

Description of three new species of *Ceratocader* (Hemiptera: Heteroptera: Tingidae) from Western Australia

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ABSTRACT – This paper describes three new species of *Ceratocader* (Tingidae), almost doubling the number of known species. *Ceratocader langlandsi* sp. nov. is found in arid south Western Australia. In contrast, *C. coatesi* sp. nov. and *C. bridgettae* sp. nov. are found in the wetter tall forests of the far south-west of Western Australia. Notes on the genus, and its sister genus, *Australocader*, as well as a key to species of *Ceratocader*, are provided.

KEYWORDS: Cantacaderinae, coextinction, short-range endemic

INTRODUCTION

The endemic Australian lacebug genus *Ceratocader* Drake, 1950 (Hemiptera: Heteroptera: Tingidae) is currently represented by four described species. *Ceratocader armatus* (Hacker, 1928), the armed lacebug, is recorded from South Australia, and *C. dentatus* (Hacker, 1928), the dented lacebug, from northern Tasmania (Hacker 1928; Cassis and Gross 1995). Lis (2000) added a further two species: *C. fulvus* Lis, 2000 from the far south-west of Western Australia and *C. monteithi* Lis, 2000 (Monteith's lacebug) from central Queensland (Figure 1).

Western Australia is particularly rich in lacebug species of the family Tingidae, with a key to the genera present in the south-west provided by Moir and Guilbert (2012). Despite recent publications documenting new species (e.g. Cassis and Symonds 2008, 2011; Guilbert and Moir 2010; Moir 2009; Moir and Guilbert 2012) many species await description. Here, we describe three new species of *Ceratocader* from Western Australia: *Ceratocader langlandsi* sp. nov. from the arid southern region, plus *C. coatesi* sp. nov. and *C. bridgettae* sp. nov. from the far south-west of the State (Figure 1). In addition, a discussion on the genus and a key to species is provided.

MATERIALS AND METHODS

The specimens examined here were collected by beating, vacuum sampling or pitfall traps (see Langlands et al. 2006; Moir et al. 2005a; Orabi et al.

2010 for detailed descriptions of the methods and sites). Specimens are pinned and deposited in the Western Australian Museum, Perth (WAM), and the M.L. Moir personal collection, Perth (MLM).

Specimens were examined with an Olympus SZ51 stereo microscope, and all images were produced using a Leica MZ16 stereo microscope and the package Auto-montage Pro version 5.02(p) (Syncroscopy, Cambridge, U.K.). A map of species distribution was produced in ArcGIS Version 9.1 (Environmental Systems Research Inc.). Tingidae terminology follows Froeschner (1996) and Lis (2000), classification follows Guilbert (2012).

SYSTEMATICS

Family Tingidae Laporte, 1833

Subfamily Cantacaderinae Stål, 1873

Tribe Ceratocaderini Lis, 1999

Genus *Ceratocader* Drake, 1950

urn:lsid:zoobank.org:act:467D998F-7ECB-4BD7-8F83-2256582A46CB

Ceratocader Drake, 1950: 157.

TYPE SPECIES

Cantacader armatus Hacker, 1928 by original designation.

REMARKS

Tingid taxonomy is based solely on the external morphology, often without any description of the genitalia, which are minimally diagnostic (Froeschner 1996; Lis 2000). *Ceratocader* was previously distinguished from other genera within the subfamily Cantacaderinae by the combination of the following characters: exposed scutellum, presence of 6–8 long spines on the lateral margins of the paranotum, and the anterior margin of the pronotum projecting a small to medium hood over the head (Froeschner 1996; Lis 2000). However, taking into account the features of the species described herein, we redefine the genus to include Cantacaderinae species with 3–8 spines on the lateral margins of the paranotum, and the pronotal hood present or absent (e.g. Figures 8–13).

