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DISTRIBUTION, ABUNDANCE AND AGE COHORTS OF *PHORCUS TURBINATUS* (GASTROPODA) IN EASTERN LIBYA'S MEDITERRANEAN SEA

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ABSTRACT: *Distribution of Phorcus turbinatus along the littoral zones of Al-Haneah and Susah, eastern Libya's Mediterranean Sea, at day, at low tide, was studied using belt transects with quadrates. P. turbinatus in both sites inhabited only the lower rocky littoral, many times in aggregates in tidal pools. P. turbinatus was absent in the mid and the upper rocky littoral, all the sandy shores, and the sublittoral. The abundance was maximum just above the shoreline (209 and 207 individuals/m2 in both sites), and decreased on moving up the littoral. Factors controlling the distribution were discussed. P. turbinatus showed no size gradient on moving upwards from the shoreline to the upper littoral. Frequency distribution of "height of shell from base to the apex" (HBA) indicated that P. turbinatus populations of both study sites exist in three age cohorts. Mean HBA of cohort 1 and 2 in Al-Haneah was 7 and 15mm, mean HBA of cohort 3 could not be determined; in Susah, HBA of cohorts 1 and 2 were 6 and 11.8mm.*

KEYWORDS: *Phorcus turbinatus*, *Monodonta turbinata*, distribution, abundance, age cohort.

INTRODUCTION

Marine snails and limpets (Gastropoda: Prosobranchia) are top shells that inhabit rocky littoral zones. Currently, rocky shores along wide stretches of the planet are subjected to heavy pressure from coastal anthropogenic activities. Gastropod snails of the genus Phorcus inhabit Central and East Indian Ocean, Indo-China, Indo-Malaysian Oceania, the Philippines, Japan, Australia (Germain, 1931; Crothers, 2001), where they play important roles in controlling abundance and distribution of many co-inhabiting animals through grazing micro-algae, the direct or indirect food base for most rocky littoral animals (Boucetta *et al*., 2016; Paulo *et al*., 2017). In the Libyan coast, marine gastropods of the rocky littoral are represented primarily by the trochids patella and members of the genus Phorcus with a dominance of the *Phorcus turbinatus*, a small gastropod found in the lower littoral of rocky shores. Littoral animals are adapted to a wide range of natural environmental conditions such as repeated exposure and inundation following low and high tides. These conditions can cause overheating/freezing of littoral organisms, extreme salinities, desiccation, etc.

The objective of this study is to establish distribution and abundance of *P. turbinatus* at day, at low tide, and the age cohort of the populations in Al-Haneah and Susah (eastern Libya) rocky and sandy littorals.

MATERIALS AND METHODS

The study sites

a- Al-Haneah

Al-Haneah, Fig. 1a, is a typical artisanal fishery landing site located on the eastern coast of Libya (Eisay, 2020). The littoral zone consists of sandy tongues alternating with rough, wind-exposed, rocky terrain with abundance of tidal pools that provide refuge for many marine animals during low tides.

