*Article*

# Gastropod shell species utilized by hermit crabs (Decapoda: Anomura) along the Turkish coast of the Levantine Sea

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**Abstract**

The present study aimed to describe the gastropod shell species utilized by hermit crabs (Decapoda: Anomura) collected during investigations of the decapod fauna of the Levantine Sea coast of Turkey. Specimens were collected from July 2005 to October 2005. A total of 715 individuals belonging to 9 hermit crab species occupying 47 gastropod shell species were collected. The hermit crabs, *Diogenes pugilator* (Roux, 1829) and *Cestopagurus timidus* (Roux, 1830) had the highest inhabitation frequency (IF), inhabiting 23.92% and 23.78% of all the samples collected respectively. The nine hermit crab species captured utilizing shells from forty-seven gastropods species. *Cerithium scabridum* Philippi, 1849 (100%) was the most commonly utilized shell by all hermit crabs.

**Keywords** shell utilization; Anomura; Decapoda; Gastropod; hermit crabs; Levantine Sea; Turkey.

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## 1 Introduction

Empty mollusc shells are often inhabited by the anomuran decapod crustaceans. Hermit crabs generally utilize gastropod shells because their abdominal exoskelton lacks calcification, and as such, gastropod shells are an indispensable resource for hermit crabs (Hasegawa et al., 2009). Shells of gastropods provide protection against predators (Vance, 1972; Hazlett, 1990) and physical stress (Reese, 1969). The life cycle of hermit crabs depends mostly on the processes that make suitable gastropod shells (Hazlett, 1981).

Studies on the utilization of gastropod shells by hermit crabs have been conducted by many authors (Fotheringham, 1976; Koutsoubas et al., 1993; Manjón-Cabeza and García Raso, 1999; Martinelli and Mantelatto, 1999; Botelho and Costa, 2000; Mantelatto and Garcia, 2000; Ateş et al., 2007; Rodrigues and Rodrigo, 2009), but no such study is available on the shell utilization by hermit crabs along the Levantine Sea coast. There are 21 hermit crabs species reported from the Turkish coast (Özcan, 2007). The only study on the occupation of gastropoda shells by hermit crabs along the Turkish seas was carried out by Ateş et al. (2007).

The objective of the present study is to characterize the gastropod shell species utilized by hermit crabs along the Levantine Sea coast of Turkey and according to the references concerned the subject, it would be the first one document gastropod shells utilized by hermit crab along the Turkish Levantine coast.

## 2 Material and Methods

Hermit crab and Gastropod shell species were collected in the summer and fall of 2005 along the Turkish Levantine sea coast by scuba diving, free diving, beam-trawl, dredge and Van veen grab from depths ranging of 0.3 m to 75 m at 47 different stations (Fig. 1; Table 1). The sampling dates, stations number, coordinates, depths, salinity, temperature and dissolved oxygen values of stations are given in Table 1. The sampled materials were fixed in 5% formalin solution. In the laboratory, hermit crabs were taken out by carefully cracking each shell after measurement. Hermit crab and gastropod species were identified based on the works of Ingle (1993), Falciai and Minervini (1996), Gianuzzi-Savelli et al. (1994, 1996, 2003) and Öztürk et al. (2008). The systematic of hermit crabs was given according to the European Register of Marine Species nomenclature (Marine species, 2012), whereas the systematic of the gastropods species are given according to Clemam (2012).

