

## The vertical distribution and abundance of *Chthamalus stellatus* Poli and *Chthamalus montagui* Southward (Crustacea, Cirripedia) at two localities of the Istrian peninsula coast (North Adriatic)

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Two species of chthamalid barnacles are well established from the upper to the lower limit of the midlittoral zone on the rocky shores of the North Adriatic Sea: *Chthamalus stellatus*, Poli and *Chthamalus montagui*, Southward. The present study deals with the vertical distribution and abundance for each species at two localities of the Istrian peninsula coast (North Adriatic Sea). For this purpose chthamalid populations were monitored in 2015 along the Slovenian marine coast (Bay of Koper, Gulf of Trieste) and along the Croatian marine coast, near Rovinj (west Istrian coast), both on limestone. The main aim of the study was to establish if there was a relationship between the vertical distribution and abundance of these two species at different spatial scales: small (between sites, about 1 kilometer) and large (between localities, 10s of kilometers). The selected localities are slightly different in tidal range, in orientation and wave exposure. Three sites were randomly selected at each locality and two transects per tidal level (upper, middle and lower) were chosen on each site. The abundance of each chthamalids species in 1 dm<sup>2</sup> plots was determined at three different tidal levels along each transect. The results indicated that the vertical distribution of *C. montagui* and *C. stellatus* was very similar between localities and even among sites, but their abundance varied. At both localities, *C. montagui* was more abundant in the upper and middle tidal levels, while *C. stellatus* was more abundant at the lower tidal level. It was also found that *C. montagui* was more abundant in sheltered conditions (Bay of Koper), while *C. stellatus* on the coast more exposed to the wave action (near Rovinj), at all tidal levels.

**Key words:** *Chthamalus montagui*, *C. stellatus*, vertical distribution, abundance, spatial variations, midlittoral, North Adriatic

### INTRODUCTION

Chthamalid barnacles are one of the most abundant and most characteristic sessile marine organisms of the midlittoral zone of the NE

Atlantic and Mediterranean rocky shores (STEPHENSON & STEPHENSON, 1949; SOUTHWARD, 1950; LEWIS, 1964; BELLAN-SANTINI *et al.*, 1994; PANNACCIULLI & RELINI, 2000; SOUSA *et al.*, 2000). For the Adriatic coasts, several authors

have reported the presence of mainly two species of chthamalids in the midlittoral zone: *Chthamalus montagui* Southward and *C. stellatus* Poli (DANDO *et al.*, 1979; ZAVODNIK, 1997; PANNACCIULLI & RELINI, 2000; ZAVODNIK *et al.*, 2000; 2005; 2006; IGIĆ, 2007).

Several studies related to the variability of the vertical (in relation to the tidal level) distribution and abundance of the *C. stellatus* and *C. montagui* in the midlittoral zone, to many factors, such as: tidal level, shore exposure to wave action, sea temperature, coastal topography, substrate type, recruitment, post-larval mortality, and interspecific competition (CONNELL, 1961; SOUTHWARD, 1976; BURROWS, 1988; SOUTHWARD, 1991; BENEDETTI-CECCHI *et al.*, 2000; DELANY *et al.*, 2003; HISCOCK *et al.*, 2004; O'RIORDAN *et al.*, 2004; HERBERT *et al.*, 2007). Among these factors, shore exposure to wave action and tidal level are considered to be the most important (SOUTHWARD, 1976; BURROWS, 1988; CRISP *et al.*, 1981; PANNACCIULLI & RELINI, 2000; SOUSA *et al.*, 2000; JENKINS, 2005; POWER *et al.*, 2006; O'RIORDAN *et al.*, 2010). As shown by these authors *C. stellatus* was more abundant at exposed sites and tended to occupy lower tidal levels, while *C. montagui* was more abundant in sheltered places and at higher tidal levels. O'RIORDAN *et al.* (2010) reported that the distribution of *C. montagui* and *C. stellatus* differ also at the small, local and large, regional scale. They noted that at local and regional scales abiotic factors, such as desiccation, temperature, wind, and wave exposure might affect the distribution of chthamalids. Several studies indicated that tolerance of the highly fluctuating temperature and desiccation stress are considered to be the main factors that control the distribution of chthamalids species. For example, BURROWS (1988), POWER *et al.* (2001, 2006, 2011) documented that *C. montagui* is more resistant to desiccation than *C. stellatus*.

