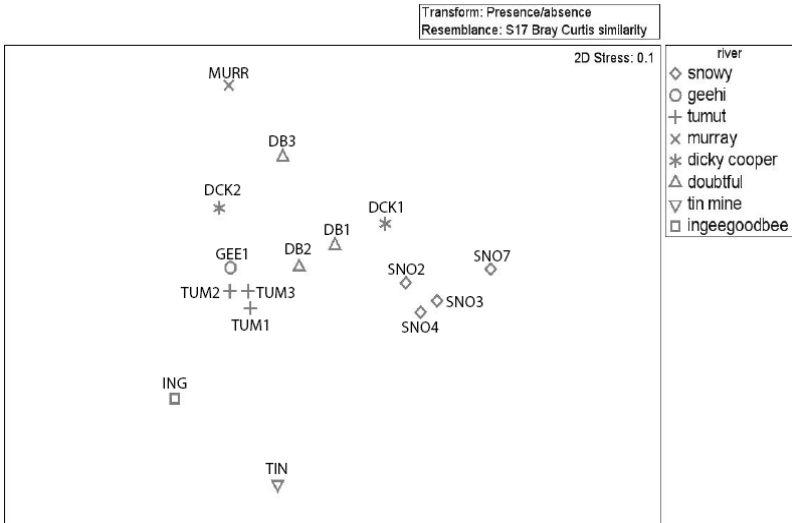


Fig. 3. MDS plot of Stonefly adult assemblages for the study sites.

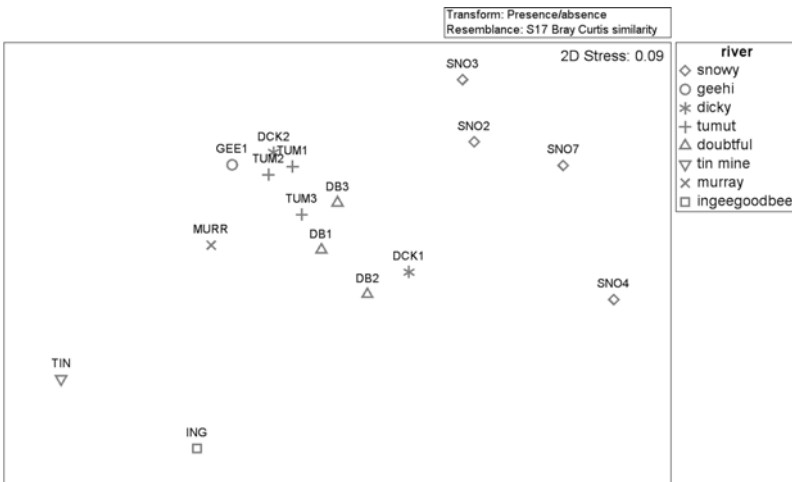


Fig. 4. MDS plot of aquatic larvae, identified to species level where possible, for the study sites riffle habitats.

The stonefly adults plot, however, identified all sites to be different and differences between rivers to be generally greater than differences between sites within each river. The exception to this was Dicky Cooper Creek, where

the two sites were dissimilar. Note that there was only one site in the Murray River, Geehi River, Ingeegoodbee River and Tin Mine Creek.

MDS plots of the aquatic larval assemblages collected from the riffle and edge habitats showed a similar general site pattern to the stonefly adult plot. The plot of the riffle larval fauna is presented in Fig. 4. The plots of the full larval assemblages were able to differentiate all sites.

Discussion

Previously, when the same Snowy Mountain sites were sampled for the monitoring program in 2008, the study only included the collection of larvae. Without adult stoneflies, only three stonefly taxa were able to be identified (by consultants) beyond family level: *Acruroperla atra*, *Cosmioperla* (? as *Sternoperla*) sp. and *Austroheptura* (? as *Tasmanoperla*) sp. By comparison, the 2009 study identified 23 different Stonefly species at the Snowy Hydro monitoring sites using adults, thus allowing analysis of differences between sites and, more importantly to the study, identification of change over time.

It appears that the geographical and habitat information from the 2009 Snowy Cloud Seeding trials, paired with confident identities for many stonefly species (see Tables 1 and 2), more than make up for the extra effort of collecting and identifying stonefly adults. The use of adult insect identifications where larvae identifications are not feasible could well prove to be an invaluable tool for the assessment of river health, biodiversity, conservation and climate change projects.

Outcomes of the study of adult stoneflies from the Snowy Hydro monitoring sites are:

Five *Dinotoperla* species were found coexisting simultaneously at the same site (TUM2) and finding diagnostic characters of these species, not only apparent in the structure of the male genitalia but also in colour and pattern of the forewings of both sexes, provides information on their ecology and may help future taxonomic and behavioural studies. Species, and particularly species assemblages, have greater indicator value for river health than family or generic-level data.

The presence in numbers of *Riekoperla alpina* in DCK2 (Dicky Cooper Creek at 1504 m), its absence in DCK1 (same creek at 1770 m) where its likely sister species *Riekoperla hynesorum* was collected in numbers, and the presence of *Riekoperla hynesorum* again in all sampled Snowy River sites (SNO2, SNO3, SNO4, SNOW07), all different in size, flow and substrate from Dicky Cooper Ck at both elevations, provides more than just very interesting ecological information. Table 2 shows clear species changes with elevation. It probably also enables taxonomists to make the first promising step to help distinguish the larvae of the *Riekoperla alpina* group morphologically without the need for expensive DNA analysis. The altitudinal detail may become significant for studies of climate change.

Table 2. Distribution of Stonefly species from the Snowy Hydro Cloud Seeding Trial. The sites are arranged with increasing elevation from left to right. The shaded boxes with crosses indicate the presence of the species at the site.

	ING	MURR	GEE1	TIN	TUM3	TUM2	TUM1	DCK2	DB3	SNO3	DB2	SNO2	DB1	SNO7	DCK1	SNO4
Stonefly adults																
<i>Acruroperla atra</i>				x												
<i>Austroheptura illiesi</i>															x	
<i>Cosmioperla kuna</i>															x	
<i>Dinotoperla brevipennis</i>	x			x	x	x	x									
<i>Dinotoperla hirsute</i>					x	x	x		x		x	x	x		x	
<i>Dinotoperla eucumbene</i>								x								
<i>Dinotoperla christinae</i>	x															
<i>Dinotoperla fontana</i>	x		x		x	x	x	x	x				x			
<i>Dinotoperla subserricauda</i>		x														
<i>Dinotoperla thwaitesi</i>		x	x		x	x	x	x			x					
<i>Dinotoperla uniformis</i>						x										
<i>Riekoperla alpine</i>								x								
<i>Riekoperla karki</i>		x						x	x				x		x	
<i>Riekoperla hynesorum</i>										x		x	x	x	x	x
<i>Riekoperla reticulata</i>										x				x	x	x
<i>Riekoperla rugosa</i>	x	x						x								
<i>Riekoperla tuberculata</i>						x				x						
<i>Newmanoperla thoreyi</i>		x														
<i>Trinotoperla montana</i>			x		x	x		x								x
<i>Trinotoperla nivata</i>			x		x	x	x									
<i>Austrocercella hynesi</i>										x		x		x		x
<i>Austrocercella ?tillyardi</i>										x				x	x	
<i>Austrocercella tasmanica</i>												x	x		x	
Stonefly larvae																
<i>Austroheptura</i> sp.			x					x					x			x
<i>Dinotoperla</i> sp.	x	x	x	x	x	x	x	x	x		x		x		x	
<i>Leptoperla</i> sp.													x	x		x
<i>Riekoperla</i> sp.	x			x				x	x	x	x	x	x	x		x
Gripopterygidae sp.																x
<i>Trinotoperla</i> sp.			x		x	x	x	x	x	x		x				
<i>Illiesoperla</i> sp.		x	x													
Notonemouridae sp	x		x	x	x	x	x	x		x	x	x	x		x	x
<i>Cosmioperla kuna</i>		x	x		x	x	x	x	x	x	x	x	x	x	x	x
elevation m asl.	1140	1160	1230	1290	1310	1360	1400	1504	1540	1650	1650	1670	1676	1730	1770	1830

Changes in species assemblages and dominance situations may be indicative of any sort of pollution and may be sensitive enough to show changes relating to climatic conditions. For the family Gripopterygidae, our lists show dominance of *Riekoperla* species of the *alpina* group in high alpine sites, together with dominance of *Dinotoperla* species and the presence of some species of the *Riekoperla tuberculata* and *rugosa* groups in lower altitude sites. The existence of the *Riekoperla alpina* group in high altitude sites probably results from warm periods making available formerly glaciated areas. On the other hand, the presence of *Dinotoperla* species and species of the *Riekoperla tuberculata* and *rugosa* groups in the cooler uplands of northern New South Wales and Queensland is probably an outcome of cooler periods in the past, facilitating dispersal northward to suitable habitats. Similar cases of speciation were discussed by Peters and Theischinger (2007) for dragonflies and by Watson and Theischinger (1984) for dragonflies, stoneflies and other aquatic groups.

The fact that the appearance of adults of certain stoneflies in some regions is highly seasonal, as found in the genus *Austrocercella* in the Snowy Mountains (Theischinger 1982), is worth investigating in more detail. More than one survey a year may significantly increase the number of species per habitat (biodiversity). Changes in altitudinal and seasonal occurrence over time of these seasonal species may prove indicative for monitoring pollutants and ecological and climatic change.

The distribution of the species across the sampled sites generally supports the existing information on the poor dispersal abilities of stoneflies. The sites that have the most similar faunal assemblages are geographically close on a river continuum (e.g. the four Snowy River sites: Tables 1 and 2). The Geehi River site GEE1 is close to, and connected by water to, the Dicky Cooper site DCK2. The two sites on Dicky Cooper Creek, DCK1 and DCK2, are close geographically and connected by water but have dissimilar assemblages; a possible cause could be a barrier to migration created by the waterfall between the two sites. Further sampling of these sites into the future is expected to add information on stonefly dispersal in the Snowy Mountains region.

By sampling adult stoneflies at sites, a clear picture of the diversity of species at individual sites can be formed. As such, a plea is made for the inclusion of adult stonefly collecting together with standard AusRivas sampling wherever stoneflies make up a significant part of the aquatic fauna, in particular Australian alpine and montane sites.

II. Summary of the Australian Plecoptera Fauna

This could also lead to a renaissance of taxonomic and ecological stonefly studies that, after a boom in the early 1980s, have been rather stagnant for the past two decades. In order to stimulate taxonomic research, an updated check-list of the Australian Plecoptera, with state distribution data, is

presented below (Table 3). Currently, the Australian Plecoptera fauna comprises 198 valid species (and subspecies) in 26 genera and 4 families. This list is followed by an outline of taxonomic research on the group (including the primary taxonomic literature) from its beginning to the present.

Table 3. Check-list of the Australian stonefly species and their known distributions. Legend: W = Western Australia, S = South Australia, T = Tasmania, V = Victoria, N = New South Wales (including ACT), Q = Queensland.

