Journal of Biological Research-Thessaloniki **20**: 228–232, 2013
J. Biol. Res.-Thessalon. is available online at http://www.jbr.gr
Indexed in: WoS (Web of Science, ISI Thomson), SCOPUS, CAS (Chemical Abstracts Service) and DOAJ (Directory of Open Access Journals)

— SHORT COMMUNICATION —

Fulvia fragilis (Forsskal in Niebuhr, 1775) (Bivalvia: Cardiidae), first record of an alien mollusk in the Gulf of Thessaloniki (Inner Thermaikos Gulf, North Aegean Sea, Greece)

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Received: 8 March 2013 Accepted after revision: 1 May 2013

The occurrence of the exotic bivalve *Fulvia fragilis* (Forsskal in Niebuhr, 1775) is recorded for the first time in the Bay of Thessaloniki (inner Thermaikos Gulf, North Aegean Sea, Greece) with no previous sign of the species in the North Aegean Sea. A total of 45 freshly dead specimens, stranded after a storm, were collected and registered in the author's collection while many others were left in place. The occurrence of this alien species in close vicinity to the port of Thessaloniki is an additional incidence of its presence in areas related to shipping activity in large harbours (Izmir, Piraeus, Malta port, Ebro delta, Syracuse). This indicates that *F. fragilis* is primarily dispersed in the Mediterranean Sea via shipping. Control over ballast tank evacuation could also confine the dispersal of this Lessepsian species in areas, which are inaccessible via natural ways.

Key words: ballast, *Fulvia fragilis*, Lessepsian species, Marine Mollusks, Thermaikos Gulf.

INTRODUCTION

Fulvia fragilis (Forsskal in Niebuhr, 1775) is a medium to large pelecypod bivalve (up to 75 mm), that belongs to the family Cardiidae and the subfamily Laevicardiinae (Keen, 1937; Schneider, 1995). The species has a fragile and light almost circular shell with a sculpture of 41 ribs (34-52). The colour of the shell is whitish to yellow externally, with a purple stain only on the umbo and internally white with purple at the posterior third and sometimes at the umbonal cavity (www.ciesm.org/atlas).

The species is native to the Indian Ocean and East African coasts, the Persian Gulf and the Red Sea (Vidal, 1994). *Fulvia fragilis*, progressively following the patterns of Lessepsian migration initially, spread in the Eastern Mediterranean Sea penetrating through the Suez Canal. The first confirmed record of its presence in the Suez Canal is that of Bavay as early as 1898 and the first confirmed Mediterranean record was made in Israel (Barash & Damin, 1973). The bivalve spread along the Eastern Mediterranean coast successively to Southern Turkey (Lindner, 1988) and Tunisia (Passamonti, 1996). Findings in these areas were made in locations visited only by small boats, so dispersal via shipping must be excluded.

Stable populations of the bivalve are reported in the Western Mediterranean Sea, on the Spanish coast (Gofas & Zenetos, 2003; Zenetos *et al.*, 2004a) and in particular in the Delta of Ebro River (López Soriano *et al.*, 2009). The authors do not relate the appearance of the species directly to accidental transportation

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via ballast tanks although there are ports in the vicinity. The same year a colony of the bivalve is reported in Malta on shores close to the port. The presence of the bivalve there was attributed to nearby shipping activity (Goud & Mifsud, 2009).

Fulvia fragilis is well established along the Italian coasts where new large and stable populations have formed (Crocetta *et al*., 2009a), mainly in Southern Italy, the Castellaneta marina (Taranto), the Gulf of Naples, the Messina strait (Crocetta *et al*., 2009b) and Sicily (Brancato & Reitano, 2009), but also as far north as Livorno (Calabrone) although this has yet to be confirmed with live specimens (Crocetta, 2005).

The species was first recorded in Greece (Vardala-Theodorou, 1999), in Saronikos Gulf (and particularly in Elefsis Bay), areas with considerable shipping activity. These findings in areas close to the port of Piraeus, also suggest dispersal of the species via shipping (Zenetos *et al*., 2004b). The first recorded colony of this species in inner Saronicos Gulf exhibited an invasive character and then declined (www.ciesm.org/atlas). Recently, it was reported again as established and expanding to the wider Saronicos and south Evoicos Gulfs (Zenetos *et al*., 2008).

There is no published record so far of the occurrence of *F. fragilis* in the North Aegean Sea. Especially for the Thermaikos Gulf, the presence of this species was not documented in recent studies recording the local bivalve mollusks (Manousis *et al.*, 2010).

