THREE NEW GENERA AND FIVE NEW SPECIES OF DYTISCIDAE (COLEOPTERA) FROM UNDERGROUND WATERS IN AUSTRALIA

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Three new genera and five new species (*Nirridessus pulpa, N. windarraensis, N. lapostaae, Tjirtudessus eberhardi* and *Kintingka kurutjutu)* of stygobiontic beetles of the family Dytiscidae, subfamily Hydroporinae, tribe Bidessini, from relatively shallow, calcrete aquifers at Paroo near Wiluna, and at Windarra near Laverton in Western Australia, are described and figured and their relationship with other Bidessini discussed. Two different species of bidessine larvae were also collected and are described and figured. The species are members of a rich, recently discovered, relictual stygofauna, predominantly of Crustacea and Oligochaeta, inhabiting calcretes lying along the line of the Lake Way-Lake Carey palaeodrainage channel.

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The presence in both fresh and brackish waters of communities of animals living in subterranean water bodies is well known (Botosaneanu 1986; Marmonier *et al.* 1993), but the presence of rich subterranean faunas, both aquatic and terrestrial, in arid Australia has only recently been established (Humphreys 1993a, 1993b, 1993c, in press a), and their derivation debatable (Humphreys in press c)

The Australian aquatic systems either contain faunas of predominantly marine derivation inhabiting anchialine waters (Humphreys 1993b, in press a, in press c; Yager and Humphreys 1996; Poore and Humphreys 1992; Bruce and Humphreys 1993; Bradbury and Williams 1997), or faunas comprising predominantly freshwater lineages inhabiting the groundwater in the shield regions (Poore and Humphreys 1998; Humphreys in press c; Wilson and Keable in press). The faunas respectively appear to be associated with those of the Tethys sea (Humphreys 1993b, in press b, in press c; Yager and Humphreys 1996) and Gondwana (perhaps Pangea; Poore and Humphreys 1998; Humphreys in press c). We report here the discovery of populations of five new species in three new genera of Coleoptera (Dytiscidae, Hydroporinae) living in calcrete aquifers occurring along the line of the large Lake Way–Lake Carey palaeodrainage channel. The dytiscids have been collected from Paroo, near Wiluna, and from Windarra, c. 345 km to the southeast in central Western Australia where they occur in communities comprising Syncarida, Amphipoda, Copepoda, Ostracoda and Oligochaeta.

Abbreviations used

- BES Prefix for field numbers.
- GSWA Prefix for Geological Survey of Western Australia monitoring bore number.
- OP Prefix for piezometer number in the Windarra Calcrete Quarry associated with the Murrin Murrin Nickel Cobalt Project run by Anaconda Operations Pty Ltd. (Dames and Moore 1998).
- SAMA South Australian Museum, Adelaide.
- WAM Western Australian Museum, Perth.

Systematics

Key To Australian Species Of Stygobiontic Bidessini

1. — Body length >3.0 mm; pronotum wider than elytra (Fig. 6); protibia bow-shaped (Fig. 6) ... *Tjirtudessus eberhardi* sp. nov.
   — Body length < 3.0 mm; pronotum same width or narrower than elytra (Figs 3–5); protibia triangular (Figs 3–5) 2
2. — Body length approximately 1.0 mm, surface strongly reticulate, legs stout, without swimming hairs on fore and

midlegs (Fig. 7) .... *Kintingka kurutjutu* sp. nov.

— Body length >1.2 mm, surface at most with weak reticulation, legs normal, all with swimming hairs (Figs. 3–5) .... *Nirridessus* 3

3. — Pronotal plicae strong with inward excavations, metatrochanters pointed, basal two metatarsal segments longer in combination than apical three (Figs 3, 14). ....*N. pulpa* sp. nov.

— Pronotal plicae weak, area between them without excavations, metatrochanters rounded, basal two segments of metatarsi in combination equal to or shorter than apical three (Figs 4, 7, 12, 13) 4

4. — Body length > 2.0 mm; eye remnant small, triangular .... *N. windarraensis* sp. nov.

— Body length < 2.0 mm; eye remnant reduced to a single suture .... *N. lapostaae* sp. nov.

Tjirtudessus gen. nov.

Description

Bidessini. Relatively flat, narrowed at base of pronotum/elytra, eyeless. Head large, without strong sculpture, lacking cervical line. Pronotum very wide, wider than elytra, smooth, basal plicae weakly impressed. Elytron elongate, smooth, evenly covered with very small punctures each with a small seta; epipleuron without basal carina. Hindwing vestigial. Maxillary palpus elongate with large apical segment about same length as segments one to three combined. Labial palpus moderately elongate with apical two segments subequal. Prothoracic process arched, not reaching mesothorax, apical half spatulate. Post-coxal plates with very weak coxal lines, without punctures, adpressed to first abdominal segment. Post-coxae and first and second sternites fused. Protibia widest in middle; protarsi pseudotetramerous. Metatrochanter large, wholly exposed. Metatibia curved, widening towards apex; tarsi elongate; claws equal, very weak.

Etymology

Western Desert Language of the region: *tjirtu*, a beetle-like insect found swimming in water holes; *dessus*, the suffix of the type genus of the tribe, *Bidessus*.

Remarks

Separated from the other eyeless Bidessini described here by its large size, very broad head and pronotum, weak pronotal plicae and metacoxal lines, and non-triangular shape of the protibiae.

Tjirtudessus eberhardi sp. nov.

Description (number examined, 3) Col. Pl. and Figs 6, 11, 15.

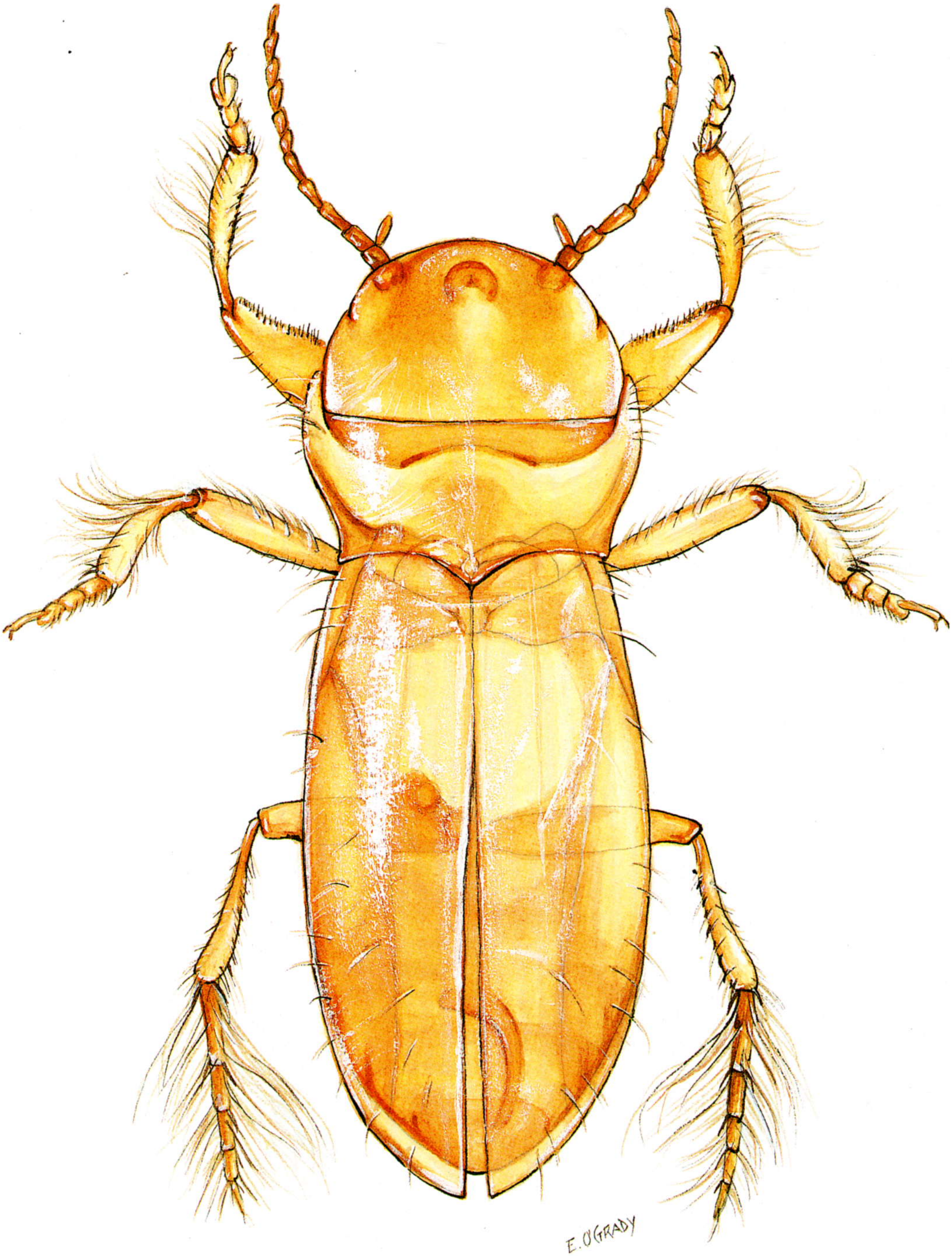
Habitus. Length 3.2–3.5 mm. Strongly constricted at junction of pronotum/elytra; relatively flat; eyeless; uniformly light testaceous. Hindwing vestigial, about half length of elytron.

Head. Large, smooth with a very fine reticulation and sparse weak punctures, subparallel in posterior half, sides with small triangular/oval area outlined by dark sutures in middle near anterior edge. Antenna relatively stout, basal two segments largest, third segment longer and narrower, then progressively shorter and stouter to penultimate, apical segment a bit longer and narrower than penultimate, each segment with some very small setae on inside apically. Maxillary palpus elongate with apical segment large, a little shorter than segments one to three combined, three long setae on outer side and some sensilla towards tip, tip truncated. Labial palpus moderate, apical two segments subequal.

