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SHORT COMMUNICATION

A new record of *Lortiella froggatti* Iredale, 1934 (Bivalvia: Unionoida: Hyriidae) from the Pilbara region, Western Australia, with notes on anatomy and geographic range

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INTRODUCTION

Accurate delimitation of a species' geographic range is important for conservation planning and biogeography. Geographic range limits provide insights into the ecological and historical factors that influence species distributions (Gaston 1991; Brown et al. 1996), whereas the extent of occurrence of a taxon is a key component of IUCN criteria used for assessing the conservation status of species (IUCN 2001).

Freshwater mussels (Unionoida) are an ancient group of palaeoheterodont bivalves that inhabit lotic and lentic freshwater environments on every continent except Antarctica (Graf and Cummings 2006). The Australian Unionoida is represented by the Hyriidae with six genera and 18 species (Ponder and Walker 2003). The Unionoida are distinguished from other bivalves by their larval stage that, with a few exceptions, are obligate parasites of fish and sometimes amphibians (Watters and O'Dee 1998; Wächtler et al. 2001). All freshwater mussels brood their larvae in specialised regions of the female's gills known as 'marsupia' (Bauer and Wächtler 2001), and in the Hyriidae, these are restricted to the inner pair of demibranchs.

An opportunistic stop along the Great Northern Highway in the Pilbara (Indian Ocean Drainage Division) of Western Australia revealed the existence of a *Lortiella* population in the De Grey River, the first record of the genus for the region. Here we identify the species, using shell morphology, present new observations of internal anatomy, and document the contemporary range of the species.

METHODS

SAMPLING METHODS

We compiled 75 distributional records (66 museum records and nine field records) of *Lortiella* species. Museum records were sourced from Ponder and Bayer (2004) and the Online Zoological Collections of Australian Museums (OZCAM 2012). Field records were from sites surveyed for 10–20 minutes by visual and tactile searches in north-western Australia during 2009–2011. Mussels were preserved in 100% ethanol for future molecular study. Water quality data were obtained from the Western Australian Department of Water. Material held by the Australian Museum, Sydney (AM C.427352, AM C.414981) from the Fitzroy River in the Kimberley region of Western Australia (Timor Sea Drainage Division) was examined to confirm details of reproductive anatomy.

SHELL MEASUREMENTS

Specimens were identified from descriptions in McMichael and Hiscock (1958), Ponder and Bayer (2004) and Walker (2004). Shells were measured to the nearest 0.01 mm with dial callipers using the same method as Ponder and Bayer (2004). We measured total shell length (TL), maximum shell height (MH), beak length (BL), beak height (BH) and width (W) (Figure 1). Shape indices were calculated as maximum height index (MHI) = MH/ML, beak height index (BHI) = BH/MH, Obesity = W/TL, beak length index (BLI) = BL/TL (all expressed as percentages).

TABLE 1 Details of *Lortiella froggatti* Iredale, 1934 collected from Western Australia in field studies and from museum specimens which were examined for marsupia characteristics.

Museum Accession No.	*n*	River name	Site	Latitude	Longitude	Collection Date	Collector
WAM S84030	3	De Grey R.	Coolenar Pool, near gauging station (AWRC 710003)	20.309° S	119.251° E	21 May 2011	J. Keleher
WAM S84140	3	Fitzroy R.	Geikie Gorge	18.052° S	125.736° E	13 Nov 2009	D.L. Morgan
WAM S84141	3	Snake Ck.	Durack Pool	17.976° S	124.261° E	13 Nov 2009	D.L. Morgan
AM C.427352	1	Fitzroy R.	At Fitzroy Crossing township, old crossing	18.180° S	125.597° E	15 Jun 2003	W.F. Ponder, J.C. Walker and L. Puslednik
AM C.414981	>20	Fitzroy R.	Geikie Gorge	18.066° S	125.733° E	10 May 1988	H.A. Jones

TABLE 2 Summary of shell morphometry of samples collected during this study in comparison with those reported in Ponder and Bayer (2004).