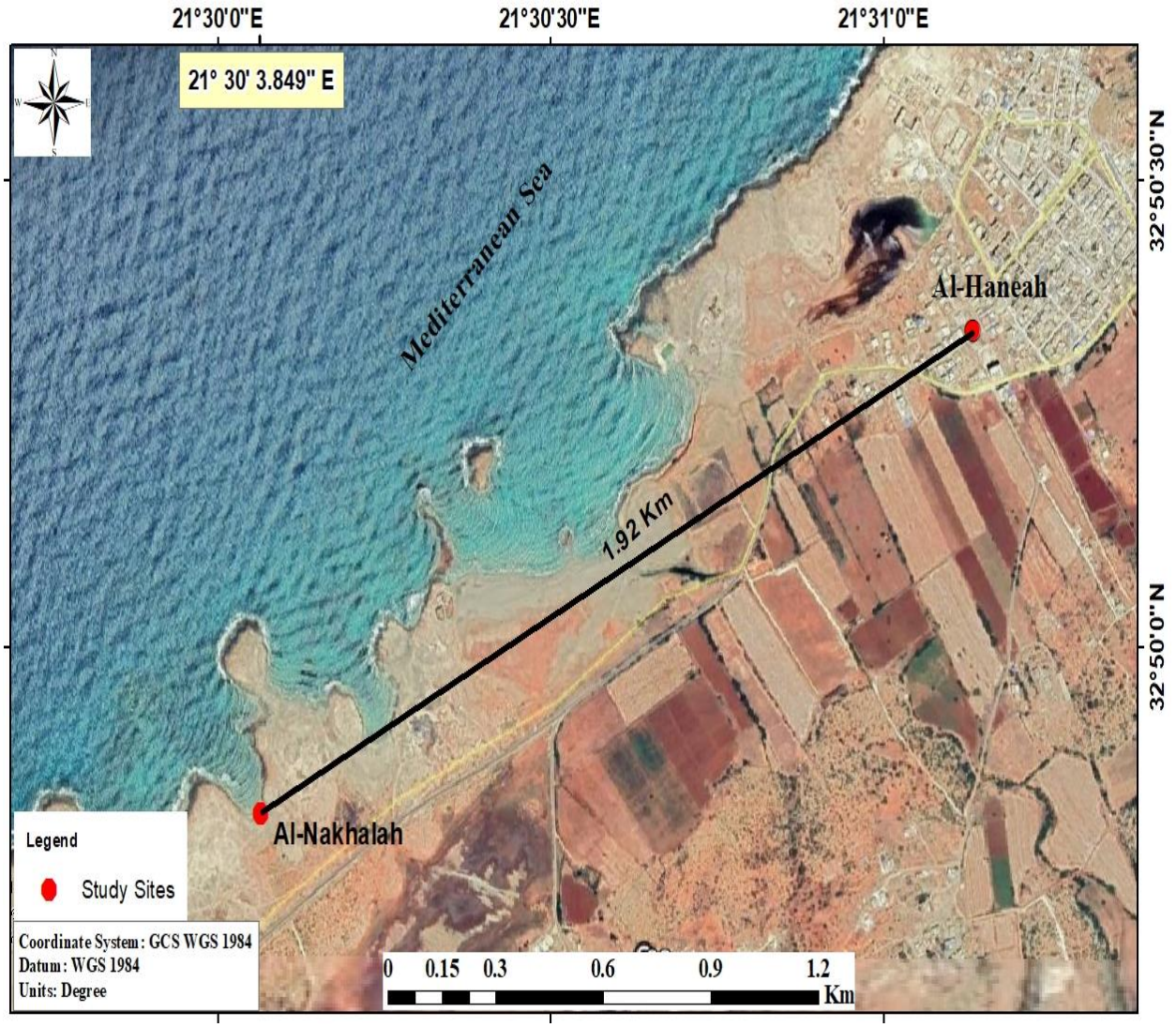


Fig. 1a. Al-Haneah

b- Susah

Susah is a small commercial and fishing port (Eisay, 2020) characterized by beautiful beaches and abundance of preserved Greek and Romanian remains (Fig. 2b).