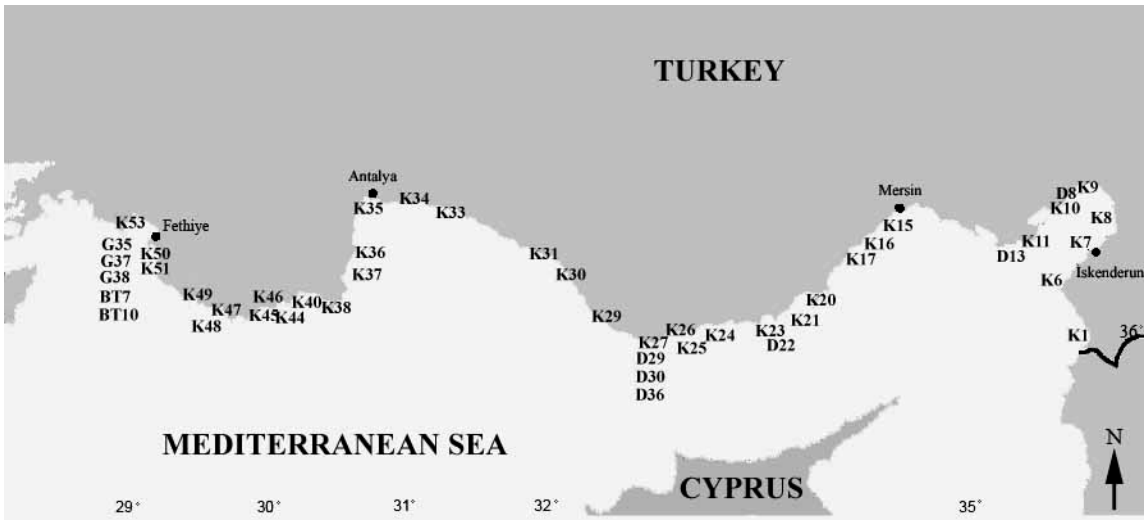


**Fig. 1** Map of study area and showing sampling stations.

Soyer's (1970) frequency index (f%) was used to determine the abundance of species at the stations, and in biotopes, and results were evaluated as constant (f≥50%), common (50%>f≥25%) and rare (f<25%). The frequency index of a particular species was estimated by $f$=m/M*100, where m= number of stations where the species was found and M= numbers of all stations.

Bellan-Santini's (1969) quantitative dominance index (DI%) was calculated. The dominance index of species was estimated by DI=m/M*100, where m= individual number of species in the stations and M= total individual numbers of all the identified species.

## 3 Results

A total of 715 specimens of nine different hermit crab species were collected. The nine hermit crab species [(*Calcinus tubularis* (Linnaeus, 1767), *Cestopagurus timidus* (Roux, 1830), *Clibanarius erythropus* (Latreille, 1818), *Diogenes pugilator* (Roux, 1829), *Paguristes syrtensis* De Saint Laurent, 1971, *Pagurus anachoretus*

Risso, 1827, *Pagurus cuanensis* Bell, 1845, *Pagurus excavatus* (Herbst, 1791) and *Pagurus* sp)] utilizing shells of forty-seven gastropod species are given in Table 2. The most commonly occupied was *Cerithium scabridum* Philippi, 1849 (30.35%).

