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Four new species of the myrmecophile *Diplocotes* Westwood (Coleoptera: Ptinidae) from Queensland and South Australia

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Abstract Four new species of the Australian ptinid genus *Diplocotes* are described. Two of these species are from the dry tropical and subtropical areas of northern and central Queensland, while the other two are from the arid areas of South Australia. While the four new species described here have not been observed with ants in the field, the species of this genus are known to be myrmecophilous, and similar interactions may occur between the new species and their host ants. Additionally, many characters are shared with other unrelated myrmecophilous species, and may be convergent adaptations to the ant-associated lifestyle.

Key words central Australia, *Diplocotes*, myrmecophilous, Ptinidae, spider beetle.

INTRODUCTION

The spider beetles (Coleoptera: Ptinidae) are a diverse group of beetles, occurring throughout most of the world, and occupying a variety of ecological niches, with high levels of diversity in arid habitats. There are roughly 700 species placed within 75 genera and currently most species are known from the southern Holarctic region and southern Africa. The Australian endemic tribe Ectrephini is myrmecophilous and wingless. It is a highly derived lineage, with a high species richness in the arid and semi-arid areas of central Australia. There are four genera of Ectrephini – *Diplocotes* Westwood, *Polyplocotes* Westwood, *Ectrephes* Pascoe and *Enasiba* Olliff – containing 35 described species (Lawrence & Reichardt 1969). Lawrence and Reichardt (1969) considered all four genera to be derived from a single ancestor based on several hypothesised synapomorphies.

The huge diversity of forms within the Ectrephini has meant that many species were originally described in monotypic genera, often diagnosed solely by differences in antennal morphology. Lawrence and Reichardt (1969) noted a lack of correlation of antennal morphologies with other characters, and considered antennal modifications to be adaptive, noting similarities to unrelated myrmecophilous Coleoptera. Accordingly, they redefined the genera based on other characters, reducing the number of genera in the tribe from 14 to 4, but did not undertake any generic revisions nor produce a phylogeny supporting the monophyly of each group. They placed 19 species in the genus *Diplocotes*, with the most consistent characters grouping the species based on the clypeus, and the absence of unique characters of the pronotum that define the genera *Polyplocotes*, *Ectrephes* and *Enasiba*.

The majority of described species of *Diplocotes* are recorded from southern and western Australia, with the fauna of the south-west being distinctly different and more diverse than the fauna of the south-east and north-west (Lawrence & Reichardt 1969). The north-eastern Australian fauna (New South Wales, Queensland and Northern Territory) is less diverse, although this may be an artefact of collecting effort. Here we describe two recently collected species from this less speciose north-eastern region, and two new species from the more species-rich region of central Australia.

We currently consider the spider beetles as a family rather than a subfamily of the Anobiidae due to the possibility that they should both be subfamilies of the Bostrichidae. Both are derived clades of the bostrichids (Ivie 1985; Philips 2000), and excluding them from this group results in a paraphyletic Bostrichidae. There is also morphological (Philips 2000) and molecular evidence (KL Bell and TK Philips, unpubl. 2007) that the spider beetles are sister to the anobiids rather than a derived clade of the latter. Lastly, based on priority of names, one could consider the anobiids to be more correctly called Ptinidae. We hope to rectify this semantic situation in the near future.

MATERIALS AND METHODS

Specimens were borrowed from the South Australian Museum, Queensland Museum and Canadian Museum of Nature. Specimens were examined under fibre optic and fluorescent light using a Leica MZ-16 microscope. Photographs were taken using an auto montage system from Syncroscopy

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(Synoptics Ltd). The construction of a key was considered but rejected due to two main reasons. First, the genera may not be monophyletic making a generic key very artificial and confusing, particularly if determinations of species in other genera are mistakenly attempted. Second, the species are very diverse in morphology but with several intermediate forms making key construction difficult. At present, the fastest way to determine a species is no doubt by examining illustrations herein and in Lawrence and Reichardt (1969). We hope in the future to have a more complete review of the spider beetle species in Australia with illustrations available online.

