First record of red swamp crayfish, *Procambarus clarkii* (Girard, 1852) (Crustacea: Decapoda: Cambaridae) in Israel – too late to eradicate?

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Abstract

The recent findings of the red swamp crayfish, *Procambarus clarkii*, in groundwater-filled pits in an abandoned quarry (Hadera, central coastal plain) constitute the first record in the wild of this notoriously invasive species in Israel. Crayfish had been offered for sale in local pet shops: twenty years ago several illegally imported specimens had been confiscated by the Israel Nature and Parks Authority and two of the specimens were deposited at the National Collections, Tel Aviv University. The recent finding of a small reproducing population established in a semi natural habitat in Israel raises great concern regarding the potential widening of its range and of the limited options for its eradication.

Key words: *Procambarus clarkii*, Cambaridae, invasive alien species, Israel, eradication

Introduction

Israel’s lotic and lentic habitats have been profoundly altered in the past century by irrigation, drainage and pollution (Gasith 1992), and the intentional and unintentional introduction of alien species has harmed the already embattled native biota (Roll et al. 2007a, b). Forty-one fish species have been introduced into Israel’s freshwater habitats unintentionally and for aquaculture, ornamental purposes, pest control, improvement of wild stock (Goren and Ortal 1999; Golani and Mires 2000; Goren and Galil 2005; Roll et al. 2007b). Only a single alien decapod crustacean, the American blue crab, *Callinectes sapidus* Rathbun, 1896, has been reported from Israeli inland water. The blue crab, though unable to reproduce in freshwater, has been repeatedly introduced into the Sea of Galilee with fish fry caught along the Mediterranean coast and used for restocking the lake (Snovsky and Galil 1990).

Freshwater crayfish are often an important component of the aquatic fauna, frequently being the largest invertebrate predator in their habitats. They are considered both key-species and ecosystem engineers (Statzner et al. 2003; Creed and Reed 2004). Crayfish do not occur in Israel’s inland water. The recent findings of the red swamp crayfish, *Procambarus clarkii* (Girard, 1852), in ponds on the central coastal plain, raises great concern, because this crustacean is widely regarded as an invasive species that adversely impact aquatic ecosystems (Barbaresi and Gherardi 2000; Gherardi 2006).

Material and methods

Study site

Several ponds at the site of an abandoned quarry (located 2 km south-west of the Hadera-West train station, 32.42328°N and 34.88725°E) were examined as part of a survey of the amphibian fauna of Israel undertaken by the Inland Aquatic Laboratory at Tel Aviv University. The largest water body is a perennial, groundwater-filled pit, measuring ca. 180 x 100 m (Figure 1). At the end
of the rainy season the water level exceeds depth of 1 m. The water level and the pond's size gradually diminish in summer. The water is brackish (salinity 2.8 psu), and clear. The bottom is sandy and the banks are covered by riparian vegetation (the common reed, *Phragmites australis* Cav., spiny rush, *Juncus acutus* L., and *Tamarix* sp). A smaller pond, (ca. 70 m in diameter) is connected to the larger one via a short channel. Schools of cichlids (*Tilapia* sp.) and mosquitofish, *Gambusia affinis* (Baird and Girard, 1853), were sighted in the latter. Fishing nets sighted along the pond’s margin raise the suspicion that the ponds were used for illegal aquaculture. Ephemeral rain-pools (ca. 10-20 m in diameter, 30 cm deep, salinity 1 psu) are located less than 100 m east and north of the groundwater-filled pit (Figure 2). These rain-pools are the home for seasonally flourishing aquatic invertebrates (e.g., flatworms, entomostracan crustaceans, aquatic insects, gastropods) and 3 species of amphibians (*Hyla savignyi* Audouin, 1827, *Bufo viridis* Laurenti, 1768 and *Rana ridibunda* Pallas, 1771).

