BioInvasions Records (2023) Volume 12, Issue 3: 775–786

Rapid Communication

First record of the American clawed lobster, *Homarus americanus* (H. Milne Edwards, 1837), in the southeastern Mediterranean

Ehud Spanier

Department of Maritime Civilizations and the Leon Recanati Institute for Maritime Studies, University of Haifa, Mount Carmel, Haifa 34988-38, Israel

E-mail: *spanier@research.haifa.ac.il*

Citation: Spanier E (2023) First record of the American clawed lobster, *Homarus americanus* (H. Milne Edwards, 1837), in the southeastern Mediterranean. *BioInvasions Records* 12(3): 775–786, https://doi.org/10.3391/bir.2023.12.3.13

Received: 10 February 2023
Accepted: 30 May 2023
Published: 2 August 2023

Handling editor: Tricia Goulding
Thematic editor: April Blakeslee

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Abstract

Two live specimens of American lobster, *Homarus americanus*, were observed in very shallow waters, in Caesarea, the central Mediterranean coast of Israel at the end of 2022. This is the first record of this species or any clawed lobster, family Nephropidae, in the warm southeastern Mediterranean. The carapace lengths of the lobsters were 92 and 94 mm, which corresponds with weights of around 600–640 grams, like that of live clawed lobsters imported to Israel from the North-Eastern USA. Although the origin of these lobsters is unknown, it is assumed that they have been released from a restaurant or a cruise ship. They may survive the winter in the Israeli water, but the high temperatures of the sea water during late-spring and summer in the southern Levantine basin will be stressful and lethal for them.

Key words: Decapoda, Nephropidae, Levant, Israel, introduced species, non-indigenous species

Introduction

The southeastern Mediterranean is considered a hot spot of marine biological invasions mainly of Indo-Pacific "Lessepsian" species introduced through the Suez Canal (e.g., Spanier and Galil 1991; Shefer et al. 2004; Galil 2008; Galil et al. 2015, 2017, 2021; Zenetos et al. 2016; Spanier and Zviely 2022) but also some from Atlantic origin. The means and route of introduction of alien species are rarely known from direct evidence. They are usually inferred from the biology and ecology of the alien species, their habitats, and pattern of dispersal. It is assumed that Indo-Pacific non-indigenous species traverse the Suez Canal and proceed northwards along the Levant coast by active or passive larval or adult movements, aided directly or indirectly by human activity. The Suez Canal is recognized both as a pathway through which alien species may cross naturally and a corridor for shipping-introduced alien species. Lessepsian (or Erythrean) non-indigenous species from tropical and sub-tropical waters are common in the southeastern corner of the Mediterranean due to its proximity to the northern opening of the Suez Canal at Port Said and the dominant counter clock currents regime

Figure 1. Location of the reported *Homarus americanus* lobsters in the southeastern Mediterranean (indicated by *). Inset: 1–3 indicate locations of *H. americanus* reported in the Mediterranean [modified after Spanier and Zviely 2022, Figure 1 i.e., Background: part of "Blue Marble: Land Surface, Shallow Water, and Shaded Topography". NASA Goddard Space Flight Center Image by Reto Stöckli, Robert Simmon and MODIS Groups; https://visibleearth.nasa.gov/images/57752/blue-marble-land-surface-shallow-waterand-shaded-topography (accessed on 11 February 2002). Inset: Physical Map of the Mediterranean Sea and its surroundings. www.freeworldmaps.net/europe/mediterranean/physical.html, accessed on 20 December 2002.

(Spanier and Zviely 2022 and references therein) that serve as a transport vector for propagules of alien species from Port Said eastwards and northwards (see Figure 1). The introduction of alien species from temperate water may also be related to ballast water. Modern ships are larger (with larger ballast water tanks) and much faster than 20th century vessels, which increases the survivability of potential alien species in the ballast water. In recent years, two-thirds of global marine recreational traffic occurs in the region (Ulman et al. 2017, 2019) and 13% of the total capacity of the commercial shipping (Benamara et al. 2019). Thus, the increase of modern shipping along the Levantine coast has exacerbated migration despite international and national regulations intended to prevent it. International trade, especially with live marine organisms, may be another mean of introduction of alien species. Off the Israeli coast, at least 445 alien species were recorded thus far, more than anywhere in the Mediterranean Sea (Galil 2023). When calculated per coastline length, the number is of calamitous proportions (Galil et al. 2021).