Species descriptions without a generic revision were done as many undescribed species likely still exist in Australia. More importantly, there is a strong possibility of a lack of generic monophyly as previously mentioned. Hence we believe at this time a revision is premature.

NEW SPECIES DESCRIPTIONS

Diplocotes coliosetus sp. nov.

Types. *Holotype*. Male. Australia, Queensland. 16°58′S 145°20′E. Southedge Research Station. 12 km NW Mareeba 12.ii.1989. H. & A. Howden. Flight intercept trap. Deposited in Queensland Museum, Brisbane, registration number T.144209.

Paratype. 1 male, same data as holotype except 17.I.1989.

Diagnosis. This species is similar to *Diplocotes foveatus* (Lea), but can be distinguished by the basolateral impression being of equal depth its entire width and not forming a deep concavity in the centre, and by the presence of setal rows between the elytral striae.

Description. *Habitus*. (Figs 1a,2a,3a) Moderately rounded body; length approximately 2.25 mm ($n = 2$); elytra slightly less than twice as long as pronotum in lateral view; black; pronotum striate and shining, elytra shining.

Head. Less shiny than pronotum, densely, but sparsely punctured on vertex, striate on frons and genae, fringe of dense setae present at base by vertex; eyes very flat; no ridge between lateral edge and eyes; clypeus subtriangular, protruding; antennae 11-segmented, segments 1–3 at least as long as wide, segments 4–11 slightly flattened, broadened laterally and wider than long, segment 11 with brush of short setae at apex, all antennomeres moderately shiny, with strong punctures and setae as long as 1/4 to 1/3 length of antennomeres.

Thorax. Pronotum equally broad at apex and base, lateral edges slightly expanded outwards approximately at middle; lateral trichomes approximately at basal 1/4, each with deep fovea directly below; transverse impression located at basal 1/4.

Elytra. Approximately 1.5 times as long as wide; elytral striae with punctures moderately dense and slightly impressed, each separated longitudinally by approximately 3 times their diameters near elytral base, with setae absent on even intervals, spacing of setae slightly wider than that of punctures and approximately equal to length of setae.

Ventral surface. (Fig. 3a) Pro-, meso- and lateral edges of metasternum hirsute with dense recumbent setae; ventrites 1–3 relatively shiny, ventrites 4–5 dull; metasternum and 1st 3 ventrites with shallow, broad punctures; punctures smaller on ventrites 4–5; ventrite 2 longest, ventrites 3 slightly shorter, ventrite 5 approximately 2/3 length of ventrite 2 at centre, ventrite 1 approximately 1/3 this length, ventrite 4 approximately 1/4 this length.

Legs. Reddish-black in colour, moderately long, femora and tibiae with dull surface, fine punctures and short setae; femora straight, widening apically, more abruptly so at apical 1/3; tibiae narrow and straight, but not strongly flattened; tarsomeres robust, 1–4 approximately as long as wide, shiny, tarsomere 5 approximately 2 times as long as wide.

Genitalia. Not examined due to the small number of specimens, and the difficulty of dissecting small, compact beetles with fused sclerites without unwanted damage.

Variation. There are only 2 specimens known for this species, and both are male. Both specimens are consistent with the description above.

Etymology. The name of this species comes from the setae on the odd intervals of the elytra.

Distribution. Known only from the type locality 12 km northwest of Mareeba in North Queensland (Fig. 4).

Diplocotes concavus sp. n.

Types. *Holotype*. Sex unknown. Queensland: 22°14′S 147°15′E Mazeppa NP, N. end, 27.iii.2001. G. B. Monteith, pyrethrum, gidgee trunks, 240 m, 10089. Deposited in Queensland Museum, Brisbane, registration number T.144210.

Paratypes. 1 male, 2 sex unknown, same data as holotype.

