

## Rapid Communication

## First record of the non-native sea snail *Haminoea cyanomarginata* Heller & Thompson, 1983 (Gastropoda: Haminoeidae) in the Southern Mediterranean Sea

Jamila Rizgalla<sup>1,\*</sup>, Sophie Fridman<sup>2</sup>, Abdallah Ben Abdallah<sup>3</sup>, James E. Bron<sup>2</sup> and Andrew P. Shinn<sup>2,4</sup>

<sup>1</sup>Aquaculture Department, University of Tripoli, Tripoli, Libya

<sup>2</sup>Institute of Aquaculture, University of Stirling, UK

<sup>3</sup>Zoology Department, University of Tripoli, Tripoli, Libya

<sup>4</sup>Fish Vet Group Asia Limited, Saensook, Chonburi, 20130, Thailand

Author e-mails: [jamilarizgalla@gmail.com](mailto:jamilarizgalla@gmail.com) (JR), [sophie.fridman@stir.ac.uk](mailto:sophie.fridman@stir.ac.uk) (SF), [abdallalibfish@yahoo.com](mailto:abdallalibfish@yahoo.com) (ABA), [jeb1@stir.ac.uk](mailto:jeb1@stir.ac.uk) (JB), [andy.shinn@fishvetgroup.com](mailto:andy.shinn@fishvetgroup.com) (AS)

\*Corresponding author

Received: 17 August 2018 / Accepted: 17 September 2018 / Published online: 16 October 2018

Handling editor: Fabio Crocetta

### Abstract

The present paper documents the further spread of the invasive, non-indigenous sea snail *Haminoea cyanomarginata* Heller & Thompson, 1983 in the Mediterranean Sea. Since its original description in the Red Sea, this sea slug has been subsequently reported since 2001 from various locations throughout the Central, Eastern, and Western Mediterranean Sea. This is the first record of *H. cyanomarginata* in Libyan waters and the whole Southern Mediterranean Sea.

**Key words:** Mollusca, invasive species, Libya, Lessepsian migration

### Introduction

The cephalaspidean mollusc *Haminoea cyanomarginata* Heller & Thompson, 1983 (Haminoeidae) was first described from a single specimen found in 1980 amongst coral rubble on Harvey Reef, in the Sudanese Red Sea (Heller and Thompson 1983). It has subsequently been reported from the Gulf of Aqaba (Lederman 2005; Rudman 2005), Saudi Arabia (GBIF 2017), and from Oman (Köhler 2018), with established viable populations recorded in the Central, Eastern, and Western Mediterranean *i.e.* in Greece in 2001 (Rudman 2003; Zenetos et al. 2005), in Turkey in 2002 (Rudman 2003; Çinar et al. 2011), in Malta in 2006 (Mifsud 2007), in Italy in 2007 (Crocetta and Vazzana 2009; Crocetta et al. 2009), in Cyprus (Crocetta and Andreou 2018) and the Adriatic Sea off the Croatian coast in 2016 (Pontes et al. 2012–2018) and in Spain in 2017 (Fernández-Vilert et al. 2018). It is generally considered to be an invasive Lessepsian species (Crocetta et al. 2009;

Fernández-Vilert et al. 2018). The most recent recording of specimens reported from the Balearic Island of Mallorca (Spain) in 2017 makes this the furthest Western Mediterranean record of this species to date (Fernández-Vilert et al. 2018).

*Haminoea cyanomarginata* is a small herbivorous mollusc with an unornamented bubble shell measuring 5.5–15 mm long, readily identified by its marked white and purple colouration (Heller and Thompson 1983; Zenetos et al. 2005; Crocetta and Vazzana 2009; Fernández-Vilert et al. 2018). With the exception of a report of the native *Haminoea hydatis* (Linnaeus, 1758), collected in 2004 from Regatta (Tripoli) (see Abushaala et al. 2014) and subsequently questioned by Crocetta et al. (2015), there is nothing published on the haminoeid mollusc fauna of Libya. This report therefore first provides a confirmed record of a haminoeid bubble snail to Libyan waters and increases the distribution range of this taxon to the whole Southern Mediterranean Sea.