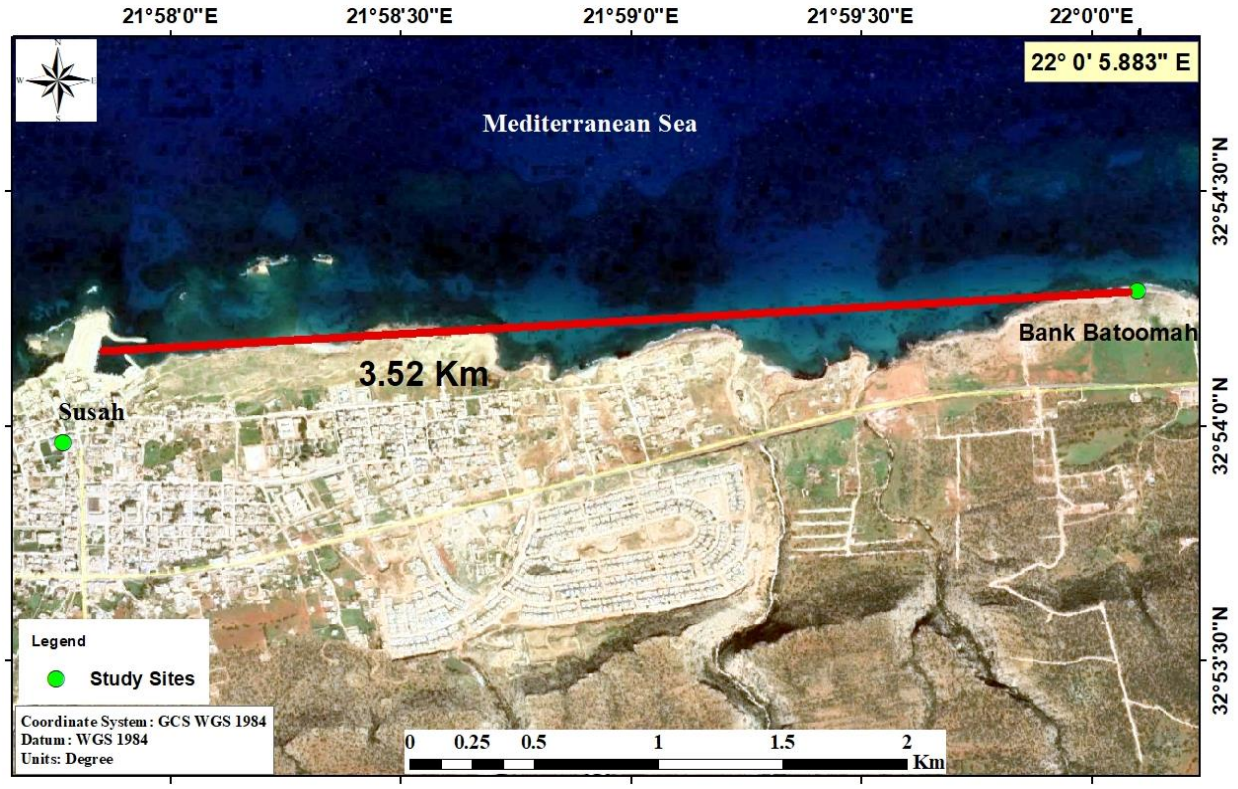


Fig. 1b. Susah

Characterization of the littoral zone and collection of *P. turbinatus* samples

Several visits were made to the rocky and sandy littorals of Al-Haneah and Susah at day, at low tide, Eastern Libya Mediterranean Sea, during December 2020, where:

- Main features of the rocky and sandy littoral were observed and recorded.
- The distribution of *P. turbinatus* within the rocky and sandy littorals at low tide, at day, was established using belt transects with quadrates.
- *P turbinatus* samples were collected from Al-Haneah and Susah for aging the gastropod.

Distribution of *Phorcus turbinatus* in Al-Haneah and Susah

Distribution of *P. turbinatus* at day, at low tide, was established using 1x1m quadrate belt transects (Figs. 2 and 3). Twenty transects set vertical to the shoreline, 10m apart, and covering a distance of 200m along the shoreline were set out on the rocky shore of Al-Haneah, a similar set of transects was used in the sandy shore. Distribution of *P. turbinatus* in Susah rocky and sandy shores was studied in the same manner. The transects covered the shallow sublittoral to the depth of 3m and the entire littoral above the water mark. *P. turbinatus* present in each quadrate were counted, and the shell height from base to apex (HBA) of each individual was measured.