Diagnosis. This species can be separated from all other *Diplocotes* species by the combination of 6-segmented antennae (*D. lawrencei* sp. n. also has 6-segmented antennae, but the dorsal median pit on the pronotum is shallower), short abdomen (elytra only slightly longer than pronotum in dorsal view) and extremely concave ventral surface.

Description. *Habitus*. (Figs 1b,2b,3b) Short and stout; length 1.5 mm ($n = 4$); elytra approximately 1.5 times as long as pronotum in lateral view; dark reddish-brown in colour; pronotum with microsculpture granular, producing relatively dull surface; elytra shining.

Head. Dull surface, densely punctured on vertex; eyes very flat; no ridge between lateral edge and eyes; clypeus subtriangular and strongly protruding; antennae 6-segmented, segments 1–3 longer than broad, segments 4–5 approximately as long as broad, segment 6 slightly elongated with brush of short setae at apex, segment 1 relatively dull, segments 2–6 more shiny, with segment 6 shiniest.

Thorax. Pronotum narrower at apex than base, lateral edges expanded outwards approximately at middle; distinct dorsal cavity above lateral projections, with dorsoventral tunnel, greatly expanded below; deep, narrow larger concavity centred medially at basal one-third.

Elytra. Lateral edges straighter than most species in this genus; slightly longer than wide; elytral striae with punctures

