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New species of Australian arid zone chelonine wasps from the genera *Phanerotoma* and *Ascogaster* (Hymenoptera: Braconidae) informed by the ‘Bush Blitz’ surveys of national reserves

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ABSTRACT

Here we focus on the poorly studied braconid wasp subfamily Cheloninae for the arid zone of the Australian continent, using material, in part, resulting from comprehensive surveys of three arid zone reserves. The Bush Blitz programme is a multi-institutional project with the aim of documenting the diversity of the flora and fauna in Australia’s National Reserve System, with describing new species being a key focus of the programme. In total, 11 species from the genera *Ascogaster* and *Phanerotoma* are treated, with species’ delimitation based on both molecular and morphological data. Two species are redescribed (*Phanerotoma behriae* Zettel, 1988a and *P. decticauda* Zettel, 1988a) and nine species are described as new (*Ascogaster brevivena* sp. nov., *A. ferruginegaster* sp. nov., *A. prolixogaster* sp. nov., *A. rubriscapa* sp. nov., *Phanerotoma bonbonensis* sp. nov., *P. bushblitz* sp. nov., *P. lutea* sp. nov., *P. nigriscapulata* sp. nov. and *P. witchelinaensis* sp. nov.). Keys to the arid zone species of these two genera are provided, along with a species richness estimation of Australian chelonine wasps.

ARTICLE HISTORY

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Bush Blitz; Hiltaba Station;
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Station

Introduction

Although about 67,000 insects have been described for Australia (Australian Faunal Directory 2013), more than 45% of the continent has never been comprehensively surveyed for terrestrial invertebrates (Chapman 2009). To ameliorate this shortcoming, a biological survey programme was initiated in 2010 to document the biodiversity of the national reserve system, with an emphasis on describing new species of plants and animals utilising the expertise of systematists from museums, herbaria, universities and other research institutions (e.g. Lambkin and Bartlett 2011; Namyatova et al. 2011; Baehr and Whyte 2012). This initiative, titled the Bush Blitz programme, is a partnership between the Australian Government, BHP Billiton and Earthwatch Australia, and is coordinated by the Australian Biological Resources Study (Bush Blitz 2013a, 2013b).

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<http://zoobank.org/urn:lsid:zoobank.org:pub:054A948A-5B2F-4A23-BC77-A8F9239094C0>

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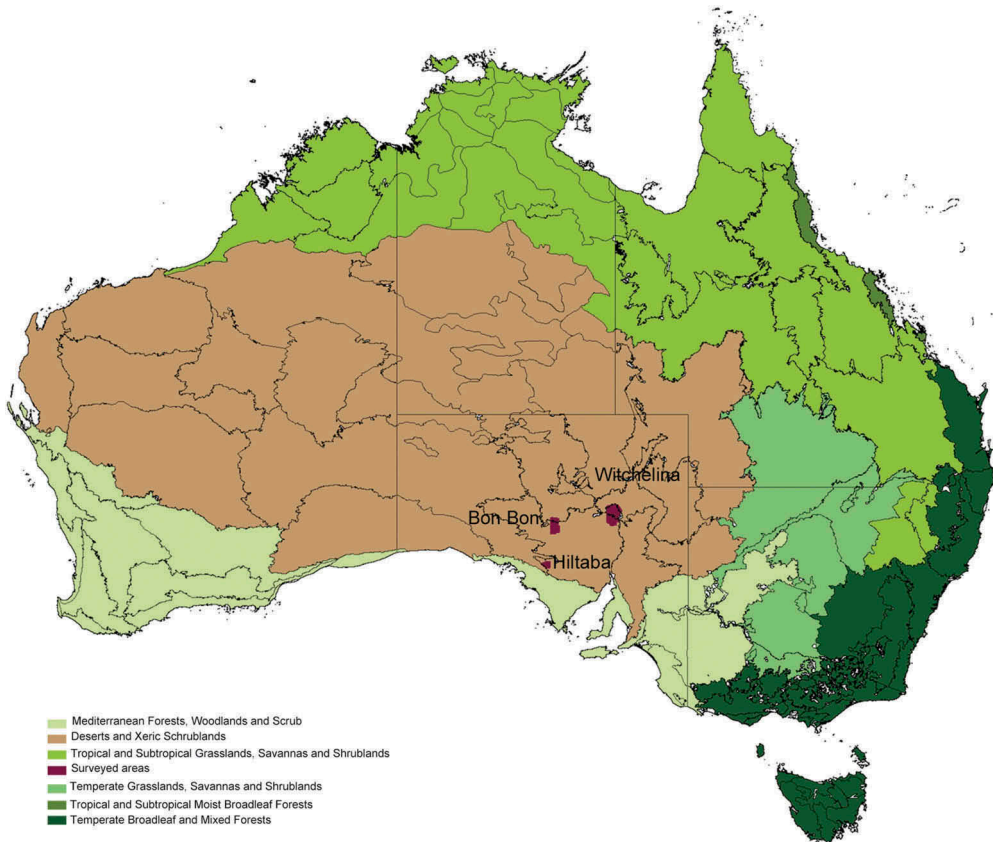


Figure 1. Map of the bioregions of Australia, showing the arid zone and the location of the three surveyed national reserves: Bon Bon Station, Hiltaba Station and Witchelina Station. The bioregions are based on the Interim Biogeographical Regionalisation for Australia (2012) version 7 classification by the Australian government.

As part of the Bush Blitz programme, the braconid wasp subfamily Cheloninae was surveyed for three arid zone reserves in South Australia: Bon Bon Station, Hiltaba Station and Witchelina Station (Figure 1). Cheloninae is a moderately large subfamily of braconid wasps with more than 1375 described species in 17 genera worldwide (Yu et al. 2005; Kittel and Austin 2014). The group can easily be distinguished from other braconid subfamilies on characters associated with the metasomal carapace, the postpectal carina and fore wing venation (Shaw 1983, 1997; van Achterberg 1990; Zettel 1990c). Members of this subfamily are solitary egg-larval koinobiont parasitoids of Lepidoptera, where oviposition occurs into a host egg but development of the parasitoid is delayed until the host has emerged as a larva (Shaw and Huddleston 1991; Shaw 1997; LaSalle 2003).

The taxonomy of chelonine wasps is generally poorly known for Australia. The first species, *Phanerotoma australiensis*, was described by Ashmead (1900), followed soon after by Szépligeti (1900) who described species of *Phanerotoma*, *Phanerotomella* and *Chelonus*. In the following years, several authors described additional new species (Cameron 1911; Turner 1917; Girault 1924; Baker 1926). After a hiatus of more than 50 years, further species were described by Zettel (1988a, 1989c) and Huddleston and Walker (1994). Most recently, (Kittel

and Austin 2014; Kittel et al. 2014) have described two new genera, *Austroascogaster* and *Phanaustrotoma*, comprising six new species; presented a key to genera and a synopsis of the 65 species known for the continent; and described 18 new species of *Phanerotomella*. Three interesting aspects can be identified in this overview of the continent's chelonine fauna: first, most previous species descriptions, with a few exceptions, are based on very few specimens; second, little material has been added to Australian collections since about 1980; and third, the majority of described species have come from mesic coastal regions, particularly areas around Sydney and Perth, while very few taxa have been described from arid central Australia.

As a first step to documenting the largely unknown chelonine fauna of the continent, particularly of the arid interior, we used material collected on the Bush Blitz surveys of the three arid Australian reserves above (Figure 1), supplemented by material from major collections, to describe four new species of *Ascogaster* and five new species of *Phanerotoma*, to redescribe two widely distributed *Phanerotoma* species and to present keys to facilitate identification of the species known from the central arid region. In so doing we took an integrative approach to delineate species, employing both fixed phenotypic differences and phylogenetic analysis of the cytochrome c oxidase subunit 1 (*COI*) barcoding region utilising generalised mixed Yule-coalescent (GMYC) and Poisson tree processes (PTP) analyses to estimate species boundaries. We also employed a Chao species richness estimator to calculate the likely diversity of the Australian fauna, and compare this to the number of morphospecies so far recognised.

Material and methods

Collecting locations, techniques and specimens

Three National Reserve System properties were surveyed as part of this project, all of which were previously large sheep-grazing properties (stations), now set aside to preserve their biodiversity. Witchelina Station was surveyed from late September to early October 2010, and is located in the northwestern part of the Flinders Ranges (Figure 1). It was purchased by the Nature Foundation of South Australia and added to the National Reserve System in 2010. The property comprises 4200 km² of river red gum and coolibah (eucalypt) woodland lining the usually dry creek beds, and bluebush (*Maireana* spp.) shrubland. Bon Station was surveyed in October 2010. This property has been owned by Bush Heritage Australia since 2008, and is located 400 km west of Witchelina and 200 km south of Coober Pedy (Figure 1). The area is situated between the Great Victoria Desert and the large salt lakes of Eyre, Torrens and Gairdner. Its desert landscape is dotted with salt lakes, freshwater wetlands, shrubland, bluebush plains and arid zone woodland. Hiltaba Station, a 775-km² area purchased by the Nature Foundation of South Australia in 2012, was surveyed in November 2012. It is located north of the Gawler Ranges, and is approximately 260 km west of Port Augusta (Figure 1). It consists of rocky granite hills with open bluebush plains and mallee vegetation (*Eucalyptus* spp.).

A range of techniques were employed to collect material during the surveys, including yellow pan traps, light traps (LTs), Malaise traps (MTs) and sweep-netting of vegetation. All material was initially stored in 100% ethanol (for DNA extractions) and later pinned. All available chelonine specimens were also borrowed from the major Australian collections (approximately 5000 specimens in total) and, along with the material from Bush Blitz sites, were sorted to morphospecies. All relevant type material was examined and compared with the sorted morphospecies.

DNA sequencing

Genomic DNA was extracted from specimens preserved in 75–100% ethanol. The right hind leg was removed from each specimen and processed after the ethanol had evaporated. DNA extractions were performed using the Gentra Systems Puregene® DNA Purification Kit (Gentra Systems 2005): the leg was heated at 55°C in a 300 µL cell lysis solution with 1.5 µL Proteinase K solution. After 12–24 hrs, excessive proteins were removed by adding 100 µL Protein Perception solution. The DNA was washed in 300 µL isopropanol (to which 0.5 µL glycogen was added) and afterwards in 300 µL 70% ethanol. DNA was restored using 50 µL DNA hydration solution. Eppendorf thermal sequencers were employed to carry out the polymerase chain reaction (PCR) amplification. Each reaction of 25 µL comprised 14.4 µL nuclease-free water, 2.5 µL Taq Gold Buffer, 3 µL Magnesium chloride (MgCl)₂, 2 µL 10 mM deoxynucleotide (dNTPs), 1 µL of each forward and reverse primer: forward CI-J-1718 5'-GGAGGATTTGGAAATTGATTAGTTC-3', reverse 1 CI-N-2191 5'-CCCGGTAAAATATAAACTTC-3' (shorter) and reverse 2 CI-N-2329 5'-ACTGTAAATATATGATGAGCTCA-3' (longer; Simon et al. 1994), 0.1 µL AmpliTaq Gold® DNA Polymerase (Applied Biosystems Inc.), and 1 µL DNA. PCR settings started with a denaturation step of 9 min at 95°C, followed by 35 cycles of 30 sec at 94°C, 30 sec at 47°C, and an extension step of 1 min at 72°C. The final extension step was for 6 min at 72°C and 6 min at 24°C. PCR products were purified using the Ultraclean™ PCR Clean-up™ Kit (MoBio Biosystems Inc.) and sequenced by the Australian Genome Research Facility Ltd (AGRF). For specimens used and Genbank accession numbers see Table 1.

Phylogenetic analysis of COI, species delimitation and concept

One hundred and twenty-one chelonine specimens were sequenced and three outgroups (Euphorinae, Ichneutinae, Miracinae, taken from Murphy et al. 2008) were used for the phylogenetic analyses. The sequences were aligned with the Clustal W (Thompson et al. 1994) plug-in in GeneiousPro (Drummond et al. 2011). The COI sequences comprise of 489 bp and have open reading frames. Six of the 54 specimens of *Ascogaster* had a 3-bp indel, representing the five species 25, 28, 29, 34 and 35. This is rather uncommon, but not new among Hymenoptera (Schonfeld et al. 2011). Model selection was tested with JModeltest v. 0.1.1 based on the Bayesian information criterion (Posada 2008). The alignments were exported in the appropriate format for further analysis.

Bayesian phylogenetic analysis was performed using MrBayes v. 3.2.1 (Ronquist and Huelsenbeck 2003). Two independent analyses with four Monte Carlo Markov Chains (MCMC) each were run in parallel for 10 million generations under a GTR+I+G model. The first 25% were omitted as a burn-in. A consensus tree was created. Convergence was verified if the split frequencies fell below the 0.01 threshold.

The GMYC analysis is an established method to identify putative species based on molecular data. For these analyses the result of the phylogenetic analysis was used, although the optimal settings required the exclusion of outgroups (Astrin et al. 2012). The tree was first converted to an ultrametric tree using the package 'ape' (<https://r-forge.r-project.org/projects/ape/>) in the R environment (R Development Core Team 2011). The GMYC analyses were then conducted using the 'splits' package (<http://r-forge.r-project.org/projects/splits/>). We tested both analyses, one allowing for only a single speciation event and the other allowing for multiple events.

Table 1. Species of *Ascogaster* and *Phanerotoma* recognised in this study, with their state distributions, project codes and GenBank accession numbers.

Taxon	Species names	State/territory	Project code	GenBank #
<i>Ascogaster</i> sp. 1		NSW	RK29	KJ438543
<i>Ascogaster</i> sp. 2		WA	RK196	KJ438545
<i>Ascogaster</i> sp. 3		NSW	RK28	KJ438541
<i>Ascogaster</i> sp. 4		SA	RK85	KJ438636
<i>Ascogaster</i> sp. 5		QLD	RK52	KJ438544
<i>Ascogaster</i> sp. 6		NSW	RK30	KJ438546
<i>Ascogaster</i> sp. 7		SA	RK181	KJ438555
<i>Ascogaster</i> sp. 8		QLD	RK192	KJ438556
<i>Ascogaster</i> sp. 9		QLD	RK280	KJ438557
<i>Ascogaster</i> sp. 10		SA	RK86	KJ438559
<i>Ascogaster</i> sp. 11		SA	RK141	KJ438561
<i>Ascogaster</i> sp. 12		SA	RK21	KJ438560
<i>Ascogaster</i> sp. 13		SA	RK16	KJ438562
<i>Ascogaster</i> sp. 14		SA	RK11	KJ438563
<i>Ascogaster</i> sp. 15		WA	RK191	KJ438564
<i>Ascogaster</i> sp. 16		WA	RK180	KJ438558
<i>Ascogaster</i> sp. 17		WA	RK308	KJ438565
<i>Ascogaster</i> sp. 18		QLD	RK279	KJ438638
<i>Ascogaster</i> sp. 19		WA	RK278	KJ438569
<i>Ascogaster</i> sp. 20		WA	RK324	KJ438570
<i>Ascogaster</i> sp. 21		QLD	RK187	KJ438550
<i>Ascogaster</i> sp. 22		NSW	RK70	KJ438635
<i>Ascogaster</i> sp. 23		QLD	RK289	KJ438530
<i>Ascogaster</i> sp. 24		NSW	RK35	KJ438535
<i>Ascogaster</i> sp. 24		SA	RK353	KJ438536
<i>Ascogaster</i> sp. 25		WA	RK320	KJ438538
<i>Ascogaster</i> sp. 26		NSW	RK27	KJ438537
<i>Ascogaster</i> sp. 27		WA	RK305	KJ438539
<i>Ascogaster</i> sp. 27		WA	RK304	KJ438637
<i>Ascogaster</i> sp. 27		WA	RK290	KJ438540
<i>Ascogaster</i> sp. 28		SA	RK80	KJ438566
<i>Ascogaster</i> sp. 28		SA	RK81	KJ438567
<i>Ascogaster</i> sp. 29	<i>ferruginegaster</i>	SA	RK48	KJ438568
<i>Ascogaster</i> sp. 30		QLD	RK277	KJ438542
<i>Ascogaster</i> sp. 31		SA	RK198	KJ438551
<i>Ascogaster</i> sp. 32		NSW	RK69	KJ438527
<i>Ascogaster</i> sp. 32		SA	RK10	KJ438528
<i>Ascogaster</i> sp. 33		SA	RK326	KJ438529
<i>Ascogaster</i> sp. 34	<i>rubriscapa</i>	SA	RK71	KJ438533
<i>Ascogaster</i> sp. 35	<i>prolixogaster</i>	SA	RK74	KJ438534
<i>Ascogaster</i> sp. 36	<i>brevivena</i>	QLD	RK186	KJ438547
<i>Ascogaster</i> sp. 36	<i>brevivena</i>	QLD	RK195	KJ438548
<i>Ascogaster</i> sp. 36	<i>brevivena</i>	SA	RK185	KJ438549
<i>Ascogaster</i> sp. 37		QLD	RK285	KJ438532
<i>Ascogaster</i> sp. 38		QLD	RK194	KJ438552
<i>Ascogaster</i> sp. 38		WA	RK293	KJ438553
<i>Ascogaster</i> sp. 38		WA	RK301	KJ438554
<i>Ascogaster</i> sp. 39		SA	RK158	KJ438639
<i>Ascogaster</i> sp. 40		SA	RK152	KJ438531
<i>Ascogaster</i> sp. 41		WA	RK200	KJ438526
<i>Ascogaster</i> sp. 42		SA	RK318	KJ438524
<i>Ascogaster</i> sp. 43		WA	RK337	KJ438525
<i>Ascogaster</i> sp. 44		SA	RK177	KJ438522
<i>Ascogaster</i> sp. 44		SA	RK178	KJ438523
<i>Phanerotoma</i> sp. 1		NSW	RK63	KJ438571
<i>Phanerotoma</i> sp. 1		SA	RK356	KJ438572
<i>Phanerotoma</i> sp. 1		WA	RK311	KJ438573
<i>Phanerotoma</i> sp. 2	<i>witchelinaensis</i>	SA	RK04	KJ438593
<i>Phanerotoma</i> sp. 3	<i>decticauda</i>	SA	RK491	KJ438574
<i>Phanerotoma</i> sp. 3	<i>decticauda</i>	SA	RK266	KJ438575
<i>Phanerotoma</i> sp. 3	<i>decticauda</i>	SA	RK413	KJ438576
<i>Phanerotoma</i> sp. 3	<i>decticauda</i>	SA	RK415	KJ438577

(Continued)

Table 1. (Continued).

Taxon	Species names	State/territory	Project code	GenBank #
<i>Phanerotoma</i> sp. 3	<i>decticauda</i>	VIC	RK350	KJ438578
<i>Phanerotoma</i> sp. 3	<i>decticauda</i>	SA	RK267	KJ438579
<i>Phanerotoma</i> sp. 3	<i>decticauda</i>	SA	RK265	KJ438580
<i>Phanerotoma</i> sp. 3	<i>decticauda</i>	SA	RK409	KJ438581
<i>Phanerotoma</i> sp. 3	<i>decticauda</i>	SA	RK410	KJ438582
<i>Phanerotoma</i> sp. 3	<i>decticauda</i>	SA	RK02	KJ438586
<i>Phanerotoma</i> sp. 3	<i>decticauda</i>	SA	RK411	KJ438583
<i>Phanerotoma</i> sp. 3	<i>decticauda</i>	SA	RK416	KJ438584
<i>Phanerotoma</i> sp. 3	<i>decticauda</i>	SA	RK172	KJ438585
<i>Phanerotoma</i> sp. 3	<i>decticauda</i>	SA	RK271	KJ438587
<i>Phanerotoma</i> sp. 3	<i>decticauda</i>	SA	RK144	KJ438588
<i>Phanerotoma</i> sp. 3	<i>decticauda</i>	SA	RK150	KJ438589
<i>Phanerotoma</i> sp. 3	<i>decticauda</i>	SA	RK139	KJ438640
<i>Phanerotoma</i> sp. 3	<i>decticauda</i>	SA	RK263	KJ438591
<i>Phanerotoma</i> sp. 3	<i>decticauda</i>	SA	RK175	KJ438592
<i>Phanerotoma</i> sp. 3	<i>decticauda</i>	SA	RK269	KJ438590
<i>Phanerotoma</i> sp. 4	<i>nigriscapulata</i>	SA	RK251	KJ438594
<i>Phanerotoma</i> sp. 4	<i>nigriscapulata</i>	SA	RK09	KJ438595
<i>Phanerotoma</i> sp. 4	<i>nigriscapulata</i>	WA	RK310	KJ438597
<i>Phanerotoma</i> sp. 4	<i>nigriscapulata</i>	WA	RK309	KJ438598
<i>Phanerotoma</i> sp. 4	<i>nigriscapulata</i>	SA	RK412	KJ438596
<i>Phanerotoma</i> sp. 5		SA	RK408	KJ438603
<i>Phanerotoma</i> sp. 6		SA	RK418	KJ438604
<i>Phanerotoma</i> sp. 7		SA	RK140	KJ438605
<i>Phanerotoma</i> sp. 7		SA	RK143	KJ438606
<i>Phanerotoma</i> sp. 7		WA	RK258	KJ438607
<i>Phanerotoma</i> sp. 8		SA	RK351	KJ438608
<i>Phanerotoma</i> sp. 8		WA	RK313	KJ438609
<i>Phanerotoma</i> sp. 8		WA	RK312	KJ438610
<i>Phanerotoma</i> sp. 9		SA	RK160	KJ438625
<i>Phanerotoma</i> sp. 9		SA	RK249	KJ438626
<i>Phanerotoma</i> sp. 10		SA	RK03	KJ438634
<i>Phanerotoma</i> sp. 11	<i>bonbonensis</i>	SA	RK250	KJ438601
<i>Phanerotoma</i> sp. 11	<i>bonbonensis</i>	SA	RK58	KJ438599
<i>Phanerotoma</i> sp. 11	<i>bonbonensis</i>	SA	RK148	KJ438600
<i>Phanerotoma</i> sp. 11	<i>bonbonensis</i>	SA	RK417	KJ438602
<i>Phanerotoma</i> sp. 12	<i>bushblitz</i>	SA	RK272	KJ438627
<i>Phanerotoma</i> sp. 12	<i>bushblitz</i>	SA	RK407	KJ438628
<i>Phanerotoma</i> sp. 13		QLD	RK262	KJ438629
<i>Phanerotoma</i> sp. 14		SA	RK173	KJ438630
<i>Phanerotoma</i> sp. 14		SA	RK261	KJ438631
<i>Phanerotoma</i> sp. 15		SA	RK155	KJ438632
<i>Phanerotoma</i> sp. 15		WA	RK22	KJ438633
<i>Phanerotoma</i> sp. 16		WA	RK62	KJ438624
<i>Phanerotoma</i> sp. 17	<i>behriae</i>	SA	RK01	KJ438611
<i>Phanerotoma</i> sp. 17	<i>behriae</i>	WA	RK246	KJ438612
<i>Phanerotoma</i> sp. 17	<i>behriae</i>	SA	RK146	KJ438613
<i>Phanerotoma</i> sp. 17	<i>behriae</i>	SA	RK255	KJ438614
<i>Phanerotoma</i> sp. 17	<i>behriae</i>	SA	RK145	KJ438615
<i>Phanerotoma</i> sp. 17	<i>behriae</i>	SA	RK171	KJ438616
<i>Phanerotoma</i> sp. 17	<i>behriae</i>	SA	RK176	KJ438617
<i>Phanerotoma</i> sp. 17	<i>behriae</i>	SA	RK60	KJ438618
<i>Phanerotoma</i> sp. 17	<i>behriae</i>	WA	RK256	KJ438622
<i>Phanerotoma</i> sp. 17	<i>behriae</i>	SA	RK372	KJ438619
<i>Phanerotoma</i> sp. 17	<i>behriae</i>	SA	RK374	KJ438620
<i>Phanerotoma</i> sp. 17	<i>behriae</i>	SA	RK371	KJ438621
<i>Phanerotoma</i> sp. 18	<i>lutea</i>	SA	RK67	KJ438623
<i>Phanerotomella</i> sp.		WA	RK26	KJ438521
<i>Chelonus</i> sp.		SA	RK38	KJ438520
Euphorinae indet.		n/a	n/a	EU106964*
Ichneutinae indet.		n/a	n/a	EU106967*
Miracinae indet.		n/a	n/a	EU106971*

Notes: *Murphy et al. (2008). NSW, New South Wales; QLD, Queensland; VIC, Victoria; WA, Western Australia.