**Table 1 S**tation ID, sampling date, position, salinity, temperature, dissolved oxygen values and depth of stations.

| St No | Date | Position | T (‰) | S (ºC) | $O_2$ (mg/l) | Seki (m) |
|---|---|---|---|---|---|---|
| K1 | 12.09.2005 | 36º00'36" N-35º58'34" E | 38,8 | 28,9 | 4,56 | 1,5 |
| K6 | 13.09.2005 | - | 39,2 | 28,5 | 4,75 | 1,5 |
| K7 | 13.09.2005 | 36º31'36" N-36º02'03" E | 39 | 31 | 5,2 | 1 |
| K8 | 14.09.2005 | 36º45'40" N-36º11'58" E | 38,8 | 28,2 | 4,14 | 1,5 |
| K9 | 14.09.2005 | 36º54'22" N-35º58'05" E | 39,2 | 30 | 4,68 | 1,5 |
| K10 | 15.09.2005 | 36º45'59" N-35º47'18" E | 39,1 | 29,1 | 6,55 | 1 |
| K11 | 15.09.2005 | 36º33'20" N-35º22'44" E | 38,4 | 29,2 | 5,36 | 0,5 |
| K15 | 18.09.2005 | - | 37,8 | 29,8 | 6,55 | 1 |
| K16 | 18.09.2005 | 36º33'27" N-34º14'49" E | 38,7 | 29,2 | 4,65 | 0,5 |
| K17 | 19.09.2005 | 36º28'42" N-34º10'21" E | 39,3 | 28,3 | 4,65 | 1 |
| K20 | 20.09.2005 | 36º17'24" N-33º50'10" E | 39,3 | 28,4 | 4,55 | 1 |
| K21 | 20.09.2005 | 36º11'31" N-33º38'28" E | 39,2 | 29,2 | 4,45 | 1 |
| K23 | 21.09.2005 | 36º09'35" N-33º27'33" E | 37,9 | 27,8 | 4,97 | 1 |
| K24 | 21.09.2005 | 36º09'11" N-33º20'33" E | 38,5 | 28,5 | 5,08 | 1 |
| K25 | 21.09.2005 | 36º08'22" N-33º09'43" E | 38,8 | 28,8 | 4,99 | 1 |
| K26 | 22.09.2005 | 36º05'05" N-32º54'03" E | 38,9 | 28,1 | 4,98 | 1,5 |
| K27 | 22.09.2005 | 36º01'17" N-32º48'14" E | 39,2 | 28 | 5,07 | 1,5 |
| K29 | 24.09.2005 | 36º06'03" N-32º33'37" E | 39,2 | 26,9 | 5,52 | 1 |
| K30 | 24.09.2005 | 36º19'16" N-32º14'07" E | 39,3 | 26,9 | 4,89 | 1 |
| K31 | 25.09.2005 | 36º25'59" N-32º08'52" E | 39,2 | 26 | 4,75 | 1,5 |
| K33 | 25.09.2005 | 36º48'50" N-31º18'47" E | 38,8 | 27,2 | 5,12 | 1 |
| K34 | 26.09.2005 | - | 37,2 | 27,4 | 5,08 | 1,5 |
