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Rapid Communication

First documented record of the invasive cockle *Fulvia fragilis* (Forsskål in Niebuhr, 1775) (Mollusca: Bivalvia: Cardiidae) in Libya

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Abstract

The occurrence of the fragile cockle *Fulvia fragilis* (Forsskål in Niebuhr, 1775) in Libyan coastal waters (south-eastern Mediterranean Sea) is reported here for the first time based on the collection of twenty-nine live specimens from the shoreline in close vicinity to Tripoli Harbour, situated to the west of the country. The present record fills a gap in the geographic range of *F. fragilis* – its occurrence is already documented from the neighbouring territories of Egypt, Italy, Malta, and Tunisia. Although there are no certainties regarding the precise arrival date of this non-native bivalve in Libyan coastal waters, its presence within the environs of Tripoli Harbour might allude to its facilitated spread through ballast water from commercial shipping activity.

Key words: Mollusca, Lessepsian species, ballast, migrant, Tripoli Harbour

Introduction

The fragile cockle *Fulvia fragilis* (Forsskål in Niebuhr, 1775) is a bivalve mollusc belonging to the family Cardiidae Lamarck, 1809. While its origins presumably lie in the Indian Ocean, extending from the Red Sea and the Persian Gulf to the East African coasts (Barash and Danin 1973; Vidal 1994), populations of this mollusc have established within the Mediterranean Sea and have been documented from numerous countries, including Turkey, Tunisia, Greece, Spain, Italy, Malta, Lebanon, and Albania (e.g. Lindner 1988; Passamonti 1996; Vardala-Theodorou 1999; Zenetos et al. 2004a; Crocetta 2005; Öztürk and Poutiers 2005; Goud and Mifsud 2009; Angelidis 2013; Crocetta et al. 2013, 2017; Gerovasileiou et al. 2017). The possible routes of colonisation into and throughout the Mediterranean Sea have been widely debated and two routes of invasion have been proposed. The first proposes a natural dispersion through a Lessepsian migration via the Suez Canal, with a subsequent secondary spread facilitated by the prevailing Mediterranean currents – at least for some Mediterranean populations (see

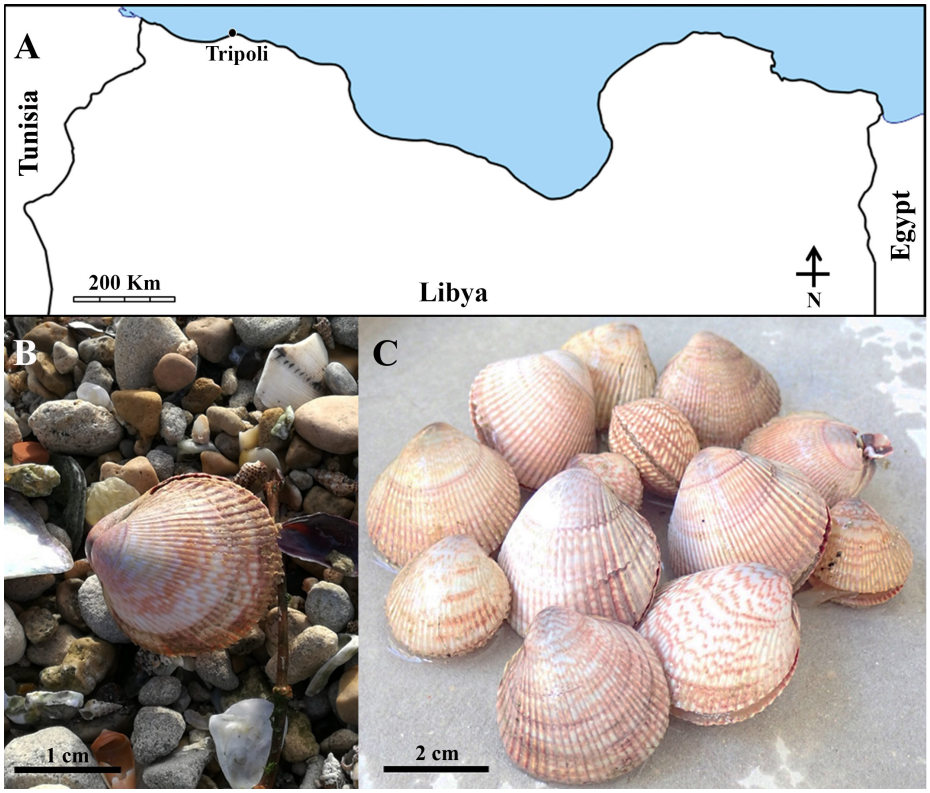

Figure 1. (A) The study site – Tripoli Harbour. (B) A sub-adult of *Fulvia fragilis* that was washed ashore and found among shoreline debris. (C) A group of living *F. fragilis* collected from the sandy shoreline at Tripoli Harbour. Photo credit: J. Rizgalla.

Crocetta et al. 2009). This hypothesis draws on the first record of *F. fragilis* from within the Suez Canal by Moazzo (1939). A second contrasting hypothesis is drawn on the finding of *F. fragilis* in sites close to harbours and ports, suggesting that its spread into new regions is facilitated through ballast waters from commercial shipping activity (Zenetos et al. 2004b; Streftaris et al. 2005; Goud and Mifsud 2009).

During the course of a marine survey conducted within the environs of Tripoli Harbour, Libya (south-eastern Mediterranean Sea), a total of 29 live specimens and several empty shells of *F. fragilis* were collected. This account details, for the first time, the occurrence of this taxon in Libyan coastal waters.