The PTP model was also used to establish a putative species estimate based on the molecular data (Zhang et al. 2013). This analysis requires a phylogenetic tree; however, it recommends using a randomised accelerated maximum likelihood (RAxML) tree obtained through RAxML 7.6.3 Blackbox on the CIPRES Science Gateway V 3.3 (Miller et al. 2010). The analysis was conducted using Python. We then compared four independent species estimates; recognition of morphospecies based on fixed phenotypic differences, the PTP estimate, GMYC with single a threshold and GMYC with multiple threshold estimates (Figures 2 and 3; see Pons et al. 2006; Fontaneto et al. 2007; Cook et al. 2010). Even though the PTP and GMYC analyses indicated the presence of cryptic species, we have refrained from describing them, and limited the study to only the description of the morphospecies (see Butcher et al. 2012), as the molecular data are based only on a single marker and the sequence variation is low in some cases. However, we indicate the presence of likely cryptic species in the comments section for the relevant species, and plan to use the results here as a basis for testing cryptic species boundaries with additional markers in the future (Pons et al. 2006; Fontaneto et al. 2007).

Species richness estimation

Species richness of Australian chelonines was calculated using a Chao species richness estimator implemented in the package 'SPECIES' (Wang 2011; <http://cran.r-project.org/>)

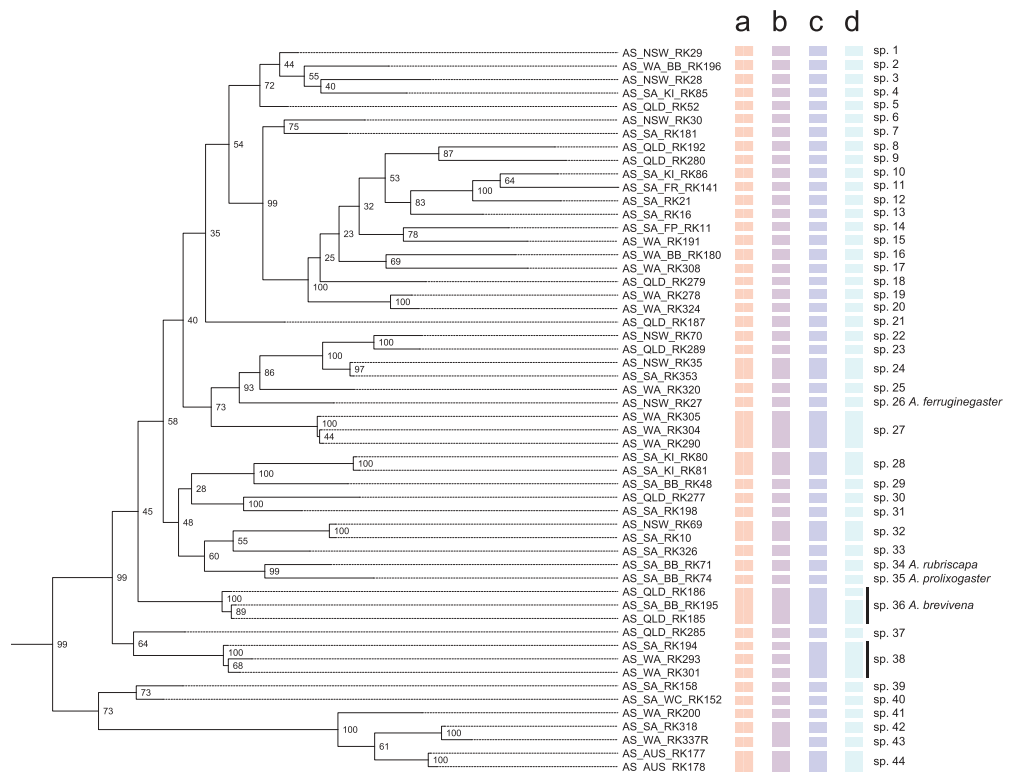


Figure 2. Tree resulting from the Bayesian phylogenetic analysis of the *COI* data for the genus *Ascogaster*. Numbers on branches show posterior probabilities. Abbreviations: (a) PTP analysis; (b) GMYC (single); (c) GMYC (multi); (d) morphology.

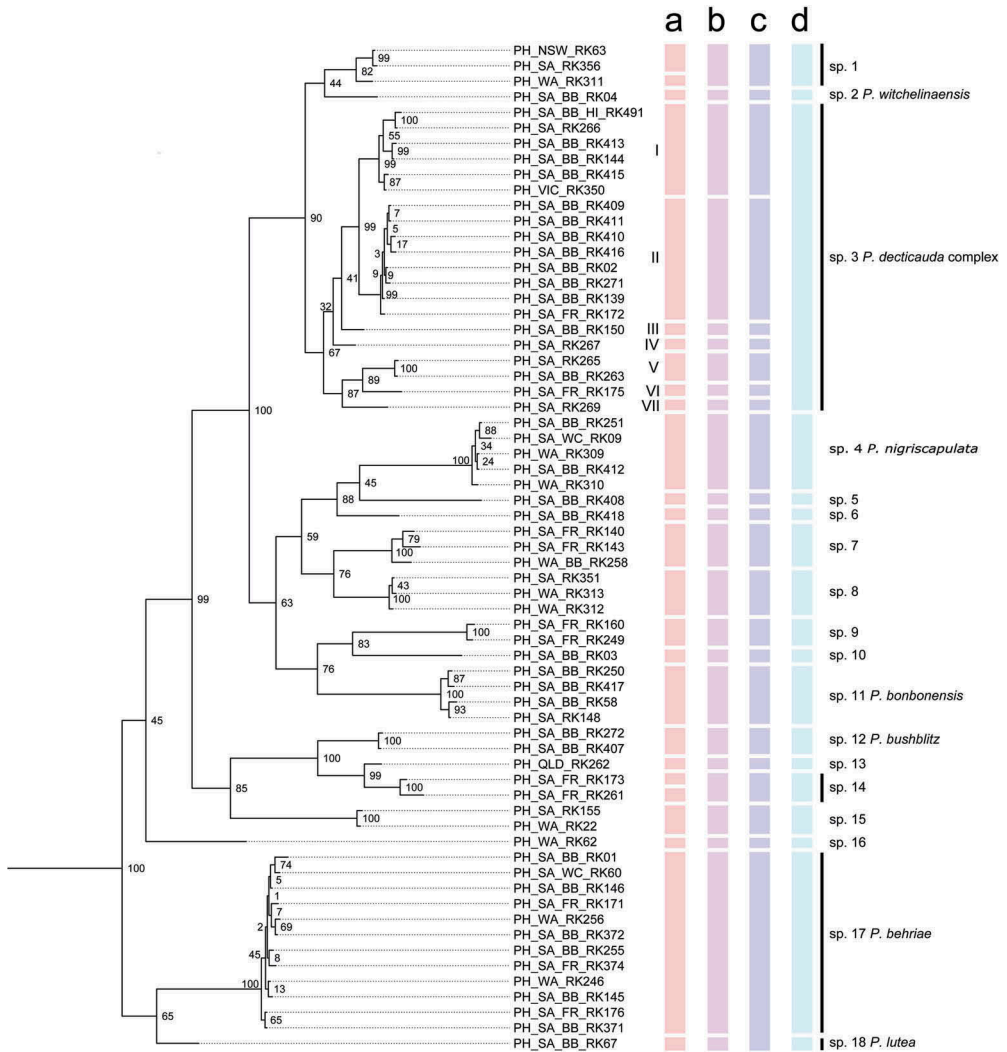


Figure 3. Tree resulting from the Bayesian phylogenetic analysis of the *COI* data for the genus *Phanerotoma*. Numbers on branches show posterior probabilities. Abbreviations: (a) PTP analysis; (b) GMYC (single); (c) GMYC (multi); (d) morphology.

web/packages/SPECIES/index.html) for the R environment (R Development Core Team 2011) for the morphospecies available, and based on frequencies of specimens per morphospecies (Wang and Lindsay 2005). These were calculated separately for each genus and summed, and also as a single estimate for Australian Cheloninae as a whole.

Terminology and imaging

Terminology follows Eady (1968), van Achterberg (1988) and Karlsson and Ronquist (2012). Images were taken using a Visionary Digital BK+ photo system with a K2 lens system attached to a 7D Canon digital camera. Final images were stacked from multiple images using Zerene Stacker software (version 1.04), and edited in Adobe Photoshop

CS5 (extended version 12.0x64). Measurements were taken using a Zeiss stereomicroscope and Adobe Photoshop CS5 software. The distribution maps were produced with DIVA-GIS (Hijmans et al. 2004). The bioregions in [Figure 1](#) are based on the Interim Biogeographical Regionalisation for Australia version 7 classification by the Australian government (28 November 2013).

Museums/collections

AMS	Australian Museum Sydney, Sydney
ANIC	Australian National Insect Collection, Canberra
BNHM	British Natural History Museum, London, UK
GKIC	R.V. Glatz Private Collection, Kangaroo Island, South Australia
IRSN	Institut Royal des Sciences Naturelles de Belgique, Brussels
NMNH	Smithsonian Institution National Museum of Natural History, Washington DC
MV	Museum Victoria, Melbourne, Victoria
MAGNT	Museum and Art Gallery of the Northern Territory, Darwin
QM	Queensland Museum, Brisbane
SAM	South Australian Museum, Adelaide
WAM	Western Australian Museum, Perth
WINC	Waite Insect and Nematode Collection, Adelaide

Results

Phylogenetic analysis and species delimitation

The phylogeny for Australian *Ascogaster* and *Phanerotoma* and the number of species predicted by the four estimation methods are shown in [Figures 2](#) and [3](#), respectively. For *Ascogaster* there was strong concordance amongst the four methods and, overall, the molecular-based estimates for species boundaries largely match our morphospecies estimates. However, there are three exceptions.

For species 36, here described as *A. brevivena* sp. nov., PTP and GMYC predict a single species, but tentatively we initially recognised it as two morphospecies. It turned out that the two morphospecies were represented by single but opposite sexes, so we made the pragmatic decision that they represent a single sexually dimorphic taxon. For species 38, PTP and GMYC (single) both predicted three species but, based on morphology and GMYC (multi), only one species could be identified, thus suggesting, albeit inconclusively, the presence of cryptic species. Lastly, for species 42 and 43, GMYC (single) suggested a single species, but the other three estimates including morphology suggested two separate species. In total, the data indicate 44 species of *Ascogaster* for which we have molecular data, four of which occur in the arid zone and are described here.

The results for *Phanerotoma* ([Figure 3](#)) were similar to those for *Ascogaster* in that there was strong concordance between the molecular-based estimates and recognition of morphospecies. The major exception was for species 3, *P. decticauda*, which was estimated to represent seven species by PTP, GMYC (single) and GMYC (multi), thus suggesting the presence of cryptic species. The specimens showed some morphological variation, but none of the seven clades had any fixed differences. Further studies of male genitalia, host association and

sequence data from additional markers will undoubtedly help confirm the validity of these likely cryptic taxa.

Minor differences were evident in species 1, species 14 and species 17/18. But in each case, two of the three molecular-based estimates matched the recognition of morphospecies. In total, the data indicate 18 species of *Phanerotoma* for which we have molecular data, seven of which occur in the arid zone and are described or redescribed here.

Species richness estimation

Examination of the approximately 5000 Australian chelonine specimens available led to the recognition of 195 morphospecies (Table 2). When the Chao species richness estimator was applied to the same set of specimens for each genus separately it generated a figure of 262 species in total, with a range of 225–377 species (Table 2). When the data were pooled for all specimens (irrespective of genus), the Chao estimator predicted a total species richness of 278 species with a range of 253–370.

The Chao estimator requires an unbiased collecting effort of an area which is clearly not the case for most terrestrial invertebrates, as indicated for Australian chelonines where the collection intensity has been far greater in eastern Australia, compared with the relatively meagre collecting effort in the arid zone and the western part of the continent. Also, a large number of morphospecies are represented by a single specimen, suggesting that collecting intensity in general, as well as geographically, needs to be significantly improved. In this respect, programmes such as Bush Blitz can make a significant contribution and help ameliorate this situation. Although the accuracy of the Chao estimator is likely to be limited, it still provides a useful starting point and indicates that there are possibly 60–170 chelonine species yet to be discovered on the Australian continent.

Species distributions

In this study, we focussed on the arid zone species of *Ascogaster* and *Phanerotoma*. However, when we compared the material from the surveys with material from other habitats of Australia, we found that the majority of species treated here occur also in other regions. Some have a distribution into the tropics, such as *P. lutea* sp. nov., or into mesic areas, such as *P. nigriscapulata* sp. nov. (both Figure 16). Two species, *P. behriae* and *P. decticauda*, are distributed very broadly across the continent (Figures 17 and 18, respectively). Species with a more restricted distribution are *A. brevivena* sp. nov. and *A. prolixogaster* sp. nov. These two species can only be found south of 25°S (Figure 15). *Ascogaster rubriscapa*, *P. bonbonensis* sp. nov. and *P. bushblitz* sp. nov. are the only species with an exclusively arid Australian distribution (Figures 15 and 16, respectively).

Table 2. Comparison of Australian chelonine species richness based on morphospecies delineation and the calculated species richness using a Chao estimator.

Genus	Morphospecies	Chao estimated species richness	Ranges of Chao estimation
<i>Ascogaster</i>	68	116	105–138
<i>Austroascogaster</i>	4	5	3–14
<i>Chelonus</i>	57	68	59–83
<i>Phanerotoma</i>	42	43	35–59
<i>Phanaustrotoma</i>	2	3	2–35
<i>Phanerotomella</i>	21	26	20–47
<i>Wushenia</i>	1	n/a (1)	n/a (1)
Total	195	262	225–377

Taxonomic treatment of species

Genus **Ascogaster** Wesmael, 1835
(Figures 2, 4–7, 15)

<http://species-id.net/wiki/Ascogaster>

Type. *Ascogaster instabilis* Wesmael, 1835: 227 (by subsequent designation: Förster, 1862: 244), IRSN (examined).

Ascogaster: Shenefelt 1973: 814, Shaw 1983: 7, Huddleston 1984: 348, Tang and Marsh 1994: 281.

For diagnosis of Australian taxa, see Kittel and Austin (2014).

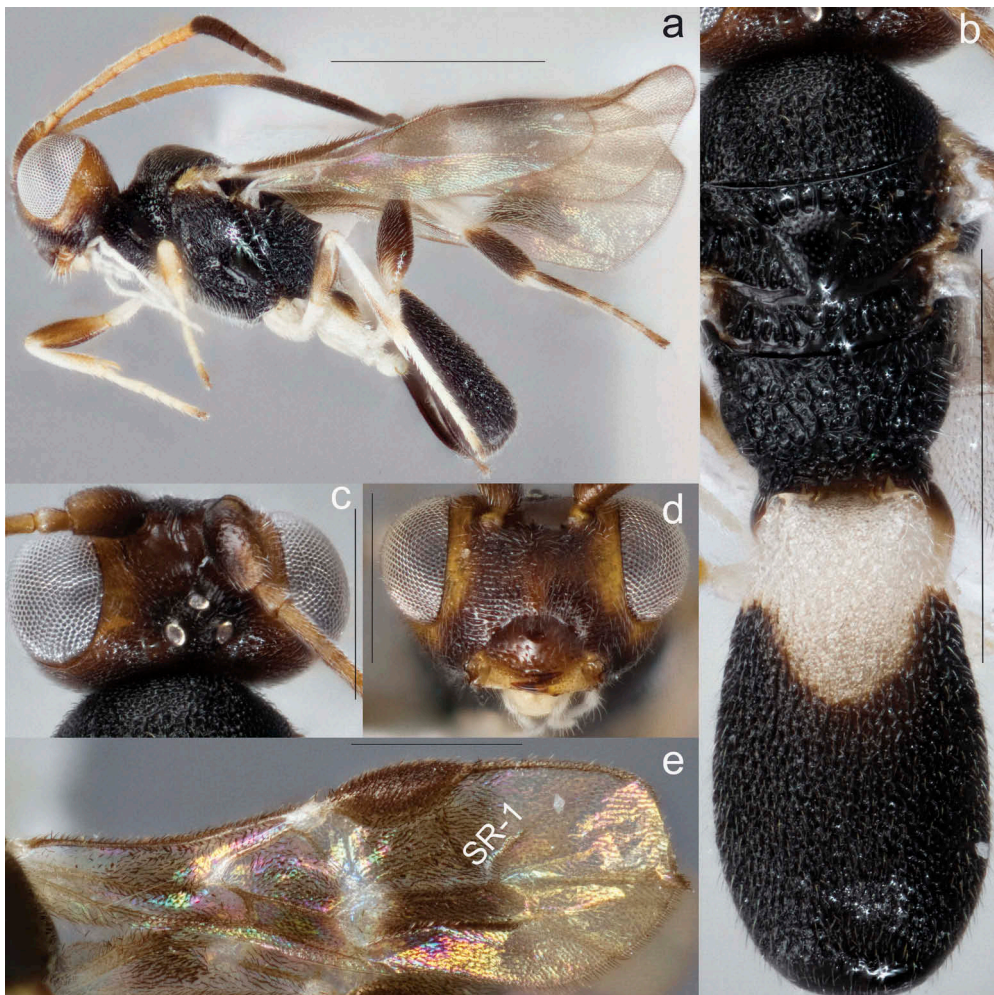


Figure 4. *Ascogaster brevivena* sp. nov.: (a) habitus, lateral, holotype, scale line = 1 mm; (b) mesosoma and metasoma, dorsal view, holotype, scale line = 1 mm; (c) head, dorsal, holotype, scale line = 0.5 mm; (d) head, anterior, holotype, scale line = 0.5 mm; (e) fore wing, paratype, scale line = 0.5 mm.



Figure 5. *Ascogaster ferruginegaster* sp. nov.: (a) habitus, lateral, holotype, scale line = 1 mm; (b) head, anterior, holotype, scale line = 0.5 mm; (c) head, dorsal, holotype, scale line = 1 mm; (d) mesosoma dorsal, holotype, scale line = 1 mm; (e) fore wing, holotype, scale line = 1 mm.

Comments

Leptodrepana, described by Shaw (1983) from the New World, is accepted as a valid genus by some authors (e.g. Shaw 1997; Brajkovic et al. 2010), while others have treated it as a junior synonym of *Ascogaster* (van Achterberg 1990; Yu et al. 2005). Tang and Marsh (1994) followed van Achterberg's synonymy and treated the new species from China as *Ascogaster*, but also suggested that a comprehensive revision of the group was needed as some species showed characters intermediate between *Ascogaster* and *Leptodrepana*. Shaw (1997) discussed the difficult status of *Leptodrepana*, arguing for a separate genus since *Ascogaster* would otherwise be paraphyletic. However, no comprehensive analysis has yet been undertaken using a combined morphological and multigene approach to resolve this question. Here we treat all relevant species as *Ascogaster*, but point out that *A. brevivena* sp. nov. exhibits characters intermediate between these two genera, such as having equilateral ocelli as in *Leptodrepana*.

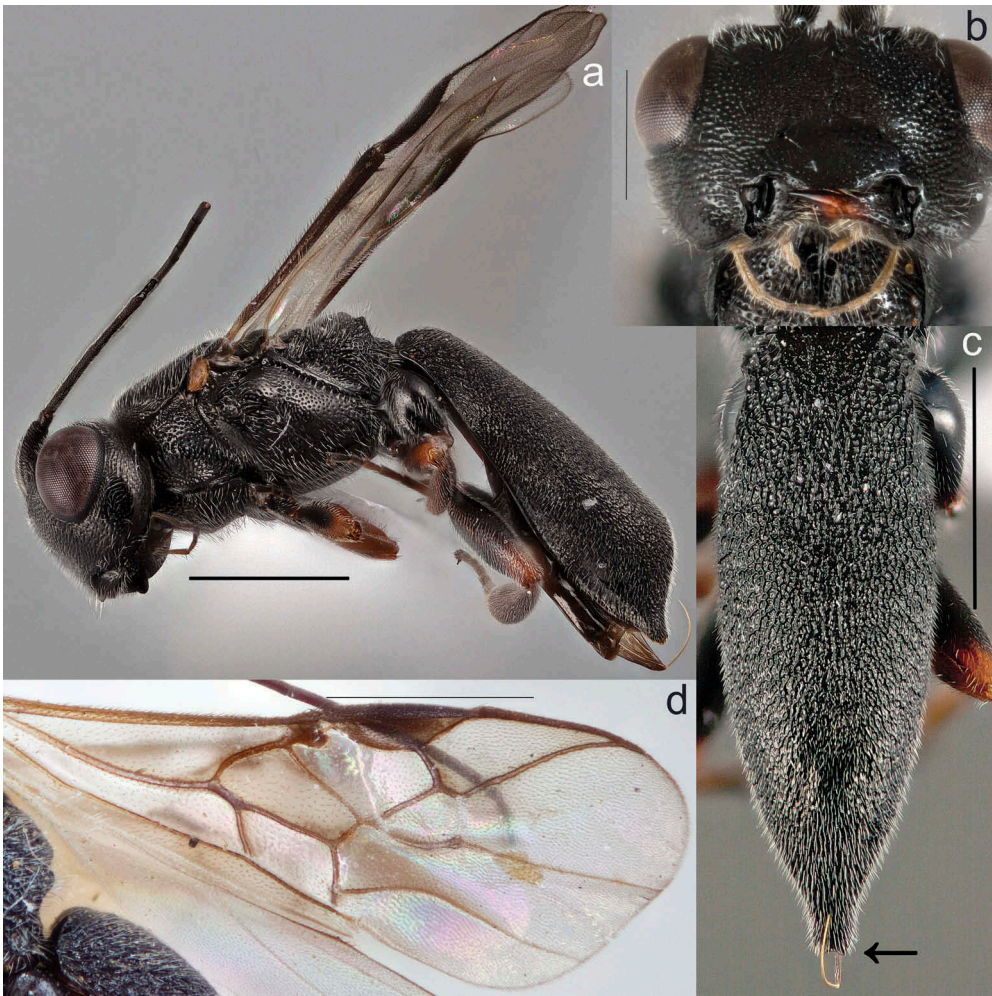


Figure 6. *Ascogaster prolixogaster* sp. nov.: (a) habitus, lateral, holotype, scale line = 1 mm; (b) head, anterior, holotype, scale line = 0.5 mm; (c) metasoma, dorsal, holotype, scale line = 1 mm, metasomal teeth arrowed; (d) fore wing, paratype, scale line = 1 mm.

Key to *Ascogaster* from the Australian arid zone

1. SR-1 not completely sclerotised, not extending to the margin of fore wing (Figure 4e); female with 22 antennomeres; ocelli equilateral (Figure 4c).....
 ***Ascogaster brevivena* sp. nov.**
 - SR-1 completely sclerotised, extending to the margin of fore wing (Figure 5e); female with 19 antennomeres; ocelli isosceles (Figure 5c)..... 2
2. Carapace elongate with extended tip, teeth on posterior end present (Figure 6c, arrowed)..... ***Ascogaster prolixogaster* sp. nov.**
 - Carapace oval, but not elongated, posterior end rounded without teeth (Figure 4a)..... 3

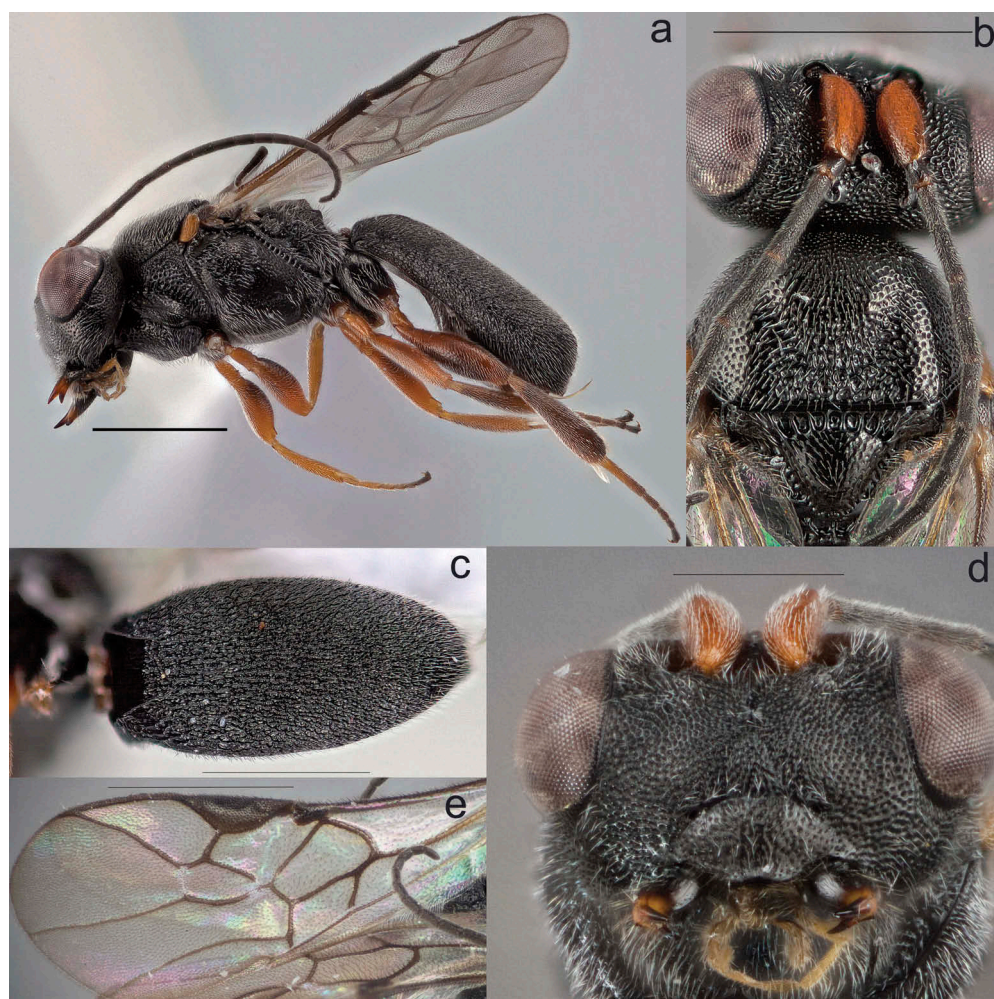


Figure 7. *Ascogaster rubriscapa* sp. nov.: (a) habitus, lateral, holotype, scale line = 1 mm; (b) mesosoma, dorsal, holotype, scale line = 1 mm; (c) metasoma, dorsal, holotype, scale line = 1 mm; (d) head, anterior view, holotype, scale line = 0.5 mm; (e) fore wing, holotype, scale line = 1 mm.