KEY TO SPECIES OF *CERATOCADER* (ADAPTED FROM LIS, 2000)

1. Lateral spines on paranotum not longer than the diameter of the eyes (Figure 9) 2
 - At least one pair of lateral spines on paranotum longer than the diameter of the eyes (Figures 10–13) 3
2. Three well-defined lateral spines on paranotum (Figure 9) *Ceratocader langlandsi*
 - Lateral spines on paranotum very small, almost non-existent, but number more than three *Ceratocader dentatus*
3. Costal area recurved over onto itself (Figures 6,7) *Ceratocader bridgettae*
 - No part of costal area recurved over onto itself 4
4. Base of posterior cephalic spines distinctly one eye length in front of eyes (Figure 13) *Ceratocader fulvus*
 - Base of posterior cephalic spines almost touching eyes (Figure 12) 5
5. Hood projecting over head (Figure 11). Posterior part of paranotum expanded and forming lobe bearing 4–5 rows of aerolae *Ceratocader armatus*
 - Hood not projecting over head (Figure 8). Posterior part of paranotum not expanded 6
6. Anterior paranotal spine not surpassing eyes in length (Figure 12) *Ceratocader monteithi*
 - Anterior paranotal spine surpassing eyes in length (Figure 8) *Ceratocader coatesi*



FIGURE 1 Map of Australia with collection localities of Australian *Ceratocader* species. Symbols represent the following: stars – *C. dentatus*; white squares – *C. armatus*; black square – *C. monteithi*; cross – *C. fulvus*; diamond – *C. coatesi*; white circle – *C. langlandsi*; and black circle – *C. bridgettae*.

Ceratocader langlandsi sp. nov.

urn:lsid:zoobank.org:act:5508DE89-0F8C-4E5D-A126-42EF035B7F69

Figures 1–3, 9

MATERIAL EXAMINED

Holotype

Australia: Western Australia: ♂, Queen Victoria Springs Nature Reserve, night beating, 30°14'S, 123°41'E, 21 March 2003, P.R. Langlands (WAM E82993).

Paratype

Australia: Western Australia: 1 ♂, 1 ♀, same as holotype (WAM E82994, WAM E82763).

Other material examined

Australia: Western Australia: 1 ♂ same as holotype (MLM 205).

DIAGNOSIS

Ceratocader langlandsi is most similar to *C. fulvus*, but the two differ in the length and number of lateral spines on the paranotum; *C. langlandsi* has three medium spines per lateral margin which are all shorter than the diameter of the eye, whereas *C. fulvus* has approximately seven spines of varying lengths, but at least one spine of equal length to the diameter of the eye (see Figures 3, 9). Also, *C. fulvus* has a prominent hood, whereas *C. langlandsi* has not.

DESCRIPTION

Body measurements. ♂ 5.96 ± 0.24 mm (n = 3), ♀ 5.80 mm (n = 1).

Colour. Eyes dark red. Body, genital capsule, 4th antennal segment, femur, distal half of tibia and markings on hemelytra (particularly band across costal region, almost midway down hemelytra) dark brown. Head, hemelytra, and pronotum golden brown. Pronotum and hemelytra (particularly main veins) infused with orange (Figure 2). Remaining antennal segments and legs brown.

Head and antennae. Head with 4 long, cephalic spines, surpassing 2nd antennal segment (Figures 2, 3). Antenniferous process slender and pointed, not surpassing 1st antennal segment. Antennae slender, antennal segments measurements: I, 0.12 mm; II, 0.10 mm; III, 1.90 mm; IV, 0.30 mm. Fourth antennal segment pilose. Rostrum long, extending to 4th visible abdominal segment.

Body. Coleopterous. Pronotum large, posterior margin bisinuate; anterior margin raised slightly over head but lacking obvious hood; three carina, each uniseriate. Lateral carina broken at one-fifth length from anterior margin of pronotum, with large gap and small spine projecting upward from anterior edge of break. Paranota large, widest at midlength, triseriate (Figure 2). Pronotum with 3 short (less than the diameter of an eye) lateral spines per side (Figures 2, 9). Forewings (or hemelytra) much wider than pronotum, extending out approximately half the width of the pronotum. Lateral margins of forewings raised and slightly recurved (Figure 2). Posterior margin rounded. Scutellum exposed, represented as a relatively large, round knob-like process, elevated above hemelytra. Stenocostal region present with one row of small round areolae, costal region with on average eight small round areolae and subcostal with six to eight rows of areolae. Hind wings absent.