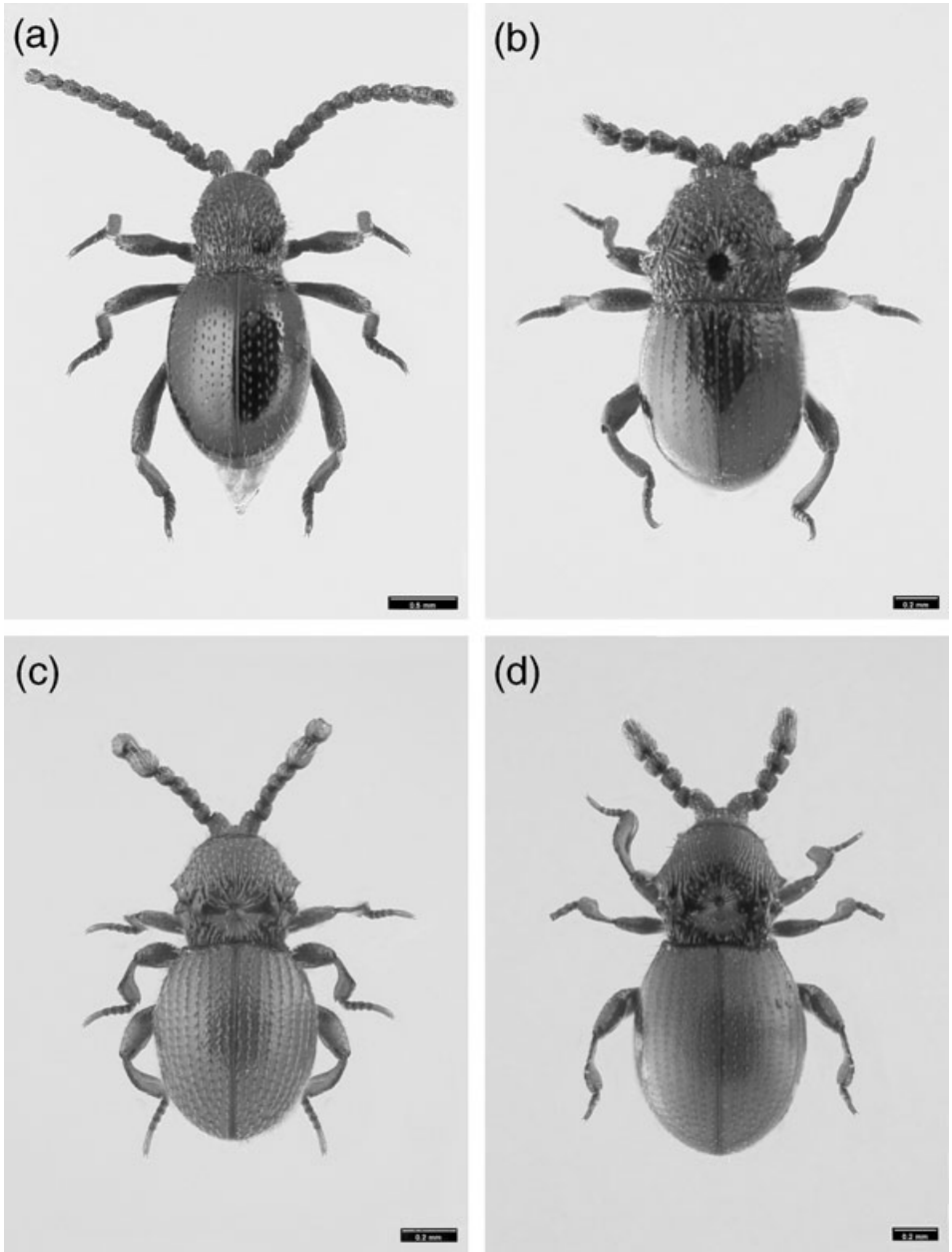

Fig. 1. Habitus, dorsal view: (a) *Diplocotes coliosetus*; (b) *Diplocotes concavus*; (c) *Diplocotes pitjantjatjara*; (d) *Diplocotes lawrencei*.

dense and slightly impressed, each separated longitudinally by slightly more than their diameters near elytral base, each with very short setae of length no more than 1/4 distance between punctures.

Ventral surface. (Fig. 3b) Pro-, meso- and metasternum dull; prosternum hirsute with dense recumbent setae; meta- and mesosternum lightly punctured; punctures shallow on ventrites, but slightly deeper on ventrites 1–3, than ventrites 4–5; meta- and mesosternum and 1st 3 ventrites extremely concave medially; metasternum with medial longitudinal ridge; suture between ventrites 1–3 indistinct; ventrite 2 longest, ventrites 3 and 5 approximately 3/4 length of ventrite 2; ventrite 1 approximately 1/2 length of ventrite 2 at centre, ventrite 4 approximately 1/4 length of ventrite 2 at centre.

Legs. Very short and stout, with dull surface, fine punctures and short setae; femora straight, widening slightly apically; tibiae narrow and straight; tarsomeres robust, 1–4 approximately as long as wide, tarsomere 5 about 2 times as long as wide, all parallel-sided and joined smoothly, to make a cylindrical-shaped tarsus.

Male genitalia. Parameres curved slightly inwards, more strongly pigmented in apical third, except for small unpigmented portion at tip, setae at tip; spiculum gastralae divided into 2 forks in basal half. The male genitalia of this species differ very slightly from that of *D. foveatus* (not shown). As these 2 species represent 2 of the more morphologically divergent species of the genus, it is expected that the genitalia is not variable across the genus.