3. Carapace and legs orange (Figure 5a); notauli absent..... *Ascogaster ferruginegaster* sp. nov.
 - Carapace black (Figure 7a), legs brown with black coxa (Figure 7a); notauli present..... *Ascogaster rubriscapa* sp. nov.

***Ascogaster brevivena* sp. nov.**
 (Figures 4a–e, 15)

Description (female)

Body measurements. Length of body 2.3–2.5 mm; ratio of antenna to body 0.78–0.79 in females, 1.06 in males; ratio of length of fore wing to body 0.94–0.97 in females, 0.85 in males; ratio of length of metasoma to mesosoma 1.2.

Head. Antenna with 22 antennomeres in females, 24 antennomere in males; ratio of length of third antennomere to fourth 1.1 in females, 1.25 in males; ratio of length of third, fourth, penultimate and terminal antennomere 3.5–3.8, 3.3–3.7, 0.9–1.2, and 1.3–1.6 in females, 3, 3, 1.3 and 1.7 in males times their width, respectively; ratio of length of eye in dorsal view to length of temple 4.3 in females, 4.2 in males; ocelli equilateral; imaginary line between anterior margins of posterior ocelli is not touching the anterior ocellus; ratio of width of face in anterior view to its height 1.9–2.1 in females, 1.8 in males; ratio of width of clypeus to its height 1.0–1.1; clypeus without teeth; ratio of length of malar space to base of mandible 1.6–1.7 in females, 1.4 in males; face and frons punctate; eyes with sparsely minute setae; ratio posterior ocelli:distance between the two posterior ocelli (POL):distance between anterior ocellus and posterior ocellus (LOL):distance between posterior ocellus and eye (OOL) 1.0:1.0:0.7–0.8:2.2–2.6.

Mesosoma. Middle lobe of mesoscutum fine rugose; notauli absent; mesoscutellum shiny, fine punctate, weakly convex; mesopleuron shiny, smooth; precoxal sulcus present; ratio of height of mesosoma to its length 1.5 in females, 1.7 in males; hind coxa shiny, smooth; ratio of length of hind tibia to hind tarsus 1.0–1.1; ratio hind coxa, hind femur, hind tibia and hind tarsus 1.8–2.2, 3.1–3.5, 5.2–5.5 and 13.0–18.0 in females, 2.1, 4.2, 4.8 and 12.5 in males times their width, respectively; ratio of length of posterior spur to length of basal tarsus 0.55 in females, 0.48 in males; fore wing: 2-R1 absent; ratio of length of 1-R1 to length of pterostigma 0.9–1.0; ratio of width of pterostigma to its length 2.5–2.8; ratio r:3-SR:SR-1:r-m 1.0:1.0–1.3:1.1–2.2:0.7 in females, 1.0:0.9:5.5:0.8 in males; SR-1 only basally sclerotised; 1-SR+M emanating from base of parastigma; 2-SR+M antefurcal or interstitial.

Metasoma. Shape of metasoma oval in dorsal view; ratio of width of metasoma to its length 0.55; carapace broadens to posterior end in lateral view; ratio keel to metasomal length 0.1; carapace rugose.

Colour. Head brown, paler around eyes; anterior half of antenna light brown, posterior half dark brown; mesosoma black; wings with long brown hair given a smoky appearance of the wings, with a white band underneath the parastigma; legs white, with femur and apical end of tibia brown; anterior end of carapace white, extending dorsal into the posterior dark end.

Male. Head beige; antenna light brown; mesosoma black; legs as female but paler; wings infuscate; wing venation brown; metasoma anterior half white, posterior half black.

Diagnosis

Females differ from all other described *Ascogaster* in Australia by having a reduced SR-1 vein (not extending to the margin of the fore wing).

Specimens examined

Holotype, Australia (South Australia): 1 ♀, "27 October 2010, Bon Bon Station 30°25'29"S, 135°28'41"E, Bush Blitz survey, R. Kittel, at light" (SAM). **Paratypes, Australia (Queensland):** 1 ♀, Mt Glorious, Hiller property, 27°20'S, 152°46'E, 12 December 1998, N. Power, MT (WINC); 1 ♀, SEQ: Enogera Res., site 3, 27°27'S, 152°55'E, 27 January–15 March 2000, C.J. Burwell, S.G.

Evans, malaise 1000 m 50274 (QM); 1 ♂, SEQ: East Woodmillar, 250 m, 25°41'S, 151°36'E, 21 August–10 October 1998, G.B. Monteith, vine scrub, FIT 7255 (WINC).

Biology

Unknown.

Etymology

The name 'brevivena' reflects the unusual short SR-1 vein in the fore wing of the females.

Distribution

Northern South Australia (Bon Bon Station), Queensland (Figure 15).

CO1 sequence

Genbank accession numbers for this species are KJ438547–KJ438549.

***Ascogaster ferruginegaster* sp. nov.** (Figures 5a–e, 15)

Description (female)

Body measurements. Length of body 3.05–3.95 mm; ratio of antenna to body 0.7–0.9; ratio of length of fore wing to body 0.75–0.88; ratio of length of metasoma to mesosoma 1.1.

Head. Antenna with 19 antennomeres; ratio of length of third antennomere to fourth 0.9; ratio of length of third, fourth, penultimate and terminal antennomere 4.0–6.0, 6.0, 2.0, and 2.0–3.0 times their width, respectively; ratio of length of eye in dorsal view to length of temple 3.3–3.6; ocelli isosceles; imaginary line between anterior margin of posterior ocelli is not touching the anterior ocellus; ratio of width of face in anterior view to its height 2–2.4; ratio of width of clypeus to its height 1.0–1.3; clypeus without teeth; ratio of length of malar space to base of mandible 3.0; face fine punctate; frons fine rugose; eyes glabrous; ratio posterior ocelli:POL:LOL:OOL 1.0:2.6–3.6:1.2–1.8:2.4–4.2.

Mesosoma. Middle lobe of mesoscutum punctate; notauli absent; mesoscutellum shiny, fine punctate, weakly convex; mesopleuron shiny, fine punctate; precoxal sulcus present; ratio height of mesosoma to length 1.6–1.7; hind coxa shiny, smooth; ratio of length of hind tibia to hind tarsus 0.8–1.0; ratio hind coxa, hind femur, hind tibia and hind tarsus 1.5–1.8, 3.7–4.2, 4.0–5.3 and 13.0–24.0 times their width, respectively; ratio of length of posterior spur to length of basal tarsus 0.4–0.46; fore wing: 2-R1 present; ratio of length of 1-R1 to length of pterostigma 0.8–0.9; ratio of width of pterostigma to its length 2.0–4.0; ratio r:3-SR:SR-1:r-m 1.0:0.9–1.2:4.4:0.9–1.6; SR-1 completely sclerotised; 1-SR+M emanating from 1+M; 2-SR+M antefurcal or interstitial.

Metasoma. Shape of metasoma oval in dorsal view; ratio of width of metasoma to its length 0.5–0.6; carapace broadens to posterior end in lateral view; ratio keel to metasoma length 0.2–0.3; carapace fine rugose.

Colour. Head and metasoma black; antenna brown; legs and carapace red brown; wing venation, parastigma and pterostigma dark brown.

Diagnosis

The colour of the carapace distinguishes this species from all those currently described species in Australia. In addition, *A. ferruginegaster* is one of only five species, along with *A. prolixogaster*, *A. rubriscapa* and two undescribed species (*Ascogaster* sp. 25 and *Ascogaster* sp. 28), that has a 3-bp indel in its *CO1* sequence at position 271–273.

Specimens examined

Holotype, Australia (South Australia): 1 ♀, “18 October 2010 Witchelina Station 29°55'11" S, 137°56'13"E, S. Mantel, sweeping; Bush Blitz survey SM080, on *Pittosporum angustifolia*" (SAM). **Paratypes, Australia (Queensland):** 1 ♀, 13 km E by S Weipa, 12.40°S, 143.00°W, 16 January–16 February 1994, P. Zborowski, D Khalu, MT (ANIC); 1 ♀, 13 km E by S Weipa, 12.40° S, 143.00°W, 15 November–16 December 1993, P. Zborowski, MT (ANIC); 1 ♀, 13 km E by S Weipa, 12.40°S, 143.00°W, 12 September–24 October 1993, P. Zborowski and D. Rentz, MT (ANIC); 1 ♀, 13 km E by S Weipa, 12.40°S, 143.00°W, 15 November–16 December 1993, P. Zborowski, FIT (ANIC); **Northern Territory:** 1 ♀, 1 km E Baralil Ck near Jabiru, 25 June 1980, I. D. Naumann, LT, ex ethanol collection (ANIC); 1 ♀, Amadeus Basin, 30 June 1962, P. Ranford, ex ethanol collection (ANIC).

Male. Unknown.

Biology

The holotype was collected from butterbush (*Pittosporum angustifolium* Lodd) Pittosporaceae.

Etymology

The name refers to the red–brown carapace.

Distribution

Northern Territory, Queensland, and South Australia (Witchelina Station; Figure 15).

CO1 sequence

Genbank accession number for this species is KJ438568.

Ascogaster prolixogaster sp. nov. (Figures 6a–d, 15)

Description (female)

Body measurements. Length of body 3.65–5.8 mm; ratio of antenna to body 0.6–0.8; ratio of length of fore wing to body 0.7–0.8; ratio of length of metasoma to mesosoma 1.3–1.5.

Head. Antenna with 19 antennomeres; ratio of length of third antennomere to fourth 1.1–1.2; ratio of length of third, fourth, penultimate and terminal antennomere 10.0, 8.0–10.0, 2.0, and 2–2.5 times their width, respectively; ratio of length of eye in dorsal view to length of temple 2.5–3.2; ocelli isosceles; imaginary line between anterior margins of posterior ocelli is not touching the anterior ocellus; ratio of width of face in anterior view to its height 1.9–2.3; ratio of width of clypeus to its height 1.0–1.4; clypeus without teeth; ratio of length malar space to base of mandible 1.9–2.8; face punctate; frons rugose; eyes glabrous; ratio posterior ocelli:POL:L:OL:OOL 1.0:2.6–3.6:1.3–2.0:2.9–4.4.

Metasoma. Middle lobe of mesoscutum punctate; notauli weakly present; mesoscutellum shiny, fine punctate, convex; mesopleuron shiny, punctate; precoxal sulcus present; ratio of height of mesosoma to its length 1.7–1.8; hind coxa shiny, fine punctate; ratio of length of hind tibia to hind tarsus 0.9; ratio hind coxa, hind femur, hind tibia and hind tarsus 2.0, 3.0–4.0, 4.0–5.0 and 14.0–16.0 times their width, respectively; ratio of length of posterior spur to length of basal tarsus 0.3–0.5; fore wing: 2-R1 absent; ratio of length of 1-R1 to length of pterostigma 0.9; ratio of width of pterostigma to its length 2.7–3.0; ratio r:3-SR:SR-1:r-m 1.0:0.8–0.9:3.8–4.4:0.9–1.1; SR-1 completely sclerotised; 1-SR+M emanating from 1+M; 2-SR+M antefurcal.

Metasoma. Shape of metasoma long oval from dorsal view; ratio of width of metasoma to its length 0.4–0.5; carapace broadens to posterior end in lateral view and narrows down in dorsal view, with an extended tip for the ovipositor; ratio keel to metasoma length 0.03–0.04; carapace rugose.

Colour. Black; femur, tegula, tibia and tarsus dark brown to brown.

Diagnosis

The shape of the carapace with its elongated tip is unique among all Australian *Ascogaster*. In addition, *A. prolixogaster* is one of only five species, along with *A. ferruginegaster*, *A. rubriscapa* and two undescribed species (*Ascogaster* sp. 25 and *Ascogaster* sp. 28), that has a 3-bp indel in its *CO1* sequence at position 271–273.

Specimens examined

Holotype, Australia (South Australia): 1 ♀, “25–28 October 2010; Bon Bon Station 30°37.56'S, 135°24.18'E, S. Mantel, F. Colombo, R. Kittel & G. Taylor, MT amongst *Senna artemisioides*, *Acacia tetragonophila*, *Acacia aneura* & *Acacia victoriae*; Bush Blitz survey 367 Malaise 9” (SAM). **Paratypes, Australia (New South Wales):** 1 ♀, Pigeon House Ra. via Nerriga, 25 October 1979, I.D. Naumann, J.C. Cardale (ANIC); 2 ♀♀, Trangie, 21 October 1949, S.J. Paramonov (ANIC); 2 ♀♀, 1902, W.W. Frogatt Collection (ANIC); 3 ♀♀, Trangie, 20 October 1949, E.F. Riek (ANIC); **Queensland:** 1 ♀, Bundaberg, 18 September 1972, H. Frauca (ANIC); **South Australia:** 1 ♀, Brookfield Con Pk, 34.19°S, 139.30°E, 2 December 1991–2 January 1992, J. Steiman, S. Williams (ANIC); **Victoria:** 1 ♀, 15 km S Yarrara, 34.33°S, 141.25°E, 18 October 1983, I.D. Naumann, J.C. Cardale (ANIC); **Western Australia:** 1 ♀, 30°W Coolgardie, 29 October 1958, E.F. Riek (ANIC); 1 ♀, 12°N Norseman, 25 November 1958, E.F. Riek (ANIC), 1 ♀, 12 mi WSW of Eucla Motel, 7 October 1968, Key, Upton, Balderson (ANIC); 1 ♀, 17.7 km S of Nerren Nerren homestead

(HS), N of Galena, North-West Coast Hwy, 27 September 1973, L.P. Kelsey (ANIC); 1 ♀, Broomehill, 33.51°S, 117.38°E, 11 November 1978, R.P. Mcmillan (WAM); 1 ♀, Lake Cronin, 32°23'S, 119°46'E, 19–26 September 1978, T.F. Houston *et al.* (WAM). **Other material, Australia (New South Wales):** 1 ♀, 1902, W.W. Frogatt Collection (ANIC); mounted on the same cardboard with a specimen from another braconid subfamily.

Male. Unknown.

Biology

Unknown.

Etymology

The name reflects the elongated tip of the carapace.

Distribution

Widely spread across Australia (including Bon Bon Station in South Australia), except Northern Territory and Tasmania (Figure 15).

CO1 sequence

Genbank accession number for this species is KJ438534.

Ascogaster rubriscapa sp. nov. (Figures 7a–e, 15)

Description (female)

Body measurements. Length of body 4.4 mm; ratio of antenna to body 0.5; ratio of length of fore wing to body 0.7; ratio of length of metasoma to mesosoma 1.4.

Head. Antenna with 19 antennomeres; ratio of length of third antennomere to fourth 1.2; ratio of length of third, fourth, penultimate and terminal antennomere 5.8, 4.8, 1.7 and 2.3 times their width, respectively; ratio of length of eye in dorsal view to length of temple 5.8; ocelli isosceles; imaginary line between anterior margins of posterior ocelli is not touching the anterior ocellus; ratio of width of face in anterior view to its height 2.4; ratio of width of clypeus to its height 2.0; clypeus without teeth; ratio of length malar space to base of mandible 2.8; face punctate; frons rugose; eyes glabrous; ratio posterior ocelli:LOL:POL:OOL 1.0:3.0:1.5:3.0.

Mesosoma. Middle lobe of mesoscutum punctate; notauli present; mesoscutellum shiny, fine punctate, weakly convex; mesopleuron shiny, punctate; precoxal sulcus present; ratio of height of mesosoma to its length 1.5; hind coxa shiny, fine punctate; ratio of length of hind tibia to hind tarsus 1.0; ratio hind coxa, hind femur, hind tibia and hind tarsus 1.7, 5.6, 4.7 and 11.0 times their width, respectively; ratio of length of posterior spur to length of basal tarsus 0.5; fore wing: 2-R1 absent; ratio of length of 1-R1 to length of pterostigma 1.0; ratio of width of pterostigma to its length 2.8; ratio r:3-SR:SR-1:r-m 1.0:0.7:4.2:0.8; SR-1 completely sclerotised; 1-SR+M emanating from 1+M; 2-SR+M antefurcal.

Metasoma. Shape of metasoma long oval in dorsal view; ratio of width of metasoma to its length 0.48; carapace broadens strongly to posterior end in lateral view; ratio keel to metasoma length 0.11; carapace rugose.

Colour. Black; except legs, pedicel, tegula and wing venation brown.

Diagnosis

Superficially similar to *A. prolixogaster*, but *A. rubriscapa* lacks the elongated tip of the carapace. Overall, it can be distinguished from all other Australian *Ascogaster* species by the combination of its colour and size, the shape of the carapace and the number of antennomeres. In addition, *A. rubriscapa* is one of only five species, along with *A. ferruginegaster*, *A. prolixogaster* and two undescribed species (*Ascogaster* sp. 25 and *Ascogaster* sp. 28), that has a 3-bp indel in its *CO1* sequence at position 271–273.

Specimens examined

Holotype, Australia (South Australia): 1 ♀, "25–28 October 2010, Bon Bon Station 30° 37.56'S, 135°24.18'E, S. Mantel, F. Colombo, R. Kittel & G. Taylor, MT amongst *Senna artemisioides*, *Acacia tetragonophila*, *Acacia aneura*, and *Acacia victoriae*; Bush Blitz survey 367 Malaise 9" (SAM).

Male. Unknown.

Biology

Unknown.

Etymology

The name refers to the red scape of the specimen.

Distribution

South Australia (Bon Bon Station; Figure 15).

CO1 sequence

Genbank accession number for this species is KJ438533.

Genus *Phanerotoma* Wesmael, 1838

(Figures 3, 8–14, 16–18)

<http://species-id.net/wiki/Phanerotoma>

Type *Chelonus dentata* Wesmael, 1838: 165 (designated by Haliday, 1840: 63) IRSN (examined).

Phanerotoma: Shenefelt 1973: 909, Zettel, 1988a: 216; Zettel 1988b: 199, 1989a: 318,

1989b: 528; van Achterberg, 1990: 10; Zettel 1990a: 4, 1990b: 147, 1990d: 1, 1990e:

153, 1990f: 336, 1991: 375, 1992a: 664, 1992b: 278; Kittel and Austin, 2014.

For diagnosis of Australian taxa, see (Kittel and Austin 2014).

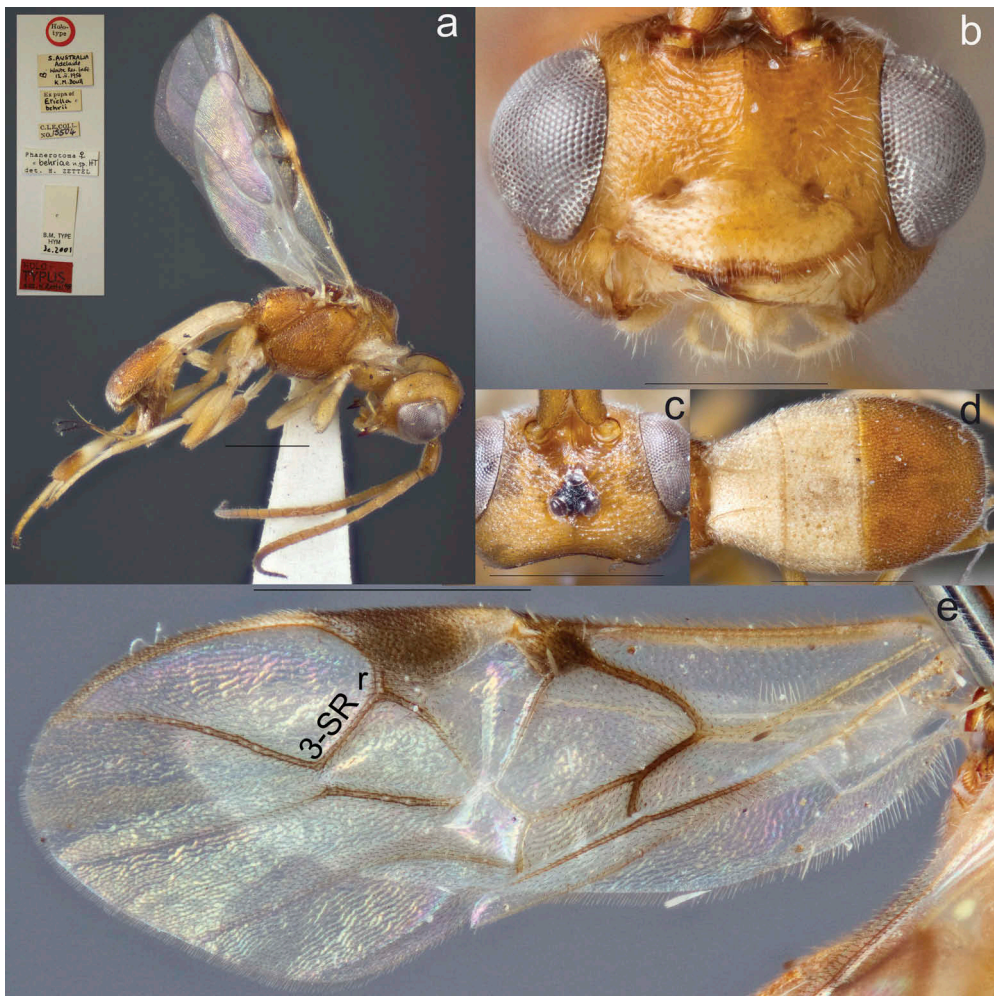


Figure 8. *Phanerotoma behriae* Zettel, 1988a: (a) habitus, lateral, holotype, scale line = 1 mm, inset type label; (b) head, anterior, holotype, scale line = 0.5 mm; (c) head, dorsal, holotype, scale line = 1 mm; (d) metasoma, dorsal, holotype, scale line = 1 mm; (e) fore wing, other material, scale line = 1 mm.

Comments

Van Achterberg (1990) stated in his diagnosis of *Phanerotoma* the presence of three distinctive clypeal teeth, although the number of teeth varies between two and three (Zettel 1990c). However, for Australia only a minority of species have three clypeal teeth, and belong to a species group including *P. behriae*, *P. lutea* sp. nov., *P. novaguineensis* and *P. pacifica* which have a reduced r vein and a much longer 3-SR vein.

The subgenus *Bracotritoma* was discussed by van Achterberg (1990), and a detailed key was provided to distinguish it from the subgenus *Phanerotoma*; however, *Bracotritoma* was later treated as a junior synonym by Zettel (1990c). The Australian *Phanerotoma* fauna consists of species which are not easily recognised as belonging to either subgenus, and thus we follow Zettel's broader definition of the genus here.

