

CONSERVATION OF IMPERILED CRAYFISH—*EUASTACUS JAGARA*  
(DECAPODA: PARASTACIDAE), A HIGHLAND CRAYFISH FROM THE MAIN RANGE,  
SOUTH-EASTERN QUEENSLAND, AUSTRALIA

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INTRODUCTION

Common Name.—None. Morgan (1988) did not designate a common name in the original description, and we are unaware of any common name having been applied subsequently. We suggest ‘The Jagara Hairy Crayfish’ would be suitable.

Conservation Status.—*Euastacus jagara* Morgan, 1988 (Fig. 1) is currently listed as ‘Endangered’ on the International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species (Crandall, 1996). A recent assessment and revision of the conservation status of the genus *Euastacus* (the ‘spiny crayfish’) considered that a listing of ‘Critically Endangered’ is now appropriate under current IUCN criteria (Coughran and Furse, 2010; Furse and Coughran, in press a, b, c). The conservation assessment noted that further information is urgently required on the species, in order to both refine its conservation status and enable specific conservation and management programs. The species is not currently listed under any State or Federal conservation legislation.

Identification.—*Euastacus jagara* was described by Morgan (1988) from six museum specimens collected in 1973. Although the largest and best developed of these specimens, the holotype unfortunately had a badly damaged thorax, and aspects of thoracic spination were not described with complete certainty (Morgan, 1988). The species is poorly spinose, with minimal development of spines on the pleon. It can be further distinguished from other regional crayfishes by: the presence of 3-6 mesial carpal spines, including the presence of additional, small spines situated anterior to the ‘typical’ large, mesial carpal spines; the small size of the suborbital spines; a lack of any spines above the propodal cutting edge; and a dense covering of setation. Morgan (1988) was unable to locate any specimens in the field for the description, and was thus unable to record any information on its colouration. However, following recent surveys we can now describe the colouration as follows. *Euastacus jagara* is dark green or green-blue to orange-brown dorsally, with a bluish tint developing ventro-laterally. The legs are a light blue or

blue-brown colour and the chelae have a distinct mottled pattern, with a greenish tint highlighted with a brighter blue. The larger mesial carpal spines are generally red with yellow tips.

NATURAL HISTORY

Distribution.—*Euastacus jagara* was described from a single site in Flaggy Creek, a highland tributary of the Brisbane River on Mount Mistake, south-east Queensland, Australia. In 2000, the species was collected from a second site, Shady Creek, as part of a phylogenetic revision of the genus (Shull et al., 2005). Both of these creeks are upper tributaries of Blackfellow Creek, situated within the North-eastern Coastal drainage division (NEC) of Australia, east of the Great Dividing Range. In 2005, the ongoing Australian Crayfish Project (ACP) was established with the aim of addressing specific knowledge gaps on all Australian crayfishes. As part of the broader ACP, we have recently completed more intensive field surveys for *E. jagara*, to better define its distribution and habitat (Australian Aquatic Biological, 2008). Streams were sampled with baited traps, hand-held nets and active search methods, i.e., by lifting rocks and excavating burrows by hand, from summer to spring, 2009. The species was recorded from four headwater streams, including the type locality (Flaggy Creek) and three branches of Dalrymple Creek, situated further south (Fig. 2). Morgan (1988) initially suggested that the species may occur further south than the type locality, and the recent ACP surveys confirmed this. Three of the sites inhabited are situated at the southern end of the species’ range on the opposite (western) side of the Great Dividing Range, in the Murray-Darling Basin drainage division (MDB) of inland Australia. The occurrence of *E. jagara* in both the NEC and MDB drainages is noteworthy, given that the Great Dividing Range is the only major mountain belt on the continent, separating coastal and inland drainages along the length of the eastern Australian mainland (Unmack, 2001).