Little is known about the vertical distribution on the local and regional scales of *C. montagui* and *C. stellatus* on the North Adriatic rocky shore. The only works were published by PANNACCIULLI & RELINI (2000) and PITACCO *et al.* (2013), but they were limited to the Gulf of Trieste. The authors observed that these species

occupy all tidal levels of the midlittoral zone but their abundance varies from level to level: *C. montagui* has been found to be more common in the upper and in the middle tidal level, while *C. stellatus* is in the lower level. The results of the study conducted along the Slovenian coast by BATTELLI & DOLENC ORBANIĆ (2008; 2009) revealed a very similar situation, where the two species co-occur.

Our work deals with the vertical distribution and the abundance of two species of chthamalids, *C. montagui* and *C. stellatus* at two localities along the Istrian peninsula coast: one located along the coast of the Bay of Koper (Gulf of Trieste) and one in a broader geographical area, along the west Istrian coast, near Rovinj.

The main aims of the study were: (a) to determine the pattern of vertical distribution and the abundance of the two co-occurring selected species in the midlittoral zone at two investigated localities, and (b) to establish if there was a relationship between the vertical distribution and the abundance of these two species on a small, local spatial scale (among sites, within each locality, of about 1 kilometer), and on a large, regional scale (between localities, 10s of kilometers).

## MATERIAL AND METHODS

### Study area

The main characteristics of the North Adriatic Sea are its relatively high tidal range (up to 1 m), with high temperature and salinity variations, wind-driven water circulation, stratification of its water column, nutrient discharges by rivers, and high productivity (STRAVISI, 1983; STACHOWITSCH, 1991; VUČAK, 1996). The study was carried out in two localities situated along the Istrian peninsula coast (North Adriatic Sea) (Fig. 1).

The first locality (Lo1) comprised three sites (Si1, Si2, and Si3) located along the Slovenian coast (Bay of Koper), in the southeastern part of the Gulf of Trieste. The depth inside the Gulf is around 15 m, with a maximum of 25 m in the central part. The embayed situation of the Gulf,

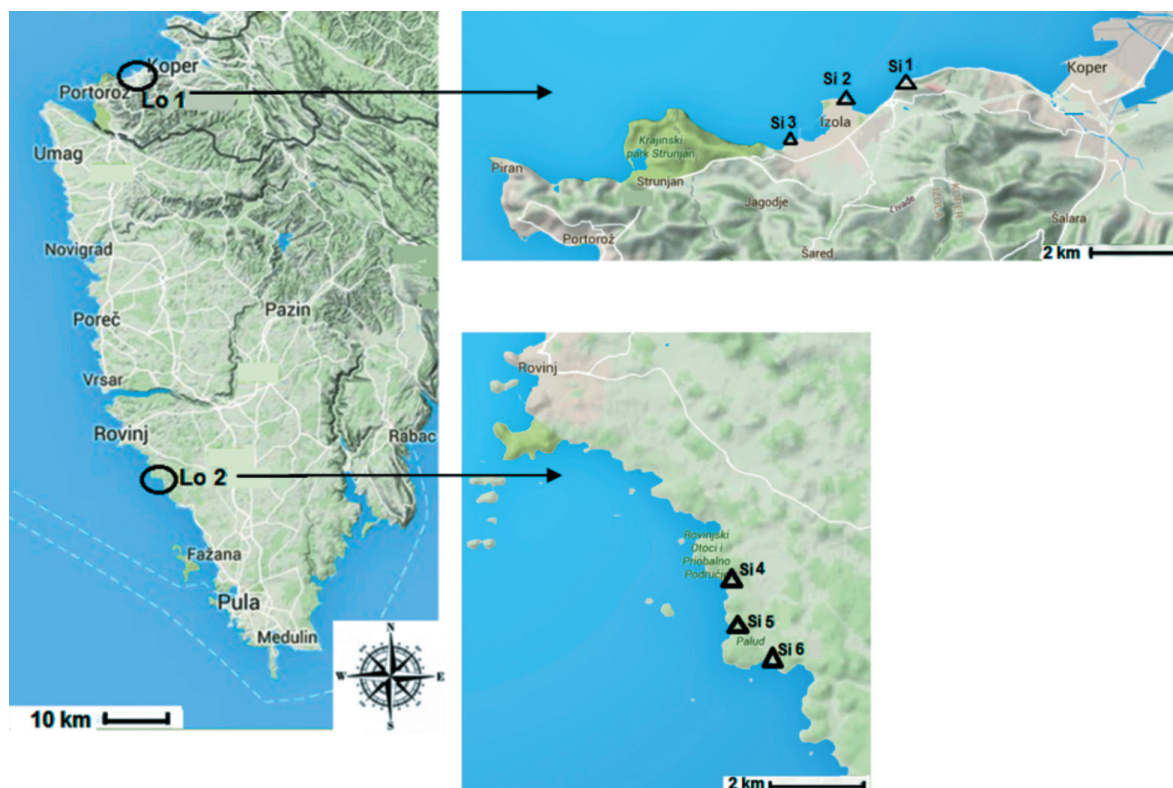


Fig. 1. Map of the investigated area indicating the sampling localities (left) and corresponding sites (right)