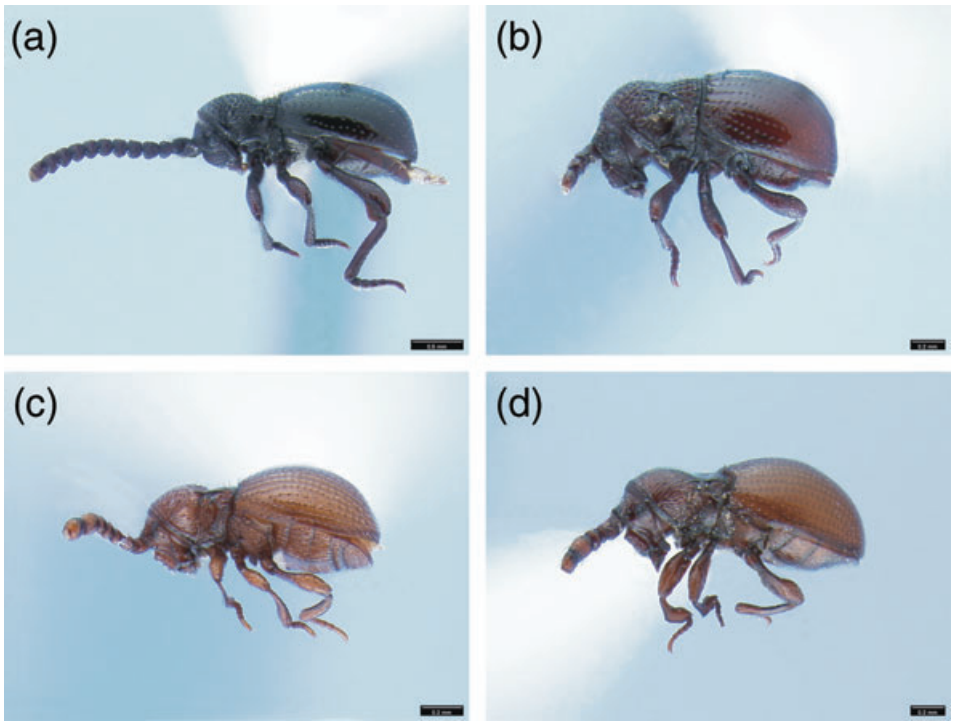

Fig. 2. Habitus, lateral view: (a) *Diplocotes coliosetus*; (b) *Diplocotes concavus*; (c) *Diplocotes pitjantjatjara*; (d) *Diplocotes lawrencei*.

Variation. This species is only known from 4 specimens, all from the same locality. Males and females do not differ externally. The description above could equally apply to any specimens of the type series.

Etymology. This species is named based on the concave shape of the ventral surface.

Distribution. Known only from the type locality, Mazeppa National Park in Central Queensland (Fig. 4).

Diplocotes pitjantjatjara sp. n.

Types. *Holotype*. Sex unknown. S. Aust. Sand dune PIL0101 13.2 km NW Cheesman Peak pitfalls 22–25.x.1996 27°20′09″S 130°13′34″E Pitjantjatjara Lands Survey. Deposited in South Australian Museum, registration number I.21804.

Paratypes. 1 Sex unknown, same data as holotype; 2 Sex unknown, sand dune WAT0301 3.1 km WNW Mt Lindsay pitfalls 16–20.x.1996 27°01′09″S 129°51′01″E Pitjantjatjara Lands Survey; 1 Sex unknown, sand plain PIL0201 12.2 km NW Cheesman Peak pitfalls 22–25.x.1996 27°20′13″S 130°14′15″E Pitjantjatjara Lands Survey.

Diagnosis. This species resembles *Diplocotes kingi* (Westwood), *D. cuneiformis* (Oke) and *D. lawrencei* sp. n. in size and pronotal modifications. This species is the only *Diplocotes* species with 7 antennal segments.

Description. *Habitus*. (Figs 1c,2c,3c) Length approximately 1.25 mm ($n = 5$); rounded abdomen, elytra slightly less than 2 times as long as pronotum in lateral view; light yellowish-brown in colour; pronotum shining and striate; elytra less shiny.

Head. Shiny surface, lightly punctured, with short setae on vertex; eyes very flat; longitudinal ridge at lateral edge of eyes, clearly visible from above; clypeus subtriangular and protruding; antennae 7-segmented, segments 1–3 longer than wide, segments 4–5 approximately as long as wide, segments 6–7 enlarged, with segment 6 longer than segment 7, segment 7 with a hollow filled with setae at apex; antennae shiny, with setae on all segments, but shorter on segment 1.

Thorax. Pronotum with lateral edges expanded outwards to form sharp projection, approximately at middle; deeper concavity centred medially at basal one-third; basolateral trichomes, posterior to lateral projections, with deep ventral cavity directly below; ventral surface striate below trichomes, with a row of long setae looped at the end (Fig. 3c).

