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V. St Raykov, Mario Lepage, R. Perez Dominguez. First record of oriental shrimp, *Palaemon macrodactylus* Rathbun, 1902 in Varna Lake, Bulgaria. *Aquatic Invasions*, 2010, 5 (Suppl 1), pp.S91-S95. 10.3391/ai.2010.5.S1.019 . hal-01550575

HAL Id: hal-01550575

<https://hal.science/hal-01550575>

Submitted on 29 Jun 2017

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First record of oriental shrimp, *Palaemon macrodactylus* Rathbun, 1902 in Varna Lake, Bulgaria

Violin St.Raykov^{1*}, Mario Lepage² and Rafael Pérez-Domínguez³

¹Institute of Oceanology, "Parvi May" Str. 40, P.O. Box 152, Varna 9000, Bulgaria

²Cemagref, 50 avenue de Verdun Gazinet, 33612 Cestas Cedex, Bordeaux, France

³Institute of Estuarine & Coastal Studies (IECS), University of Hull, Hull, HU6 7RX, United Kingdom

E-mail: vraykov@io-bas.bg (VSR), mario.lepage@cemagref.fr (ML), R.Perez@hull.ac.uk (RPD)

Received: 13 April 2010 / Accepted: 14 August 2010 / Published online: 20 August 2010

Abstract

In September 2009 a non-native shrimp species was found at two sampling sites in Varna Lake, a brackish coastal water body connected to the Bulgarian Black Sea. Diagnosis based on morphological features confirmed that the examined individuals belonged to the species *Palaemon macrodactylus* Rathbun, 1902. All specimens found were ovigerous, 2+ year females suggesting the presence of a viable population in the system. Possible ways of introduction and community effects for Varna Lake are discussed.

Key words: *Palaemon macrodactylus*, Varna Lake, Bulgaria, non-native

Introduction

Palaemon macrodactylus (Rathbun, 1902) originates from the temperate north-western Pacific: Japan, Korea and China (Holthuis 1980). The species was originally described by Rathbun (1902) and Kubo (1942). *P. macrodactylus* has been recorded outside of its native range in the waters of USA (Newman 1963; Jensen 1995), in Australia (Davie 2002; Poore 2004; Walker and Poore 2003) and Argentina (Spivak et al. 2006). In Europe large populations of *P. macrodactylus* have been recorded in some estuaries on the southwestern Iberian Peninsula (Cuesta et al. 2004; Chicharo et al. 2009). In 2006, *P. macrodactylus* was also reported in the Gironde Estuary, France (Beguer et al. 2007). Ashelby et al. (2004) found *P. macrodactylus* in the Orwell and Stour estuaries in south-eastern England, North Sea. More recently, D'Udekem d'Acoz et al. (2005) reported the oriental shrimps being caught at different sites along the southern bight of the Northern Sea. First observations in German waters, and some important conclusions about the oriental shrimp presence in other estuarine habitats of the North Sea, were published by González-Ortegón et al. (2007). *P. macrodactylus* have recently been recorded in estuarine water bodies along the Romanian coast in the Black Sea (Micu and Niță 2009).

In the present paper we report the first sightings of *P. macrodactylus* in Bulgarian waters.

Materials and methods

Varna Lake (43°11'25"N, 27°49'30"E – 43°12'28"N, 27°53'00"E) is the largest by volume and is the deepest liman along the Black Sea coast, separated from the sea by a 2km-wide strip of sand. It has an area of 17km², a volume of 166 million m³ and a maximum depth of 19 m (Figure 1). Varna Lake is permanently connected to the Black Sea by two man-made canals. Vertical distribution of oxygen and hydrogen sulphide (H₂S), along with temperature, seasonal stratification and the presence of pollutants determine the abiotic environment of Varna Lake (Konsulov 1971). A sharp thermocline is a common feature during summer months, which prevents oxygen from reaching the bottom layers under 4-5m, inducing hypoxia and resulting in the production of hydrogen sulphide. The hypoxic and anoxic phenomena result from the decomposition of organic material and lead to mass mortalities of fish and crustaceans (Dineva 1999). In recent years a marked improvement of water quality has been noticed during summer months compared to historical records.