| K35 | 28.09.2005 | 36º47'35" N-30º34'31" E | 38,7 | 26,5 | 4,91 | 1,5 |
| K36 | 28.09.2005 | 36º31'37" N-30º33'08" E | 39,4 | 26,5 | 4,91 | 1 |
| K37 | 29.09.2005 | 36º17'53" N-30º28'20" E | 39,1 | 25,4 | 5,3 | 1,5 |
| K38 | 29.09.2005 | 36º16'32" N-30º24'15" E | 39,1 | 26,9 | 5,27 | 1 |
| K40 | 01.10.2005 | 36º15'12" N-30º07'05" E | 38,3 | 26,6 | 4,68 | 1,5 |
| K44 | 03.10.2005 | 36º11'26" N-29º50'51" E | 37,7 | 24,7 | 5,65 | 1,5 |
| K45 | 03.10.2005 | 36º12'06" N-29º37'30" E | 37,3 | 24,8 | 5 | 1,5 |
| K46 | 03.10.2005 | 36º12'03" N-29º37'30" E | 39,1 | 25,4 | 5,78 | 1,5 |
| K47 | 04.10.2005 | 36º12'44" N-29º30'49" E | 38,9 | 24,8 | 5,65 | 1,5 |
| K48 | 04.10.2005 | 36º15'47" N-29º24'45" E | 33,8 | 24,1 | 5,62 | 1,5 |
| K49 | 04.10.2005 | 36º17'36" N-29º15'47" E | 34,6 | 23,2 | 5,5 | 0 |
| K50 | 05.10.2005 | 36º38'40" N-29º05'30" E | 35,6 | 24,3 | 4,43 | 1,5 |
| K51 | 05.10.2005 | 36º38'38" N-29º04'36" E | 39,1 | 25,7 | 5,95 | 1,5 |
| K53 | 07.10.2005 | 36º44'20" N-28º55'43" E | 38,8 | 25,2 | 5,52 | 1,5 |
| G35 | 06.10.2005 | 36º37'59" N-29º04'20" E | 39,3 | 20,6 | 6,91 | 21 |
| G37 | 06.10.2005 | 36º37'47" N-29º04'39" E | 39,1 | 24,7 | 5,87 | 16 |
| G38 | 06.10.2005 | 36º37'44" N-29º04'39" E | 38,7 | 25,3 | 5,18 | 10 |
| D8 | 09.09.2005 | 36º51'748 N-35º55'024 E | 39,1 | 28,6 | 5,12 | 4 |
| D13 | 10.09.2005 | 36º33'369 N-35º34'287 E | 39,3 | 28,6 | 4,13 | 1,5 |
| D22 | 10.09.2005 | 36º20'954 N-35º48'718 E | 38,9 | 28,5 | 4,59 | 7 |
| D29 | 23.09.2005 | 36º02'59" N-32º53'49" E | 39,2 | 27,3 | 5,33 | 38 |
| D30 | 23.09.2005 | 36º02'37" N-32º54'06" E | 39,4 | 27,1 | 5,36 | 37 |
| D36 | 23.09.2005 | 36º02'55" N-32º53'43" E | - | - | - | - |
| BT7 | 06.10.2005 | 36º37'44" N-29º04'39" E | - | - | - | - |
| B10 | 06.10.2005 | 36º38'47" N-29º04'34" E | - | - | - | - |