the dominant winds blowing offshore (from the Northeast) and very shallow waters create a quite sheltered condition (PANNACIULLI & RELINI, 2000; MALAČIĆ & JEROMEL, 2005).

Site Si1 was situated along the coast between Koper and Izola (45° 32' 49'' N, 13° 41' 11'' E). The shore formed from limestone breakwater rocks was exposed to wave action and winds blowing from the southwest to the northeast (MALAČIĆ & JEROMEL, 2005). Site Si2 was situated on the northern part of Izola (45° 32' 32'' N, 13° 39' 42'' E), while site Si3 was located in St. Simon Bay (45° 32' 04'' N, 13° 38' 47'' E). The substratum of the sites Si2 and Si3 consisted of limestone (PAVLOVEC, 1985), and had a generally more irregular and heterogeneous structure, with many outcrops and crevices of various sizes. The wind exposure was northwesterly and northeasterly (MALAČIĆ & JEROMEL, 2005).

The second one (Lo2), about 65 km as the crow flies from Lo1, lying along the Croatian, west Istrian coast, near Rovinj, comprised the site Si4 (45° 02' 02'' N; 13° 41' 27'' E), site

Si5 (45° 01' 46'' N; 13° 41' 34'' E), and site Si6 (45° 01' 27'' N; 13° 42' 07'' E). All of them were situated south of Rovinj and were exposed to westerly winds (SMIRČIĆ *et. al.*, 1996; ZAVODNIK *et al.*, 2002). Locality Lo2 was characterized by a limestone rocky substratum; the structure of the substratum was similar to that described for Si2 and Si3. The depth of the sea near Rovinj (Lo2) was around 20–40 m, which was deeper than in the Gulf of Trieste (Lo1).

In the North Adriatic the vertical extent of the midlittoral zone, ranging between the mean higher high water (MHHW) and the mean lower low water (MLLW) tide levels, was at Lo1 approximately 90 cm, and at Lo2 67 cm (VUČAK, 1996). Based on our field observations three levels were clearly recognized at all sites of the selected localities: upper, middle, and lower, as proposed by BATTELLI (2016) for the Gulf of Trieste. The upper level of this zone ranges from a mean higher high water (MHHW) to a mean high water (MHW) tide level. Among the fauna, the most characteristic components

were populations of chthamalids. The middle level extends from MHW to a mean low water (MLW) tide level. The chthamalids of this level were mixed with other faunal species such as gastropods (*Monodonta* sp., *Gibbula* sp, *Patella* sp.) and anthozoans (*Actinia* sp.). The lower level ranges from MLW to MLLW tidal levels. It was mainly occupied by aggregates of the bivalve *Mytilus galloprovincialis*.

It is important to note that while the two selected localities are similar regarding the type of substratum, they slightly differ in the mean tidal amplitude (VUČAK, 1996), in orientation (Lo1 to north, Lo2 to west), in exposure to wave action (Lo2 is more exposed than Lo1) (SMIRČIĆ *et al.*, 1996), and in the depth of the coastal sea (deeper at Lo2). Lo2 is exposed to the open sea (ZAVODNIK, 1967; ZAVODNIK *et al.*, 2002), while Lo1 in a semi-enclosed shallow area (MALAČIĆ & JEROMEL, 2005).

### Methods

Sampling was carried out in September 2015. Three sites of the midlittoral zone (about 1 km apart, 60 m in length) within each locality were randomly chosen. Each site was divided into 12 transects (5 m in length) and each transect in three tidal levels (upper, middle and lower). At each tidal level, two transects were randomly selected for each species (6 sampled areas for each species). Within each area, three plots (10 cm x 10 cm) were analyzed. Only areas where chthamalids were more abundant and formed a homogeneous community along the whole transect were selected. The abundance was determined by counting the individuals directly from each plot during the fieldwork with a magnifier hand lens. Counts were made for each species in separate plots to maintain the independence of the samples for statistical purposes. Only adult chthamalids were counted. We considered adults after POWER *et al.* (2001), as all individuals that were more than 2 mm in opercular diameter. For the identification of the selected chthamalids species we only used the external morphological features, according to the works of SOUTHWARD (1976), RELINI (1980),

and BATTELLI & DOLENC-ORBANIĆ (2009), as follows: (a) the shape of the opercular opening, (b) the shape of the adductor muscle scar, and (c) the position and curvature of the articulation between the terga and scuta.