Nymphs. unknown

ETYMOLOGY

This species is named in honour of the collector, Dr Peter Langlands, for his continued enthusiasm in collecting new and interesting species of Hemiptera, often from relatively inaccessible regions of Western Australia.

COMMON NAME

Langlands' lacebug.

***Ceratocader coatesi* sp. nov.**

urn:lsid:zoobank.org:pub:14E1F58D-47BE-4839-85EC-8CCEF76FBAC8

Figures 1, 4, 5, 8

MATERIAL EXAMINED

Holotype

Australia: Western Australia: ♂, Porongurups National Park, Devils Slide, site 6, 34°40'31"S, 117°51'05"E, ex *Gastrolobium crenulatum* [Note: plant species misidentified = *G. subcordatum*], beat, 15 October 2006, M.L. Moir and J.M. Waldock (WAM E82995).

DIAGNOSIS

Ceratocader coatesi resembles both *C. monteithi* and *C. armatus*, but differs from both species by fewer (c. 5) spines per lateral margin of the paranotum, with the anterior spine long, extending forward and surpassing the eyes (see Figures 4, 8).

DESCRIPTION

Body measurements. ♂ 3.80 mm (n = 1).

Colour. Eyes red. Collar region, 4th antennal segment and markings on hemelytra (particularly band across costal region near middle of hemelytra) dark brown. Head, body, hemelytra, genital capsule, pronotum, remaining antennal segments and legs golden brown. Cephalic spines, pronotum, hemelytra and body infused with orange (Figure 4).

Head and antennae. Head with four long, cephalic spines, surpassing 2nd antennal segment (Figures 4, 8). Antenniferous process slender and pointed, not surpassing 1st antennal segment. Antennae slender, antennal segments measurements: I, 0.10 mm; II, 0.07 mm; III, 1.20 mm; IV, 0.20 mm. Fourth antennal segment pilose. Rostrum extending to 1st visible abdominal segment.

Body. Coleopterous. Pronotum large, posterior margin bisinuate; anterior margin raised slightly over head but lacking obvious hood; 3 carina consisting of one row of areolae. Lateral carina discretely broken (without gap) at one-fifth length from anterior margin of pronotum. Paranota large, widest in anterior half, consisting of 3 rows of round areolae (Figure 4). Pronotum with 6–7 lateral spines per side of varying lengths; anterior spine the longest, surpassing eyes (Figures 4, 8). Forewings (or hemelytra) wider than pronotum, extending out approximately a quarter the width of the pronotum. Lateral margins of forewings raised (Figure 4). Scutellum exposed, represented as a small rounded rectangular process, elevated slightly above hemelytra. Stenocostal region present with 1 row of small round areolae, costal region with 4 to 5 rows of small round areolae and subcostal with 6 rows of areolae. Hind wings present.