The shells of gastropod species occupied by hermit crabs are given in Fig. 2. The specimens of gastropod families such as Trochidae, Phasianellidae, Cerithiidae, Riissoidae, Vermetidae, Strombidae, Muricidae, Nassariidae, Columbelidae were mostly utilized by hermit crabs. Frequencies (Fr) of gastropod shells occupied by hermit crabs are shown in Fig. 3. According to Soyer's Frequency (f) categorizations, 7 species (14.89%) were classified as continuous, 13 (25.53%) as common and 27 (59.57%) as rare (Table 2). *C. scabridum*

(100%) was the most commonly utilized shell by all hermit crabs and that *E. junionae* and *S. persicus* (Fr= 88.89%) by eight of the nine hermit crabs collected and *Gibbula divaricata* (Linnaeus, 1758) and *Pisania striata* (Gmelin, 1791) (Fr= 66.67%) by 6 hermit crabs (Fig. 3; Table 2).

**Table 2** Gastropod shells utilizeid by 9 hermit crabs collected Levantine Sea coast of Turkey, as well as their dominance and frequency.

| | **Hermit crab species** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gastropod species** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | Fr | Dom |
| *Alvania cimex* (Linnaeus, 1758) | - | 1 | - | - | - | - | - | - | - | 11,11 | 0,14 |
| *Alvania discors* (Allan, 1818) | - | 6 | - | 1 | - | - | - | - | 1 | 33,33 | 1,12 |
| *Alvania fractospira* Oberling, 1970 | - | - | - | - | - | - | - | - | 1 | 11,11 | 0,14 |
| *Alvania geryonia* (Nardo, 1847) | - | 5 | - | 1 | - | - | - | 1 | 5 | 44,44 | 1,68 |
| *Bittium latreillii* (Payraudeau, 1826) | 1 | 6 | - | 1 | - | - | - | - | - | 33,33 | 1,12 |
| *Bittium reticulatum* (da Costa, 1778) | - | 4 | - | - | - | 5 | - | - | 2 | 33,33 | 2,10 |
| *Bolinus brandaris* (Linnaeus, 1758) | - | - | 1 | 1 | - | - | - | 1 | - | 33,33 | 0,42 |
| *Calliostoma conulus* (Linnaeus, 1758) | - | - | 1 | - | - | - | - | - | 1 | 22,22 | 0,28 |
| *Cerithium scabridum* Philippi, 1848 | 17 | 98 | 11 | 52 | 2 | 24 | 1 | 1 | 11 | 100 | 30,35 |
| *Cerithium vulgatum* Bruguière 1792 | 1 | 2 | - | 10 | - | 2 | - | - | 3 | 55,56 | 3,08 |
| *Clanculus cruciatus* (Linnaeus, 1758) | - | - | - | - | - | - | - | - | 1 | 11,11 | 0,14 |
| *Columbella rustica* (Linnaeus, 1758) | 1 | 2 | 2 | - | - | - | - | - | 1 | 44,44 | 0,84 |
| *Conus mediterraneus* Hwass in Bruguière, 1792 | 1 | 1 | 2 | - | - | - | - | - | - | 33,33 | 0,56 |
| *Ergalatax junionae Houart, 2008* | 30 | 9 | 33 | 34 | 7 | 26 | 1 | - | 6 | 88,89 | 20,42 |
| *Euthria cornea* (Linnaeus, 1758) | - | - | 2 | 3 | 1 | 1 | - | - | - | 44,44 | 0,98 |
| *Gibbula divaricata* (Linnaeus, 1758) | - | 1 | 6 | 1 | 1 | 1 | 1 | - | - | 66,67 | 1,54 |
| *Gibbula turbinoides* (Deshayes, 1835) | - | - | - | - | - | - | - | - | 3 | 11,11 | 0,42 |