Character	*n*	*L. froggatti* [A] Min-max	Mean ±SE	*n*	*L. froggatti* [B] Min-max	Mean ±SE	*n*	*L. froggatti* [C] Min-max	Mean ±SE
TL (mm)	32	25.5–80.8	60.8 ± 2.3	6	50.6–89.0	72.8 ± 6.1	180	29.9–94.9	58.0 ± 0.8
MH (mm)	32	13.0–37.5	28.1 ± 1.06	6	23.8–36.9	31.2 ± 2.2	181	15.0–38.7	26.3 ± 0.4
BH (mm)	32	11.0–29.6	22.1 ± 0.7	6	21.0–27.8	24.9 ± 1.3	182	13.4–34.8	23.5 ± 0.3
W (mm)	32	4.9–12.5	9.8 ± 0.3	6	9.0–14.0	11.5 ± 0.8	182	5.1–13.6	9.1 ± 0.1
BL (mm)	32	10.0–22.9	17.8 ± 0.5	6	15.1–25.7	21.8 ± 1.7	182	11.4–29.4	20.0 ± 0.3
MHI (%)	32	35.7–51.4	46.4 ± 0.5	6	40.8–46.9	43.1 ± 0.8	178	35.0–55.0	45.0 ± 4.0
BHI (%)	32	73.0–116.9	79.8 ± 1.7	6	73.5–88.3	80.7 ± 2.0	180	77.0–103.0	90.0 ± 5.0
Obesity (%)	32	11.0–26.8	16.4 ± 0.4	6	14.6–17.8	15.8 ± 0.4	179	11.0–19.0	16.0 ± 1.0
BHL (%)	32	31.2–56.5	36.9 ± 0.8	6	30.5–41.4	34.8 ± 1.5	179	27.0–41.0	35.0 ± 2.0
BLI (%)	32	24.9–39.3	29.7 ± 0.6	6	27.6–31.4	30.0 ± 0.6	179	30.0–48.0	41.0 ± 4.0

[A] Fitzroy River catchment (this study)

[B] De Grey River catchment (this study)

[C] Ponder and Bayer (2004)

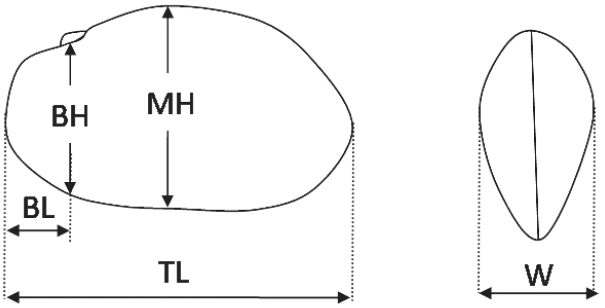

FIGURE 1 Morphometric measurements of freshwater mussel shells. (a) Adults: BH = beak height; MH = maximum height; BL = beak length; W = width; TL = total length. Adapted from McMichael and Hiscock (1958).

Comparisons of shell shape were made by comparing mean differences in the four shape indices between the De Grey River (Indian Ocean Drainage Division) and the Fitzroy River (Timor Sea Drainage Division) populations with Hotelling's T^2 statistic (Rencher 1995). T-tests were used to compare shape indices from our study with those reported by Ponder and Bayer (2004). All analyses were carried out in R (R Core Team 2012).

ABBREVIATIONS

AM – Australian Museum, Sydney, NSW, Australia

AWRC – Australian Water Resources Council

WA – Western Australia

WAM – Western Australian Museum, Welshpool, W.A., Australia

Hwy – Highway

R – River

RESULTS

A new population of *L. froggatti* was found in Coolenar Pool (De Grey River) near a gauging station (AWRC 710003). Details of specimen records are presented in Table 1.

