Invasion of a New South Wales stream by the Tropical Crayfish, *Cherax quadricarinatus* (von Martens)

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ABSTRACT

The tropical redclaw crayfish *Cherax quadricarinatus* is increasingly being reported as an aquatic pest in parts of the world where it has been introduced or translocated. In this paper, we briefly document the invasion of a stream system in New South Wales, Australia. We discuss possible pathways of introduction, and the potential threats the invading species presents to the receiving environment. We suggest immediate action is required to ascertain the invasive potential of this species.

Key words: alien, aquatic pest, *Cherax quadricarinatus*, crayfish, Emigrant Creek, invasive species, redclaw, Richmond River, translocation.

Introduction

Background

Redclaw *Cherax quadricarinatus* is native to New Guinea and northern Australia (Austin 1986). Due to its prominence in the aquaculture and aquarium trades, it has been translocated to many parts of the world (e.g. Paraguay, South Africa, Western Samoa, Jamaica) without any assessment of its potential to become an ecological pest (Lowery 1996; Fisheries Global Information System 2004; Todd and D'Andrea 2003). A warning by Unestam (1975) against introducing crayfishes, including the introduction of Australian crayfishes to overseas countries, has largely been in vain. In Australia, *Cherax quadricarinatus* is one of three species of crayfish that are widely cultivated, and it has been introduced into southern Queensland and New South Wales for this purpose (Horwitz 1990; Wingfield 2002). In Queensland, it has also been accidentally or intentionally introduced into a number of impoundments outside its natural range for recreational fishing purposes (Short 2000; Hollaway and Hamlyn 2001). The species has also been recorded in the tropical north of Western Australia (Doupé *et al.* 2004). In this paper, we document the establishment of a feral population of this species in a New South Wales stream.

Recently, there have been sporadic, anecdotal reports of *Cherax quadricarinatus* from Emigrant Creek, a coastal stream in the Richmond River catchment (Figure 1). The Emigrant Creek catchment has been heavily modified for agriculture (e.g. cattle grazing and orchards), and features a water storage dam that supplies small, coastal communities. A recent aquatic survey also recorded the species within the dam (Moore 2003). The catchment is inhabited by a wide range of native fishes and invertebrates, as well as feral species such as plague minnow, *Gambusia holbrooki*, and carp, *Cyprinus carpio* (pers. obs.). Two native species of crayfish are known to inhabit the catchment: *Cherax cuspidatus* and *Euastacus valentulus* (Coughran 2005a).

Methods

An examination of crayfish carapace remains forwarded by local recreational fishers, from one of their catches in Emigrant Creek Dam, verified that they do indeed belong to the translocated *Cherax quadricarinatus*. Following this, we undertook field verifications of further anecdotal reports of the species during the Spring (Sep-Nov) of 2004. Crayfish were collected by a range of methods, including: hand netting; kick seining; seine netting; and flipping rocks in the stream and collecting animals by hand. Specimens of the native *C. cuspidatus* and *E. valentulus* were returned to the water, and specimens of *C. quadricarinatus* were returned to Southern Cross University.

Species Identification

Cherax quadricarinatus has several distinctive morphological traits that easily distinguish it from the Richmond River catchment's native crayfishes (Figure 2; Coughran 2006). It has four strong ridges (carinae) on the dorsal surface of the cephalon (the