| *Gibbula umbilicaris* (Linnaeus, 1758) | 1 | - | - | - | - | - | - | - | - | 11,11 | 0,14 |
| *Gibbula varia* (Linnaeus, 1758) | - | - | - | - | - | - | 1 | - | - | 11,11 | 0,14 |
| *Hexaplax turunculus* (Linnaeus, 1758) | 2 | - | 15 | 2 | 3 | 3 | - | - | - | 55,56 | 3,5 |
| *Jujubinus exasperatus* (Pennant, 1777) | 1 | 1 | - | - | - | - | - | - | 1 | 33,33 | 0,42 |
| *Melarhaphe neritoides* (Linnaeus, 1758) | - | - | - | - | - | - | - | - | 1 | 11,11 | 0,14 |
| *Mitrella* sp. | - | 1 | - | - | - | - | - | - | - | 11,11 | 0,14 |
| Muricidae | - | - | - | - | - | 1 | - | - | - | 11,11 | 0,14 |
| *Muricopsis cristata* (Brocchi, 1814) | - | 3 | - | 2 | - | - | - | - | - | 22,22 | 0,7 |
| *Nassarius circumcinctus* (Adams A., 1852) | - | - | - | 2 | - | - | - | - | - | 11,11 | 0,28 |
| *Nassarius cuvierii* (Payraudeau, 1826) | - | 1 | - | - | - | - | - | - | - | 11,11 | 0,14 |
| *Nassarius gibbosulus* (Linnaeus, 1758) | - | - | 1 | 18 | 1 | - | - | - | - | 33,33 | 2,8 |
| *Nassarius incrassatus* (Ström, 1768) | 1 | 4 | 1 | 1 | - | - | - | - | - | 44,44 | 0,98 |
| *Nassarius mutabilis* (Linnaeus, 1758) | - | 1 | - | 3 | - | - | - | - | - | 22,22 | 0,56 |
| *Nassarius pygmaeus* (Lamarck, 1822) | - | 1 | - | 1 | - | - | - | - | 1 | 33,33 | 0,42 |
| *Nassarius* sp. | - | 2 | - | 1 | - | - | - | - | - | 22,22 | 0,42 |
| *Nassarius unifasciatus* (Kiener, 1834) | - | 11 | - | 2 | - | - | - | - | - | 22,22 | 1,82 |
| *Nassarius circumcinctus* (Adams A, 1852) | - | - | - | 3 | - | - | - | - | - | 11,11 | 0,42 |
| *Neverita jesephinia* Risso, 1826 | - | - | 1 | - | - | - | - | 1 | - | 22,22 | 0,28 |
| *Ocinebrina edwardsii* (Payraudeau, 1826) | - | 1 | - | - | - | - | - | - | - | 11,11 | 0,14 |
| *Osillinus articulatus* (Lamarck, 1822) | - | - | 1 | 1 | - | - | - | - | - | 22,22 | 0,28 |
| *Osillinus turbinatus* (Born, 1778) | 1 | - | 13 | 2 | - | 1 | - | - | - | 44,44 | 2,38 |
| *Pisania striata* (Gmelin, 1791) | 2 | 2 | 6 | - | 2 | 2 | - | - | 1 | 66,67 | 2,10 |
| *Pollia dorbignyi* (Payraudeau, 1826) | 1 | - | - | - | - | - | - | - | - | 11,11 | 0,14 |
| *Pusillina radiata* (Philippi, 1836) | - | - | - | - | - | - | - | - | 1 | 11,11 | 0,14 |
| *Smaragdia viridis* Swainson, 1821 | - | - | - | 1 | - | - | - | - | 1 | 22,22 | 0,28 |
| *Strombus persicus* Swainson, 1821 | 15 | 1 | 49 | 27 | 7 | 3 | 1 | 1 | - | 88,89 | 14,55 |
| *Tricolia pullus pullus* (Linnaeus, 1758) | - | 1 | - | - | - | - | - | - | - | 11,11 | 0,14 |
| *Vermetus rugulosus* Monterosato, 1878 | 1 | - | - | - | - | - | - | - | - | 11,11 | 0,14 |
| *Vermetus* sp. | 5 | - | 1 | - | - | - | - | - | - | 22,22 | 0,84 |
| *Vexillum ebenus* (Lamarck, 1811) | 1 | - | - | - | - | - | - | - | - | 11,11 | 0,14 |
| Total | 82 | 170 | 146 | 171 | 24 | 70 | 5 | 5 | 42 | | |