SHELL MORPHOLOGY AND MORPHOMETRY

A summary of the shell measurements and shape indices for specimens collected from the De Grey and Fitzroy Rivers is presented in Table 2 and examples of specimens are shown in Figure 2. The shell outlines of the collected specimens were elongated and 'adze-shaped' with a short, rounded anterior, straight ventral margin and obliquely truncated posterior margin. Most shells had obvious winging. The periostracum colour ranged from light olive in small shells to dark brown or almost black in large specimens. Shell surfaces and beaks lacked sculpture and the larger shells had beaks which were considerably eroded. Internally, lateral teeth were sharp, lamellar and blade-like in small specimens and flattened or blunt in larger shells. Pseudocardinal teeth were lamellar and semi-serrated in small shells and either peg-like, or flattened, and smooth in larger shells. Shells had a single, sub-triangular tooth on the left valve and one shallower, sometimes grooved, pseudocardinal tooth on the right valve. Anterior muscle scars were lightly impressed, more deeply in large shells with fusion of the adductor-retractor muscle scars. In most cases, the posterior muscle scars were very faint and the pallial line was distinct only in larger shells, and even then was very lightly impressed. The nacre was mostly dull white with iridescent blue at the posterior margin with occasional staining near the umbones.

The shell shapes of populations from the De Grey and Fitzroy Rivers did not differ significantly (Hotelling's T^2 = 8.768, P = 0.116). However, the MHI in the De Grey River specimens were significantly different from the Fitzroy populations (t = 2.49,d.f. =36; P<0.05), although BHI, BLI and obesity were not. In comparison with Ponder and Bayer (2004) our specimens from the Fitzroy River catchment were significantly different for BHI (t = -9.05, d.f. =209; P < 0.001), and BLI (t = -15.16, d.f. = 209; P < 0.001), but not for MHI (t = 1.88, d.f. = 208, P = 0.061) or Obesity (t = 1.58, d.f. = 209, P = 0.116).

ANATOMY

Gross anatomy matched published descriptions for the genus (Ponder and Bayer 2004). The demibranchs were attached dorsally to the mantle, and the inner demibranchs were attached anteriorly near the labial palps and posteriorly there was a minute perforation separating the supra and infrabranchial chambers. The palps were large and semi-cordiform in shape, rounded posteriorly and not fused to the mantle. The siphons were pigmented with mottled patches, black and tan in colour, and had 2–4 rows of bulbous/pyramidal pale-coloured papillae on the inhalant siphon. The inhalant siphon was ca. 1⅓ times the size of the exhalent siphon. There was no supra-anal opening in any of the specimens.

A single specimen collected from the De Grey River was female and contained embryonic, immature glochidia within the marsupia. The marsupia occupied most of the inner demibranchs in all gravid females examined from the De Grey and Fitzroy Rivers. The marsupia occupied 90% of the inner demibranchs which were approximately twice the size of the outer demibranchs.

HABITAT

The climate of the Pilbara region is arid with hot, dry conditions for most of the year. Rainfall is variable and episodic with summer and autumn thunderstorms (Kennard et al. 2010). The De Grey River is the largest in the Pilbara region with a catchment area of 56,890 km^2, a mean annual rainfall of 400 mm.yr^{-1} (records

TABLE 3 Physico-chemical characteristics of the De Grey River at Coolenar Pool Gauging Station (AWRC 710003). Data from1983-2005, supplied by the Western Australian Department of Water.

	Mean	Range
Electrical conductivity (µS cm^{-1})	642	124–1388
pH	7.8	6.5–10.2
Water temperature (°C)	25.9	12.5–38.8
Total phosphorus (µg L^{-1})	61	2–271
Total nitrogen (µg L^{-1})	640	110–4550
Turbidity (NTU)	57.3	0.7–1025.0

from 1974 to 2010; see flow regime classifications in Kennard et al. 2010) and the river has a mean annual discharge of 1,342 $GLyr^{-1}$(DOW 2008) that is strongly seasonal with predictably intermittent summer flows (see Figure 6, p. 182 in Kennard et al. 2010).

In-stream habitat consists primarily of coarse sand and rock with fine-grained or clay stream banks. Mussels were found along stream banks at the edge of the river in shallow burrows ca. 50 mm deep with the tips of the posterior ends of shells exposed.

