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Short Communication

Fouling of invasive red swamp crayfish, *Procambarus clarkii* (Girard, 1852) by the zebra mussel, *Dreissena polymorpha* (Pallas, 1771) in Lake Trasimeno, Italy

Vera Gonçalves[1]*, Rui Rebelo[2] and Francesca Gherardi[1]

1 *Department of Biology, University of Florence, Via Romana 17, 50125 Florence, Italy*
2 *Department of Animal Biology and Centre for Environmental Biology, F.C.U.L. Campo Grande, C2, 1749-016 Lisbon, Portugal*

E-mail: vera.goncalves@unifi.it (VG), rmrebelo@fc.ul.pt (RR)

**Corresponding author*

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Abstract

Observations of *Procambarus clarkii* fouling, by alien zebra mussels (*Dreissena polymorpha*) in Lake Trasimeno (and in the laboratory) are recorded. Results agree with previous reports that zebra mussels can be found, if only occasionally, on most parts of the swamp crayfish body, with a general preference for the ventral surface, and in this case, the pereopods. The frequency of colonization on *P. clarkii* in the wild varied from 0 to 4%; much lower than other crayfish species (e.g. 65% in *Orconectes limosus* or 12–24% in *O. rusticus*). Adults of both sexes were colonized equally. Multiple zebra mussels observed on individual crayfish were unexpectedly high; this may relate to poor crayfish condition and may also explain the only colonization of a live crayfish individual recorded in the laboratory.

Key words: *Dreissena polymorpha; Procambarus clarkii*; invasive species; colonization; fouling; Lake Trasimeno; Italy

Introduction

Zebra mussel, *Dreissena polymorpha* (Pallas, 1771) is an ever expanding invasive Ponto-Caspian bivalve (Karatayev et al. 2002). During the last two centuries it has invaded large regions of Europe through rivers and artificial channels (Bij de Vaate et al. 2002). Its life cycle includes a planktonic larval (veliger) phase. After several days in the water column, it attaches to a substratum by byssal threads and there metamorphoses into an adult. In Lake Trasimeno (43°08′N 12°06′E, Umbria, central Italy), only one period of successful reproduction exists, from June to July (Lancione and Gaino 2006). Adult mussels retain the ability of abandoning their byssi at any time and may crawl over the substratum to find a new suitable home (Ackerman et al. 1994).

Typically, shells of conspecifics are the preferred location for veliger settlement (Mörtl and Rothhaupt, 2003), but where dense populations of zebra mussels exist, they may colonize alternative substrates, including mobile, hard-shelled organisms (Ďuriš et al. 2007).

Zebra mussel colonization of invertebrates, particularly unionid mussels (Schloesser et al. 1996; Sousa et al. 2011) and odonate larvae (Weihrauch and Borcherding 2002; McCauley and Wehrly 2007) has already been documented. Colonization or fouling of crayfish species has only occasionally been reported, e.g., *Astacus astacus* (Kulmatycki, 1932), *Astacus leptodactylus* (Lamanova 1971), *Orconectus limosus* (Ďuriš et al. 2007), *Orconectus rusticus* (Brazner and Jensen 2000), *Orconectes luteus* (Wetzel et al. 2004) and in the last decade *Orconectes pardalotus* (Wetzel et al. 2005).

The first record of *D. polymorpha* in Lake Trasimeno dates from the year 2000, and refers to sporadic findings of adults, as well as the first zebra mussel fouling on *Procambarus clarkii* (Spilinga et al. 2000). Presently, *D. polymorpha* density is 200,000 individuals/m^2 (Lancione and Gaino 2006), an abundance comparable to North American lakes (Nalepa and Schloesser 1993).

The invasive red swamp crayfish *Procambarus clarkii* (Girard, 1852) is a large, prolific, aggressive species (Barbaresi and Gherardi 2000), has

Table 1. Number and size of zebra mussels attached to *P. clarkii,* in Lake Trasimeno, during the summer periods 2011 and 2012.

	2011				2012	
	June 1	June 13	July 28	September 13	June 19	July 28
No. of crayfish examined	200	187	279	168	526	508
No. of crayfish with attached mussels	0	2	3	7	10	0
Total number of mussels attached	0	3	3	13	14	0
% crayfish with attached mussels	0	1.07	1.075	4.17	1.90	0
Range mussel size (mm)	0	2.3-3.8	2.9-4.3	3.1-8.8	1.5-3.3	0

Table 2. Distribution (%) of attached zebra mussels on crayfish.

Zebra mussels attached on crayfish	Frequency %	
	2011	2012
Eyes	8.3	10
Mouth area	8.3	30
Chelae	8.3	0
Abdomen (ventral)	25	30
Pereopods	66.7	40
Telson & uropods	41.7	20
Genital area	0	10

many established populations in Italy (Aquiloni et al. 2010) and is present in large quantities, since 2000, in Lake Trasimeno, an optimal habitat for this species (Dörr et al. 2006).