### Data analysis

In order to determine the vertical distribution pattern and the abundance of *Chthamalus montagui* and *C. stellatus* on different spatial scales (small - among sites, and large - between localities), the data were analyzed using the GraphPad Prism 5.02 program.

The non-parametric Kruskal-Wallis H-test (KRUSKAL & WALLIS, 1952) was used in order to indicate statistically significant differences in mean abundance of chthamalids (at each tidal level) among sites within a single locality, separately for both species. In order to establish whether there was a statistically significant difference in the mean abundance of the two chthamalids species (at each tidal level) between localities, the Mann-Whitney U-test (MANN & WHITNEY, 1947), was performed. The data were expressed as the mean  $\pm$  SE (standard error of mean).

## RESULTS

### Vertical distribution and abundance

The main aim of our study was to establish whether there was a relationship between vertical distribution and abundance of *C. montagui* and *C. stellatus* at different spatial scales: small (among sites) and large (between localities).

The results of our study indicated that the distribution of these species was confined between the upper and the lower limit of the midlittoral zone on the rocky shore of both of the selected localities. During the investigation, we found that at both localities these two chthamalid species co-occurred at all levels (upper, middle, lower) of the midlittoral zones. The results revealed that *C. montagui* was more abundant (mean number/dm<sup>2</sup> = 39.00  $\pm$  SE) than *C. stellatus* (mean number/dm<sup>2</sup> = 5.14  $\pm$  SE) at

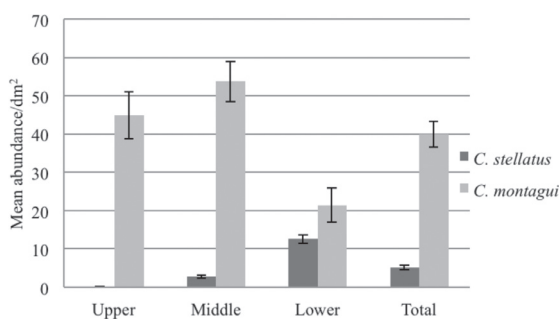


Fig. 2. The mean abundance ( $\pm$  SE) of *Chthamalus stellatus* and *C. montagui* according to the tidal level and the total abundance of both species at the research area, Izola (three sites) and Rovinj (three sites)

all levels and at all the considered sites at both localities (Fig. 2), although the pattern of abundance of the single species among levels was different. The highest mean abundance ( $12.56 \pm$  SE) of *C. stellatus* was found in the lower level and the lowest ( $0.08 \pm$  SE) in the upper, while for *C. montagui* the highest mean abundance was in the middle ( $53.72 \pm$  SE) and the lowest in the lower ( $21.44 \pm$  SE). From Fig. 2, a great difference between the abundance of the two selected species in the upper and in the middle level of the midlittoral zone, was evident. The Mann-Whitney U test showed that the differences in the total mean abundance between the two species at the research area at all levels were statistically significant ( $U = 1215$ ,  $p < 0.0001$ ). At the upper and middle level the differences were significant ( $U = 0.0000$ ,  $p < 0.001$ ;  $U = 16.00$ ,  $p < 0.001$  respectively), while the difference in the lower level was statistically not significant.

### Comparison in the mean abundance of two chthamalids species among the sites

A considerable variability in the mean abundance of *C. montagui* on small spatial scales (among sites) at locality Lo1 (Izola) was found. From Fig. 3a it is evident that this species was more abundant at the upper and middle tidal level than at the lower level. The Kruskal-Wallis test showed statistically significant differences in abundance at the upper level ( $H = 6.50$ ,  $df = 2$ ,  $p = 0.0389$ ), between site Si1 and site Si2; at the middle level ( $H = 14.34$ ,  $df = 2$ ,  $p = 0.0008$ ),

between site Si1 and site Si3, and at the lower level ( $H = 10.13$ ,  $df = 2$ ,  $p = 0.0063$ ) between site Si1 and site Si3.