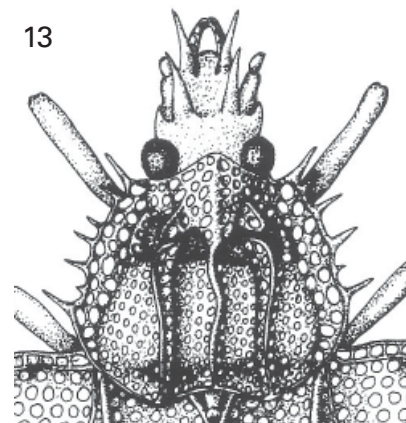
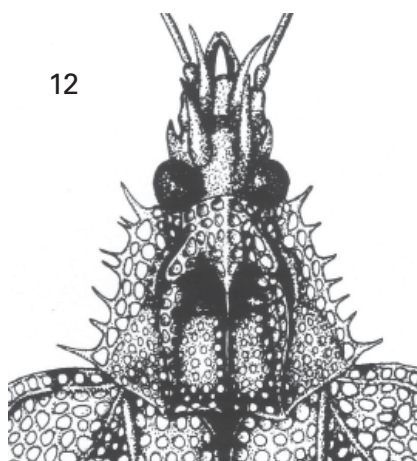
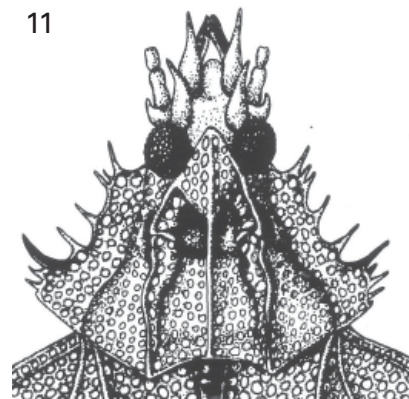
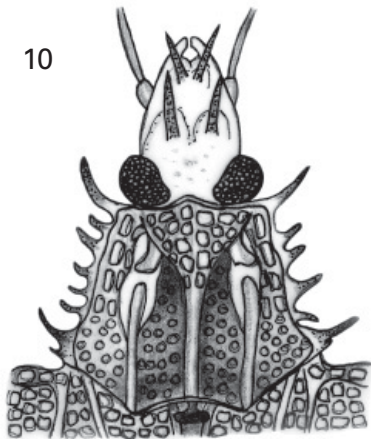
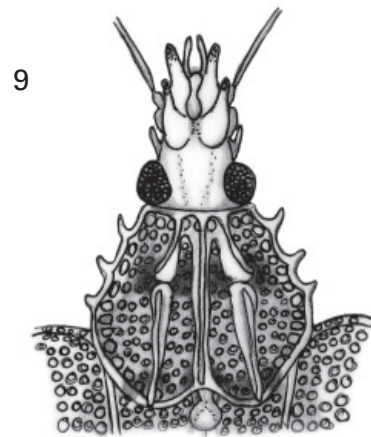
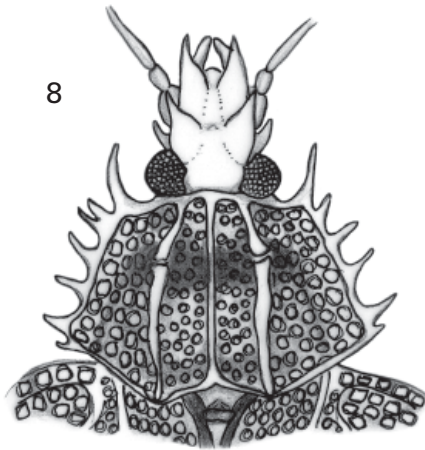
Nymphs. Nymphs unknown.

ETYMOLOGY

This species is named in honor of Dr David Coates, for his contribution towards the conservation of many threatened Western Australian plant species, and his support of the first author's work highlighting the potential coextinction of insects on these plants.



FIGURES 2–7 Dorsal and lateral views of the three new species of *Ceratocader*: 2, 3, *C. langlandsi* sp. nov. (MLM 205); 4, 5, *C. coatesi* sp. nov. holotype (WAM 82995); 6, 7, *C. bridgettae* sp. nov. paratype (WAM 82997).



FIGURES 8–13 Head and pronotum of *Ceratocader* spp.: 8, *C. coatesi* sp. nov.; 9, *C. langlandsi* sp. nov.; 10, *C. bridgettae* sp. nov.; 11, *C. armatus*; 12, *C. monteithi*; 13, *C. fulvus*. Figures 11, 12 and 13 adapted from Lis (2000), copyright Wiley-VCH Verlag GmbH & Co. KGaA; reproduced with permission.

COMMON NAME

Coates' lacebug.

***Ceratocader bridgettae* sp. nov.**

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Figures 1, 6, 7, 10

MATERIAL EXAMINED

Holotype

Australia: Western Australia: ♂, Boddington, site NP96 (mine), pitfall trap, April 2003, G. Orabi (WAM E82996).