Species	Distribution					
	W	S	T	V	N	Q
<i>Acruroperla atra</i> (Samal, 1921)				+	+	
<i>Austroheptura campbelli</i> Theischinger, 1993				+		
<i>Austroheptura illiesi</i> Hynes, 1974				+	+	
<i>Austroheptura nevoissi</i> Illies, 1969				+		
<i>Austroheptura picta</i> (Riek, 1973)					+	+
<i>Austropentura hynesorum</i> Theischinger, 1988			+			
<i>Austropentura victoria</i> Illies, 1969				+	+	
<i>Cryptoperla paradoxa</i> Illies, 1969			+			
<i>Tasmanoperla larvalis</i> (Illies, 1969)			+			
<i>Tasmanoperla thalia</i> (Newman, 1839)			+			
<i>Cosmioperla australis</i> (Tillyard, 1921)					+	+
<i>Cosmioperla denise</i> (Theischinger, 1983)					+	+
<i>Cosmioperla kuna</i> (Theischinger, 1983)				+	+	
<i>Cosmioperla macrops</i> (Theischinger, 1983)						+
<i>Cosmioperla w. wongoonoo</i> (Theischinger, 1983)					+	+
<i>Cosmioperla wongoonoo tropica</i> (Theischinger, 1983)						+
<i>Eusthenia costalis</i> Banks, 1913			+			
<i>Eusthenia lacustris</i> Tillyard, 1921			+			
<i>Eusthenia nothofagi</i> Zwick, 1979				+		
<i>Eusthenia reticulata</i> (Tillyard, 1921)			+			
<i>Eusthenia spectabilis</i> Gray, 1832			+			
<i>Eusthenia v. venosa</i> (Tillyard, 1921)				+		
<i>Eusthenia venosa brachyptera</i> (Tillyard, 1924)					+	
<i>Thaumatoperla alpina</i> Burns & Neboiss, 1957			+			
<i>Thaumatoperla flaveola</i> Burns & Neboiss, 1957			+			
<i>Thaumatoperla robusta</i> Tillyard, 1921			+			
<i>Thaumatoperla timmsi</i> Zwick, 1979			+			
<i>Cardioperla diversa</i> McLellan, 1971			+			
<i>Cardioperla edita</i> Hynes, 1982			+			
<i>Cardioperla falsa</i> Hynes, 1982			+			
<i>Cardioperla flindersi</i> Hynes, 1982			+			
<i>Cardioperla incerta</i> Hynes, 1982			+			
<i>Cardioperla lobata</i> McLellan, 1971			+			
<i>Cardioperla media</i> Hynes, 1982			+			
<i>Cardioperla nigrifrons</i> (Kimmins, 1951)			+			
<i>Cardioperla spinosa</i> Hynes, 1982			+			
<i>Dinotoperla arcuata</i> Theischinger, 1982					+	+
<i>Dinotoperla bassae</i> Hynes, 1982	+		+	+	+	
<i>Dinotoperla brevipennis</i> Kimmins, 1951		+		+	+	
<i>Dinotoperla bunya</i> Theischinger, 1982						+
<i>Dinotoperla cardaleae</i> Theischinger, 1982						+
<i>Dinotoperla carnarvonensis</i> Theischinger, 1982						+
<i>Dinotoperla carpenteri</i> Tillyard, 1921					+	+
<i>Dinotoperla christinae</i> McLellan, 1971				+	+	+
<i>Dinotoperla cobra</i> Theischinger, 1982					+	+

Species	Distribution					
	W	S	T	V	N	O
<i>Dinotoperla dalrymple</i> Theischinger, 1993						+
<i>Dinotoperla dolichoprocta</i> Theischinger, 1982					+	
<i>Dinotoperla duplex</i> Theischinger, 1982					+	+
<i>Dinotoperla eucumbene</i> McLellan, 1971				+	+	
<i>Dinotoperla eungella</i> Theischinger, 1982						+
<i>Dinotoperla evansi</i> Kimmins, 1951		+				
<i>Dinotoperla fasciata</i> Tillyard, 1921					+	+
<i>Dinotoperla fontana</i> Kimmins, 1951				+	+	
<i>Dinotoperla hirsuta</i> McLellan, 1971				+	+	
<i>Dinotoperla hybrida</i> Theischinger, 1984						+
<i>Dinotoperla inermis</i> Theischinger, 1988					+	
<i>Dinotoperla kirrama</i> Theischinger, 1982						+
<i>Dinotoperla leonardi</i> Theischinger, 1982					+	+
<i>Dinotoperla marmorata</i> Hynes, 1976			+			
<i>Dinotoperla opposita</i> (Walker, 1852)			+			
<i>Dinotoperla parabrevipennis</i> Theischinger, 1982					+	
<i>Dinotoperla pseudodolichoprocta</i> Theischinger, 1982					+	
<i>Dinotoperla schneiderae</i> Theischinger, 1982						+
<i>Dinotoperla serricauda</i> Kimmins, 1951			+	+	+	
<i>Dinotoperla spinosa</i> Theischinger, 1982						+
<i>Dinotoperla subserricauda</i> Theischinger, 1988					+	?
<i>Dinotoperla thwaitesi</i> Kimmins 1951				+	+	
<i>Dinotoperla uniformis</i> Kimmins, 1951				?	+	+
<i>Dinotoperla vulcanica</i> Theischinger, 1982						+
<i>Dinotoperla walkeri</i> Dean & St Clair, 2006				+		
<i>Dundundra wanungra</i> (Theischinger, 1982).						+
<i>Eunotoperla kershawi</i> Tillyard, 1924				+	+	
<i>Illiesoperla australis</i> (Tillyard, 1924)		+		+	+	
<i>Illiesoperla austrosimplex</i> Theischinger, 1984				+		
<i>Illiesoperla barbara</i> Theischinger, 1984						+
<i>Illiesoperla brevicauda</i> Theischinger, 1984				+	+	
<i>Illiesoperla carnarvonensis</i> Theischinger, 1984						+
<i>Illiesoperla cerberus</i> Theischinger, 1984						+
<i>Illiesoperla echidna</i> Theischinger, 1984				+	+	
<i>Illiesoperla franzeni</i> (Perkins, 1958)				+	+	
<i>Illiesoperla frazieri</i> Theischinger, 1984				+		
<i>Illiesoperla mayi</i> (Perkins, 1958)		+	+	+	+	+
<i>Illiesoperla tropica</i> Theischinger, 1984						+
<i>Kirrama abolos</i> Theischinger, 1981						+
<i>Kirrama naumanni</i> Theischinger, 1993						+
<i>Leptoperla alata</i> Theischinger, 1984						+
<i>Leptoperla albicincta</i> Theischinger, 1981				+		
<i>Leptoperla angularis</i> Theischinger, 1981						+
<i>Leptoperla australica</i> (Enderlein, 1909)		+				
<i>Leptoperla beroe</i> Newman, 1839			+			
<i>Leptoperla bifida</i> McLellan, 1971				+	+	
<i>Leptoperla bubalus</i> Theischinger, 1980					+	
<i>Leptoperla cacuminis</i> Hynes, 1974					+	
<i>Leptoperla collessi</i> Theischinger, 1981						+
<i>Leptoperla commoni</i> Theischinger, 1981						+
<i>Leptoperla curvata</i> Theischinger, 1980				+	+	
<i>Leptoperla dahmsi</i> Theischinger, 1984						+
<i>Leptoperla kalliste</i> Hynes, 1974				+		
<i>Leptoperla kimminsi</i> McLellan, 1971				+		

Species	Distribution					
	W	S	T	V	N	O
<i>Leptoperla longicauda</i> Theischinger, 1988				+	+	
<i>Leptoperla magnicauda</i> Theischinger, 1981						+
<i>Leptoperla membranosa</i> Theischinger, 1988					+	
<i>Leptoperla nevoissi</i> McLellan, 1971				+	+	
<i>Leptoperla primitiva</i> McLellan, 1971		+		+	+	
<i>Leptoperla rieki</i> Theischinger, 1981					+	
<i>Leptoperla rotunda</i> Theischinger, 1984						+
<i>Leptoperla rubiconis</i> Theischinger, 1984				+	+	
<i>Leptoperla smithersi</i> Theischinger, 1981				+	+	
<i>Leptoperla tasmanica</i> Kimmins, 1951		+		+	+	
<i>Leptoperla thompsoni</i> Theischinger, 1988						+
<i>Leptoperla truncata</i> Theischinger, 1980				+	+	
<i>Leptoperla uptoni</i> Theischinger, 1981						+
<i>Leptoperla varia</i> Kimmins, 1951			+			
<i>Neboissoperla alpina</i> McLellan, 1971				+	+	
<i>Neboissoperla monteithi</i> Theischinger, 1982					+	
<i>Neboissoperla spinulata</i> Theischinger, 2002					+	
<i>Nesciopterla curtisae</i> Theischinger, 1982						+
<i>Newmanoperla exigua</i> (Kimmins, 1951)	+					
<i>Newmanoperla hackeri</i> McLellan, 1971				+	+	
<i>Newmanoperla prona</i> Hynes, 1982			+			
<i>Newmanoperla thoreyi</i> (Banks, 1920)		+		+	+	+
<i>Riekoperla alpina</i> McLellan, 1971				+	+	
<i>Riekoperla angusta</i> Theischinger, 1985				+	+	
<i>Riekoperla barringtonensis</i> Theischinger, 1985					+	
<i>Riekoperla citrea</i> Theischinger, 1985						+
<i>Riekoperla compressa</i> Theischinger, 1985				+	+	
<i>Riekoperla cornuta</i> Theischinger, 1985				+		
<i>Riekoperla darlingtoni</i> (Illies, 1968)				+		
<i>Riekoperla elongata</i> Theischinger, 1985					+	+
<i>Riekoperla hynesorum</i> Theischinger, 1985					+	
<i>Riekoperla intermedia</i> Theischinger, 1985				+		
<i>Riekoperla isosceles</i> Theischinger, 1985				+		
<i>Riekoperla karki</i> McLellan, 1971				+	+	
<i>Riekoperla montana</i> Theischinger, 1985				+	+	
<i>Riekoperla naso</i> Theischinger, 1981		+		+		
<i>Riekoperla occidentalis</i> Hynes & Bunn, 1984	+					
<i>Riekoperla perkinsi</i> Theischinger, 1985					+	+
<i>Riekoperla pulchra</i> Hynes, 1982			+			
<i>Riekoperla reticulata</i> (Kimmins, 1951)				+	+	
<i>Riekoperla rugosa</i> (Kimmins, 1951)				+	+	
<i>Riekoperla serrata</i> Theischinger, 1985				+		
<i>Riekoperla tillyardi</i> McLellan, 1971				+		
<i>Riekoperla trapeza</i> Theischinger, 1985				+	+	
<i>Riekoperla t. triloba</i> McLellan, 1971			+	+	+	
<i>Riekoperla triloba regalis</i> Hynes, 1982			+			
<i>Riekoperla tuberculata</i> McLellan, 1985				+	+	
<i>Riekoperla williamsi</i> McLellan, 1971				+	+	
<i>Riekoperla zwicki</i> Theischinger, 1985				+		
<i>Trinotoperla comprimata</i> Hynes, 1982			+			
<i>Trinotoperla groomi</i> Perkins, 1958						+
<i>Trinotoperla hardyi</i> Perkins, 1958			+			
<i>Trinotoperla inopinata</i> Hynes, 1982			+			
<i>Trinotoperla irrorata</i> Tillyard, 1924				+	+	
<i>Trinotoperla maior</i> Theischinger, 1982					+	?