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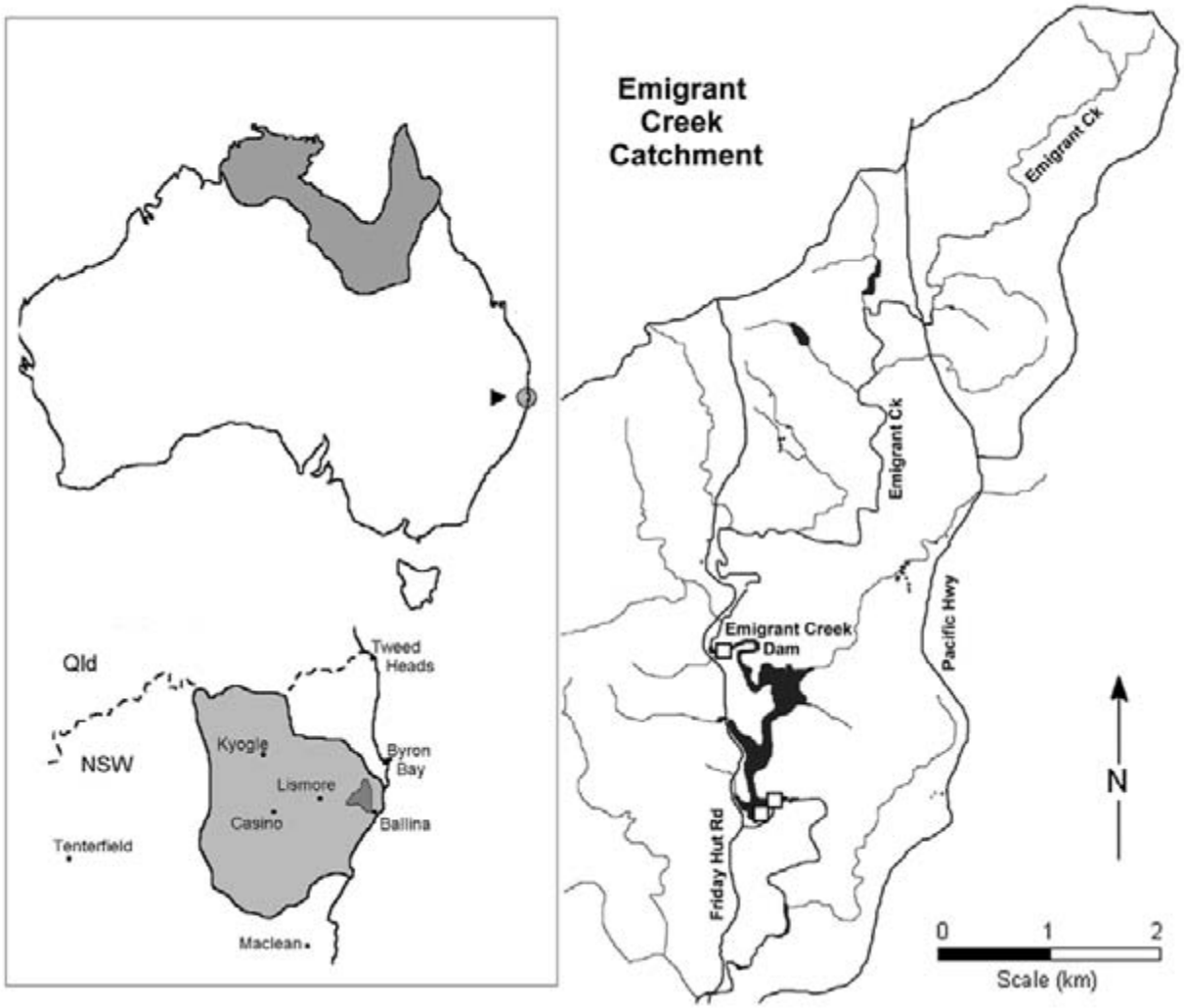

Figure 1. Locality map of Emigrant Creek Catchment. The three confirmed sites of record for *Cherax quadricarinatus* are indicated with squares. Inset: upper left = map of Australia showing locality and natural distribution* of red claw (dark grey) (Wingfield 2002); lower left = location of the Emigrant Creek Catchment (dark grey) within the Richmond drainage (light grey). *The distribution is based on the revision by Austin (1986, 1996), who synonymised *C. bicarinatus* (north-western Northern Territory) and *C. albertisii* (southern New Guinea) with *C. quadricarinatus.*

'head'); a distinct ridge on the cephalon laterally; a long, parallel rostrum with several distinct spines per side; and elongate claws. Adult males usually develop a soft, fleshy, red patch on the outer margin of the claw. However, the 'red claw' is an unreliable feature, and leads to considerable public misunderstanding. We have known people to misidentify the native *C. cuspidatus*, which often develops an orange-red colour on the tips of the chelae and the ventral surface of the claw, as 'red claw'. Verification of anecdotal reports of redclaw will thus be essential for future management of this pest species.

Results

We recorded *Cherax quadricarinatus* at three proximal sites: upstream of, in and immediately below Emigrant Creek Dam (28°45.414'S 153°31.012'E; 28°45.898'S 153°31.000'E; 28°46.188'S 153°31.182'E). The animals collected included live and dead specimens and carcasses (from predation). Thus, the presence of the species in Emigrant Creek, a major tributary of the Richmond River, has been confirmed.

The animals collected ranged in size up to a maximum of 60mm orbital carapace length (total length 190mm). The presence of a wide size range of animals, including several small animals (~20mm OCL; likely young-of-the-year) recorded during our field trips suggest that the population is self-sustaining. Several of the female animals bore mature gonopore characters (dense setae surrounding swollen gonopores). One female animal that had been retained alive by a recreational fisher was carrying three eggs when we examined her (Figure 3). The eggs were undeveloped (no embryo visible), suggesting that they were either recently laid or infertile.