These authors report that the most speciose taxa are mollusks, crustaceans, fish, and macroalgae. A considerable percentage of species of the above major groups has established large reproductive populations along the Israeli coast.

One of the most successful crustaceans' taxa that demonstrates global dispersal is the Decapoda with many successful alien species (Galil et al. 2011). Non-indigenous crustaceans are the second-most abundant group in the Mediterranean Sea, among which more than 90 species belong to the order Decapoda (Galil et al. 2015). Most of the reported alien decapods are thermophilic Indo-Pacific species. Nearly 77% of all alien Mediterranean decapod species have an Indo-Pacific origin, while only 23% are from the Atlantic (Klaoudatos and Kapiris 2014).Yet, there are also reports of Atlantic alien decapods species that established considerable populations in the Mediterranean, such as the Atlantic blue crab *Callinectes sapidus* (Mancinelli et al. 2017; Kampouris et al. 2019), the northern brown shrimp *Penaus aztecus* Ives, 1891 (Kampouris et al. 2018; Özcan et al. 2019) and the Atlantic seabob *Xiphopenaeus kroyeri* (Heller, 1862) (Khafage and Tasha 2019). As well as the cold-water *Cancer bellianus* and *Paralithodes camtschaticus* (Kampouris et al. 2021).

Decapods include five families of lobsters, the species of which can be found in many marine habitats around the world. Three of these families – clawed lobsters, Nephropidae, spiny lobsters, Palinuridae, and slipper lobsters, Scyllaridae, include dozens of commercial species, some of which are fished worldwide (annual yield of hundreds of thousands metric tons) and are a highly valuable resource (Spanier et al. 2015). Yet despite the large natural geographic and ecological dispersal potential and the economic importance of many species there are only limited reports on non-indigenous lobsters. Only two reports of Lessepsian alien species of lobsters are known from the Israeli Mediterranean coast. Galil et al. (1989) reported of a single Indo-Pacific ornate spiny lobster *Panulirus ornatus* (Fabricius, 1798), and Spanier and Friedmann (2019) documented a single exuvia of the tropical long-legged spiny lobster *Panulirus longipes longipes* (A. Milne-Edwards, 1868). Spanier (2021) suggested that passage of lobsters' sensitive propagules in ballast waters of ships was less probable due to the long and complex life history of these crustaceans. He also doubted if the delicate planktonic early stages of lobsters could survive and complete their life cycle in the environmental conditions of the regions of destination.

An exception of this shortage of reports on non-indigenous species of lobsters is the American clawed lobster *Homarus americanus* H. Milne Edwards, 1837. This lobster, native to the northwest Atlantic coast, is a species with high commercial value. In the U.S.A. alone, the landings for 2019 were reported to be more than half a billion Euros (NOAA 2020). *Homarus americanus* is imported worldwide for human consumption, with adult lobsters transferred live, mainly by flight transport, from North America to countries in Europe, Asia (e.g., Doi et al. 2011; Yeo et al. 2011) and

elsewhere. Some of these alien lobsters were released/escaped and recorded in north European waters. Despite prohibitions to release or hold *H. americanus* in net cages, there have been recorded findings of live *H. americanus* in Sweden as well as in several other European countries including Denmark, Ireland, Norway, and Great Britain (Jørstad et al. 2007; van der Meeren et al. 2008; Stebbing et al. 2012; Øresland et al. 2017). *Homarus americanus* has likely established populations in the water of northern Europe and can hybridize with the indigenous European Lobster, *H. gammarus* (Linnaeus, 1758), leading to fertile or sterile offspring (Jørstad et al. 2007; Stebbing et al. 2012; Barrett et al. 2020). The hybrids might be fast growing and viable and thus potentially increase the competition for food, habitat, and mates. The relative success of the American Lobsters in northern Europe may be due to similarity of the North European habitats and environmental conditions to the American one and its rather short life cycle (Factor 1995). Several *H. americanus* lobsters were reported to have escaped in Japan (Watabe 1993; Doi et al. 2011). Deliberate introduction of *H. gammarus* in New Zealand early in the 20th century was unsuccessful (Dodgshun et al. 2007).