This short communication refers to the first documented record of *F. fragilis* (Forsskal in Niebuhr, 1775) in the Thessaloniki Gulf of the Inner Thermaikos Gulf, in the vicinity of the port of Thessaloniki.

MATERIALS AND METHODS

Gulf of Thessaloniki is a large semi-closed gulf that constitutes the north end of Thermaikos Gulf situated in the North Aegean Sea. The sea front of the Thessaloniki urban area and the city harbor border the greater part of the eastern and southern coastline of

FIG. 1. Thessaloniki gulf (Google Earth). Arrows indicate the sampling localities. The city port and river estuaries in the vicinity are also indicated.

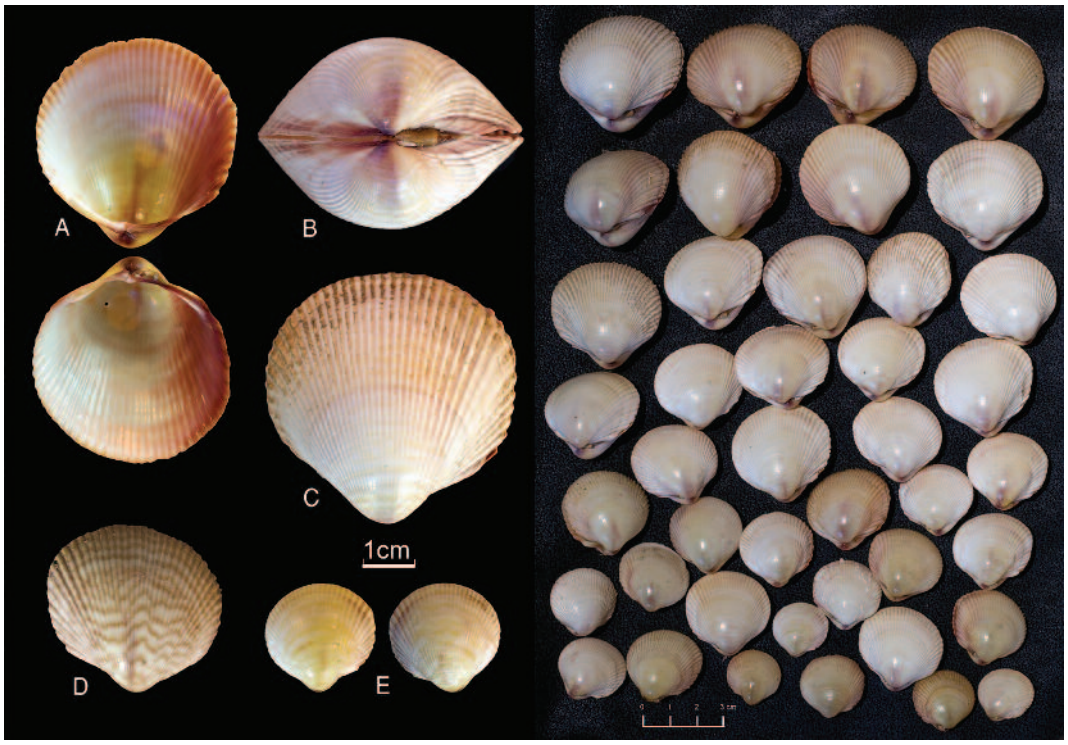

FIG. 2. *Fulvia fragilis* (Forsskal in Niebuhr, 1775). A: interior, B: umbilical view of the biggest individual found, C: biggest individual found measuring 44×44 mm, D: single valve with particular indented pattern, E: smallest individual found measuring 17×17 mm. On the right, a portion of the bivalves found and kept in author's collection.

the bay, whereas, along the northwest coastline, river mouths and cultivated lands exist. Paralia Pylaias (Florida) beach, where *F. fragilis* specimens were found, is a south-eastern beach, situated between the city airport and the urban area of Thessaloniki (Fig. 1). This beach has shallow sandy stretches and receives considerable amounts of effluent waters through two main draining canals. The area is considered as polluted and it is not used for swimming. The beach is exposed to strong local N/NW winds, which may occasionally reach up to 8 Beaufort (Bft) during the winter. Owing to the semi-closed character of the bay, wave activity may be fairly strong but of moderate wave height and span (Fig. 1).

