

Rapid Communication

The first occurrence of the Australian redclaw crayfish *Cherax quadricarinatus* (von Martens, 1868) in the contiguous United States

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Abstract

The Australian redclaw crayfish, *Cherax quadricarinatus*, is a popular aquaculture crayfish that has been introduced around the world. Here we report the first occurrence of the species in the United States in Lake Balboa, Los Angeles, California. The impacts of this species are largely unknown, and further research is needed to determine the species' effects on native ecosystems. Sampling is needed to evaluate the population status in Lake Balboa to determine to what extent the species has spread in the greater Los Angeles River basin.

Key words: Decapoda, Parastacidae, AIS, aquatic invasive species, impact, risk, citizen science

Introduction

The spread of species outside of their native range is one of the leading threats to freshwater biodiversity (Dudgeon et al. 2006). Competition, food web interactions, habitat alteration, and disease transmission are among the primary impacts to aquatic systems by introduced species (Gallardo et al. 2015; USGS 2019). The Australian redclaw crayfish, *Cherax quadricarinatus* (von Martens, 1868), has been introduced from North-eastern Australia and South New Guinea around the world (Ahyong and Yeo 2007; Beatty et al. 2019; Bortolini et al. 2007; Coughran and Leckie 1997; Patoka et al. 2016; Williams et al. 2001). The main vectors for spread of this species are escape from aquaculture farms (Bortolini et al. 2007; Daniel 2019) and aquarium release (Ahyong and Yeo 2007; Patoka et al. 2018a, b; Weiperth et al. 2019), but in some countries *Cherax* are also introduced in the wild as a food and bait source (Coughran and Daly 2012).

In the United States, *C. quadricarinatus* occurs only in Puerto Rico (an unincorporated US territory), where it was introduced via illegal importation and stocking for aquaculture, and subsequently spread via flooding associated with Hurricane Georges in 1998 (Williams et al. 2001). Since its

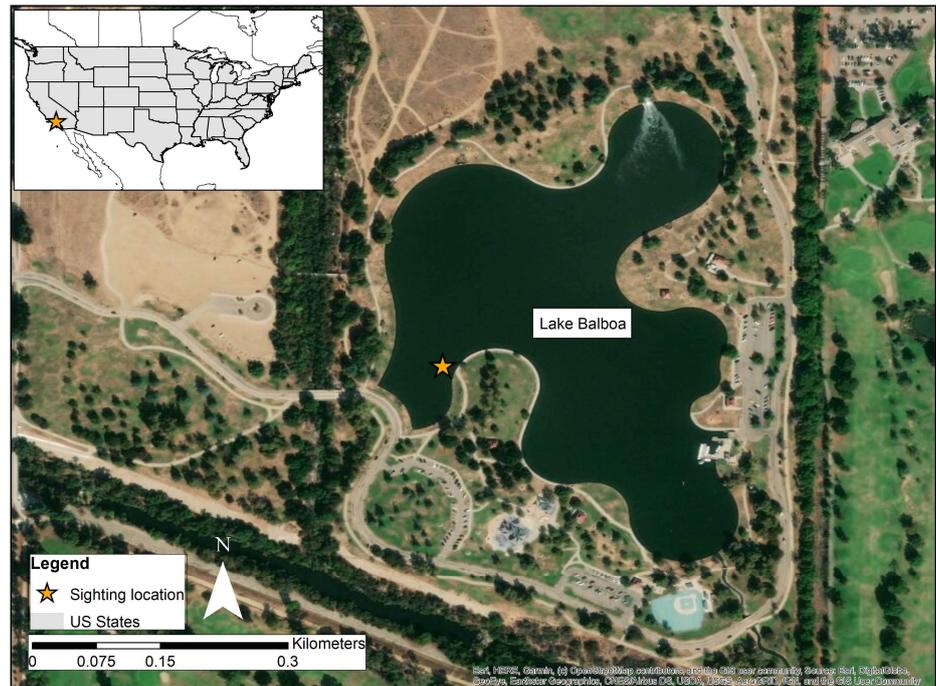


Figure 1. Location of the *Cherax quadricarinatus* sighting report, Lake Balboa, Los Angeles, California, USA.

