Rapid Communication

First wild record of Australian redclaw crayfish *Cherax quadricarinatus* (von Martens, 1868) in the East Coast of Peninsular Malaysia

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Abstract

Six individuals of Australian redclaw crayfish *Cherax quadricarinatus* (von Martens, 1868) (Decapoda: Parastacidae), the identity of which was confirmed through morphological and molecular characterization. They were caught from the wild environment in Terengganu, East Coast of Peninsular Malaysia. Since there is no record of redclaw aquaculture in close vicinity of the sampling site, it is hypothesized that the introduction of the species has been caused through a release by aquarists. Further studies are essential to understand the distribution and potential impacts of this invasive species in the area, and in the East Coast of Peninsular Malaysia.

Key words: introduction, Decapoda, Parastacidae, invasive aquatic species, Terengganu

Introduction

The introduction of non-native species outside their native range has had many negative impacts including biodiversity loss of native species especially in freshwater ecosystems (Harper et al. 2002; Nystrom 2002; Rodríguez et al. 2005; Torres and Alvarez 2012; Khairul Adha et al. 2013; Khaleel et al. 2020). The impact of invasive species on native freshwater species diversity is higher due to the confined geographical nature compared to marine habitats (Maitland 1995; Moorhouse and Macdonald 2015).

Cherax quadricarinatus (von Martens, 1868) is native to the freshwater environments of northern Australia and southern New Guinea (Lawrence and Jones 2002; Bláha et al. 2016; Patoka et al. 2016). The redclaw crayfish has been translocated worldwide mainly for aquaculture and aquarium pet trade purposes (Harlioğlu and Harlioğlu 2006; Ahyong and Yeo 2007; Bortolini et al. 2007; Belle and Yeo 2010; Snovsky and Galil 2011; Torres-Montoya et al. 2016; Azofeifa-Solano et al. 2017; Nunes et al. 2017; Patoka et al. 2018; Weiperth et al. 2019; Morningstar et al. 2020). In Malaysia, the

introduction of redclaw is associated with the aquaculture production of this species, which can be traced back to 2003 in Johor (border with Singapore), the southern part of Peninsular Malaysia (Chang 2001; Naqiuddin et al. 2016). Accidental escape or intentional release from aquaculture facilities and aquaria have caused the introduction of redclaws into the wild. To date, redclaw is the only invasive non-native crayfish that has successfully established wild populations in Malaysia. Its invasion success might be due to the similarity of the environmental conditions between Malaysia and their native range. Since their first introduction, wild redclaw populations have been sighted not only in the southern part of the country (Johor), but also in other parts of Malaysia including the West Coast of Peninsular Malaysia (Selangor) and Borneo Island (Sarawak) (Johan et al. 2012). This study reports the first occurrence of redclaw in the wild of the East Coast of Peninsular Malaysia.

Materials and methods

Sampling

This research began with an online survey using the social media platform Facebook. We posted a question looking for information from Facebook users about the location of wild populations of redclaw in Malaysia. Feedback from locals revealed the presence of this species at a number of locations in Malaysia, most of them already known. We decided to focus solely on a report of the species in a location in Terengganu, East Coast of Peninsular Malaysia, as no wild redclaw population had previously been recorded in the region. Based on the information provided in the survey, on 21st October 2019 we headed to a small village located in Felda Tenang, Besut, Terengganu (5°33′42.6″N; 102°29′49.9″E) (Figure 1) for field sampling. The search covered a total length of approximately 0.48 km of the drainage system where redclaws had been confirmed to be sighted by locals. The drainage system of the village is connected to Besut River, the main river in the area. The system has been constructed with concrete materials, has approximately 2 m depth and 1 m width, and is characterised by the accumulation of soils washed out during rainfall (Figure 2). Weeds and macrophytes develop on such accumulated soil and in between the cracks of the drainage and provide a suitable hideout for redclaws.

We used two different methods to sample redclaws; hand picking and modified crayfish traps. For hand picking, the redclaws were caught by hand in shallow waters of the drainage area. We spent about 1 hour searching for crayfish at dawn, during which each of six people covered approximately 70–100 meters area of the drainage. In addition, six modified crayfish traps with a fish head and burned shredded coconut as bait were randomly placed in the shallow waters of the drainage area for 4 hours during dawn, from 6 pm to 9 pm (Figure 3). After 4 hours, the traps were checked for any

Figure 1. Sampling location (red marker) of *Cherax quadricarinatus* specimens in Felda Tenang, Besut, Terengganu, Malaysia (5°33′42.6″N; 102°29′49.9″E). Map generated using Google Earth Pro Version 9.125.0.0.

Figure 2. Sampling location of *Cherax quadricarinatus* in the drainage system of Felda Tenang, Besut, Terengganu, Malaysia. Photograph by Syed Naguib Syed Idrus.