Abundance.—No quantitative data are available on abundance. However, despite its extremely restricted distribu-

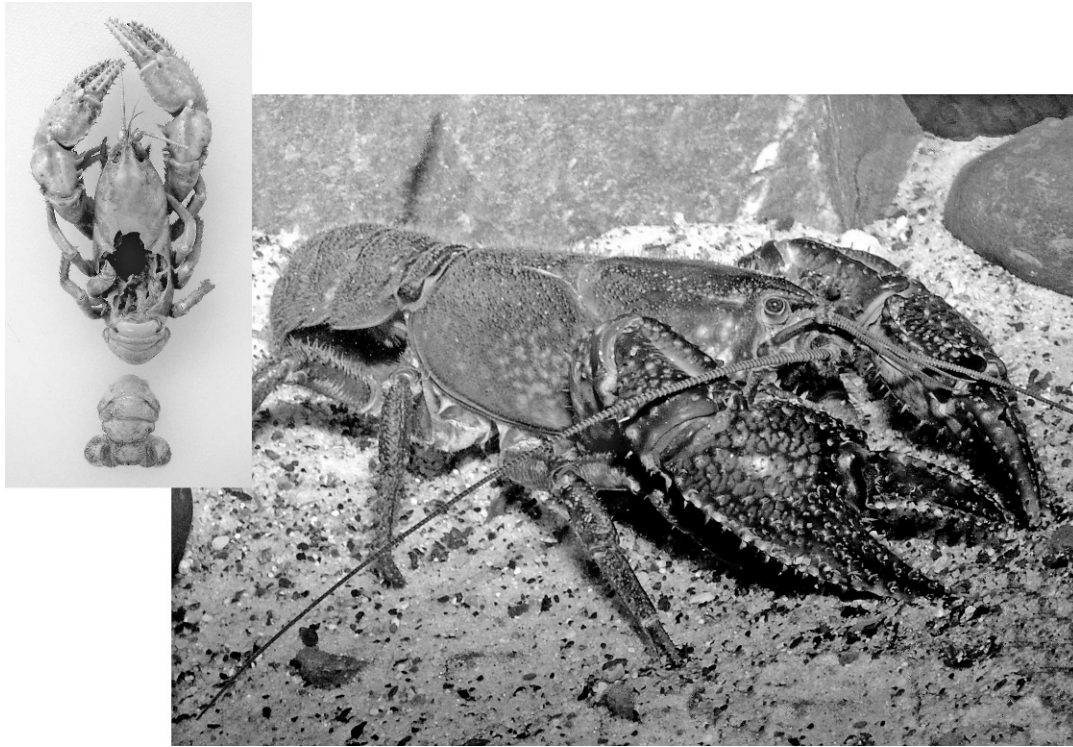


Fig. 1. *Euastacus jagara* Morgan, 1988. Inset: Holotype, showing extent of thoracic and pleonal damage.

tion, the species generally appears to be present in reasonably high numbers at the sites inhabited. Crayfish and burrow abundance appear to be appreciably higher at elevations greater than 920 m above sea level (a.s.l.), where the stream banks and surrounding forest floor often feature high densities of active burrows. Specific research is required to quantify abundance.

**Habitat and Ecology.**—The species appears to be restricted to highland, headwater reaches of five small first order streams in two different drainage divisions (MDB and NEC), at elevations ranging from 714–1028 m a.s.l. The streams are well shaded by a rainforest canopy. Local geology is solid volcanic bedrock overlain with a good cover of gravel to cobble sized rocks, a fine-grained basaltic soil, with occasional emergent sections of solid bedrock. The species inhabits all sections of the streams, in both pools and riffles. Abundant woody debris and leaf litter are common in these small streams.

The apparent restriction of *E. jagara* to altitudes greater than 710 m coincides with a change in vegetation, from open forest to rainforest. This is clearly evident in the Dalrymple Creek catchment, where three creek branches have been surveyed along the entire gradient between the sections occupied by *Cherax* (the ‘smooth crayfish’ genus) and *E. jagara*. In all branches, *E. jagara* first occur at an altitude of approximately 720 m a.s.l., coinciding with the change of vegetation. Below 700 m a.s.l. the vegetation is dry sclerophyll forest (*Eucalyptus* spp.) with an understorey of she-oaks (*Casuarina* spp.), wattles (*Acacia* spp.), grass trees (*Xanthorrhoea* spp.) and tussock grasses (*Poa* spp.). Along the stream margins a soft nettle, *Elatostema stipitatum*, is common. At 700 m a.s.l., there is a transition