## Material and methods

A series of shallow water dives using a snorkel were set out between 8<sup>th</sup> July and 11<sup>th</sup> August 2018 to investigate the biodiversity of sea slugs within a natural bay situated 10 km west of Tripoli Harbour (32°51'14.5"N; 13°03'16.7"E) (Figure 1A–B). The sandy and rocky bay, which is subject to tidal movement, is marked by two islands to the north, and the Libyan mainland to the south.

*Haminoea cyanomarginata* specimens (Figure 1C) were found at depths ranging 30–60 cm and were either photographed *in situ* using a Tough TG-4 Olympus underwater camera or were transferred to the laboratory for closer examination. Representative specimens were subsequently fixed in 10% neutral buffered formalin or in 85% ethanol for archiving and reference. Specimens were identified based on the original description of Heller and Thompson (1983).

## Results

A total of 44 individuals of *H. cyanomarginata* were collected from three different locations throughout the sampling period (Figure 1A–B). All specimens were found attached to rocks covered by algae, some of which were identified as belonging to the family Corallinaceae and to the genus *Cystoseira*. A single 7 mm long specimen (Figure 1C) was found attached to algae on a rock formation of island 1 on the eastern side of the bay (32°51'15.0"N; 13°03'17.2"E) (Figure 1B) while a second 5 mm long specimen was found attached to the southern wall of island 2 (32°51'13.9"N; 13°03'14.3"E). Most specimens, i.e. a total of 42 individuals, however, were found over 20 days along the west side of island 2 (32°51'13.5"N; 13°03'12.9"E), where specimens ranged from 3 to 12 mm in length. The sea snails were commonly encountered in small groups of two or three individuals and were seen to exhibit trailing behaviour – a behaviour associated with mating (Figure 1D, 1E).

On the 2<sup>nd</sup> August, an egg mass (photograph not shown) was found within algae near several specimens of *H. cyanomarginata*. Specimens transferred from their marine habitat to an aerated 20 litres aquarium were also observed displaying the same trailing behaviour within a few hours of their translocation (Figure 1E). Mating behaviour was also observed between captive held individuals (Figure 1F).

### Specimen description

The specimens had transparent unornamented shells, through which the soft-body appeared either whitish (Figure 1C) or greenish in colour (Figure 1D). Despite

