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Patterns in molluscan death assemblages along the Israeli Mediterranean continental shelf

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ABSTRACT

The Mediterranean coast of Israel can be divided into two distinct provinces (south to north): the Nilotic, which up to the construction of the Aswan Dam received most of its quartz-rich sediments from the Nile, and the Levantine, which receives most of its sediments from local, carbonate-rich sources. These differences in sediment composition should have a strong effect on the faunal composition. We studied the very abundant molluscan fauna, a major biogenic component of the shallow Mediterranean sediments and suggest that variations in assemblages are associated with different substrates. We examined the dead molluscan component of sediment samples collected at 40 m water depth at five stations along the Israeli Mediterranean coast to determine the variations in biodiversity trends. The use of shelly death assemblages that accumulate on the seafloor averages out short-term, environmental fluctuations such as seasonality and reproduction, and presents a more complete "modern" picture than would be attained based on single live censuses alone. More than 2000 specimens yielded 114 species, with the bivalve *Corbula gibba* being the most abundant. Samples originating from the Levantine Province show greater species richness and a higher portion of epifaunal species compared to samples from the Nilotic Province. Specifically, 30 bivalves and 20 gastropods were only found in the Levantine samples, while only six bivalves and three gastropods were only found in the Nilotic samples. Our results point to a spatial biodiversity pattern along the Israeli coast, in which the Levantine Province is richer in species, feeding strategies and life habits than the Nilotic Province. The data collected can be used as a baseline for future ecological studies in the area, as they shed light on the under-studied molluscan benthos of the intermediate continental shelf of the Israeli Mediterranean.

1. Introduction

Human-driven activities, such as the construction of dams and coastal development, can have detrimental effects on natural sedimentological, nutrient regimes, marine biodiversity, and species distribution (e.g., Nixon, 2003; Zenetos et al., 2004; Syvitski et al., 2005). These effects, in return, can significantly impact marine biodiversity. Macroinvertebrates such as mollusks (Phylum: Mollusca) are dominant in benthic environments and widespread in diverse marine ecosystems (Russell-Hunter, 1983), and especially in shallow waters. These depths (0–50 m) are most likely to be affected by human-driven activities such as coastal development (Coll et al., 2010). The large biodiversity of shelled mollusks and their abundant fossils contribute to their use both as means for paleoecological reconstructions (Kidwell and Bosence, 1991; Kidwell, 2002; Garilli, 2011) and recent ecological assessments (Bouchet et al., 2002; Edelman-Furstenberg, 2008), where they serve as a proxy for environmental change on the seafloor (Benson, 1972; Kidwell and Tomasovysch, 2013).

Dead molluscan assemblages are often used as a tool for ecological assessment, since they usually contain shells from multiple generations that participated in the ecosystem throughout annual and perennial cycles (i.e., they are time-averaged; Kidwell and Bosence, 1991; Kidwell, 2013; Kidwell and Tomasovych, 2013). Age distributions of shells in death assemblages are right skewed (Kidwell, 2013), meaning that very old shells comprise a negligible portion of the total assemblage. These "time-averaged" death assemblages smooth out short-term variability such as seasonal and annual variations of the live community (e.g., larval blooms, storm events). Thus, death assemblages, unlike live censuses, are not prone to over-representation of species that are only abundant in the particular season during which the sampling took place. In

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this way, death assemblages represent a more complete ecological picture of a specific habitat than would a single live-assemblage.

Another advantage of death assemblages is that they contain individuals not only from their immediate environment, but also from some distance around them (i.e., spatial averaging; Kidwell, 2013). Kidwell (2013) showed that death assemblages are equivalent to data gathered from living censuses collected over decades on a regional scale. Pruss et al. (2011) found differences in mollusk predation ecology between two beaches only 21 km apart using death assemblages. Kidwell and Tomasovych (2013) suggest that the regional scale of spatial averaging of molluscan death assemblages is in the order of tens to hundreds of meters. Therefore, sampling death assemblages may allow us to explore and describe biogeographical patterns of relatively large geographical units.

We focused on two classes of mollusks, Gastropoda and Bivalvia, whose skeletal material can be buried after death and preserved in the sediment record, and which comprise ~93% of the total molluscan species in the Mediterranean (Coll et al., 2010). We aim to describe the under-studied fauna of marine benthic mollusk at the rapidly changing Levant Basin, and to suggest some possible drivers for the observed patterns. These data might serve as a baseline (Pauly, 1995; Kidwell and Tomasovych, 2013) for evaluating future changes in the local biota. Moreover, we want to determine whether Levantine Nanism also applies to mollusks.