Summary data of mean water quality is provided in Table 3. The De Grey River is typically fresh to mildly brackish with a mean electrical conductivity value of 642 µS cm^{-1}, near neutral to alkaline with a mean pH of 7.8, variable in temperature and turbidity and typically high in nutrients (see ANZECC 2000 for trigger values of total P and total N).

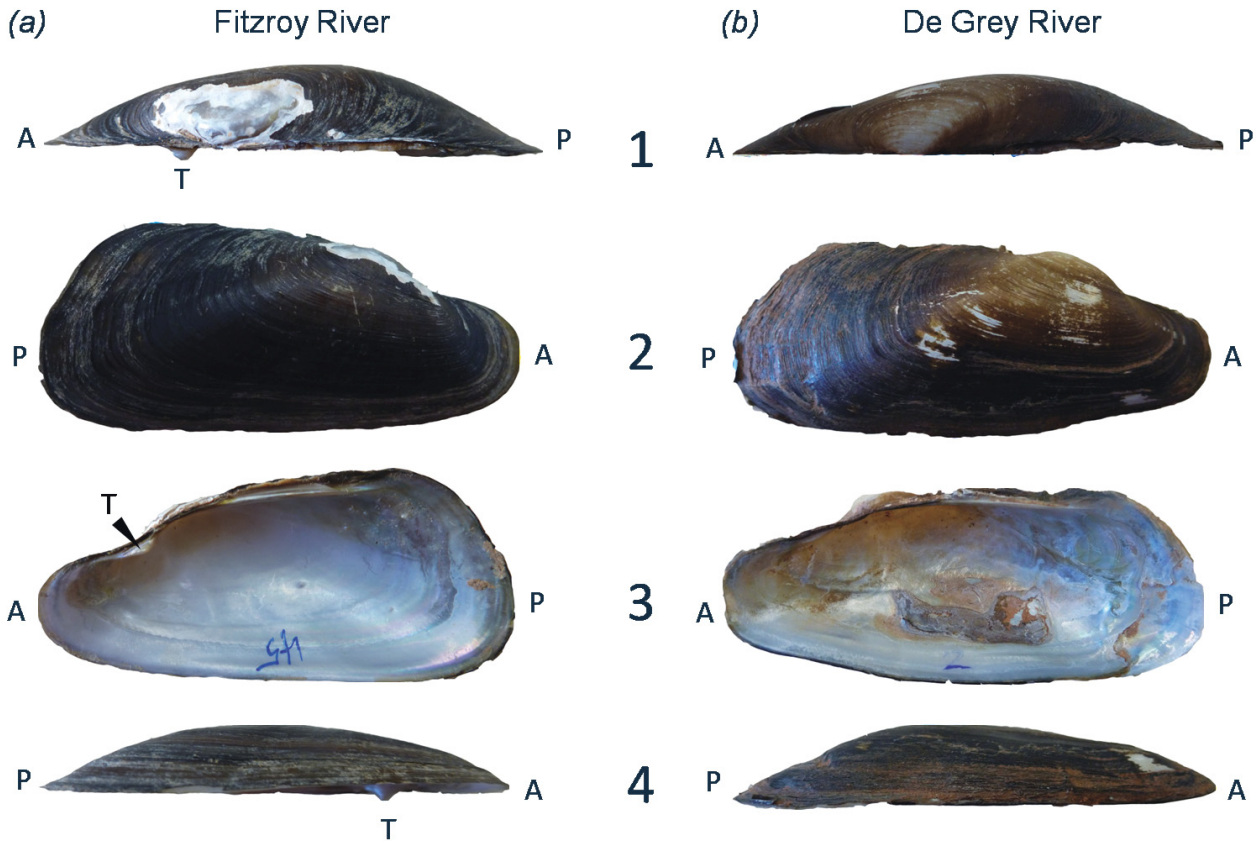

FIGURE 2 *Lortiella froggatti* from (a) Fitzroy River, Geikie Gorge and (b) De Grey River, Coolenar Pool. From top to bottom in each column: 1) dorsal view of right valve; 2) Lateral external view of right valve; 3) Lateral internal view of right valve; 4) ventral view of right valve. A = anterior; P = posterior; T = triangular lamellar pseudocardinal tooth.