to rainforest, with hoop pines (*Araucaria cunninghamii*), tree ferns (*Cyathea cooperi*), and palms (*Calamus*, *Licuala* and *Linospadix* spp.) becoming more common, and a second nettle appears along the stream margins, the darker and softer *Elatostema reticulatum*. By 750 m a.s.l., the streams are in dense rainforest, and only the darker nettle, *E. reticulatum*, remains. The presence of *E. reticulatum*, or Rainforest Spinach, appears to be a good indicator of *E. jagara* habitat, and has also been found to be a useful indicator for other highland species of *Euastacus* in eastern Australia (Coughran 2006; Coughran and McCormack, unpublished data). Although *E. jagara* does occur in the interface between open and closed forest types, it is present in much higher densities further upstream in the closed forest. The substrate also becomes finer with increasing altitude, and *E. jagara* may require the finer substrates at higher altitudes to construct its burrows.

*Euastacus jagara* constructs intricate burrows located in the stream bed, along the stream banks or on the adjacent forest floor, up to 2 m away from the stream. Burrows can be deep and complex, with five or more entrances and numerous chambers. Excavated material is mounded around the burrow entrances, which are open and lack any true chimney-like structure. In places the species appears to live in high densities with burrows in close proximity to each other, and it is not unusual to find two crayfish sheltering under the same rock. No crayfish were observed actively wandering in the streams during recent summer (January) surveys. During autumn (April) surveys, crayfish were active in Dalrymple Creek during the day and this activity increased throughout the afternoon until midnight, with a peak in activity just after sunset. On the forest floor,



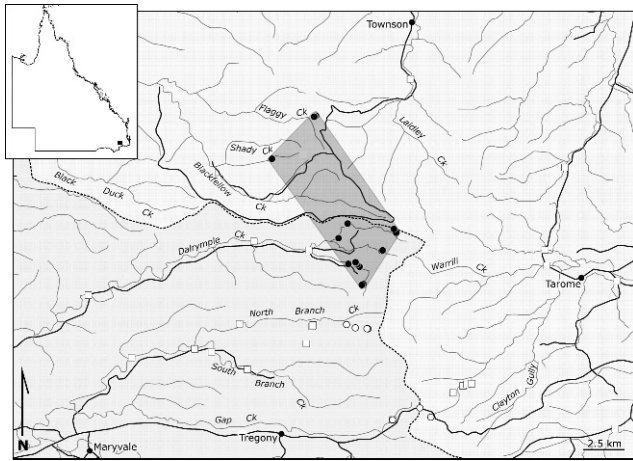


Fig. 2. Distribution of *E. jagara* (black circles), and other crayfish species that occur in the area. *Euastacus jagara* occurs in highland streams on both sides of the Great Dividing Range (dashed line), in both the NEC (unshaded) and MDB (light shading) drainage divisions. The species has an overall Extent of Occurrence (EOO; dark grey polygon) of 21.5 km<sup>2</sup>. Its distribution does not overlap with that of the much larger *E. sulcatus* Riek 1951 (white circles), which is found to the south. Two species of *Cherax* inhabit lowland sites (white squares): *C. destructor* Clark 1936 (MDB) and *C. depressus* Riek 1951 (NEC). An additional 31 sites within the map boundaries yielded no crayfish (not illustrated). The Australian Crayfish Project has also undertaken numerous surveys in the surrounding region, with no records of *E. jagara*.

nocturnal activity was largely limited to the maintenance and cleaning of burrow entrances and although crayfish were commonly observed at their burrow entrance at night, they were not observed walking openly in the forest.

*Euastacus jagara* was not observed or collected in association with any other species of crayfish. The larger congener, *E. sulcatus* Riek, 1951 has been recorded at sites in Branch and Gap Creeks to the immediate south of Dalrymple Creek, and *Cherax* spp. inhabit lowland sites on both sides of the Great Dividing Range (*C. destructor* Clark, 1936 in the MDB drainage division, *C. depressus* Riek, 1951 in the NEC drainage division). Interestingly, rather than an overlap between the highland *E. jagara* and lowland *Cherax* spp., there appears to be an intervening section of Dalrymple Creek (~ 2-3 km in length) devoid of any crayfish. Although *C. destructor* occurs at higher altitudes elsewhere in its range (McCormack, 2008), neither species of *Cherax* have been recorded above 690 m a.s.l. in the Mistake Mountains area. Thus, there is an apparent altitudinal separation between these *Cherax* spp. and the highland *E. jagara*, which has not been observed below 710 m a.s.l. To the immediate south, both *C. destructor* and *E. sulcatus* occur together at Cunningham's Gap (685 m a.s.l.).