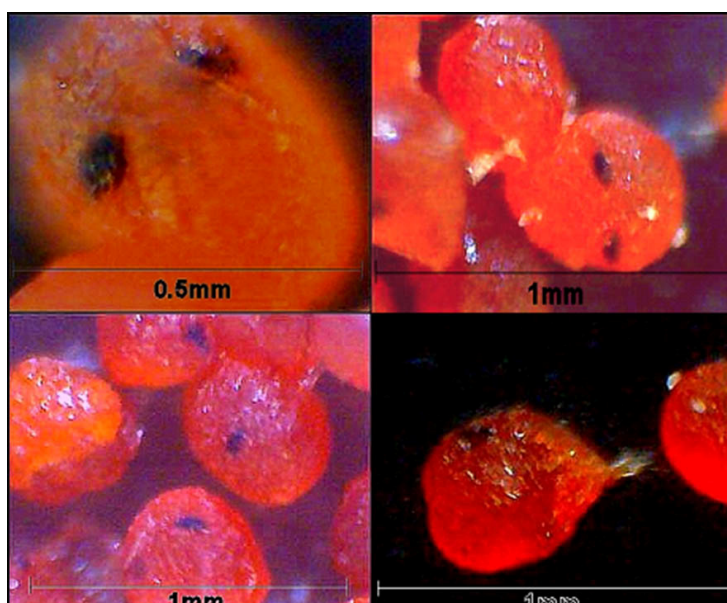
Figure 1. Black Sea with general study area (black rectangle, site of discovery with red asterisk); two canals connecting Varna Bay with the Lake and sites of oriental shrimp discovery (red asterisk, S1 and S2). Picture: Google Earth.



Figure 2. General aspect of ovigerous female *Palaemon macrodactylus* Rathbun, 1902 (scale bar in millimeters). Photograph by V.Raykov.



Figure 3. *Palaemon macrodactylus* Rathbun, 1902 eggs stage III of maturation with visible compound eyes. Photographs by V.Raykov.



Sampling stations and sampling method

In the period 31 August - 4 September 2009, nine fyke nets and fourteen beam trawl stations comprising a total of 32 sampling events in the Varna Lake and adjacent Varna Bay were examined (Figure 1). The fyke nets were double with two facing trap nets jointed by a central panel 5.50m in length and 0.55m in height. The fyke nets had a 12mm mesh size (stretched mesh) and were left fishing overnight (ca. 10 to 18 hours). The 1.50m wide and 0.50m height beam trawl equipped with one small tickle chain was fitted with a 10mm mesh (stretched mesh) in the codend. The beam trawl was towed for approximately 10 min covering an area of approximately 450 to 500m².

Habitat

The fyke net sampling stations (Figure 1) were located in the north-eastern part of Varna Lake (S1). This area was characterized by a soft muddy bottom with a high content of decaying organic matter. Typical vegetation found between 0.7 to 1.2 m (Fyke placement) is composed of mixed communities of *Potamogeton natans* (Linnaeus, 1753), *P. perfoliatus* (Linnaeus, 1753), *P. crispus* (Linnaeus, 1753) and *P. pectinatus* (Linnaeus, 1753). Deeper areas are dominated by tape grass *Vallisneria spiralis* (Linnaeus, 1758). Native *Palaemon elegans* (Rathke, 1837) populations are often found in these habitats across all depths and among the canopy of common reed *Phragmites australis* (Cav.) Trin. ex Steud. bordering the shores of the lake. Other water plant species, such as *Typha angustifolia* Linnaeus, *Typha latifolia* Linnaeus, and *Schoenoplectus lacustris* Linnaeus (Palla) are also present in this lake margin habitat.

At the second sampling site (S2) (Figure 1), the specimens were caught with a beam trawl, at depths of up to 8m. This area contains a mixture of *Cladophora vagabunda* (Linnaeus) Van Den Hoek; *Ulva intestinalis* (Linnaeus, 1758) and *Ulva compressa* (Linnaeus, 1758). The nature of the sediment is silt, containing rich organic matter.

Temperature and salinity

At the shallower sampling station S1, the bottom water temperature was 23.5°C and the salinity was 16.3 psu. Surface temperature and salinity at the site were 24.4°C and 16.2 psu, respectively.

At the deeper station (S2), the temperature at the bottom (8 m) was 22.7°C and the salinity was 16.2 psu. Surface temperature was 24.2°C and salinity 15.7 psu, respectively.

Results

At S1, one ovigerous female was caught and identified on board as *Palaemon macrodactylus* and this identification was subsequently confirmed in the laboratory (Figure 2). In the same fyke nets, ten individuals of *P. elegans* Rathke, 1837 were caught. At station S2 (Annex 1) two *P. macrodactylus* were found along with three specimens of *Rhydroporopsis harisii* (Gould, 1841), 2 *P. elegans* and two *Upogebia pusilla* (Petagna, 1792).

Most of the separated eggs had clearly visible compound eyes, and were assigned to stage III of development, following Fisher and Clark Jr, (1983) (Figure 3). The eggs were oval in shape, and had an average length of 0.46mm, and width of 0.37mm.

