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THE STRUCTURE AND SEASONAL VARIATIONS OF *BANGIA ATROPURPUREA* (ROTH) C. AGARDH (BANGIALES, RHODOPHYCEAE) COMMUNITY FROM THE SLOVENIAN COAST (NORTHERN ADRIATIC)

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ABSTRACT

The results of a study on Bangia atropurpurea *community, carried out in 2003 on hard substrata of the upper midlittoral zone at two stations on the Slovenian coast (northern Adriatic Sea), are presented. The investigation was based on monthly sampling that permitted a better characterization of the floristic composition, seasonal variations, community structure and reproductive phenology of* B. atropurpurea *at both stations.*

Key words: *Bangia atropurpurea* community, marine vegetation, northern Adriatic Sea

STRUTTURA E PERIODISMO DEL POPOLAMENTO A BANGIA ATROPURPUREA *(BANGIALES, RHODOPHYCEAE) DELLA COSTA DELLA SLOVENIA (ALTO ADRIATICO)*

SINTESI

Vengono presentati i risultati di uno studio su un popolamento a Bangia atropurpurea, *svolto nel 2003 e presente su substrato duro del mediolitorale superiore in due stazioni della costa della Slovenia (alto Adriatico). Lo studio, basato su rilievi mensili, ha permesso di meglio caratterizzare tale popolamento riguardo la composizione floristica, la variazione stagionale, la struttura e la fenologia riproduttiva della* B. atropurpurea *in entrambi le stazioni.*

Parole chiave: popolamento a *Bangia atropurpurea*, vegetazione marina, alto Adriatico

INTRODUCTION

The red algae belonging to the genus *Bangia* are cosmopolitan entities widely distributed from subtropical to colder regions of both hemispheres. They have a great capacity to tolerate a wide range of salinity, so are commonly found in both freshwater and marine habitats (Sheath & Cole, 1980, 1984).

Bangia atropurpurea (Roth) C. Agardh is the only species of the genus *Bangia* known from freshwater and marine habitats of the Mediterranean region, although numerous species of the same genus have been described from the Mediterranean areas, but under different names (Trevisan De Saint Leon, 1841; Ardissone, 1883; De Toni, 1897, 1904; Preda, 1908). Marine populations of *B. atropurpurea* usually occur in a wide zone above the water line (upper midlittoral) in moderately exposed habitats (Gargiulo *et al.*, 1991).

The thallus of the algae *B. atropurpurea* is formed by filaments usually 5–10 cm long, aggregated into patches. The filaments are attached at base adhering closely to rocks with rhizoids. Filaments are purple-violet in colour, but often more reddish in summer; initially, they are uniseriate, but eventually become multiseriate through successive divisions of the cells. The life-cycle of the Mediterranean *B. atropurpurea* species consists of two distinct heteromorphic phases involving an alternation between macroscopic, gametophytic phase, and microscopic sporophytic, *"conchocelis"* phase. The thalli of this species consist of different types of filaments: vegetative, sporophytic, gametophytic male and female. Vegetative filaments are uniseriate and multiseriate and produce monospores. Gametophytic filaments form male and female reproductive structures on separate thalli. Male filaments produce spermatia, while female filaments produce carpogonia. After fertilization, the developed zygotosporangia produce zygotospores. Spores germinate in uniseriate-branched sporophytic filaments, which represents the conchocelis phase. The conchocelis filaments release conchospores that germinate forming new gametophytic filaments (Gargiulo *et al.*, 1996).