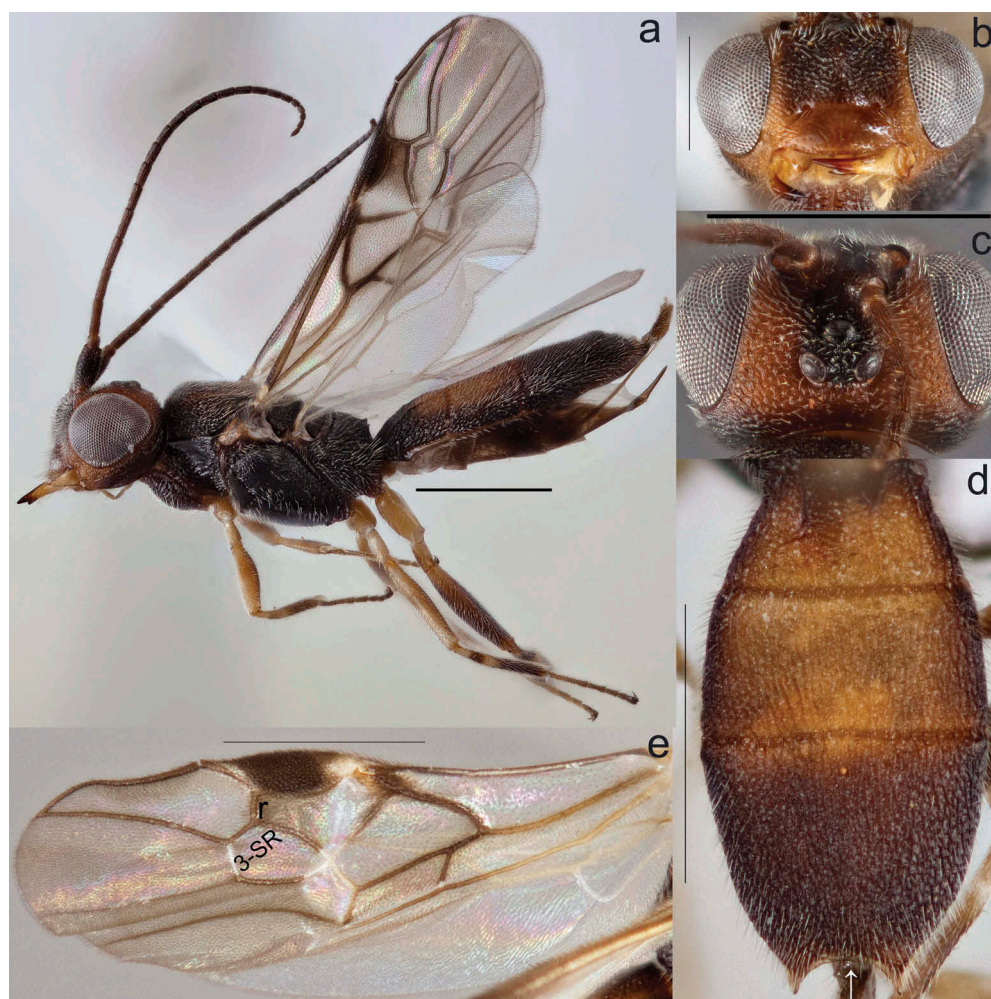


Figure 9. *Phanerotoma bonbonensis* sp. nov.: (a) habitus, lateral, paratype, scale line = 1 mm; (b) head, anterior view, holotype, scale line = 0.5 mm; (c) head, dorsal, holotype, scale line = 0.5 mm; (d) metasoma, dorsal, paratype, scale line = 1 mm, indent arrowed; (e) fore wing, paratype, scale line = 1 mm.

Key to *Phanerotoma* from the Australian arid zone

1. Three teeth present on clypeus (Figure 8b); 3-SR long, at least 4 times as long as vein r (Figure 8e)..... 2
 - Two teeth present on clypeus (Figure 9b); 3-SR short, shorter than the vein r or max. 2 times as long as r (Figure 9d)..... 3
2. First and second metasomal tergites white, third orange (Figure 8d); face, vertex and frons finely rugose (Figures 7b–c)..... ***Phanerotoma behriae* Zettel, 1988a**
 - All metasomal tergites completely yellow (Figure 12c); face, vertex and frons strigose (Figure 12b)..... ***Phanerotoma lutea* sp. nov.**

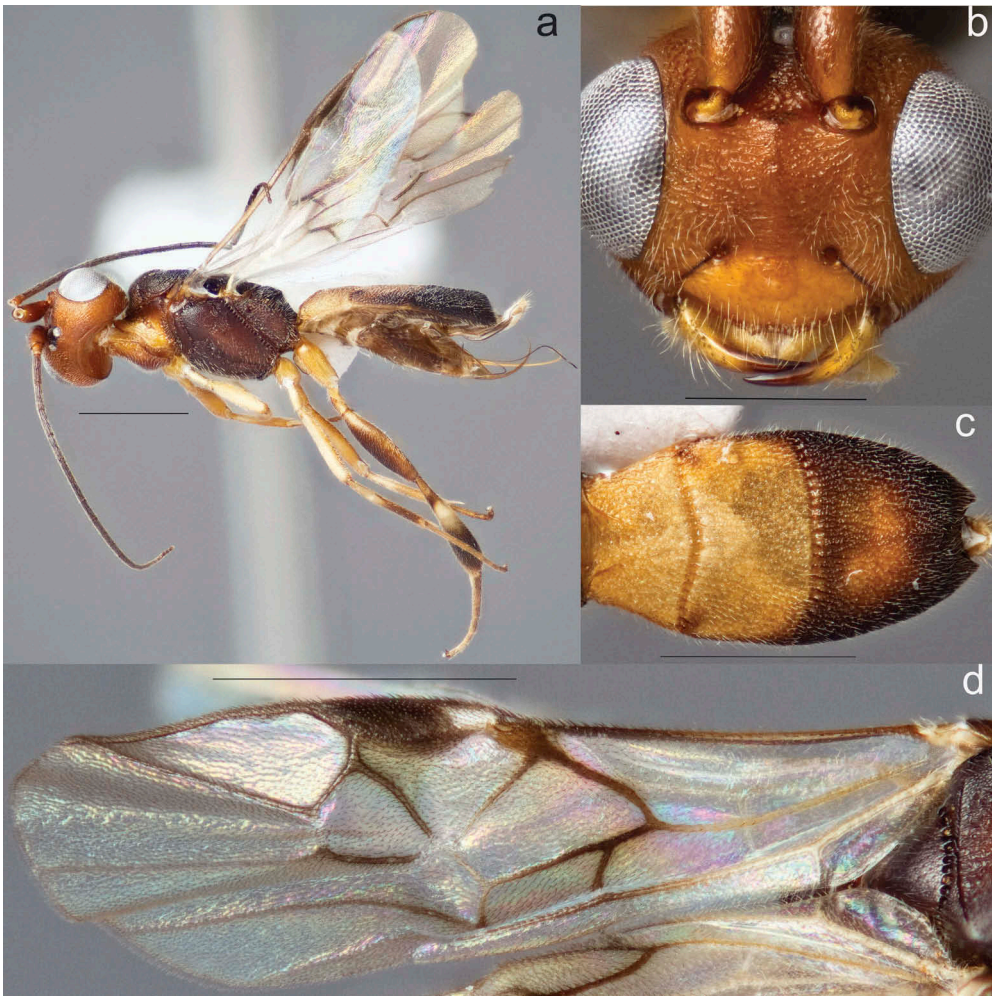


Figure 10. *Phanerotoma bushblitz* sp. nov.: (a) habitus, lateral, holotype, scale line = 1 mm; (b) head, anterior view, paratype, scale line = 0.5 mm; (c) metasoma, dorsal, paratype, scale line = 1 mm; (d) fore wing, paratype, scale line = 1 mm.

3. Carapace narrowing to a pointed posterior tip, in dorsal view (Figure 14d); ratio of first metasomal tergite to third > 1.8;..... ***Phanerotoma witchelinaensis* sp. nov.**
 - Posterior end of carapace rounded in dorsal view (Figure 8d); ratio of first metasomal tergite to third < 1.8; 4
4. Posterior end of carapace of female not indented (Figure 13a)..... 5
 - Posterior end of carapace of female deeply indented (Figure 9d, arrowed)..... 6
5. Carapace with tergites longitudinally strigose; face, vertex and frons finely rugose (Figure 7b–c)..... ***Phanerotoma nigriscapulata* sp. nov.**
 - Carapace with tergites rugose (Figure 11b); face, vertex and frons finely punctate (Figure 11d)..... ***Phanerotoma decticauda* Zettel, 1988a**

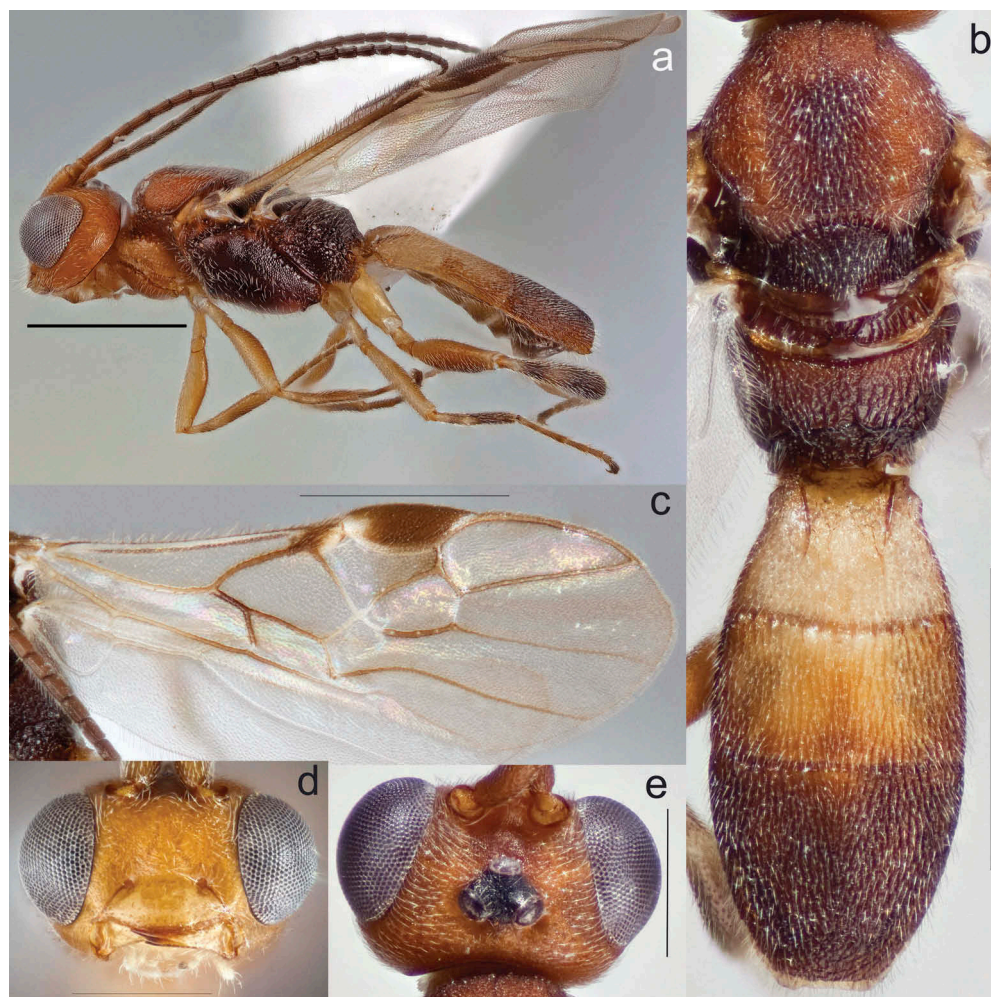


Figure 11. *Phanerotoma decticauda* Zettel, 1988a: (a) habitus, lateral, other material, scale line = 1 mm; (b) mesosoma and metasoma, dorsal, other material, scale line = 1 mm; (c) fore wing, other material, scale line = 1 mm; (d) head, anterior view, other material, scale line = 0.5 mm; (e) head, dorsal, other material, scale line = 0.5 mm.

6. All tergites of carapace rugose (Figure 10c); metasoma shorter (females) or equal (males) in length to mesosoma (Figure 10a)..... *Phanerotoma bushblitz* sp. nov.
 - First and second tergites strigose, third tergite rugose (Figure 9d); metasoma 1.1–1.3 times as long as mesosoma (Figure 9a)
 *Phanerotoma bonbonensis* sp. nov.

***Phanerotoma behriae* Zettel, 1988a**
 (Figures 8a–e, 17)

Phanerotoma behriae Zettel, 1988a: 234. Holotype: BNHM (examined). Type locality: Adelaide, South Australia. Host: *Etiella behrii* (Zeller, 1848) (Pyrilidae).

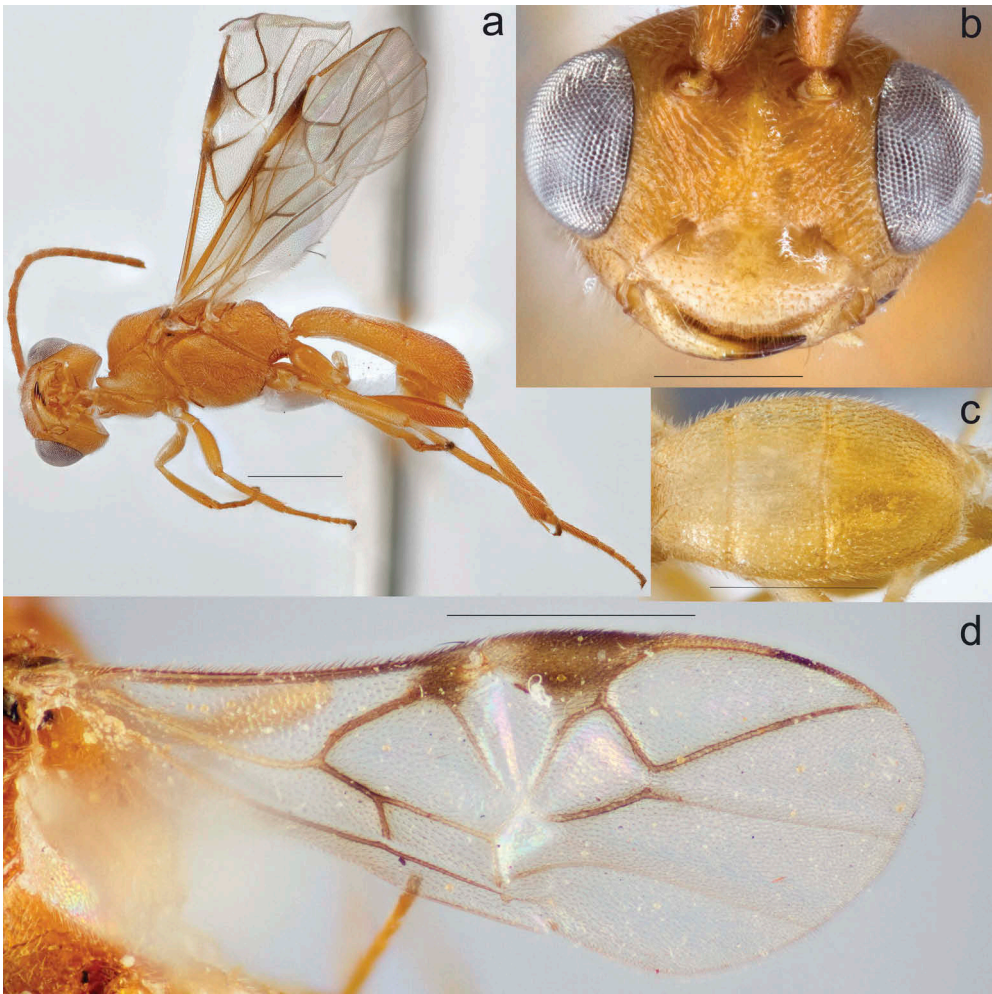


Figure 12. *Phanerotoma lutea* sp. nov.: (a) habitus, lateral, holotype, scale line = 1 mm; (b) head anterior, holotype, scale line = 0.5 mm; (c) metasoma, dorsal, paratype, scale line = 1 mm; (d) fore wing, other material, scale line = 1 mm.

Redescription

Body measurements. Length of body 2.5–5.6 mm; ratio of antenna to body 0.7–0.8; ratio of length of fore wing to body 0.8; ratio of length of metasoma to mesosoma 1.15.

Head. Ratio of length of third antennomere to fourth 0.9–1.1; ratio of length of third, fourth, penultimate and terminal antennomere 2.4–3.3, 2.6–3.6, 2.3–2.6 and 2.0–3.3 times their width, respectively; ratio of length of eye in dorsal view to length of temple 1.9–2.4; ratio of width of face in anterior view to its height 1.8–2.3; ratio of width of clypeus to its height 1.5–2.15; clypeus with three teeth; ratio of length of malar space to base of mandible 0.6–0.8; face, vertex, and frons fine rugose; ratio posterior ocelli:LOL:POL:OOL 1.0:0.6–0.9:0.7:2.3–2.8.

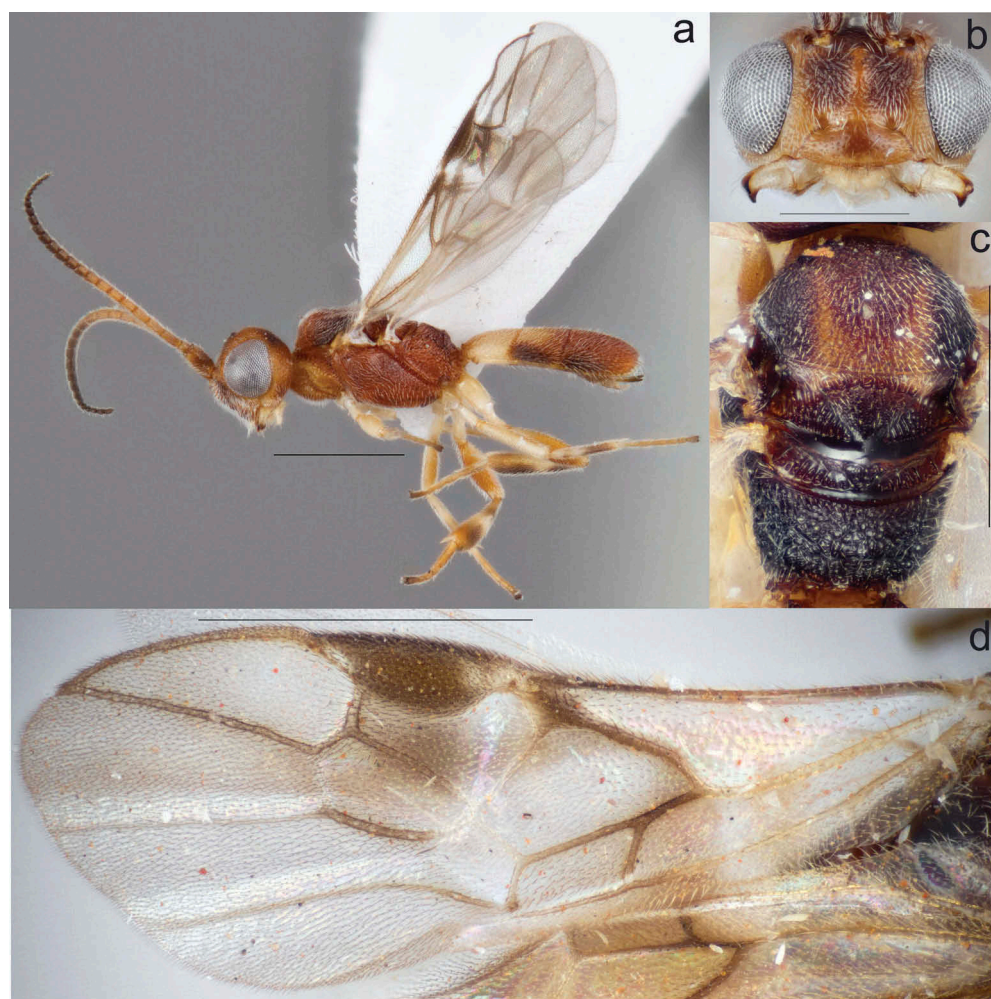


Figure 13. *Phanerotoma nigriscapulata* sp. nov.: (a) habitus, lateral, paratype, scale line = 1 mm; (b) head, anterior, holotype, scale line = 0.5 mm; (c) mesosoma, dorsal, paratype, scale line = 1 mm; (d) fore wing, paratype, scale line = 1 mm.

Mesosoma. Middle lobe of mesoscutum rugose; notauli absent; mesoscutellum rugose; mesopleuron rugose; precoxal sulcus absent; ratio of height of mesosoma to its length 1.6; propodeal tubercles present; blister on mid tibia present; ratio of length of hind tibia to hind tarsus 1.0; ratio of length of posterior spur to length of basal tarsus 0.4–0.5; ratio hind coxa, hind femur, hind tibia and hind tarsus 1.7, 3.0–3.8, 4.5–6.0 and 16.0–17.5 times their width, respectively; fore wing: 2-R1 absent; ratio of length of 1-R1 to length of pterostigma 1.1–1.2; ratio of width of pterostigma to its length 2.7–3.7; ratio r:3-SR:SR-1:r-m 1.0:5.0–5.8:12.3–14.8:1.1–2.0; 1-SR+M emanating from parastigma; 2-SR+M interstitial.

Metasoma. Shape of metasoma oval in dorsal view; ratio of width of metasoma to its length 0.6; carapace flat in lateral view; ratio of keel to length of metasoma 0.2–0.3; first

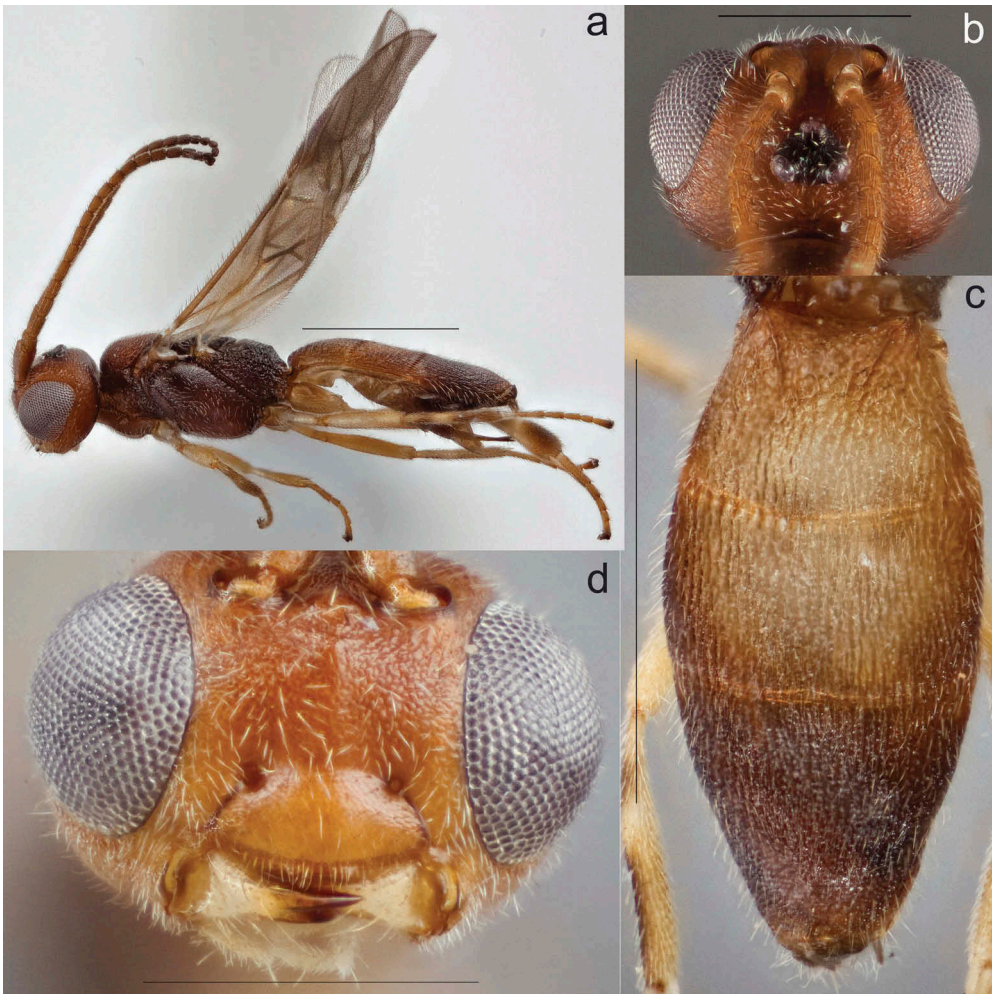


Figure 14. *Phanerotoma witchelinaensis* sp. nov.: (a) habitus lateral, scale line = 1 mm; (b) head dorsal, scale line = 0.5 mm; (c) head, anterior, scale line = 0.5 mm; (d) metasoma dorsal, scale line = 1 mm; all holotype.

and second metasomal tergite longitudinal strigose; third tergite rugose; posterior suture curved anteriorly; posterior end of carapace with a straight margin; ratio of the three metasomal tergites 1.0:0.9:1.4–1.5.

Colour. Head and mesosoma orange; antenna beige, gradually darker to tip; legs beige with posterior half of tibia orange; hind tibia black–white–black striped; wing venation brown, pterostigma and parastigma brown, white between them; wing hyaline; first and second metasomal tergite white, third orange.