Recently there have been two confirmed records of a single *H. americanus* each, in the Mediterranean region. In January 2018, a live female American lobster was caught near the northwest coast of the Istrian Peninsula in the northern Adriatic Sea, Croatia (45°30.502′N; 13°28.656′E) (Pavičić et al. 2020) (Figure 1, inset – "1"). The second record, a male American lobster, was caught by artisanal fishermen at Chalkidiki Peninsula, Greece, northwest Aegean Sea (39°54′50.7″N; 23°41′10.7″E), in August 2019 (Kampouris et al. 2021) (Figure 1, inset – "2"). The origin of these specimens is unknown, but their presence is likely due to live seafood importation to markets in these countries.

The present paper documents the first observation of *H. americanus* in the shallow coastal water of Israel, the first record of this species, or any clawed lobster, in the warm Southeastern Mediterranean Sea.

Materials and methods

On January 1st, 2023, in a public (non-scientific) Facebook group "There is much to see in the Mediterranean Sea" (Hebrew translation) (https://he-il.facebook.com/groups/656969671489575/?mibextid=6NoCDW), an amateur fisherman reported an observation of *H. americanus* in the central Mediterranean coast of Israel. This happened while he was fishing from shore with a fishing rod, accompanied by his young son, on the morning (10:30–11:00 AM) of December 31, 2022, in the Aqueducts Beach (near the ancient Herodian aqueduct, north of ancient Caesarea) (32°30′48.3″N; 34°53′44.0″E) (* in Figure 1). The lobster was observed in very shallow water (20–30 cm deep) in a calm sea (seaward eastern winds). The bottom of this area is sandy covered with rocks and the lobster was first detected hiding

Figure 2. An American clawed lobster (*Homarus americanus*) (white arrow) detected in the coast of Caesarea, Israel, on December 31, 2022. Photo by Yaron Koren.

under one of these rocks (Figure 2). The sport fisherman removed the lobster with a dip net and put it in a plastic bucket (Figure 3). He then released the lobster back to the water and it moved and hid again under a rock. The author contacted this fisherman, who sent him pictures and videos of the lobster. Via contacts with other members of this Facebook group, the author reached a tourist guide that took pictures and videos of two clawed lobsters just before sunset of December 30, 2022 (16:00–17:00 PM) at the same exact site (Figure 4). This person removed one of the lobsters from the water and photographed it (Figure 5). He then returned the lobster to the water where the 2 lobsters continued to interact. The species of the clawed lobsters were identified, and their sizes were estimated by the author [using the known size of an object such as the diameter of the bucket where the lobster was temporarily held (Figure 3), or the hand holding

Figure 3. An American clawed lobster (*Homarus americanus*) caught (and released) in the coast of Caesarea, Israel, on December 31, 2022. Photo by Yaron Koren.

the lobster out of the water (Figure 5)]. Restaurants in the nearby historic Caesarea were questioned about using live clawed lobsters as well as the only importer of clawed lobsters to Israel (*Shlal Dagim LTD*).

Results and discussion

The clawed lobsters were identified as *Homarus americanus* based on the rostrum with a ventral tooth (Figure 5, inset) typical to *H. americanus* (Holthuis 1991, Figure 105a, page 57) and not to *H. gammarus.* Also, the colors were those described for *H. americanus,* especially the dorsal spines on both rostrum and chelipeds that were of orange-reddish coloration (Figure 5), compared to those of *H. gammarus* which are always white (Williams 1995; Jørstad et al. 2007). The carapace lengths of the lobsters were

Figure 4. Agonistic interaction between two American clawed lobsters (*Homarus americanus*) in the coast of Caesarea, Israel, on December 30, 2022. Photo by Michael Tuval.