Elytra. Bulbous, approximately 1.25 times as long as wide; elytral striae with punctures dense and moderately impressed, separated longitudinally by approximately their diameters near elytral base, each with long setae of length approximately equal to distance between punctures.

Ventral surface. (Fig. 3c) Pro-, meso- and metasternum and 1st ventrite hirsute, with dense recumbent setae; meta- and mesosternum and 1st 3 ventrites concave; 5 ventrites visible; ventrites 2, 3 and 5 longest, ventrites 1 and 4 approximately 1/3 this length; ventrites 2 and 3 striate with short, sparse setae, ventrites 4 and 5 lightly punctured with short, sparse setae.

Legs. Short and stout, with shiny surface, with sparse punctures and long, sparse setae; femora slightly curved, broadened medially, tibiae broadened medially, flattened and strongly curved; tarsomeres robust, 1–4 approximately as long as wide, tarsomere 5 about twice as long as wide, all segments joined smoothly.

Genitalia. Not examined due to the small number of specimens, and the difficulty of dissecting small, compact beetles with fused sclerites without unwanted damage.

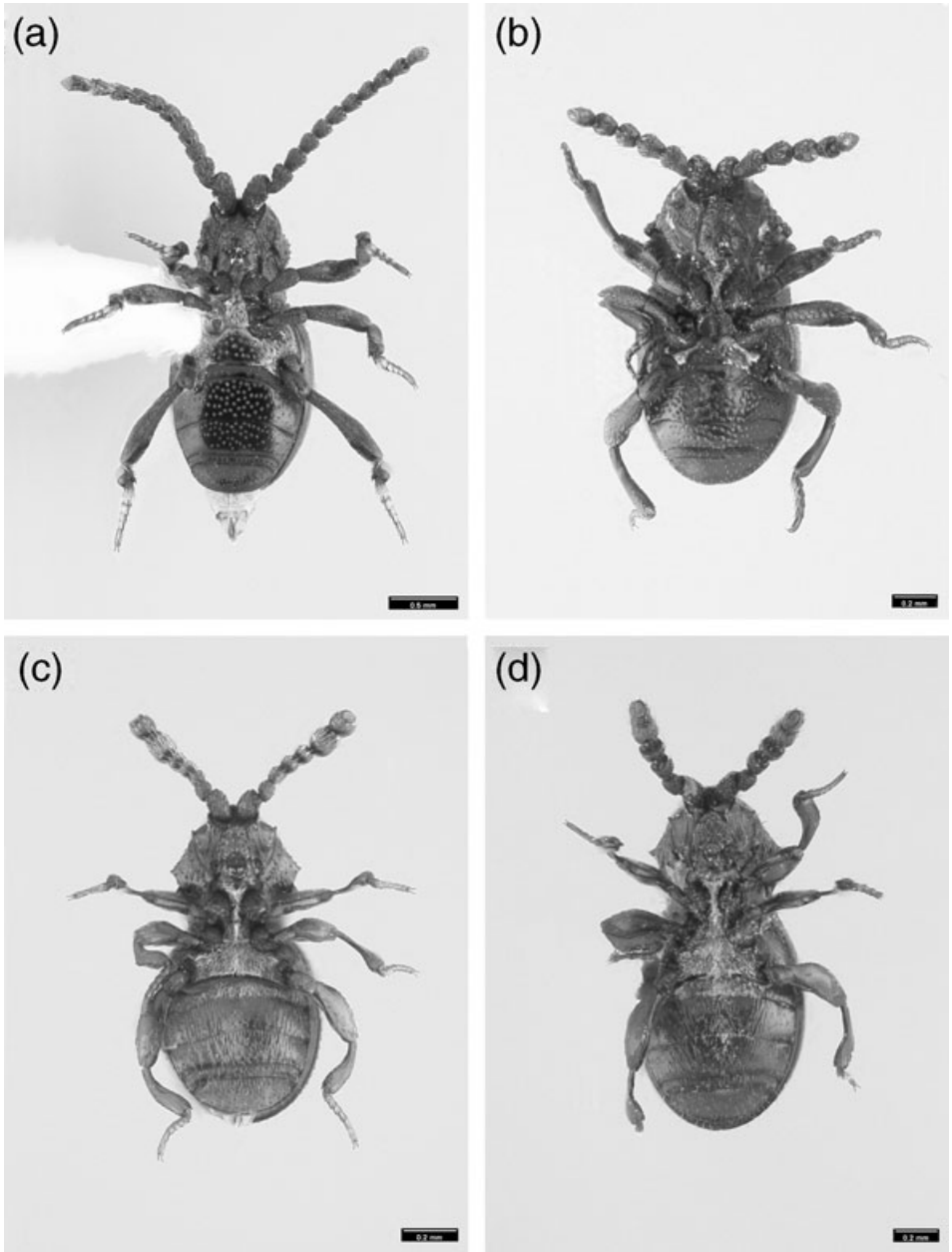

Fig. 3. Habitus, ventral view: (a) *Diplocotes coliosetus*; (b) *Diplocotes concavus*; (c) *Diplocotes pitjantjatjara*; (d) *Diplocotes lawrencei*.

Variation. Brown to yellowish-brown in colour. Specimen from Mt Lindsay darker in colour and slightly larger than specimens from Cheesman Peak. No sexual dimorphism noted.

Etymology. This species is named after the Pitjantjatjara people, the traditional owners of the land that includes the type locality of this species.

Distribution. Known from 2 locations both on Pitjantjatjara lands in the deserts of Central Australia (Fig. 4).

Diplocotes lawrencei sp. n.

Types. *Holotype*. Sex unknown, S. Aust. Whyalla Middleback soil cores October 1981 P. Greenslade. 33°02′S 137°35′E. Deposited in South Australian Museum, registration number I.21805.