Morphology identification

The morphological characteristics of the caught ovigerous females in Varna Lake are undoubtedly those of the species *P. macrodactylus*. Rostrum with 10-12 dorsal teeth (including postorbital teeth but not the superior tooth of the apical cleft), of which 2 or 3 teeth are on carapace behind orbit; shorter ramus of the outer flagellum of antennula fused for about 20% of its length to longer ramus; chela of P2 with fingers $\approx 0.7\times$ as long as palm. The described identification keys are with agreement with those described by González-Ortegón and Cuesta 2006; D'Udekem d'Acoz et al. 2005; Ashelby et al. 2004).

Discussion

Palaemon macrodactylus, already has well established populations in the Romanian Black Sea and, taking into consideration the invasion record and the ecology of this species, it is very likely that it will successfully invade the whole of the Black and Azov Seas and the adjacent estuaries, deltas and limans (Micu and Niță 2009).

There are two alternative sources of introduction of *P. macrodactylus* in Bulgarian waters:

a) natural expansion from the close-by, already well-established population in Romania, and

b) artificial introduction via shipping activities from already established European populations.

It is evident from research in Romanian waters that a large and widespread population of *P. macrodactylus* has already existed for at least a decade no farther than 200km from Varna and this seems a highly plausible source for the invasive shrimps. It is unclear whether the species has reached Varna Lake by means of range expansion or has been vectored by short range shipping from its nucleus in Romania. A less likely alternative is that *P. macrodactylus* has been introduced from one of the other European populations via shipping.

Rathbun (1902) and Newman (1963) state that their largest specimens were 55mm long, whilst Ashelby et al. (2004) recorded a specimen of 70mm. D'Udekem d'Acoz et al. (2005) reported a specimen with a total length of 61mm, caught in Zeebrugge. The specimens of *P. macrodactylus* reported here from the Varna Lake have a maximum total length of 59mm and carapace length of 15.8mm (specimen in the fyke net sample). The other two individuals from the beam trawl had total lengths of 55 and 57mm, and carapace dimensions of 15.4mm and 15.6mm, respectively. These values are well in agreement with the maximum size of carapace as length of individuals from the Romanian Black Sea coast was 15.8mm (Micu and Niță 2009).

When occurring in sympatry, *P. macrodactylus* has a clear competitive advantage over native prawn species through its mixed reproductive strategy and high reproductive output, as well as in the length of its spawning season (Micu and Niță 2009; Beguer et al. 2007). In California, USA, Ricketts et al. (1968) observed that *P. macrodactylus* was responsible for the disappearance of the native *Crangon* spp. D'Udekem d'Acoz et al. (2005) conclude that *P. macrodactylus* will colonize, or has already colonized a large part of the European coasts, but it is not clear if it will become as abundant and widespread as in the temperate eastern Pacific. In Europe, in contrast to USA, there is a number of widely distributed native Palaemonidae occupying a wide range of habitats therefore *Palaemon macrodactylus* may have to share space and food with the native competitors.

Conclusion

The presence of ovigerous individuals and their state of maturation indicated that the species can reproduce naturally. Most probably, it is expanding naturally or has been introduced from Romanian Black sea waters. Another, less likely alternative is that the oriental shrimp has been introduced from one of the other European populations via shipping. The co-evolution of shrimp populations should be investigated in order to determine any possible negative effects of the newcomers.

Acknowledgements

The authors want to thank to Martin Parushev, the skipper of the low draft vessel "BH 4298" for his assistance, to the reviewers for the useful comments and suggestions on the manuscript, and to Dr. Violeta Velikova, PC Officer, BSC for the valuable comments and English language improvements. This paper is a result of the project WISER (Water bodies in Europe: Integrative Systems to assess Ecological status and Recovery) funded by the European Commission under the 7th Framework Programme, Theme 6 (Environment including Climate Change) (contract No. 226273), <http://www.wiser.eu>. Publication of this paper is partly supported by the European Commission FP7 project *enviroGRIDS* (<http://www.envirogrids.net>).

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Annex 1. Records of *Palaemon macrodactylus* Rathbun, 1902 in the Varna Lake, Bulgaria in 2009 (present study).

Record No.	Location	Type of gear	Record coordinates		Record date	Number of recorded specimens
			Latitude, N	Longitude, E		
1	Varna Lake (North-eastern part) - S1	Fyke net	43°12'50"	27°51'53"	31.08.2009	1 ♀ ovigerous
2	Varna Lake (South-western part) – S2	Beam trawl	Start:	Start:	01.09.2009	2 ♀ ovigerous
			43°11'456"	27°47'33"		
			End:	End:		
			43°11'478"	27°47'86"		