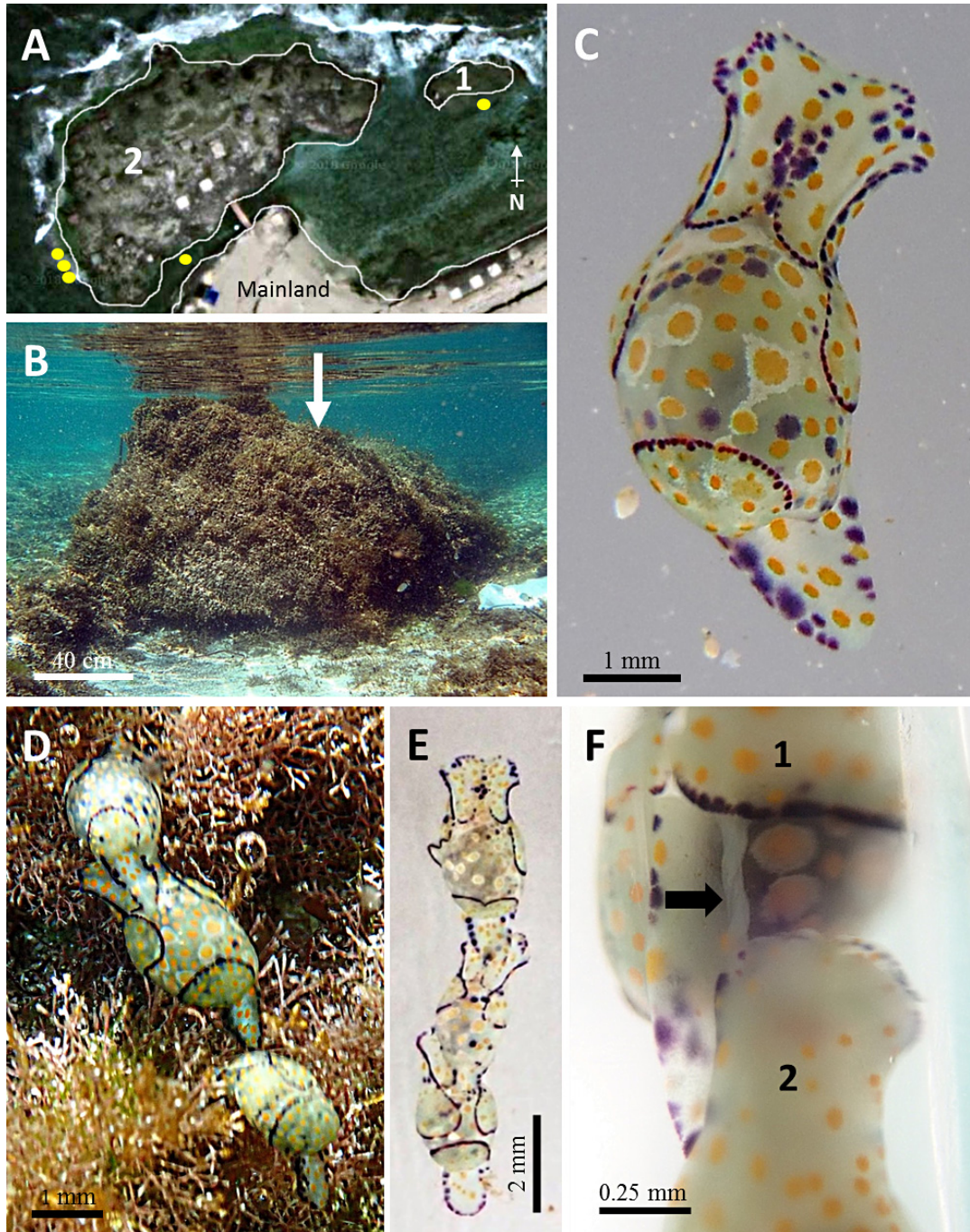
the background colour, all specimens had scattered yellow circular markings both dorsally and ventrally, with white and yellow patches of a fried egg appearance that were located on the dorsal and ventral side of the body. These markings sometimes fused forming an elongated band. Spots of dark blue to purple could often be seen between the yellow and white patches. Coloured spots of purple grading through to dark blue also are seen to line the edges of the mantle, parapodia, head shield, and infrapallial lobe, which could be either a continuous or discontinuous line.

The black eyes of *H. cyanomarginata* were separated by dark blue to purple blue markings. Only a few specimens (i.e. 3 out of the 44 specimens examined) had eye spots surrounded by dark blue markings, while only a single specimen had two yellow circular markings in addition to the dark blue spots between its two eyes.

## Discussion

Although the exact status of *H. cyanomarginata* as either an indigenous or non-indigenous species to the Mediterranean Sea has not yet been clarified (Rudman 2003; Fernández-Vilert et al. 2018), the suggestion of its entry into the Mediterranean via the Suez Canal as a Lessepsian species is postulated, and is supported in part, by its fairly recent records from Greece, Turkey, Malta, Italy, Cyprus, and Spain, more than 20 years after its original description from the Red Sea. Regardless of its origin, almost seventeen years after its first description in the Eastern Mediterranean Sea, it appears that viable populations of *H. cyanomarginata* have established in locations extending from the east to west of the Mediterranean (Rudman 2003; Mifsud 2007; Crocetta and Vazzana 2009; Çinar et al. 2011; Zenetos et al. 2017; Fernández-Vilert et al. 2018). This is supported by observations of large numbers of individuals in single locations at any given time (Crocetta and Vazzana 2009; Pontes et al. 2012–2018), some of which exceed 150 specimens (Crocetta et al. 2009). The observation of trailing behaviour of individuals and the presence of egg masses (Crocetta and Vazzana 2009) further supports the existence of self-sustained breeding populations in the Mediterranean.

