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First record of *Anadara transversa* (Mollusca: Bivalvia: Arcidae) in Croatian waters (Adriatic Sea)

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Six specimens of the alien bivalve Anadara transversa (Say, 1822) were found on the muddy bottom at a depth of 4.4 m in the innermost part of Lim Bay in June 2011; this species is being newly reported from the Croatian part of the Adriatic Sea.

Key words: *Anadara demiri*, *Anadara transversa*, alien species, Adriatic Sea, Croatia, new record

INTRODUCTION

The family Arcidae, known as 'ark clams' (Bivalvia: Arcoida), is represented by five genera in the Mediterranean basin, namely: *Arca* Linnaeus, 1758; *Asperarca* Sacco, 1898; *Barbatia* Gray, 1842; *Anadara* Gray, 1847; and *Bathyarca* Kobelt, 1891 (GIANNUZZI-SAVELLI *et al.,* 2001; CLEMAM, 2008). The genus *Anadara* has seven species in the Mediterranean (CLEMAM, 2008; ZENETOS *et al.*, 2010), five of which *A. transversa* (Say, 1822), *A. kagoshimensis* (Tokunaga, 1906) formerly *A. inaequivalvis* (Bruguière, 1789), *A. granosa* (Linnaeus, 1758), *A. inflata* (Reeve, 1844) and *A. natalensis* (Krauss, 1848) are known as alien species (ZENETOS *et al.*, 2010; ÇINAR *et al.*, 2011). In the Mediterranean Sea, *Anadara transversa* was first recorded as *Arca amygdalum* in Izmir Bay, Turkey (DEMIR, 1977) while later ZENETOS (1994) reported it in the Thermaikos and Thessaloniki Gulfs (Aegean Sea, Greece). MORELLO & SOLUSTRI (2001) first found it in the Adriatic Sea (Italian coast) and its establishment was confirmed within three years (MORELLO *et al.*, 2004). This species seems to be well distributed throughout these areas and is locally abundant within the Mediterranean (MORELLO *et al.*, 2004; ZENETOS *et al.,* 2005; ÇINAR *et al.*, 2006, 2008). This paper documents the first occurrence of this species within the Croatian part of the Adriatic Sea.

MATERIAL AND METHODS

The specimens of *Anadara transversa* were collected in Lim Bay (the northern part of the Adriatic Sea, 45°07'48.93'' N; 13°44'12.51'' E) near a mussel (*Mytilus galloprovincialis*) farm in June 2011 (Fig.1). The specimens were attached, by byssus, to a tile near a mesh bag of *M. galloprovincialis* at a depth of 4.4 m. The estuary of Lim Bay is a protected area that is situated on the west side of the Istrian peninsula in the northeast Adriatic Sea (Fig. 1).

It is a fjord-like bay – more precisely, a ria – that is 11 km long and less than 600 m wide,

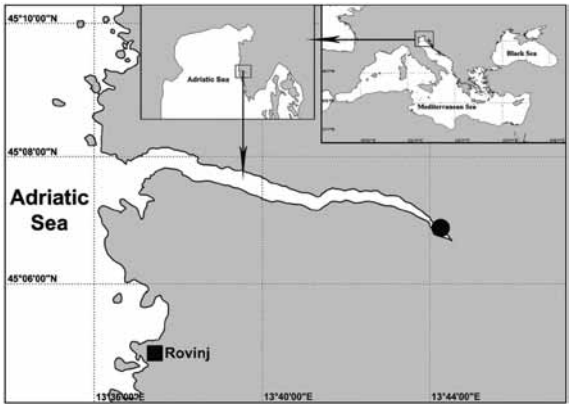

Fig. 1. Map showing the investigated area. The circle indicates the location in Lim Bay where the specimens were sampled

with a maximum depth of about 33 m. This karst region has numerous underwater freshwater springs, especially throughout the inner area, which contributes to the productivity of Lim Bay. Being a semi-enclosed marine ecosystem, Lim Bay has great importance as a natural shellfish spawning ground.