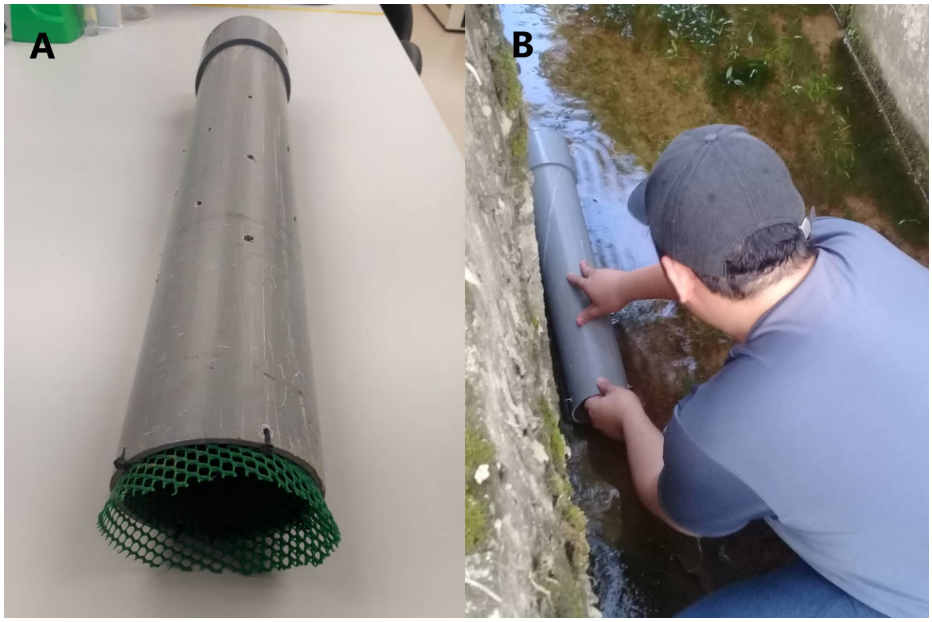

Figure 3. A. Crayfish modified trap. B. Trap was located in shallow waters of the drainage system during sampling of *Cherax quadricarinatus* in Besut, Terengganu, Malaysia. Photographs by Ahmad Safuan Sallehuddin.

redclaws being trapped. The sampled individuals were transported to the laboratory for morphological and molecular identification.

Morphological identification and measurements

Morphological identification of the specimens was made following characteristics published by Soutty-Grosset et al. (2006) and Holdich (2009). The redclaws were measured for total length (cm) using vernier calipers by measuring the distance from the tip of the rostrum to the extreme of the telson. Weight (g) was taken using a weighing balance (Shimadzu, ATX224, Japan). The sex of the specimens was determined by observation of the gonopore placement. Males were identified by the presence of genital openings or/and *appendix masculinae* at the base of the fifth pereiopods and females were identified by the presence of gonopores at the basis of the third pereiopods. Males can also be differentiated from females by the presence of a red patch at the outer surface of the prodopus (López 2007; Coughran and Leckie 2007; Azofeifa-Solano et al. 2017). Specimens collected were preserved in 70% ethanol and deposited at the Aquatic Science Laboratory, UniSZA, Terengganu.

Molecular identification

Muscle tissue from the redclaws was taken and preserved in 95% ethanol for DNA extraction purposes. DNA extraction was conducted using FavorPrep™ Tissue Genomic DNA Extraction Kit (Favorgen Biotech Corp, Taiwan) according to the kit protocol. Redclaw cytochrome oxidase I (COI) mitochondrial DNA region was amplified using universal primers and the protocol established by Folmer et al. (1994) (LCO1490: 5′-GGTC

Table 1. Total length (TL; cm), weight (g) and sex of *Cherax quadricarinatus* captured in Besut, Terengganu, Malaysia.

SAMPLE	TL (cm)	WEIGHT (g)	SEX
1	4.25	1.75	Female
2	5.41	3.80	Female
3	6.25	4.35	Female
4	6.69	5.78	Female
5	9.49	14.93	Male
6	13.2	27.46	Male

Figure 4. *Cherax quadricarinatus*, male specimen caught in Besut, Terengganu, Malaysia. Photograph by Norshida Ismail.

AACA AATC ATAA AGAT ATTGG-3′ and HCO2198: 5′-TAAA CTTC AGGG TGAC CAAA AAAT CA-3′), which produced approximately 710 bp. The sequences were aligned with clustalW in MEGA v7 (Kumar et al. 2016) and queried in BLAST tool of NCBI Genbank. This was to compare the identity similarity between current study sequences and the deposited nucleotide sequences from GenBank.