In the present study, a total of 44 specimens were found at three locations in the coastal waters of Libya throughout the period mid-July to mid-August 2018. Specimens observed in the wild and subsequently transferred to the lab exhibited trailing behaviour within a few hours of their collection. Copulation events were also seen where the animal to the rear inserted its penis forward and beneath the parapodium of the animal in front (Figure 1F).



**Figure 1.** *Haminoea cyanomarginata* Heller and Thompson, 1983 collected from the coastal waters close to Tripoli, Libya. (A) Geographical location (satellite image captured from Google Maps (2018)) of the snorkeling sites and positive sightings (yellow dots) of *H. cyanomarginata* referred to in this study. The “Regatta” natural bay is located approximately 10 km west of Tripoli Harbour, Libya showing the position of two islands and the Libyan mainland (all depicted by a solid white outline). (B) Underwater image of the algae-covered rock formations from which one specimen of *H. cyanomarginata* was collected (white arrow). (C) Dorsal view of a 7 mm long specimen exhibiting an off-white colour to its soft body parts marked with yellow and yellow-on-white blotches with marked purple blue spots and conspicuous dark purple markings along body margins. (D) Underwater image showing three specimens of *H. cyanomarginata* on an algae covered substrate exhibiting trailing behaviour. (E) *Haminoea cyanomarginata* in the laboratory exhibiting trailing behaviour. (F) Ventral view showing the trailing and mating behaviour of two *H. cyanomarginata* in the laboratory, one hour after capture. The penis (black arrow) of specimen (2) can be seen inserting beneath the parapodium of specimen (1). Images B–F original taken by J. Rizzgalla.

Unlike previous reports from the Mediterranean Sea where specimens were found at depths ranging between 3–30 m (Rudman 2003; Crocetta and Vazzana 2009; Fernández-Vilert et al. 2018), in the current study all specimens were found during the day (9:30–17:00) attached to algae at depths ranging from 30–60 cm.

The colour and pattern of specimens of *H. cyanomarginata* described from the Mediterranean (see Rudman 2003; Crocetta and Vazzana 2009; Fernández-Vilert et al. 2018), from the Red Sea (see Lederman 2005; Rudman 2005), and from Oman (see Köhler 2018) appear to vary. Spots on the body may be yellow and/or orange and may be with or without yellow and white blotches. Regardless, all described specimens bear conspicuous purple to dark blue margins on their mantle, parapodia, head shield, and infrapallial lobe which distinguishes this species from other *Haminoea* species within the genus. Although differing from the typically described continuous line (Heller and Thompson 1983), the margins are delineated by either a continuous or a discontinuous line.

Further investigations, including molecular sequencing, are now needed to examine the population structure of *H. cyanomarginata* within the Mediterranean and further afield to rule out the potential existence of cryptic species and/or sub-species.

## Acknowledgements

The authors wish to thank the anonymous reviewers who provided insightful comments that improved the quality of this manuscript.