Species	Distribution					
	W	S	T	V	N	O
<i>Trinotoperla minima</i> Theischinger, 1982						+
<i>Trinotoperla minor</i> Kimmins, 1951				+	+	+
<i>Trinotoperla montana</i> (Riek, 1962)				+	+	
<i>Trinotoperla mouldsi</i> Theischinger, 1982						+
<i>Trinotoperla nivata</i> Kimmins, 1951				+	+	
<i>Trinotoperla sinuosa</i> Theischinger, 1982				+		
<i>Trinotoperla tasmanica</i> (McLellan, 1971)			+			
<i>Trinotoperla woodwardi</i> Perkins, 1958						+
<i>Trinotoperla yeoi</i> Perkins, 1958					+	+
<i>Trinotoperla zwicki</i> McLellan, 1971			+			
<i>Austrocercera riei</i> Illies, 1975			+			
<i>Austrocercera tasmanica</i> (Tillyard, 1924)		+	+	+	+	
<i>Austrocercella alpina</i> Theischinger, 1984				+	+	
<i>Austrocercella autumnalis</i> Theischinger, 1984				+	+	
<i>Austrocercella christinae</i> Illies, 1975			+			
<i>Austrocercella columbae</i> Hynes, 1981			+			
<i>Austrocercella c. communis</i> Theischinger, 1984					+	+
<i>Austrocercella communis obtusa</i> Theischinger, 1984				+		
<i>Austrocercella distans</i> Theischinger, 1984				+		
<i>Austrocercella elevata</i> Theischinger, 1984				+		
<i>Austrocercella forcipula</i> Theischinger, 1984				+		
<i>Austrocercella hynesi</i> Illies, 1975						+
<i>Austrocercella i. illiesi</i> Theischinger, 1984				+	+	
<i>Austrocercella illiesi tarraensis</i> Theischinger, 1984				+		
<i>Austrocercella mariannae</i> Illies, 1975				+	+	
<i>Austrocercella nivalis</i> Theischinger, 1984				+	+	
<i>Austrocercella tillyardi</i> (Kimmins, 1951)				+	+	
<i>Austrocercella verna</i> Theischinger, 1984						+
<i>Austrocercella weiri</i> Theischinger, 1984						+
<i>Austrocercoides bullata</i> (Kimmins, 1951)			+			
<i>Austrocercoides kondu</i> Theischinger, 1993			+			
<i>Austrocercoides nevoissi</i> Illies, 1975				+	+	
<i>Austrocercoides tunta</i> Theischinger, 1993			+			
<i>Austrocercoides zwicki</i> Illies, 1975			+			
<i>Kimminsoperla albomacula</i> (Kimmins, 1951)			+			
<i>Kimminsoperla biloba</i> Illies, 1975			+			
<i>Kimminsoperla hystrix</i> Illies, 1975					+	+
<i>Kimminsoperla kaputaris</i> Theischinger, 1980					+	
<i>Kimminsoperla mcalpinei</i> Theischinger, 1981					+	
<i>Kimminsoperla nevoissi</i> Theischinger, 1988			+			
<i>Kimminsoperla williamsi</i> Illies, 1975			+			
<i>Notonemoura lynchi</i> Illies, 1975			+	+		
<i>Notonemoura maculata</i> (Weir, 1967)				+	+	+
<i>Tasmanocerca bifasciata</i> (Kimmins, 1951)			+			
Total number of species group taxa = 198	4	9	51	75	91	57

Historical perspectives

The taxonomic history of Australian Plecoptera started with the description of *Eusthenia spectabilis* from Tasmania (Gray 1832). Additions of new species mostly came from contributions of one or two species each by Newman (1839), Walker (1852), Enderlein (1909), Banks (1913, 1920), Samal (1921), Burns and Neboiss (1957), Riek (1962, 1973), Weir (1967)

and Hynes and Bunn (1984). Early family/genus revisions allowed Tillyard 1921, 1924) to add twelve, Perkins (1957) to add six and Kimmins (1951) to establish 18 more species. Revisions of all families, undertaken by eminent overseas plecopterists between 1968 and 1982, provided 15 additional species described by Illies (1968, 1969, 1975), 19 by McLellan (1971), two by Zwick (1979) and 17 by Hynes (1974-1982). Theischinger (1980-2002) added a further 94 species, mainly in generic revisions based on personal collecting in the field (mainly New South Wales and Queensland) and from museum holdings. The concluding 198th Australian species (*Dinotoperla walkeri*) resulted from river health studies and was added by Dean and St Clair (2006), suggesting a closer synergy between taxonomy and environmental studies might be established. As recently as 1996, McLellan established the genus *Cosmioperla* for the Australian species previously included in *Stenoperla* McLachlan.

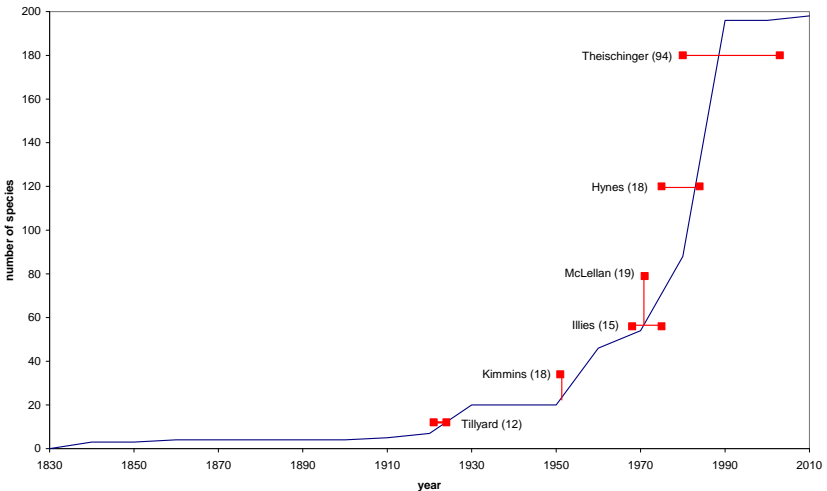


Fig. 5. Historical record of establishment of species-group taxa in Australian Plecoptera. In the above historical outline, taxa regarded as synonyms are not included. Vertical lines mark the year of single publications, horizontal lines indicate the time span between first and last publications of the author and numbers in brackets indicate the number of new species added to the fauna.

Larval taxonomy was seldom extensively covered in revisions or descriptive papers. There are, however, two comprehensive treatments by Hynes (1978) and Yule (1997) of the larvae from Victoria, and New South Wales and northern Victoria, respectively, and a more specialised publication (Tsyrlin 2001) which included only a key to the Australian stonefly genera and to the species of *Leptoperla* from Victoria. An ‘Illustrated Guide to the Adults of the Australian Stoneflies (Plecoptera)’, including brief descriptions and

illustrations of the adults of all Australian species, was presented by Theischinger and Cardale (1987). Based largely on this publication, the then known Australian stonefly fauna was catalogued by Michaelis and Yule (1988).

Acknowledgements

Access to the remote sites was made possible by Snowy Hydro. Specifically, John Denholm arranged for helicopter access to sites and accommodation for the field team. The helicopter pilot, Colin De Pagter, assisted with sampling at the sites. Theresa Dye of Cardno Pty Ltd provided information on site locations and previous samplings. Klaus Koop of DECCW facilitated the sampling program. The manuscript benefited greatly from critical comments from Dr D.J. Bickel (Sydney), Dr R. Marchant (Melbourne), Dr A.L. Sheldon (Crawfordville, Florida, USA) and last but not least from the editorial input of Dr A.G. Orr. The contributions of these people are gratefully acknowledged.

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A NEW SPECIES OF FORESTER MOTH FROM VICTORIA (LEPIDOPTERA: ZYGAENIDAE: PROCRIDINAE)

AXEL KALLIES¹ and BERNARD MOLLET²

¹*The Walter and Eliza Hall Institute, 1G Royal Parade, Parkville, Vic 3050
(Email: kallies@wehi.edu.au)*

²*16, Parc Vatonne, 91190, Gif-sur-Yvette, France
(Email: molletb@wanadoo.fr)*

Abstract

A new species of forester moth, *Pollanisia marriotti* sp. n., is described from Victoria. It is similar to *Pollanisia angustifrons* Tarmann, 2004 and several closely related species from northern Queensland but distinguishable by its size, the breadth of its head and by the structure of the antennae. *Pollanisia marriotti* sp. n. is currently known from a single locality in the vicinity of Gembrook, east of Melbourne, where it occurs together with *Pollanisia lithopastus* Turner, 1926, from which it can be readily distinguished by the coloration of the abdomen and the size of the head and compound eyes.

Introduction

The Zygaenidae of Australia were revised recently by Tarmann (2004). The most speciose genus is the Australian endemic *Pollanisia* Walker, with currently 20 species described. *Pollanisia* species are distributed mainly along the eastern and south-eastern coast of Australia and Tasmania, with relatively few species occurring in South and Western Australia.

Despite Tarmann's (2004) revision, a relatively large number of species remain unnamed due to the lack of sufficient material. This is especially true in the case of *Pollanisia* from the northern part of the genus' range. The species from south-eastern Australia, in particular from Victoria and southern New South Wales, however, have been collected extensively and can be considered well-known; the discovery of a previously unknown species of *Pollanisia* in the vicinity of Melbourne therefore came as a surprise. This new species belongs to a group of species known previously only from the tropical and sub-tropical north-east of Australia, and is clearly distinct from all other species that occur in Victoria or New South Wales.

Methods

The terminology of the setal combination of the first abdominal segment of the first instar larvae follows Efetov *et al.* (2000) and describes the position, number and colour of setae. Abbreviations used in the description as are follows: D (dorsal), SD (subdorsal), L (lateral), *l* (light), *d* (dark).

Material

The acronyms of the following depositories are given in parentheses: ANIC - Australian National Insect Collection, CSIRO Entomology, Canberra, Australia; CAKM – Collection of Axel Kallies, Melbourne, Australia; CBMG - Collection of Bernard Mollet, Gif-sur-Yvette, France.



Figs 1-10. *Pollanisus* spp. and host plant. (1-2) *P. marriotti* sp. n.: (1) male (holotype), dorsal; (2) female (paratype), dorsal. (3-4) *P. lithopastus*: (3) male, dorsal; (4) female, dorsal. (5) *P. angustifrons* (paratype) male, dorsal. (6-7) *P. marriotti* sp. n., male: (6) head, ventral; (7) abdomen, dorsal. (8-9) *P. lithopastus*, male: (8) head, ventral; (9) abdomen, dorsal. (10) *Hibbertia empetrifolia* (DC.) Hoogland, the assumed host plant of *P. marriotti* sp. n. at the type locality, Gilwell Park, Gembrook, Victoria.

***Pollanisus marriotti* sp. n.**

(Figs 1, 2, 6, 7, 11-15)

Types. Holotype ♂ (Fig. 1): 'Australia, Victoria, E of Melbourne, Gembrook, Gilwell Park, S37°26' E145°39', 3.ii.2008, lux, leg. A. Kallies & P. Marriotti' (to be deposited in ANIC). *Paratypes*: 1 ♂, same data as holotype but 10.i.2008 (P. Marriotti) (CAKM); 2 ♂♂, 1 ♀ (GP698), same data as holotype but 3.ii.2008 (A. Kallies & P. Marriotti) (CBMG); 2 ♂♂, 1 ♀, same data as holotype but 6.ii.2009 (A. Kallies & A. Young) (CAKM); 2 ♂♂, same data as holotype but 27.i.2009 (A. Kallies, S. & B. Mollet) (CBMG); 4 ♂♂ (GP697), 1 ♀ (Fig. 2), same data as holotype but 8.ii.2009 (A. Kallies, S. & B. Mollet) (CBMG); 1 ♀, same data as holotype but 7.ii.2009 (M. Vagg) (CAKM); 3 ♂♂, same data as holotype but 2.ii.2010 (A. Kallies, P. Marriotti & M. Hewish) (CAKM); 1 ♂, same data as holotype but 21.ii.2010 (A. Kallies) (CAKM).

