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FIRST RECORD OF *CHTHAMALUS MONTAGUI* SOUTHWARD, 1976 (CRUSTACEA, CIRRIPIEDIA) ON THE SLOVENIAN COAST (GULF OF TRIESTE, NORTHERN ADRIATIC SEA)

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ABSTRACT

The article deals with the mediolittoral chthamalid barnacle Chthamalus montagui Southward, 1976, not previously noted along the Slovenian coast (Gulf of Trieste, northern Adriatic Sea). The investigation was carried out in the mediolittoral zone during the summer 2007 at 9 sites. Results showed that the main constituents of the sampled chthamalids were C. montagui and C. stellatus (Poli, 1791) and that C. montagui was more abundant. A synoptic table for identification of these two species, based on the external morphological features, is presented.

Key words: mediolittoral, chthamalid barnacles, *Chthamalus montagui*, *Chthamalus stellatus*, Gulf of Trieste, northern Adriatic Sea

PRIMA SEGNALAZIONE DI *CHTHAMALUS MONTAGUI* SOUTHWARD, 1976 (CROSTACEI, CIRRIPEIDI) LUNGO LA COSTA DELLA SLOVENIA (GOLFO DI TRIESTE, ALTO ADRIATICO)

SINTESI

L'articolo tratta la presenza dello Chthamalus montagui Southward, 1976, una specie appartenente agli ctamalidi del mediolitorale segnalata per la prima volta lungo la costa della Slovenia (Golfo di Trieste, Alto Adriatico). I campionamenti sono stati effettuati in 9 stazioni su substrato duro del mediolitorale nell'estate del 2007. I risultati della ricerca hanno rilevato che i componenti fondamentali degli ctamalidi raccolti sono C. montagui e C. stellatus (Poli, 1791) e che il più abbondante è C. montagui. Viene presentata inoltre una tabella sinottica per l'identificazione di queste due specie, basata sulle caratteristiche morfologiche esterne.

Parole chiave: mediolitorale, ctamalidi, *Chthamalus montagui*, *Chthamalus stellatus*, Golfo di Trieste, Alto Adriatico

INTRODUCTION

Barnacles are the most abundant and common sessile organisms that live on rocky shores especially in the supralittoral and in the mediolittoral zones throughout the world (Stephenson & Stephenson, 1949; Lewis, 1964; Bellan-Santini *et al.*, 1994). Their biological characteristics and life histories have been well studied by Southward (1987). Barnacles were one of the subjects in Darwin's studies on the Cirripedia (Darwin, 1854). In his works, Darwin described only one species of the genus *Chthamalus*, *Chthamalus stellatus*, with a number of races or varieties. In the Mediterranean, *Chthamalus depressus* (Poli, 1791), which Darwin considered to be a variety of the species *C. stellatus* (Poli, 1791) has been classified as a separate species, recently assigned to the genus *Euraphia* (Newman & Ross, 1976). In 1976, *Chthamalus montagui* Southward, 1976, which was also considered a variety of *C. stellatus*, was identified as a distinct species, due to differences in its vertical zonation on the shore and morphology, particularly in the shape of opercular plates and in setation of the smaller cirri (Southward, 1976).

The main constituents among different species of the mediolittoral chthamalid barnacles belt of the Mediterranean rocky shores, those belonging to the genus *Chthamalus* are *C. montagui* Southward and *C. stellatus* that usually occur together (Pannacciulli & Falautano, 1999; Pannacciulli & Relini, 1999; O'Riordan *et al.*, 2004).

Many works deal with the distribution of barnacles in the Adriatic Sea (Matisz, 1899; Brusina, 1907; Kolosváry, 1947, 1951; Zei, 1955; Zavodnik *et al.*, 1978, 1981). The occurrence of the species *C. stellatus* in the Northern Adriatic Sea (Gulf of Kvarner) has been well known since 1863, when Lorenz (1863) defined it as a guide species of the community – facies "*Patellae et Balaneta*".