Pronotum. Very broad, wider than elytra, anterolateral angles projecting strongly forward, base quite strongly narrowed, posterolateral angles produced backwards, smooth, with sparse, very weak punctures and a row of stronger punctures along front margin, basal plicae very weakly impressed, only visible in some lights, with row of long setae laterally, denser towards front.

Elytra. Not fused, lacking inner ridges. Elongate, widest behind middle, smooth, sparsely but evenly covered with very small punctures each with a small seta, row of long setae near lateral edge, a few additional long setae more frequent towards sides, some setiferous micropunctures at base and near apex. Epipleuron very broad in anterior fifth, then rapidly narrowing to be virtually absent over rest of elytron..

Ventral surface. Prothoracic process relatively broad, strongly narrowed between coxae, not reaching mesothorax, apical half spatulate, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae meet. Metathorax bluntly triangular in front in



COLOUR PLATE. Adult *Tjirtudessus eberhardi*. Length 3.2–3.5 mm. Artist: Elyse O'Grady.

midline, wings very narrow, virtually absent. Metacoxal plates large, not differentiated into raised central portion and lateral portion. metacoxal lines very short and weak, widely spaced, almost obsolete; punctures very sparse, very weak; closely adpressed to first abdominal sternite. First and second sternites fused, sutural line virtually obliterated, sternites three to five mobile, very sparsely covered with small seta-bearing punctures, sternites three and four with a large central seta or bunch of setae.

Legs. Smooth, without reticulation or punctures. Profemur moderately broad, with a sparse row of thin spines on anterior and posterior edges, a short row of short stout closely spaced spines on front edge at apex; protibia moderately broad, inner edge straight, outer edge bowed, widest near middle, where it is about four times its basal width, with several stout spines at apex, a closely spaced row of small peg-like spines on inner edge and a row of long swimming hairs along outside edge; protarsi with fourth segment very small and hidden within deeply lobed third segment, basal segment broadest, apical segment long and relatively thin, segments one to three with adhesive setae, claws short and simple. Midleg as for foreleg except for lack of small spines. Metatrochanter large, broadly oval, wholly exposed; metafemur elongate, lacking spines, a few short setae; metatibia strongly curved, widening towards apex, a row of about seven relatively long spines on inner edge, two large spines on inner apex, a row of long swimming hairs on ventral surface and a few scattered spines on outer edge; tarsi elongate, with swimming hairs on two sides, basal segment longest, apical segment a little longer than fourth, segments one and two in combination a little longer than others; claws weak (Fig. 15).

Male. Antennae a little stouter, pro- and mesotarsi a little stouter, three basal segments covered on ventral surface with small adhesive setae. Central lobe of aedeagus narrow, narrowing rapidly in apical fifth; paramere broad, two-segmented, apical segment with pronounced, narrow, apical lobe (Fig. 11).

Types

Holotype: ♂. BES 6026, GSWA Bore # 6(B) Paroo Station 25/6/98, 26°26'S 119°47'E, collected by S. M. Eberhard, in spirit, WAM. Registration number WAM 99/60.

Paratype: ♂. Same data as holotype, mounted on slide, WAM. Registration number WAM 99/61.

Associated specimen: ♂. BES 5999 GSWA Bore # 15(A), trap, Paroo Station 25/6/98, 26°24'S 119°46'E, collected by S. M. Eberhard, in spirit, SAMA.

Etymology

Named after Stefan Eberhard in recognition of his expertise and enthusiasm in collecting subterranean fauna.

Nirridessus gen nov.

Description

Bidessini. Broadly elongate, flattened, narrowing somewhat at base of pronotum. Head broad, without strong sculpture, lacking cervical line. Pronotum with sparse weak punctures, basal plicae moderately to strongly impressed. Elytra subparallel, with fine dense punctures; epipleuron quite rapidly narrowing before middle, without basal carina. Hindwing vestigial. Maxillary palpus robust, apical segment equal in length to other three combined. Labial palpus short, stout, apical segment about twice length of penultimate segment. Pronotal process arched, not reaching metathorax, apical half spatulate. Metacoxal plates with relatively short, widely separated coxal lines, weakly granulate/punctate, adpressed to first abdominal sternite. Metacoxal plates and first two sternites probably fused. Protibia strongly triangular; protarsi pseudotetramerous. Metatrochanter large, completely exposed. Metatibia curved, thickening apically; tarsal segments variably elongate; claws equal, weak.

Etymology

Western Desert Language of the region: *Nirri-nirri*, a general term for beetle; *dessus*, suffix of the type genus of the tribe, *Bidessus*.

Remarks

Separated from *Tjirtudessus* by its less expanded head and pronotum (Figs 3–5), relatively strong pronotal plicae, triangular pro- and mesotibiae and presence of a row of large punctures adjacent to the elytral suture; and from *Kintingka* by its larger size, less robust legs, much weaker reticulation, much sparser setae and the presence of swimming hairs on all legs.

Type species

Nirridessus pulpa sp. nov.

Nirridessus pulpa sp. nov.

Description (number examined, 3) Figs 3, 10, 14.

Habitus. Length 2.0–2.2 mm. Elongate, flattened; pronotum broad, narrowing somewhat at base; uniformly testaceous. Hindwing vestigial, reduced to about one quarter length of elytron.

Head. Broad, small; narrow triangular area delineated by dark sutures in middle at edge; very weak reticulation; punctures sparse, weak, row of punctures running backwards from above antennal base. Antenna relatively stout, robust, basal two segments largest, third and fourth smaller then slowly increasing in size to penultimate, apical segment a little longer than penultimate; a few small setae near apex of each segment. Last segment of maxillary palpus elongate, tip truncated, a few small setae near tip.

Pronotum. Broad, a little narrower than elytra; narrowing behind, strongly extended forward at anterolateral angles; very sparse weak punctures and a few larger punctures along front edge; two strongly impressed basal plicae, curving slightly inwards, which reach about half way along pronotum, a depression inwards from each plica at their bases; row of long, thin setae in front half at edges.

Elytra. Fused, lacking inner ridges; subparallel; with sparse small setiferous punctures, small areas of micropunctures at apex and base, a row of much larger weakly impressed punctures beside suture; sides of elytra strongly vertical with scattered, short, fine setae; row of long thin setae at edge, denser towards front.

Ventral surface. Pronotal process arched in lateral view, highest (viewed ventrally) between coxae, apical half narrowly spatulate, narrowing between coxae; not reaching metathorax. Metathorax weakly reticulate, a few fine punctures; sharply triangular in midline in front; wings very narrow, subobsolete, metacoxal plates with weakly raised central portion; coxal lines well separated, weakly diverging anteriorly, reaching to between one half and one third way to mesosternum; weakly reticulate, virtually impunctate; adpressed to abdominal sternite. Metacoxal plates and first and second sternites fused but sutures evident, other sternites free, sternites three and four with central group of setae, otherwise virtually without setae; sparsely and weakly punctate. Epipleuron very broad in front quarter, narrowing quite rapidly to middle then thin to apex, difficult to differentiate from disc, without basal carinae.

Legs. Protibia triangular, about four times as broad at apex than at base which is very narrow, with long swimming hairs; profemur with row of closely spaced small spines on front margin in apical one third to one half with scattered larger spines; protarsi weakly expanded, the fourth segment very small and hidden within deeply bilobed third segment; adhesive setae weak or absent; claws weak. Midleg similar but without small spines. Metatrochanter large, completely exposed, tapering to a broad point, well separated from femur at apex; femur narrowly elongate, anterior edge straight, impunctate, without spines; tibia strongly curved, thickening apically, with a row of long setae in apical half; segments relatively stout, progressively smaller towards apex, apical segment a little longer than fourth, basal two segments longer in combined length than apical three, with two rows of long setae and a number of stout setae at apex of first four segments; claws weak, equal in length (Fig. 14).

Male. Appendages and legs as for female. Central lobe of aedeagus narrow, weakly narrowing to rounded, slightly upturned tip; parameres broad, two-segmented, apical segment with pronounced narrow apical portion (Fig. 10).

Types

Holotype: ♂, BES 6032, Bore # GSWA 5, Paroo Station, 25/6/1998, 26°26'S 119°46'E, collected S. M. Eberhard, in spirit, WAM. Registration number WAM 99/72

Paratypes 3: 1, ♂, BES 6015, Bore # GSWA 6(A), Paroo Station, 25/6/1998, 26°26'S 119°46'E, collected by S. M. Eberhard, lacking head, mounted, WAM. Registration number WAM 99/73; 2, ♀, BES 6002, Bore # GSWA 15(C), trap, Paroo Station, 25/6/1998, 26°24'S, 119°46'E, collected by S. M. Eberhard, in spirit, WAM. Registration number WAM 99/74, ♂, SAMA.

Etymology

Western Desert Language of the region: *pulpa*, "cave".

Remarks

Nirridessus pulpa differs from both *N. windarraensis* and *N. lapostaae* in its much stronger pronotal plicae, much more pointed metatrochanters, narrower more elongate metafemora and stouter metatarsi with relatively short apical segments.

Nirridessus lapostaae sp. nov.

Description (number examined 10) Figs 4, 9, 12.

Habitus. Length 1.3–1.5 mm. Elongate, pronotum narrowing strongly at base; uniformly very light testaceous. Hindwing vestigial, reduced to about one third length of elytron.

Head. Broad, parallel-sided in basal half; rapidly narrowing forward of area where eye would be; a short dark suture at each side in middle at edge; very weak reticulation; punctures sparse, weak, row of setiferous punctures running backwards from above antenna base. Antenna relatively stout, robust, basal two segments broad, third and fourth smaller, then progressively widening until penultimate, apical segment thinner and longer, a few small setae near apex of each segment. Tip of last segment of maxillary palpus truncate, a few small setae towards tip.

Pronotum. Broad in front, narrowing quite markedly behind, strongly extended forward at anterior lateral angles, very sparse weak punctures and a few larger punctures towards front edge; two finely impressed basal plicae, straight, reaching about a third way along pronotum; row of long, thin setae in front half at edges and on forward extensions.

Elytra. Not fused but tightly locked, lacking inner ridges; sides subparallel: with very fine, sparse punctures each with a small seta, a few punctures with longer setae; moderately covered with micropunctures at base and apex, a row of much larger weakly impressed punctures beside suture; sides of elytra quite strongly vertical; with row of long thin setae at edge, denser towards front.