Etymology

marriotti – a noun in the genitive case: this new species is dedicated to Peter Marriotti, Bentleigh, Victoria, main author of the 'Moths of Victoria' book series, who collected the first specimen.

Description

Male (Fig. 1). Forewing length: 8.5-9.5 mm. Head dorsally dark brown with a bluish green sheen, with metallic green frontal scales and a narrow stripe of shiny bluish green scales running along the margin of the black compound eye; frons *ca* 1.2 x broader than breath of compound eye in frontal view, significantly protruding beyond compound eyes in both lateral and dorsal view; labial palps light brown without metallic scales; proboscis yellow to light brown; distance of ocellus from compound eye 0.8 x diameter of ocellus; chaetosemata dark brown, the anterior extension overreaching ocellus and completely covering the space between compound eye and ocellus. Antenna dark brown with a weak bluish green sheen on dorsal side of the shaft; segments 1 to 29-31 bipectinate, segments 30-32 to 39-42 biserrate; at segment 15 pectination 6-6.5 x longer than breath of shaft in dorsal view and 4-4.5 x longer at segment 25; sensory hairs on pecten very short. Collar with bright metallic golden green scales.

Thorax dark brown with a weak bluish green sheen dorsally and with shiny metallic bluish green scales laterally and ventrally; patagia dark brown with golden green scales proximally. Legs dark brown, femur of hind leg metallic green blue laterally. Abdomen dark brown on the first segment and mostly metallic golden green dorsally on other segments, dark brown with a very weak bluish green sheen ventrally.

Wings broad, forewing elongate triangular, hindwing almost rectangular, rounded apically, posterior margin straight; forewing upperside dark brown with a weak bluish green sheen and a patch of green metallic scales near the cell (on fresh specimens); underside dark grey-brown without metallic scales; hindwing upperside dark brown with a slightly translucent space between

veins CuP and Cu2; underside dark brownish grey with metallic bluish green scales in a band between cell and costa and at anal angle. Fringe blackish brown with a weak sheen.

Female (Fig. 2). Forewing length: 7-7.5 mm. Similar to male but with narrower and more rounded wings. Antenna biserrate. Abdominal hair tuft bright yellow.

Male genitalia (Figs 11-12). Valva pointed distally, slightly convex dorsally, folded translucent central part triangular, ventral sclerotization broad, ventral margin of valva straight with a proximal part lobed, saccus strongly sclerotized. Aedeagus slightly tapered and upcurved, *ca* 4.5 x longer than broad; cornutus large and slender, straight, pointed distally, its length *ca* 80% of aedeagus.

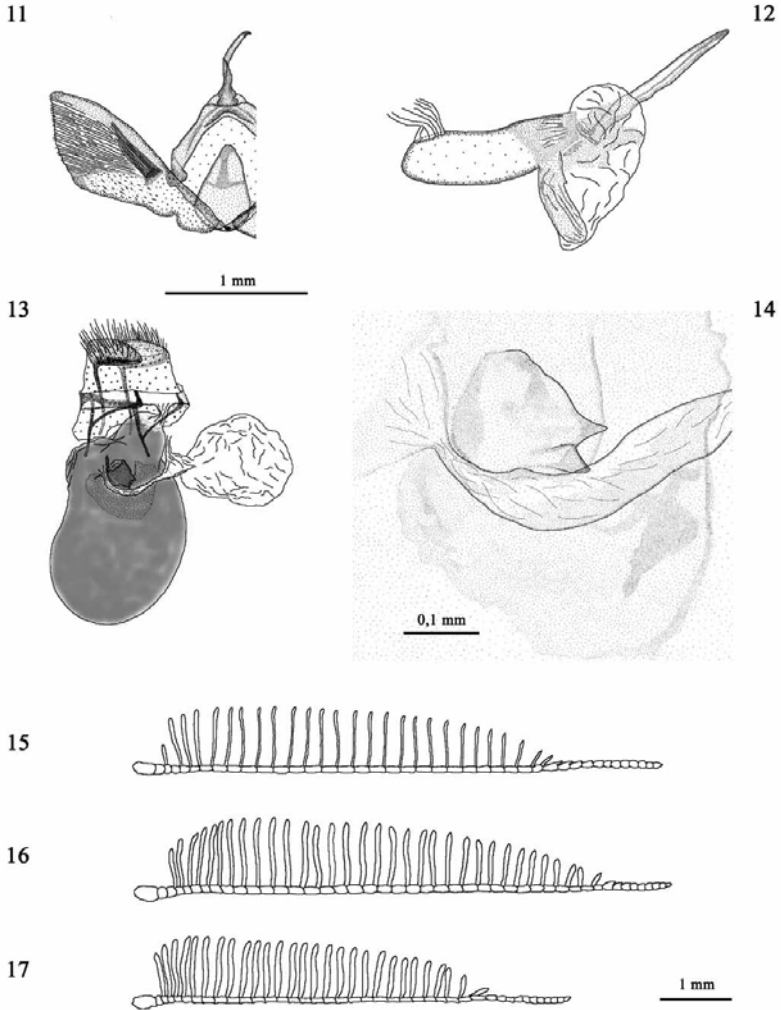
Female genitalia (Figs 13-14). Sternite VIII not sclerotized, ductus bursae short, translucent, wall of corpus bursae near point of insertion of ductus bursae with a sclerotization bearing 2 small teeth. Ductus seminalis arising near lumen of corpus bursae.

Description of the first instar larva

The L1 (first instar) is cream coloured and about 1 mm in length. It has a combination of three anal combs, an arrangement known for the genus *Pollanisus* and other genera of the tribe Artonini (Mollet and Tarmann 2010). There are no brown lateral spots on the subdorsal part of the third thoracic segment and on the second and fifth abdominal segments visible. The setal formula of the first abdominal segment is: D: 1*d*; SD: 1*d*, 1*l*; L: 2*l*. This appears characteristic of the Artonini (Mollet and Tarmann 2010).

Diagnosis

Pollanisus marriotti sp. n. is similar and appears to be most closely related to *P. angustifrons* Tarmann, 2004, *P. eungellae* Tarmann, 2004, *P. eumetopus* Turner, 1926, *P. acharon* (Fabricius, 1775) and a number of unnamed species, all of which occur in the northern parts of Queensland and the Northern Territory. These all belong to a group of species characterized by their dark brown forewings with sparse metallic scales, their bright metallic green collar and a conspicuous green metallic mark that gradually widens from a point at the centre of the 2nd tergite and covers most of the caudal part of the abdomen. Within this group, *P. marriotti* sp. n. is remarkable in that it occurs outside of the tropics in temperate sclerophyll forest in Victoria. *P. marriotti* sp. n. can be distinguished from all other species of the group by its relatively wider wings and larger size. In particular, *P. angustifrons* (Fig. 5) is smaller, has a wider head, more extended pectination of the antennae (Fig. 17) and the forewings are relatively narrower. *Pollanisus eungellae*, *P. eumetopus* and *P. acharon* are smaller and their forewings are relatively narrower; *P. eungellae* and *P. eumetopus* have a broader frons.



Figs 11-17. *Pollanisus* spp. (11-14) *P. marriotti* sp. n., genitalia: (11) ventral view of male genitalia, aedeagus removed, left valve omitted; (12) aedeagus; (13) overview of female genitalia, praebursa with spermatophore; (14) sclerotization at insertion of ductus seminalis. (15-17) *Pollanisus* spp., male antenna with shaft, pectination on only one side shown: (15) *P. marriotti* sp. n.; (16) *P. lithopastus*; (17) *P. angustifrons*.

Pollanisus marriotti sp. n. also shows similarities to *P. subdolosus* (Walker, [1865]) and some related species. With these it shares the general morphology such as wing and body shape and the distribution of metallic scales on the abdomen. However, *P. subdolosus* and related species can be readily distinguished by the colour of its abdomen and collar, which are metallic copper-red, but never metallic green. Females of *P. subdolosus* also differ by the lack of metallic scales on the abdomen, which are always present in *P. marriotti* sp. n., by their relatively larger yellow anal tuft and by their somewhat narrower wings. *P. subdolosus* has not been found at the type locality of *P. marriotti* sp. n.; however, it occurs in other forests in the vicinity of Melbourne and other parts of southern Victoria and is also attracted to light. Furthermore, *P. subdolosus* has two generations per year with adults being on the wing in November and December and again in March, whereas *P. marriotti* sp. n. occurs only in a single generation in summer.

Superficially, *P. marriotti* sp. n. is also similar to *P. lithopastus* Turner, 1926 (Figs 3-4) and both species occur syntopically at the type locality. *P. marriotti* sp. n. differs from *P. lithopastus* as follows: head narrower, eyes smaller and proboscis yellow (Fig. 6) (head wider, eyes larger and proboscis dark brown in *P. lithopastus*, Fig. 8); dorsal side of the 1st abdominal segment without metallic scales, with a conspicuous green metallic mark that gradually widens from a point at the centre of the 2nd tergite and covers most of the caudal part of the abdomen (Fig. 7) (dorsal side of abdomen completely metallic blue in *P. lithopastus*, Fig. 9); fore and hindwings narrower (broader in *P. lithopastus*); hindwings lighter (darker in *P. lithopastus*). Furthermore, the apical biserrate part of the antennae is relatively longer in *P. marriotti* sp. n. (Figs 15-17).

The new species cannot be confused with any of the other *Pollanisus* species (*c.f.* Tarmann 2004).

Phenology and bionomics

The only known locality of this species is a semi-dry to wet eucalypt forest at about 300 m altitude with a rich understorey of *Leptospermum*, *Banksia* and *Hibbertia*. The locality is a mosaic of slopes and wet gullies and harbours a rich lepidopterous fauna, including many species that apparently reach their most southern and western distribution limit in this area.

At the type locality, *P. marriotti* sp. n. shares its habitat with *Hestiochora furcata* Tarmann, 2004 and *P. lithopastus*, the latter being very common in this locality. The adults of *P. marriotti* sp. n. fly from early January to late February, whereas *P. lithopastus* has a longer flight period from late November to early March. Although both species are also likely to be active during the day, most specimens were observed or collected at the light between 22.00h and 24.00h. Up to 50 specimens of *P. lithopastus* were

attracted to the light on warm and dark nights and hundreds were observed over the course of the flight period, all but two being males. *P. marriotti* sp. n. is comparatively rare, with typically only a few specimens attracted to the light during one night. Despite extensive searching during the day, few specimens of *P. marriotti* sp. n. were found, two flying at about 5 pm and one male on the flowers of *Leptospermum* at about 10.00h. Despite extensive fieldwork around Melbourne by one of us (AK), *P. lithopastus* was observed only once during daytime, when a female was found resting on a grass stem in the afternoon.

The hostplant of both *P. lithopastus* and *P. marriotti* sp. n. in Gilwell Park is likely to be the Trailing Guinea-flower, *Hibbertia empetrifolia* (DC.) Hoogland (Fig. 10). Larvae that hatched from eggs obtained from females of both species started feeding on the leaves of this species. Larvae of *P. marriotti* sp. n. also accepted *Hibbertia scandens* (Willd) Dryand as a surrogate, but died subsequently, whereas the larvae of *P. lithopastus* refused this plant. *P. lithopastus* seems to utilize different *Hibbertia* species as hostplants as it can be common in places where *Hibbertia empetrifolia* is apparently absent.