Diagnosis

This species belongs to a species complex that have three teeth on the clypeus, a short r vein and a long 3-SR vein. The complex comprises (at least in Australia) only *P. behria*

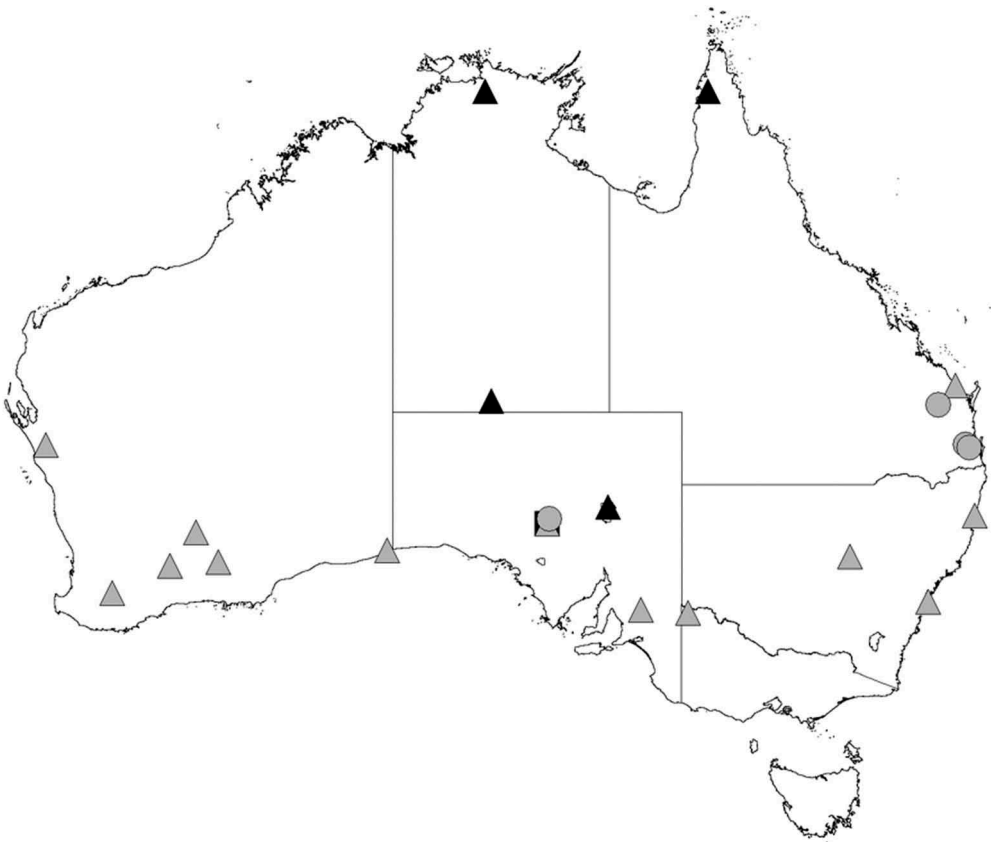


Figure 15. Distribution map: *Ascogaster brevivena* sp. nov., grey circle; *Ascogaster ferruginegaster* sp. nov., black triangle; *Ascogaster prolixogaster* sp. nov., grey triangle; *Ascogaster rubriscapa* sp. nov., black square.

and *P. lutea*. *Phanerotoma behria* can be distinguished from *P. lutea* by the distinct colour pattern: first and second metasomal tergites white, last tergite orange.

Specimens examined

Holotype, Australia (South Australia): ♀, *Phanerotoma behriae* Zettel, 1988a, Adelaide.

Other material, Australia (New South Wales): 1 ♀, Evanslookout, Blue Mts National Park (NP), 4 December 1971, G. Daniels, Mercury vapor lamp (MVL) (AMS, K358164); 1 unknown sex, Congo, 8 km SEbyE of Moruya, 35.58°S, 150.09°E, 15–16 May 1980, M.S. Upton (ANIC); 1 ♂, 20 mi SSW of Bourke on bank of Darling River, 25 December 1973, G. F. Gross, LT (SAM); 1 ♂, Fowlers Gap Res Stn, 31.05°S, 141.42°E, 8–9 December 1982, I.D. Naumann, ex ethanol (ANIC); 1 ♂, 32 km E of Warren, 8 December 1976, E.M. Exley and T. Low on *Atalaya hemiglauca* (QM); **Northern Territory:** 1 ♂, 32 km WNW of Alice Springs, 23.36°S, 133.35°E, 8 October 1978, J.C. Cardale (ANIC); 8 ♂♂, 1 ♀, 39 km E Alice Springs, 23.41°S, 134.15°E, 25 September 1978, J.C. Cardale, ex ethanol (ANIC); 4 ♂♂, 1 ♀, 39 km E Alice Springs, 23.41°S, 134.15°E, 5 October 1978, J.C. Cardale, ex ethanol (ANIC); 1 ♂, 53 km EbyN of Alice Springs, 23.43°S, 134.22°E, 6 October 1978, J.C. Cardale (ANIC); 3 ♀,

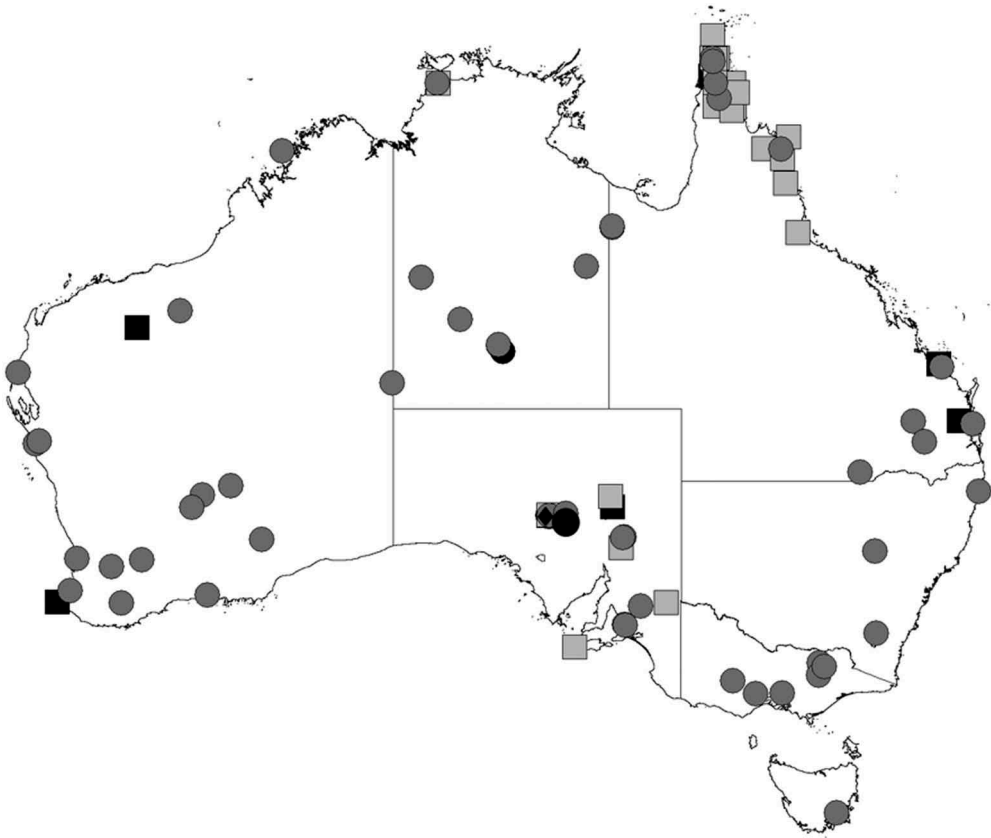


Figure 16. Distribution map: *Phanerotoma bushblitz* sp. nov., black diamond; *Phanerotoma lutea* sp. nov., grey square; *Phanerotoma witchelinaensis* sp. nov., black square; *Phanerotoma nigriscapulata* sp. nov., grey circle; *Phanerotoma bonbonensis* sp. nov., black circle.

1 ♂, Roe Creek, 12 km SWbyW Alice springs, 23.46°S, 133.47°E, 9 October 1978, J.C. Cardale, ex ethanol (ANIC); 1 ♂, 3 km SSW of Kathrine, 14.30°S, 132.15°E, 12 November 1979, I.D. Naumann, collected LT, ex alcohol collection (ANIC); 1 ♂, Robin Falls, 13.21°S, 131.08°E, 8 June 1993, E.D. Edwards (ANIC); 1 ♂, 1 ♀, Camfield River, 17.01°S, 131.07°E, 4 June 1993, E.D. Edwards (ANIC); 1 ♀, 35 km S of The Granites Mine, Tanami Desert, 20.51° S, 130.16°E, 29 October–2 November 1988, D.C.F. Rentz (ANIC); 1 ♂, Camfield HS 17.08°S 131.21°E, 17–18 August 1982, I. Archibald, MV light (MAGNT); 1 ♀, Ruby NP, 23°28'50"S, 134°59'00"E, 20 March 1993, J.A. Forrest and D. Hirst, MT (in ethanol) (SAM); 6 ♂♂, 8 ♀♀, 7 unknown sex, Darwin, G.F. Hill; Par on larvae of *Lygraphia clyusalis* Walk 'Currajong Bag shelter moth' (in ethanol) (SAM); 1 unknown sex, 10 mi NW of Yuenduni Creekbed, 20 February 1968, LT (SAM); 1 ♀, 10 mi E of Daly River, 28 June 1972, B.K. Head, LT (SAM); 1 ♂, 2.8 mi S of Renner Springs, 8 April 1966, N. McFarland, ultraviolet (UV) light (SAM); 1 ♂, Tennant Creek, 8 August 1990, R.P. McMillan (WAM 82895); 1 ♀, 10mi N Mid Br Gasgoyne Ranges, 11 July 1958, R.P. McMillan (WAM 82811); 3 ♀♀, Kakadu NP, 3 km S Nourlangie Camp, 17 November 1992, A.D. Austin and P.C. Dangerfield, LT, *Acacia* and *Pandanus* (WINC); 1 ♂, 195 km E of Ayers Rock, on Lassiter's Hwy, 5 November 1992, P.C.

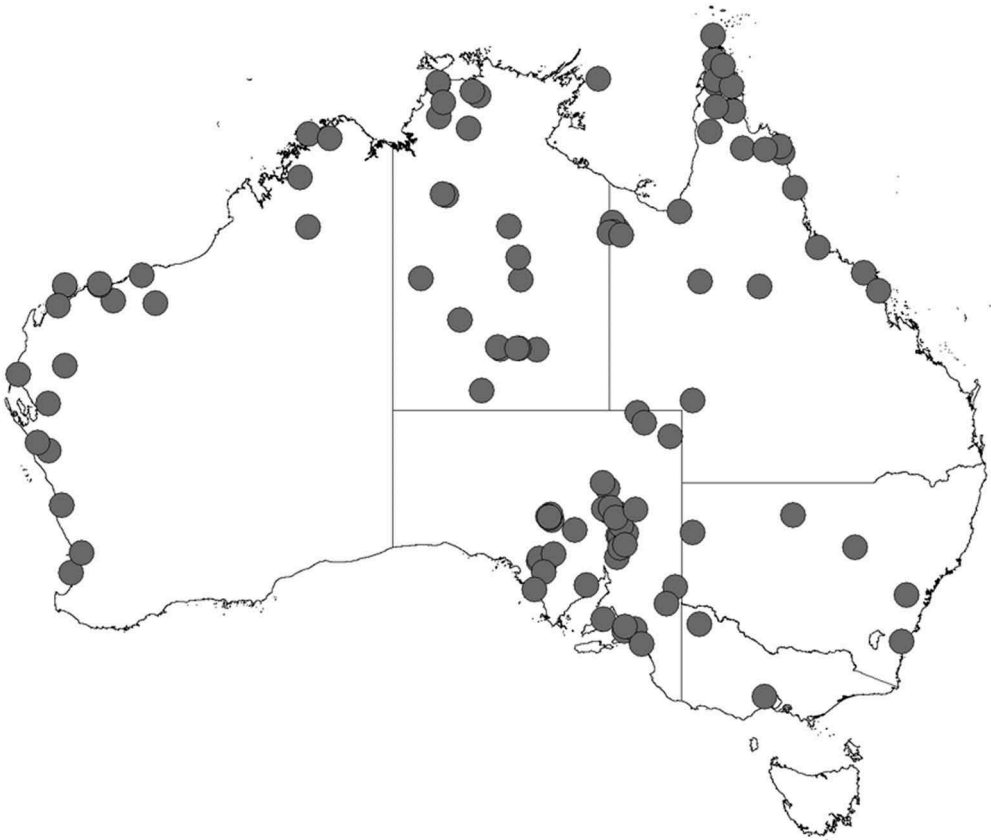


Figure 17. Distribution map: *Phanerotoma behriae* Zettel, grey circle, incl. holotype.

Dangerfield, sweeping *Leptospermum* sp. (WINC); 1 ♀, Magela Ck ARR, 28 May 1991, Wells and Webber, MV, LT (WINC); 1 ♀, Darwin, Alawa, 18 May 1991, A. Wells, LT (WINC); 1 ♂, Devil's Marbles CP, 11 June 1992, A.D. Austin and P.C. Dangerfield, LT (WINC); 1 ♀, 5 km NNW of Cahills Crossing (East Alligator River), 12.23°S, 137.52°E, 5 October 1975 A. Allwood and T. Angeles (QM); **Queensland:** 1 ♂, 7 km S Batavia Downs, 12.43°S, 142.42° E, 24 October–23 November 1992, P. Zborowski and A. Calder, MT (ANIC); 1 ♀, Mt. White, 13.58°S, 143.11°E, 12 January 1994, P. Zborowski and E.D. Edwards, LT (ANIC); 1 ♀, Mt Cook NP, 15.29°S, 145.16°E, 10–12 May 1981, I.D. Naumann, ex ethanol (ANIC); 1 ♂, Australia, Nth Qld, Black River, 9 December 1990 T. Woodger (ANIC); 1 ♀, Bacusia, Nth Qld, Ken., 5 November 2003, J. Sandery (ANIC); 2 ♂♂, 5 km EbyS Peak Hill, 10.44°S, 142.29°E, 20 June 1993, P. Zborowski and I.D. Naumann (ANIC); 1 ♂, Heathlands, 11.45°S, 142.35°E, 12 August 1993, P. Zborowski and J. Balderson (ANIC); 1 ♂, 1 ♀, Moreton HS, 12.27°S, 142.38°E, 21 August 1992, I.D. Naumann and P. Zborowski, LT (ANIC); 1 ♂, 7 km S Batavia Downs, 12.43°S, 142.42°E, 23 November–11 December 1992, P. Zborowski and W. Dressler, MT (ANIC); 1 ♂, 1 km WbyN Bolt Head, 12.55°S, 143.05°E, 22 October 1992, P. Zborowski and T. Weir (ANIC); 3 ♀♀, Rokeby HS, 13.40°S, 142.40°E, 23 June 1993, I.D. Naumann and P. Zborowski, LT (ANIC); 1 ♂, 3 km SbyE Coen, 13.55°S, 143.11°E, 24 June

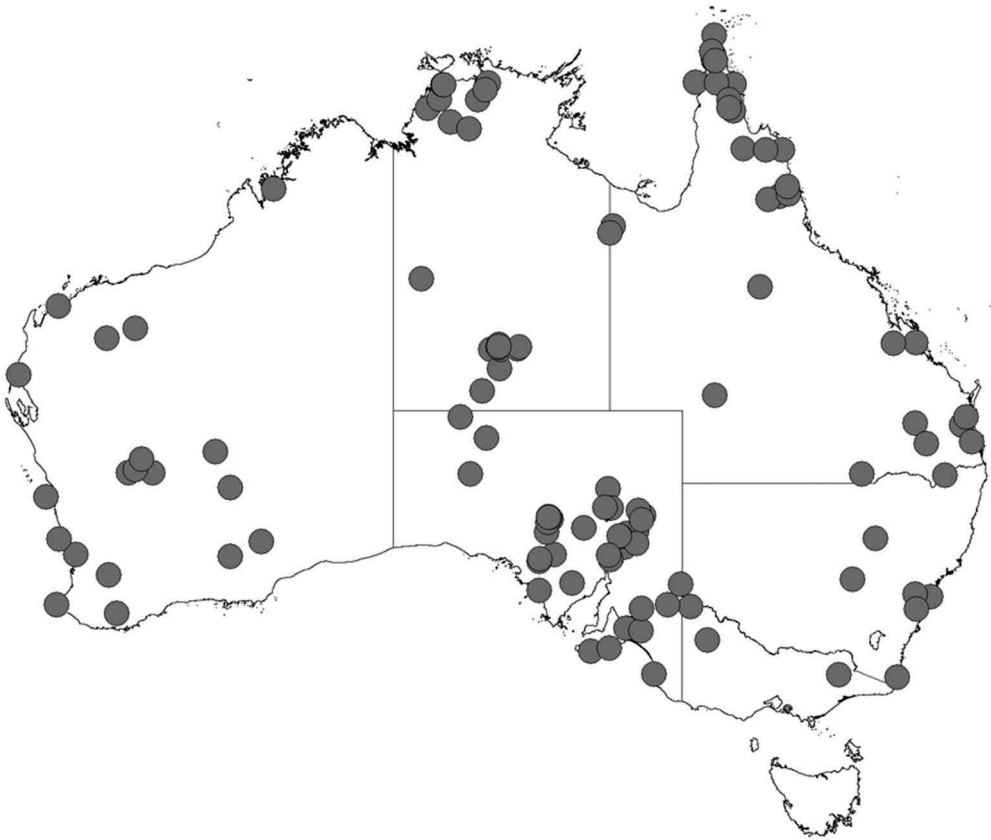


Figure 18. Distribution map: *Phanerotoma decticauda* Zettel, grey circle, incl. holotype.

1993, I.D. Naumann and P. Zborowski, LT (ANIC); 1 ♂, The Bend, 3 km NbyW Coen, 13.56° S, 143.12°E, 25 June 1989, I.D. Naumann, ex ethanol (ANIC); 1 ♂, Edwards River, 14.41°S, 142.16°E, 14 September 1993, P. Zborowski and S. Shattuck, LT (ANIC); 1 ♂, Mt Webb NP, 15.04°S, 145.07°E, 27–20 April 1981, I.D. Naumann, ex ethanol; collected LT (ANIC); 4 ♂♂, 2 ♀♀, Hann R, 73 km NWbyW Laura, 15.12°E, 143.52°E, 27 June 1986, J.C. Cardale, at MV light (ANIC); 1 ♀, Battle Camp Range, 15.17°S, 144.44°E, 27 June 1993, P. Zborowski, LT (ANIC); 1 ♂, 28 km NbyE Musselbrook Camp, Amphitheatre, 18.21°S, 138.11°E, 12 May 1995, I.D. Naumann, LT (ANIC); 1 ♂, 1 ♀, 8 km SEbyE Musselbrook Camp, 18.38°S, 138.11° E, 11 May 1995, I.D. Naumann, LT (ANIC); 1 ♀, 9 km SEbyE Musselbrook Camp, 18.38°S, 138.12°E, 20 May 1995, I.D. Naumann, LT (ANIC); 1 ♂, 10 km SE Musselbrook Camp, 18.39°S, 138.12°E, 13 May 1995, I.D. Naumann, LT (ANIC); 1 ♂, 1 ♀, 16 km SSE Musselbrook Camp, 18.44°S, 138.12°E, 18 May 1995, I.D. Naumann, LT (ANIC); 1 ♀, Musselbrook Resources Centre, Lawn Hill NP, near monument, 160 m, 18°35'52"S, 138° 07'23"E, 19 April 1995, G. Daniels and M.A. Schneider, MVL (QM); 1 ♂, Border Waterhole, 15 km W of Musselbrook Resources Centre Lawn Hill NP, 18°36'44"S, 137°59'30"E, 200 m, 6 May 1995, G. Daniels and M.A. Schneider (QM); 1 ♂, Louie Ck Lawn Hill NP, 18.47°S, 138.31°E, 17–18 May 1995 I.D. Naumann (ANIC); 1 ♀, 70.23 km ENE (72°) Betoota, 25° 34'31"S, 141°26'14"E, 5 April 1994, G.V. Maynard and G. Davis, from *Grevillea sida*

cordifolia GVM-AB040256 (ANIC); 3 ♀♀, Canobie Stn, 23–25 November 1984, D.S. Gibson, light (ANIC); 1 ♀, Hughenden Stn, 19–21 November 1984, D.S. Gibson, LT (ANIC); 1 ♂, 1.5 km WNW Riversleigh HS at Gregory River ford, 20 April 1986, J.A. Forrest, blacklight (in ethanol) (SAM); 1 ♀, 2 km WNW Riversleigh HS, near Gregory River, 28 April 1986, J.A. Forrest, blacklight (in ethanol) (SAM); 3 ♀♀, 1 ♂, Normanton, 7 May 1963, P. Aitken and N.B. Tindale, LT (SAM); 1 ♂, Cairns, Turtle Ck Australia, 5–6 August 1972, B. Hooking; (QM); 1 ♀, Bamaga Capt Billy Ck Rd junction 16 km NE Heathlands HS, 11°41'S, 142°42'E, 22 March 1992, G. Daniels and M.A. Schneider, MVL (QM); 1 ♀, Cairns, Turtle Ck Australia, 6–7 August 1972, B. Hooking (QM); 1 ♀, Lawn Hill NP, Qld, 18°42'08"S, 138°29'06"E, 140 m, 26 April 1995, G. Daniels and M.A. Schneider, MVL (QM); **South Australia:** 1 ♀, Brachina Creek, 31.20°S 138.35°E, 8 November 1987, J.C. Cardale, LT (ANIC); 1 ♀, 1 ♂, Bon Bon Stn, 30°32'08"S, 135°35'37"E, 26 October 2010, S. Mantel, Bush Blitz survey SM140 sweeping on *Acacia aneura* (in ethanol) (SAM); 1 ♂, Bon Bon Stn, 30°25'26"S, 135°28'39"E, 28 October 2010, R. Kittel, Bush Blitz survey RK133, LT (SAM); 1 ♀, Bon Bon Stn, 30°28'22"S, 135°28'44"E, 24 October 2010, S. Mantel, Bush Blitz survey SM131 *Acacia aneura*, LT (SAM); 2 ♀♀, Bon Bon Stn, 30°25'29"S, 135°28'41"E, 27 October 2010, R. Kittel, Bush Blitz survey RK125 LT (in ethanol) (SAM); 3 ♀♀, Bon Bon Stn, 30°18'50"S, 135°32'50"E, 28 October 2010, R. Kittel; Bush Blitz survey RK129 sweeping on *Acacia victoriae* (in ethanol) (SAM); 1 ♀, Bon Bon Stn, 30°25'28"S, 135°28'40"E, 28 October 2010, S. Mantel, LT, Bush Blitz survey (SAM); 2 ♂♂, Bon Bon Stn, 30°23'41"S, 135°26'52"E, 25 October 2010, R. Kittel, LT (1 ♂ in ethanol) (SAM); 1 ♀, 1 ♂, Chillata Springs Lake Newland Eyre Pen., 29 November 1986, J.A. Forrest, LT (in ethanol) (SAM); 22 ♀♀, Danggali CP 3 km N Tomahawk Dam, 33°19'39"S, 140°42'50"E, 25 November 1996, J.A. Forrest, LT (in ethanol) (SAM); 1 ♂, Dingly Dell Camp, Oraparinna Ck 7, 31.21°S 138.42°E, November 1987, I.D. Naumann, J.C. Cardale, ex ethanol (ANIC); 1 ♂, Flinders Ranges: Blinman, Rose Cottage, 31°05'43"S, 138°40'43"E, 7 April 2011, R. Kittel and G. Taylor, LT (WINC); 2 ♀♀, Flinders Ranges: Road to Warraweena, 30°46.335'S, 138°29.040'E, 7 April 2011, R. Kittel, Sweeping *E. camaldulensis* and *S. molle* (WINC); 1 ♀, Flinders Ranges: Wirreander 32°05.936'S, 138°17.802'E, 3 April 2011, R. Kittel and G. Taylor, Sweeping *Schinus molle* (WINC); 1 ♀, 3 ♂♂, Flinders Ranges: Blinman, Rose Cottage, 31°05'43"S, 138°40'43"E, 7 April 2011, R. Kittel and G. Taylor, LT (in ethanol) (WINC); 2 ♂♂, Flinders Ranges, Blinman 31°05'43"S, 138°40'43"E, 6 April 2011, R. Kittel, LT (in ethanol) (WINC); 1 ♂, Yudnamutana Bore Arkaroola Stn, 30.10°S, 139.07°E, 22 October 1993, E.D. Edwards and E.S. Nielsen (ANIC); 1 ♂, 32 km NNE Cowell, 33.26°S, 137.03°E, 28 November 1992, I.D. Naumann and J.C. Cardale (ANIC); 1 ♀, 21 km NW Renmark, 34.02°S, 140.36°E, 8 November 1995, Cardale, Lee, Pullen and Domingues, LT (ANIC); 1 ♀, 9.6 km N of Hawker, 29 February 1972, E.G. Matthews, LT (SAM); 1 ♂, Hiltaba Bush Blitz, 32°09'21"S, 135°04'12"E, 20 September 2012, G. Taylor, sweeping (in ethanol) (SAM); 1 ♂, Hiltaba Bush Blitz, 32.24262°S, 135.05908°E, 12 September 2012, R. Kittel sweeping (in ethanol) (SAM); 1 ♀, Hiltaba Bush Blitz, 32°14'59"S, 135°03'27"E, 13–21 September 2012, R. Kittel, M. Cheng and G. Taylor, MT (in ethanol) (SAM); 1 ♀, Hiltaba Bush Blitz, 32°22'13"S, 135°17'22"E, 20 September 2012, R. Kittel sweeping (in ethanol) (SAM); 1 ♀, 1 ♂, Alton Downs Stn 17 km NW Karrathunka WH, 26°06'07"S, 139°08'45"E, 23–27 March 2001, pitfalls Sandy Des Surv KA00601; Dunefield *Zygochloa paradoxa*, *Salsola kali* and *Aristida holothera*, very open hummock grassland (in ethanol) (SAM); 1 ♂, Monarto approx 4 km E Callington, 35.07°S, 139.05°E, 6 December 1984, Woods and Foresis, Ex *Euc brockwayi* (in ethanol) (SAM); 1 ♂,