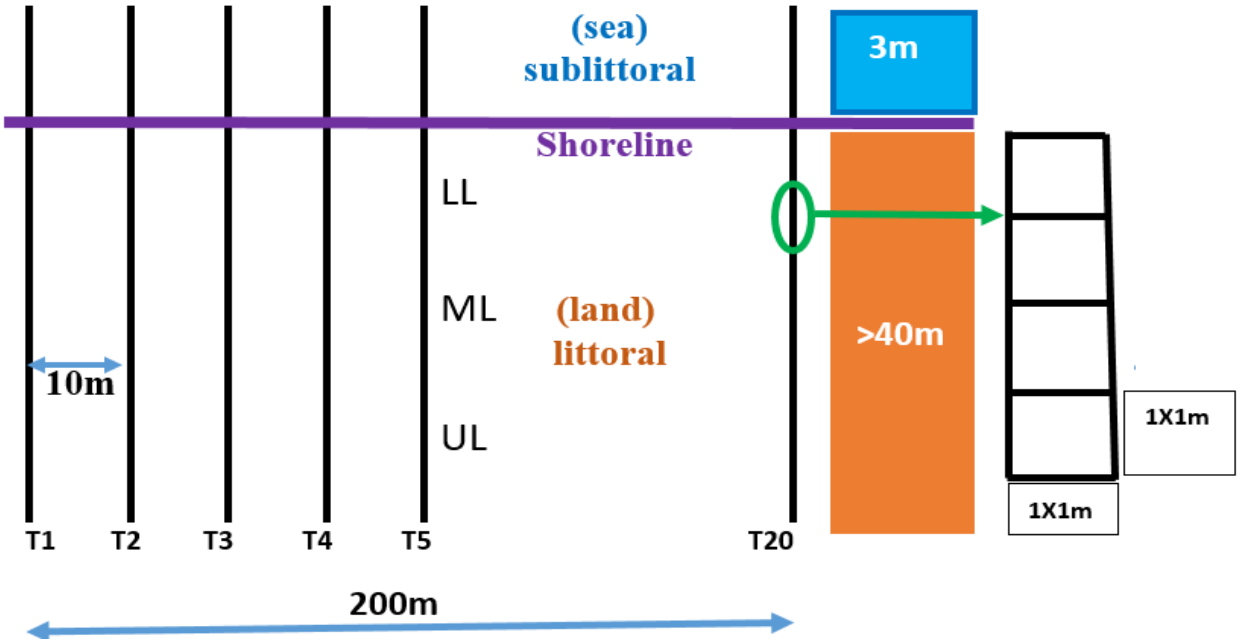


Fig. 2. The layout of the 20 belt transects (T1 – T20) set out in the present study. A segment of a transect consisting of 4 consecutive quadrates (1X1m each) is shown at right. LL: lower littoral; ML: mid littoral; UL: upper littoral.

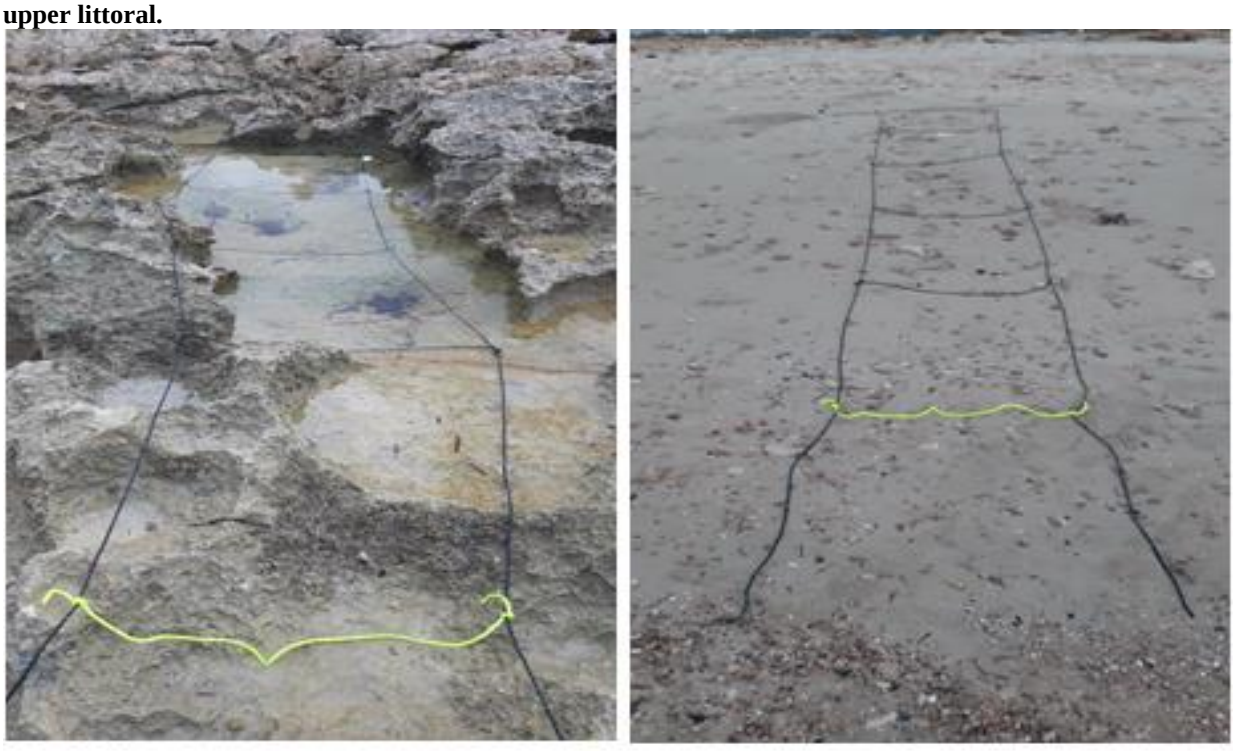


Fig. 3. Setting part of a transect on rocky (left) and sandy (right) littorals.