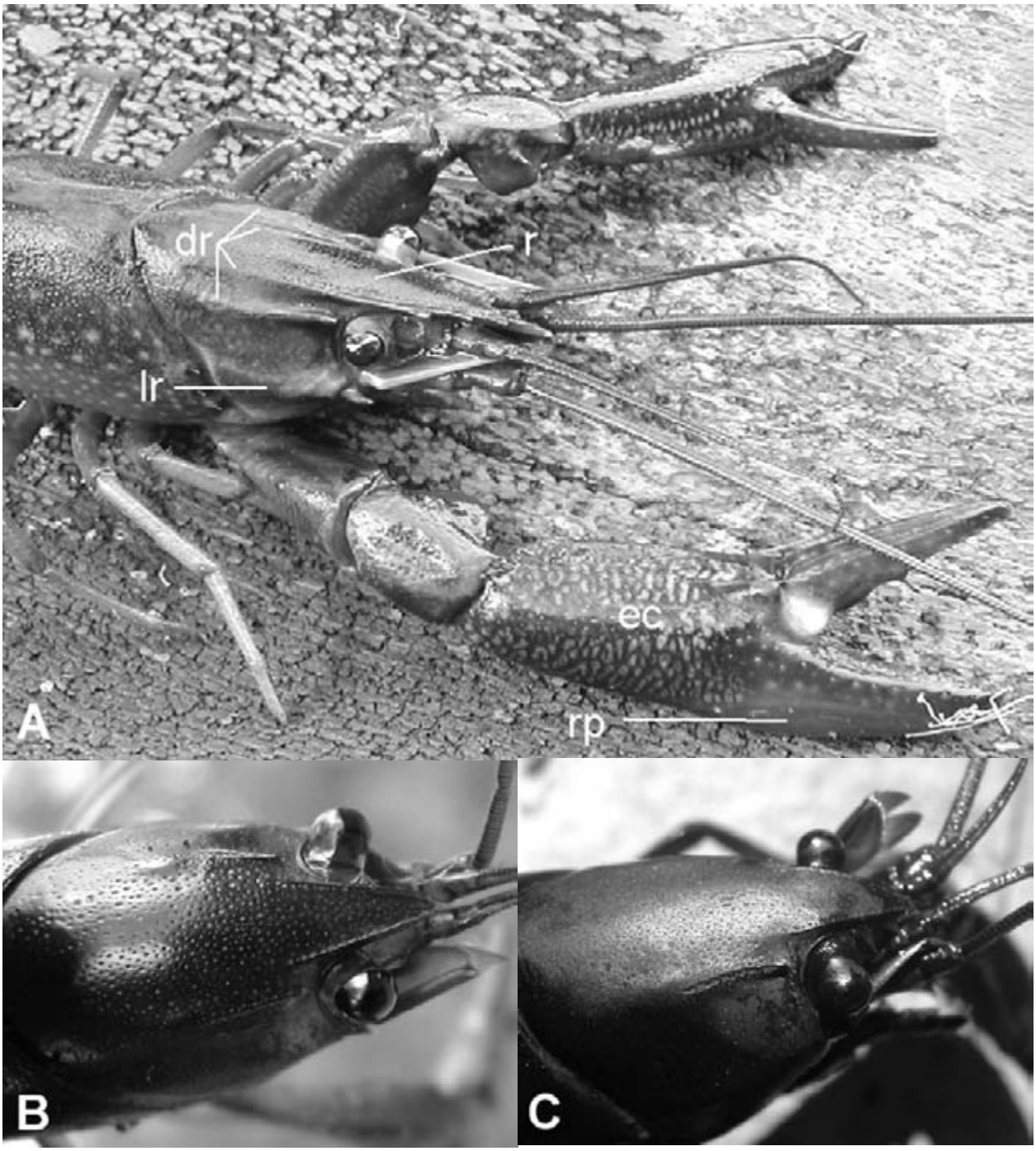

Figure 2. Morphological features useful in distinguishing the redclaw, *Cherax quadricarinatus* (A), from other local crayfishes in northeastern New South Wales, *C. cuspidatus* (B) and *C. leckii* (C). Several features of the introduced species, *C. quadricarinatus*, are useful in diagnosis: r, elongate rostrum with several spines per side; dr, four strongly raised ridges on the dorsal surface of the cephalon; lr, a strongly raised lateral ridge on the cephalon; ec, elongate chelipeds; rp, a soft, red patch that usually develops on adult males, and occasionally on females. The features of the cephalon and rostrum are the most reliable and simple characteristics to distinguish the species from the two indigenous *Cherax* species, which exhibit: short, triangular rostra with 0-1 apical spines per side; poorly developed rostral carinae that do not extend as far back onto the cephalon; weaker development of the two post-orbital ridges; and no lateral cephalic ridge.