92 and 94 mm. The general coloration of the lobsters was dark-olive to rusty-brown, with some orange stains. The chelipeds had some orange margins and they, as well as the base of the telson, were mottled with dark-greenish black spots. The color of the uropods was mostly of lighter olive coloration with darker margins.

Since no picture of the ventral side of the lobsters was available, it was not possible to determine the sex of the lobsters. However, the video recordings of the lobsters, taken on December 30, 2022, clearly shows them in agonistic behavior (e.g., Figure 4) and thus one of these lobsters is certainly a male. The other lobster looks like it has some deformed claws, possibly from being banded during transport while still in the soft-shell state.

The origin of these lobsters is unknown. However clawed lobsters are imported live for gourmet restaurants in Israel (including to restaurants of

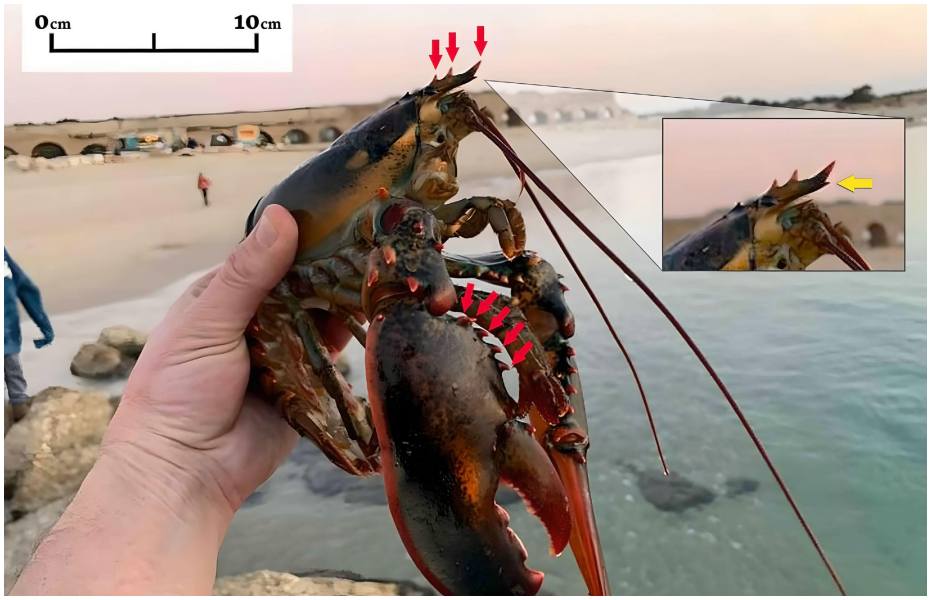

Figure 5. A side view of an American clawed lobster (*Homarus americanus*) caught (and released) in the water of the Aqueducts Beach of Caesarea, Israel, on December 30, 2022. Red arrows indicate orange-reddish spines on rostrum and cheliped. Inset: enlargement of the rostrum. The yellow arrow points to the tooth on the ventral side of the rostrum, typical to this species. Photo by Michael Tuval.

Caesarea), so perhaps this is the way by which they arrive to the Israeli coastal water. The only importer of American clawed lobsters to Israel (Avi Ben-Amitai, January 18, 2023, *personal communication*) reported that his company imported live lobsters from New England, North-Eastern USA, in weight of 600–640 grams each. This weight range corresponds with the carapace lengths of the lobsters observed in Caesarea (e.g., Wilder 1953; Hoenig et al. 2015). It is also like the sizes reported for the individuals of *H. americanus* fished in the northern Adriatic (Pavičić et al. 2020) and Northern Aegean (Kampouris et al. 2021) seas. It is postulated that these lobsters, which are expensive in Israel, were purchased and set free from a holding tank of a luxurious restaurant (restaurants in Caesarea occasionally serve *H. americanus*) or released from a cruise ship (see Spanier and Friedmann 2019). This had happened in northern Europe despite the strict regulations aimed specifically at preventing the introduction of this species into the Northeast Atlantic (e.g., Jørstad et al. 2007 and references there in). The deformed claws of one of the lobsters, possibly caused by banding during transport, may also indicate live food trade as a source of the lobsters. The gradual appearance of *H. americanus* in the Mediterranean from north-west to south-east ("1"– "3", Figure 1, inset) are not assumed to explain their appearances that could be associated only with accidental fishing/detections.