Aging of *Phorcus turbinatus* in Al-Haneah and Susah

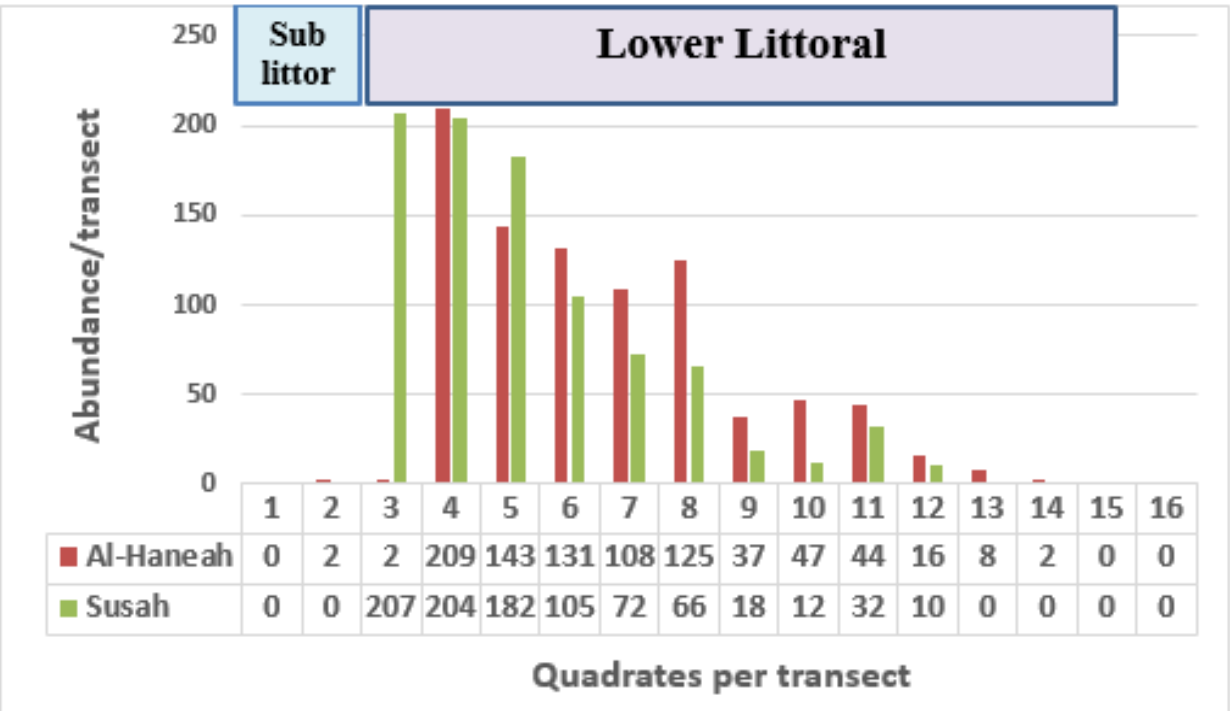
Eight hundred seventy-two and 908 *P. turbinatus* collected from Al-Haneah, and Susah consecutively were used for aging the gastropod according to HBA frequency distribution as described by Sparre and Veneama (1998).

RESULTS

Distribution and abundance of *P. turbinatus* within the littoral zone

Occurrence of *P. turbinatus* in Al-Haneah and Susah at day, at low tide, was limited to the lower rocky littoral. *P. turbinatus* was absent in the mid and the upper rocky littorals, the sub-littoral, and the entire sandy littoral. Within the lower rocky littoral, abundance was maximum just above the shoreline (209 and 207 *P. turbinatus*/m^2, quadrates 4 and 2 for both sites in Fig. 4) and decreased on moving away from the shoreline in the direction of land. *P. turbinatus* was completely absent from 12 and 10m above the shoreline and onwards in both sites (quadrates 14 and 12 for both sites in Fig. 4). This region (12 and 10m) coincides with the upper limit of the lower littoral. Within the lower littoral, *P. turbinatus* was found within tidal pools, usually in aggregates, and outside the pools on the rocky terrain (Fig. 5 and 6). Occasionally, morbid and dead *P. turbinatus* were encountered in dry pools at the upper limit of the lower littoral (Fig. 7). It seems that *P. turbinatus* had aggregated in these pools when they were full with seawater, but latter, they had dried out because high tide did not reach and furnish them with water for appreciable time. Mean abundance of *P. turbinatus* in the whole lower littoral was 72.7 and 90.8 shells per m^2 in Al-Haneah and Susah in order.

No gradient in size (mean HBA per quadrate) of *P. turbinatus* was observed on moving away from the shore in the direction of land (Fig. 8).



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Al-Haneah	0	2	2	209	143	131	108	125	37	47	44	16	8	2	0	0
Susah	0	0	207	204	182	105	72	66	18	12	32	10	0	0	0	0

Fig. 4. Abundance of *Phorcus turbinatus* at low tide as number of shells per quadrate (means of corresponding quadrates of all transects) in Al-Haneah and Susah.