Discussion

Prevalence

The findings of this study confirm the presence of the tropical crayfish, *Cherax quadricarinatus*, in the Emigrant Creek catchment, with three sites of record in the vicinity of Emigrant Creek Dam. Given that there are few real impediments to the dispersal of crayfish in the catchment, it is possible *Cherax quadricarinatus* may expand its distribution until it is prevalent throughout the Emigrant Creek system. The brackish nature of the junction of Emigrant Creek with the Richmond River may act as a barrier to the spread of this population into the wider Richmond River catchment. In laboratory experiments,

Figure 3. The eggs carried on one reproductive female Cherax quadricarinatus (below Emigrant Ck Dam). The female had been retained alive in a bucket by a recreational fisher.

however, Jones (1990) found that *C. quadricarinatus* has a high salinity tolerance, with 70% survival rates in 24ppt salinity over 21 days. Therefore, the species may be capable of overcoming the brackish nature of the junction of Emigrant creek and Richmond River, particularly during flood events. At these times, the sudden influx of freshwater could translocate crayfish downstream, from where they might migrate back up into other areas of the Richmond catchment.

Pathways of Introduction

Given the popularity of *Cherax quadricarinatus* in both aquaculture and aquarium circles there are a number of possible sources for this outbreak:

- *Commercial aquaculture*. It is unlikely that the pest stock has originated through commercial aquaculture. There is one commercial aquaculture farm in the Emigrant Creek catchment, an ornamental fish hatchery that does not produce *C. quadricarinatus* (S. Reakes, pers. comm. 2005, Palm Springs Fish Hatchery).
- *Aquarium release*. Redclaw are a popular aquarium species due to their hardiness and established aquaculture techniques and supply. Prevalence of other aquarium species in native waterways is unfortunately common in New South Wales, and it must be considered a likely possibility that redclaw have become established in Emigrant Creek through aquarium release.
- *Escape from farm dams*. Animals may also have escaped from poorly managed backyard dams, although stocking *C. quadricarinatus* in farm dams for personal use is not permitted in New South Wales (NSW Department of Primary Industries - Fisheries 2005). Given the prominent media coverage on this species, it is likely that they have been stocked into farm dams in the catchment in the past. Although the local commercial fish hatchery does not produce redclaw, they receive numerous inquiries about the species, particularly after media coverage events (S. Reakes, pers. comm. 2005, Palm Springs Fish Hatchery). Crayfish are very capable of overland movement (e.g. Smith and Schuster 1913; Olszewski 1980), and if present in local dams it is likely that redclaw will ultimately escape into to natural waterways.
- *Deliberate stocking (cultural reasons)*. Although *Cherax quadricarinatus* is not endemic to the area, it is possible that it has been deliberately stocked into Emigrant Creek. Lintermans (2004) has noted cultural motivations for introducing alien species, such as the release of captive animals to celebrate religious festivals or establish populations of preferred food species. A lack of knowledge in the local community about native and alien species could facilitate the introduction of pests into local waterways. Over the past five years, one of us (JC) has had several encounters with citizens and groups who intentionally stock fishes and crayfishes into local, public waterways of their own accord, to 'enhance' recreational fishing opportunities. A commonly cited example is silver perch, *Bidyanus bidyanus*, which now appears to be established in the Richmond River drainage (A. Moore, pers. comm. 2005, Southern Cross University).
- *Bait Buckets*. They may have been introduced into the area in bait buckets by recreational fishers (e.g. Capelli and Munjal 1992; Ludwig and Leitch 1996; Kats and Ferrer 2003; Doupé *et al.* 2004). Given the prevalence of redclaw in the local aquarium trade, it is plausible that local anglers may have purchased and/or bred redclaw as a bait animal.

Potential Threats

Like many other aquatic pests, such as plague minnow and carp, the very biological attributes that make *Cherax quadricarinatus* so successful in aquaculture and the aquarium trade also equip it to be a potentially devastating ecological pest. The genus *Cherax* itself has three disjunct centres of diversity (Austin 1995), and the evolutionarily distinct Gulf of Carpentaria species represents a particular threat to both the eastern Australian crayfish fauna and its aquatic habitat. The superior growth rates, fecundity and environmental tolerances of *Cherax quadricarinatus* (Jones 1990) equip it to be a competitor with endemic crayfishes, and where its invasion coincides with these species it may displace them. At threat are over 10 endemic species of crayfishes (from three genera) in the northeastern New South Wales region alone (Riek 1969; Horwitz 1995; Morgan 1997; Coughran 2002, 2005b,c), including the iconic powerful crayfish, *Euastacus valentulus*, one of the largest freshwater crayfishes in the world.