## References

- Abushaala NM, Shaibi T, Howaeghe HM (2014) Molluscan fauna of hard substrate along coastal zone of western Libya. *International Journal of Bioassays* 3(9): 3211–3217
- Çinar ME, Bilecenoglu M, Öztürk B, Katağan T, Yokeş MB (2011) An updated review of alien species on the coasts of Turkey. *Mediterranean Marine Science* 12: 257–315, <https://doi.org/10.12681/mms.34>
- Crocetta F, Andreou V (2018) The alien mollusc *Haminoea cyanomarginata* Heller & Thompson, 1983 in Cyprus. In: New Mediterranean Biodiversity Records (December 2018). *Mediterranean Marine Science* (in press)
- Crocetta F, Poursanidis D, Tringali LP (2015) Biodiversity of sea slugs and shelled relatives (Mollusca: Gastropoda) of the Cretan Archipelago (Greece), with taxonomic remarks on selected species. *Quaternary International* 390: 56–68, <https://doi.org/10.1016/j.quaint.2015.02.061>
- Crocetta F, Vazzana A (2009) First record of *Haminoea cyanomarginata* (Gastropoda: Haminoeidae) in the Italian seas. *Marine Biodiversity Records* 2: e11, <https://doi.org/10.1017/S1755267208000110>
- Crocetta F, Renda W, Vazzana A (2009) Alien Mollusca along the Calabrian shores of the Messina Strait area and a review of their distribution in the Italian seas. *Bollettino Malacologico* 45(1): 15–30
- Fernández-Vilert R, Giménez J, Mas G, Figueroa I, Moles J (2018) First records of the Red Sea alien mollusc *Haminoea cyanomarginata* (Gastropoda: Heterobranchia: Cephalaspidea) in the Western Mediterranean. *Journal of Natural History* 52: 1817–1823, <https://doi.org/10.1080/00222933.2018.1497212>
- GBIF (2017) GBIF backbone taxonomy checklist dataset. <https://www.gbif.org/species/4359391> (accessed 13 August 2018)
- Google Maps (2018) <https://www.google.com/maps> (accessed 12 August 2018)
- Heller J, Thompson TE (1983) Opisthobranch molluscs of the Sudanese Red Sea. *Zoological Journal of the Linnean Society* 78: 317–348, <https://doi.org/10.1111/j.1096-3642.1975.tb02263.x>
- Köhler E (2018) Medslugs – *Haminoea cyanomarginata* Heller & Thompson, 1983. [http://www.medslugs.de/E/IndNW/Haminoea\\_cyanomarginata/Haminoea\\_cyanomarginata\\_10.htm](http://www.medslugs.de/E/IndNW/Haminoea_cyanomarginata/Haminoea_cyanomarginata_10.htm) (accessed 12 August 2018)
- Lederman O (2005) Another *Haminoea cyanomarginata* from the Red Sea. Sea Slug Forum. Australian Museum, Sydney. <http://www.seaslugforum.net/find/13331> (accessed 14 August 2018)
- Mifsud C (2007) *Haminoea cyanomarginata* Heller & Thompson, 1983 (Gastropoda: Haminoeidae), a new invader for the Maltese Islands. *Novapex* 8(1): 29–30
- Pontes M, Ballesteros M, Madrenas E (2012–2018) *Haminoea cyanomarginata*. *OPK Opisthobranchis*. <https://opisthobranchis.info/en/mSGvp> (accessed 25 January 2018)
- Rudman WB (2003) *Haminoea cyanomarginata* Heller & Thompson, 1983. Sea Slug Forum. Australian Museum, Sydney. <http://www.seaslugforum.net/showall/hamicyan> (accessed 12 August 2018)
- Rudman WB (2005) Comment on another *Haminoea cyanomarginata* from the Red Sea by Oren Lederman. *Sea Slug Forum*. Australian Museum, Sydney. <http://www.seaslugforum.net/find/13331> (accessed 12 August 2018)
- Zenetos A, Çinar ME, Crocetta F, Golani D, Rosso A, Servello G, Shenkar N, Turon X, Verlaque M (2017) Uncertainties and validation of alien species catalogues: the Mediterranean as an example. *Estuarine, Coastal and Shelf Science* 191: 171–187, <https://doi.org/10.1016/j.ecss.2017.03.031>
- Zenetos A, Koutsoubas D, Vardala-Theodorou E (2005) Origin and vectors of introduction of exotic molluscs in Greek waters. *Belgian Journal of Zoology* 135(2): 279–286