In the intervening section of Dalrymple Creek where neither *E. jagara* or *Cherax* spp. occur, the fauna is dominated by freshwater river prawns (*Macrobrachium australiense* Holthuis, 1950) and small native fish (*Galaxias* sp.). Neither of these species were recorded above 750 m a.s.l. No potential predatory fish have been observed in the streams where *E. jagara* occurred, and tadpoles constitute the main stream vertebrate fauna. Eels (*Anguilla reinhardtii*) do occur within the NEC drainage division, but were not recorded at any sites inhabited by *E. jagara*.

Little is known about the diet of *E. jagara*, but they were readily attracted to meat baits in our recent survey work. During summer surveys, the streams contained a notable amount of fallen rainforest fruits and we observed and collected many fruits that had clearly been gnawed, probably by crayfish. We also observed many fruits that had been collected by crayfish and transported to their burrow systems. No data are available on growth rates or population size, and future research should be directed towards these knowledge gaps.

**Reproduction.**—A maximum size of 50.23 mm Occipital Carapace Length (OCL, Morgan, 1997) was recorded during our recent surveys, exceeding the maximum originally documented for the species (47.1 mm OCL; Morgan, 1988). Two females were carrying eggs when captured, both in June (winter). The developing eggs were mustard to brown in colour and numbered approximately 50-70 per clutch. A third female was carrying a clutch of newly hatched juveniles, in January (summer). These reproductively active females ranged from 39.20 mm to 44.73 mm OCL.

Despite intensive effort, we were unable to locate large males in the streams during summer surveys, although large females and juveniles were commonly captured from under rocks or in-stream burrows. We considered that the large males may have been residing in the deeper burrow systems in the adjacent forest floor, but we were unable to fully excavate any of these burrows to clarify this hypothesis. On the subsequent survey in autumn we planned such excavations, but immediately located large males in the stream system. Both large males and females (as well as all other sizes) were present and active in the stream during autumn, and newly moulted animals were also common (approximately 1 in 10 crayfish). The increased in-stream activity and presence of both large males and females may reflect the onset of the breeding season. Both the presence of berried females in winter, and a female with a clutch of juveniles in summer conform to the general pattern of reproduction in the genus *Euastacus* (Morgan, 1991; Honan and Mitchell, 1995), although it remains unclear if the species displays a distinct or co-ordinated breeding pattern. Morgan (1991) observed that most species of *Euastacus* in Queensland lay eggs in autumn, with the female over-wintering the attached eggs for a spring-summer release of independent juveniles, and the limited observations on *E. jagara* in the present study are consistent with that general pattern. However, variation in the proportion of breeding females and the timing and duration of reproduction has been observed in other regional *Euastacus* spp. (Coughran, 2006), and more detailed studies of the reproductive biology of *E. jagara* are warranted. The present study suggests a low fecundity and large egg size, similar to that noted for other small species of *Euastacus* such as *E. gumar* Morgan, 1997 and *E. mirangudjin* Coughran, 2002 (Coughran, in press a, b).

#### CONSERVATION FACTORS

**Threats.**—The species appears restricted to highland (714-1028 m a.s.l.), rainforested, headwater reaches of five streams in two different drainage divisions (MDB and

NEC). The overall known EOO of the species is 21.5 km<sup>2</sup>. Like other species in the genus, the restricted distribution of *E. jagara* is fragmented. Many *Euastacus* spp. occur on different sides of mountain ranges, including the most defining mountain range of eastern Australia, the Great Dividing Range (Morgan, 1997; McCormack, 2008; Coughran and Furse, 2010). This unusual distribution pattern of highland *Euastacus* remains to be resolved, but mountain ranges do form contemporary barriers to crayfish dispersal (Morgan, 1997; Ponniah and Hughes, 2006) and, as such, the distributions of species such as *E. jagara* are fragmented.