Materials and methods

Study area and sampling

Tripoli Harbour is approximately 3.95 km long and almost 2 km at its widest point and is protected by two breakwaters consequentially creating an outer and an inner harbour. As Libya's principal sea port, there is active cosmopolitan shipping traffic, including commercial tankers and cruise ships.

From the 22nd November 2018 to the 28th January 2019, daily sampling trips were undertaken by walking the shoreline marking the outer harbour – a landform that is largely composed of sand subject to tides, with rocky and pebbly substrates (32.901140°; 13.212579°; Figure 1). Beached shells and

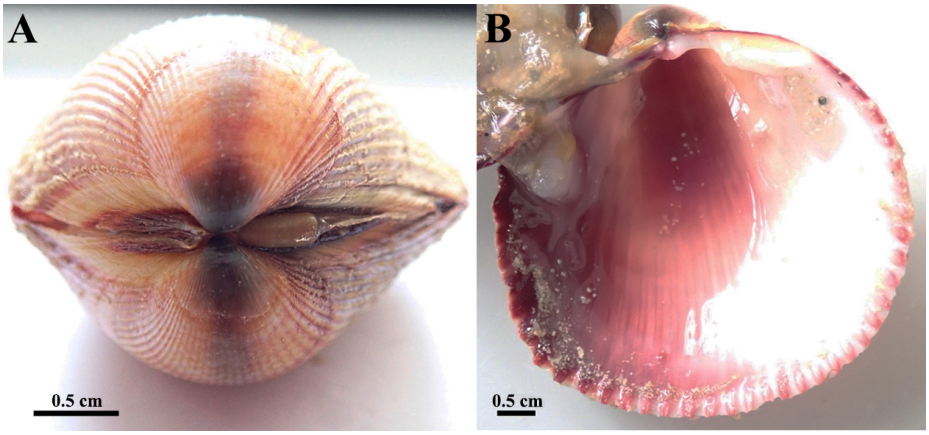

Figure 2. (A) *Fulvia fragilis* apical view with its typical purple colouration on the umbo. (B) Internal view of *F. fragilis* and its purple colouring on the inner surface. Photo credit: J. Rizgalla.

other specimens relevant to the marine surveys were collected by hand, and where appropriate to do so, were subsequently stored in 90% ethanol and archived in the principal author's private collection. Specimens were photographed using an Olympus Tough camera.

Results

Throughout the 2–month long survey study period, several empty *F. fragilis* shells were found beached alongside other commonly encountered local resident species of mollusc including, among others, *Cerastoderma glaucum* (Bruguière, 1789), *Naticarius hebraeus* (Martyn, 1786), *Venus verrucosa* Linnaeus, 1758, and *Ruditapes decussatus* (Linnaeus, 1758). During the survey walks conducted from the 27th December 2018 through to the 13th January 2019, a period marked by particularly stormy weather and high waves, a total of 29 live specimens of *F. fragilis* were found washed ashore. The specimens ranged in size from 2.2–4.6 cm in height to 2.1–3.9 cm in width (Figure 1B–C; Figure 2A–B).

Discussion

This is the first confirmed report of *F. fragilis* in Libyan waters. According to Bazairi et al. (2013), the species has already been recorded from Libya based on an unpublished report. However, each attempt to obtain a copy of the report from the putative authors of it (Zgozi SW, Haddoud D, Rough A) and through the authors of the above mentioned work were unsuccessful, and the existence of the report is in question. Yet, based on the unpublished data of Daw Haddoud (*pers. communication*), this species has been present in Libyan waters since at least 2006, when it was found during a local survey at Tobruk, to the east of the country. While its earlier record in the east of the country might suggest a natural spreading from Egyptian populations, the recording of 29 live specimens of *F. fragilis* in the immediate environs of Tripoli Harbour might suggests that local introduction and

establishment of a population may have been a consequence of translocation associated with commercial shipping. However, natural dispersion of the species from established populations in neighbouring Egyptian, Tunisian, Italian, and/or Maltese waters (Moazzo 1939; Ben Souissi et al. 2003; Zenetos et al. 2004a; Crocetta 2005; Goud and Mifsud 2009), as well as from the east of the country, cannot be discarded also here.

Fulvia fragilis is an established alien species in the Mediterranean Sea, locally showing invasive traits (Zenetos et al. 2017). Despite this, and notwithstanding the threat that non-indigenous species can pose to local biological diversity (Katsanevakis et al. 2014; Lehtiniemi et al. 2015), there seems to be a scarcity of studies on its ecological impacts in the Mediterranean Sea. Of particular note is a study conducted by Ben Souissi et al. (2003), who suggested that native populations of *Acanthocardia paucicostata* (G.B. Sowerby II, 1834) in competition for natural resources consequentially led to reduced numbers of *F. fragilis* in the lagoon of Tunis, whereas they appeared to be abundant in other parts of the lagoon. In another later study, Rifi et al. (2011) attributed the seemingly unrestricted colonisation of *F. fragilis* in Tunisian waters to its hermaphrodite nature, permitting spawning to occur all year round. As *F. fragilis* has already colonised almost the entire Mediterranean basin, the study of its impacts on the native molluscan fauna may offer an interesting case for study to deepen current knowledge regarding biological invasions within the Mediterranean Sea. While commercial ports are often considered hotspots of invasive species activity (e.g. Hewitt and Martin 2001; Ferrario et al. 2017), the findings from the current study appear to lend support to this. The current study has now been extended by looking at sites at increasing distances from the port looking for live specimens. By establishing baseline data on the local molluscan fauna, it is anticipated that the invasive nature of this and other introduced species (Rizgalla et al. 2018, 2019), as well as their impacts on the indigenous molluscan fauna, can be better characterised.

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