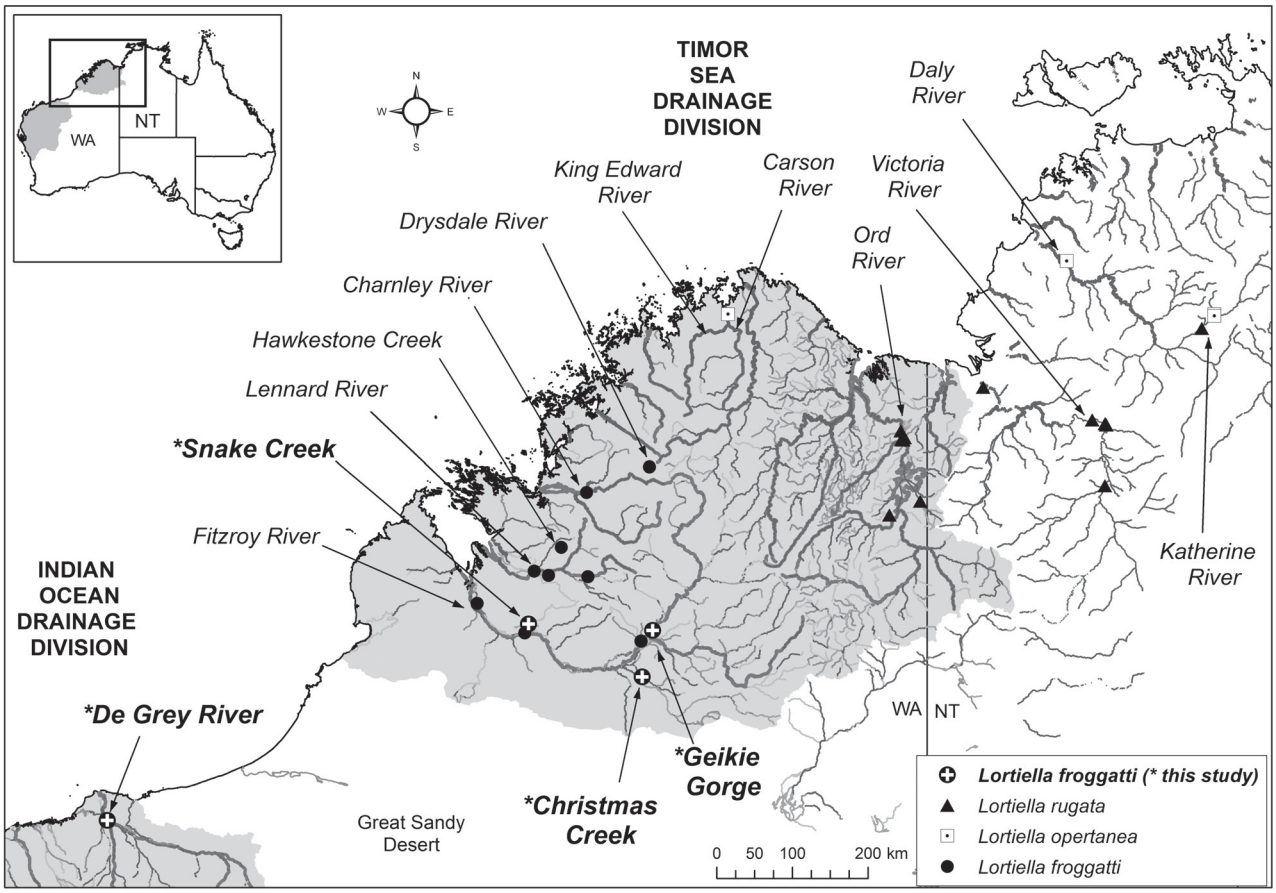

FIGURE 3 Distribution of *Lortiella* species in northern Australia. Unless otherwise indicated, all data were obtained from museum records.