Diagnosis. This species resembles *D. kingi* (Westwood), *D. cuneiformis* (Oke) and *D. pitjantjatjara*, in size and pronotal modifications, but can be recognised by having 6 antennomeres and a shallow pronotal pit.

Description. *Habitus*. (Figs 1d,2d,3d) Length approximately 1.5 mm ($n = 1$); rounded abdomen, elytra approximately 1.5 times as long as pronotum in lateral view; reddish-brown to yellowish-brown in colour; pronotum shining and striate; elytra less shiny.

Head. Shiny surface, deeply punctured, with short setae on vertex side, smooth and without setae on frons and genae; eyes very flat; longitudinal ridge at lateral edge of eyes, clearly

Fig. 4. Distribution of *Diplocotes* species: (●) *Diplocotes coliosetus*; (■) *Diplocotes concavus*; (+) *Diplocotes pitjantjatjara*; (▲) *Diplocotes lawrencei*.

visible from above; clypeus subtriangular and protruding; antennae 6-segmented, segments 2–4 wider than long, segments 5–6 enlarged, with segment 5 longer than segment 6, segment 6 with a hollow filled with setae at apex; all antennomeres shiny, segment 1 deeply punctured, segments 2–3 shallowly punctured, segments 4–6 smooth; setae on all segments, but shorter on segment 1.

Thorax. Pronotum with lateral edges expanded outwards to form a sharp projection, approximately at middle; deeper concavity centred medially at basal one-third; basolateral trichomes with deep ventral cavity directly below; ventral surface below trichomes striate, with a row of long setae looped at the end (Fig. 3d).

Elytra. Bulbous, approximately 1.25 times as long as wide; dull, light yellowish-brown in colour; elytral striae with punctures dense but shallowly impressed, separated longitudinally by approximately 2 times their diameters near elytral base, each with short setae of length no more than 1/3 length between punctures.