Ventral surface. Pronotal process arched in lateral view, highest point (viewed ventrally) between coxae, apical half broadly spatulate, narrowing between coxae, not reaching metathorax. Metathorax with a few very small punctures; quite sharply triangular in midline in front, wings very narrow, subobsolete. Metacoxal plates with weakly raised central portion; metacoxal lines weak, well separated, diverging in anterior third, reaching about halfway to mesosternum; sparsely punctate; adpressed to first abdominal sternite. Metacoxal plates and first and second sternites fused but sutures evident, other sternites free, sternites three and four with central group of setae, otherwise virtually without setae; virtually impunctate. Epipleuron very broad in front quarter, narrowing quite rapidly to middle, then thin to apex, difficult to differentiate from disc.

Legs. Protibia about five times as broad at apex than at base which is very narrow, with long swimming hairs, row of closely placed small spines on most of inner margin and some large spines towards apex; profemur with row of closely spaced small spines on front margin in apical one third, with scattered larger setae; protarsi quite strongly expanded, the fourth segment very small and hidden within deeply bilobed third segment, adhesive setae weak or absent; claws weak. Midleg similar except for less strongly expanded tarsi and lack of small spines. Metatrochanter large, completely exposed, elongate oval, well separated from femur at apex; femur relatively narrow, anterior edge weakly sinuate, impunctate, without spines; tibia strongly curved, thickening apically, with a row of long setae in apical half; segments elongate, progressively smaller towards apical segment which is a little longer than penultimate, combined length of basal two segments approximately equal to other three, two rows of long setae and a number of stout setae at apex of first four segments; claws weak, outer one slightly smaller than other (Fig. 12).

Male. Appendages and legs as for female. Central lobe of aedeagus moderately broad, concave above, narrowing rapidly close to tip; parameres moderately broad, two-segmented, apical segment with pronounced narrow apical portion (Fig. 9).

Types

Holotype: ♂, BES 6712, piezometer OP122, Windarra W.A. 28°28'40"S 122°07'40"E 18/11/1998, collected by W. F. Humphreys, in spirit, WAM. Registration number WAM 99/65.

Paratypes 6: 1, ? same data as holotype, WAM, registration number WAM 99/66, in spirit; 1, ♀, BES 6548, piezometer OP124, Windarra W.A. 28°29'04"S 122°07'22"E, 18/11/1998, WAM, registration number WAM 99/67, in spirit; 1, ♂, same data, mounted, SAMA; 1, ♀, BES 6559, piezometer OP123, Windarra W.A. 28°28'46"S 122°08'08"E, 18/11/1998, in spirit, WAM, registration number WAM 99/68; 1, ♀, BES 6564, piezometer OP122, Windarra W.A. 28°28'40"S 122°07'40"E, 19/11/1998, in spirit, WAM, registration number WAM 99/69; 2, ♀, BES 6549, piezometer OP122, Windarra W.A. 28°28'40"S 122°07'40"E, 18/11/1998, in spirit, WAM, registration numbers WAM 99/70 & 99/71. All collected by W. F. Humphreys.

Associated specimens: 1, ♂, BES 6712 same data as holotype, in spirit, damaged, SAMA; 1, ♀, BES 6549, piezometer OP122, Windarra W.A.

28°28'40"S 122°07'40"E, 18/11/1998 in spirit, SAMA; fragments of two specimens, same data, in spirit, WAM.

Etymology

Named after Daniella LaPosta of the South Australian Museum for her essential but unsung accounting help and skills.

Remarks

Nirridessus lapostaae differs from *N. pulpa* by its much weaker pronotal plicae and the shape of the midleg. It is more similar to *N. windarraensis* from which it differs in its smaller size, more reduced eye remnant, broader pronotal process, stouter pro- and mesotarsi, relatively shorter apical segment of metatarsi and stouter antennae.

Nirridessus windarraensis sp. nov.

Description (number examined 4) Figs 5, 8, 13.

Habitus. Length 2.2–2.3 mm. Elongate, eyeless, pronotum constricted at base, uniformly light testaceous. Hindwing vestigial, reduced to about one third length of elytron.

Head. Broad, straight-sided in basal half; a very narrow triangular area delineated by dark sutures in middle at edge; punctures sparse, weak, two or three rows of small setiferous punctures running backwards from above antenna base.

Pronotum. Broad, a little narrower than elytra, narrowing smoothly to base, posterolateral angles right angled, anterolateral angles strongly extended forward; very sparse weak punctures; plicae weak, almost straight, reaching to about halfway along pronotum; sparse row of long, thin setae in front half at edges with concentration on anterolateral projections.

Elytra. Elytra not fused but tightly locking, lacking inner ridges; elongate, subparallel in middle half; with sparse weak setiferous punctures, a row of much larger weakly impressed punctures beside suture, quite large areas of micropunctures near base and near apex, sparse over rest of elytra; sides of elytra quite strongly vertical with short fine setae; with row of moderately long thin setae at edge, denser towards front. Antenna moderately stout, basal two segments relatively broad, third segment narrowly triangular, successive segments gradually shortening and thickening, except apical segment which is bit longer than penultimate, a cluster of small setae near apex of each segment. Apical segment of maxillary palpus weakly bifid at tip, oblique ring of small setae near tip.

Ventral surface. Pronotal process relatively narrow, strongly arched in lateral view, highest point (viewed ventrally) between mesocoxae, apical half spatulate, narrowing between coxae, not reaching metathorax. Metathorax with a few scattered weak punctures; broadly pointed in midline in front, wings very narrow, subobsolete. Metacoxal plates large, with weakly raised central portion, coxal lines weak, well separated, moderately diverging in anterior half; reaching to about one third way to mesosternum; smooth, virtually impunctate except a few towards midline; adpressed to first abdominal sternite. Metacoxal plates and first and second sternites fused, suture lines between first and second sternites obliterated laterally, other sternites free, sternites three and four with central group of setae, otherwise virtually without setae; weakly and very sparsely punctate. Epipleuron broad in front quarter, narrowing quite rapidly to middle then thin to apex, difficult to differentiate from disc.

Legs. Protibia triangular, about five times as broad at apex than at base which is very narrow, with long swimming-hairs, row of closely spaced small spines on inner margin and some strong spines towards apex; profemur with row of closely spaced small spines on front margin in apical one third, with scattered larger setae; protarsi weakly expanded, the fourth segment very small and hidden within deeply bilobed third segment, adhesive setae small; claws weak. Midleg similar except for lack of fine spines. Metatrochanter large, completely exposed, oval, well separated from femur at apex; femur relatively narrow, anterior edge weakly sinuate, virtually impunctate, without spines; tibia strongly curved, thickening apically, with a row of long setae in apical third; segments relatively thin, apical one longer than penultimate, basal two segments shorter in combined length than apical three, with two rows of long setae and a number of stout setae at apex of first four segments; claws weak, inner one slightly shorter than outer (Fig. 13).

Male. Appendages and legs as for female. Central lobe of aedeagus narrow, concave on top, narrowing rapidly near apex to narrow tip; parameres not particularly broad, two-segmented, apical segment with pronounced narrow apical portion (Fig. 8).

Types

Holotype: ♂, BES 6712, piezometer OP122, Windarra W.A. 28°28'40"S 122°07'40"E 18/11/

1998, collected by W. F. Humphreys, in spirit, WAM. Registration number WAM 99/62.

Paratypes 2: 1, ♂, BES 6549, piezometer OP122, Windarra W.A. 28°28'40"S 122°07'40"E. 18/11/1998, mounted on slide, WAM, registration number WAM 99/63; 1, ♂, BES 6559, piezometer OP123, Windarra W.A. 28°28'S 122°08'08"E, 18/11/1998, in spirit, WAM, registration number WAM 99/64. All collected by W. F. Humphreys.

Associated specimens: 1 ♀, BES 6549, same data as paratype, in spirit, SAMA; parts of two specimens, BES 6558, piezometer OP123 same data as above.

Etymology

Named after the type locality.

Remarks

Separated from *N. pulpa* by its much weaker pronotal plicae and the structure of the midleg. From *N. lapostaae* it differs in its larger size, more parallel-sided elytra, presence of small triangular areas where eyes would be, narrower pronotal process, more elongate metatarsi, and less robust pro- and mesotarsi.

Kintingka gen. nov.

Description

?Bidessini. Narrowly oval, weakly flattened, eyeless. Head very broad, strongly reticulate, lacking cervical line. Pronotum strongly reticulate, basal plicae finely, sharply impressed. Elytron strongly reticulate, with numerous short fine setae, epipleuron without basal carina. Hindwing vestigial. Maxillary palpus broad, apical segment greater than length of other three combined. Labial palpus stout, approximately the same size and length as maxillary palpus. Pronotal process moderately arched, apical half spatulate, not reaching mesosternum. Metacoxal plate strongly reticulate, coxal lines weak; coxal lobes adpressed to but possibly not fused to first abdominal sternite. First two abdominal sternites possibly fused. Protibia strongly triangular; protarsi pseudotetramerous. Metatrochanter completely exposed; metatibia stout, straight, expanding a bit towards apex; tarsal segments robust; claws equal, very small. Fore and midlegs without swimming hairs.

Etymology

Western Desert Language of the region; *Kintingka*, a beetle-like insect found swimming in water holes.

Remarks

Separated from the other eyeless Bidessini described here by its small size, strong reticulation, relatively dense covering of setae, stout palpi, stout legs and lack of swimming hairs on fore and midlegs.

Kintingka kurutjutu sp. nov.

Description (number examined, 1) Figs 7, 16.

Habitus. Length 1.0 mm. Narrowly oval, weakly flattened; uniformly testaceous; hindwing vestigial.

Head. Broad, bulges outwards at sides behind where eyes normally are; strongly reticulate; a few setiferous punctures on each side about where inner edge of eye would be; small suture at side of head in middle. Antenna stout, basal two segments largest, next two smallest, then slowly increasing in size to penultimate, apical segment twice length of penultimate; a few very small setae on inside at apex of each segment. Maxillary palpus very broad; apical segment greater than length of other three combined; tip narrowed, truncated, a diagonal row of a few setae towards tip. Labial palpus broad, approximately the size and length of maxillary palpus.