Statistically significant differences in abundance among sites were also found at locality Lo2 (Rovinj): at the upper level ( $H = 11.09$ ,  $df = 2$ ,  $p = 0.0039$ ) between site Si4 and site Si5; at the middle level ( $H = 11.82$ ,  $df = 2$ ,  $p = 0.0027$ ) between site Si5 and site Si6 and lower level ( $H = 8.12$ ,  $df = 2$ ,  $p = 0.0172$ ) between site Si4 and site Si5. The Fig. 3b shows that *C. montagui* reached the highest abundance at the middle tidal level and the lowest at the lower level.

For *C. stellatus* at the locality Lo1, the Kruskal-Wallis test showed a statistically significant difference in the mean abundance

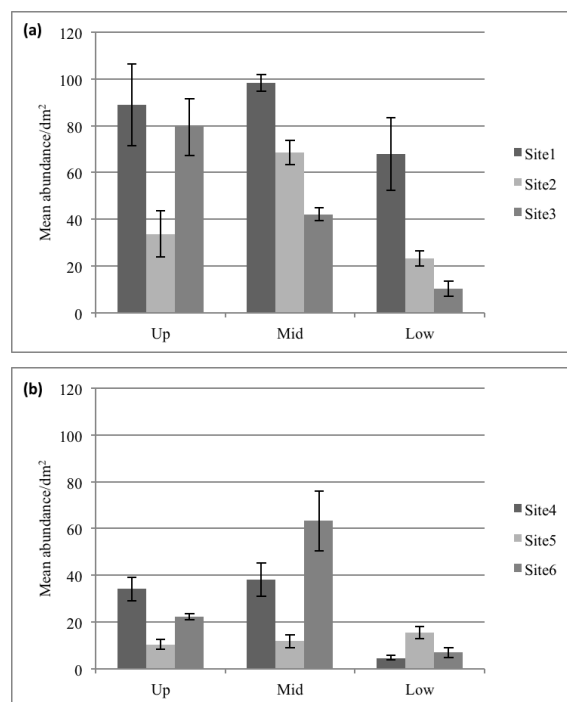


Fig. 3. Comparison of the mean abundance ( $\pm$  SE) of *Chthamalus montagui*, among the sites, at the upper (up), middle (mid), and the lower level (low) of the midlittoral zone at (a) locality 1 (Izola) and (b) locality 2 (Rovinj)

only for the middle level ( $H = 7.37$ ,  $df = 2$ ,  $p = 0.0252$ ) between site Si1 and site Si2 ( $p < 0.05$ ), while at locality Lo2 the differences among the sites were not statistically significant. The abundance of this species was higher at the

lower tidal level compared with the other tidal levels at both localities (Fig. 4a and 4b).

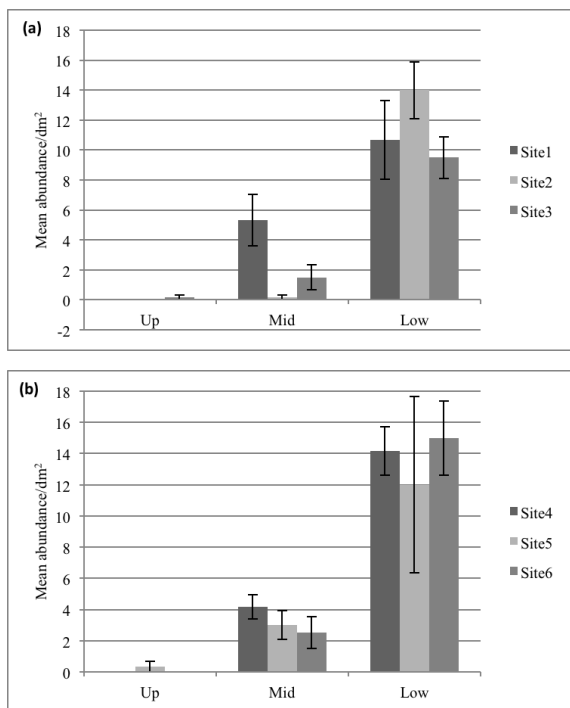


Fig. 4. Comparison of the mean abundance ( $\pm$  SE) of *Chthamalus stellatus*, among the sites, at the upper (up), middle (mid), and lower level (low) of the midlittoral zone at (a) locality 1 (Izola) and (b) locality 2 (Rovinj)

### Comparison of the mean abundance of two chthamalids species between localities

A marked spatial variability in the mean abundance of *C. montagui* at the large scale (between localities) at each tidal level was found, as evident from Fig. 5a and Fig. 5b.

