Introduction

The endobystate arid bivalve Anadara transversa is an invasive species that was first recorded in the Mediterranean Sea in the early 1970s in the harbour of Izmir, Turkey, where it was identified as Arca amygdalum, presumably introduced from Chinese waters. Later, the taxon was rearranged as Anadara dimitri, a junior synonym for Anadara transversa, which is a temperate species from the eastern coast of North America. Subsequent records date from the 1990s in the Aegean Sea, and first records in the Adriatic Sea start with 2001 from coastal waters in the northern and western basin. Only since 2012 has Anadara transversa been reported from Croatian waters, with a small number of specimens from some coastal areas and signs of established populations also in more offshore parts of the eastern Adriatic. Assuming a “stepping stone” colonization pattern for A. transversa, we hypothesize that the species was introduced by maritime transport much earlier to the different Mediterranean distribution areas than the date of the several “first records” suggests.

Sampling sites and methods

Sampling was performed within the framework of a project on the historical ecology of the northern Adriatic Sea that uses down-core changes of molluscan death assemblages as indicators for ecological shifts. Multiple sediment cores (core diameter 16 vs. 9 cm) were taken at seven sampling stations spread throughout the whole basin. The sediments were analysed granulometrically and dated using Pb-radiometric dating methods, and the molluscan death assemblages were studied in detail. At several coring stations, shells of Anadara transversa were found. The sediment dating yielded accurate sedimentation rates for the last 120 years, thus enabling us to date the sediment layers in which A. transversa shells were found.

Sedimentation rates

The sedimentation rates varied widely between the individual sampling sites. The highest value (~1.6 cm/a) was recorded at the Po River Delta stations, the lowest (~0.2 cm/a) at the Brijuni islands in Croatian waters.

Results

The abundance of Anadara transversa shells was strongly correlated with sediment composition, confirming this species’ preference for muddy environments like the Po River Delta. The Venice station, characterized by almost pure sands, was the only station where no A. transversa shells were found at all. By taking the age of the deepest sediment layer with A. transversa shells as the time of their first appearance at a given site, the following colonization pattern emerges: In the Po Delta area, the species seems to be present since the late 1960s; off the Slovenian coast the findings are more ambiguous, suggesting colonization between the mid-1970s and 1980s, while the bay of Panzano may host A. transversa since the mid-1980s. At the Brijuni island station on the eastern coast of the northern Adriatic Sea, only one shell of A. transversa was found at a sediment depth corresponding to the mid-1950s.

Discussion

Many of the first records of Anadara transversa in the Mediterranean Sea are from harbours or polluted marine areas. This points to ships as the most likely vector of introduction. It also underlines the ability of this species to cope with adverse ecological conditions and to outcompete local species in more arduous environments.

Our results suggest that A. transversa was brought into northern Adriatic waters much earlier than the dates of first records in the scientific literature might indicate. Rather, the first appearance here lies much closer to or even precedes the date of the first ever record in the Mediterranean Sea (1972 in Turkey). This almost contemporaneous wide-scale occurrence supports the “stepping stone” model of dispersal, according to which the species was introduced into the Mediterranean and also into the Adriatic by maritime transport. This vector may easily have carried individual specimens to different, far-away destinations (industrial ports or aquaculture areas) within a relatively short time-span already during the 1960s or 1970s. Starting from such “point sources”, the species may have conquered ever bigger adjacent areas, aided in its dispersal by currents and also by commercial fishing activities.

Although our approach that correlates the age of a sediment layer with the age of the shells contained therein could be compromised by the effects of bioturbation and anthropogenic disturbance of the seafloor, it has recently been shown that 14C and radiocarbon chronologies lead to remarkably similar results. The application of radiometric sediment dating in the study of invasive marine molluscs can help clarify the actual spatial and temporal patterns of their dispersal and may thus contribute to re-assessing the “invasive power” of individual species.

References