Distribution

Despite recent intensive collecting around Melbourne and occasional activity in parts of Gippsland and East Gippsland, *P. marriotti* sp. n. was only found at the type locality. However, it can be assumed that other colonies of this species exist in sheltered coastal forests east of Melbourne. *P. lithopastus*, on the other hand, is relatively widespread east of Melbourne and also occurs in the Otway Ranges and near Nelson in the west of Victoria.

Conservation status

Pollanisia marriotti sp. n. is currently known only from a single locality, Gilwell Park, in the vicinity of Gembrook. This is remarkable as light trapping was frequently conducted in similar forests east of Melbourne. Whereas *P. lithopastus* was found in most of these locations, *P. marriotti* sp. n. was not. A similar distribution pattern was observed for various other moth species (Kallies and Marriott, unpublished observations). Although the reasons for the restricted distribution of these species are unknown, we speculate that lack of fire is a major factor. In an area well known for its high bushfire risk, Gilwell Park has escaped widespread fire damage for over 80 years and was not subject to 'controlled' back burning. This lack of fire may well be the key factor for the high diversity observed in this area.

Although parts of Gilwell Park are frequently used by Scouts and other groups for camping and other outdoor activities and the vegetation is controlled by regular slashing, other parts of the park are relatively undisturbed. Importantly, these activities do not seem to have obvious negative impacts on plant and insect diversity. This shows that use of forest

for recreational activities when carefully managed is fully consistent with protection of a diverse fauna and flora. It furthermore underlines the importance of woodland and forest protected from bushfires and back burning as refugia that ensure long-term survival of a diverse array not only of birds and mammals but also of butterflies, moths and other insects. Gilwell Park is a prime example of such a place. *P. marriotti* sp. n., due to its restricted distribution and its potential susceptibility to fire, should be considered a threatened species.

Acknowledgements

We would like to express our gratitude to Peter Marriott who collected and provided the first specimens of this interesting new species, to Murray Vagg who helped us with our fieldwork, and to the Gilwell Park authorities for allowing us to conduct research on their premises and for allowing us to use the facilities of the Park. We furthermore would like to thank the Victorian Department of Sustainability and Environment for providing appropriate research permits.

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THE NOMENCLATURE OF *OGYRIS HALMATURIA* (TEPPER, 1890) (LEPIDOPTERA: LYCAENIDAE)

M.F. BRABY^{1,2*}, F. DOUGLAS³ and R.C. WILLAN¹

¹Museum and Art Gallery of the Northern Territory, GPO Box 4646, Darwin, NT 0801

²Research School of Biology, The Australian National University, Canberra, ACT 0200

³PO Box 37, Rainbow, Vic 3424

*E-mail: michael.braby@nt.gov.au

Abstract

The purpose of this paper is to clarify and resolve the nomenclature of *Ogyris halmaturia* (Tepper, 1890), a nationally threatened butterfly which has had a long and complex nomenclatural history. This complexity has arisen because: (1) the species group name *halmaturia* was based on a mixed series comprising two different species; (2) historically at least six authors have attempted to resolve the nomenclature of *halmaturia*, but most failed to render a valid and unambiguous lectotype designation; (3) one of these authors (N.B. Tindale) made a particularly confusing lectotype designation in 1923; and (4) introduction of the name *Ogyris waterhousei* (Bethune-Baker, 1905). The proposal to treat *O. waterhousei* as a junior synonym of *O. halmaturia* is accepted. We argue that Tindale made the first valid and unambiguous lectotypification in 1923. Consequently, we propose, with the intention of bringing closure to this matter, that *O. halmaturia* is the senior synonym of *O. waterhousei* and that Tepper's syntype 'female' is the lectotype male of *O. halmaturia*. Attention is drawn to ambiguity in Article 74.5 (lectotype designation made before 2000) in the most recent edition of the International Code of Zoological Nomenclature.

Introduction

The Australian endemic butterfly *Ogyris halmaturia* (Tepper, 1890) (Eastern Bronze Azure) is an endangered species of heathland and mallee-heathland habitats in coastal and semi-arid areas of South Australia and (formerly) western and south-western Victoria (Braby and Douglas 2008). Its taxonomic status is now agreed upon as a valid species, but a consensus on its nomenclature needs to be resolved urgently to effectively underpin conservation efforts.

The species has had a long and complex nomenclatural history (see Braby and Douglas 2008 for review). This complex nomenclature has arisen in at least four different ways. The first stems from the fact that Tepper (1890) had a mixed series comprising four syntypes representing two species (Table 1). The type specimens were all collected from near Kingscote (given as 'Queenscliffe'), Kangaroo Island, South Australia, on 20-21 November 1886, viz: three males of *O. otares* (C. & R. Felder, 1865) and a male of *O. halmaturia*, which Tepper incorrectly assumed represented the female of his new species. Because Tepper (1890) did not designate a type specimen or make reference to a type of any sort, a taxonomist must therefore determine which specimen of Tepper's type material (*i.e.* his syntypic series) represents the name-bearing 'type' in order to fix the name *O. halmaturia* to the species in question.

According to Article 74 of the ICZN (1999), the fixation of a name from syntypes is dependent on the designation of a lectotype; that specimen then becomes the unique bearer of the name of the nominal species group taxon and the standard for its application. And here lies the second issue, which is at the core of this complex problem.

In historical times, at least six authors (Lower 1893, Tepper 1893, Waterhouse 1903a, 1903b, Bethune-Baker 1905, 1916, Waterhouse and Lyell 1914, Tindale 1923) have attempted to resolve the taxonomy of *O. halmaturia* but few attempted to do so definitively by making a lectotype designation. Lower (1893) placed Tepper's male *O. halmaturia* under *O. otanes* and Tepper's 'female' *O. halmaturia* in synonymy with *O. idmo* (Hewitson, 1862) but did not refer to 'types' of any form. Tepper (1893) himself maintained *O. halmaturia* as a species distinct from *O. otanes* and *O. idmo*, and restricted its distribution to Kangaroo Island (and possibly on the mainland at Port Lincoln on the tip of Eyre Peninsula, SA), but he did not refer to type material and still failed to realise that he had a mixed series. Waterhouse (1903b p. 249) concurred with Lower (1893) and listed *O. halmaturia* as a synonym of *O. otanes* and remarked that 'I almost certainly agree with Lower who says that Tepper's *O. halmaturia* comprises *O. otanes* ♂ and *O. idmo* ♂'. He subsequently treated *O. halmaturia* as a synonym of both *O. otanes* and *O. idmo* in his catalogue of Australian butterflies (Waterhouse 1903a), but again did not examine or make reference to a single 'type' specimen that would bear the name. Waterhouse and Lyell (1914) later subsumed *O. halmaturia* under *O. otanes* in an attempt to resolve the taxonomy, but did not examine type material to clear up the nomenclature. Bethune-Baker (1905, 1916) and Tindale (1923) did, however, both refer to 'types', which we expand upon below. But here lies the third part of the problem: Tindale's (1923) type designation was confusing in that he partly synonymised Tepper's concept of *O. halmaturia* under *O. otanes*. Lastly, 15 years after the species was formally described, another name, *O. waterhouseri* (Bethune-Baker, 1905), was introduced for it.

In attempting to resolve this complex nomenclatural problem, Braby and Douglas (2008) traced and critically examined the type series (= syntypes) of *O. halmaturia* (currently housed in the South Australian Museum (SAM) and The Natural History Museum, London (BMNH)), reviewed the historical literature and concluded that the name *O. halmaturia* is a junior synonym of *O. otanes*, and consequently that Tepper's syntype of the second species is a paralectotype of *O. halmaturia*. In contrast, Field (1999), and more recently Grund (2010), proposed that *O. waterhouseri* is a junior synonym of *O. halmaturia*. Grund's argument was based on three lines of evidence: (1) that of Tepper's (1890) description of *O. halmaturia* and his original intention; (2) crediting Tindale (1923) as the first taxonomist to validly select a lectotype of *O. halmaturia*; and (3) espousing the premise of nomenclatural stability and the presumption that the name *waterhouseri* was interfering with

Table 1. Tepper's (1890) syntypic series of *Ogyris halmaturia* and their type status.

Specimen, Complete label data, Repository, Type status and Current valid species name
<p>♀ <i>O. halmaturia</i> “Queenscliffe, 1 mile N.W. very shy, ♀, 20.11.86. Tepper” [in Tepper's original handwriting], “Ogyris halmaturia Tepper, Type female = ♂, Kangaroo Island n348, vide, TRSSA. 1923”, “SAMA Database No. 31–001699” SAM. Lectotype. <i>O. halmaturia</i> ♂</p>
<p>♂ <i>O. halmaturia</i> “Queenscliffe, ♂, 1 m. N.W. very shy, 21.11.86. Tepper” [in Tepper's original handwriting], “Ogyris halmaturia Tepper, Type male, = not type, Kangaroo Island vide TRSSA 1923, p. 389”, “Ogyris otnes ♂ not halmaturia”, “SAM Database No. 31-001700” SAM. Paralectotype. <i>O. otnes</i> ♂</p>
<p>♂ <i>O. halmaturia</i> “Queenscliffe, 1 m. N.W. very shy, 20.11.86. Tepper” [in Tepper's original handwriting], “Ogyris halmaturia Tepper, Cotype male, Kangaroo Island vide TRSSA 1923, p. 389”, “Ogyris otnes ♂ not halmaturia”, “SAM Database No. 31-001701” SAM. Paralectotype. <i>O. otnes</i> ♂</p>
<p>♂ <i>O. halmaturia</i> “Queenscliffe, 1 mile N.W., in scrub. ♂, 20.11.86. Tepper” [in Tepper's original handwriting], “Ogyris halmaturia, Queenscliffe, Kang. Island, Nov. 1886., legit J.G.O. Tepper”, “Bethune- Baker Coll. B.M. 1927-471.” BMNH. Paralectotype. <i>O. otnes</i> ♂</p>

common usage. We discuss each of these components of evidence in turn and show that, while the hypothesis to treat *O. halmaturia* as the senior synonym is supported, two of Grund's (2010) arguments are misguided on nomenclatural grounds.

Tepper's description of *O. halmaturia*

Grund (2010) argued that Tepper (1890) intentionally gave first priority in his description to the 'female' of *O. halmaturia* (= ♂ *O. halmaturia*) because Tepper made reference to its similarity with the underside of *O. oroetes* (Hewitson, 1862). 'This was the normal way of describing new species during this historical time period, viz. describing the important reference specimen first, be it male or female' (Grund 2010 p. 115). However, Tepper (1890) actually made no reference to the underside of *O. oroetes*, he just stated 'It comes nearest to *O. oroetes*, Hew., but differs from various details from Hewitson's figure'. More importantly though, Tepper (1890) did not describe the 'female' first, but in fact described the two supposed sexes together: after first giving approximate size measurements of the 'female' and male, he then described in some detail the upperside of *both sexes* (our emphasis) simultaneously'; he then proceeded to describe the underside of the 'female' and then the underside of the male. Whether Tepper (1890) intended to give priority to the 'female' of *O. halmaturia* or not is irrelevant in terms of nomenclature under the ICZN (1999) because Tepper (1890, 1893) did not refer to the specimens before him at the time of description (*i.e.*

his type material). As noted above, in such cases where there are two or more syntypes, especially where two or more species are involved, a lectotype must be selected from the type series in order to fix the name of the nominal species group taxon (Article 74.1) (ICZN 1999).