In the upper level the mean abundance ( $67.30 \pm$  SE) of *C. montagui* at locality Lo1 was significantly ( $U = 59.00$ ,  $p = 0.0012$ ) higher than at locality Lo2 ( $22.28 \pm$  SE). A very similar trend was found for the middle ( $U = 63.00$ ,  $p = 0.0018$ ) and the lower tidal level ( $U = 61.00$ ,  $p = 0.0015$ ) (Fig. 5a).

The vertical distribution pattern of the abundance of *C. stellatus* among the levels was very similar at both localities, although the abundance at Lo2 was slightly higher than at Lo1 (Fig. 5a and 5b). The minimum values of the abundance of *C. stellatus* were found at

the upper level at both localities (Lo1 =  $0.06 \pm$  SE; Lo2 =  $0.11 \pm$  SE), and the maximum at the lower (Lo1:  $11.39 \pm$  SE; Lo2:  $13.72 \pm$  SE). The Mann–Whitney  $U$  test revealed no statistically significant difference in mean abundance between the localities within each level.

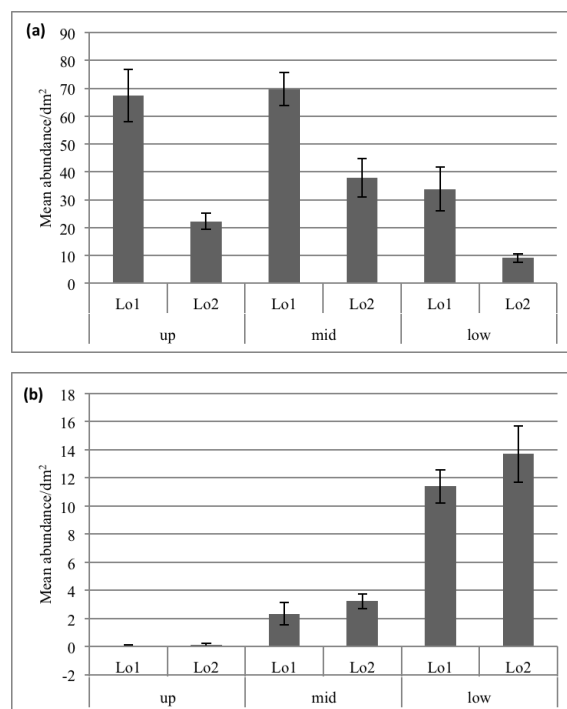


Fig. 5. Comparison of the mean abundance ( $\pm$  SE) of (a) *Chthamalus montagui* and (b) *C. stellatus* between localities (Lo1- Izola and Lo2- Rovinj), at the upper (up), middle (mid), and lower level (low) of the midlittoral zone

## DISCUSSION

The results of our investigations showed that the distribution of both chthamalids species, *Chthamalus montagui* and *C. stellatus*, were confined to the midlittoral zone, ranging between the upper and the lower limit of this zone on the rocky shore of the research areas. These observations were similar to those for the Gulf of Trieste (North Adriatic Sea) but in contrast to the Gulf of Genova (Ligurian Sea), where, as reported by PANNACCIULLI & RELINI (2000), the distribution of these two species stretched further up as wave action prevails over the tides. BURROWS *et al.* (1992) noted that *C. montagui* has a greater vertical

distribution, extending above and below that of *C. stellatus*. One possible explanation is that *C. montagui* has a greater resistance to desiccation stress compared with *C. stellatus*. FOSTER (1971) observed that desiccation is a lethal factor which may determine the upper limit of barnacles and CRISP *et al.* (1981) found that *C. stellatus* reached its largest numbers in places shaded from the direct sun.

Several factors probably interact to create the patterns of vertical distribution of the investigated *Chthamalus* species. Many studies conducted for the Mediterranean and NE Atlantic rocky shores (e.g. SOUTHWARD, 1976; CRISP *et al.*, 1981; BURROWS, 1988; SOUSA *et al.*, 2000; POWER, 2000; O'RIORDAN *et al.*, 2004) have revealed that the tidal amplitude and the wave exposure are the major factors that significantly determine the vertical distribution of chthamalids in the midlittoral zone, and even that different species can be separated by these factors.