DISCUSSION

The discovery of *L. froggatti* in the De Grey River within the Indian Ocean Drainage Division represents an approximate 540 km range extension across the Great Sandy Desert, with little to no drainage, from the nearest population in the Fitzroy River catchment (Figure 3).

Prior to this study, representatives of *Lortiella* spp. were known only from the Timor Sea Drainage Division. The specimens match the descriptions of *L. froggatti* given by McMichael and Hiscock (1958) and Ponder and Bayer (2004). The adze-shaped oblong shell with posterior oblique truncation with a wing posterior to the beak and a rounded posterior end is characteristic of *L. froggatti*. Measurements of shell shape indices are within the reported ranges of MHI (35–55%), BHI (77–103%), Obesity (11–19%) and BLI (30–48%) (McMichael and Hiscock 1958; Ponder and Bayer 2004). Shell shape indices for the De Grey population and those reported by Ponder and Bayer (2004) were in agreement although some discrepancies may have arisen due to the small number of specimens collected from the De Grey River. Furthermore, because the De Grey and Fitzroy specimen morphometrics were mostly similar and *L. froggatti* is the only known *Lortiella* species from the Fitzroy River catchment (Ponder and Bayer 2004), the De Grey population is here considered to be *L. froggatti*.

Although the De Grey and Fitzroy Rivers are separated by a large expanse of desert, reconstruction of Pleistocene drainage patterns in this region when sea levels were much lower than today, indicate that there was previously far greater connectivity between these rivers (Unmack 2001). This could make possible dispersal via host-fish between neighbouring rivers, perhaps joined by flood plumes resulting from monsoonal rains (N.B. There are freshwater fish species in common between both catchments; see Morgan and Gill 2004; Morgan et al. 2004).

The extent of development of the marsupium in *L. froggatti* is greater than in most other velesunionine species (McMichael and Hiscock 1958). However, the proportion of the inner demibranch occupied by the marsupium, while unusual, is not unique among the Velesunioninae. Humphrey (1984) noted that the marsupium occasionally occupied the entire inner demibranch in *Velesunio angasi* collected from eutrophic waters but only 2/3 of the inner demibranchs in other populations.

The diagnosis of the De Grey River population of *Lortiella* as *L. froggatti* will be clarified by molecular analysis, as has been demonstrated for other species of Australian Hyriidae (e.g. Baker et al. 2003). Collection of a larger sample size and a full range of

shell sizes and shapes coupled with molecular analysis of representative *Lortiella* spp. from throughout their range will strengthen (or possibly refute) our species determination. This is a significant range extension for the genus *Lortiella*.

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REFERENCES

Australian and New Zealand Environment and Conservation Council (ANZECC). (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. National Water Quality Management Strategy, Paper No. 4. Canberra.

Baker, A.M, Bartlett, C., Bunn, S.E., Goudkamp, K., Sheldon, F. and Hughes, J.M. (2003). Cryptic species and morphological plasticity in long-lived bivalves (Unionoida: Hyriidae) from inland Australia. *Molecular Ecology* **12:** 2707–2717.

Balla, S.A. and Walker, K.F. (1991). Shape variation in the Australian freshwater mussel *Alathyria jacksoni* Iredale (Bivalvia, Hyriidae). *Hydrobiologia* **220**: 89–98.

Bauer, G. and Wächtler, K. (2001). *Ecology and Evolution of the Freshwater Mussels Unionoida*. Springer-Verlag, New York. 388 pp.

Bogan, A.E. and Roe, K.J. (2008). Freshwater bivalve (Unioniformes) diversity, systematics, and evolution: status and future directions. *Journal of the North American Benthological Society* **27**: 349–369.

Brown, J.H., Stevens, G.C. and Kaufman, D.M. (1996). The geographic range: size, shape, boundaries and internal structure. *Annual Review of Ecology and Systematics* **27**: 597–623.

Department of Water (DOW), Western Australia. (2008). *Statewide River Water Quality Assessment*. Available at: www.water.wa.gov.au.

Gaston, K.J. (1991). How large is a species' geographic range? *Oikos* **61**: 434–438.