Ventral surface. (Fig. 3d) Pro-, meso- and metasternum and 1st ventrite hirsute; meso- and metasternum and 1st 2 ventrites concave; 5 ventrites visible; ventrite 2 longest, ventrites 3 and 5 slightly shorter, ventrites 1 and 4 approximately 1/3 length of ventrite 2; ventrites 2–3 striate with short, sparse setae, ventrites 4–5 shallowly punctured with short, sparse setae.

Legs. Short and stout, with shiny surface and sparse setae; femora slightly curved, broadened medially, tibiae broadened medially, flattened and strongly curved; tarsomeres robust, 1–4 approximately as long as wide, tarsomere 5 about twice as long as wide, all segments joined smoothly.

Genitalia. Not examined due to a single specimen known.

Variation. This species is known only from the holotype.

Etymology. This species is named after John Lawrence, in recognition of his earlier work on the Ectrephini, which has made further work on the taxonomy of this group much less difficult than it would otherwise have been.

Distribution. Known only from the type locality near Whyalla, on the coast of South Australia (Fig. 4).

DISCUSSION

The biology and evolution of the Ectrephini has been reviewed by Lawrence and Reichardt (1969), as part of a work on all of the myrmecophilous Ptinidae. They consider the myrmecophilous ptinids to be true symphiles. As the behaviour of most species had not been observed, they came to this conclusion based on the morphological similarities with other myrmecophilous species outside of the Ptinidae, and behavioural observations of the Western Australian *Enasiba tristis* Olliff and *E. microcera* Clark (Clark 1923), and the South African *Diplocotidus formicola* Peringuey (Wasmann & Brauns 1925). More recently, live specimens of the North American *Gnostus floridanus* and their host ants *Crematogaster ashmeadi* Mayr have been taken from an ant nest and observed in the

laboratory. Ants were seen grooming the beetles, picking them up by the prothorax and feeding them by oral trophallaxis (Thomas *et al*. 1992). While the four new species described here have not been observed in the field or lab, similar interactions may occur between these species and their host ants.

Lawrence and Reichardt (1969) combined many different forms in the genus *Diplocotes*, as they believed that too many generic names would be required to separate the species further. They claim that if antennae are used, five genera would be recognised. With the new species described here, seven genera would be needed. They suggested that the structure of the prothorax could also be used to further subdivide the genus, putting *D. armicollis* Lea*, D. laticornis* (Lea)*, D. carinaticipes* (Oke)*, D. kingi* (Westwood) and *D. cuneiformis* (Oke) in one group. They did not do this as *D. foveicollis* Olliff is intermediate between these species and the remainder of the group. Moreover, if we were to use this grouping, *D. pitjantjatjara* and *D. lawrencei* would be in the former group, *D. coliosetus* would be in the latter group and *D. concavus* would be in a new monotypic genus. In the absence of phylogenetic information, we consider it most sensible to continue to use the generic limits of Lawrence and Reichardt (1969).

The genus *Diplocotes* has evolved to live in the arid and semi-arid regions of Australia west of the Great Dividing Range. Lawrence and Reichardt (1969) consider both winglessness and myrmecophily to be adaptations to an arid environment. The trend towards increasing aridity commenced in the mid-Miocene in north-western and central Australia, and in the late Pliocene-Pleistocene in south-eastern Australia. A marked increase in aridity occurred across the continent during the late Pliocene-Pleistocene, with the present-day level of aridity being reached about a half million years ago (Martin 1998). If myrmecophily and winglessness are indeed adaptations to an arid environment, the group would be expected to have started radiating at this time, a hypothesis that could be tested with molecular clock methods.

In the arid regions of Australia (which make up the majority of the continent), collecting focus is concentrated around the main cities of Perth and Adelaide, both located on the coast. The sparsely inhabited central region is difficult to access beyond the major highways, so collection effort there has been relatively sparse. It is therefore expected that further collection will discover more undescribed species. Additionally, the winglessness and myrmecophilous habit may both act to reduce gene flow between populations, leading to fine scale subdivision and speciation by genetic drift. This further leads us to believe that there are probably many species remaining to be discovered.

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