Furthermore, *Cherax quadricarinatus* likely differs to the endemic species in its ecological roles (e.g. diet, predation on aquatic fauna and egg masses, burrowing, etc.) and its ectosymbiotic fauna (temnocephalids, nematodes, ostracods, copepods, oligochaetes, etc.). Given its potential to successfully colonize the lower reaches of Emigrant Creek system, the species may have adverse impacts on important nursery habitat (e.g. macrophytes, woody and leafy debris) for many species of fish and invertebrates, both marine and freshwater. However, the actual impacts of the species in the foreign receiving waters of New South Wales are unpredictable. For example, although in its native environment it is not observed to rely on burrowing (Wingfield 2000), in Jamaican streams it has developed a strong burrowing habit that may pose a threat to the integrity of the stream banks and riparian zone (Todd and D'Andrea 2003). Elsewhere in the world (e.g. the U.S.A.), introduced crayfishes have drastically altered lake and stream environments, damaged fisheries and extirpated native species (Lodge *et al.* 2000). Unestam (1975) compared the potential of introduced crayfishes to damage the receiving biotope with the documented damage caused by the introduction of the rabbit to Australia. Unestam (1975) also pointed out that crayfish ectosymbionts themselves could become aggressive to other biota in a new environment.

Importantly, a low incidence of disease was recorded in a recent study of populations of crayfish endemic to northeastern New South Wales (Coughran 2005a). It is conceivable that foreign disease organisms could be introduced to the receiving waters via the establishment of this translocated crayfish. A startling case example that should serve as a warning is that of the European crayfishes, which have been decimated by the disease Crayfish Plague, introduced on an evolutionarily distinct crayfish from America (Alderman and Polglase 1988; Westman 1995). Europe's endemic crayfishes are now seriously threatened, and recreational and commercial fishers rely heavily on intentionally re-stocked supplies of the pest species from America, which is a resistant carrier of the fungus responsible for the disease.

Management Considerations

There is an urgent need to further investigate the prevalence of this invading species in New South Wales waters in order to minimize the spread of this outbreak, ascertain the species' invasive potential, and assess the viability of management or eradication programs. We suggest two initiatives:

- To inform and involve the recreational fishing community, and the wider community, in an integrated effort to contain the spread of *Cherax quadricarinatus*.
- To initiate research projects that elucidate the most effective measures for long-term control and, ultimately, eradication, of this translocated species, in order to protect the important recreational species, habitat and biodiversity of the Richmond River catchment.

Successful management of this invading crayfish will require a concerted effort from fisheries scientists and managers, the recreational fishing community, landholders and the general public. In order to maximize the potential for successful management or eradication, action should be initiated immediately. At a broader level, the very ease with which this species could be successfully introduced into other waterways in New South Wales (and elsewhere in Australia) is of great concern. There is a high probability that there are other, as yet undocumented, cases. Furthermore, as its popularity as an aquarium and aquaculture species continues to grow, the likelihood of future invasions will also increase. The prevention of such outbreaks will require a more pro-active role by scientists and managers in educating the public as to both the outstanding diversity of crayfishes in Australia (>100 species; Merrick 1995) and the dangers of introducing animals into foreign aquatic environments.

Although the present example of redclaw in New South Wales might be readily accepted as a translocated population, it is conceivable that future reports of translocated redclaw elsewhere in Australia and New Guinea may involve previously unidentified, distinct populations (or species). In order to prevent the eradication of any such populations, a revision of the taxonomy and distribution of this species is required. The application of genetic techniques may be of particular use in clarifying any uncertain cases, and should be initiated prior to eradication programs.

While it is important to consider the potential threats redclaw could pose to the aquatic systems of northeastern New South Wales, it is important to stress that this species has been prominent in aquarium and aquaculture for around two decades. It is likely that many accidental or intentional releases of redclaw into the region's waterways have occurred during that time, and yet the species appears uncommon. The species was not recorded from any of 242 other sites sampled during a broader study on the crayfish fauna of northeastern New South Wales, including sites further up- and downstream of the three sites of record (Coughran 2005a). The actual 'invasiveness' of the species is therefore uncertain, and specific research is required to ascertain its invasive potential.

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