Graf, D.L. and Cummings, K.S. (2006). Paleoheterodont diversity (Mollusca: Trigonoida + Unionoida): what we know and what we wish we knew about freshwater mussel evolution. *Zoological Journal of the Linnaean Society* **148**: 343–394.

Humphrey, C.L. (1984). *Biology and Ecology of the freshwater mussel* Velesunio angasi *(Bivalvia: Hyriidae) in the Magela Creek, Alligator Rivers Region, NorthernTerritory*. Ph.D. Thesis, University of New England, Armidale.

International Union for the Conservation of Nature (IUCN). (2001). *IUCN Red List Categories and Criteria: Version 3.1*. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK. ii + 30 pp.

Jones, H.A., Simpson, R.D. and Humphrey, C.L. (1986). The reproductive cycles and glochidia of freshwater mussels (Bivalvia: Hyriidae) of the Macleay River, northern New South Wales, Australia. *Malacologia* **27**: 185–202.

Kennard, M., Pusey, B., Olden, J., Mackay, S., Stein, J. and Marsh, N. (2010). Classification of natural flow regimes in Australia to support environmental flow management. *Freshwater Biology* **55**: 171–193.

McMichael, D.F. and Hiscock, I.D. (1958). A monograph of the freshwater mussels (Mollusca: Pelecypoda) of the Australian Region. *Australian Journal of Marine and Freshwater Research* **9**: 372–507.

Morgan, D.L. and Gill, H.A. (2004). Fish fauna in inland waters of the Pilbara (Indian Ocean) Drainage Division of Western Australia – evidence for three subprovinces. *Zootaxa* **636**: 1–43.

Morgan, D.L., Allen, M.G., Bedford, P. and Horstman, M. (2004). Fish fauna of the Fitzroy Riover in the Kimberley region of Western Australia – including the Bunuba, Gooniyandi, Ngarinyin, Nyikina and Walmajarri Aboriginal names. *Records of the Western Australian Museum* **22**: 147–161.

Online Zoological Collections of Australian Museums (OZCAM). 2012. Specimen search results for *Lortiella*. Available at: http://www.ozcam.ala.org.au;occurences/search?taxa=lortiella.

Ponder, W.F. and Bayer, M. (2004). A new species of *Lortiella* (Mollusca: Bivalvia: Unionoidea: Hyriidae) from northern Australia. *Molluscan Research* **24**: 89–102.

Ponder, W.F. and Walker, K.F. (2003). From Mound Springs to Mighty Rivers: The conservation Status of Freshwater Molluscs in Australia. *Aquatic Ecosystem Health & Management* **6**: 19–28.

R Core Team. (2012). R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. Available at: http://www.R-project.org

Rencher, A.C. (1995). *Methods of Multivariate Analysis*. John Wiley & Sons, New York.

Unmack, P.J. (2001). Biogeography of Australian freshwater fishes. *Journal of Biogeography* **28**: 1053–1089.

Wächtler, K., Dreher-Mansur, M. C. and Richter, T. (2001). Larval types and early postlarval biology in naiads (Unionoida). In: G. Bauer and K. Wächtler (Eds.) *Ecology and Evolution of the Freshwater Mussels Unionoida*. Springer-Verlag, New York, pp. 93–125.

Walker, K.F. (2004). *A guide to the provisional identification of the freshwater mussels (Unionoida) of Australasia*. CRC Freshwater Ecology Identification Guide 51. Murray Darling Freshwater Research Centre, Albury.

Walker, K.F., Byrne, M., Hickey, C.W. and Roper, D.S. (2001). Freshwater mussels (Hyriidae) of Australia. In: G. Bauer and K. Wächtler (eds.), *Ecology and Evolution of the Freshwater Mussels Unionoida*. Springer-Verlag, New York, pp. 5–31.

Watters, G.T. and O'Dee, S.H. (1998). Metamorphosis of freshwater mussel glochidia (Bivalvia: Unionidae) on amphibians and exotic fishes. *American Midland Naturalist* **139**: 49–57.

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