EJSIT
European Journal of Science, Innovation and Technology
ISSN: 2786-4936
www.ejsit-journal.com
Volume 5 | Number 2 | 2025

A Review of the Global Effects of *Cherax quadricarinatus* on Native Biodiversity in Non-Native Ecosystems

Geofrey Makwelele[1*], Katongo Cyprian[2], Makeche Mauris[3], Masuzyo S. Nyirenda[4] and Matthews Mwambo[5]
[1]Department of Biological Sciences, School of Technology, Science and Mathematics, Chalimbana University, Chongwe, Zambia
[2,5]Department of Biological Sciences, School of Natural Sciences, University of Zambia, Lusaka, Zambia
[3]Institute of Basic and Biomedical Sciences, Levy Mwanawasa Medical University, Lusaka, Zambia
[4]Central Fisheries Research Institute, Department of Fisheries, Chilanga, Zambia

ABSTRACT

Cherax quadricarinatus, also known as the red claw crayfish, is an alien invasive species (AIS) in numerous freshwater ecosystems outside its native range in northern Australia and southern New Guinea. Its introduction to non-native ecosystems, often driven by aquaculture, accidental incidents and the pet trade, has significant ecological implications for native biodiversity. This species' adaptability to various environmental conditions and high reproductive rate facilitates its establishment and spread in new habitats. The presence of *C. quadricarinatus* in non-native ecosystems results in several detrimental effects on native biodiversity, including competition with indigenous crayfish and other aquatic species for resources, predation on native species, and alteration of habitat structures.

C. quadricarinatus competes directly with native crayfish species, often leading to a decline in native populations due to its aggressive behavior and more efficient resource utilization. This competition extends to other aquatic invertebrates and small vertebrates, resulting in reduced biodiversity and disruptions in local food webs. Predation by *C. quadricarinatus* on native fish, amphibians and invertebrates further exacerbates these impacts, often leading to declines in vulnerable native populations. In addition, the burrowing behavior of *C. quadricarinatus* causes physical alterations to habitats, such as increased sedimentation and destruction of aquatic vegetation, which are crucial for the survival of many native species. These habitat modifications can lead to long-term changes in ecosystem structure and function, affecting water quality and availability of resources. Hybridization with native crayfish species can occur, leading to genetic dilution and loss of unique genetic traits in native populations. *C. quadricarinatus* crayfish can carry diseases and parasites that may infect native species.

Keywords: global, ecological impact, *Cherax quadricarinatus*, native biodiversity, non-native ecosystem

INTRODUCTION

Cherax quadricarinatus, native to northern Australia and southern New Guinea, is among the largest freshwater decapods (Haubrock et al., 2021; Sallehuddin et al., 2021; Sanjar et al., 2023). Despite generally preferring slow-moving streams in its native range, it has a wide environmental tolerance, making it capable of establishing populations when introduced to a wide range of other conditions and habitats (Haubrock et al., 2021). The

* Corresponding Author

biological and ecological features of *C. quadricarinatus* render it a highly suitable and popular species for aquaculture worldwide, being the second (after the red swamp crayfish, *Procambarus clarkii*) most important crayfish species economically (Haubrock et al., 2021; Sallehuddin et al., 2021). Today, *C. quadricarinatus* is widely translocated, and various established wild populations have been reported on every continent except Antarctica region (Haubrock et al., 2021). It has successfully established its range and population in a number of nations beyond its original habitat, where it is regarded as an invasive or nuisance species (Sallehuddin et al., 2021).