Fig. 5. An aggregate of *Phorcus turbinatus* inside a water-full intertidal pool at low tide.

Fig. 6. *Phorcus turbinatus* on the terrain outside intertidal pools.

Fig. 7. Morbid and dead *Phorcus turbinatus* in a dry intertidal pool at the upper limit of the lower littoral.

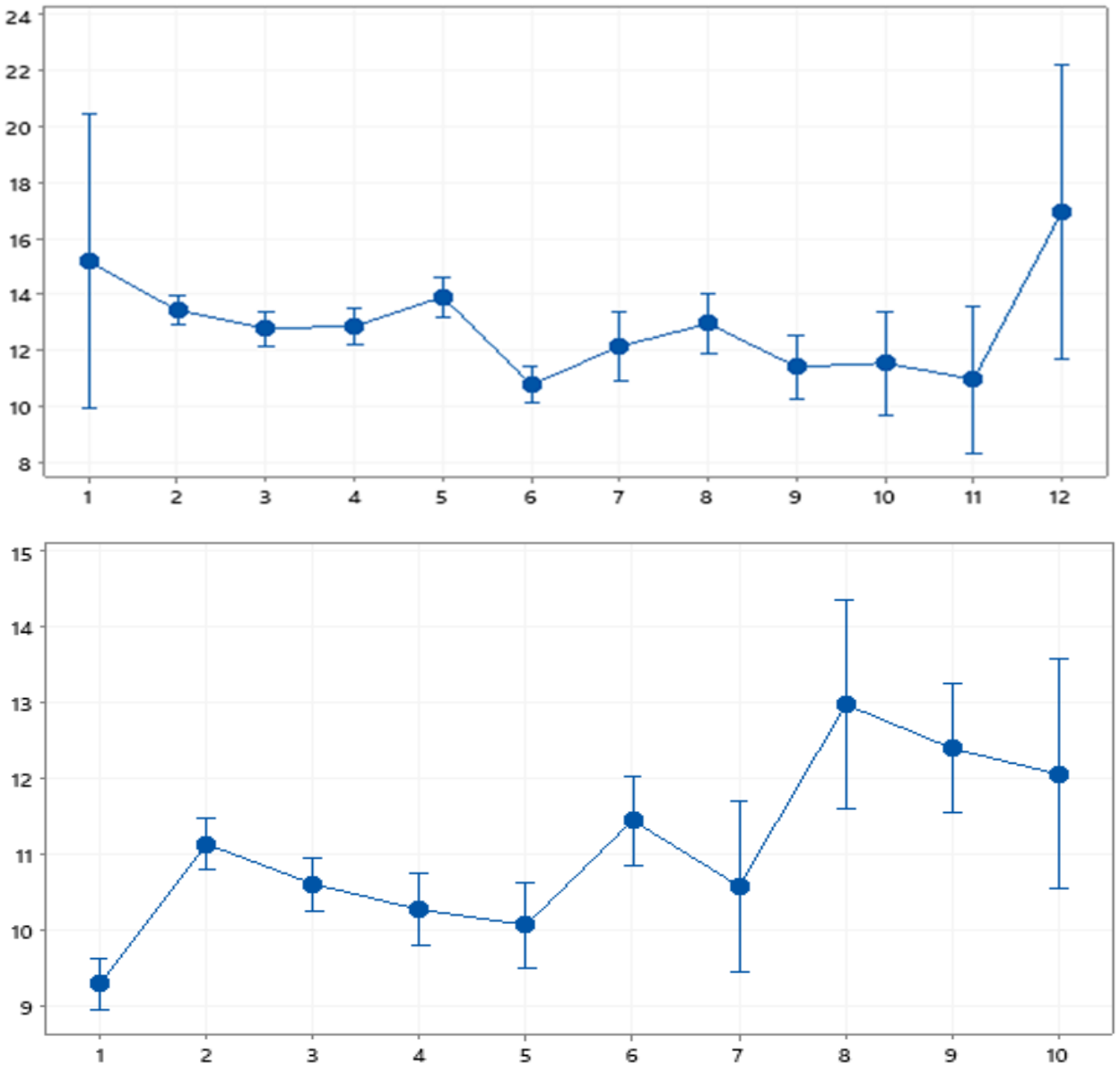


Fig. 8. Mean HBA in mm (on the y-axis) per quadrate (quadrate no. is on the x-axis) of Al-Haneah (top curve) and Susah (bottom curve) *Phorcus turbinatus.* The bars are St D**.**