RESULTS AND DISCUSSION

A total of 6 specimens were found in the area, and these specimens, which were collected from Lim Bay, were then compared with the specimens sampled from Izmir Bay (Fig. 2). The main features of the specimens of *Anadara transversa* from Croatian waters correspond with those from Izmir Bay (Table 1). As the population of *A. transversa* in Izmir Bay is well established, those specimens are larger than the encountered specimens from Lim Bay. According to their main morphometric characteristics, these specimens correspond with *A. transversa* as described by DEMIR (1977). Some shells – especially those in juvenile phases, as mentioned by DEMIR (1977) – had a slight depression on each valve, and which on the valves of old shells is usually located at the umbonal part instead (Fig. 2). The Croatian specimens were found to be attached by byssus to the tail, lying down on the bottom close to a mesh bag of *M. galloprovincialis*. This species is able to attach by means of byssus threads to all varieties of hard substrata, from plastic to living bivalves. It can also remain unattached, buried within the sediment of muddy and sandy-muddy bottoms (SOLUSTRI *et al.*, 2003; CROCETTA, 2009). *Anadara transversa* were found at a depth of 4.4 m. Previous studies reported various depths within a range of 3 to 22 metres (5 - 15 m, DEMIR, 1977; 15 - 22 m, ZENETOS, 1994; 10 - 11 m, MORELLO & SOLUSTRI, 2001; 3 - 15.5 m, MORELLO *et al.*, 2004;

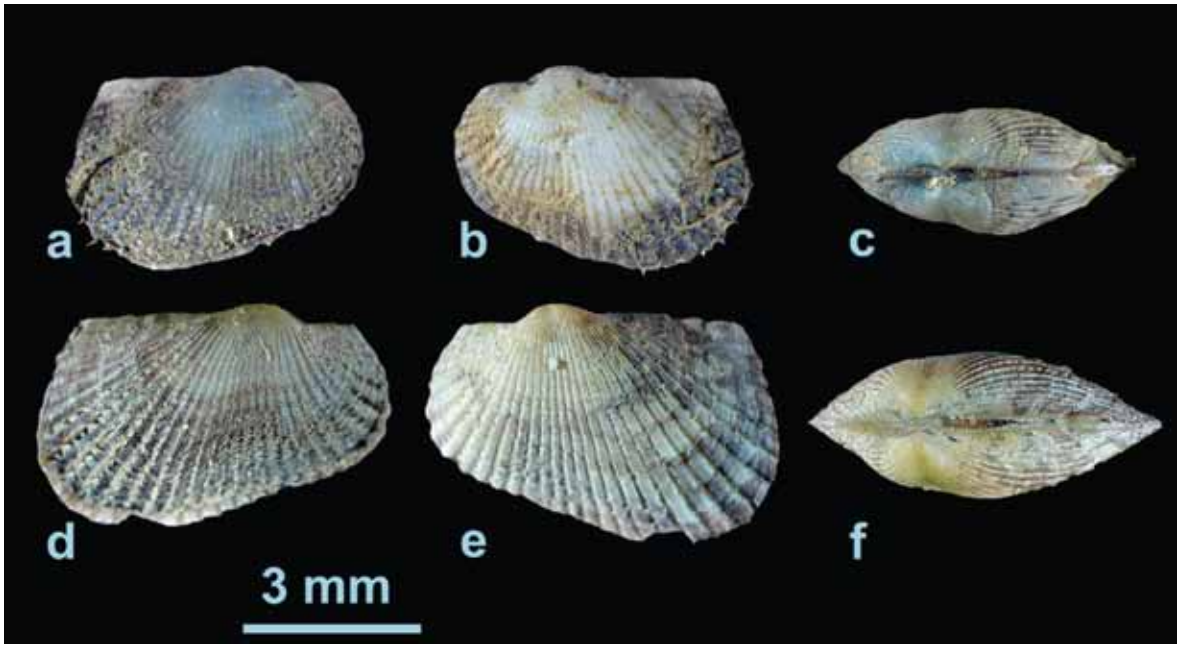

Fig. 2. Lateral and dorsal views of the specimens from Lim Bay (a-c) and from Izmir Bay (d-f)

Table. 1. Main morphometric characteristics of the specimens from Lim Bay and from Izmir Bay

	Lim Bay (N:6)		Izmir Bay (N:10)	
	Mean ± SE	Range	Mean± SE	Range
Length (mm)	4.01 ± 0.84	1.7-7.6	21.4 ± 4.4	5.6-39.2
Height (mm)	2.65 ± 0.6	5.2-1.1	15.5 ± 3.3	3.9-28.5
Width (mm)	1.85 ± 0.52	4.2-0.6	12.2 ± 2.9	2.6-23.4
Number of ribs	31.6 ± 0.33	31-33	33.2 ± 0.3	32-36

and 6 - 11 m, ÇINAR *et al.,* 2006).