The first occurrence of the species *C. montagui* in the Adriatic Sea was reported by Dando *et al.* (1979), but their studies were restricted to the western coast of the Adriatic. Relini (1981), however, reported on the occurrence of this species from the northern Adriatic (Gulf of Trieste and Rijeka Bay) as well. In the mediolittoral zone of the Gulf of Trieste it has been noted that *C. montagui* is more frequent than *C. stellatus* (Pannacciulli & Relini, 2000).

Recent studies report that there are two species of chthamalids that occur in the mediolittoral zone throughout the Adriatic: *C. stellatus* and *C. montagui* (Zavodnik & Zavodnik, 1994; Zavodnik, 1997, 1998; Zavodnik *et al.*, 2000, 2005, 2006).

Along the Slovenian coast, the chthamalid barnacle species have not been thoroughly studied so far. Information on this group mostly concerns specimens occasionally collected within the frameworks of several environmental studies, where only *C. stellatus* is mentioned for the mediolittoral zone (Lipej *et al.*, 2005).

The aim of the present work was: (a) to investigate the species composition of the mediolittoral chthamalids along the Slovenian rocky shore and (b) to give a general description of the new found species, as well as its basic morphological feature and its habitat. The study was carried out in the summer 2007 at nine sites along the Slovenian coast. The results obtained provide detailed data on the species composition of the mediolittoral chthamalid species, currently unavailable for the considered region.

MATERIALS AND METHODS

Study area

The Slovenian coast covers the southern part of the Gulf of Trieste. The coastline is approximately 46 km long with two main bays, the Bay of Koper and the Bay of Piran, and two smaller bays, the Bay of Izola and the Bay of Strunjan. The coast is composed mainly of Eocene flysch layers (Ogorelec *et al.*, 1997), while in certain areas of Izola the coast is composed of limestone with alveolines and nummulites (Pavlovec, 1985).

The study was restricted to hard, rocky substrata in the mediolittoral of nine sites located along the Slovenian coast (Fig. 1). Sites S1 (Valdoltra: 45°34'51" N, 13°43'20" E) and S2 (Ankaran: 45°34'17" N, 13°44'32" E) are located on the northern side of Koper Bay, which is generally exposed to wave action generated by southwesterly and southeasterly winds. The substratum of the two sites is composed of limestone and sandstone breakwater rocks. Site S3 (Viližan: 45°32'49" N, 13°41'11" E) is situated on the southern part of Koper Bay between Koper and Izola. The shore, which is composed of limestone breakwater rocks, was at that time exposed to wave action and winds blowing in southwest-northeast direction. Site S4 (Izola-Lighthouse: 45°32'32" N, 13°39'42" E) is situated in the

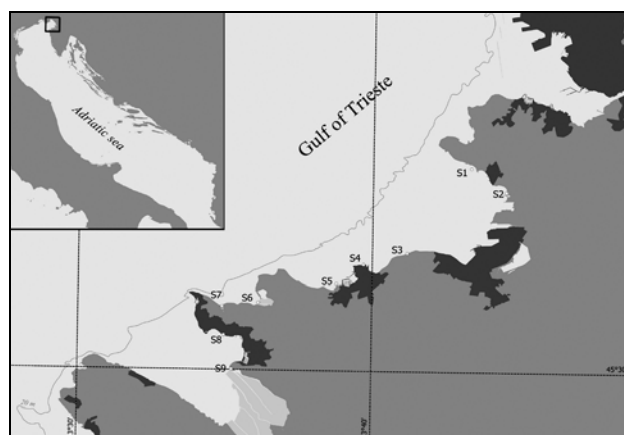


Fig. 1: Map of the investigated area indicating sampling sites.