Aging *Phorcus turbinatus* of Al-Haneah and Susah

Age cohorts, and corresponding HBA, of *Phorcus turbinatus* (Fig. 14) were as follows:

Al-Haneah:

- Cohort 1, HBA = 7mm
- Cohort 2, HBA = 15mm
- Cohort 3, (HBA could not be estimated)

Susah:

- Cohort 1, HBA = 6mm
- Cohort 2, HBA = 11.8mm
- Cohort 3, (HBA could not be estimated)

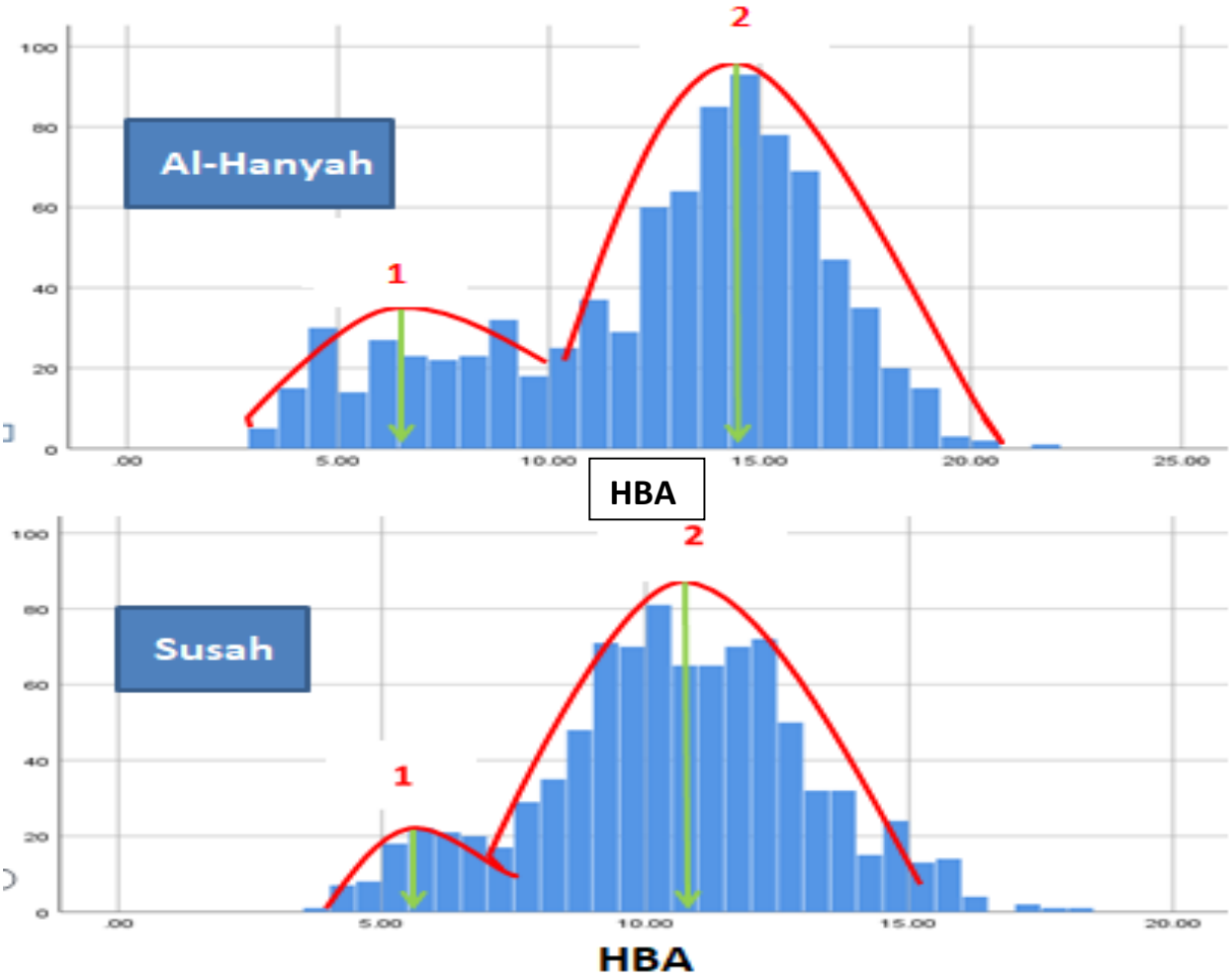


Fig. 9. Age cohorts, and corresponding HBA, (on the x-axis) of *Phorcus turbinatus* in Al-Haneah and Susah based on HBA frequency (on the y-axis).