Designation of lectotype of *O. halmaturia*

Article 74.5 of the ICZN (1999) stipulates that ‘In a lectotype designation made before 2000, either the term ‘lectotype’, or an exact translation or equivalent expression (e.g. ‘the type’), must have been used or the author must have unambiguously selected a particular syntype to act as the unique type of the taxon.’ That is, the Code appears to recognise three different situations or criteria under which a lectotype may be designated. In this case, three authors (Bethune-Baker 1905, 1916, Tindale 1923, Field 1999) potentially qualify as having undertaken acts of lectotypification under this ruling.

In his revision of the genus *Ogyris*, Bethune-Baker (1905 pp 276-277) remarked under the taxon *O. otanes* that ‘Mr. Waterhouse has kindly sent me for examination two specimens from Kangaroo Island with a query as to whether they are Felder’s insect, but after a very careful comparison I believe them to be distinct, and they are the form named by Tepper *halmaturia*. I have now before me the type of this species as well as Felder’s type (I must here express my best wishes to Mr. Tepper for the loan of it); and I consider that they are distinct forms; more material may prove them to be sub-species, but they differ sufficiently to warrant them being named.’ In other words, Bethune-Baker (1905) is saying that *O. otanes* (from the South Australian mainland) and *O. halmaturia* (from Kangaroo Island) are closely related species, but further research may prove them to be conspecific. Indeed, he later remarked ‘... in the closing sentence of p. 277 of my monograph I broadly hint at the possibility of *halmaturia* being a form of *otanes*, Felder, and I am quite willing to concede it as a race of that species’ (Bethune-Baker 1916 p. 390). This later statement was made in response to comments by Waterhouse and Lyell (1914), who did not recognise *O. halmaturia*, subsuming it (i.e. the Kangaroo Island population) under the species *O. otanes*. Bethune-Baker (1905) was unaware of the fact that Tepper had a mixed series until much later (see Bethune-Baker 1916); he examined only one of Tepper’s syntypes (= ♂ *O. otanes*) and referred to that specimen as a ‘type’, ‘I regard Tepper’s species as distinct from *otanes*, Feld., both of which types are now before me’ (Bethune-Baker 1905 p. 275) and ‘I only had the ♂ type of this insect before me’ (Bethune-Baker 1916 p. 390).

Edwards *et al.* (2001) interpreted Bethune-Baker’s (1905) reference to a type as an intentional and valid lectotype designation; however, Braby and Douglas (2008) and Grund (2010) did not consider this to be the case because Bethune-Baker (1905 p. 277) used the term ‘type’ rather vaguely to describe all the syntypes of *O. halmaturia*, ‘The types from Kangaroo Island are in the

S. Australian Museum. Mr. Waterhouse also has specimens from the same locality.’ and as such he did not intentionally or explicitly make a formal type designation, at least not one that could be deemed ‘unambiguous’ in the sense of Article 74.5. Although there is some uncertainty in the current edition of the ICZN (1999) in relation to Article 74.5, particularly with interpretation of the second criterion ‘an exact translation or equivalent expression (e.g. ‘the type’), must have been used’ in a lectotype designation made before 2000, many taxonomists would interpret the use of the word ‘type’ by Bethune-Baker for one of Tepper’s syntypes to be construed as a valid lectotype designation by inference, provided the specimen could be identified and unambiguously located. The specimen is currently located in the BMNH and was identified and illustrated by Braby and Douglas (2008 Figs 7-9 p. 319), who considered it to be a paralectotype of *O. halmaturia*. On the other hand, an alternative interpretation of Article 74.5 is that a lectotype designation must satisfy all three criteria: that of being intentional, unambiguous and based on a single or unique type specimen (C. Thompson pers. comm. 2010). Although it is clear that Bethune-Baker (1905) had only one of Tepper’s syntypes available to him, and on two occasions in that publication he referred to that specimen as the ‘type’ (see also remarks by Tindale 1923), he was not *intentionally* selecting that specimen among the type series to be the *unique* type specimen and, moreover, he used the word ‘type’ in different senses, both in the singular and plural. Bethune-Baker (1916) again referred to that specimen as ‘the male type’, but this was prefixed by the phrase ‘I only had...’ (our emphasis), indicating that he was aware of other ‘types’ (*i.e.* Tepper’s syntypic series); hence, here again there is ambiguity as to whether or not he was intending the loaned syntype to be the primary type of *halmaturia*.

We now reconsider the work of Tindale (1923) because this was the second line of evidence used by Grund (2010) to synonymise the name *O. waterhouseri*. Tindale’s publication is interesting because of the confusing way it was written. Tindale (1923 p. 347) considered *O. halmaturia* and *O. otales* to be conspecific and synonymised *O. halmaturia* under *O. otales* in part. Tindale also illustrated one of Tepper’s male syntypes (in SAM) from Kangaroo Island in Plate 24, Figure 16, and in the figure caption (p. 354) referred to that specimen as ‘*Ogyris halmaturia*, Tepper, Type male, Kangaroo Island = *otanes*, Felder.’ Braby and Douglas (2008) considered Tindale’s (1923) action on p. 347 to be an intentional designation of a lectotype on the basis that: (1) he referred to one of Tepper’s syntypes as the ‘type’ in the figure caption (p. 354); and (2) he illustrated that specimen (Plate 24), but these authors overlooked the fact that Tindale explicitly wrote ‘(part)’ at the end of the synonymy line. Tindale (1923) did the same for *O. halmaturia* on the next page (p. 348) on which he redescribed and illustrated Tepper’s ‘female’ syntype in Plate 24, Figure 20 and referred to it as the ‘type’ of *O. halmaturia* in the figure caption (p. 354). Tindale (1923 p. 348)

stated 'The type male is a typical specimen of *O. otares*, Feld.; the 'female' is the male of a species very close to *O. waterhousei*, Bethune-Baker and, as in the original description, the 'female' is mentioned and described first, the name *halmaturia* will stand.' Grund (2010) considered this action by Tindale to be evidence in support of an intentional lectotype designation; that is, Tindale deliberately selected the 'female' to be the primary type or name-bearer of *O. halmaturia*. In considering this particular aspect we concur with Grund (2010) of Tindale's intent; it is likely that Tindale (1923 p. 347) was merely referring to, and illustrating, the syntype male of *O. halmaturia* (= ♂ *O. otares*) to show that it belonged to a different species, rather than attempting to synonymise the whole of Tepper's concept of *O. halmaturia* with *O. otares*.

Tindale's (1923) action on p. 348 in which he explicitly refers to Tepper's 'female' type specimen therefore, in our opinion, fixes the name *O. halmaturia* to the taxon. Because the lectotype of *O. halmaturia* is the same species as the lectotype of *O. waterhousei*, which was described 15 years later, the species group name *waterhousei* is therefore a junior synonym of *O. halmaturia*. Accepting Tindale (1923 p. 348), rather than Tindale (1923 p. 347) or Bethune-Baker (1905, 1916), as the first taxonomist to validly and unambiguously designate a lectotype for the nominal species group name *halmaturia*, renders the subsequent action of Field (1999), who also designated Tepper's 'female' syntype as a lectotype of *O. halmaturia*, as an incorrect subsequent lectotype designation. That is, once a lectotype has been validly designated, all subsequent lectotypifications have no validity (Article 74.1.1) and, moreover, this designation permanently deprives all other specimens that were formerly syntypes of that status in that they automatically become paralectotypes (Article 74.1.3). Tepper's three syntype males (= ♂ *O. otares*) thus all qualify as paralectotypes of *O. halmaturia* (Table 1).

Nomenclatural stability

Grund (2010) argued that because the name *O. halmaturia* has been in usage for the past 86 years (*i.e.* since Tindale 1923) at one level or another it qualifies for nomenclatural 'protection' in some way. It is true that the name has been in common usage for a long period, but it is also true that the name *O. waterhousei* has had continuous usage for an almost equally long period, from 1905 to 1972 (67 years) (see synonymic list and review of literature in Braby and Douglas 2008). In terms of actual usage, *waterhousei* has appeared unambiguously with full species status four times or as a subspecies of *O. idmo* eight times; *halmaturia* has appeared unambiguously with full species status only twice or as a subspecies of *O. idmo* 20 times; and once they have appeared ambiguously with both names combined, as *O. halmaturia waterhousei* (Tindale 1923). Moreover, the name *waterhousei* has appeared unambiguously as valid in a major checklist of type material in

the Australian Museum, Sydney (Peters 1971) and in several books (Common 1964, D'Abrera 1971, McCubbin 1971), as well as in the perceptive paper by Quick (1972).

The ICZN (1999) does allow for the automatic reversal of precedence of a long-unused senior synonym under its Reversal of Precedence provision (Article 23.9), but then only under two strict conditions. If either of these conditions cannot be met completely, then an author must refer the case to the Commission of the ICZN for a formal decision requesting existing usage of the junior synonym to be maintained instead of acting unilaterally. A recent entomological example under this provision is that by Jendek (2007), wherein the name *Buprestis angustulata* Illiger, 1803 was given precedence by the ICZN (2009) over *B. pavidata* Fabricius, 1793. There is no way this provision by itself could be invoked to conserve *halmaturia* over *waterhousei* because *halmaturia* is not the junior synonym.

In closing, our hope in resolving and clarifying the nomenclature of *Ogyris halmaturia* – that it is a senior synonym of *O. waterhousei* based on interpretation of Tindale (1923 p. 348) as making the first valid lectotype designation – is that it will meet acceptance amongst the wider entomological community, and that it will be the name adopted by students of Lepidoptera, government agencies and non-government organizations in attempts to improve the conservation status of the species, which ranks as one of Australia's most threatened butterflies (Braby and Douglas 2008). We deem this more preferable than attempting to decipher confusion inherent in Article 75.4 and prepare an Application to the International Commission of Zoological Nomenclature to reject *O. halmaturia* in favour of *O. waterhousei*.

Acknowledgements

We thank Pete Cranston and Penny Gullan (UC Davis, USA), Ted Edwards (ANIC, Canberra), Tim New (La Trobe University, Melbourne), Graham Brown (MAGNT, Darwin), Alan Beu (GNS Science, New Zealand) and past/present ICZN Commissioners Chris Thompson (Smithsonian Institution, USA), Bruce Halliday (ANIC, Canberra) and Gary Rosenberg (ANSP, USA) for their wise council on this note.

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MATERNAL CARE, FOOD PLANTS AND DISTRIBUTION OF AUSTRALIAN ONCOMERINAE (HEMIPTERA: HETEROPTERA: TESSARATOMIDAE)

G.B. MONTEITH

Queensland Museum, PO Box 3300, South Brisbane, Qld 4010

(Email: geoff.monteith@bigpond.com)

Abstract

New information is given on maternal care, host plants and distribution for 9 Australian Tessaratomidae: Oncomerinae in the genera *Cumare* Blöte, *Garceus* Distant, *Lynamorpha* Westwood, *Musgraveia* Leston & Scudder, *Oncoscelis* Westwood, *Peltocopta* Bergroth, *Plisthenes* Stål and *Stilida* Stål. Corrections to some recorded distributions and host plants are discussed and a summary table of data for all 15 Australian species is presented.