During the third week of February 2012, after such a strong NW wind of 8 Bft, considerable amounts of stranded material consisting of *Zostera noltei* (Hornemann 1832) algae accompanied by many half-dead individuals of various other species were washed ashore. A lot of *Modiolus barbatus* (Linne, 1758) clusters, *Arca noae* (Linne, 1758), *Pinctada radiata* (Leach, 1814), *Gastrana fragilis* (Linne, 1758), and *Venerupis decussata* (Linne, 1758), were soon to be consumed by birds; among them, there was a considerable number of semi or freshly dead *F. fragilis* specimens together with single valves of the same species. Although the area had been regularly visited and screened by the author during the period 2009-2012, no sign of this bivalve had ever been noted and its first appearance was considered significant. Along 1 km of beach, thirty-eight specimens in perfect condition with the dead mollusk inside were collected (Fig. 2) and 26 others half broken or single valves were counted but left in place. The collected specimens were cleaned and preserved in the author's collection. Two days later, another beach of the same orientation but closer to the city (Kalamaria beach, Fig. 1) was visited and 16 single un-matching valves were collected on a 0.5 km stretch of the beach. In the course of the following months until the end of February 2013, despite regular visits, findings were scarce but always occurred, producing two or three specimens each time. The size of the specimens ranges from 17×17 to 44×44 mm and some of them have a particular pattern of indented orange-coloured concentric lines not present in others (Fig. 2).

RESULTS AND DISCUSSION

The number and varying sizes of collected specimens evidence a self-maintaining population established in the area. Young animals measuring 17 to 22 mm were found together with adults measuring up to 44 × 44 mm. Observation of annual growth rings on mature specimens indicated an age of at least 3 years for most of the collected specimens. Continuous gametogenic production related to successive spawning along the year, observed in a study of *F. fragilis* in the Bay of Tunis, may explain its successful establishment in its new areas (Riffi *et al.*, 2012). The fact that the specimens were all washed ashore indicates that they inhabit shallow waters.

The bivalve is known to inhabit protected soft bottom biotopes and to be strongly adaptive to variations of salinity and temperature (López Soriano *et al.*, 2009). Indeed, the characteristics of the sampling locality followed this pattern, receiving considerable amounts of muddy effluents. Water temperature varies significantly in the area throughout the year and this is intensified because of the shallowness and the enclosed character of the Gulf. The geographical latitude of Thermaikos Gulf (40˚ N) equals that of the Ebro River Delta on the Catalonian coast, where stable populations of the bivalve have been recorded (López Soriano *et al*., 2009). Both localities are the northernmost points in the Mediterranean Basin where the species has been recorded, with lowest sea surface temperatures that can decline to 10˚C in winter (poseidon.hcmr.gr, February 2012). Establishment of the species in such geographical latitudes suggests its eurythermal character. It has also been observed that the species reproductive activity is mainly depended on the rise of temperature (Riffi *et al*., 2012); therefore, the recent successful establishment of *F. fragilis* to northern areas of the Mediterranean Sea may be attributed to global warming.

The lack of findings in the North Aegean Sea and nearby locations must exclude their transportation via natural dispersal (personal observations). The port of Thessaloniki as one of the main Mediterranean ports, receives annually a considerable amount of commercial shipping traffic emptying their ballast tanks, usually full of alien water, in the bay; this strongly suggests that the bivalve was transported here via shipping. This is a way of dispersal of *F. fragilis* in the Mediterranean Sea, verified in many similar cases as mentioned above (Zenetos *et al*., 2004b; Crocetta *et al*., 2009b; Goud & Mifsud, 2009).

North Aegean Sea is a major sub area of Hellenic waters and due to its hydrographic characteristics constitutes a natural 'frontier' against alien species invasion. The percentage of alien species in North Aegean Sea with the exception of those transported via shipping, is negligible (Pancucci-Papadopoulou *et al.*, 2005). Control over ballast tank evacuation in Thessaloniki Bay (inner Gulf of Thessaloniki, Fig. 1) may contribute to the maintenance of natural balance in a larger hydrographic area.

The ecosystem of the Thermaikos Gulf is not only complex because of its geographical characteristics but also because of extensive human interference. The new occurrence of the invasive alien species *F. fragilis* must also be considered as a potential indicator for evaluating the status of this ecosystem. It will also be useful to trace any further expansion or decline of the reported population in the wider Thermaikos area.

REFERENCES

Barash A, Danin Z, 1973. The Indo-Pacific species of Mollusca in the Mediterranean and notes on a collection from the Suez Canal. *Israel Journal of Zoology*, 21: 301-374.