Given its highly restricted and fragmented range, the species is extremely susceptible to localized impacts, including bush fires, poor forestry practices, habitat destruction and over exploitation by collectors. Furthermore, species such as *E. jagara* are not spiny (Morgan, 1988; Coughran, 2008), and thus may be easily confused with the smooth *Cherax* (unprotected) and inadvertently taken by recreational fishers.

It is probable that its highland distribution reflects a requirement for cool conditions (see Horwitz, 1990; Morgan, 1991; Ponniah and Hughes, 2004) in highland forested areas, and therefore climate change is considered a serious threat to *E. jagara*. Increasing temperature, decreased rainfall and alterations to hydrological regimes, increased incidence of severe weather events, loss of suitable rainforest habitat and increased potential for bushfires are all predicted for the region (Chiew and McMahon, 2002; Howden, 2003; Hughes, 2003; Pittock, 2003; Hennessy, 2006; Westoby and Burgman, 2006; IPCC, 2007). There is also a potential threat from Cane Toads (*Bufo marinus*) (DEH, 2004), which occur throughout the region, although there are no specific data on impacts from this species. Other exotic species such as cats (*Felis catus*), foxes (*Vulpes vulpes*), pigs (*Sus scrofa*) and goats (*Capra hircus*) also occur within the range of *E. jagara*; including within National Parks. These species have generally been found to impact on crayfish elsewhere (Green and Osbourne, 1981; Horwitz, 1990; Merrick, 1995; Eyre et al., 1997; ACT Government, 2007; O'Brien, 2007) and, given its highly restricted distribution, these exotic species could have serious impacts on *E. jagara* by contributing to declines in its distribution, habitat quality and/or abundance.

**Conservation Action.**—The entire range of *E. jagara* is restricted to within the Main Range National Park, and is subject to a total ban on recreational fishing for species of *Euastacus* that applies throughout Queensland (DPIF, 2009), but there are no specific conservation measures in place for this species.

**Conservation Recommendations.**—The species satisfies the current IUCN criteria for listing as Critically Endangered (CR), and should also be nominated for listing under State conservation legislation. The Queensland Nature Conservation Act 1992 includes categories for listing threatened species that are based on similar criteria to those used in the IUCN classification, but lacks a category of Critically Endangered. *Euastacus jagara* satisfies the Nature Conservation Act 1992 criteria for listing as Endangered (EN).

Any future conservation or management initiatives for *E. jagara* will be greatly facilitated by further research. This should include: an assessment of population genetics; habitat requirements and population monitoring; biological and life history information; investigations into thermal tolerance; and resilience to exotic species. Given the damaged state of the type material, associated uncertainties in its original description, and the recent location of further material (including specimens from headwaters of streams in the MDB), a taxonomic reassessment of *E. jagara* is also warranted.

**Remarks.**—The distribution of *E. jagara* in the northern (NEC) end of its range may be better defined with additional surveys. Our survey attempts in this area were often hindered by restricted access to the higher elevation stream reaches, where the species may occur. It is also of note that the species has not been recorded from any streams draining the north-east or east sides of the mountain range, e.g., Laidley or Warrill Creeks. A steep escarpment runs along the eastern face of the mountain range in that area (Stevens and Willmott, 1996), although *E. jagara* may occur in minor soaks and gullies along the top of the escarpment. Further research in these potential areas of suitable habitat would be beneficial and, although it is unlikely that the EOO of the species will be significantly increased, any new records should nonetheless be reported.

#### CONCLUSIONS

*Euastacus jagara* satisfies the IUCN Red List criteria for listing as Critically Endangered, CR B1+2(a), (b) iii, based on: an EOO < 100 km<sup>2</sup> (~ 21.5 km<sup>2</sup>), severely restricted and fragmented distribution (five known headwater streams, in two drainage divisions), and anticipated decline in area, extent and/or quality of habitat and EOO due to climate change, and threats from exploitation and exotic species. Similarly, the species satisfies the Queensland Nature Conservation Act 1992 criteria for listing as Endangered. Preparation of a conservation management plan is warranted for this species given that it is clearly at risk of extinction, and that there are currently no specific management measures in place.