Introduction

The subfamily Oncomerinae of the Tessaratomidae comprises 15 genera of large, often colourful, shield bugs. It has its greatest generic diversity (12 genera) in Australia (Sinclair 2000). Species of *Oncomeris* Laporte are the largest shield bugs in the world, one of which, *O. flavicornis* (Guérin), occurs in northern Queensland. Cassis and Gross (2002) listed 18 species from Australia but three of these (*Lynamorpha perelegans* Vollenhoven, 1868, *L. diluta* Stål, 1863 and *Oncomeris ostracipterus* (Montrouzier, 1855)) are based on literature records from the 1800s which have never been confirmed, so the fauna is probably only the 15 species listed in Table 1. They can be readily identified using the generic key of Sinclair (2000) and the species keys of Leston and Scudder (1957). All species are restricted to the eastern parts of Queensland and New South Wales. Old records from Tasmania, Victoria and South Australia (Gross 1975, Cassis and Gross 2002) have not been verified in modern times and are not considered here. All species except *Cumare pallida* Blöte, 1945 and *Agapophyta bipunctata* Guérin, 1831 are virtually restricted to rainforests.

The group is well known for the parental care of eggs and nymphs shown by some species, first observed by the pioneer Australian naturalist F. P. Dodd (Dodd 1904, 1916), with later records by Kumar (1969) and Sinclair (2000). Previous observations were summarised by Monteith (2006), who gave new information on several species with photographs of parental behaviour and discussion of its significance. In the most advanced forms (*Cumare* Blöte, *Garceus* Distant and *Peltocopta* Bergroth), the female carries the nymphs on her abdomen for a significant period of time. This so-called 'nymphal phoresy' is also seen in certain SE Asian Tessaratomini (Gogala *et al.* 1998).

Oncomerines feed on the sap of woody plants, especially from apical shoots when in flush growth. All species have a rather narrow host range. *Musgraveia sulciventris* (Stål, 1863), the Bronze Orange-Bug, which feeds on native species of *Citrus* L. (Rutaceae), has become a pest of cultivated



Figs 1-6. Oncomerinae. (1-4) *Lyramorpha parens*: (1) female and large nymphs feeding at stem internode of *Castanospora alphanthii*; (2) female brooding 2nd instar nymphs; (3) gregarious group of 2nd and 3rd instar nymphs on non-food plant, *Passiflora*; (4) adults feeding on *Jagera pseudorhus* (5-6) *Oncoscelis australasiae* on *Medicosma cunninghamii*: (5) female brooding egg clutch; (6) eggs in clutch of 14. Photos: A. Gillanders (1, 3), D. C. F. Rentz (2), K. Aland (4), J. Wright (5-6).

citrus and is well studied (Cant *et al.* 1996a, 1996b). Recorded food plants for other Australian species are given by Kumar (1969), Sinclair (2000), Cassis and Gross (2002) and Monteith (2006). A North Dakota State University website (Rider 2010) lists all recorded food plants but without assessing veracity. Some literature records of food plants are clearly simply resting records and caution is needed in recording food plants in the absence of actual feeding.

This paper records new information and/or photographs for nine species of Australian Oncomerinae. Several doubtful food plant records are excluded and a summary table of details for all Australian species is presented (Table 1). Plant nomenclature is taken from Henderson (2002). Vouchers for many of the insects mentioned are in the Queensland Museum (QM), Brisbane.

***Cumare pallida* Blöte, 1945**

Eggs have been recorded (Monteith 2006) but not measured. Those from a preserved clutch from Auburn River NP (in QM) are barrel shaped, 1.2 mm high and 1.1 mm in diameter. Micropyles not countable.

***Garceus fidelis* Distant, 1893**

Eggs in a hatched clutch of 14 eggs from Garradunga (in QM) are 1.5 mm high and 1.7 mm in diameter. Micropyles not countable.

***Lyramorpha rosea* Westwood, 1837**

Lyramorpha Westwood has two species in Australia: *L. rosea* in NSW and southern Queensland with 4 antennal segments and *L. parens* Breddin in northern Queensland with 5 antennal segments. *L. rosea* has been recorded from five genera of the Sapindaceae (Table 1), four of them native plus the cultivated lychee (*Litchi chinensis* Sonn.). Kumar (1969) found brooding females on *Alphitonia* Reissek ex Endl. (Rhamnaceae) and *Flindersia* R. Br. (Rutaceae) in Brisbane but this record has not been repeated for these common trees in 40 years and they are deleted as host plants pending confirmation. Similarly, the early record from *Synoum glandulosum* (Sm.) A. Juss. (Meliaceae) by Musgrave and Whitley (1931) requires confirmation as this is not a 'beach plant' as described and might be a misidentification of the confirmed food plant *Cupaniopsis anacardioides* (A. Rich.) Radlk., which is a beach plant at the site and has similar leaves and fruit.

***Lyramorpha parens* Breddin, 1900 (Figs 1-4)**

No native food plants have been recorded for this species. During April 2010, Mr Alan Gillanders recorded it from the following six species of rainforest Sapindaceae at three localities on the northern Atherton Tableland: *Arytera divaricata* F. Muell. (Atherton), *A. pauciflora* S.T. Reynolds (Yungaburra), *Castanospora alphanthii* (F. Muell.) F. Muell. (Yungaburra), *Guioa acutifolia* Radlk. (Lake Eacham), *G. lasioneura* Radlk. (Yungaburra), *Sarcotoechia serrata* S.T. Reynolds (Yungaburra). Mr Garry Sankowsky recorded it from the

Table 1. List of confirmed Australian Oncomerinae showing recorded information on distribution, host plants, egg clutch size and aspects of brood care. Queensland is divided into 4 latitudinal zones: SQ, from NSW border to 22°S; NQ, from 16-22°S; CYP, from 16°S to tip of Cape York; TS, Torres Strait Islands. Blank cells indicate no

SPECIES AND SOURCE LITERATURE	AUSTRALIAN DISTRIBUTION	AUSTRALIAN FOOD PLANT FAMILIES & GENERA
<i>Agapophyta bipunctata</i> Guérin, 1831 (1,3,6)	NQ, CYP, TS	CAESALPINIACEAE: <i>Cassia</i>
<i>Cumare pallida</i> Blöte, 1945 (3,4,6,8)	SQ, NQ, CYP	EUPHORBIACEAE: <i>Petalostigma</i>
<i>Erga longitudinalis</i> (Westwood, 1837) (1)	NSW, SQ	FABACEAE: <i>Austrorostenia</i>
<i>Garceus fidelis</i> Distant, 1893 (3,4,6)	NQ	ELAEOCARPACEAE: <i>Elaeocarpus</i>
<i>Lynamorpha rosea</i> Westwood, 1837 (1,3,4,5)	NSW, SQ	SAPINDACEAE: <i>Alectryon, Atalaya,</i> <i>Cupaniopsis, Guioa, Litchi</i>
<i>Lynamorpha parens</i> Breddin, 1900 (6,7,8)	NQ, CYP, TS	SAPINDACEAE: <i>Alectryon, Arytera,</i> <i>Castanospora, Cupaniopsis,</i> <i>Elattostachys, Guioa, Jagera,</i> <i>Litchi, Nephelium, Sarcotoechia</i>
<i>Musgraveia antennatus</i> (Distant, 1880) (8)	CYP, TS	RUTACEAE: <i>Citrus</i>
<i>Musgraveia sulciventris</i> (Stål, 1863) (1,3,6)	NSW, SQ	RUTACEAE: <i>Citrus</i>
<i>Oncomeris flavicornis</i> (Guérin, 1831)	NQ, CYP	-
<i>Oncoscelis australasiae</i> Westwood, 1837 (3,8)	NSW, SQ	RUTACEAE: <i>Acronychia,</i> <i>Medicosma, Melicope</i>
<i>Peltocopta crassiventris</i> (Bergroth, 1895) (1,6,8)	NSW, SQ	EUPHORBIACEAE: <i>Mallotus</i>
<i>Plisthenes australis</i> Horváth, 1900 (3,6,8)	NQ, CYP	MELIACEAE: <i>Aglaiia</i>
<i>Stilida indecora</i> Stål, 1863 (1,3,6)	NSW, SQ, NQ	SAPINDACEAE <i>Alectryon, Arytera,</i> <i>Cupaniopsis, Guioa</i>
<i>Stilida sinuata</i> Stål, 1870	CYP	-
<i>Tibiospina darlingtoni</i> Sinclair, 2000	NQ	-

information. Literature sources for each species are as follows: 1, Kumar 1969; 2, Cant *et al.* 1996a, b; 3, Sinclair 2000; 4, Cassis and Gross 2002; 5, Waite and Hwang 2002; 6, Monteith 2006; 7, Astridge 2006; 8, Monteith, this paper.

EGG CLUTCH	EGG BROODING	BROODING 1ST INSTARS	BROODING 2ND INSTARS	NYMPHAL PHORESY
14	Yes			No
14	Yes	Yes	Yes	Yes
24-26	Yes			No
14	Yes	Yes	-	Yes
up to 42	Yes	-	-	No
40-42	Yes	Yes	Yes	No
-	-	-	-	-
14	No	No	No	No
-	-	-	-	-
14	Yes	?Yes		No
24-39	Yes	Yes	Yes	Yes
-	-	-	-	-
40-42	Yes	Yes	-	No
-	-	-	-	-
-	-	-	-	-

following seven additional Sapindaceae planted on his property, 8.5 km NNW of Atherton: *Alectryon coriaceus* (Benth.) Radlk., *A. semicinerus* (F. Muell.) Radlk., *Cupaniopsis anacardioides* (A. Rich.) Radlk., *C. diploglottoides* Adema, *C. flagelliformis* (F.M. Bailey) Radlk. var. *flagelliformis*, *Elattostachys megalantha* S.T. Reynolds, *E. microcarpa* S.T. Reynolds. The author recorded it feeding on *Jagera pseudorhus* (A. Rich.) Radlk. (Sapindaceae) at Iron Range in December 2010 (Fig. 4). *Lynamorpha parens* also feeds on the exotic sapindaceous fruit trees lychee (specimens in the Mareeba DPI collection from Innisfail) and rambutan, *Nephelium lappaceum* L. (Astridge 2006), but is not of pest status. Thus both Australian species of *Lynamorpha* apparently feed exclusively on Sapindaceae. Fig. 1 shows an adult and several late stage nymphs feeding together at an internode of *Castanospora alphanthii*.

Gende and Kumar (2001) listed *Dodonea viscosa* Jacq., plus a variety of non-sapindaceous plants, from label data of New Guinea specimens identified as *Lynamorpha parens*. However, both the identity of the *Lynamorpha* and the feeding status of the plant records need confirmation and will not be pursued for this Australian treatment.

The only breeding behaviour noted previously has been of a female brooding a clutch of 40 eggs (Monteith 2006). A photograph taken at Kuranda by Dr David Rentz (Fig. 2) shows a female standing guard over about 20 uniformly sized nymphs. First instars in Oncomerinae are invariably subglobose in shape and become flattened when they moult to second instar (Kumar 1969, Monteith 2006). In *L. rosea* the nymphal colour pattern changes from chequered red and black in first and second instars to uniform red in the older instars (Kumar 1969); this also seems to be the case in *L. parens*. Based on the size of the nymphs in Fig. 2, their flattened form and their colour pattern, it can be assumed that they are second instars. This is evidence that *L. parens* broods its young beyond moulting to the second instar.