**Survey for Procambarus clarkii**

The first recording of the crayfish (March 11th, 2008) was fortuitous. Since then the perennial and ephemeral water bodies were visited 8 times over a 3 month period (including 2 night visits; daytime: March 11th and 21st, April 7th, 14th, 21st and 28th; nighttime: March 26th and May 6th). The crayfish were sampled by hand to avoid damage that often occurs when dip-netted. Five specimens were preserved (70% ethanol), identified and deposited in the Tel-Aviv University Zoological Museum (ZMTAU).

**Results**

*Procambarus clarkii* adults' and juveniles' molts were first collected on March 11th, 2008. In subsequent samplings ca. 30 specimens adults and juveniles were collected and released except for 5 live specimens and a molt that were transferred to the laboratory for identification. During the night surveys tens of adults and juveniles were observed on the bottom of the smaller perennial pond. The collected specimens were identified as *Procambarus clarkii*, sexed and measured from the apex of the rostrum to the mid-dorsal posterior margin of carapace (Table 1). Larger specimens were observed (Figure 3A) but not measured. A female and 4 males were deposited at the National Collections (ZMTAU).

<table>
<thead>
<tr>
<th>Sex</th>
<th>Carapace length (mm)</th>
<th>Collection date</th>
<th>Catalogue number</th>
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<tr>
<td>♀</td>
<td>44.2</td>
<td>1988</td>
<td>AR 28358</td>
</tr>
<tr>
<td>♂</td>
<td>52.1</td>
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<td>AR 28359</td>
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<td>38.3</td>
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<td>30.6</td>
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<tr>
<td>♂</td>
<td>33.9</td>
<td>21.03.2008</td>
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<tr>
<td>♂</td>
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<td>Molt</td>
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</tr>
</tbody>
</table>

*The specimen had been kept for two years in a freshwater aquarium.

*Procambarus clarkii* adults' and juveniles' molts were first collected on March 11th, 2008. In subsequent samplings ca. 30 specimens adults and juveniles were collected and released except for 5 live specimens and a molt that were transferred to the laboratory for identification. During the night surveys tens of adults and juveniles were observed on the bottom of the smaller perennial pond. The collected specimens were identified as *Procambarus clarkii*, sexed and measured from the apex of the rostrum to the mid-dorsal posterior margin of carapace (Table 1). Larger specimens were observed (Figure 3A) but not measured. A female and 4 males were deposited at the National Collections (ZMTAU). On one occasion (April 7th, 2008) a live specimen was observed on land underneath a plastic bag, at a distance of ca. 10 m from a rain-pool. The rain-pools dried early this year
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due to a severe drought. On April 21st the rain-pools were already dry and several individuals of *P. clarkii* were observed digging burrows under stones (Figure 3B). On April 28th, two males (Figure 3C) and two females (one gravid, Figure 3D), were removed from a single burrow, at least 20 cm deep. On May 2nd, the dried up rain-pool was searched again for burrowing crayfish. Three specimens were found alive, each in a separate waterlogged burrow that was topped by wet soil. Three other specimens were found dead in their burrows. We attribute the latter to the failure of the crayfish to reach groundwater due to rocky strata that blocked their way.

Discussion

*Procambarus clarkii*, native to northeastern Mexico and south-central U.S.A (Hobbs 1989) has been widely introduced since the mid 20th century because of its commercial value in aquaculture (Hobbs et al. 1989). Following intentional release or unintentional escape from farms the crayfish entered and colonized natural water bodies forming self-sustaining populations in the wild (Gherardi 2006). The life history traits that endear the species to the aquaculture industry – rapid growth, high fecundity, polytrophism, resistance to disease and to pollution and extreme environmental conditions – make it an invincible invasive (Barbaresi and Gherardi 2000). It is known to tolerate drought periods, low oxygen concentrations (2 mg/l), a relatively wide range of salinity and temperature (5-38ºC) (Gutiérrez-Yurrita et al. 1999). Spain was the first peri-Mediterranean country to introduce the species in 1973 (Habsburgo-Lorena 1979). In 1979 *P. clarkii* was reported from Portugal (Ramos and Pereira 1981); in the early 1980s in Egypt (El Zein 2005) and since 1990 in Italy (Gherardi et al. 1999). Recent studies supported previous observations that *P. clarkii* is capable of flourishing in most types of water bodies, including small, ephemeral ones, and anthropogenically-disturbed habitats. There is evidence that the crayfish is able to move overland and thereby increase its range (Aquiloni et al. 2005; Cruz and Rebelo 2007).