establishment in Puerto Rico, preliminary evidence reports competition and the potential for extirpation of native shrimp species (Williams et al. 2001). In North America, the Australian redclaw crayfish has not previously been found in the wild in Canada or the contiguous United States (although present in aquaculture; Hauck et al. 2001), but the species is established in northern Mexico (Bortolini et al. 2007). Here we report the first known introduction of *C. quadricarinatus* in the contiguous United States.

Materials and methods

The Nonindigenous Aquatic Species Program (NAS) of the United States Geological Survey tracks obligate aquatic non-native species across the entire United States (USGS 2019). One of the many functions of the database is to help detect and predict spread of non-native species, and this assists managers and other interested parties with early detection and rapid response (EDRR). Data are collected from numerous sources including: state and federal agency researchers, managers, museums and citizen scientists. When a new sighting is found for a state, drainage, or county the NAS program will send out an alert to inform registered stakeholders as part of the national EDRR system.

On August 17, 2019, a specimen of *C. quadricarinatus* was reported from Lake Balboa, Los Angeles, California, United States (34.18054, -118.49641; Figure 1), where it had been unintentionally caught on hook and line by one of the authors of this study (A.K. Yazaryan) in December 2018. Lake Balboa is a 11-hectare, a maximum of 3 m deep, urban, man-made lake with concrete sea walls and little-to-no vegetation that is supplied with



Figure 2. Photos of male *Cherax quadricarinatus* found in Lake Balboa. The presence of the four distinct carinae (ridges) on the cephalon (A) and red patch on the outside of the major chelae (claw; B) are characteristic of the species, as well as the thick, wide chelae and the large size of the animal. Photos by Ara K. Yazaryan.

reclaimed wastewater from the Donald C. Tillman Water Reclamation Plant (City of Los Angeles Sanitation and Environment 2020). It is primarily used for fishing and other shore-side recreation, with swimming prohibited and motorless boating-only permitted.

Upon further dialogue, Nonindigenous Aquatic Species program (NAS) scientists were able to obtain more information about the occurrence with additional photos of the specimen (Figure 2). After receiving the official report of *C. quadricarinatus* in Lake Balboa, NAS scientists searched social media platforms (consisting of a search of iNaturalist, Youtube, and Reddit via a Google search) for additional reports (with photos) of the species in the lake to attempt to verify the potential presence of a redclaw crayfish population there.

Results and discussion

Based on the specimen of *C. quadricarinatus* reported by Ara Yazaryan (<https://go.usa.gov/xV97T>; Figure 2A), NAS scientists confirmed the identification and the first known record of the species in the contiguous United States. The specimen exhibited all main diagnostic characteristics of the species, including large size (~ 30 cm), four distinct cephalon ridges, and a red margin along major chelae (claw; a trait of males) (Figure 2B; Coughran and Leckie 1997; Daniel 2019). The morphologically similar species *C. albertisii* could be ruled out by the far-thicker chelae present in *C. quadricarinatus*. Casual further observations (A.K. Yazaryan *pers. obs.*) and the media platform investigation performed led to the detection of several other observations of *C. quadricarinatus* in Lake Balboa. All

observations from these platforms ranged from November 2018 to May of 2019 and included both male and female specimens, suggesting that the species overwintered and could potentially become established in the lake, or that the lake has experienced multiple introductions of the species. Formal and thorough sampling is needed to determine the status of the species in the lake and surrounding waterbodies.