Observations by Alan Gillanders show that the older nymphs of *L. parens* form massed groups, which feed together and frequently move in close-packed groups to new feeding sites when old sites are exhausted. They are often to be found on non-host plants while in transit (Fig. 3). Clearly, their brilliant aposematic colours reinforce the group defence they enjoy from their dorsal defence glands during these exposed journeys. This feeding strategy contrasts with that of oncomerines such as *Cumare* and *Peltocopta*, which have solitary, camouflaged and rather sedentary later-stage nymphs (Monteith 2006).

***Musgraveia antennatus* (Distant, 1880)**

The southern citrus pest, *Musgraveia sulciventris*, feeds solely on native and cultivated species of *Citrus* (Rutaceae), including species of 'native limes' previously included in the genera *Eremocitrus* Swingle and *Microcitrus*

Swingle, now placed in *Citrus* (Henderson 2002). The rare *Musgraveia antennatus* is found only in Torres Strait (Moa Island) and northern Cape York Peninsula. Sinclair (2000) recorded it from cultivated West Indian Lime (*Citrus aurantiifolia* (Christm.) Swingle) and there is a record from cultivated Pomelo (*Citrus maxima* Merr.) at Lockhart River in the AQIS collection, Cairns (Sally Cowan pers. comm.). It overlaps with the native *Citrus garrawayi* F.M. Bailey in the southern part of its range (Iron Range) and this plant is a candidate for a natural host, but in the northern part of its range (Lockerbie, Torres Strait) there are no native *Citrus* (fide Australia's Virtual Herbarium, <http://www.ersa.edu.au/avh/> and Garry Sankowsky pers. comm.) and it must have a non-*Citrus* native host there. Mr Sankowsky suggests this may be the rutaceous *Zanthoxylum rhetsa* (Roxb.) DC, which is common in the region and used there by various citrus-breeding papilionid butterflies.

***Oncoscelis australasiae* Westwood, 1837** (Figs 5-9)

Cassis and Gross (2002) restored the original generic name *Oncoscelis* Westwood for this species, instead of *Rhoecus* Bergroth or *Rhoecocoris* Bergroth which have usually been used in modern times (e.g. Leston and Scudder 1957, Sinclair 2000).

There are no published observations on the biology of this large but uncommon species apart from records on *Melicope micrococca* (F. Muell.) T.G. Hartley (Rutaceae) by Sinclair (2000). It has also been taken on *Melicope elleryana* (F. Muell.) T.G. Hartley on Stradbroke Island (pers. obs.). A specimen (in QM) from near Harrington, NSW, was taken on *Acronychia oblongifolia* (A. Cunn ex Hook.) Endl. ex Heynh (Rutaceae) by Geoff Williams, who reports that it also occurs there on *Acronychia imperforata* F. Muell. In February 2009, Chris Burwell (QM) discovered a colony feeding and breeding on *Medicosma cunninghamii* (Hook.) Hook. f. (Rutaceae) along upper Enoggera Creek near Brisbane.

Several adults from this last collection were brought to the Queensland Museum and maintained on the food plant in plastic bags. On 7 February, a female laid a batch of 14 eggs on the underside of a leaf and took up a guarding position over them (Fig. 5). The eggs were arranged in the standard 3,4,4,3 pattern (Fig. 6), which has been described for several other species (Monteith 2006). The eggs were large (3.2 mm diameter), spherical, with 46-48 micropyles, the largest number known for any oncomerine. The female abandoned the eggs during photography two days after deposition. They hatched on 20 February to give convex, non-feeding, white nymphs (Fig. 7) which clustered together in an immobile group until the night of 27 February, when all moulted to highly flattened, semi-transparent second instars (Fig. 8) which dispersed. This post-hatching nymphal behaviour indicates that the female would almost certainly have continued to brood the first instars until their moult, as is usually the case (Monteith 2006).



Figs 7-14. Oncomerinae. (7-9) *Oncoscelis australasiae* on *Medicosma cunninghamii*: (7) eggs hatching to 1st instar nymphs; (8) newly hatched 2nd instar and exuvium; (9) male showing enlarged hind legs. (10-12) *Peltocopta crassiventris*: (10) female from Toogoom; (11) 2nd instar on underside of *Mallotus discolor* leaf; (12) female being predated by grey butcher bird. (13-14) *Plisthenes australis*: (13) male (L) and female on *Aglaia meridionalis*; (14) two adults and a nymph on presumed *Aglaia sapindina*. Photos: J. Wright (7-9), M. Robinson (10-12), M. Cermak (13), G. Monteith (14).

***Peltocopta crassiventris* (Bergroth 1895)** (Fig 10-12, 15)

This extremely rare species has been known from a few coastal localities over a latitudinal range of 160 km between Iluka in New South Wales and Surfers Paradise in Queensland (Monteith 2006). Its only food plant is *Mallotus discolor* F. Muell. ex Benth. (Euphorbiaceae) and it exhibits the most advanced maternal care known in the family. In late March 2010, Mrs M. Robinson recorded the species from her garden at Toogoom (25.258°S152.696°E), which is on the coast 330 km further north. Females (Fig. 10) carrying both first and second instar nymphs (Fig. 11) were present. The author visited and confirmed that the host plants were *M. discolor* which was very abundant in this area of partly cleared remnant rainforest. This is a major range extension for this unique species.

In December 2010, Mrs Robinson noted many bugs on the same trees at Toogoom, with specimens commonly falling from overhanging *Mallotus* trees onto the driveway and verandahs of the house. This coincided with a heavy wet season and parallels the population outbreak of this usually rare species described by Monteith (2006) at Surfers Paradise in 1961 and for several years thereafter. Other observations by Mrs Robinson included several instances of the unique copulation posture adopted by this species, including one involving a female that was brooding a batch of 33 eggs at the time (Fig. 15). Although *Peltocopta* has the same acrid defense secretions shared by other oncomerines, a successful predation of a female by a grey butcher bird, *Cracticus torquatus* (Latham), was also noted (Fig. 12).



Fig. 15. *Peltocopta crassiventris*: male and female in copulation above a clutch of 33 eggs, which the female was brooding when copulation was initiated. Note the bright colours of the male (left) compared with the pallid female. Photo: M. Robinson.

***Plisthenes australis* Horváth, 1900** (Figs 13-14)

Sinclair (2000) listed the locality of Byfield (22.858°S, 150.695°E) as the southern limit for this otherwise far northern tropical species. The specimen on which this is based has proved to be *Oncoscelis australasiae*, so the southern limit for *Plisthenes australis* is now confirmed as being 740 km further north at the Mulgrave River (17.34S°).

The only foodplant listed for this species is *Citrus*, in the Rutaceae (Sinclair 2000). This record is based on a single specimen taken from a planted West Indian Lime tree at Iron Range in 1978 by M. DeBaar (now in the Queensland Forestry Collection). This same individual tree is usually host for the related citrus-feeding *Musgraveia antennatus* (pers. obs.). *Citrus* is commonly available within the range of *Plisthenes* Stål so, without other feeding records, it seems best to treat this single specimen as just a resting record. Two confirmed host records are now available for *P. australis* on *Aglaia* Lour. in the Meliaceae: Michael Cermak photographed it on *Aglaia meridionalis* Pannell at Cape Tribulation in 2004 (Fig. 13) and the present writer took it feeding with nymphs on a plant identified by experienced field botanist Garry Sankowsky, from the May 1973 photograph taken at Lockerbie (Fig. 14), as almost certainly *Aglaia sapindina* (F. Muell.) Harms.

***Stilida indecora* Stål, 1863**

Monteith (2006) recorded and pictured a female brooding a clutch of 42 eggs which hatched into first instars. These nymphs dispersed because the food plant was dead, so it was not possible to be sure that normally they would have been brooded until the critical moulting from first to second instar. This has now been confirmed: in February 2007, a female (in QM) was taken on a species of *Arytera* in vine scrub at 'Toomba' station (19.966°S, 145.582°E), brooding a mass of nymphs on top of a hatched clutch of 36 eggs. There were 12 first instars and 20 seconds, demonstrating that female brooding does persist to the second instar.

Discussion

With the additions and corrections presented here we now have a relatively full body of reliable information on the biology and distribution of the 15 accepted species of Australian Tessaratomidae (Table 1). Host plants are known for 12 species and at least partial breeding behaviour is recorded for 10 species. Nothing of this behaviour is known for the giant, lowland, northern Queensland species *Oncomeris flavicornis* (Guérin, 1831), or for the curious endemic monotypic genus and species *Tibiospina darlingtoni* Sinclair, 2000, known from high altitudes in the Wet Tropics. The author would welcome observations on these or other species.

Australian oncomerines feed on a relatively limited range of plant taxa, comprising only seven families in four plant orders. All genera of oncomerines are restricted to a single plant family. In the Malvales, *Garceus*

occurs on Elaeocarpaceae; in the Fabales, *Agapophyta* Guérin and *Erga* Walker occur on the legume families Caesalpiniaceae and Fabaceae respectively; in the Euphorbiales both *Peltocopta* and *Cumare* feed on Euphorbiaceae; in the Sapindales, *Lyrarmorpha* and *Stilida* Stål feed on Sapindaceae; *Oncoscelis* and *Musgraveia* Leston & Scudder feed on Rutaceae; and *Plisthenes* on Meliaceae.

The Oncomerinae show five progressive levels of maternal care: (1), those that lay eggs and abandon them (*Musgraveia sulciventris*); (2), those in which the female broods the eggs until hatching (*Erga* and *Agapophyta*); (3), those in which the female continues to brood the sedentary first instars until they moult to second instars (*Stilida* and *Oncoscelis*); (4), those in which females continue to shepherd mobile second instars (*Lyrarmorpha parens*); (5), those in which the brooding female is modified to carry the first and second instars on her body after hatching (*Peltocopta*, *Cumare* and *Garceus*).

This study confirms that more species than previously suspected guard their young until the second instar. This supports the idea proposed by Monteith (2006) that maternal care is largely a device to protect the vulnerable, usually non-feeding, sub-globose first instars (Fig. 7) until they moult to the flattened, camouflaged second instars, which disperse and begin to feed (Figs 8, 11).

As evidence for maternal care in more species accumulates, the complete lack of parental care in *Musgraveia sulciventris* becomes more unusual. Maternal care slows the potential for rapid population increase because females invest time and energy in one egg clutch. Two of the three natural food plants of *M. sulciventris* are typical of dry vine forests (*Citrus australasica* F. Muell.) or of inland plains (*C. glauca* (Lindl.) Burkill), where rainfall and plant growth are seasonal and unreliable. For *M. sulciventris*, the loss of maternal care and the ability to produce multiple eggs clutches (Cant *et al.* 1996a) might give populations the ability to multiply rapidly in temporarily favourable conditions. This characteristic of the species may have pre-adapted it for the pest status it gained when cultivated citrus became available.

Acknowledgements

I am grateful to the following for allowing me to include their observations: Chris Burwell (QM, Brisbane), Michael Cermak (Cairns), Murdoch DeBaar (Brisbane), Alan Gillanders (Yungaburra), David Rentz (Kuranda), Meg Robinson (Toogoom), Garry Sankowsky (Tolga) and Geoff Williams (Lansdowne). Photos are by Michael Cermak, Meg Robinson, Alan Gillanders, Jeff Wright (QM, Brisbane) and David Rentz. Harry Fay (DEEDI, Mareeba) helped with information about lychee feeders.

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