Pronotum. Broad, narrowing towards rear; anterolateral angles strongly projecting forward; posterolateral angles bluntly produced backwards; reticulate, sparsely covered with very small punctures each with a relatively long fine setae; pronotal plicae very fine, sharply impressed, reaching half way along pronotum.

Elytra. Not fused; without inner ridge; reticulate; moderately covered with minute punctures, each with a relatively long fine setae; with a row of long thin setae at edges.

Ventral surface. Pronotal process moderately arched in lateral view, highest point (viewed ventrally) between coxae; spatulate in apical half; very narrow between coxae; not reaching metasternum. Mesocoxae meet. Metasternum sharply triangular in midline in front; wings very narrow; reticulate; a few relatively long setae in mid line. Metacoxal plate not raised in midline; coxal lines virtually absent; strongly reticulate; with sparse, very small punctures, more frequent towards midline, each with a quite long seta; adpressed to, but possibly not fused to first abdominal sternite. First and second sternites fused, with obvious suture; sternites three to five free, covered with rather long setae; three and four with small patch of very long setae in middle. Epipleuron rather narrow in front, progressively narrowing to apex.

Legs. Foreleg very stout; femur strongly reticulate, virtually without spines; tibia triangular, about five times as broad at apex than at base; reticulate; a row of closely spaced small spines on inner margin and some strong spines towards apex; tarsi with fourth segment very small and hidden within deeply bilobed third segment, basal three segments moderately expanded, almost bare of setae ventrally, apical segment stout; claws rather weak. Midleg very stout; femur and tibia strongly reticulate; tibia and tarsi a little less stout than on foreleg. Metatrochanter reticulate, completely exposed, very large, inner edge rounded, outer edge straighter, apex well separated from femur; femur reticulate, stout, without setae, with one spine at apex on inside; tibia stout, straight, much narrower at base than apex, with numerous spines, some strong; tarsi robust, with numerous stout spines, segments progressively smaller except apical which is a bit smaller than fourth, basal two segments in combination about same length as other three; claws equal, extremely small. Fore and midlegs without swimming hairs, swimming hairs weakly developed on metatibia and tarsi (Fig. 16).

Male. Not known.

Types

Holotype: ♀, BES 6032, GSWA 5, Paroo Station 25/6/1998, 26°26'S 119°46'E, coll. S. M. Eberhard, mounted on slide, WAM. Registration number WAM 99/75.

Etymology

Western Desert Language of the region; *kurutjutu*, "blind".

Larva form 1. Figs 17–22

Length 4.2 mm (not including urogomphi). Light testaceous, head darker than rest; eyeless; head proportionally very broad. Head capsule broad, relatively round without marked neck region, sides with some quite strong spines; nasal large, as long as the rest of head, broad, without lateral notches but with a prominent downward pointing small spine/tooth on each side near middle, band of small spines/teeth around front edge ventrally (Fig. 19). Mandibles relatively strong. Labium small, with a few long setae, palpus long and slender (Fig. 20). Maxillary stipe simple, palpus long and slender (Fig. 18). Antenna a little shorter than maxillary palpus, second and third segments same length, apical segment smaller, accessory appendage well developed, a little shorter than apical segment. Thoracic segments weakly sclerotized, sparse row of quite strong setae on posterior edges dorsally. Abdominal segments weakly sclerotized, quite numerous strong setae on posterior edges dorsally and at sides, microsetae arranged in rather short irregular lines. Apical segment with moderate siphon. Trachea in siphon and those at sides of abdominal segments of normal size. Urogomphi broken, only a short basal portion of one remaining which has a long ventral setae near base, a very small dorsal seta near base and a slight notch on the outer side which is the attachment point of a seta which has been broken off; shaft microreticulate, meshes moderate with very fine microsetae along edges of reticulation, becoming noticeably stronger near base. Legs long, relatively thin, with standard set of hydroporine primary setae, moderate number of secondary setae, lacking setae TR2 (Nilsson 1987), lacking swimming hairs (Figs 21, 22). A few very long setae on sides of thoracic and abdominal segments, more frequent posteriorly.

Association with adult

We think that this larval specimen is an early final instar that will thicken and elongate considerably before pupation. Most probably it is the larva of *T. eberhardi* since it would seem to be already too large to belong to *N. pulpa*.

Specimen data

1, BES 6017, Bore # GSWA 6(A), Paroo Station, 25/6/1998, 26°26'S 119°47'E, collected by S. M. Eberhard, mounted on slide, WAM.

Larva form 2. Figs 23–29

Length 1.2 mm (not including urogomphi). Almost transparent, head a very light testaceous. Head broad, relatively large, eyeless, without neck region, without lateral spines, with a few very long setae towards front at sides; nasal very broad, lacking lateral notches, about as long as rest of head, row of very large strong setae/teeth around much of ventral edge (Figs 24, 26, 27). Labium small; palpus robust, apical segment narrower in apical half (Fig. 25). Maxillary stipe simple; palpus robust, apical segment small (Fig. 23). Antenna short, stout, apical segment thin, accessory appendage about half length of apical segment. Mandibles relatively thin. Thoracic and abdominal segments weakly sclerotised; a few moderate setae and some very long ones laterally, more numerous posteriorly; microsetae relatively dense, in long lines. Apical segment with moderate siphon; urogomphi moderately long, two segmented, basal segment with three long setae plus a group of three long setae at apex, apical segment with one long seta attached a short distance from apex; microreticulation meshes large, almost annular, with short fine microsetae along edges. Tracheae absent. Legs relatively stout with only the standard hydroporine set of primary setae, TR2 absent, swimming hairs absent; tarsal claws moderately strong (Figs 28, 29).

Association with adult

All four specimens are similar in size and structure. Their fragile appearance, absence of tracheae, sparseness of abdominal setae, and lack of secondary setae on the legs suggest that they are first instar larvae. If so, their size would associate them with *N. pulpa*. Their very stout cephalic appendages and broad squat nasal are too different from those of form 1 for them to belong to the same species.

Specimen data

1, BES 6028, Bore # GSWA 6(B), Paroo Station, 25/6/1998 26°26'S 119°47'E, mounted on slide, WAM; 1, same data, in spirit, SAMA; 1, BES 6022, Bore # GSWA 6, Paroo Station, 25/6/1998 26°26'S 119°47'E, in spirit, WAM; 1, BES 5994, Bore # GSWA 16, Paroo Station, 24/6/1998 26°26'S 119°44'E, in spirit, WAM. All collected by S. M. Eberhard.

Systematic Relationships

Tribal placement

The small size, lack of a visible scutellum, pronotal process on two planes, pseudotetramerous protarsi and larval nasal, place these new genera in the subfamily Hydroporinae. They all lack defining synapomorphies for the Hydrovatini (incised metacoxal process, very broad pronotal process, modified apical sternite [Biström 1996]), and Hyphydrini (unequal metatarsal claws) and appear, quite clearly, to belong within Bidessini and/or Hydroporini.

We place all three new genera in the Bidessini. Our reasons, in descending order of importance, are as follows.

The two genera whose parameres are known possess the unique Bidessini synapomorphy of two-segmented parameres (Biström 1988, 1996).

The two known larval species lack notched nasals and hence would seem to lie outside of the Hydroporini, if Wolfe's identification of this character state as a synapomorphy for Hydroporini is correct (Wolfe 1985). This is true within Australia. However the larvae of *Haideoporus* and *Morimotoa* which are both subterranean and currently placed in the Hydroporini (a placement supported by their single segmented parameres) do not have notched nasals (Young and Longley 1976; Longley and Spangler 1987; Uéno 1957).

The species lack spines along the outside edge of the metatarsi. Such spines are present in all Australian hydroporini but are absent in all Australian bidessini except for one or two on the basal segment in some species. The usefulness of this character outside Australia or its polarity is unknown (*Hydrovatus* and *Hyphydrus* lack such spines, whereas *Laccornis* has them).

The presence of pronotal plicae. Although found in the Australian hydroporines, *Sternopriscus*, *Necterosoma* and *Barrethydrus*, this character is more typical of bidessines (Biström 1988).

Open metatrochanter bases. Typical of bidessines but also approached in some hydroporines, particularly the Australian *Paroster*, *Necterosoma* and *Carabhydrus* and in Hyphydrini. Not present in the Hydrovatini (Biström 1996).

Fusion of metacoxal plates and first and second abdominal sternites. Again almost universally present in the Bidessini but also present in some hydroporines (Biström 1988; Wolfe 1985; Larson and Storey 1994).

Metatibia strongly narrowed at base and, in *Tjirtudessus* and *Nirridessus*, also strongly curved. This is a typical bidessine character but is also present in some Hydroporini including the Australian *Sternopriscus* (Biström 1988; Larson and Storey 1994).

There are three other possible tribal placements that need to be considered.

Smrz (1982) created a separate tribe, Siettitini, specifically for Hydroporinae living below ground and exhibiting such characters as eyelessness, flightlessness, lack of pigment, development of long sensory setae and prosternal process not reaching the mesosternum. Although useful taxonomically, it is widely recognised that this is an artificial classification, grouping together phylogenetically unrelated taxa simply because of common adaptations to an underground existence

(Young and Longley 1976; Pederzani 1995).

Watts (1978) created the tribe Carabhydrini for the peculiar Australian genus *Carabhydrus*. Larson and Storey (1994) discussed this placement, concluding that although some uncertainty regarding its true position remained, it was probably best to consider *Carabhydrus* to be a member of the Hydroporini. We accept their argument and tentative conclusion.

The new genera could be considered as a separate tribe. We can find no good reasons to suggest this.