Moonaree Stn 8.2 km ESE Moonaree Hill, 31°57'09"S, 135°40'46"E, 15–20 October 2006, WHC Moonaree Survey; ACR camp, open shrub; *Eucalyptus socialis*, *Casuarina*, *Acacia*, *Dodonea*, red brown sandy-loam flat, LT (in ethanol) (SAM); 3 ♀♀, Mt. Lyndhurst Stn, 15 September 1993, S. Donnellan, MT (in ethanol) (SAM); 1 ♀, 'Douglas Scrub' near McLaren Flat, 4 April 1985, L. Oveale, sweeping (in ethanol) (SAM); 1 ♀, Witchelina Stn, 30°07'27"S, 137°55'43"E, 19–22 October 2010, S. Mantel, F. Colombo, R. Kittel, MT dam floods with young *Eucalyptus* sp and flowering herbs Bush Blitz survey 363 (SAM); 1 ♂, Witchelina Stn, 30°09'13"S, 137°53'87"E, 18–22 October 2010, S. Mantel, F. Colombo and R. Kittel, MT well-vegetated sand dune Bush Blitz survey 356 (SAM); 1 ♀, Witchelina Stn, 30°04'38"S, 137°45'13"E, 30 October 2010, R. Kittel, Bush Blitz survey RK067 sweeping on *Hakea leucoptera* (SAM); 3 ♂♂, Gawler Ranges 4 km SW Scrubby Peak, 12 December 1989, J.A. Forrest, LT (in ethanol) (SAM); 3 ♀♀, Witchelina Stn, 30°08'06"S, 137°53'55"E, 19 October 2010, R. Kittel, Bush Blitz survey RK061, sweeping, sand dune (1 ♀ in ethanol) (SAM); 1 ♀, Witchelina Stn, 30°01'20"S, 138°02'46"E, 13 October 2010, R. Kittel, LT, Bush Blitz survey, RK 007 (SAM); 1 ♂, Witchelina Stn, 30°11'07"S, 137°58'38"E, 18–22 October 2010, S. Mantel, F. Colombo, R. Kittel, MT, Bush Blitz survey MT2 (SAM); 1 ♂, 1 km W Koolymilka, 30°58'14"S, 136°32'15"E, 23–24 April 2007, Woomera PA survey, LT (SAM); 1 ♂, 32 km N Innamincka, 11 October 1987, J.A. Forrest, LT (SAM); 1 ♀, 9.6 km N of Hawker, 29 February 1972, E.G. Matthews, LT (SAM); 1 ♀, Clifton Hills OS (ruin), 26°31'S, 139°26'E, 21 November 1993, J.A. Forest and G. Hirst, LT (SAM); 1 ♂, Highgate, 20–27 February 1957, H.A. Lindsay, LT (SAM); 1 unknown sex, Springbanks, January–March 1960, R.V. Southcott, from light housing (SAM); 1 ♀, Sulphur Peninsula, Madigan Gulf, Lake Eyre North, 30 October 1966, G.F. Grossm (SAM); 1 ♂, Wirreandah Ck Crossing, 30 km S Hawker, 26 November 1975, G.F. Gross and V. Potezny, LT (SAM); 1 ♀, Douglas Scrub, McLaren Flat, 35°11'09"S, 138°36'01"E, 24 September 2013, R. Kittel, LT (WINC); 2 ♂♂, Muloorina HS via Maree, near bore lake, 29°14'S, 137°55'E, 9–10 February 1989, A.D. Austin and P.C. Dangerfield, LT (WINC); 1 ♂, 5 km WNW Myrtle Springs HS, 30°27'S, 138°14'E, 8 February 1989, A.D. Austin and P.C. Dangerfield, sweep (WINC); 1 ♂, Meningie, 25 January 1990, G. Howard, LT (WINC); 1 ♀, Yorke Peninsula, Curramulka, 34°40'11"S, 137°43'47"E, 19 October 2011, S. Mantel and H. De Graaf sweeping, in wheat crop (WINC); 1 ♀, Yorke Peninsula, Curramulka, 34°40'11"S, 137°43'47"E, 19 October 2011, S. Mantel and H. De Graaf sweeping, in wheat crop (WINC); **Victoria**: 1 ♀, Little River Ripley Rd, 20 km N of Geelong, 37°52.709'S, 144°25.401'E, 9 December 2011, R. Kittel and L. Krieger sweeping (WINC); 1 unknown sex, Birthday Tank, 50 km NE Cowangie, 10 May 1971, A. J. Coventay (MV); **Western Australia**: 2 ♀♀, 2 ♂♂, 'The Crusher', CALM Site 9/1, 4 km SbyW Mining Camp Mitchell Plateau, 14.52°S, 125.50°E, 2–6 June 1988, I.D. Naumann, closed forest and margin (ANIC); 1 ♀, 'The Crusher', CALM Site 9/1, 4 km SbyW Mining Camp Mitchell Plateau, 14.52°S, 125.50°E, 2–6 June 1988, I.D. Naumann, MT and closed forest (ANIC); 1 ♀, Kalumburu Mission Airfield, 14.71°S, 126.38°E, 23 May 1993, E.D. Edwards (ANIC); 1 ♀, CALM site 25/1, Synnot Ck, 16.31°S, 125.16°E, 17–20 June 1988, T. A. Weir, LT, open forest (ANIC); 2 ♀♀, SSE of Fitzroy Crossing, 18.39°S, 125.49°E, 10 May 1995, M. Horak and M. Matthews (ANIC); 1 ♀, 14 km ENE of Carnarvon, 24.50°S, 113.46°E, 21 October 1992, E.D. Edwards and E.S. Nielsen (ANIC); 4 ♀♀, Lookout on loop road, Kalbarri, 27.33°S, 114.26°E, 25 October 1992, E.D. Edwards and E.S. Nielsen (ANIC); 1 ♂, Millstream, 17–20 April 1972, N.R. Mitchell (ANIC); 2 ♀♀, LTR1 Barrow Island, WGS84: 337551, -7699293, 15 March 2006, Callan and Graham LTR1 (WAM); 1 ♂, John Forrest

NP, 8 km E of Midland, 16 November 1978, Neboiss (MV); 1 ♂, Onslow, Nov 1955, E.T. Smith (MV); 1 ♂, CALM site 25/1, Synnot Ck, 16.31°S, 125.16°E, 17–20 June 1988, T.A. Weir; LT, open forest (SAM); 1 ♀, 4 ♂♂, Yalgarup NP, White Hill Rd, 32°44.704'S, 115°39.360'E, 3 November 2011, R. Kittel and L. Krieger, sweeping *Acacia* and *Eucalyptus* among others (in ethanol) (WAM SF008307–15, 20–23); 1 ♂, Cadjeput Rockhole 21°31'55"S, 119°08'57"E, 29 September 1988, B.P. Hanich *et al.*, LT (UV) at night 6:00–8.45 pm (in ethanol) (WAM 82903); 1 ♂, 11 km SE Eurardy HS, 27°39'17"S, 114°43'25"E, 25 October 2000, T.F. Houston and O. Mueller, TFH 1056–1 on flowers of *Personia bowgada* (Proteaceae) (WAM 82873); 1 ♂, Billy Well Creek, 20 km NE Mt Sandiman HS, 11–13 May 1981, B. Hanich and T.F. Houston, LT at night (WAM 82783); 2 ♂♂, Eneabba, 29°49'S, 115°16'E, 26 December 1983, R.P. McMillan, LT (WAM 82814, 82815); 1 ♀, 10 km ESE Meedo HS, 25°40'S, 114°37'E, 7–8 May 1981, B. Hanich and T.F. Houston, LT at night (WAM 82804); 2 ♂♂, LTR6 Barrow Island, WGS84: 341230, –7707278, 6 May 2006, Callan and Graham (in ethanol) (ANIC); 2 ♀♀, LTR6 Barrow Island, WGS84: 328389, –7699655, 6 May 2006, Callan and Graham (in ethanol) (ANIC); 2 ♀♀, LTR4 Barrow Island, WGS84: 334071, –7691818, 6 May 2006, Callan and Graham (in ethanol) (ANIC); 1 ♀, LTR3 Barrow Island, WGS84: 338064, –769438, 6 May 2006, Callan and Graham (in ethanol) (ANIC); 1 ♂, LTR5 Barrow Island, WGS84: 332894, –7697016, 6 May 2006, Callan and Graham (in ethanol) (ANIC); 1 ♂, LTR6 SUC Barrow Island, WGS 84: 341230, –7707278, 6 May 2006, Callan and Graham (ANIC); 1 ♂, LTR5 SUC Barrow Island, WGS 84: 332894, –7697016, 6 May 2006, Callan and Graham (ANIC); 1 ♀, NO4 SUC Barrow Island, WGS 84: 340413, –7707558, 06 May 2006, Callan and Graham (ANIC); 1 ♀, NW Coastal Highway 5 ml S of Karratha, 17 February 1973, E.M. Exley (QM); 1 ♀, 7 ml S of Port Hedland, 22 February 1973, E.M. Exley, on *Acacia* sp (QM); 1 ♀, Karratha, 17 February 1973, E.M. Exley, on *Eucalyptus* sp. (QM).

Biology

The type for this species was reared from *Etiella behrii* Zeller (Pyralidae). Some specimens have been reared from the 'Currajong Bag shelter moth' (*Dichocrocis clytusalis* Walker), but due to the poor condition of the specimens it is difficult to determine whether they actually belong to a separate species or not. One specimen was reared from an unknown host on Dundas Mahogany (*Eucalyptus brockwayi* C.A. Gardner) Myrtaceae, and additional specimens have been collected from true mulga (*Acacia aneura* F.Muell. ex Benth.), Gundabluiie (*Acacia victoriae* Benth.) Fabaceae, toothbrush plant (*Grevillea* sp.), silver needlewood (*Hakea leucoptera* R. Br.), Snottygobbles (*Personia bowgada* P.H. Weston) Proteaceae, tea tree (*Leptospermum* sp.) Myrtaceae and American pepper (*Schinus molle* L.) Anacardiaceae, and in a wheat crop.

Distribution

Previously only recorded from South Australia, New South Wales and Northern Territory (Zettel 1988a), but additional material shows this species to be distributed widely across mainland Australia with new records from Queensland, Victoria, and Western Australia. This species was also found at Bon Bon Station, Hiltaba Station and Witchelina Station (Figure 18).

CO1 sequence

Genbank accession numbers for this species are KJ438611 – KJ438622.

***Phanerotoma bonbonensis* sp. nov.**
(Figures 9a–e, 16)

Description

Body measurements. Length of body 3.6–4.7 mm females, 3.3–4.2 mm males; ratio of antenna to body 0.7–0.87; ratio of length of fore wing to body 0.8; ratio of length of metasoma to mesosoma 1.1–1.3.

Head. Ratio of length of third antennomere to fourth 1.1; ratio of length of third, fourth, and penultimate antennomere 3.3–4.0, 3.2–3.5, 2.4–2.7 in females and males and terminal antennomere 2.0–3.0 in females, 4.5–5.0 in males times their width, respectively; ratio of length of eye in dorsal view to length of temple 3.0–4.0; ratio of width of face in anterior view to its height 1.6–1.8; ratio of width of clypeus to its height 1.5; clypeus with two teeth; ratio of length of malar space to base of mandible 0.5; face punctate; vertex and frons rugose; ratio posterior ocelli:LOL:POL:OOL 1.0:0.8:0.8–0.9:1.5–2.5.

Mesosoma. Middle lobe of mesoscutum rugose; notauli absent; mesoscutellum fine punctate; mesopleuron punctate; precoxal sulcus present; ratio of height of mesosoma to its length 1.7–1.9; propodeal tubercles absent in females, present in males; blister on mid tibia present; ratio of length of hind tibia to hind tarsus 1.0–1.2; ratio of length of posterior spur to length of basitarsus 0.3–0.5; ratio of hind coxa, hind femur, hind tibia and hind tarsus 2.0–2.3, 3.3–3.8, 4.0–5.0 and 13.0–17.0 times their width, respectively; fore wing: 2-R1 absent; ratio of length of 1-R1 to length of pterostigma 1.1–1.2; ratio of width of pterostigma to its length 2.7–3.3; ratio r:3-SR:SR-1:r-m 1.0:1.0–1.3:5.0–8.0:0.9–1.3; 1-SR+M emanating from base of parastigma; 2-SR+M interstitial or postfurcal.

Metasoma. Shape of metasoma oval from dorsal view; ratio of width of metasoma to its length 0.5–0.6; carapace flat in lateral view; ratio of keel to length of metasoma 0.16–0.21; first and second tergite longitudinal strigose; third tergite rugose; posterior end of carapace deeply indented; ratio of the three metasomal tergites 1.0:0.9:1.4–1.5.

Colour. Head orange, face and temple somewhat darker; metasoma dark reddish brown; lateral lobes of mesoscutum orange; wing venation, parastigma, and pterostigma brown; carapace darker around the edges; third tergite completely dark.

Diagnosis

One of only four species of *Phanerotoma* that have an indented carapace. It differs from the other species by the ratio of metasoma to mesosoma being less or equal to 1 (*P. bonbonensis*: more than 1), ratio of length to width of antennomeres being less than 3.5 (*P. filicornis* more than 4), and its dark colour (*P. australiensis* is yellow brown with black teeth).

Specimens examined

Holotype, Australia (South Australia): 1 ♀, “26 October 2010, Bon Bon Station 30° 25'22”S, 135°28'41”E, D.A. Young, manual; Bush Blitz survey SM177” (SAM).

Paratypes, Australia (South Australia): 1 ♀, Bon Bon Stn, 30°24'41”S, 135°26'52”E, 25 October 2010, S. Mantel, Bush Blitz survey SM134 in swale with *Rutidosia*

helichrysoides, LT (SAM); 1 ♂, Bon Bon Stn, 30°25'22"S, 135°28'41"E, 24 October 2010, R. Kittel, Bush Blitz survey RK093, LT (SAM); 9 ♀♀, 5 ♂♂, Bon Bon Stn, 30°25'29"S, 135°28'41"E, 26 October 2010, S. Mantel; Bush Blitz survey SM164 under *Acacia aneura*, LT (SAM); 4 ♀♀, 3 ♂♂, Bon Bon Stn, 30°28'22"S, 135°28'44"E, 24 October 2010, S. Mantel, Bush Blitz survey SM131 *Acacia aneura*, LT (SAM); 1 ♀, Bon Bon Stn, 30°25'28"S, 135°28'40"E, 28 October 2010, S. Mantel, Bush Blitz survey, LT (SAM); 8 ♀♀, 3 ♂♂, Bon Bon Stn, 30°25'28"S, 135°28'40"E, 28 October 2010, S. Mantel, Bush Blitz survey, LT (SAM); 1 ♀, Bon Bon Stn, 30°25'29"S, 135°28'41"E, 26 October 2010, S. Mantel, Bush Blitz survey, *Acacia aneura*, LT (SAM). **Other material, Australia (South Australia):** 1 ♂, Bon Bon Stn, 30°28'22"S, 135°28'44"E, 24 October 2010, S. Mantel, Bush Blitz survey SM131 *Acacia aneura*, LT (SAM); 1 ♂, Bon Bon Stn, 30°25'22"S, 135°28'41"E, 24 October 2010, R. Kittel, Bush Blitz survey RK093, LT (SAM); **Northern Territory:** 1 ♀, Ewaninga Rock, Engravings, 23.59°S, 133.56°E, 27 November 1987, J. Archibald, MV light (MAGNT).

Biology

Collected in the proximity of Wrinklewort (*Rutidosis helichrysoides* Grey Wrinklewort) Asteraceae or directly from true mulga (*Acacia aneura* Benth.) Fabaceae.

Etymology

Named after the type locality, Bon Bon Station.

Distribution

South Australia (Bon Bon Station) and Northern Territory (Figure 16).

CO1 sequence

Genbank accession numbers for this species are KJ438599 – KJ438602.

Phanerotoma bushblitz sp. nov. (Figures 10a–d, 16)

Description

Body measurements. Length of body 3.25–3.5 mm females, 3.0 mm males; ratio of antenna to body 0.8–0.9; ratio of length of fore wing to body 0.83–0.86; ratio of length of metasoma to mesosoma 0.8 females, 1.0 males.

Head. Ratio of length of third antennomere to fourth 1.0–1.1; ratio of length of third, fourth, penultimate and terminal antennomere 4.6, 4.2, 2.0 and 2.5 in females, 5.0, 5.0, 4.0 and 5.0 in males times their width, respectively; ratio of length of eye in dorsal view to length of temple 2.9–3.3; ratio of width of face in anterior view to its height 1.7; ratio of width of clypeus to its height 1.4–1.5; clypeus with two teeth; ratio of length of malar space to base of mandible 0.64; face, vertex and frons rugose; ratio posterior ocelli:LOL:POL:OOL 1.0:0.8:0.8:1.8–2.7.

Mesosoma. Middle lobe of mesoscutum rugose; notauli weakly present; mesoscutellum fine punctate; mesopleuron fine punctate; precoxal sulcus weakly present; ratio of height of mesosoma to its length 2.1 in females, 1.8 in males; propodeal tubercles absent; blister on mid tibia present; ratio of length of hind tibia to hind tarsus 1.0; ratio of length of posterior spur to length of basal tarsus 0.38–0.42; ratio hind coxa, hind femur, hind tibia and hind tarsus 2.1–2.3, 3.0–4.0, 4.5–4.8 and 15.0–16.0 their width, respectively; fore wing: 2-R1 present; ratio of length of 2-R1 to length of 1-R1 10.0–11.0; ratio of length of 1-R1 to length of pterostigma 1.0–1.2; ratio of width of pterostigma to its length 2.9–3.7; ratio r:3-SR:SR-1:r-m 1.0:2.6–3.0:12.0–15.0:2.0–2.2; 1-SR+M emanating from parastigma; 2-SR+M antefurcal or interstitial.

Metasoma. Shape of metasoma oval in dorsal view, ratio of width of metasoma to its length 0.6–0.7; carapace flat in lateral view; ratio of keel to length of metasoma 0.17–0.21; carapace rugose; sutures straight; posterior end of carapace indented; ratio of the three metasomal tergites 1.0:1.0:1.2–1.5.

Colour. Scape, pedicel and head orange; antenna brown; interocellar area dark; mesosoma reddish brown; fore and mid legs yellow; hind leg with brown tibia and femur; first two metasomal tergites beige; second tergite on the margin with a dark stripe; third tergite brown; wings golden infused; wing venation, parastigma and pterostigma brown.

Diagnosis

The wing venation 2-SR+M antefurcal makes this species unique among all Australian *Phanerotoma*.

Specimens examined

Holotype, Australia (South Australia): 1 ♀, "28 October 2010, Bon Bon Station 30° 25'28"S, 135°28'40"E, S. Mantel, at light; Bush Blitz survey SM178" (SAM). **Paratypes, Australia (South Australia):** 1 ♀, 1 ♂, as holotype (SAM); 1 ♀, Bon Bon Stn, 30°25.48'S, 135°28.69'E, 24–30 October 2010, G. Taylor, LT, Bush Blitz survey (SAM). **Other material, Australia (South Australia):** 1 ♀, Bon Bon Stn, 30°25'28"S, 135°28'39"E, 28 October 2010, R. Kittel, Bush Blitz survey RK133, LT (SAM).

Biology

Unknown.

Etymology

Species names refers to the Bush Blitz programme, during which this species was discovered.

Distribution

South Australia (Bon Bon Station; [Figure 16](#)).

CO1 sequence

Genbank accession numbers for this species are KJ438627 and KJ438628.

***Phanerotoma decticauda* Zettel, 1988a**
(Figures 11a–e, 18)

Phanerotoma decticauda Zettel, 1988a: 222. Holotype: NMNH (examined). Type locality: Mt Molly, Queensland.

Redescription

Body measurements. Length of body 2.5–5.55 mm females, 2.55–4.3 males; ratio of antenna to body 0.7–0.9; ratio of length of fore wing to body 0.8–0.9; ratio of length of metasoma to mesosoma 1.1–1.3.

Head. Ratio of length of third antennomere to fourth 1.0–1.4; ratio of length of third, fourth, penultimate and terminal antennomere 3.0–3.8, 2.7–3.3, 1.3–3 and 1.7–2.8 in females, 3.2–3.8, 2.8–3.3, 2.0–2.5 and 3.3–4.2 in males times their width, respectively; ratio of length of eye in dorsal view to length of temple 2.6–3.3; ratio of width of face in anterior view to its height 1.7–1.8; ratio of width of clypeus to its height 1.4–1.7; clypeus with two teeth; ratio of length malar space to base of mandible 0.7–1.0; face, vertex and frons punctate; ratio posterior ocelli:LOL:POL:OOL 1.0:0.8–0.9:0.7–0.8:1.9–2.3.

Mesosoma. Middle lobe of mesoscutum punctate; notauli absent; mesoscutellum punctate; mesopleuron punctate; precoxal sulcus weakly present; ratio of height of mesosoma to its length 1.7–2.0; propodeal tubercles absent; blister on mid tibia present; ratio of length of hind tibia to hind tarsus 1.0; ratio length of posterior spur to length of basal tarsus 0.33–0.47; ratio hind coxa, hind femur, hind tibia and hind tarsus 1.9–2.3, 3.5–5.0, 4.0–5.0 and 13.0–20.0 times their width, respectively; fore wing: 2-R1 absent; ratio of length of 1-R1 to length of pterostigma 1.0–1.2; ratio of width of pterostigma to its length 2.7–4; ratio r:3-SR:SR-1:r-m 1.0:1.0–1.8:5.0–9.0:1.1–1.7; 1-SR+M emanating from parastigma; 2-SR+M interstitial or postfurcal.

Metasoma. Shape of metasoma oval in dorsal view; ratio of width of metasoma to its length 0.46–0.59; carapace flat in lateral view; ratio of keel to length of metasoma 0.1–0.2; carapace rugose; sutures straight; posterior end of carapace not indented, ratio of the three metasomal tergites 1.0:0.9–1.1:1.3–1.6.

Colour. Head orange; antenna brown; interocellar area dark; mesosoma mostly reddish brown; pronotum, mesoscutum and prosternum orange; first tergite beige to light brown, gradually from second tergite darker to posterior end; third tergite completely dark reddish brown.

Diagnosis

Phanerotoma decticauda can be distinguished from the other species of *Phanerotoma* by the rounded carapace, the overall dark colour and the sculpturing. Molecular evidence suggests that this species may well be a species complex (Figure 3). However, the

specimens are extremely uniform morphologically, which makes separation into potential new species very difficult. Due to the presence of cryptic species, it is not possible to assign *P. decticauda* to a specific clade/haplotype.