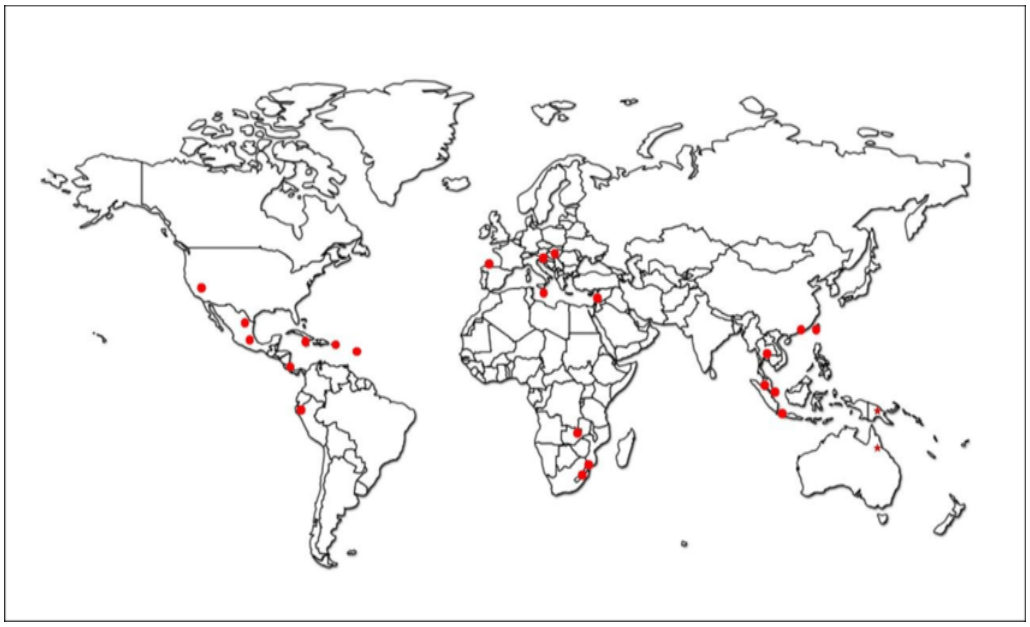

Figure 1: Global distribution of *C. quadricarinatus* Note: Red dotted labels refer to detected introduced crayfish area and red star refer as native origin of the species
Source: Sallehuddin et al. (2021)

C. quadricarinatus has been translocated to various locations around the world as illustrated in Figure 1. Wide spreading of this species has mainly been in tropical regions and is associated with the suitability of the condition that favors their habitation for foraging base and establishment. The introductions have mainly been for aquaculture activities and unintentional release into the wild.

This paper is going to address effect of *C. quadricarinatus* on indigenous biodiversity on non-indigenous ecosystems worldwide. *C. quadricarinatus* are generalist omnivores, and thus, have large effects on both primary and secondary producers (Twardochleb et al., 2013). *C. quadricarinatus* are ecosystem engineers that increase rates of leaf-litter breakdown and nutrient cycling in streams (Twardochleb et al., 2013), and their grazing and burrowing can reduce benthic algae and macrophyte cover, producing a state change in lakes and wetlands from clear- to phytoplankton-dominated turbid-water systems (Twardochleb et al., 2013). Coupled with habitat modification, *C. quadricarinatus* predation drives decline in diversity and abundances of native invertebrates (Twardochleb et al., 2013), and reduces amphibian populations through predation on eggs and larvae (Twardochleb et al., 2013). The organism's invasions have resulted in fish declines through predation, shelter competition, and indirect competition for prey (Reynolds, 2011; Twardochleb et al., 2013).

METHODS

We collected data through desk review approach. Our data assemblage through searching; selecting and collecting of materials followed those outlined by Twardochleb et al. (2013) and Sallehuddin et al. (2021) for systematic review, which included formation of search protocol, data collection, data extraction and analysis. We searched the Institute of Scientific Information (ISI; Thomson Reuters), Web of Science online database (WSOD) and identified peer-reviewed papers published that contained the effect of *C. quadricarinatus* on native biodiversity of non-native recipient ecosystems. Other online databases such as Google Scholar (GS), Web of Knowledge (WK) and other related sites were also searched. We also included reliable and reputable PhD thesis, conference reports, studies referenced within articles obtained from such search. We further broadened and filtered search results to include journals that publish articles within the categories of ecology, freshwater biology, fisheries, biodiversity and limnology. We analyzed and summarized reputable published research work on the impact of *C. quadricarinatus* on native biodiversity in places where it has been introduced worldwide.

The review captured relevant data on impact of *C. quadricarinatus* on habitats invaded around the globe and effects of the invasion on native aquatic biodiversity including food chains (FC), food webs (FW), macrophytes, basal algae biomass, invertebrates, fish, amphibian and ecosystem functioning. Other sources considered were online books and other related materials on *C. quadricarinatus*. Further, our search included other journals articles containing ecological related effects of *C. quandricarinatus* on native biodiversity in non-native ecosystems published not long ago. Recent studies and publications were given priority.

RESULTS AND DISCUSSION

Global Effect of *Cherax quadricarinatus* on Native Biodiversity in Non-Native Ecosystems

C. quadricarinatus (von Martens, 1868), the Australian red claw crayfish, is a species of the family parastacidae native to Australia and Papua New Guinea which has become an emerging freshwater invasive species in tropical and subtropical waterbodies worldwide (Sanjar et al., 2023). Its introduction to non-native ecosystems triggered by aquaculture, the aquarium trade and accidental releases has resulted in significant impacts on native biodiversity. This analysis through our study review examines the effects of *C. quadricarinatus* on native biodiversity in native ecosystems across different continents and countries highlighting specific ecological impacts. The main impacts are categorized into competition with native species, predation on native species, habitat modification, genetic impacts and disease and parasite transmission.