Sl. 1: Zemljevid raziskovanega območja z vzorčišči.

northern part of Izola, while Site S5 (Simonov zaliv: 45°32'04" N, 13°38'47" E) is located in Simon Bay approximately 500 m away. The substratum of both sites consists of limestone with alveolines and nummulites (Pavlovec, 1985) and is generally of more or less irregular and heterogeneous structure, with many outcrops and crevices of variable sizes. The wind exposure was north-westerly and northeasterly. Site S6 (Strunjan: 45°31'36" N, 13°36'08" E) is situated in Strunjan Bay along the outer border of the salt pans. It was exposed to wave action and winds blowing mainly from the west; the substrata consisted of limestone breakwater. Site S7 (Fiesa: 45°31'30" N, 13°34'54" E) was located between Strunjan and Piran and was exposed to wave action and winds blowing mainly westwards from northeast. The substrata consisted mainly of solid sandstone. Site S8 (Portorož: 45°30'49" N, 13°34'58" E) is situated in the northern part of the Gulf of Piran on hard substrata composed by limestone. The site was exposed to winds blowing from the south. Site S9 (Seča: 45°30'01" N, 13°35'15" E) is located in the middle of Piran Bay (Seča). The substrata is composed of limestone breakwater rocks and exposed to wave and winds blowing from the west.

Collection and examination of samples

Sampling was carried out in August 2007. At each site, one transect 10 cm wide was randomly selected in the mediolittoral zone, from the upper to the lower limit of the chthamalid barnacles. Only areas, where chthamalids were more abundant and formed homogeneous community along the whole transect, were used. Each transect was scraped clean using a paint scraper and then rinsed with seawater. Samples were preserved in seawater-ethanol (80%) for later study. The collected material is now kept in the laboratory of the Faculty of Education Koper.

Determination and counting of samples took part in the laboratory, with stereo microscope. According to the

works of Southward (1976) and Relini (1980), there are many criteria used to distinguish the mediolittoral chthamalid barnacles. But, as suggested by A. J. Southward (*pers. comm.*), only the external morphological features were used in this study, as follows: (a) shape of the opercular opening, (b) shape of the adductor muscle scar, and (c) position and curvature of the articulation between terga and scuta.

RESULTS AND DISCUSSION

In general, the mediolittoral zone of the investigated sites was dominated by various combinations of barnacles, mussels, limpets, snails, brown, green and red algae. It was dominated by chthamalid barnacles on the one hand, and by dense populations of the macrobenthic algal and faunal communities on the other.

Zonation patterns of the investigated sites

A number of communities occurred in mediolittoral zone of the investigated sites, where three horizons (upper, middle and lower) could be recognized. The upper horizon was occupied by chthamalid communities that formed a belt of 15–20 cm in height. They were associated with various communities of microscopic cyanobacteria (among them *Calothrix* sp. formed very large macroscopic colonies in summer time) and macrobenthic green algae (mainly belonging to the genera *Blidin-gia*, *Ulva*, *Chaetomorpha* and *Cladophora*).

Further down, the middle horizon formed a belt of about 60 cm in height (between the mean high water and mean low water). It was occupied by *Chthamalus* species and other faunal species typically found on rocks as gastropods (*Monodonta* sp., *Gibbula* sp.), limpets (*Patella* sp.) and anthozoans (*Actinia equina*). The most common macrobenthic algae of this horizon were red algae (belonging to the genera *Gelidium* and *Polysiphonia*). Most abundant among the green algae were