Specimens examined

Holotype, Australia (Queensland): ♀, *Phanerotoma decticauda* Zettel, 1988a, Mt. Molly.
Other material, Australia (New South Wales): 1 ♀, 1 ♂, Australia, N. Sydney Narrabeen; 4 January 1981, Hangey and Vojnits No 46; *Phanerotoma decticauda* det. H. Zettel 1987 (WINC); 1 ♂, Eden, Bungastree, Exotic/Native garden blend + Eucalyptus forest, 21–27 December 2005, C. Stephens, MT (WINC); 1 ♂, Grosse Riv Grosewold, 30 March 1971, G. Daniels, MVL (AMS K358147); 1 ♂, Warrumbungle NP, 23 April 1973, G. Daniels, MVL (AMS K358192); 1 ♀, Wilton Pear, 14 December 1964 location and collector unknown (ANIC); 1 ♀, Wilton Pear, 8 February 1965 location and collector unknown (ANIC); 1 ♂, Bogan Riv, 1935, J. Armstrong (QM); **Northern Territory:** 1 ♀, 3 km SSW of Katherine, 14.30°S, 132.15°E, 12 November 1979, I.D. Naumann (ANIC); 6 ♀♀, 4 ♂♂, 30 km NWbyW of Alice Springs, 23.25°S, 133.38°E, 7 October 1978, J.C. Cardale, ex ethanol (ANIC); 2 ♀♀, 2 ♂♂, 30 km NWbyW of Alice Springs, 23.32°S, 133.38°E, 7 October 1978, J.C. Cardale, ex ethanol (ANIC); 2 ♀♀, 2 ♂♂, 53 km EbyN Alice Springs, 23.35°S, 134.22°E, 6 October 1978, J.C. Cardale, ex ethanol (ANIC); 4 ♀♀, 4 ♂♂, 32 km WNW of Alice Springs, 23.36°S, 133.35°E, 8 October 1978, J.C. Cardale, ex ethanol (ANIC); 13 ♀♀, 8 ♂♂, 39 km E Alice Springs, 23.41°S, 134.15°E, 25 September 1978, J.C. Cardale, ex ethanol (ANIC); 25 ♀♀, 8 ♂♂, 39 km E Alice Springs, 23.41°S, 134.15°E, 5 October 1978, J.C. Cardale, ex ethanol (ANIC); 1 ♀, Ellery Gorge, 85 km W of Alice Springs, 23.46°S, 133.04°E, 5 November 1979, I.D. Naumann (ANIC); 1 ♀, 3 km SSW of Kathrine, 14.30°S, 132.15°E, 12 November 1979, I. D. Naumann (ANIC); 1 ♀, 2 ♂♂, Roe Creek, 12 km SWbyW Alice Springs, 23.46°S, 133.47°E, 9 October 1978, J.C. Cardale, ex ethanol (ANIC); 1 ♀, 35 km S The Granite Mine Tanami Desert, 20.51°S, 130.16°E, 29 October–2 November 1988, D.C.F. Rentz Stop T-9 (ANIC); 1 ♀, Daly River, 13.45°S, 130.42°E, 9–10 August 1980, M.B. Malipatil, MV light (MAGNT); 1 ♀, Cannon Hill via Jim Jim, 18 August 1971, T. Weir and A. Allwood (MAGNT); 1 ♀, Umbrawarra Gorge, 14.00°S, 131.38°E, 23 August 1982, J. and I. Archibald, MV light (MAGNT); 1 ♀, U.D.P. Falls, 18–19 July 1980, M.B. Malipatil, at MV light (MAGNT); 2 ♀♀, Howard River on Gunn Pt Rd, 27 September 1978, Arilwood (MAGNT); 1 ♀, Koungarra, 9 March 1973, M.S. Upton (SAM); 1 ♀, near Centre of Aust marker, 29 March 1993, J.A. Forrest and D. Hirst, LT (SAM); 3 ♀♀, Litchfield NP, around magnetic termite mounds, 14 November 1992, P.C. Dangerfield, sweeping (WINC); 1 ♀, 195 km E of Ayers Rock, on Lassiter's Hwy, 5 November 1992, P.C. Dangerfield, sweeping *Leptospermum* sp. (WINC); 1 ♀, Howard River on Gunn Pt Rd, 27 September 1978 Arilwood (QM); **Queensland:** 2 ♀♀, 1 ♂, Pistol Gap, near Byfield, 23°10'S, 150°40'E, 10 January 1970, G.A. Holloway, MVL (AMS K358107, K358108, K358121); 3 ♀♀, Gunshot Creek Telegraph Xing, 11.44°S, 142.29°E, 4–5 April 1992, M. Crossland (ANIC); 9 ♀♀, Heathlands, 11.45°S, 142.35°E, 15–26 January 1992, I.D. Naumann and T. Weir, LT (ANIC); 3 ♀♀, Heathlands, 11.45°S, 142.35°E, 17 July 1992, J.C. Cardale and P. Zborowski, LT (ANIC); 2 ♀♀, Heathlands, 11.45°S, 142.35°E, 18 November 1992, P. Zborowski and A. Calder, LT (ANIC); 1 ♀, Heathlands, 11.45°S, 142.35°E, 15 July 1992, J.C. Cardale and P. Zborowski, LT (ANIC); 1 ♀, Heathlands, 11.45°S, 142.35°E, 7 December 1992, P. Zborowski and W. Dressler, LT (ANIC); 1 ♀, Heathlands, 11.45°S, 142.35°E, 11–12 November 1993, P. Zborowski and M. Horak, LT

(ANIC); 1 ♂, Cockatoo Ck Xing, 17km NW Heathlands, 11.39°S, 142.27°E, 15–26 January 1992, I.D. Naumann and T. Weir, LT (ANIC); 1 ♀, Heathlands, 11.45°S, 142.35°E, 15–26 January 1992, I.D. Naumann and T. Weir, night collecting (ANIC); 1 ♀, Heathlands, 11.45°S, 142.35°E, 20–22 June 1992, T. Weir, LT (ANIC); 2 ♀♀, Heathlands, 11.45°S, 142.35°E, 18 August 1992, J.C. Cardale and P. Zborowski, LT (ANIC); 2 ♀♀, Heathlands dump, 11.45°S, 142.35°E, 20 November 1992, P. Zborowski and A. Calder, LT (ANIC); 1 ♀, 2 km NE Weipa, 12.37°S, 141.54°E, 14 November 1993, P. Zborowski and M. Horak, LT (ANIC); 3 ♀♀, 3 km SbyE Coen, 13.55°S, 143.11°E, 24 June 1993, I.D. Naumann and P. Zborowski, LT (ANIC); 1 ♂, Hann R 73 km NW by W of Laura, 15.12°S, 143.52°E, 27 June 1986, T. Weir and A. Calder (ANIC); 1 ♀, Hann R 73 km NW by W of Laura, 15.12°S, 143.52°E, 27 June 1986, J.C. Cardale, at MVL (ANIC); 1 ♀, 1 km N of Rounded Hill, 15.17°S, 145.13°E, 5–7 May 1981, I.D. Naumann, ex ethanol (ANIC); 2 ♀♀, 8 km W Dimbulah, 17.09°S, 145.02°E, 22 March 1988, D.C. Rentz Stop A-36, collected LT (ANIC); 1 ♀, Holts Ck 8 km N Musselbrook Camp, 18.33°S, 138.11°E, 15 May 1995, I.D. Naumann, LT (ANIC); 1 ♀, Beerburum St For., 26.58°S, 152.58°E, 28 December 1991, J.A. Berry (ANIC); 1 ♂, Barakula, via Chinchilla, 4 October 1994, F.R. Wylie, J. King and M. De Baer (ANIC); 5 ♀♀, 8 ♂♂, Noondoo, 26 February 1963, A.L. Dyce and M.D. Murray, ex ethanol (ANIC); 1 ♀, Cape York, 10.41°S, 142.32°E, 20 June 1993, I.D. Naumann and P. Zborowski (ANIC); 1 ♀, Jardine R, 11.08°S, 142.21°E, 19 October 1992, P. Zborowski and T. Weir, night collecting (ANIC); 1 ♂, 4 km NE Batavia Downs, 12.39°S, 142.42°E, 11 December 1992–17 i 1993, P. Zborowski, MT (ANIC); 1 ♀, 2 km NNE Mt Tozer, 12.44°S, 143.13°E, 3 July 1986, J.C. Cardale, at MVL (ANIC); 1 ♀, Battle Camp Range, 15.17°S, 144.44°E, 27 June 1993, I.D. Naumann and P. Zborowski, LT (ANIC); 1 ♀, Hughenden Stn, 19–21 November 1984, D.S. Gibson, LT (ANIC); 1 ♀, Mothar Mtn, 12 km SE of Gympie, 29 October 1980, A. Neboiss, MVL (ANIC); 7 ♀♀, 2 ♂♂, Lake Broadwater, 19–21 November 1985, G. and A. Daniels, LT (WINC); 1 ♀, 15 km W of Windorah, 24 September 1983, S.R. Monteith, on *Eucalyptus terminalis* (QM); 1 ♀, 8.4 km CE Chillagoe NEQ on Rd to Mareeba, 17°12'45"S, 144°33'06"E, 31 March 1992, E.C. Dahms and G. Sarnes (QM); 2 ♀♀, 9.7 km N Ellis Beach NEQ, 17 April 1987, E.C. Dahms and G. Sarnes (QM); 1 ♀, Archer River crossing, 13°25'S, 142°56'E, 5 April 1989, G. and A. Daniels, MVL (QM); 1 ♀, Brisbane, 19 February 1965, B. Cantrell (QM); 1 ♀, Lake Broadwater near Dalby, site A, 27°21'S, 151°06'E, 24 October 1986 G. and A. Daniels, MVL (QM); 1 ♀, Lake Broadwater near Dalby, site A, 27°21'S, 151°06'E, 27 September 1986, G. and A. Daniels, MVL (QM); 2 ♀♀, MEQ, Boomer Ra, site 2 180 m, 23°12'S, 149°45'E, 28–29 September 1999, S. Evans and A. Ewart, at MVL open forest 7779 (QM); 1 ♀, Border Waterhole, 15 km W of Musselbrook Resources Centre Lawn Hill NP, 18°36'44"S, 137°59'30"E, 200 m, 19 April 1995, G. Daniels and M.A. Schneider (QM); 1 ♀, Border Waterhole, 15 km W of Musselbrook Resources Centre Lawn Hill NP, 18°36'44"S, 137°59'30"E, 6 May 1995, 200 m, G. Daniels and M.A. Schneider (QM); 1 ♀, NEQ, 3 km NE Mareeba, 17°00'S, 145°24'E, 25–28 November 1997, C.J. Burwell (QM); 1 ♀, Petrie, 5 September 1965, A.E. May (QM); 1 ♂, 1 ♀, Blunder Cr., Brisbane 2–9 October 1979, A. Hook and H.E. and M.A. Evans (QM); 1 ♀, Blunder Cr., Brisbane, 30 November 1979, H.E. and M.A. Evans and A. Hook (QM); 1 ♀, Wenlock River, 13°05'S, 142°56'E, 13 December 1986. G. Daniels and M.A. Schneider, MT (QM); **South Australia:** 2 ♀♀, Arkaroola Stn, Petalinka Falls, 30.11°S, 139.17°E, 20 October 1993, E.D. Edwards and E.S. Nielsen (ANIC); 1 ♀, Arkaroola Stn, Petalinka Falls, 30.11°S, 139.17°E, 19 October 1993, E.D. Edwards and E.S. Nielsen (ANIC); 1 ♀, Brachina Creek, 31.20°S, 138.35°E, 8 November 1987, J.C. Cardale,

LT (ANIC); 1 ♀, Slippery Dip Camp, Brachina Creek, 31.20°S, 138.36°E, 9 November 1987, J.C. Cardale, LT (ANIC); 2 ♀♀, Trezona Camp, Brachina Creek, 31.20°S, 138.37°E, 7 November 1987, J.C. Cardale, LT (ANIC); 4 ♀♀, 2 ♂♂, Bucharinga Gorge c. 30 km NNW Quorn, 18 December 1985, C. Reid, ex ethanol (ANIC); 1 ♂, Dingly Dell Camp, Oraparinna Ck, 31.21°S, 138.42°E, 7 November 1987, I.D. Naumann and J.C. Cardale, ex ethanol (ANIC); 1 ♂, Lake Tungketta, 33.46°S, 135.06°E, 30 November 1992, I.D. Naumann and J.C. Cardale (ANIC); 1 ♂, 8.5 km SbyW Calperum HS, 34.05°S, 140.38°E, 2 March 1995, J.C. Cardale, LT (ANIC); 1 ♀, Brookfield CP, campsite, 34.21°S, 139.29°E, 30 March–3 April 1992, A. Calder and W. Dressler, LT (ANIC); 1 ♀, Arkaroola Stn, Petalinka Falls, 30.11°S, 139.17°E, 20 October 1993, E.D. Edwards and E.S. Nielsen (ANIC); 2 ♀♀, Trezona Camp, Brachina Creek, 31.20°S, 138.37°E, 7 November 1987, J. C. Cardale, LT (ANIC); 1 ♀, 8.5 km SWbyW Calperum HS, 34.05°S, 140.38°E, 2 March 1995, J.C. Cardale, LT (ANIC); 22 ♀♀ and 3 ♂♂, Boobook Hill Reserve, SE Kangaroo Island, various dates 2001–2011, R.V. Glatz (GKIC 3000, 12184, 5303, 2251, 3314, 2264, 9187, 2265, 8087, 3302, 1439, 10879, 3329, 2813, 8887, 3328, 10523, 8977, 12169, 12183, 4113, 2984, 2963); 1 ♀, Vivonne Bay 'Melaleuca Cottage' S Kangaroo Island, 35°58.691'S, 137°10.875'E, 4 January 2008, D.A. Young, to mercury vapour light (GKIC 12182); 1 ♂, Kimba, 4 i 1960, P. Aitken, LT (SAM); 1 ♀, 2 ♂♂, Bon Bon Stn, 30°37.56'S, 135°24.18'E, 25–28 October 2010, Bush Blitz survey 367 Malaise 9, S. Mantel, F. Colombo, R. Kittel and G. Taylor, MT amongst *Senna artemisioides*, *Acacia tetragonophila* and *A. victoriae*, Bush Blitz survey SM367, MT9 (SAM); 2 ♀♀, Flinders Ranges, Blinman Rose Cottage, 31°05'43"S, 138°40'43"E, 7 April 2011, R. Kittel and G. Taylor, LT (SAM); 1 ♀, Flinders Ranges, Blinman Rose Cottage, 31°05'43"S, 138°40'43"E, 8 April 2011, R. Kittel, LT (WINC); 1 ♂, Bon Bon Stn, 30°23.68'S, 135°26.86'E, 25 October 2010, G. Taylor, LT (mercury vapour) (WINC); 1 ♀, Hiltaba Bush Blitz, 31°02'33"S, 135°22'14"E, 17 September 2012, R. Kittel and M. Golebiowski, sweeping (SAM); 1 ♂, Hiltaba Bush Blitz, 32°09'21"S, 135°04'12"E, 19 September 2012, R. Kittel, LT (SAM); 1 ♂, Hiltaba Bush Blitz, 32°14'21"S, 135°03'52"E, 14 September 2012, R. Kittel, LT (SAM); 1 ♀, Danggali CP 2 km NW Mulga Dam, 33°11'35"S, 140°54'45"E, 23–24 March 2001, J.A. Forrest and D. Hirst, mallee, *Triodia* sp., LT (SAM); 1 ♀, Musgrave Ra NG01 10 km NNE Mt Woodroffe, 26°14'55"S, 131°47'36"E, 13 October 1994, Pitjantjatjara Lands survey, LT (SAM); 1 ♀, Blue Hills Bore, 27°7'52"S, 132°51'58"E, 22 March 1993, Pitjantjatjara Lands survey, pitfall (SAM); 1 ♀, Arkaroola Stn, Arkaroola shearers' quarters, 30°20'02"S, 139°22'07"E, 20–23 October 1999, Flinders Ra survey, LT (SAM); 1 ♂, Witchelina Stn, 30°01'20"S, 138°02'46"E, 11 October 2010, S. Mantel, LT, Bush Blitz survey SM102 (SAM); 4 ♀♀, Bon Bon Stn, 30°24'41"S, 135°26'52"E, 25 October 2010, S. Mantel, LT; Bush Blitz survey SM134 *Rutidosia heliochrysoidea* (SAM); 8 ♀♀, 6 ♂♂, Bon Bon Stn, 30°25'22"S, 135°28'41"E, 24 October 2010, R. Kittel, LT; Bush Blitz survey RK093 (SAM); 2 ♀♀, 1 ♂, Bon Bon Stn, 30°25'26"S, 135°28'39"E, 28 October 2010, R. Kittel, LT; Bush Blitz survey RK133 (SAM); 6 ♀♀, 2 ♂♂, Bon Bon Stn, 30°25'28"S, 135°28'40"E, 28 October 2010, S. Mantel, LT; Bush Blitz survey SM178 (SAM); 8 ♀♀, 5 ♂♂, Bon Bon Stn, 30°25'29"S, 135°28'41"E, 26 October 2010, S. Mantel, LT; Bush Blitz survey SM164 under *Acacia aneura* (SAM); 5 ♀♀, 12 ♂♂, Bon Bon Stn, 30°28'22"S, 135°28'44"E, 24 October 2010, S. Mantel, LT; Bush Blitz survey SM131 *Acacia aneura* (SAM); 1 ♀, 1 ♂, Bon Bon Stn, 30°25.48'S, 135°28.69'E, 26 October 2010, G. Taylor, LT (mercury vapour) (SAM); 2 ♀♀, Bon Bon Stn, 30°23'14"S, 135°26'52"E, 25 October 2010, R. Kittel, LT, Bush Blitz survey RK100, in swale with *Rutidosia heliochrysoidea* (SAM); 2 ♀♀, Bon Bon Stn, 30°25'29"S, 135°28'41"E,

27 October 2010, R. Kittel, LT (SAM); 2 ♂♂, Bon Bon Stn, 30°25'22"S, 135°28'41"E, 24 October 2010, D.A. Young, LT, Bush Blitz SM 145 *Acacia aneura* (SAM); 1 ♀, Balcanoona Ck, 23 October 1975, G.F. Gross and V. Potezny, LT (SAM); 1 ♂, Witchelina Stn, 30°00'37" S, 137°46'35"E, 20 October 2010, F. Colombo, sweeping, Bush Blitz survey FC060A (SAM); 2 ♀♀, 1 ♂, Witchelina Stn, 30°01'20"S, 138°02'46"E, 11 October 2010, D.A. Young, LT, Bush Blitz survey SM023 (SAM); 8 ♀♀, Witchelina Stn, 30°01'20"S, 138°02'46"E, 13 October 2010, R. Kittel, Bush Blitz survey RK028, LT (SAM); 1 ♀, 10 km NW Emu Junc., Great Vict. Desert, 10 October 1976, G.F. Gross and J.A. Herridge, LT (SAM); 1 ♀, 10 km NW Emu Junction Great Vict. Desert, 7 October 1976, G.F. Gross and J. Greenslade, at night (SAM); 2 ♀♀, 4.3 km NW Purple Downs HS, 30°50'48"S, 136°54'58"E, 24 April 2007, Woomera PA Survey, LT (SAM); 1 ♀, Moonaree Stn, 8.2 km ESE Monaree Hill, 31°57'09"S, 135°40'46"E, 15–20 October 2006, WHC Moonaree Survey ACR camp, open scrub, *Eucalyptus socialis*, *Casuarina*, *Acacia*, *Dodonea*, red-brown sandy-loam flat (SAM); 1 ♂, Witchelina Stn, 30°01'20"S, 138°02'46"E, 11 October 2010, R. Kittel, Bush Blitz survey, RK 007, LT (SAM); 1 ♂, Flinders Ranges: Road east of Blinman, 30°59.100'S, 139°05.865'E, 8 April 2011 R. Kittel, Sweeping *Eucalyptus* sp. (WINC); 1 ♀, Muloorina HS via Maree, near bore lake, 29°14'S, 137°55'E, 9–10 February 1989, A.D. Austin and P.C. Dangerfield, LT (WINC); 1 ♀, 'Woorabinda' Stirling Linear Park, Mt Lofty Ranges, 8 February–13 May 2001, N. Stevens, MT in remnant sclerophyll woodland (WINC); 1 ♂, Brachina Gorge, Flinders Ranges, 31°30'S, 139°05'E, 16 February 1989, A.D. Austin and P.C. Dangerfield (WINC); 1 ♀, Belair NP Gate 11, 16–23 December 2007, J.T. Jennings, MT (WINC); 1 ♀, Murray Bridge, November 1985–January 1986, J. Hardy, LT (WINC); **Victoria:** 1 ♀, 12 km NNW Omeo, 28 February 1980, I.D. Naumann and J.C. Cardale (ANIC); 1 ♀, Ned's Corner, Bush Blitz survey, 1 December 2011, Lillywhite, MT, BBNC site 14 (MV); 1 ♀, Wyperfield NP, 25 mi N Rainbow, 18–23 February 1970, H.E. Evans and R.W. Matthews, MT (NMNH); **Western Australia:** 1 ♀, 14 km ENE of Carnavon, 24.50°S, 113.46°E, 21 October 1992, E.D. Edwards and E.S. Nielson (ANIC); 4 ♀♀, Kanjini NP Mt Bruce Rd Hamersley, 25 April–14 May 2003, C. Lambkin and T. Weir, MT, dry rocky creekbed 757 m *Eucalyptus* grassland ANIC 2056 22°34'14"S 118°17'52"E (ANIC); 1 ♀, Kimbolton March–April 1983, C. Sambell, ex ethanol (ANIC); 1 ♀, Porongurup NP, 34.40°S, 117.52°E, 16 April 1983, E.S. Nielsen and E.D. Edwards (ANIC); 1 ♂, 63 km EbyN of Norseman, 32.04°S, 122.25°E, 6 May 1983, E.D. Edwards and E.S. Nielson (ANIC); 1 ♀, 1 ♂, Loch McNess, Yanchep NP, 31.33°S, 115.15°E, 20 March 1996, E.D. Edwards and E.S. Nielson (ANIC); 1 ♀, 1 km S of Leeman, 29.58°S, 114.59°E, 30 October 1992, E.D. Edwards and E.S. Nielson (ANIC); 1 ♂, Onslow, November 1955, E.T. Smith (MV); 2 ♀♀, 2.5 km N of Mt Linden, 29.19°S, 122.25°E, 17–23 March 1979, T.F. Houston *et al.* 259–1 (WAM 82792, 82793); 2 ♀♀, 1 unknown sex, 37 km SW Youanmi, 28.45°S, 118.31°E, 13–14 March 1982, T.F. Houston and B. Hanich 437–8; LT at night (WAM 82808, 82809, 82810); 1 ♀, 7.5 km NNW of Mt Linden, 29.19°S, 122.25°E, 17–23 March 1979, T.F. Houston *et al.* 259–1 (WAM 82794); 1 ♂, 9.8 km SSE of Mt Linden, 29.19°S, 122.25°E, 17–23 March 1979, T.F. Houston *et al.* 259–1 (WAM 82799); 2 ♀♀, 1 ♂, Buningonia Spring (Well), 31°26'S, 123°33'E, 18–25 November 1978, T.F. Houston *et al.* 225/10 (WAM 82790, 82789, 82786); 1 ♀, Dyandra State Forest 12.8 km SE of Cuballing, 4 April 1984, R.P. McMillan (WAM 82812); 1 ♀, Koonong Pool Ashburton R 11 km E Ashburton Downs HS, December 1982, H. Esler (WAM 82879); 1 ♀, 11 km ENE Anketell HS, 28.00°S, 118.57°E, 15–16 March 1982, T.F. Houston and B. Hanich 439–8 (WAM 82784); 1 ♀, 12.5 km SSE of Banjiwarn HS, 27°42'S, 121°37'E, 22–28 February 1980,

WAM survey site BWR2 T.F. Houston *et al.* 316–10, LT at night (WAM 82803); 1 ♀, 7.5 km E of Yuinmery HS, 28°34'S, 118°01'E, 11–19 February 1980, WAM survey site yyeamb T.F. Houston *et al.* 310–1, LT at night (WAM 82802); 1 ♀, ca 9 km SE of Yuinmery HS, 28°34'S, 119°01'E, 25 March 1980, T.F. Houston *et al.* 262, LT at night (WAM 82801); 2 ♀♀, Kings Park (Perth), 16 April 1997, T.F. Houston 930–1, at MVL (WAM 82871, 82872).

Biology

Two specimens were reared from 'Wilton Pear' (*Pyrus* sp. probably in New South Wales). Additional specimens were collected from true mulga (*Acacia aneura* F.Muell. ex Benth.), coast golden wattle (*Acacia leiophylla* Myrtaceae), and Wrinklewort (*Rutidosia helichrysoides* Grey Wrinklewort) Asteraceae.

Distribution

Previously known from New South Wales, Queensland, and South Australia (Zettel 1988a), this study reveals a much wider distribution for the species including Northern Territory, Victoria, and Western Australia. It was also found at Bon Bon Station, Hiltaba Station and Witchelina Station (Figure 17).