Paratype

Australia: Western Australia: 1 ♀, Boddington, site MO4J (Jarrah forest), litter sample, April 2004, G. Orabi (WAM E82997).

DIAGNOSIS

Ceratocader bridgettae could be confused with *C. dentatus*, but differs from the latter by having the costal region of the hemelytra curved up and back upon itself (also termed 'recurved') for almost the entire length, whereas the costal region of *C. dentatus* is only recurved in anterior half (Hacker, 1928). In addition, *C. dentatus* has only six short pronotal spines, shorter than the diameter of the eye (Froeschner, 1996), whereas *C. bridgettae* has 6–8 spines with at least one spine longer than the diameter of the eye.

DESCRIPTION

Body measurements. ♂ 3.83 mm (n = 1), ♀ 3.94 mm (n = 1).

Colour. Eyes red. Body, genital capsule, 4th antennal segment, majority of lateral paranotum spines and markings on hemelytra (particularly band across costal region almost midway down hemelytra) dark brown. Cephalic spines and lateral carina on pronotum surrounded by white 'foam-like' substance (Figures 6,7). Head, body, hemelytra, pronotum, legs and remaining antennal segments yellow-brown.

Head and antennae. Head with four long, cephalic spines, surpassing 2nd antennal segment (Figure 6). Antenniferous process slender and pointed, not surpassing 1st antennal segment. Antennae slender, antennal segments measurements: I, 0.10 mm; II, 0.08 mm; III, 1.35 mm; IV, 0.20 mm. Fourth antennal segment pilose. Rostrum extending to 1st visible abdominal segment.

Body. Coleopterous. Pronotum large, posterior margin bisinuate; 3 carina uniseriate for most of length. Lateral carina broken at one-fifth length from anterior margin of pronotum. Hood present, inflating approximately half of central pronotal carinae, projecting slightly over head. Paranota consisting of 2 rows of square areolae

for almost entire length (Figure 6). Pronotum with 6–8 lateral spines per side of varying lengths; anterior spine the longest, almost surpassing eyes (Figures 6,10). Forewings (or hemelytra) wider than pronotum, extending out approximately a quarter the width of the pronotum. Lateral margins of forewings raised and recurved to such an extent that underside is visible when viewed dorsally (Figures 6,7). Scutellum exposed, represented as a small rectangular process, elevated above hemelytra. Stenocostal region present with 1 row of small round areolae, costal region with on average 6 rows of small round areolae and subcostal with 7 rows of areolae. Hind wings present.

Nymphs. Nymphs unknown.

ETYMOLOGY

This species is named in honor of Bridgette Brennan, the first author's eldest daughter.

COMMON NAME

Bridgette's lacebug.

DISCUSSION

Ceratocader is closely related to other Gondwanan Cantacaderini genera, in particular the Australian *Australocader* Lis, 1997, and more distantly, the Australian *Allocader* Drake, 1950, Brazilian *Nectocader* Drake, 1928 and New Caledonian *Caledoderus* Guilbert, 2012 (Lis 1999; Schuh et al. 2006; Guilbert 2012). *Ceratocader* has been considered a primitive group of Cantacaderinae by Zhang et al. (2005), because species supposedly retain the basal cell of the hemelytron. These authors, however, only examined the illustration of *C. armatus* in Froeschner (1996, figure 7), the venation of which differs considerably from that given by Lis (2000, figure 3). The latter does not show a well defined, separate basal cell.