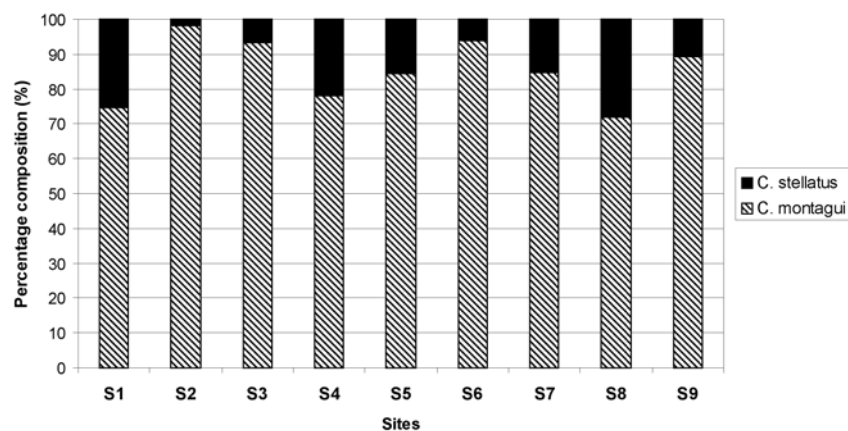


Fig. 2: Percentage composition of *C. stellatus* and *C. montagui* at sampling sites.
Sl. 2: Odstotna sestava vrst *C. stellatus* in *C. montagui* na posameznih vzorčičih.

Ulva compressa and *Cladophora* sp. The most characteristic alga of this horizon was the brown algae *Fucus virsoides*, which generally occupied the entire horizon.

The lower horizon occupied an area of about 15–20 cm in height. It was inhabited mainly by dense aggregates of the bivalve *Mytilus galloprovincialis*. Among macrobenthic algae, it was the green *Ulva laetevirens* that dominated this horizon. Where the surface of the shore was poor in vegetation and fauna, the chthamalids dominated.

Species composition

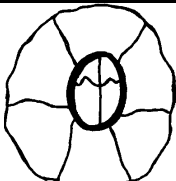
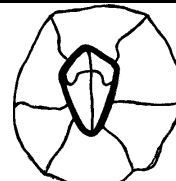
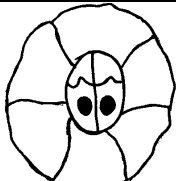
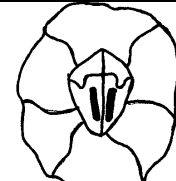
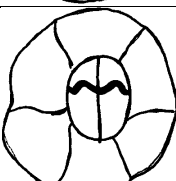
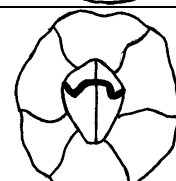


During the investigation, three chthamalid barnacle species were identified: *Euraphia depressa*, *Chthamalus stellatus* and *C. montagui*. *E. depressa*, characteristic of

supralittoral zone, was restricted only to the upper horizon of mediolittoral zone and was very rare, which is the reason why it was not considered in this study. The chthamalid populations were in general more abundant in the upper horizon of the midlittoral. In the middle and in the lower horizons they were rare, but where the surfaces were poorer in vegetation and fauna, the chthamalids prevailed.

The results of the analysis concerning the percentage composition in chthamalid populations showed that two species, *C. montagui* and *C. stellatus*, co-occurred in mediolittoral zone of the sampling sites. Although the percent composition of these two species varied from site to site, *C. montagui* was, in general, significantly more abundant than *C. stellatus* at all investigated sites (Fig. 2).

Tab. 1: General synoptic table indicating basic external morphological features for identification of *C. stellatus* and *C. montagui*.

Tab. 1: Preglednica, ki ponazarja temeljne določevalne zunanje morfološke znake vrst *C. stellatus* in *C. montagui*.

Criteria for identification		<i>Chthamalus stellatus</i>		<i>Chthamalus montagui</i>	
Shape of the opercular opening		Oval or circular		Kite-shaped	
Shape of the adductor muscle pit		Wide, deep and rounded		Long, narrow and close to the occludent margin	
Articulation between terga and scuta	position	One third or more of the opercular opening (from the carina to the rostrum)		Less than one third of the opercular opening (from the carina to the rostrum)	
	curvature	Convex towards rostral plate		Concave towards rostral plate	
Figure					