Other non-native species have been found in the lake, including convict cichlids (*Archocentrus nigrofasciatus*), sailfin armored catfish (*Pterygoplichthys* sp.), and Mozambique tilapia (*Oreochromis mossambicus*; A.K. Yazaryan *pers. obs.*; USGS 2019). No crayfish are native to this area in California, however, iNaturalist (iNaturalist 2019) sightings show a variety of unidentified crayfish present in the area, and the red swamp crayfish (*Procambarus clarkii*) is confirmed just downstream from Lake Balboa in the hydrologically connected Los Angeles River (Nagy et al. 2019).

Containment of *C. quadricarinatus* in Lake Balboa is essential, as the species is known to reach high densities (Masser and Rouse 1997), disperse among rivers (Williams et al. 2001), and it has used overland travel and flooding to disperse and become established in Mexico just 200 miles from the Texas border (Bortolini et al. 2007). This record is particularly troubling, as climate-match predictions for this species' colonization possibilities in the United States put Los Angeles as a low match location possibility (USFWS 2012). The impacts of *C. quadricarinatus* outside of its native range have not been thoroughly studied, but circumstantial evidence suggests that the species may deplete macrophyte cover and change invertebrate communities in its introduced range (Pinder et al. 2019), as well as potentially out-compete native species (Daniel 2019; Leland et al. 2012; Williams et al. 2001). Although the impacts of *C. quadricarinatus* are not comprehensively known (Coughran and Leckie 1997; Williams et al. 2001), considering the impacts of other non-native crayfish on systems in the United States (Lodge et al. 2000), it is reasonable to be concerned about the spread of the species in the country. Translocated and exotic crayfish impact food webs (Lodge et al. 1994; Prestie et al. 2019), outcompete native crayfish (Reid and Nocera 2015; Taylor and Redmer 1996), modify habitat (Roessink et al. 2017; Cronin et al. 2002), and adversely impact threatened and endangered species (Gamradt and Kats 1996; Mueller et al. 2006).

Preventing the introduction and spread of invasive species requires knowledge of the vectors responsible for the introduction and spread of specific species, and education for those that may initiate or aid an introduction (Patoka et al. 2018a). Human recreational activities are the primary pathways for introduced aquatic species in the US (USGS 2019). Drake et al. (2015) show that while many stakeholders support invasive species prevention and control, a simultaneous lack of knowledge of vectors and the personal responsibility of animal release leads to behaviors that increase invasive species introductions. Aquarium releases account for

many aquatic invasive species introductions in popular lakes in urban areas such as Lake Balboa, which might have been the case here. In fact, a simple internet search for the common name of the species (redclaw crayfish) will yield more than ten websites where specimens can be purchased in bulk or individually in the United States. Nevertheless, there is also the possibility that a ceremonial release may have been the introduction pathway for this species (Liu et al. 2012; Nuwer 2014). This is a practice that is common in large cities, although many other potential vectors could have been responsible for the species introduction into this lake (see USGS 2019).

The present report is partially a cautionary tale for human vectors, but it is also a demonstration of the power of citizen science; assistance from amateur naturalists, anglers, and outdoor enthusiasts can prove to be vital in the discovery of non-native species, not just in avoiding their introduction (USFWS 2019). Correspondence with local managers has occurred to report the occurrence of *C. quadricarinatus* in Lake Balboa. A risk map identifying potential short-term dispersal extent from the lake was created and sent to natural resource managers, biologists, and other users of the system, and is displayed on the NAS website (<https://nas.er.usgs.gov/queries/SpecimenViewer.aspx?SpecimenID=1613837>; USGS 2019). A comprehensive survey of the lake would inform the status of the *C. quadricarinatus* introduction to determine if the species is established. If established, the species' spread from Lake Balboa into the hydrologically connected Los Angeles River would be a concern (USGS 2019). Evaluating and monitoring *C. quadricarinatus* in California and the established populations bordering the southern United States in Mexico (Bortolini et al. 2007), where the climate is favorable for the species' establishment (Masser and Rouse 1997; USFWS 2012), is essential moving forward if the United States is to prevent this species from becoming established in the lower 48 states.

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