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## REFERENCES

- ACT Government. 2007. Ribbons of Life: ACT Aquatic Species and Riparian Zone Conservation Strategy, Action Plan No. 29. Department of Territory and Municipal Services, Canberra, Australia.
- Australian Aquatic Biological. 2008. Australian Crayfish Project. Australian Aquatic Biological Pty Ltd, Karuah, New South Wales. Available online via: <http://www.aabio.com.au/crayfish.htm>
- Chiew, F. H. S., and T. A. McMahon. 2002. Modelling the impacts of climate change on Australian streamflow. *Hydrological Processes* 16: 1235-1245.
- Clark, E. 1936. The freshwater and land crayfishes of Australia. *Memoirs of the Natural Museum of Victoria* 10: 5-58.
- Coughran, J. 2002. A new species of the freshwater crayfish genus *Euastacus* (Decapoda: Parastacidae) from northeastern New South Wales, Australia. *Records of the Australian Museum* 54(1): 25-30.
- . 2006. Biology of the Freshwater Crayfishes of Northeastern New South Wales, Australia. Ph.D. Thesis, School of Environmental Science and Management, Southern Cross University.
- . 2008. Distinct groups in the genus *Euastacus*? *Freshwater Crayfish* 16: 125-132.
- . in press (a). Biology of the Blood Crayfish, *Euastacus gumar* Morgan 1997, a small freshwater crayfish from the Richmond Range, northeastern New South Wales. (Australian Zoologist).
- . in press (b). Biology of the Orange-bellied Crayfish, *Euastacus mirangudjin* Coughran 2002. (Australian Zoologist).
- , and J. M. Furse. 2010. An assessment of genus *Euastacus* (49 species) versus IUCN Red List criteria. Unpublished report prepared for the for the global species conservation assessment of crayfishes for the IUCN Red List of Threatened Species. The Environmental Futures Centre, Griffith School of Environment, Griffith University, Gold Coast Campus, Queensland, Australia, 170 pp.
- Crandall, K. A. 1996. *Euastacus jagara*. In: IUCN 2009. IUCN Red List of Threatened Species. Version 2009.1. <[www.iucnredlist.org](http://www.iucnredlist.org)>. Downloaded on 20 July 2009.
- DEH. 2004. The feral cane toad (*Bufo marinus*). Invasive species fact sheet. Department of the Environment and Heritage, Canberra, ACT, Australia.
- DPIF. 2009. Recreational fishing rules and regulations for Queensland: A brief guide. Queensland Department of Primary Industries and Fisheries. Queensland Government, Brisbane, Australia. Available online via: [http://www.dpi.qld.gov.au/documents/Fisheries\\_RecreationalFishing/RecFishing-RegsGuide.pdf](http://www.dpi.qld.gov.au/documents/Fisheries_RecreationalFishing/RecFishing-RegsGuide.pdf)
- Eyre, T., D. Barratt, and M. Venz. 1997. Systematic Vertebrate Fauna Survey Project: Stage II – Assessment of Habitat Quality for Priority Species in Southeast Queensland Bioregion. Queensland CRA/RFA Steering Committee.
- Furse, J. M., and J. Coughran. in press a. An assessment of the distribution, biology, threatening processes and conservation status of the freshwater crayfish genus *Euastacus* (Decapoda: Parastacidae) in continental Australia I. *Crustaceana Monographs*.
- , and ———. in press b. An assessment of the distribution, biology, threatening processes and conservation status of the freshwater crayfish genus *Euastacus* (Decapoda: Parastacidae) in continental Australia II. *Crustaceana Monographs*.
- , and ———. in press c. An assessment of the distribution, biology, threatening processes and conservation status of the freshwater crayfish genus *Euastacus* (Decapoda: Parastacidae) in continental Australia III. *Crustaceana Monographs*.
- Green, K., and W. F. Osbourne. 1981. The diet of foxes, *Vulpes vulpes* (L.) in relation to abundance of prey above the winter snowline in New South Wales. *Australian Wildlife Research* 8: 349-60.
- Hennessy, K. 2006. Climate change scenarios for initial assessment of risk in accordance with risk management guidance. Commonwealth Scientific and Industrial Research Organization, Australia.