Israel’s natural water bodies are already stressed by the diversion of water for human use (Gasith 1992). Penetration of an invasive, large, opportunistic, omnivorous predator such as *P. clarkii* further stresses the aquatic ecosystems. Furthermore, in Israel *P. clarkii* has no known

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**Figure 3. Procambarus clarkii**: A – a large male, observed on 6 May 2008, night survey; B - in a water-filled burrow, 28 April 2008; C - two males observed at the mouth of a burrow, 28 April 2008; D - a gravid female, 28 April 2008. Photographs by Gil Wizen
predator and is likely to become a predominant species in these ecosystems. The exertion of high predation pressure may result in irreparable damage to the native aquatic biota (Pérez-Bote 2005; Rodríguez et al. 2005; Geiger et al. 2005; Gherardi and Acquistapace 2007). Especially vulnerable are the eggs and tadpoles of amphibians breeding in ephemeral ponds. It has been proposed that invasion of _P. clarkii_ may have played an important role in structuring amphibian communities in temporary ponds. Presence of this species in the water body may force the amphibians to marginal and isolated habitats, reducing their reproductive success, ultimately leading to local extinctions (Cruz and Rebelo 2005; Cruz et al. 2006a, b). A case in point is the impact of the introduction of _P. clarkii_ to Egypt. A shrimp farmer in Al Qanater released the imported crayfish into the Nile in the 1980s after they had damaged the mud banks of his ponds. The crayfish have since spread from the Delta to Bani Swaif, 500 km to the south of Cairo, with densities as high as 0.65/m² (El Zein 2005). The crayfish damaged earth dams, irrigation canals and fish stock, and though marketed, are considered of little commercial value. El Zein (2005) admits “such an introduction is now recognized to have bad consequences on biodiversity without economical profits”.

Once widespread, aquatic aliens are difficult if not impossible to be rid off. Unless detected early enough, their eradication may become impractical. If proven isolated in one site, the decimation of _P. clarkii_ population in Israel may still be possible, reducing the risk of spreading to other water bodies. However, decimation and certainly eradication are by no means an easy task. Organophosphate insecticides have been proven effective in laboratory and large-scale field trials in controlling _P. clarkii_ in rice ponds (Chang and Lange 1967; Eversole and Sellers 1997). Pesticides may be equally successful if used in the groundwater-filled pits, however, pesticides adversely impact non-target organisms. In addition, connection of the groundwater-filled pits to the coastal aquifer may further limit use of toxicants. Physical measures, including the use of traps, nets and electro-fishing, can control populations if used intensively enough. Eradication is unlikely as the crayfish may hunker down in their burrows. In fact, culling may stimulate earlier maturation age and result in greater egg production (http://www.issg.org/database/species/management_info).

There is no doubt that _P. clarkii_ poses a serious threat to the native aquatic biota in Israel. If indeed the Hadera population is an isolated self-maintaining one, all efforts should be made to eradicate it. We suggest that prompt action be taken to eradicate or at least control this population, either by applying physical means for removal or the use of organophosphate insecticides (after consulting the National Water Authority experts). Applying the insecticide while the crayfish population is small and at the time the water bodies are at their lowest water level, may reduce the amount of biocide needed.

**Acknowledgements**

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**References**


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