2. Regional setting

The Levant Basin, the eastern most section of the Mediterranean Sea (Por, 1989), has been subject to widespread environmental changes during the last centuries. These trends include, for example, coastal development, the damming of the Nile River (Nir, 1984; White, 1988; Nixon, 2003; Zviely et al., 2007), the construction of Suez Canal and the Lessepsian migration that followed it (Zenetos et al., 2004; Galil, 2007), and over-fishing (Edelist et al., 2014).

The Nile River was one of the most important rivers flowing into the East Mediterranean Basin until the construction of the Aswan High Dam in 1964, which significantly lowered the output of nutrients and sediments into the sea (Nir, 1984; Stanley, 1988). The large input of Nile sediments into the Israeli Mediterranean shores in the past (Nir, 1984), together with the dominant northern flow (Zviely et al., 2007), created a south–north gradient of seafloor substrates. The sediments at 40 m depth that were sampled in this study are fine sediments, with silt dominating in the south, and fine-sand and silt in the north (Almogi-Labin et al., 2012). The area ranging from the southern Israeli coast to the Carmel Promontory at Haifa Bay in the north received most of its sediments from the Nile, and is termed the "Nilotic Province". The area from the Carmel Promontory at Haifa Bay in the south to Rosh Ha'Niqra in the north is termed the "Levantine Province" (*sensu* Hyams-Kaphzan et al., 2008 – fig. 8 therein). It is considerably less affected by the Nile (Nir, 1984), and is dominated by sediments rich in carbonate. A recent study found that despite considerable constructions along the Israeli shoreline and Aswan High Dam, these sand accumulation trends have not been affected (Zviely et al., 2007). The Levant Basin is defined biogeographically to include both the Levantine Province and the Nilotic Province (Por, 1989).

The decline in sediment flow from the Nile into the Levant Basin is superimposed on the already extreme environmental conditions in the Levant Basin (e.g., high salinity and temperature, oligotrophy; Por, 1989; Coll et al., 2010). It has been suggested that these extreme conditions are responsible for Levantine Nanism, a phenomenon in which species from the Levant Basin with an Atlantic origin are smaller than their conspecifics outside the Levant (Por, 1989). This phenomenon has been demonstrated in several animal groups [for sponges, sipunculids and polychaetes see Por (1989) and references therein; fish (Sonin et al., 2007); marine mammals (Sharir et al., 2011); but see Aronov and Goren (2008)]. However, there is little evidence to support this phenomenon in mollusks (Mienis, 2005).

Despite the severity of the anthropogenic impacts, an up-to-date, comprehensive study of the eastern Mediterranean benthic shelly mollusks is not available, to the best of our knowledge. In this study, we examine the variations in bivalve and gastropod species composition, relative abundance, trophic levels and life habits (infauna vs. epifauna) along a south–north transect of the Israeli Mediterranean coast.

3. Material and methods

3.1. Sample collection

The samples were collected using the R/V Shikmona during two cruises. Sample B-2 was collected during May 2009 and the remaining samples were collected in a single cruise during August 2011 (Table 1, Fig. 1). Samples were taken at ~40 m water depth using a box corer (Instrument Company, BX 700 AL), and, when not possible, using a Van Veen grab. This water depth was selected to control for sea floor character. Rocky bottoms are found at Akhziv (one of the localities in the Levantine Province) at shallower depths, and thus could not be compared to our samples taken from the sandy-silty sediments from deeper waters. The top two centimeters of sediment in each sampling site were examined for mollusks.

3.2. Sample preparation

The sediment of each sample was washed with freshwater and sieved through a 2 mm sieve. The B-2 sample was wet sieved through a 1 mm sieve, but later dry-sieved through a 2 mm sieve to allow for comparison with the rest of the samples. The samples were dried in a 50 °C oven and a minimum of 300 specimens were collected from each of the samples for further quantitative analyses. All specimens collected during the sampling originated from death assemblages (i.e., empty shells). None of the specimens were live endangered or protected species. The samples were not taken within protected (e.g., nature reserves) or privately owned sea territories. Therefore, no specific permissions were required for these activities.

Table 1
Site locations and mass of the samples.

Sediment province	Site name	Water depth (m)	Latitude (°)	Longitude (°)	Dry sample mass	Mass >2 mm fraction
Levantine Province	Akhziv 1-40	40	33.034757 N	35.040035 E	605.26 g	37.37 g
Levantine Province	Bustan HaGalil B-2	37	32.9767 N	35.015533 E	867 g	267.05 g
Nilotic	Dor 6-40	40	32.616423 N	34.877273 E	830.06 g	6.18 g
Nilotic	Palmahim 12-40	40	31.979165 N	34.652779 E	581.77 g	13.03 g
Nilotic	Ashdod 13-40	40	31.879641 N	34.591095 E	671.36 g	6.41 g