CO1 sequence

Genbank accession numbers for this species are KJ438574–KJ438592, KJ438640.

***Phanerotoma lutea* sp. nov.**

(Figures 12a–d, 16)

Description

Body measurements. Length of body 3.7–5.45 mm females, 3.65–5.1 mm males; ratio of antenna to body 0.8 in females, 1.0 in males; ratio of length of fore wing to body 0.8; ratio of length of metasoma to mesosoma 1.1.

Head. Ratio of length of third antennomere to fourth 1.0; length of third, fourth, penultimate and terminal antennomere 3.3–4.3, 3.2–4.7, 1.2–2.7 and 1.5–2.8 times their width, respectively; ratio of length of eye in dorsal view to length of temple 1.7–2.1; ratio of width of face in anterior view to its height 1.9–2.3; ratio of width of clypeus to its height 1.7–2.2; clypeus with three teeth; ratio of length of malar space to base of mandible 0.4–0.9; face, vertex and frons traverse strigose; ratio posterior ocelli:LOL:POL:OOL 1.0:0.6:0.6:2.0 females 1.0:0.7:0.7:1.9 males.

Mesosoma. Middle lobe of mesoscutum rugose; notauli weakly present; mesoscutellum rugose; mesopleuron rugose; precoxal sulcus present; ratio of height of mesosoma to its length 1.6–1.7; propodeal tubercles present; blister on mid tibia present; ratio of length of hind tibia to hind tarsus 0.9–1.1; ratio of length of posterior spur to length of basal tarsus 0.35–0.48; ratio hind coxa, hind femur, hind tibia and hind tarsus 2.2, 3.0–5.0, 4.0–5.0 and 14.0–23.0 times their width, respectively; fore wing: 2-R1 absent; ratio of length of 1-R1 to length of pterostigma 1.3; ratio of width of pterostigma to its length 2.4–3.3;

ratio r:3-SR:SR-1:r-m 1.0:4.0–6.0:13.0–16.0:1.6–2.2; 1-SR+M emanating from parastigma; 2-SR+M interstitial, antefurcal or postfurcal.

Metasoma. Shape of metasoma oval in dorsal view; ratio of width of metasoma to its length 0.55–0.6; carapace broadens to posterior end in lateral view; ratio of keel to length of metasoma 0.19–0.21; first and second tergite longitudinal strigose, third tergite rugose; curvature of second suture slightly towards anterior end; ratio of the three metasomal tergites 1.0:0.7–0.9:1.2–1.3.

Colour. Overall orange; interocellar area dark; wing venation, parastigma and pterostigma brown.

Diagnosis

Phanerotoma lutea forms along with *P. behriae* a species complex, where species have three teeth on the clypeus, a short r vein and a long 3-SR vein. Only these two species represent the complex in Australia. Hence, *P. lutea* can be distinguished from *P. behriae* by its overall yellow colour and from all other species by the above characters.

Specimens examined

Holotype, Australia (South Australia): 1 ♀, "27 October 2010, Bon Bon Station 30°25'29"S, 135°28'41"E, R. Kittel, at light; Bush Blitz survey RK125" (SAM). **Paratypes, Australia (Queensland):** 2 ♀♀, 2 km N Rokeby, 13.40°S, 142.40°E, 12 September 1993, P. Zborowski and S. Shattuck, LT (ANIC); 1 ♀, Woobadda River, 15.58°S, 145.22°E, 25 August 1992, J.C. Cardale and P. Zborowski, LT (ANIC); 1 ♀, Rockhampton, 24 km S, 23°37'S, 150°06'E, 28 November 1990, T. Gush, on flowering tree, Tom Gush Collection 2567 (ANIC); 1 ♀, 11 km WbyN Bald Hill, Mcllwraith Ra., 500 m, 13.44°S, 143.20°E, 26 June–13 July 1989, I.D. Naumann, LT, search party campsite (ANIC). **Other material, Australia (New South Wales):** 1 ♂, North Beach, Bellinger R, 21 February 1965, D.K. McAlpine and R. Lossin (AMS 358175); 1 ♀, Pilliga Scrub, via Coonabarabran, 15 December 1976, I.D. Naumann; beating and sweeping, dry sclerophyll forest (QM); **Northern Territory:** 1 ♀, Darwin, 17 June 1962, R. V. Southcoll (SAM); **Queensland:** 1 ♀, 1 ♂, 10 km SSW Cape York, 10.46°S, 142.30°E, 15 October 1992, P. Zborowski and T. Weir, LT, rainforest (ANIC); 1 ♂, Captain Billy Landing, 11.38°S, 142.51°E, 21 January 1992, I.D. Naumann and T.A. Weir (ANIC); 1 ♀, Cockatoo Ck Xing 17 km NW Heathlands, 11.39°S, 142.27°E, 15–26 January 1992, I.D. Naumann and T. Weir, LT (ANIC); 1 ♀, 14 km ENE Heathlands, 11.41°S, 142.42°E, 12 November–14 December 1993, P. Zborowski, MT (ANIC); 1 ♀, 14 km ENE Heathlands, 11.41°S, 142.42°E, 21 November 1992, P. Zborowski and A. Calder, LT rainforest (ANIC); 1 ♂, Heathlands, 11.45°S, 142.35°E, 15–26 January 1992, I.D. Naumann and T. Weir, LT (ANIC); 1 ♀, Batavia Downs, 12.41°S, 142.41°E, 22–23 August 1992, J.C. Cardale and P. Zborowski (ANIC); 1 ♀, 9 km NNW Lockhart River, 12.43°S, 143.18°E, 25 October 1992, P. Zborowski and T. Weir, LT rainforest (ANIC); 1 ♀, 2 km N Rokeby, 13.40°S, 142.40°E, 12 September 1993, P. Zborowski and S. Shattuck, LT (ANIC); 1 ♀, WbyN Bald Hill Mcllwraith Ra 500 m, 13.44°S, 143.20°E, 11 km, 26 June–13 July 1989, I.D. Naumann, LT search party campsite (ANIC); 1 ♀, Mt White, 13.58°S, 143.11°E, 12 January 1994, P. Zborowski and E.D. Edwards, LT (ANIC); 1 ♂, Turnoff to Captain Billy Landing, 11.41°S, 142.42°E, 20 August 1992, J.C. Cardale and P. Zborowski, LT (ANIC); 1 ♀, Lizard Island, NNE of Cooktown, N. Qld, 16 November 1974, M.S. and B.J. Moulds (AMS K

358191); 1 ♀, Tonga 20 July 57 D.J.P. (QM); 1 ♂, East Claudie Riv, 1 July 1982, M.A. Schneider and G. Daniels, MVL (QM); 1 ♀, Lam. NP 25 May 1962 J. Cribb (QM); 1 ♀, Gatton 15 December 1952 Prasai (QM); 1 ♂, ex *Cissus antarctica* (QM); 1 ♂, NEQ, 'Kingfisher Park' 1 km N Julatten, 16°36'S, 145°20'E, 29 September 1997 C.J. Burwell (QM); 1 ♂, NEQ, Wallaman Falls Rd Junction, 650 m, 18°39'S, 145°52'E, 5–12 February 1996, Monteith, Flight intercept, RF (QM); **South Australia:** 1 ♀, Kangaroo Island, Flinders Chase NP, West Bay, coastal Mallee, January 1986, A.D. Austin (WINC); 1 ♀, 9.6 km N of Hawker, 29 February 1972, E.G. Matthews, LT (SAM); 1 ♂, Marree, 3 December 1964, P. Aitken and W. Head, LT (SAM); 4 ♂♂, 11 km SW by W Calperum HS, 34.06°S, 140.37°E, 28 February 1995, Cardale, Colloff, Pullen, LT; Calperum Station/Bookmark Biosphere Reserve Invertebrate Survey (ANIC).

Biology

One specimen reared from Kangaroo Treebine (*Cissus antarctica*) Vitaceae.

Etymology

The name 'lutea' refers to the overall yellow appearance of the species.

Distribution

New South Wales, Queensland, and South Australia (including Bon Bon Station; Figure 16).

CO1 sequence

Genbank accession number for this species is KJ438623.

Phanerotoma nigriscapulata sp. nov.

(Figures 13a–d, 16)

Description

Body measurements. Length of body 2.15–4.0 mm females, 2.4–4.1 mm males; ratio of antenna to body 0.6 in females, 0.76–0.86 in males; ratio of length of fore wing to body 0.9 in females, 0.8 in males; ratio of length of metasoma to mesosoma 1.0–1.2.

Head. Ratio of length of third antennomere to fourth 1.0–1.4; ratio of length of third, fourth, penultimate and terminal antennomere 2.5–3.6, 2.0–3.2, 1.3–2.0 and 2.0–2.7 times their width, respectively; ratio of length of eye in dorsal view to length of temple 2.5–2.7; ratio of width of face in anterior view to its height 1.6–1.8; ratio of width of clypeus to its height 1.5–1.9; clypeus with two teeth; ratio of length of malar space to base of mandible 0.8–1.4 in females, 0.5–0.8 in males; face, vertex and frons rugose; ratio posterior ocelli:LOL:POL:OOL 1.0:0.6–1.3:0.6–1.2:2.0–3.0.

Mesosoma. Middle lobe of mesoscutum rugose; notauli absent; mesoscutellum rugose; mesopleuron rugose; precoxal sulcus present; ratio of height of mesosoma to its length 1.8–2.0; propodeal tubercles present but small; blister on mid tibia present; ratio of length of hind tibia to hind tarsus 1.0–1.1; ratio of length of posterior spur to length of basal tarsus 0.4–0.5; ratio of hind coxa, hind femur, hind tibia and hind tarsus 2.4–2.5,

3.3–4.4, 4.0–5.0 and 13.0–18.0 times their width, respectively; fore wing: 2-R1 absent; ratio of length of 1-R1 to length of pterostigma 1.0–1.2; ratio of width of pterostigma to its length 3.0–3.6; ratio r:3-SR:SR-1:r-m 1.0:0.6–1.4:5.5:0.8–1.3; 1-SR+M emanating from base of parastigma; 2-SR+M interstitial or postfurcal.

Metasoma. Shape of metasoma oval in dorsal view; ratio of width of metasoma to its length 0.6; carapace flat in lateral view; ratio of keel to length of metasoma 0.15–0.2; carapace longitudinal sculptured; both sutures straight; posterior end of carapace not indented; ratio of the three metasomal tergites 1.0:0.9–1.0:1.2.

Colour. Head orange with reddish brown face and temple; antenna brown; interocellar area dark; metasoma dark reddish brown; with middle lobe of mesoscutum dark orange; first tergite of carapace beige, second and third gradually darker, reddish brown; wing venation, parastigma and pterostigma brown.

Diagnosis

This species differs from all other species by not having an indented carapace on the posterior end, in its sculpturing, and by having a unique colour pattern where the scapula is black and the mesoscutum is light brown forming an 'M'.

Specimens examined

Holotype, Australia (South Australia): 1 ♀, "27 October 2010, Bon Bon Station, 30° 25'29"S, 135°28'41"E, R. Kittel, LT" (SAM). **Paratypes, Australia (Northern Territory):** 1 ♂, 30 km NWbyW of Alice Springs, 23.35°S, 133.38°E, 7 October 1978, J.C. Cardale, ex ethanol (ANIC); 1 ♀, Mt Weht, Soudan, Narkly Tableland, 17 August 1960, E.M. Exley (QM); **South Australia:** 1 ♀, Waite Campus, Arboretum, UofA, Urrbrae, 1–20 March 2002, N. Stevens (WINC); 1 ♀, Bon Bon Stn, 30°25'29"S, 135°28'41"E, 26 October 2010, S. Mantel, LT; Bush Blitz survey SM164 under *Acacia aneura* (SAM); **Western Australia:** 1 ♀, Capel, Bussell Hwy, 33°33.323'S, 115°33.073'E, 31 October 2011, G. Taylor (WINC); 1 ♀, 60 km W Esperance, South Coast Hwy, Lort River Bridge, 33°44.630'S, 121°15.375'E, 6 November 2011, G. Taylor, Swept *Acacia* sp. (WINC); 2 ♀♀, 5 km SE of Tambellup, Toolbrunup Rd, 34°04.301'S, 117°40.789'E, 10 November 2011, R. Kittel and L. Krieger sweeping (WAM SF 008307–11). **Other material, Australia (Australian Capital Territory):** 1 ♂, Canberra, 15 January 1979, N.J. Short, MT (ANIC); **New South Wales:** 1 ♂, 5 mi S Mendooran, 17 March 1972, G. Daniels, MVL (AMS K358071); 2 ♂♂, Nyngan dist, 1–9 February 1960, T.E. Woodward (QM); 1 ♀, Rainforest Iluka Clarence R, 24 November 1970, D.K. McAlpine, MVL (AMS K351901); **Northern Territory:** 6 ♀♀, 30 km NWbyW of Alice Springs, 23.32S, 133.38E, 7 October 1978, J.C. Cardale, ex ethanol (ANIC); 1 ♀, 35 km S The Granite Mine Tanami Desert, 20.51S, 130.16°E, 29 October–2 November 1988, D.C.F. Rentz Stop T-9 (ANIC); 1 ♀, East Point, 13 May 1981, D.P.A. Sands, ex *Hibiscus tilaceus* (ANIC); 1 ♂, Yuendumu, February 1968 (ANIC); **Queensland:** 1 ♀, Cockatoo Ck Xing, 17 km NW Heathlands, 11.39°S, 142.27°E, 15–26 January 1992, I.D. Naumann and T. Weir, LT (ANIC); 1 ♀, Bertie Ck Xing, 12 km SW Heathlands, 11.50°S, 142.30°E, 15–26 January 1992, I.D. Naumann and T. Weir, LT (ANIC); 1 ♀, Batavia Downs, 12.41°S, 142.41°E, 22–23 July 1992, J.C. Cardale and P. Zborowski, LT (ANIC); 1 ♀, Wenlock R Crossing, Portland Roads Road, 13.06°S, 142.56°E, 17 July 1986, J.C. Cardale,

at MVL (ANIC); 1 ♀, 1 km N of Rounded Hill, 15.17°S, 145.13°E, 5–7 May 1981, I.D. Naumann, ex ethanol (ANIC); 1 ♀, 1 ♂, 8 km SEbyE Musselbrook Camp, 18.38°S, 138.11°E, 11 May 1995, I.D. Naumann, LT (ANIC); 3 ♀♀, 10 km SE Musselbrook Camp, 18.39°S, 138.12°E, 13 May 1995, I.D. Naumann, LT (ANIC); 1 ♂, 16 km SEE Musselbrook Camp, 18.44°S, 138.12°E, 18 May 1995, I.D. Naumann, LT (ANIC); 1 ♂, Barakula, via Chinchilla, 4 October 1994, F.R. Wylie, J. King, M. De Baer (ANIC); 1 ♂, Noonadoo, 26 February 1963, A.L. Dyce and M.D. Murray, ex ethanol (ANIC); 1 ♀, Mudjimba Beach, E of Nambour, 29 November 1985, G. Cassis (ANIC); 1 ♀, 1 km N of Rounded Hill, 15.17°S, 145.13°E, 5–7 May 1981, I.D. Naumann, ex ethanol (ANIC); 2 ♂♂, Corallie R. Bruce Highway, NW Fladstone N. Qld, 23 January 1970, G.A. Holloway, MVL (AMS K358159); 1 ♀, Lake Broadwater near Dalby, site A, 27°21'S, 151°06'E, 24 October 1986, G. and A. Daniels, MVL (QM); 1 ♀, Eurimbula Ck., via Round Hill Head, 3–5 May 1975, I.D. Naumann; sweeping low vegetation, open forest/subtropical rainforest boundary (QM); **South Australia:** 1 ♀, Brookfield CP, 34.19°S, 139.31°E, 24 November 1992, I.D. Naumann, J.C. Cardale (ANIC); 1 ♀, Brookfield CP, 34.21°S, 139.29°E, 17–20 February 1992, J.C. Cardale, LT (ANIC); 1 ♂, Brookfield CP, 34.21°S, 139.29°E, Campsite, 30 March–3 April 1992, A. Calder and W. Dressler, LT (ANIC); 1 ♂, 5 km NNE Prices Bore, 30°20'41"S, 136°11'46"E, 18 April 2007, Woomera PA Survey, LT (SAM); 1 ♀, Belair NP, Gate 11, 1–8 March 2008, J.T. Jennings, MT (WINC); 1 ♀, Flinders ranges, Brachina Gorge, 31°19.954'S, 138°35.916'E, 5 April 2011, G. Taylor, *Acacia lingulata* (WINC); 1 ♂, Flinders ranges, Brachina Gorge, 31°20.630'S, 138°33.635'E, 5 April 2011, R. Kittel and G. Taylor, Sweeping *Eucalyptus socialis* (WINC); **Tasmania:** 2 ♀♀, Cambridge, 21 February 1967, A. Neboiss (MV); **Victoria:** 1 ♀, Abbeyard, 27 January 1960, A. Neboiss (MV); 1 ♀, Latrobe R. Survey St 8 U7/s, 17 February 1973, R. Morwell, LT (MV); 2 ♀♀, Meredith, 12–13 February 1959, A. Neboiss (MV); 1 ♀, Meredith, 13 February 1959, A. Neboiss (MV); 1 ♀, Myrtleford, 23 June 1973, A. Neboiss, *Eucalyptus* spp., MVL-trap (MV); 1 ♀, Nunawading, 1 March 1960, A. Neboiss (MV); 4 ♀♀, Porepunkah, 26 January 1960, A. Neboiss (MV); 1 ♂, Mt Langi Ghiran, 17 December 1966, A. Neboiss (MV); **Western Australia:** 1 ♀, 18 mi E Pingelly, 2 January 1971, G.A. Holloway and H. Hughes, MVL (AMS K351888); 1 ♀, 1 ♂, Miaboolya Beach, N of Carnarvon, 24.48°S, 113.38°E, 22 October 1992, E.D. Edwards and E.S. Nielson (ANIC); 2 ♀♀, Loop Road, 30 km NE by E of Kalbarri, 27.34°S, 114.26°E, 17 October 1984, Kalbarri NP, D.C.F. Rentz Stop 48 (ANIC); 8 ♀♀, Kalbarri, 27.43°S, 114.10°E, 15 October 1992, E.D. Edwards and E.S. Nielson (ANIC); 3 ♀♀, 1 ♂, Kalbarri, 27.43°S, 114.10°E, 24 October 1992, E.D. Edwards and E.S. Nielson (ANIC); 2 ♀♀, Augustus Island, CALM Site 26/1, 15.25°S, 124.38°E, 11–16 June 1989, I.D. Naumann (ANIC); 1 ♀, 1 km W of Wave Rock, 32.27°S, 118.53°E, 31 January 1993, E.D. Edwards and E.S. Nielsen (ANIC); 1 ♂, Gill Pinnacle, Mural Crescent, 2 November 1963, P. Aitken and N.B. Tindale, LT (SAM); 1 ♀, Gill Pinnacle, Mural Crescent, 10 November 1963, P. Aitken and N.B. Tindale, LT (SAM); 1 ♀, 3.8 km NE of Comet Vale Siding, 29.57°S, 121.07°E, 7–15 March 1979, T.F. Houston *et al.* 256–8 (WAM 82791); 1 ♀, Nullagine, 19–20 January 1974, A.M. and M.J. Douglas (WAM 82875); 3 ♂♂, Buningonia Spring (Well), 31°26'S, 123°33'E, 18–25 November 1978, T.F. Houston *et al.* 225/10 (WAM 82785, 82787, 82788); 1 ♀, 9.8 km SSE of Mt Linden, 29.19°S, 122.25°E, 17–23 March 1979, T.F. Houston *et al.* 259–1 (WAM 82800); 1 ♂, Spectacles Yargan, 32°12.893'S, 115°49.758'E, 2 November 2011, R. Kittel and L. Krieger, sweeping *Eucalyptus* and *Banksia* (WAM SF 008307–17); 1 ♂, Credo Station, 30°04.476'S, 120°36.910'E, 7 September 2011, R. Kittel Sweeping *Senna*, Bush Blitz survey (WAM).

Biology

One specimen was reared from sea hibiscus (*Hibiscus tiliaceus* L.) Malvaceae. Additional specimens were collected from *Acacia lingulata* A. Cunn. ex Benth. Fabaceae and Christmas Mallee (*Eucalyptus socialis* F.Muell. ex Miq.) Myrtaceae.

Etymology

The species is named after the dark scapula area, as opposed to the orange–light brown mesoscutum.

Distribution

Recorded from across Australia, but it is not as abundant as *P. decticauda* or *P. behriae*. It is known from the Australian Capital Territory, New South Wales, Northern Territory, Queensland, South Australia (including Bon Bon Station), Tasmania, Victoria, and Western Australia (Figure 16).

CO1 sequence

Genbank accession numbers for this species are KJ438594 – KJ438598.

***Phanerotoma witchelinaensis* sp. nov.**
(Figures 14a–d, 16)

Description

Body measurements. Length of body 2.9–3.5 mm females, 3.0–3.5 mm males; ratio of length of fore wing to body 0.88; ratio of length of metasoma to mesosoma 1.2.

Head. Ratio of length of third antennomere to fourth 1.2; ratio of length of third and fourth antennomere 2.4 and 2 their width, respectively; ratio of length of eye in dorsal view to length of temple 2.2; ratio of width of face in anterior view to its height 1.7; ratio of width of clypeus to height 1.3; clypeus with two teeth, ratio of length malar space to base of mandible 0.6; face fine rugose; vertex and frons rugose; ratio posterior ocelli:LOL:POL:OOL 1.0:1:0.8:2.4

Mesosoma. Middle lobe of mesoscutum rugose; notauli present; mesoscutellum fine punctate; mesopleuron punctate; precoxal sulcus present; ratio of height of mesosoma to length 1.9; propodeal tubercles absent; blister on mid tibia present; ratio length of hind tibia to hind tarsus 1.0; ratio of length of posterior spur to length of basal tarsus 0.4; ratio hind coxa, hind femur, hind tibia and hind tarsus 1.7, 4.3, 5.7 and 20.0 times their width, respectively; fore wing: 2-R1 absent; ratio of length of 1-R1 to length of pterostigma 1.4; ratio of width of pterostigma to its length 2.6; ratio r:3-SR:SR-1:r-m 1.0:1.3:7.7:1.15; 1-SR+M emanating from parastigma; 2-SR+M postfurcal.

Metasoma. Shape of metasoma oval in dorsal view, narrows down to posterior end; ratio of width of metasoma to its length 0.5; carapace flat in lateral view; ratio of keel to length of metasoma 0.17; carapace longitudinal strigose; both sutures straight; third tergite without lobes or teeth; ratio of the three metasomal tergites 1.0:1.2:1.9.

Colour. Head orange; antenna light brown; mesosoma reddish-brown except mesoscutum and mesosternum orange; legs light brown; first and second tergites beige, gradually darker (reddish-brown) towards posterior end; wing venation dark brown.

Diagnosis

This species differs from all other species by the shape of the carapace. The last tergite of the carapace has a long triangular shape.

Specimens examined

Holotype, Australia (South Australia): 1 ♀, “14 October 2010, Witchelina Station 30° 05'44”S, 138°08'09”E, R. Kittel, sweeping; Bush Blitz survey RK035 on *Acacia* sp.” (SAM). **Other material, Australia (Queensland):** 1 ♀, Eurimbula, Miriam Vale distr. Site 4, 27 March 1975, D.K. McAlpine, MV light (AMS K358188); 1 ♀, S.E. Queensland Beerwak, 26.51°S, 152.57°E, 28 September–29 October 86, B.K. Cantrell, M.T. (WINC); 1 ♂, Bertiehaugh Creek, 12.12°S, 142.22°E, 13 August 1993, P. Zborowski and J. Balderson, LT (ANIC); 1 ♂, Heathlands, 11.45°S, 142.35°E, 15–26 January 1992, I.D. Naumann and T. Weir, LT (ANIC); **Western Australia:** 1 ♀, Pilganoova Well, 25 May 1953, T.B. Tindale (SAM); 1 ♀, Kanjini NP, Mt Bruce Rd, Hamersley, 22°37'27”S, 118°20'47”E, 25 April–1 May 2003 Lambkin and Weir, MT, 755 m, dry rocky creekbed (ANIC); 2 ♀♀, Leeuwin Naturaliste NP, Gnarabug Cave, 34°03.014'S, 115°01.501'E, 5 November 2011, Kittel and Krieger, sweep (WAM SF008307-18, 19).

Biology

Unknown.

Etymology

Named after the type locality Witchelina Station.

Distribution

Found in South Australia (Witchelina Station), Queensland, and Western Australia (Figure 16).

CO1 sequence

Genbank accession number for this species is KJ438593.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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