Results

In total, six redclaw individuals (four females and two males) were captured through the hand picking method from the drainage system in Felda Tenang. All traps were empty without any redclaw trapped after being left in the drainage area for 4 hours. No gravid female was recorded. Males were larger in size than females, with total length (TL), weight (g) and sex of the captured redclaws tabulated in Table 1. Based on their morphological features, all specimens collected in this study were identified as *C. quadricarinatus* (von Martens, 1868) (Crustacea: Malacostraca: Decapoda) of the family Parastacidae (Figure 4).

Regarding molecular identification of the species, after removal of low quality sequences at the 5′ and 3′ ends, a 573 bp DNA barcode was obtained in FASTA format. The sequence was deposited in GenBank with the accession number MT924262. The *C. quadricarinatus* sequence showed 98.39% similarity with sequences of the same species in GenBank (KU821427) and in BOLD identification engine (Ratnasingham and Hebert 2007), including sequences of the same species collected in New Guinea (Bláha et al. 2016). It confirms the identification of the species as *C. quadricarinatus*.

Discussion

The commercial aquaculture of redclaw has been rapidly growing in Malaysia. At the early stage of the species introduction in the late 2000s, the aquaculture of this species was more common in the southern part of Peninsular Malaysia because broodstocks of redclaw were often imported from Indonesia (Naqiuddin et al. 2016). Malaysia has been recorded as the main producer of redclaw, with increasing trends of production from 2013 to 2017 (FAO 2020). The market price for redclaw varies according to size and grade, but it can achieve up to MYR120/kg (≈ 30USD/Kg), which attracts many farmers and hobbyists towards commercial production of the species. For years, commercial farms and hatcheries of redclaws have existed across the entire country, including the East Coast of Peninsular Malaysia (e.g. Pantai Sepat, Kuantan; Abdullah 2012). However, wild populations of redclaws have only been reported from the West Coast of Peninsular Malaysia and Sarawak, Borneo (Naqiuddin et al. 2016). The finding of six redclaws in the wild in Felda Tenang, Terengganu is considered the first record of introduced redclaw in the East Coast of Peninsular Malaysia.

Introduction of any non-native aquatic species into Malaysia must comply with rules and regulations stipulated under the Fisheries Act 1985 and MAQIS Act 2011 (National Committee of Invasive Alien Species Malaysia 2018). Although redclaw has been classified as an invasive species in Malaysia, the species is not specified as prohibited to be imported or cultivated. Only one species of crayfish, *Cherax destructor* (Common Yabby), is prohibited for import, sale, culture and keeping in Malaysia, because it is considered a threat to the local aquatic species under Fisheries Regulations, Amendment 2011, Fisheries Act 1985.

Based on information acquired from locals during our survey, no aquaculture facility of redclaw is currently, or has previously been, operating in Felda Tenang. A small hatchery and holding facilities, where the owner acts as a distributor of redclaws purchased from bigger aquaculture farms outside the state, exists in the Besut area, 28 Km away from the sampling point. As this small hatchery was only established in 2018, and given that the villagers of Felda Tenang claim that redclaws have been sighted in the

drainage area for more than eight years, we speculate that the occurrence of redclaw in the wild in this village has been instead caused by an intentional release or accidental escape of one ore more redclaw specimens by an hobbyist (or prospective farmer). Such pathway of introduction for this species has also been reported by Belle et al. (2011) in Singapore, Arias and Torralba-Burrial (2021) in Spain, and Nunes et al. (2017) in South Africa.

In this study, failure to capture redclaw specimens in traps might have been due to leaving them in the drainage for a short time period. Increasing trap duration to e.g. a minimum of 24 hours will probably lead to more success in capturing redclaw specimens. As the specimens caught in this study were relatively small (likely juvenile stage), and also taking into account information acquired from locals, adult redclaws probably do exist in the sampling site, or in the adjacent river and waterbodies connecting to the drainage system.

The present finding shows the perturbing spread of the introduced redclaw crayfish in the wild in yet another area of Malaysia. Although to date no study has been done about the impact of the introduction, spread and establishement of the redclaw in Malaysia, and information on this species impacts elsewhere remains scarce, previous studies have shown that introduction of redclaw may cause potential negative impacts such as predation on native species, food web imbalances and act as carriers of diseases which can directly affect native fauna (Ahyong and Yeo 2007; Lodge et al. 2012; Twardochleb et al. 2013; Xu et al. 2016). Weighing the importance of redclaw aquaculture in the socio-economic development in Malaysia, it seems impossible to slow down the expansion of commercial farming of the species. However, locals and farmers interested in redclaw farming, as well as hobbyists, need to be educated on the possible impacts from escapes or releases of the species into the wild on native ecosystems and biodiversity. Our findings also highlight the urgent need of further comprehensive studies to assess the current distribution and potential impacts of this invasive species in the Besut River and surrounding water bodies.

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