The water temperature at the site was estimated by the reported persons to be ~18–19 °C. The water temperature measured by the CTD of Hadera station (MedGloss # 80) of the Israeli Marine Data Center (https://isramar.ocean.org.il/isramar2009/), located about 5.5 km south of Caesarea, at 10–11 m depth, 2.2 kms offshore was between 21.4–21.7 °C on December 30–31,

2022. However, due to the shallow water depth at the detection site of the lobsters, the cool air temperatures, and the eastern wind during the detection times on December 30 and 31, 2022 (air temperatures: 17.6–18.8 °C, wind: 7.6–12.6 km/hour and air temperatures: 15.9–16.8 °C, wind: 22–31 km/hour for the two dates respectively in Hadera port according to the Israel Meteorological data base (https://ims.gov.il/he/data_gov)), it is reasonable to assume that the temperatures of the shallow water in Caesarea were lower than those recorded by the CTD.

These lobsters may or may not survive in the southeastern Mediterranean until the summer (if not injured by the force of the breaking waves in this shallow water, fished by humans or preyed upon by local predators). Yet as water temperatures start rising in late May–beginning of June to 24 °C or more and especially in July–September when water temperatures may reach over 29 °C (Ozer et al. 2022), with even higher values in shallow water, they will not be able to survive let alone mate and brood eggs. Theoretically they can move under the thermocline that develops in the summer, but this may be too deep (~ 50–60 m) (e.g., Idan et al. 2020) and far offshore for them to travel.

The literature suggests that physiological limits for benthic American clawed lobster are > 20 °C (Jury and Watson 2013; Wahle et al. 2015; Haar et al. 2020). Lethal limits may be under 30 °C and high water temperatures may negatively affect fecundity, reproduction, and growth (Waddy and Aiken 1995; Tlusty et al. 2008; Koopman et al. 2015).

Discussing the initial records of *H. americanus* in the northern Mediterranean coasts, Pavičić et al. (2020) and Kampouris et al. (2021) referred to possible ecological risks involved if these were persistent introductions, and not just isolated incidents. In this case they suggested that *H. americanus* might negatively impact Mediterranean biodiversity and affect ecosystem services. It might compete with its indigenous congener, *H. gammarus,* and other native lobsters that are important for the local fisheries. Multiple releases of *H. americanus* in the UK put them at a potential competitive advantage over and hybridization with the native *H. gammarus*, a valuable seafood in the UK (Stebbing et al. 2012; Barrett et al. 2020). This risk does not exist in the extreme eastern part of the Mediterranean, east of Crete, since this region is out of the distribution range of *H. gammarus* (Holthuis 1991). It is, however, recommended requiring that live markets/ importers of *H. americanus* etch a code on the carapace or claws of the imported lobsters to allow tracing the origin of these animals if they are released or escape to the Mediterranean.

Acknowledgements

Thanks are due to the Sport fisherman, Yaron Koren, the tourist guide, Michael Tuval, and Olga Zlatkin for providing information and photographic material on the American clawed lobsters in Israel. Drs. Jason Goldstein, Ben Gutzler, Kari Lavalli, Rick Wahle, and Dor Edelist are acknowledged for their useful information and suggestions. Prof. Dov Zviely and Eran Spanier are appreciated for their help in preparing the illustrations. Thanks are due also to the anonymous reviewers of this article and the editor for their useful comments and advices.

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