The Croatian specimens were collected in a biocoenosis of coastal terrigenous muds (VTC) – facies of soft muds with *Turritella communis* Risso, 1826. Its occurrence in association with that species was already published by CROCETTA *et al.* (2009). *Anadara transversa* was also reported in the external belt biocoenosis of well-sorted fine sands (SFBC), (PÉRÈS & PICARD, 1964; MORELLO *et al.,* 2004), sandy-muddy and muddy bottoms (DEMIR, 1977; MORELLO *et al.,* 2004: ÇINAR *et al.,* 2006), muddy-sandy (ZENETOS, 1994) and sandy bottoms (MORELLO & SOLUSTRI, 2001; MORELLO *et al.,* 2004).

Anadara transversa was first reported from Izmir Bay as *Arca amygdalum* Philippi, 1847 and was thought to be an alien species that was introduced to the area from the coast of China (DEMIR, 1977). Four years later, PIANI (1981) proposed a new name, *Scapharca demiri*, as the name *A. amygdalum* was already in use by LINK (1807). Later, *Scapharca demiri* was re-assigned to *Anadara demiri* (PIANI, 1981). However, *A. demiri* has never been reported in Chinese waters nor in other areas of Southeast Asia. RINALDI (2006) observed many similarities between *A. demiri* and *A. transversa* (Say, 1822). ALBANO *et al.* (2009) recently conducted morphological and molecular analyses based on specimens collected from Turkey, Greece and Italy, and concluded that *A. demiri* is a junior synonym of *A. transversa* (Say, 1822) which is a common species along the eastern coasts of North America.

Anadara transversa is among the top 100 "worst invasive species threatening biodiversity in Europe" (STREFTARIS & ZENETOS, 2006). The mode of its entry into the Mediterranean is uncertain, although shipping seems to be the most likely vector of introduction (ZENETOS *et al.,* 2005). *Anadara transversa* seems to have become well established along the Italian coasts of the Adriatic Sea (RINALDI, 2001; MORELLO & SOLUSTRI, 2001; MIZZAN, 2002, 2007; ZENETOS *et al.,* 2004; MORELLO *et al.,* 2004; CROCETTA *et al.,* 2009). Empty shells of *A. transversa* were also found in the Croatian part of the Adriatic Sea near the mouth of the Jadro River in Kaštela Bay (PEHARDA *et al.,* 2010). However, no further research has yet been conducted in order to provide conclusive evidence that would prove the actual presence of *A. transversa* in that area.

Specimens collected from Lim Bay might have been introduced either by shipping or by aquaculture. Although Lim Bay is a natural spawning ground, juvenile shellfish (*Mytilus galloprovnicialis* and *Ostrea edulis*) from other areas have been recently added in order to increase production. Furthermore, the inner and middle sections of the bay are reserved solely for mariculture (HRS-BRENKO, 1969, 1974; SKARAMUCA *et al.*, 1997; KRAJNOVIĆ-OZRETIĆ *et al.*, 2001). The introduction of some species outside of their native distribution for aquaculture has been suggested as being one of the main modes of introduction for alien marine species (GALIL & ZENETOS, 2002; ZENETOS *et al.*, 2005). MORELLO *et al.* (2004) mentioned both modes of introduction of *A. transversa* "either as planktonic larvae carried within the ballast waters of ships, or as benthic stages within shipments of other bivalves that were the object of aquaculture". *Anadara transversa* once dominated the highly-polluted bottom of Izmir harbour (DEMIR, 1977) and the Thessaloniki Gulf (ZENETOS, 1994) although recently its abundance has decreased due to improved environmental conditions in that area (GALIL & ZENETOS, 2002;

ÇINAR *et al.,* 2006). Although recent studies in Lim Bay have indicated good ecosystem quality and environmental conditions (NAJDEK *et al.,* 2007), a targeted field survey should be conducted within the inner section where the specimens of *A. transversa* were encountered. The discovery of juvenile specimens indicates that the species is already established in Lim Bay though further investigation will be required in order to confirm this statement and ascertain its validity.

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Prvi nalaz vrste *Anadara transversa* (Mollusca: Bivalvia: Arcidae) u hrvatskim vodama

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SAŽETAK

Šest primjeraka alohtonog školjkaša, *Anadara transversa* (Say, 1822), je nađeno u unutarnjem dijelu Limskog zaljeva u lipnju 2011. godine. Školjkaši su pronađeni na dubini od 4,4 metra na muljevitom dnu. Ovo je prvi nalaz spomenute vrste u hrvatskim vodama Jadrana.

Ključne riječi: *Anadara demiri*, *Anadara transversa,* egzotične vrste, Jadransko more, Hrvatska, novi nalaz