We found that in the midlittoral zone of the research area *C. montagui* was dominant over *C. stellatus*, which was in accordance with the results of the study of SOUSA *et al.* (2000) along the southern coast of Portugal, and PANNACCIULLI & RELINI (2000) for the Gulf of Trieste. The opposite situation was described by PANNACCIULLI & RELINI (2000) for Genova and by BEŞİR & ÇINAR (2012) for Antalya Bay (Eastern Mediterranean Sea), where *C. stellatus* was dominant.

The results of this study indicated that the vertical distribution and the abundance of each of the investigated *Chthamalus* species were different at various (upper, middle, and lower) tidal levels: *C. montagui* was more abundant in the middle and upper tidal level than in the lower, while *C. stellatus* was more abundant in the lower than at the other levels. This agrees with several studies of different European areas, such as the Gulf of Trieste (PANNACCIULLI & RELINI, 2000), the NE Atlantic coast (SOUTHWARD, 1976; BURROWS, 1988; CRISP *et al.*, 1981), and Southwest coast of Portugal (SOUSA *et al.*, 2000). The opposite pattern was observed by BENEDETTI-CECCHI *et al.* (1999) and MENCONI *et al.* (1999) in the northwest Mediterranean, where *C. stellatus* was more

abundant in high-shore habitats. As reported in many works (e.g. SOUTHWARD, 1976; BURROWS, 1988; POWER *et al.*, 2001; 2006; 2011) the differences in abundance of *C. montagui* and *C. stellatus* at each tidal level has been associated with desiccation. SOUTHWARD (1955) highlighted that the higher the species occurred up on the shore, the more resistant to desiccation influences they tend to be. BURROWS (1988), for example, observed that *C. montagui* is more tolerant towards high temperatures and desiccation than *C. stellatus* due to morphological differences in the shape of the opercular plates: the opercular plates of *C. montagui* are more closely-fitting than those of *C. stellatus*.

A different pattern of the abundance of each of the *Chthamalus* species was observed at a large, regional spatial scale (between localities). It is important to note that the two selected localities were similar in the type of substratum, but slightly different in tidal amplitude, in orientation and wave exposure. Lo1 was a semi-enclosed embayed area, oriented to the north, characterized by very shallow waters and moderate wave action, which create a sheltered condition. On the contrary, Lo2 was oriented to the west, exposed to the open sea, with a stronger wave action and deeper coastal sea. The analyses indicated that the abundance of *C. montagui* was higher at Lo1 than at Lo2, at each tidal level, while *C. stellatus* was more abundant at Lo2 at all tidal levels. This is in accordance with several authors (e.g. SOUSA *et al.*, 2000; POWER *et al.* 2001; JENKINS, 2005) who have found that the abundance of both *Chthamalus* species, at each tidal level, differ along a wave exposure gradient.

Since the difference in tidal amplitude between the two selected localities was small, we are inclined to consider that the exposure of the shores to the wave action is one of the most significant factors in determining the differences in the pattern of vertical distribution and abundance observed for each of the investigated *Chthamalus* species. The results of our study are similar to those found in other studies. Several authors (e.g. SOUTHWARD, 1976; CRISP *et al.*, 1981; PANNACCIULLI & RELINI, 2000; POWER *et al.*, 2001,

2006, 2011) observed that *C. stellatus* was more abundant on the coasts more exposed to wave action or wet and shady places, as noted by PANNACCIULLI & RELINI (2000) for Genova and by BEŞİR & ÇINAR (2012) for Antalya Bay. In contrast, *C. montagui* reached peak abundance where the wave action was reduced and where the tidal amplitude was high, about 1 m, as reported by PANNACCIULLI & RELINI (2000) for the Gulf of Trieste, which is in agreement with the present study. One possible explanation is that the physical stress due to the wave action could be more variable at the upper and middle levels than at the low tidal level, due to the longer immersion period of the lower level. Another explanation is the difference in larval settlement and post-settlement processes. DELANY *et al.* (2003) considered post-settlement mortality, rather than larval supply, to be the more significant factor in determining the characteristic patterns of these chthamalid species. As noted by JENKINS (2005) the adult distribution across the wave exposure gradient may be determined at settlement. The larval settlement choice rather than a differential larval supply determined the setting-up of species vertical zones. *C. stellatus* cyprids have been proposed to be better adapted to settle or the adults survive in wave-exposed areas (CRISP *et al.*, 1981; POWER *et al.* 2001).