Note: 1. *Calcinus tubularis* (Linnaeus, 1767), 2. *Cestopagurus timidus* (Roux, 1830), 3. *Clibanarius erythropus* (Latreille, 1818), 4. *Diogenes pugilator* (Roux, 1829), 5. *Paguristes syrtensis* De Saint Laurent, 1971, 6. *Pagurus anachoretus* Risso, 1827, 7. *Pagurus cuanensis* Bell, 1845, 8. *Pagurus excavatus* (Herbst, 1791), 9. *Pagurus* sp.

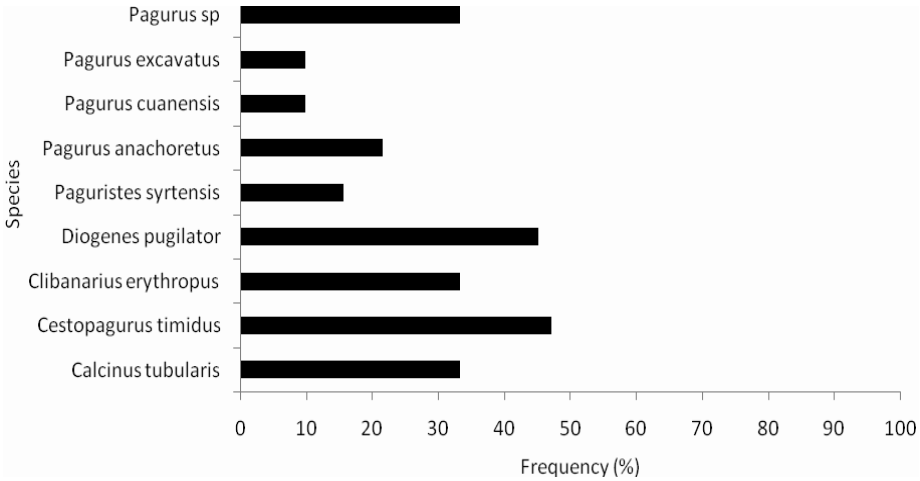


**Fig. 2** Frequency of Hermit crab utilized gastropod shell species.

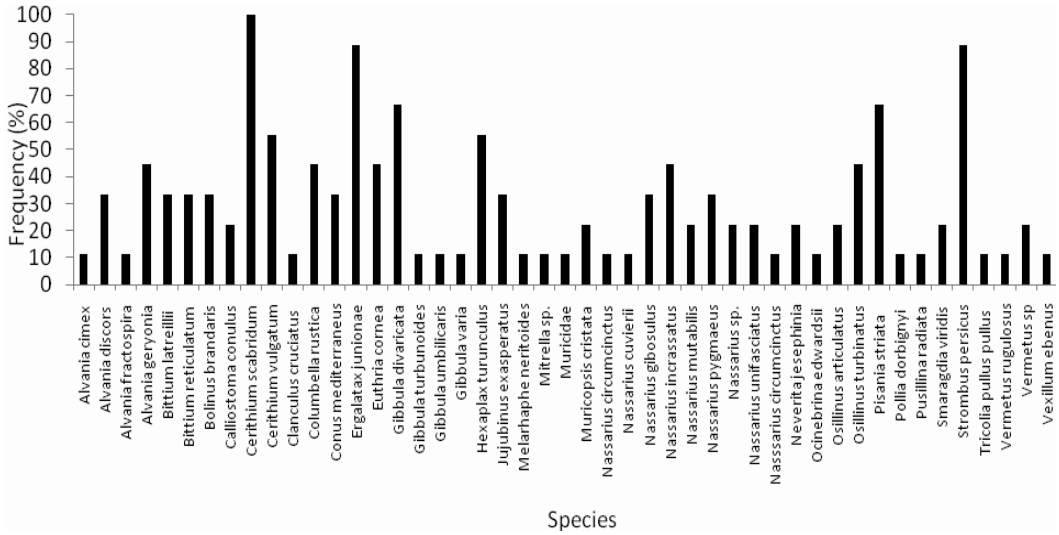


**Fig. 3** Frequency of utilized of shell species by Hermit crabs.

*C. timidus* (Fr= 47.1%) utilized 24 gastropod shells while *D. pugilator* (Fr= 45.1%) 23, *C. erythropus*, *C. tubularis* and *Pagurus* sp (Fr= 33.3%) 17; *P. anachoretus* (Fr= 21.6%) 11, *P. syrtensis* (Fr= 15.7%) 8 and *P. cuanensis* as well as *P. excavatus* (Fr= 9.8%) utilized 5 gastropod shells (Fig. 2; Table 2)

According to frequency-index values of the gastrpod shell utilized by hermit crabs, 7 species could be classified as 'Constant' (≥50%), 13 species as 'Common' (*F* between 25 and 50%) and 27 species as 'Rare' (<25%). The constant species, *C. scabridum* achieved the highest value (100%), followed by *E. junionae* and *S. persicus* (88.89%).

During the study 3 exotic gastropod species belonging to three different families (*C. scabridum*, *S. persicus* and *E. junionae*) were obtained (Table 2). These exotic species; *C. scabridum* (Fr=100%), *E. junionae* and *S. persicus* (Fr= 88.89%) was most commonly utilized shell by hermit crabs (Fig. 3).

**4 Discussion**

The result of study showed that 9 hermit crab species inhabited 47 different gastropod shells in the Levantine Sea coast of Turkey.