Observations of *P. clarkii* fouling by *D. polymorpha* in Lake Trasimeno, as well as in a laboratory experiment are reported.

Methods

In the wild, colonization data was documented from crayfish collected by professional fishermen in Lake Trasimeno. Crayfish were captured on six occasions with baited traps at a depth of approx. 1.5 m, over two summers 2011-2012 (Table 1). Crayfish with mussels attached were measured and sexed; attached mussels were also measured (shell length).

In the laboratory, four crayfish were introduced singly into four aquaria (with 4L dechlorinated tap water), and each was left for two weeks in the presence of 150 zebra mussels (shell length 5–15 mm).

Results and discussion

Overall abundance of attached zebra mussels was low; a total of 19 individuals on 12 crayfish (7 males and 5 females) in 2011, and 14 individuals on 10 crayfish (3 males and 7 females) in 2012 (Table 1). The proportion of each sex amongst colonized individuals did not differ from the normal sex ratio at Trasimeno (which is of 1.15:1 in favour of females; Dorr et al. 2006) ($G=0.731$; $p<0.75$).

Colonized crayfish presented a mean total length of 9.89 ($\pm$1.53) cm in 2011 and 8.56 ($\pm$1.15) cm in 2012. *P. clarkii* at Trasimeno is characterized by having a relatively large body size (8.4 cm to 13.5 cm total length) (Dörr et al. 2006).

The majority of zebra mussels attached to *P. clarkii* were small (< 5 mm long), corresponding to juveniles less than one year old (Ackerman et al. 1994). Larger sizes were observed in September.

Despite the rarity of the phenomenon (0 to 4.17% of crayfish with attached mussels; Table 1), 32% of crayfish colonized had more than one mussel. There was a clear preference for the ventral surface of the crayfish, namely the pereopods and uropods/telson (Table 2).

In the laboratory, after a period of 5 days, only one mussel was found attached to a male crayfish measuring 30.7 mm, in the proximity of the antennules (Figure 1A). Post death, 15 days after the start of the experiment, the crayfish was colonized overnight by 18 mussels, on its ventral side (Figure 1B).

Ďuriš et al. (2007) show strong seasonality variation in the percentage of the crayfish *O. limosus* colonized by zebra mussels, exceeding 75% in spring and early summer, but sharply dropping to 0–20% in August, post molting (Ďuriš et al. 2007). This effect was not found in this instance; as the summer progressed, both the number and size of the colonizing zebra mussels increased. This is most likely related to the crayfish moulting at Trasimeno, that takes place from April to July (Dörr et al. 2006).

The rapid colonization of a dead *P. clarkii* in the laboratory shows that the exoskeleton of this

Figure 1. *Procambarus clarkii* adult male alive (A) and dead (B) with zebra mussels attached, in laboratory aquarium.

species is a good substratum for the attachment of *D. polymorpha*. However, the overall proportion of colonized crayfish at Trasimeno was very low, compared to observations on *O. limosus* (17–94%) (Ďuriš et al. 2007) and *O. rusticus* (Brazner and Jensen 2000). This low frequency of colonization cannot be explained by molting (see above) or by *P. clarkii*'s burrowing habits, as the individuals tested in the laboratory did not molt and could not burrow. The intensity of grooming in *P. clarkii* is also quite low, when compared with other species (Bauer 2002). However it is not possible to exclude an increase of individual grooming after being colonized as this behaviour was not examined during the experiment. Furthermore, the overall high activity rate of this crayfish may simply preclude a secure establishment of *D. polymorpha*.

Observations made in this study, confirmed reports by Ďuriš et al. (2006, 2007), that zebra mussels are occasionally found on most parts of the crayfish body, with a preference for the ventral surface, and particularly in our case, the pereopods. According to Smietana (1996) young specimens of zebra mussels that settle on crayfish find favourable living conditions, especially those attached to the upper parts of the body, but this preference can apparently vary among species. The observation of preferential ventral colonization on *O. limosus* by Ďuriš et al. (2006) differs significantly from data of Brazner and Jensen (2000) on epibiosis on *O. rusticus*, which refers to the chelae, telson, uropods, and carapace as the most heavily colonized parts.

The negative effects of zebra mussel attachment on odonate larvae include reduced

mobility, foraging success, larval mobility, hydrodynamic destabilization and difficulty in burrowing into sediments (Hughes and Fincke 2012). Prey capture and predator avoidance may also be affected (McCauley and Wehrly 2007). The effects of zebra mussels on crayfish condition remain speculative.

The death of the single individual that was colonized in the laboratory may imply that its defences were somehow affected. Individual vulnerability may also explain the relatively high frequency of multiple mussels on single crayfish at Trasimeno. Zebra mussel colonization may be a consequence of individual poor condition, and not its cause.

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