- Holthuis, L. B. 1950. The Decapoda of the Siboga Expedition. Part X. The Palaemonidae collected by the Siboga and Snellius Expeditions with remarks on other species. I. Subfamily Palaemoninae. *Siboga Expeditie* 39(A9): 1-268.
- Honan, J. A., and B. D. Mitchell. 1995. Reproduction of *Euastacus bispinosus* Clark (Decapoda: Parastacidae), and trends in the reproductive characteristics of freshwater crayfish. *Marine and Freshwater Research* 46: 485-499.
- Horwitz, P. 1990. The conservation status of Australian freshwater crustacea with a provisional list of threatened species, habitats and potentially threatening processes. Report No. 14. Australian National Parks and Wildlife Service, Canberra.
- Howden, M. 2003. Climate trends and climate change scenarios, pp. 8-13. In: M. Howden, L. Hughes, M. Dunlop, I. Zethoven, D. Hilbert and C. Chilcott (eds.), *Climate Change Impacts on Biodiversity in Australia*. Outcomes of a workshop sponsored by the Biological Diversity Advisory Committee, 1-2 October 2002, Commonwealth of Australia, Canberra.
- Hughes, L. 2003. Climate change and Australia: Trends, projections and impacts. *Austral Ecology* 28:423-443.
- IPCC. 2007. Climate Change 2007—Synthesis Report. An Assessment of the Intergovernmental Panel on Climate Change. Fourth Assessment Report, 52 pp. Intergovernmental Panel on Climate Change, Geneva, Switzerland.
- McCormack, R. B. 2008. The Freshwater Crayfish of New South Wales Australia. Australian Aquatic Biological Pty Ltd., Karuah, NSW.
- Merrick, J. R. 1995. Diversity, distribution and conservation of freshwater crayfishes in the eastern highlands of New South Wales. *Proceedings of the Linnean Society of New South Wales* 115: 247-258.
- Morgan, G. J. 1988. Freshwater Crayfish of The Genus *Euastacus* Clark (Decapoda: Parastacidae) from Queensland. *Memoirs of The Museum of Victoria* 49: 1-49.
- . 1991. The spiny freshwater crayfish of Queensland. *Queensland Naturalist* 31 (1-2): 29-36.
- . 1997. Freshwater crayfish of the genus *Euastacus* Clark (Decapoda: Parastacidae) from New South Wales, with a key to all species of the genus. *Records of the Australian Museum Supplement* 23: 1-110.
- O'Brien, M. B. 2007. Freshwater and terrestrial crayfish (Decapoda, Parastacidae) of Victoria, status, conservation, threatening processes and bibliography. *The Victorian Naturalist* 14(4): 210-229.
- Pittock, B. 2003. Climate Change: An Australian Guide to the Science and Potential Impacts. Australian Greenhouse Office, Canberra.
- Ponniah, M. and J. M. Hughes. 2004. The evolution of Queensland spiny mountain crayfish of the genus *Euastacus*. I. Testing vicariance and dispersal with interspecific mitochondrial DNA. *Evolution* 58(5): 1073-1085.
- and ———. 2006. The evolution of Queensland spiny mountain crayfish of the genus *Euastacus*. II. Investigating simultaneous vicariance with intraspecific genetic data. *Marine and Freshwater Research* 57(3): 349-362.
- Riek, E. F. 1951. The freshwater crayfish (Family Parastacidae) of Queensland, with an appendix describing other Australian species. *Records of the Australian Museum* 22(4): 368-388.
- Shull, H. C., M. Pérez-Losada, D. Blair, K. Sewell, E. A. Sinclair, S. Lawler, M. Ponniah, and K. A. Crandall. 2005. Phylogeny and biogeography of the freshwater crayfish *Euastacus* (Decapoda: Parastacidae) based on nuclear and mitochondrial DNA. *Molecular Phylogenetics and Evolution* 37: 249-263.
- Stevens, N., and W. Willmott. 1996. The Main Range. Rocks and Landscapes Notes. Geological Society of Australia Inc., Brisbane.
- Unmack, P. 2001. Biogeography of Australian freshwater fishes. *Journal of Biogeography* 28: 1053-1089.
- Westoby, M., and M. Burgman. 2006. Commentary. Climate change as a threatening process. *Austral Ecology* 31: 549-550.

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