A significant difference in the abundance on a small, local spatial scale (among sites within each locality), were detected for both species. The patterns of vertical distribution and the abundance of *C. montagui* revealed a statistically consistent difference among the sites at each tidal level at both localities. We observed that, in general, this species was more abundant in the upper and middle tidal levels than in the lower levels at both localities. In contrast to *C. montagui*, at each site of both localities, the abundance of *C. stellatus* was higher in the lower tidal level compared with the other tidal levels. For this species, the only statistically significant difference in the mean abundance among the sites of Lo1 was found in the middle level, while at Lo2 these differences were not statistically significant. This variability can be due to small-scale variations in the settlement and post-settlement processes on shores with

different degrees of wave action as noted by CAFFEY (1982). Several authors (e.g. BURROWS, 1988; POWER *et al.*, 2001; 2006) in their work suggested that abiotic factors such as temperature and desiccation are the major determinants of the distribution patterns of chthamalids, that *C. montagui* survives better in desiccating microhabitats than *C. stellatus*, and that the mortality of *C. montagui* is lower in desiccating tidal regimes compared with *C. stellatus*.

## CONCLUSIONS

In conclusion, the results of our investigation showed a very similar pattern of vertical distribution, but a considerable variability in the abundance of each of the investigated *Chthamalus* species on a small, local spatial scale (among sites) and on a large, regional spatial scale (between localities). This study demonstrated that:

1. The pattern of vertical distribution of *Chthamalus montagui* and *C. stellatus* ranged between the upper and the lower limits of the midlittoral zone on the rocky shore of the research areas.

2. At both selected localities *C. montagui* was more abundant in the upper and middle tidal levels, while *C. stellatus* was more abundant at the lower tidal level.

3. *C. stellatus* was more abundant than *C. montagui* on the shore more exposed to wave action (Lo2), while *C. montagui* was more abundant on more sheltered shores (Lo1).

Several factors probably affect the distribution pattern and the abundance of the investigated *Chthamalus* species. In our opinion, more extensive studies, incorporating a larger number of localities and factors, are necessary to gain a better understanding and to clarify the vertical distribution and abundance of *C. montagui* and *C. stellatus* in the North Adriatic.

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## Vertikalna raspodjela i brojnost ciripednih rakova *Chthamalus stellatus*, Poli i *Chthamalus montagui*, Southward (Crustacea, Cirripedia) na dva lokaliteta na obalama istarskog poluotoka (sjeverni Jadran)

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### SAŽETAK

Dvije vrste ciripednih rakova vitičara dobro su razvijene od više do niže gornje granice mediolitoralne zone na stjenovitim obalama sjevernog Jadrana: rak vitičar brumbuljak (*Chthamalus stellatus*, Poli i *Chthamalus montagui*, Southward). Ova studija se bavi vertikalnom raspodjelom i brojnošću ovih vrsta na dva lokaliteta na obalama istarskog poluotoka (sjever Jadranskog mora). U tu svrhu su 2015. promatrane populacije ciripeda duž slovenske obale (Koparski zaljev, Tršćanski zaljev) te duž hrvatske obale u blizini Rovinja (zapadna obala Istre), obje na vapnencu. Glavni cilj istraživanja bio je utvrditi postoji li povezanost između vertikalne raspodjele i brojnosti ovih dvaju vrsta u različitim prostornim skalama: mala (među lokalitetima, otprilike jedan kilometar) i velika (među lokalitetima, deseci kilometara). Odabrani lokaliteti pomalo se razlikuju po rasponu plime i oseke, smještaju i izloženosti valovima. Nasumce su odabrana tri mjesta na svakome od ovih lokaliteta i dva presjeka za razinu plime i oseke (viši, srednji i niži) odabrana su na svakoj pojedinoj lokaciji. Brojnost pojedine vrste chthamalida u dijelovima od 1 dm<sup>2</sup> određeni su trima različitim razinama duž svakog presjeka. Rezultati su upućivali da je vertikalna raspodjela *C. montagui* i *C. stellatus* vrlo slična na svim lokacijama pa čak i na svim kontrolnim mjestima dok je njihova brojnost varirala. Na obje lokacije, *C. montagui* je bila brojnija pri nižim razinama plime i oseke. Također smo utvrdili da je *C. montagui* brojnija u zaštićenijim uvjetima (Koparski zaljev), dok je *C. stellatus* brojniji na obalama koje su izloženije valovima (blizu Rovinja), prilikom svih razina plime i oseke.

**Ključne riječi:** *Chthamalus montagui*, *Chthamalus stellatus*, vertikalna raspodjela, brojnost, prostorne varijacije, mediolitoral, sjeverni Jadran