Relationships within the Bidessini

None of the new genera appears close to any Australian Bidessini. However the presence of pronotal plicae, the form of the parameres, the simple central lobe of aedeagus, the lack of or weak development of elytral setae, the lack of sutural striae, the weak punctation and lack of basal carinae on the epipleura point quite strongly to a relationship to *Limbodessus*, *Liodessus* or *Boongurrus*, even though the new genera lack a cervical stria, identified by Biström (1988) to be a phylogenetically significant character in the Bidessini, and which is present in *Liodessus* and *Boongurrus*. However this character appears in the process of being lost in *Boongurrus* (Larson and Storey 1994), which is a very small species found in sand and gravel at the headwaters of small streams and shows signs of an incipient underground existence suggesting that this character could have been lost in the truly subterranean genera.

Beyond Australia four genera of subterranean Bidessini (based primarily on the presence of two-segmented parameres [Biström 1988]) have been reported: *Trogloguignotus* Sanfilippo, 1958 from Venezuela; *Comaldessus* Spangler and Barr, 1995 from the United States of America; *Sinodytes* Spangler, 1996 from China; and *Glareadessus* Wewalka and Biström, 1998 from the Persian Gulf region. In addition a species of *Uvarus* Guignot, 1939 (*U. chappuisi* [Peschet 1932]) has been collected from a well in Upper Volta (Burkina Faso). Of these, *U. chappuisi* is little modified from its surface congeners and the two species of *Glareadessus* are not greatly different from *Hydroglyphus* Motschulsky, 1853 (Wewalka and Biström 1998). Both *Trogloguignotus* and *Comaldessus* differ from the Australian genera in the presence of elytral plicae, and in having the prosternal process reaching the metasternum. *Sinodytes* is more similar but differs in its four segmented pro- and mesotarsi, the prosternal process reaching the metasternum, relatively strong punctation and, from *Tjirtudessus* and *Nirridessus*, lack of swimming hairs on legs. None of these non-Australian genera appear to be close to the new Australian ones.

A much more detailed phylogenetic study is needed before a clear idea of the relationships of the new genera is obtained but we predict the sister group, or groups, will be found within the current Australian bidessines, possibly near *Liodessus*, *Limbodessus* or *Boongurrus*.

Relationships between the new genera and species

The three new genera share a number of characteristics which suggest a relatively close relationship between them within the Bidessini, based on Biström's 1988 review. All lack a cervical stria, a basal carina on the epipleuron, a margined frons, elytral plicae or sutural striae and all have short, moderate to strongly arched pronotal processes not reaching the metasternum which is rarely found in the Bidessini and not found in any Australian genus. This would seem to suggest a relatively recent common origin from within a restricted section of the Bidessini. Unfortunately the polarity of these character states is unknown. They may also, as is likely in the case of the short, arched pronotal process, represent adaptations to a subterranean existence and hence have little phylogenetic content.

Of the five species *K. kurutjutu* appears more distant than the others. Its rounded shape, stout legs and appendages and unusually strong reticulation appear to be characters retained from its terrestrial ancestor and to suggest a more distant phylogenetic origin to the others. In all these characters it most closely resembles *Paroster*, and the blind, terrestrial, *Terradessus*, both in the Hydroporini, although, as argued above, we have placed it in the Bidessini, a position that must be considered tentative until the discovery of the male.

The strikingly similar parameres of the four other species, a character perhaps less subject to evolutionary change in a new environment, suggest a relatively close relationship between them. Within these the large size, cordate shape, subobsolete pronotal plicae and metacoxal lines, and bow-shaped protibiae separate *T. eberhardi* from the remaining species which seem relatively closely related to each other, reflected in our placement of them in the one genus, *Nirridessus*. Within *Nirridessus* the rounded metatrochanters, sinuate metafemora and elongate metatarsi seem, on a first analysis, to be derived characters and to link *N. windarraensis* and *N. lapostaae* as sister species. They also lack the strong pronotal plica of *N. pulpa*. These differences are quite large in terms of bidessine taxonomy and it is quite possible that future studies will support their separation into two genera.

The two larvae, which we have associated with *T. eberhardi* and *N. pulpa*, are very different with ? *T. eberhardi* having long legs, elongate cephalic appendages, enlarged nasal but without strong spines/teeth in contrast to the stout legs and cephalic appendages and greatly developed spines/teeth on the nasal in ? *N. pulpa*, and, if the associations are correct, support the generic separation of the two species.

In summary we tentatively suggest that *N. windarraensis* and *N. lapostaae* are sister species. *Tjirtudessus* and *Nirridessus* are sister genera with the position of *Kintingka* more distant and problematical.

Adaptations To Subterranean Life

Many species found living underground display certain characteristic traits that are thought to be adaptive to underground life. These include both the reduction or loss of characters (regressive evolution) and the enhancement of others (constructive evolution), which together produce the convergence characteristic of cave-adapted animals, that is termed troglomorphy. These adaptations include morphological, ecological, physiological and behavioural characteristics (Christiansen 1992; Culver et al. 1995).

General shape and size. Enlarged head, flattening of the body and narrowing at the pronotal elytral junction are common features of subterranean Hydroporines. *Tjirtudessus* exhibits these characters to the greatest degree with *Nirridessus* and *Kintingka* seemingly less altered. Size is a character that often changes in animals exhibiting marked adaptation to subterranean life, those living in large voids are larger while those inhabiting interstices are smaller than is typical for their lineage. *Kintingka* is among the smallest Dytiscidae while on the other hand *Tjirtudessus* is unusually large for a Bidessine, only *Bidessodes grossus* approaches it in size within the Australian fauna. Whether these size characteristics reflect the spaces they inhabit or some other aspect of niche partitioning is unknown: nonetheless the size (length) ratios of the two series of sympatric species are well beyond that considered necessary for niche separation, being for Paroo 1.6 and 2.1 (mid-point of range) and for Windarra 1.6.

Eyes. Loss of eyes is typical of subterranean animals. All three genera are eyeless. In some lights "ghosts" of ocelli can be seen in *N. pulpa*. At the sides of the head, where the eyes would have been, there is a cuticular area bounded by sutures. In *T. eberhardi*, *N. pulpa* and *N. windarraensis* this is a small, narrowly oval area. This is further reduced to a small suture in *K. kurutjutu* and *N. lapostaae*.

Wings. The elytra of *N. pulpa* are fused. In all the other species the elytra separated on dissection/preparation. In most Hydroporinae there is an inner ridge near the side of the elytron, thought to be associated with locking the elytra against the abdomen (Wolfe 1985). This is lacking in the new species suggesting that even in *Tjirtudessus* and *Kintingka* the elytra are normally tightly closed by some other mechanism.

In *T. eberhardi* and the three *Nirridessus* species and probably also in *K. kurutjutu*, the forewing is quite long but narrow, flimsy and veinless. In all five species it is obviously well on the way to being lost.

Sensory structures. All five species have the long thin sensory setae around the body recorded for all subterranean Hydroporinae (Spangler 1986). On the antennae and palpi there are small setae that probably have a sensory function. All the species have concentrations at the base and apex of the elytra of minute setae-bearing punctures. Apart from their very small size and seeming absence in the few terrestrial species we have looked at, these appear normal but they may have a specific sensory function. In *Kintingka* there are a few cuticular sensilla on the top of the head, but otherwise we have been unable to find any sensory organs, such as described by Smrz (1983) for other subterranean Hydroporinae. More detailed investigation of new material may well find more such organs.

Colour. As in most subterranean animals the new genera lack pigment and all are partially transparent, particularly the larvae.

Sculpture. All known subterranean Hydroporinae have smooth shiny surfaces, with weak to very weak punctures or setae on both dorsal and ventral surfaces. Only two, *Trogloguignotus* and *Uvarus*, have raised structures such as plicae or striae. In both *Tjirtudessus* and *Kintingka* pronotal plicae are traceable but very fine, suggesting that they are in the process of being lost. However in *Nirridessus* the plicae are relatively strong and, in *N. pulpa*, have a well marked excavation inside them. In *Kintingka* the reticulation on both surfaces is unusually strong, even for a terrestrial bidessine. The setae in the dorsal punctures are strong in *Kintingka*, although the density of punctures is not great.

Larvae. Both larval types show the typical loss of eyes and colour of subterranean animals. Compared with Australian terrestrial Bidessini larvae the larger larva form 1 has a disproportionately large head and long legs and a strong nasal. The smaller larva form 2 is most noticeable for its strong development of nasal spines (Fig. 21).

Habitat

All the beetles were taken by plankton net or trap from boreholes in calcrete aquifers associated with the Lake Way–Lake Carey palaeodrainage channel (Fig.1) on the Yilgarn craton of Western Australia.

The palaeodrainage channels in the Yilgarn are old – they contain patches of Permian fluvio/glacial sediments – and were deeply incised into a plateau of Precambrian rocks during the Permian or earlier: there is an absence of sediment between the Permian and Eocene throughout the Western Proterozoic basins (L. Worrall, personal