North America

In the United States, particularly in states like Florida and Texas, *C. quadricarinatus* was introduced primarily through the aquarium trade and aquaculture activities. The species competes with native crayfish such as *Procambarus clarkii*, *Procambarus alleni* and *Procambarus fallax*, leading to declines in native populations due to direct competition for food and habitat (Morningstar et al., 2020). It has led to the decline of native crayfish species due to its aggressive nature and efficient foraging behavior (Morningstar et al., 2020). Additionally, *C. quadricarinatus* predation on native invertebrates and small fish disrupts local food webs, reducing biodiversity. In Mexican freshwater ecosystems, the introduction of *C. quadricarinatus* has been associated to the decline of native fish and amphibian species due to predation on eggs and juveniles, invertebrates, disturbing native food webs. The

crayfish's broad diet and high reproductive rate enable it to establish and expand rapidly in new environments, exacerbating its impact on native species (Morningstar et al., 2020).

South America

In Brazil, *C. quadricarinatus* was introduced for aquaculture purposes. Studies have shown that its presence in natural water bodies has led to significant competition with native crayfish and other aquatic fauna (Magalhães et al., 2017). The aggressive nature of *C. quadricarinatus* and its high reproductive rate exacerbate its impact, often leading to the displacement of native species (Rodrigues & Freire, 2020).

Europe

In Spain, the *C. quadricarinatus* has established populations in several freshwater systems. Its introduction has resulted in competition with native species such as *Austropotamobius pallipes*, a crayfish species already under threat from habitat loss and disease. *C. quadricarinatus* also causes habitat modifications through its burrowing activities, leading to increased sedimentation and destruction of aquatic plants, which further impacts native biodiversity. Similarly, in Italy, the introduction of *C. quadricarinatus* has led to the decline of native crayfish populations. *C. quadricarinatus*'s omnivorous diet and high reproductive potential allow it to out compete native species for resources, leading to reduced biodiversity. The presence of *C. quadricarinatus* has been linked to the decline of native amphibians and macroinvertebrates, disrupting local food webs. Additionally, the species' burrowing behavior causes significant alterations to the aquatic habitats, affecting water quality and availability of shelter for native species. In Germany, the *C. quadricarinatus's* burrowing activities has led to enhanced soil erosion and sediment modification, which negatively affects the habitat of native biodiversity. This habitat alteration impacts the overall health of aquatic ecosystems, leading to declines in native species populations.

C. quadricarinatus carry diseases and parasites that may infect native species. For example, crayfish plague is a disease which has devastated native crayfish populations in Europe. Alien crayfish species can host other pathogens that threaten native aquatic organisms. The introduction of diseases by *C. quadricarinatus* poses a significant risk to the health and stability of native aquatic communities.

Africa

In South Africa, *C. quadricarinatus* was introduced through aquaculture and is now found in several freshwater ecosystems. The species competes with native freshwater crabs (*Potamonautes spp.*) and other aquatic organisms, leading to reduced growth rates, reproductive success in the native species and a general decline in native biodiversity (Madzivanzira et al., 2022; Nunes et al., 2017). *C. quadricarinatus* has resulted in the decline of native species such as the Cape River crab, *Potamonautes perlatus*, due to their competitive superiority in resource acquisition (Nunes et al., 2017). The predatory nature of *C. quadricarinatus* on native fish and invertebrates further exacerbates their impact on the local ecosystem. The presence of *C. quadricarinatus* has also altered the structure of aquatic communities by preying on benthic invertebrates and small fish, reducing their abundance and indirectly affecting species that rely on them for food.

In Kenya, the introduction of *C. quadricarinatus* has led to noticeable habitat alterations due to their burrowing activities. Increased erosion and sediment displacement have negatively affected the habitats of benthic organisms, leading to declines in native species populations (Muhoho et al., 2020). In Malawi, outbreaks of crayfish-related diseases have been correlated with the presence of non-native crayfish species, including *C. quadricarinatus*.

Asia

In Thailand, the introduction of *C. quadricarinatus* for aquaculture has resulted in its establishment in natural water bodies. The species competes with native crustaceans and fish, leading to declines in native populations (Lipták et al., 2017). *C. quadricarinatus* has led to declines in native prawn and fish species, disrupting the ecological balance (Sodsuk & Nabhitabhata, 2020). The burrowing activities of *C. quadricarinatus* also contribute to habitat degradation, affecting aquatic vegetation and water quality (Köck et al., 2018).

In China, the *C. quadricarinatus* is found in several regions where it competes with native crayfish species such as *P. clarkii*. The aggressive behavior and high reproductive rate of *C. quadricarinatus* lead to the displacement of native species and reductions in biodiversity. The species' impact on habitat structure through burrowing further affects the overall ecosystem (Wang et al., 2018).

Oceania-Australia (Non-Native Regions)

While native to northern Australia, *C. quadricarinatus* has been introduced to regions outside its natural range within Australia. In these non-native regions, it competes with other crayfish species and affects local biodiversity. The species' burrowing behavior and high reproductive rate lead to significant ecological changes, impacting native species and habitat structures.