In total 12 hermit crab species utilizing 16 different gastropod shells have been reported to inhabit Aegean Sea coast, Turkey. *P. anachoretus*, had the highest inhabitation frequency (IF), inhabiting 37.5% of all the samples collected. The gastropod shell mostly commonly inhabited was *Bittium latreillii* (Payraudeau, 1826), which accounted for 66.7% of inhabited shells (Ateş et al., 2007). Species *Dardanus arrosor* (Herbst, 1796), *Paguristes eremita* (Linnaeus, 1767), *Anapagurus laevis* (Bell, 1845), *Anapagurus petiti* Dechancé & Forest, 1962, *Pagurus alatus* Fabricius, 1775, *Pagurus chevreuxi* (Bouvier, 1896), *Pagurus forbesi* Bell, 1845 and *Pagurus prideauxi* Leach, 1815 were not recorded in the study. On the other hand, *C. tubularis*, *C. timidus*, *C. erythropus*, *P. excavatus* and *Pagurus* sp reported in the study were not recorded by Ateş et al. (2007).

It has been reported in connection to Aegean Sea coast, Greece, that 56 gastropod shells were utilized by 11 different hermit crab species and that 5 hermit crab species utilized *Phyllonutus tunculus* gastropod shells while 4 hermit crab species preffered *Cerithium vulgatum* Bruguière, 1792 (Koutsoubas et al., 1993). The species *Dardanus callidus* (Risso, 1827), *P. eremita*, *A. laevis*, *P. forbesi* and *P. chevreuxi* were not recorded in the study. However, *C. tubularis*, *P. syrtensis* and *Pagurus* sp reported in the study were not recorded by (Koutsoubas et al., 1993).

In this study, it was established that 9 (100%) hermit crab species utilized by *C. scabridum* gastropod shell while 8 hermit crab species utilized *E. junionae* and *S. persicus* (Fr= 88.89%) gastropod shells.

Eleven species of gastropod shells occupied by *C. erythropus* along the south coast of São Miguel, Açores. *Columbella adansoni* Menke, 1853, *Mitra cornea* (Lamarck, 1811) and *Stramonita haemastoma* (Linnaeus, 1766) were the most commonly occupied shells, followed by *Pollia dorbignyi* (Payraudeau, 1826) and *Nassarius incrassatus* (Ström, 1768) (Rodrigues & Rodrigo 2009). In the Azores, *C. erythropus* occupied 19 species of gastropod shells: those most commonly occupied were *Littorina striata* King & Broderip, 1832, *N. incrassatus*, *Mitra* sp. and *S. haemastoma* (Botelho and Costa, 2000).

*D. pugilator* occupied shells of 27 gastropod species in the Barbate Bay, Cadiz and most commonly utulized were *Mesalia varia* (Kiener, 1843), *Turritella communis* Risso, 1826, *Nassarius reticulatus* (Linnaeus, 1758), *N. mutabilis* (Linnaeus, 1758), *T. turbona* Monterosato, 1877 and *Gibbula magus* (Linnaeus, 1758) (Manjón-Cabeza and Garcia Raso, 1999).

In this study *C. erythropus* occupied 17 gastropod shells (56.16% *S. persicus* and *E. junionae*). Also, *D. pugilator* occupied 23 gastropod shells, and most commonly utilized were three exotic species (*C. scabridum*, *S. persicus* and *E. junionae*). We suggest that these factors (the region and site features) may have been effect the selectivity gastropod shells by hermit crabs.

Shell use in nature was also demonstrated to be dependent on hermit crab species. Also, shell use is dependent on a combination of site-specific features such as wave energy, predators, habitat complexity, shell availability, and shell use history, which may or may not differ among areas (Dominciano et al., 2009).

As a conclusion, gastropod shells preferred by hermit crabs were depending on the region and site features. It was found out that exotic gastropod shells are mostly preferred along the Levantine Sea coast. Further studies monthly or seasonal are required to be done along the this coast determined whether there is a variation in utilized of this shells by juvenil or adult hermit crabs and whether exotic gastropod shells are occupied by

hermit crabs through their live only for certain stages or their life.

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