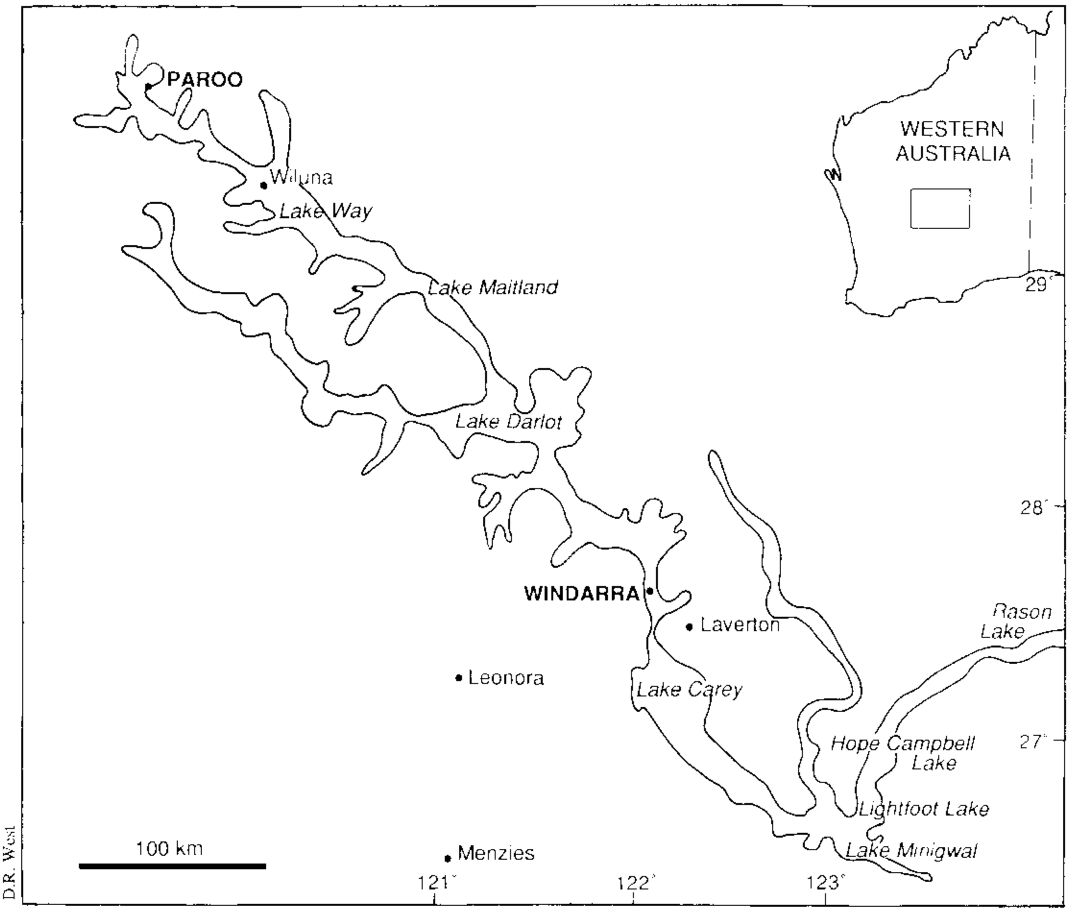


FIGURE 1. Map showing the extent of the Lake Way-Lake Carey palaeodrainage channel on the Yilgarn craton. The channel continues through Rason Lake to the Eucla Basin. The adjacent palaeodrainage channels are not shown. Groundwater calcretes are mostly associated with the 'lakes' (salinas, playas) that overlie the palaeodrainage channel in places. **Inset**: location of the site in Western Australia.

communication 1998). Towards the south the minor palaeodrainage lines probably formed after the uplift of the Darling Plateau and Eocene marine transgressions deeply penetrated the palaeovalleys along the western margin of the Eucla basin (Jones 1990; L. Worrall, personal communication 1998) when conditions were tropical. It is of interest that the amphipods from the southern sites are Ceinidae (J. Bradbury, personal communication 1998), a family of marine ancestry (Barnard and Karaman 1984) while those from the northern site are crangonyctoids, an ancient freshwater lineage (J. Bradbury personal communication).

The northern samples were from an aquifer in Tertiary calcrete deposits on Paroo Pastoral Station (altitude 520 m AHD) in the Paroo sub-basin of the Lake Way Basin in central Western Australia (Figs 1 and 2). All bores from which stygofauna were obtained overlay Proterozoic shale. Locally the calcretes overlay Proterozoic dolomite, sandstone and shale, and are overlain in places by Quaternary alluviums and colluviums (Fig. 2), and this juxtaposition is probably the source from which this possibly old fauna – by analogy with other areas (Humphreys 1993; in press a, in press b; Poore and Humphreys 1998) – invaded these inland-draining palaeochannels. Bores in the Proterozoic and Quaternary facies (Fig. 2) were also investigated but no stygofauna was found.

Calcretes are carbonate deposits forming near the water table in arid lands as a result of concentration processes by near-surface evaporation (Jacobson and Arakel 1986). Groundwater calcretes (Arakel 1996) often

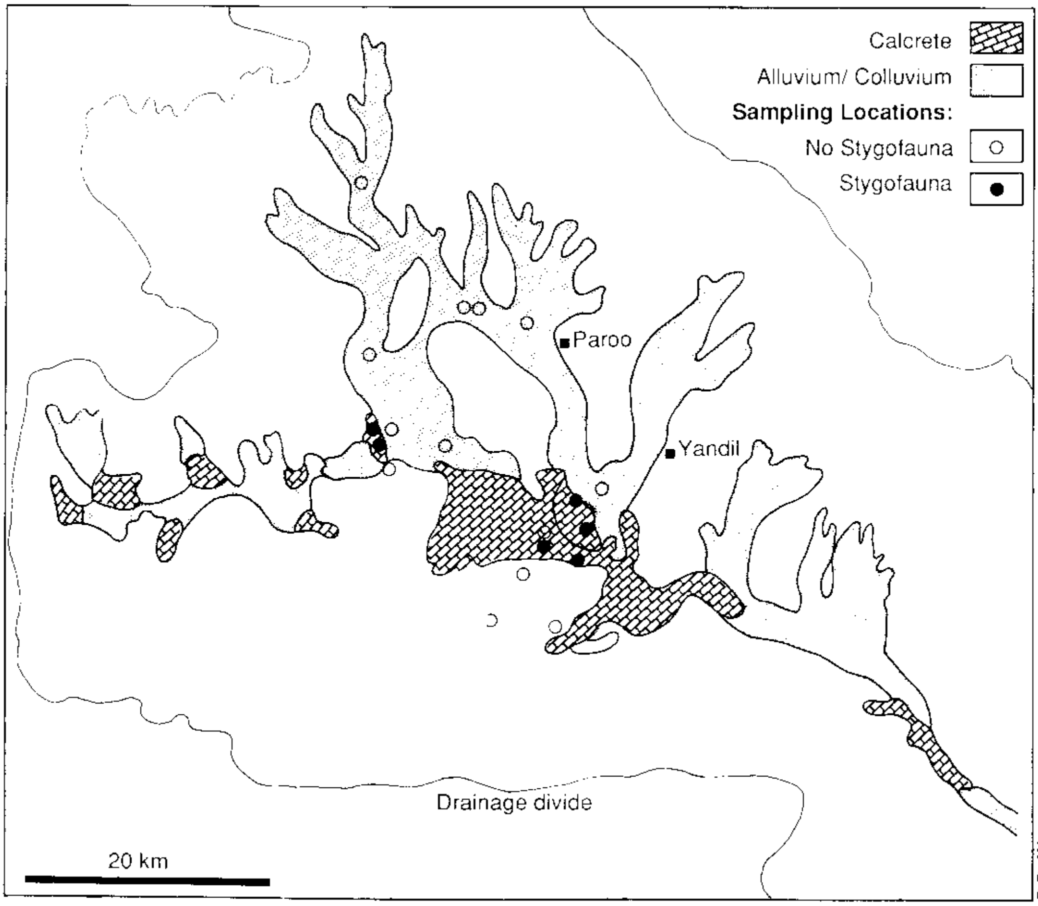


FIGURE 2. Location of the sample sites in the Paroo sub-basin of the Lake Way Basin in Western Australia. **Inset**: location of the site in Western Australia. Base map after Sanders (1973).

TABLE 1. Data for collecting localities.

Bore	Latitude	Longitude	Depth(m)	Comments
GSWA Bore#15	26° 24' 02" S	119° 45' 47" E	27.4	cavernous calcrete/ shale
GSWA Bore#16	26° 25' 31" S	119° 43' 43" E	15.0	shale
GSWA Bore#5	26° 26' 25" S	119° 46' 19" E	22.3	shale
GSWA Bore#6 (A)	26° 26' 02" S	119° 46' 38" E	30.5	observation well, shale
GSWA Bore#6 (B)	26° 26' 02" S	119° 46' 38" E	•	observation well
GSWA Bore#6 (C)	26° 26' 02" S	119° 46' 38" E	•	observation well
OP 113	28° 29' 28.4" S	122° 07' 07.2" E	4.20 (0.05)	piezometer
OP 118	28° 29' 11" S	122° 07' 13" E	5.25 (1.55)	piezometer
OP 122	28° 28' 40" S	122° 07' 40" E	3.50 (0.40)	piezometer
OP 123	28° 28' 46" S	122° 08' 08" E	2.05 (0.15)	piezometer
OP 124	28° 29' 04" S	122° 07' 22" E	3.95 (0.10)	piezometer

develop typical karst features (Barnett and Commander 1985). Such a calcrete aquifer covers c. 90 km^2 of Paroo Station. The upper surface of the calcrete is rubbly and sometimes karstic and so the surface is permeable because of sinkholes and caverns. Opaline silica occurs at about the water table. Below this layer caverns and interconnected conduits have also developed in the friable calcareous material as the result of groundwater circulation. The calcrete varies in thickness between 7.6 and 11.6 m with an average saturation thickness of 4.5 m (Sanders 1973).

Groundwater occurs widely in the Paroo sub-basin and as close to the surface as 4.3 m in places (Table 1). The calcrete is recharged by rainfall through the porous surfaces. Rainfall in the region is low, c. 200 mm per year, and highly episodic with storm rainfalls of 76 mm and 119 mm expected at frequencies of once every two years and five years respectively (Sanders 1973). In consequence the groundwater table varies quite widely between storm events.

When investigated in 1973 – attributes may now differ – the total salinities within the Paroo calcrete ranged from 710–1330 mg L^{-1} TDS when the borefield characteristics were established (Sanders 1973) but was not much stratified within boreholes. There is a general increase in salinity downstream up to 4400 mg L^{-1} TDS. The calcrete aquifers eventually drain to the salt lakes in the Lake Way system which act as evaporation basins.

The southern samples were taken from piezometers (altitude 416–418 m AHD) associated with a calcrete quarry at Windarra (Fig. 1), adjacent to the lower reaches of the Lake Way–Lake Carey palaeodrainage system at depth. In this region no subterranean fauna was recovered from either the Roy-Valais Borefield or the Korong North Borefield developed in aquifers in basal palaeosands overlain by substantial layers of clays in the palaeovalley deposits.