CONCLUSION

The global spread of *C. quadricarinatus* has significant implications for native biodiversity in non-native ecosystems. Across continents, the species competes with native crayfish and other aquatic organisms, preys on native species and disrupts local ecosystems, leading to declines in native species populations and alterations in habitat structure. Effective management strategies, including prevention, public education, and targeted removal efforts, are essential to mitigate these impacts and protect native biodiversity.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the partial financial support offered by Chalimbana University Management and the university community. Special thanks once more go to Chalimbana University team of co-authors and supervisors for the unflinching technical expertise, guidance and support.

REFERENCES

Haubrock, P. J., Oficialdegui, F. J., Zeng, Y., Patoka, J., Yeo, D. C. J. & Antonın Kouba, A. (2021). The red claw crayfish: A prominent aquaculture species with invasive potential in tropical and subtropical biodiversity hotspots. *Reviews in Aquaculture, 13*(3), 1488–1530. https://doi.org/10.1111/raq.12531

Köck, G., Tait, L. & Füreder, L. (2018). Effects of introduced crayfish on native species. *Hydrobiologia, 825*(1), 47-60.

Lipták, B., Mrugała, A., Pekárik, L., Gruľa, D., Mutkovič, A., Petrusek, A. & Kouba, A. (2017). Expansion of the red claw crayfish (*Cherax quadricarinatus*) in the wild in the tropical Americas. *Knowledge and Management of Aquatic Ecosystems, 418,* 31.

Madzivanzira, T. C., Weyl, O. L. F. & South, J. (2022). Ecological and potential socioeconomic impacts of two globally-invasive crayfish. *NeoBiota, 72,* 25–43. https://doi.org/10.3897/neobiota.72.71868

Magalhães, A. L. B., Serejo, C. S. & Buckup, L. (2017). Biological invasions and the conservation of biodiversity in Brazilian inland waters. *Oecologia Australis, 21*(3), 207-237.

Morningstar, C.R., Daniel, W.M., Neilson, M.E. & Yazaryan, A.K. (2020). The first occurrence of the Australian red claw crayfish *Cherax quadricarinatus* (von Martens, 1868) in the contiguous United States. *BioInvasions Records, 9,* 120–126. https://doi.org/10.3391/bir.2020.9.1.16

Muhoho, J. M., Otieno, P. E., & Mungai, N. W. (2020). Impact of red claw crayfish (*Cherax quadricarinatus*) on aquatic ecosystems in Kenya. *East African Journal of Ecology, 23*(1), 15-26.

Nunes, A. L., Zengeya, T. A., Measey, G. J. & Weyl, O. L. (2017). Freshwater crayfish invasions in South Africa: Past, present and potential future. *African Journal of Aquatic Science, 42*(3), 309-323.

Reynolds, J. D. (2011). A review of ecological interactions between crayfish and fish, indigenous and introduced. *Knowledge and Management of Aquatic Ecosystems, 401*, 10. http://dx.doi.org/10.1051/kmae/2011024

Rodrigues, L. C. & Freire, C. A. (2020). Invasive potential of *Cherax quadricarinatus* in Brazil: A threat to biodiversity. *Journal of Aquatic Invasive Species, 15*(2), 139-152.

Sallehuddin, A. S., Kamarudin, A. S., & Ismail, N. (2021). Review on the global distribution of wild population of Australian Redclaw Crayfish, *Cherax quadricarinatus* (von Martens, 1868). *Bioscience Research, 18*(SI-2), 194-207. Retrieved October 30, 2023, from https://www.researchgate.net/publication/354792147_Review_on_the_global_distribution_of_wild_population_of_Australian_Redclaw_Crayfish_*Cherax_quadricarinatus*_von_Martens_1868

Sanjar, A., Davis, D. R. & Kline, R. J. (2023). Evidence of an established population of *Cherax quadricarinatus* (von Martens, 1868) in south Texas, USA. *BioInvasions Records, 12*(1), 284–291. https://doi.org/10.3391/bir.2023.12.1.24

Sodsuk, P. & Nabhitabhata, J. (2020). Invasive crayfish in Thailand: Impacts and management strategies. *Journal of Environmental Management, 269*, 110829. https://doi.org/10.1016/j.jenvman.2020.110829

Twardochleb, L. A., Olden, J. D. & Larson, E. R. (2013). A global meta-analysis of the ecological impacts of non-native crayfish. *Freshwater Sci., 32*(4), 1367–82. https://doi.org/10.1899/12-203.1

Wang, Y., Zeng, Y., Li, Q. & Guo, Z. (2018). The invasion and spread of *Procambarus clarkii* (Girard, 1852) in China. *Biodiversity Science, 26*(2), 181-184.