DISCUSSION

The present study concludes that *P. turbinatus* avoids overheating/overcooling, extreme salinities, desiccation, and starvation at low tide by staying within the lower rocky littoral, preferentially close to the shoreline (209 and 207 individuals/m^2 in both sites), on the terrain or in tidal pools, where the splash created by waves breaking on the rocky shore keeps them constantly wet even when rising tide didn't inundate them for several days; hence, the lower rocky littoral, especially its near shore section, was always well covered with encrusting "food" micro-algae. The almost complete absence of *P. turbinatus* in the shallow sublittoral is due to dislodging by waves of individuals that venture

there. *P. turbinatus* is completely absent from sandy shores as they cannot attach themselves to sand, or find food micro-algae in it. *P. turbinatus* that wonders beyond the upper limit of the lower rocky littoral may desiccate and die if the rising tide didn't reach them at the right time. Lavie and Nevo (1982) studied the genetic structure and diversity of several populations of *M. turbiformis* and *Phorcus turbinatus*. They found that *P. turbinatus* present along the Israeli Mediterranean shore was found principally in the lower mid-littoral zone. Pérès and Picard (1964) and Boucetta *et al.* (2008) considered *P. turbinatus* as typical of the lower mid-littoral. The aggregation of *P. turbinatus*, co-existing in tidal pools, frequently observed in the present study, cannot be described as gregarious behavior as not all individuals participated in it, this aggregation cannot be explained on bases of the available data. Aggregation of aquatic organism is generally described as breeding or feeding behavior, protective or anti-predatory mechanism, or territorial behavior, which in our case, may be achieved by the aggregating *P. turbinatus* mutually secrete a repellant chemical in the water that deter other animals from seeking refuge in the same tidal pool from approaching them. Ali *et al.* (2017) mentioned that the many bioactive compounds of potential medical importance isolated from gastropods possibly have a role in chemical defense against predators.

P. turbinatus population in Al-Haneah and Susah existed in 3 age cohorts: cohort 1 and 2 shell heights (HBA) were 7 and 15mm for Al-Haneah gastropods, and 6 to 11mm for Susah gastropods; an additional 3rd cohort which contained a small fraction of the population was present but its peak HBA cannot be determined because of insufficient sample size. Previous studies have established that longevity of *P. turbinatus* ranged between 3 to 10 years (Crothers, 2001; Prendergast *et al*., 2013 and 2016). Boucetta (2017) found that *P. turbinatus* in Algeria Mediterranean Sea existed in six cohorts, shell heights of the control station gastropods were: 5.1, 14.9, 18.43 and 22.02mm for 1, 2, 3, and 4 years old females. The values for the males were: 5, 14.36, 18.67 and 20.43mm. These shell height values were close to the ones obtained in the present study.

Implication to research and practice

The present study calls attention to the way that habitat traits, such as nature of terrain, shore topography and morphology, wave action and splash, tidal regime and the inundation/exposure arising from it, availability of food, and diurnal/nocturnal activity, govern abundance and distribution of littoral biota. Global climate change can alter these parameters at a rate that littoral animals cannot adapt genetically to it. The rise of sea level by few centimeters could be devastating for the low littoral communities of the study sites, where the terrain rises only few centimeters above sea level. The Mediterranean, being a semi closed sea, is known for its small tidal range because of its limited connection with the Atlantic Ocean.

CONCLUSIONS

P. turbinatus inhabits lower littorals of rocky shores. It was completely absent from sandy shores because it cannot attach itself to soft substrata. The gastropod was absent from the sub-littoral because waves will dislodge it. Within the lower rocky littoral, *P. turbinatus* was mostly abundant just above the shoreline because tidal range and water splash keep this area wet and conducive for micro-algae growth, abundance decreased on moving away from the shoreline in the direction of land because wetness, and hence, algal cover decrease in this direction. *P. turbinatus* that wonders above the upper limit of the lower littoral will eventually die from desiccation because high tide may not extend to them in many days.

Three age cohorts constituted *P. turbinatus* population in the rocky shores.

Future Research

There is a need to study distribution of *Phorcus turbinatus* at night at low tide, and at day and night at high tide. The methodologies should pay attention to the fact that rocky littoral terrain is very rough, slippery and difficult to walk on especially at night and high tide, and that it is not yet known whether *P. turbinatus* hides below rocks and within pools, or forage actively when it is awash; it also yet to be confirmed that *P. turbinatus* forage mostly at night as was shown for some top shells.

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