The calcrete deposit at Windarra reaches a maximum thickness of about six metres – it is overlain by c. 1 m of ferruginous, clayey, unconsolidated sand – and is typical of the groundwater calcretes widely occurring in the Australian arid zone. There are well developed karst features within the area covered by the piezometric field that are typical of those found elsewhere in calcrete (Sanders 1973) and in those supporting stygofauna (Poore and Humphreys 1998; W. F. Humphreys, unpublished). In the quarry area the water table is shallow (3.34 m [s.d. 0.89 range 1.90–4.15 below the natural surface,] at the time of sampling) (Table 1). As such the calcrete comprises a highly permeable aquifer with limited saturation thickness. The salinity in the Windarra Calcrete Quarry area ranged from c. 1500–3200 mg L^{-1} TDS at the time of sampling but has been reported as high as 4100 mg L^{-1} TDS in places (Dames and Moore 1998).

Associated Fauna And Biology

The three genera of dytiscids are sympatric at Paroo (Table 2) and two congeneric species are sympatric at Windarra (Table 3) and they are found together with syncarid crustacea (Bathynellacea), crangonyctoid amphipods (gen. nov.; J. H. Bradbury, pers. comm.), phreodrillid oligochaetes (a Gondwanan lineage), cyclopoid copepods and candonine ostracods (Tables 2 and 3). Undoubtedly more comprehensive sampling of the aquifer will add to this fauna, especially at Windarra where the entire volume of water accessible for sampling was only c. 4.4 L.

TABLE 2. The distribution of stygofauna in the Paroo area. Ten bores were sampled from six sites and only one site yielded no fauna. The numbers under 'Wells' denote the number of wells out of 12 from which taxon was sampled. L denotes larvae presumed to represent *N. pulpa* and *T. eberhardi*. Note the more or less complete restriction of stygofauna to bore samples as opposed to open wells.
* = stygofauna, otherwise epigean species.

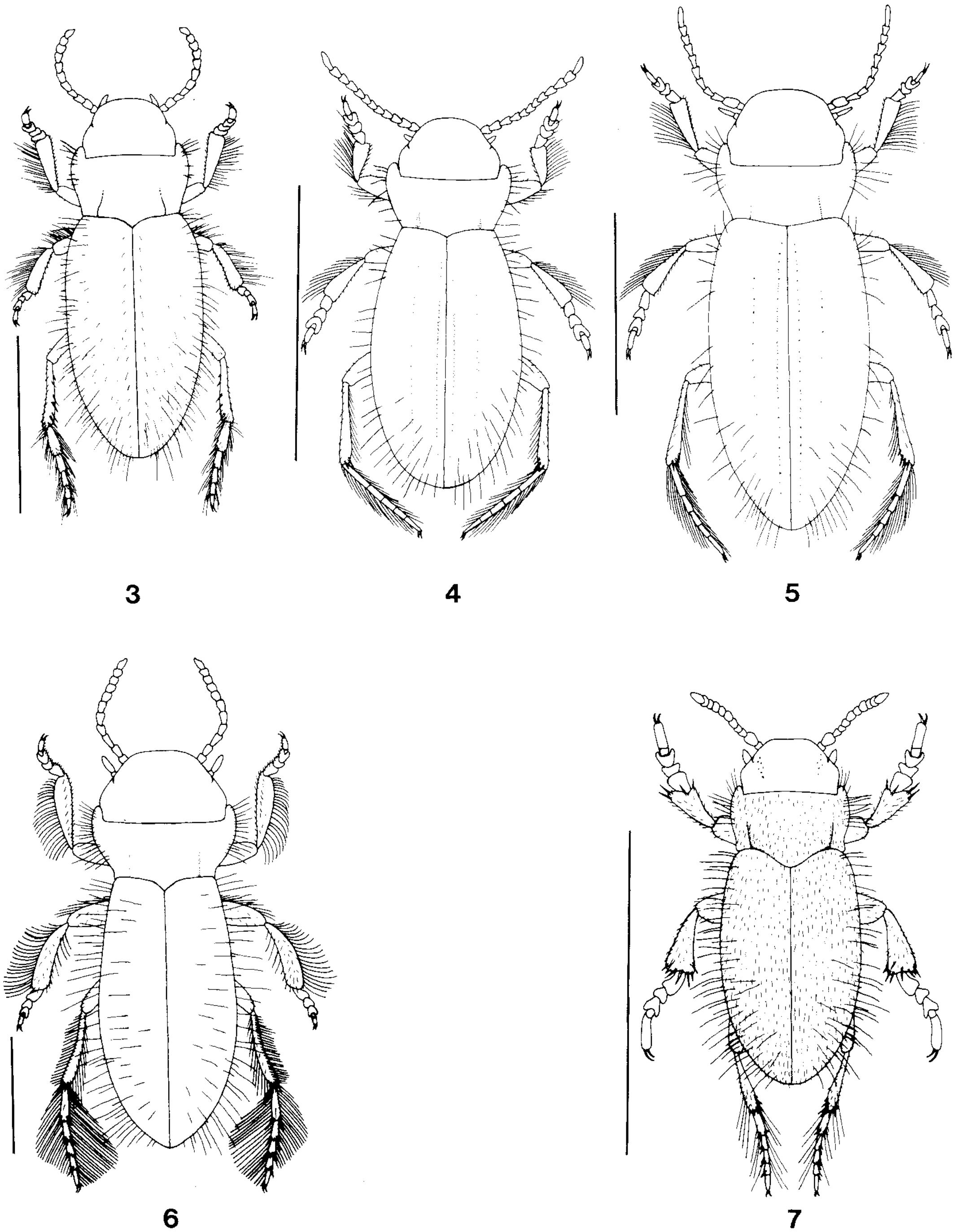
	GSWA Bore	5	6	15	16	20	Wells
Dytiscidae	*Tjirtudessus eberhardi* sp. nov.*	–	+L	+	–	–	–
	Nirridessus pulpa sp. nov.*	+	+L	+	L	–	-
	Kintingka kurutjutu sp. nov.*	+	+	–	–	–	–
Crustacea	Bathynellacea*	-	+	+	–	+	+
Amphipoda	Crangonyctoid*	+	+	+	+	+	–
Copepoda	Cyclopidae	+	+	+	+	+	+
Ostracoda	Cypridinae	–	–	–	–	–	1
	Sarcypridopsis cf *aculeata* (Cypridinae)	–	–	–	–	–	6
	Cypretta sp. (Cypridinae)	–	–	–	–	–	2
	Candoninae*	–	+	+	+	–	–
Hydracarina	*Arrenurus (Micuracarus) separatus* Smit	–	–	–	–	–	3
Oligochaeta	Phreodrillidae*	–	+	+	–	+	-
Minimum number of species		4	8	7	4	4	6

Owing to their habitat little is known of the biology of subterranean dytiscids. The fullest account is by Uéno (1957) who reports that *Morimotoa phreatica* swam weakly, walked on the substrate and did not surface for air. The adults of *Tjirtudessus* and *Nirridessus* have swimming hairs on all their legs, so presumably they need to swim at times. *Kintingka* have weak swimming hairs only on their hind legs and their small size and proportionally very strong fore and midlegs suggest an adaptation to crawling forcibly through gravel/sand – this is consistent with the hypothesis that their small size for their lineage is an adaptation to interstitial life as discussed under 'Adaptations to subterranean life'. Both species of larvae lack swimming hairs but still have urogomphi and long cerci suggesting that they are still air breathing and need to hold their urogomphi above the water with the help of the cerci. Larva form 1 have tracheae of normal appearance. Against this is the very small body size of the small form-2 larva which, like similar-sized larvae of surface species, would allow it to breathe cutaneously. It is doubtful if the much larger form-1 larva could do so.

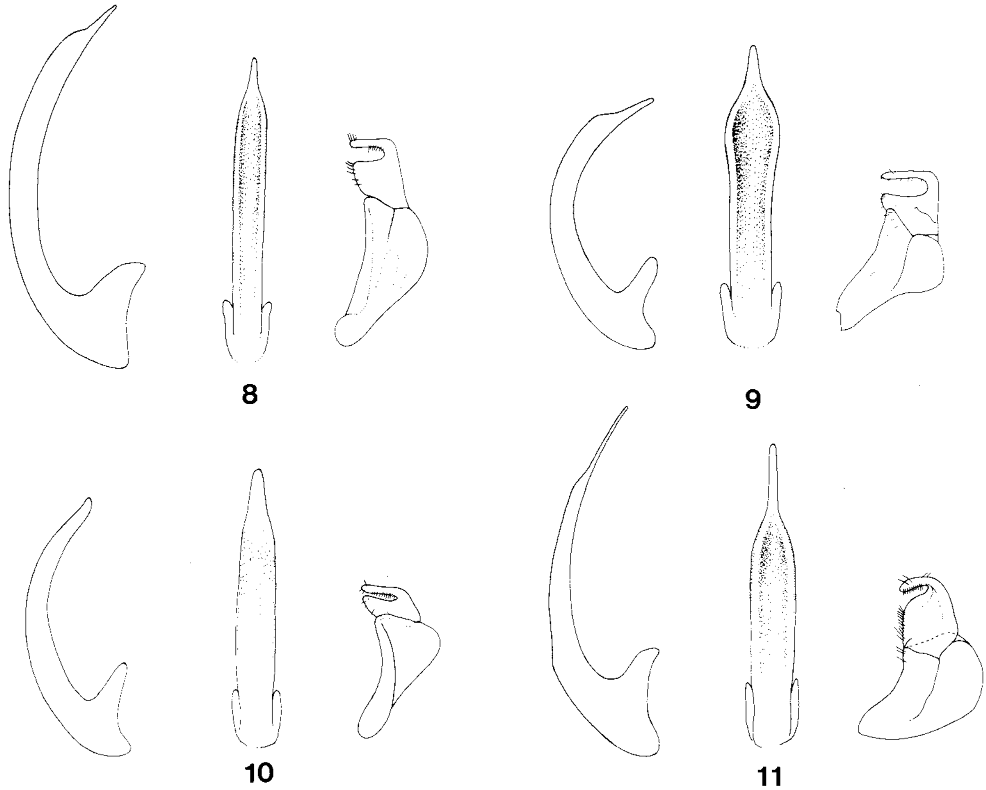
Most adult Dytiscidae are scavengers on freshly dead animals rather than active predators and live off moribund or newly dead animals. Uéno (1957) reported that *M. phreatica* fed both on living (copepod) and dead (isopod, amphipod) crustaceans and we suspect that the new genera have similar feeding habits and are feeding on the range of subterranean crustaceans including amphipods, copepods and syncarids (Table 2) which were found with them. In contrast to the adults, larval dytiscids are active predators. The large head and relatively weak body and legs of the larger larva suggest an ambush predator. The