Both *Ceratocader* and the closely related *Australocader* have not been discovered outside Australia to date. The two genera differ in their distribution within Australia, with *Australocader* restricted to the east coast of the mainland. In contrast, *Ceratocader* has dispersed across Australia, including Tasmania, and has a hotspot of endemism in the Western Australian South-West (four of seven species found here: Figure 1). The distribution of the genus across Australia indicates that species may not be dispersal inhibited, and this is further supported by the collection of *C. bridgettae* in a relatively recently restored mine pit (9 year-old) (Orabi et al. 2010). In addition, the capture of *C. monteithi* in intercept traps (Lis 2000) suggests good powers of dispersal via flight. Paradoxically, however, a number of species (*C. langlandsi*, *C. dentatus*, *C. fulvus*, *C. monteithi*) lack hind wings and cannot fly. Presumably all of these species would not be able to disperse far by walking, and there is evidence that *Ceratocader* may represent short-range endemic species restricted to specific

refugial sites (see below). But there are two perplexing contradictions to the suggestion that *Ceratocader* species without hind wings are dispersal inhibited: 1. how were two specimens of *C. monteithi* captured by intercept traps?; and 2. the new locality record that we present here of *C. dentatus* on mainland Australia, in highlands in the Australian Capital Territory, results in a very wide distribution for a species lacking hind wings (Figure 1).

Ceratocader species are found in a variety of habitat types and rainfall climates (e.g. arid, *C. langlandsi*; cool and wet temperate, *C. dentatus*; temperate, *C. bridgettae* and *C. armatus*). Despite this, and their occurrence across most states of Australia, few specimens of the genus have been collected. Most species are known only from a single locality (Figure 1). As such, it is highly likely that *Ceratocader* are restricted to specific habitat types represented at these localities. For example, *C. monteithi* has been identified as a possible short-range relictual species endemic to Carnarvon National Park in Queensland (Grant 2005). A restricted range also appears to apply to all new species described here. *Ceratocader coatesi* is found in the most north-eastern disjunct population of wet Karri (*Eucalyptus diversicolor* F. Muell.) forest of the Porongurups National Park (for a discussion of the biotic and abiotic features of the National Park see Wills and Abbott, 2003). This area not only features a distinct genetic population of Karri (Coates and Sokolowski, 1989), but is a recognised hotspot of endemism for other invertebrates due to its high rainfall and mountainous terrain (e.g. Moir et al. 2009), and as a historical refugium for invertebrates from past sea level changes and aridity (Main 1999). *Ceratocader langlandsi* is found at Queen Victoria Springs Nature Reserve, which is recognised as a unique area where several habitat types overlap and result in high plant diversity (Langlands et al. 2006). *Ceratocader bridgettae* is found in the northern Jarrah (*Eucalyptus marginata* Sm.) forest, which has a relatively high rainfall when compared to surrounding northern, eastern and western areas (Orabi et al. 2010).

It is possible that the perceived rarity of *Ceratocader* is a result of collectors' under-sampling the preferred host plant species, and thus individuals have been collected as tourists on other plants, or opportunistically via pitfall traps, litter samples and intercept traps. However, in several localities in south-west Australia (e.g. Jarrahdale, Boddington, Stirling Range National Park, Ravensthorpe, south coastal region) many plants have been sampled intensively as part of other surveys without a single occurrence of a *Ceratocader* individual (Moir et al. 2005a, 2005b, 2010; Framenau et al. 2008; Moir et al. unpublished data). Thus, the reasons behind the rarity of *Ceratocader* remain a mystery. Interestingly, four specimens of *C. langlandsi* were caught by beating an unknown plant at night (P.R. Langlands, personal communication 2012). For this species at least, this could suggest that individuals feed

on host plants at night and potentially shelter elsewhere during the day (perhaps in leaf litter, as the area where *C. langlandsi* was collected was long unburnt: P.R. Langlands, personal communication 2012). Furthermore, *C. coatesi* was captured on *Gastrolobium subcordatum* (Benth.) G. Chandler and Crisp, a plant which is considered rare (see <http://florabase.dec.wa.gov.au/browse/profile/20507> and Chandler et al. 2002). Therefore, *C. coatesi* may be restricted in range due to the small range of the host plant and could require conservation itself (co-threatened: Moir et al. 2011). However, no conclusion is possible as yet because only one specimen has been found. Further study and collecting of these elusive lacebugs is ultimately required to answer questions concerning habitat requirements, dispersal potential, host plant preferences and their possible requirement for conservation.

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