Brancato A, Reittano A, 2009. Segnalazione di *Fulvia fragilis* (Forskål, 1775) e *Musculista senhousia* (Benson in Cantor, 1842) nelle acque del Porto Grande di Siracusa (Sicilia Sud-Orientale) (*Mollusca Bivalvia*). *Il Naturalista Siciliano*, S. IV, XXXIII: 207-212.

Crocetta F, 2005. Prime segnalazione di *Fulvia fragilis* (Forskal in Niebuhr, 1775) (Mollusca: Bivalvia: Cardiidae) per i mari italiani. *Bollettino Malacologico*, 41: 23-24.

Crocetta F, Renda W, Colamonaco G, 2009a. New distributional and ecological data of some marine alien molluscs along the southern Italian coasts. *Marine Biodiversity Records*, 2: e23.

Crocetta F, Renda W, Vazzana A, 2009b. Alien Mollusca along the Calabrian shores of the Messina Strait area and a review of their distribution in the Italian seas. *Bollettino Malacologico*, 45: 15-30.

Gofas S, Zenetos A, 2003. Exotic molluscs in the Mediterranean: current status and perspectives. *Oceanography and Marine Biology*, 41: 237-277.

Goud J, Mifsund C, 2009. *Fulvia fragilis* (Forskål in Niebuhr, 1775) (Bivalvia: Cardiidae), an alien species new to the Maltese malacofauna. *Aquatic Invasions*, 4: 389-391.

Keen AM, 1937. Nomenclatural units of the pelecypod family Cardiidae. *Bulletin du Musée Royal d'Histoire Naturelle de Belgique*, 13: 1-22.

Lindner G, 1988. *Laevicardium (Fulvia) papyraceum* (Bruguière, 1788) von der sudturkischen Mittelmeerkuste

(Leg. der Familie Schmidt, Feldkirchen). *Club Conchylia Informationen*, 20: 35-37.

López Soriano J, Salgado SQ, Tarruela A, 2009. Presencia de poblaciones estables de un inmigrante lessepsiano, *Fulvia fragilis* (Forsskål in Niebuhr, 1775), en el Delta del Ebro (Cataluña, España). *Spira*, 3: 53-58.

Manousis T, Mpardakis C, Paraskevopoulos C, Galinou-Mitsoudi S, 2010. The bivalvia Mollusca of Thessaloniki & Thermaikos Gulfs (North Aegean Sea, Greece) with emphasis on new species for Hellenic waters. *Journal of Biological Research-Thessaloniki*, 14: 161-179.

Pancucci-Papadopoulou MA, Zenetos A, Corsini-Foka M, Politou C-Y, 2005. Update of marine alien species in Hellenic waters. *Mediterranean Marine Science*, 6: 147-158.

Passamonti M, 1996. Nuova segnalazione per le coste Tunisine di *Papyridea papyracea* (Gmelin, 1791) (Bivalvia: Cardiidae). *Bollettino Malacologico*, 32: 153-156.

Rifi M, Ben Souissi J, Zekri S, Jaafoura MH, Le Pennec G, 2012. Gametogenic cycle and monthly variations of oocyte size in the invasive cockle *Fulvia fragilis* (Bivalvia: Cardiidae) from the Bay of Tunis (northern Tunisia, central Mediterranean). *Cahiers de Biologie Marine*, 3: 221-230.

Schneider JA, 1995. Phylogeny of the Cardiidae (Mollusca, Bivalvia): Protocardiinae, Laevicardiinae, Lahilliinae, Tulongocardiinae subfam. n. and Pleuriocardiinae subfam. n. *Zoologica Scripta*, 24: 321-346.

Vardala-Theodorou GE, 1999. The occurrence of the Indo-Pacific molluscan species *Fulvia fragilis* (Forsskål, 1775) and *Bulla ampulla* L., 1758 in Elefsis Bay. *Newsletter of the Hellenic Zoological Society*, 31: 10-11.

Vidal J, 1994. A review of the genus Fulvia Gray, 1853 (Mollusca, Cardiidae). *Apex*, 9: 93-118.

Zenetos A, Gofas S, Russo G, Templado J, 2004a. *CIESM Atlas of exotic species in the Mediterranean, Vol. 3.* CIESM Publishers, Monaco.

Zenetos A, Koutsoubas D, Vardala-Theodorou E, 2004b. Origin and vectors of introduction of exotic molluscs in Greek waters. *Belgian Journal of Zoology*, 134: 161-168.

Zenetos A, Vassilopoulou V, Salomidi M, Poursanidis D, 2008. Additions to the marine alien fauna of Greek waters (2007 update). *Marine Biodiversity Records*, 1: e91.