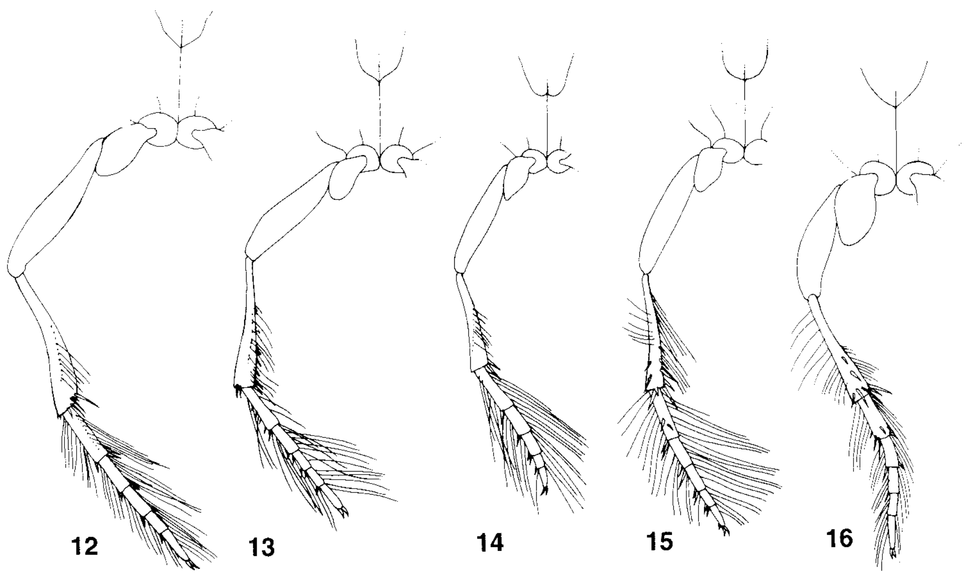
TABLE 3. Fauna in the Windarra Calcrete Quarry piezometric field. L and W refer to *Nirridessus lapostaae* and *N. windarraensis* respectively.

Location	Amphipoda	Copepoda Cyclopoida	Copepoda Harpacticoida	Coleoptera Dytiscidae	Oligochaeta
OP 113	+	–	–	–	–
OP 118	+	–	–	LW	-
OP 122	+	+	–	LW	+
OP 123	+	+	–	LW	–
OP 124	+	–	–	L	–

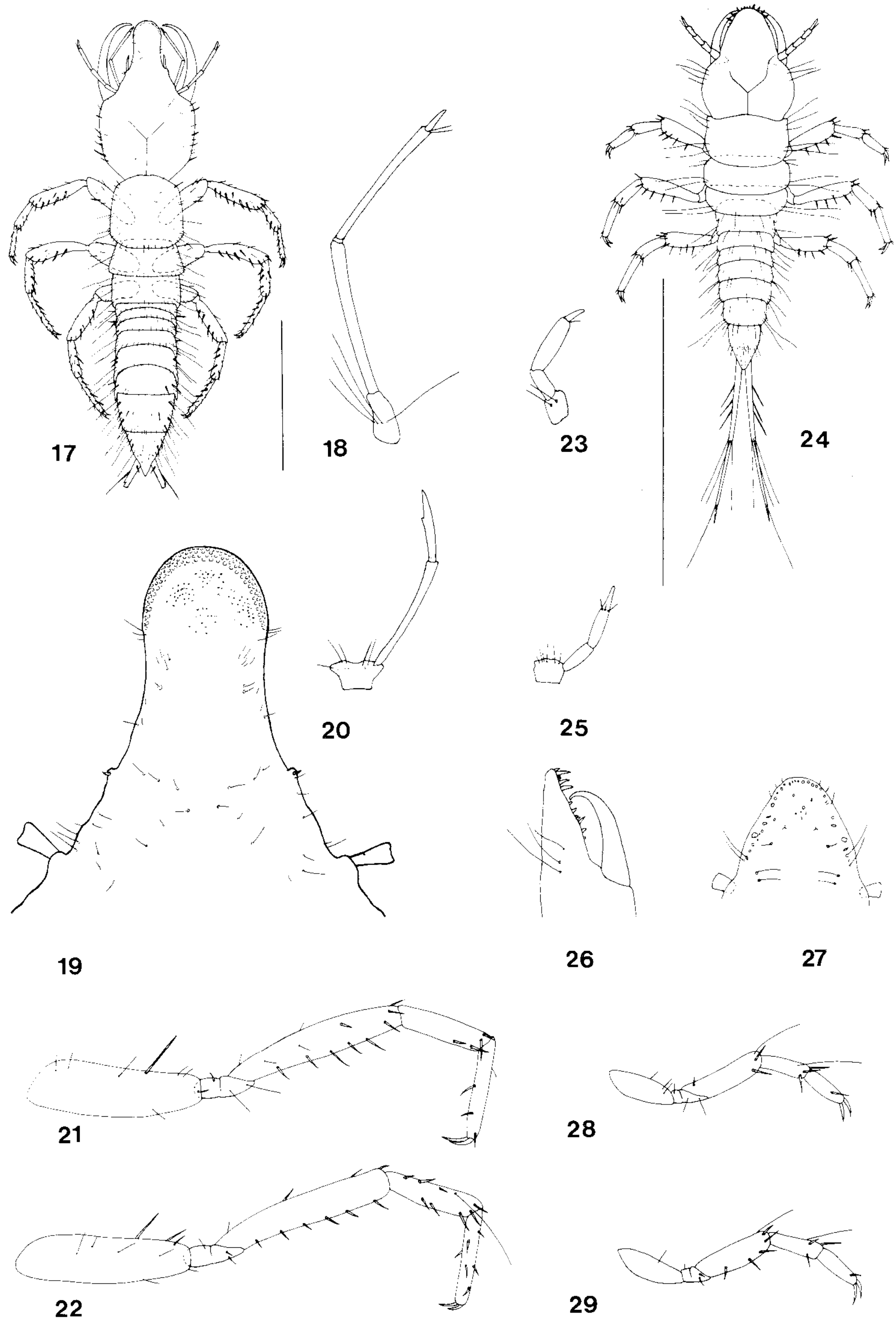


FIGURES 3–7. Dorsal views. **3**, *Nirridessus pulpa*; **4**, *N. lapostaae*; **5**, *N.windarraensis*; **6**, *Tjirtudessus eberhardi*; **7**, *Kintingka kurutjutu*. Figs 3–6 male; Fig. 7, female. Scale bar = 1mm.





FIGURES 8–11. Lateral and ventral views of central lobe of aedeagi and lateral view of a paramere. **8**, *Nirridessus windarraensis*; **9**, *N. lapostaae*; **10**, *N. pulpa*; **11**, *Tjirtudessus eberhardi*. Figures 12–16. Ventral views of hindlegs. **12**, *N. lapostaae*; **13**, *N. windarraensis*; **14**, *N. pulpa*; **15**, *T. eberhardi*; **16**, *Kintingka kurutjutu*. Drawn to approximately same size, not to scale.



FIGURES 17–22. Larva form 1. **17**, dorsal view; **18**, maxillary palpus; **19**, ventral view of nasal; **20**, labial palpus; **21**, anterior view of foreleg; **22**, posterior view of foreleg. Figures 23–29. Larva form 2. **23**, maxillary palpus; **24**, dorsal view; **25**, labial palpus; **26**, lateral view of nasal; **27**, ventral view of nasal; **28**, anterior view of foreleg; **29**, posterior view of foreleg.

strong nasal spines and strong legs of the smaller larvae suggests a much more active pursuit of a rather slippery prey.

Three of the seven adults at Paroo were taken in traps, while the remainder, and all those from Windarra, were captured in plankton nets hauled through the water column in the bores. The bore samples may not reflect the density of the fauna in the general groundwater because the bores may serve to concentrate the stygofauna owing to the steady influx of organic matter dropping down the mosly capped but not sealed bore heads.

Conservation

Groundwater calcretes mostly occur in palaeodrainage channels in arid climates where the annual rainfall is less than 200 mm and potential evaporation exceeds 3000 mm per year (Mann and Horwitz 1979). Hence, they occur widely throughout mid-latitudes of central and western Australia (map in Humphreys in press c).

The Lake Way Basin has been examined for its water potential (Sanders 1969, 1972a, 1973, 1974). Some work has been conducted on the hydrogeochemistry of aquifers in the region (Mann and Deutscher 1978; Passmore 1983). Such aquifers are actually and potentially much exploited for water resources (Environmental Protection Authority 1981), often inappropriately (Sanders 1972b). There has been and is considerable mining in the general vicinity of Wiluna and further expansion of mining activity is planned.

We need to recognise that these ecosystems may face significant risks resulting from the lowering of the water table below ecologically appropriate levels as a result of surface operations (sealing or clearing), as well as those below ground (water abstraction, mine dewatering). This is especially the case for the shallow and thin calcrete aquifer at Windarra. In addition, such processes may result in the physical modification or loss of subterranean environments through general surface slumping in floodplain calcrete aquifers resulting from the withdrawal of supporting water.

The recent discovery that these aquifers contain rich relictual faunas (Poore and Humphreys 1998; Humphreys in press c; this paper) poses challenging management issues as these aquifers often constitute the principal water supply for human activities in the arid zone.

From evolutionary and hydrological considerations it is likely that the areas occupied by these relict faunas are small and isolated, as found in the Pilbara (Poore and Humphreys 1998; W. F. Humphreys, unpublished), analogous to rainforest patches in Eastern Australia. In these conditions the threat of unwittingly harming these ancient relictual communities (discussed by Humphreys in press c) is ever present. We hope that harm can be avoided, or at least minimised, by an active program of discovery and description of these newly discovered unique faunas followed by sound management of the water resource.

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