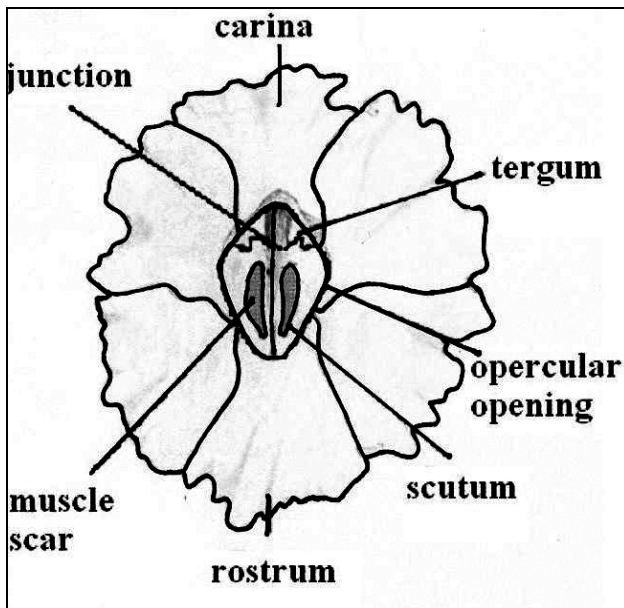


Fig. 3: General structure of *C. montagui* by external features.

Sl. 3: Splošna zgradba vrste *C. montagui* po zunanjih znakih.

Description of *C. montagui*

During the present investigation, the occurrence of *C. montagui* was noted for the very first time along the Slovenian coast. To this end, a brief description of this species, based on the external morphological features, is given (Southward, 1976).

The shell of *C. montagui* is up to 6 mm (max distance from the rostrum to the carina) and is composed of 6 coarsely ridged wall plates (rostrum, carina, 2 rostrolaterals plates and 2 carinolaterals plates). It is often difficult to distinguish the single plates because of corrosion and overgrowth of algae, endolithic and epilithic cyanobacteria and lichens. The shell has a more angular appearance due to the kite-shaped opercular opening. Adductor muscle pits (visible on the scuta) are long, narrow and close to the occludent margin. Articulations between terga and scuta that cross the centre line are quite close to the carina, less than one third the distances to the rostrum. Scuta are longer than wide, while terga are short and wide. The apical angle is usually less than 90° (Fig. 3).

Table 1 illustrates the identification procedure of *C. stellatus* and *C. montagui* based on external morphological features. This investigation indicated that: (a) two chthamalid barnacle species co-occur in mediolittoral zone of the Slovenian rocky shore: *C. montagui* and *C. stellatus*, and (b) that the former was significantly more abundant than the latter. This is in accord with previous studies by Pannacciulli & Relini (2000) for the Italian part of the Gulf of Trieste.

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PRVI PODATKI O VRSTI *CHTHAMALUS MONTAGUI* SOUTHWARD, 1976 (CRUSTACEA: CIRRIPIEDIA) VZDOLŽ SLOVENSKEGA MORSKEGA OBREŽJA (TRŽAŠKI ZALIV, SEVERNI JADRAN)

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POVZETEK

Prispevek obravnava mediolitoralno vrsto rakov vitičnjakov iz rodu *Chthamalus*, *Chthamalus montagui* Southward 1976, ki doslej ni bila znana za slovensko morsko obrežje (Tržaški zaliv, severni Jadran). Raziskava je potekala v poletnem obdobju leta 2007 v mediolitoralu trdne podlage na devetih vzorčiščih vzdolž slovenskega obrežja. Namen raziskave je bil: (a) ugotoviti vrstno sestavo populacij rakov iz rodu *Chthamalus* vzdolž mediolitorala slovenskega morskega obrežja in (b) podati splošni opis nove ugotovljene vrste na temelju zunanjih morfoloških značilnosti ter opisati življenjski prostor te vrste. Raziskava je pokazala, da sta vrsti *C. montagui* in *C. stellatus* Poli, 1791 temeljni komponenti mediolitoralnih združb rakov iz rodu *Chthamalus* in da je vrsta *C. montagui* številčnejša. V prispevku je prikazana tudi splošna preglednica, ki ponazarja temeljne določevalne zunanje morfološke znake obeh vrst.

Ključne besede: mediolitoral, *Chthamalus montagui*, *Chthamalus stellatus*, Tržaški zaliv, severni Jadran

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