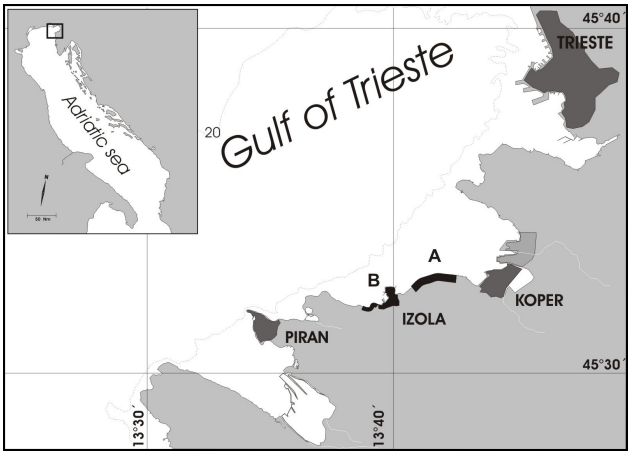

Fig. 1: Study area with sampling stations A and B.
Sl. 1: Raziskovalno območje z vzorčevalnima postajama A in B.

Temperature and photoperiod are the most important ecological factors acting in the regulation of the sporophytic and gametophytic phase alternation of *Bangia* populations in nature. Gametophytic filaments occur in the upper part of the midlittoral zone from winter to springtime. It is notable that the macroscopic phase begins to disappear in nature at temperatures higher than 25 °C (Gargiulo *et al.*, 1996, 1998).

The Mediterranean marine *B. atropurpurea* communities have been described by many authors, such as Lorenz (1863) who reported them from the Adriatic Sea as *"Bangieta";* Funk (1927) included them in the association with *Bangia-Enteromorpha-Corallina* from Naples (Italy); Feldmann (1937) described the "Association à *Bangia-Ulothrix"* from France; Boudouresque (1971) included this community in the facies *Chthamaletum stellati* (Feldmann) Boudouresque 1971. Recently, Ballesteros (1992) described the presence of a "Comunitat de *Bangia*" from Spain. In their phytosociological revision of both supralittoral and midlittoral marine algal communities from the Mediterranean Sea, Giaccone *et al.* (1993) described the *Bangietum atropurpureae* Giaccone 1993 association with *B. atropurpurea* and *Ulothrix flacca* (Dyllwin) Thuret, as characteristic species.

Along the Slovenian coast, *B. atropurpurea* is widely distributed on rocks or, during high tides, especially in habitats moderately exposed to wave action subjected to frequent exposure to air and desiccation. The *B. atropurpurea* community is visually recognized as closely adherent, often shiny purplish red to brownish mats of filamentous growth. In late winter and early spring, *B. atropurpurea* may the community's predominant species. The presence of *B. atropurpurea* along the Slovenian coast has been reported by Matjašič & Štirn (1975), Vukovič (1980, 1981, 1982, 1984), Munda (1988, 1991, 1993), Turk & Vukovič (1994), Vrišer & Vukovič (1996) and Battelli (2000, 2002). The presence of *B. atropurpurea* in Slovenian coastal waters was documented in the work "Cenno sulle alghe di Capodistria", in which its author Accurti (1858) described the marine algal vegetation from Koper Bay (Koprski zaliv). Historically important algal collections with many samples of this species, collected along Slovenian coastal waters, are found in museums, scientific and educational institutions, such as: Museo Civico di Storia Naturale in Trieste, Italy (Accurti and Zaratin collections); "Gian Rinaldo Carli" Grammar School in Koper, Slovenia (Zaratin collection); Center for Marine Research Rovinj, Croatia (Zaratin collection); minorite monasteries in St. Francis's monastery of Cres, Croatia (Titius collection), monastery of the Holy Spirit in Zagreb, Croatia, and Biblioteca Antoniana

in Padova, Italy (both from Titius collection) (Alberti & Battelli, 2001).

The purpose of this study was to investigate the floristic composition, structure and seasonal variations of *B. atropurpurea* community on hard substrata of the midlittoral zone from two stations on the Slovenian coast, *i.e.* on the Koper – Izola shore and along St. Simon Bay (Simonov zaliv). The research was carried out monthly during the year, which permitted a better characterization of the reproductive phenology of *B. atropurpurea* algae.

MATERIALS AND METHODS

The study was carried out on the hard substrata in the upper midlittoral zone at two stations on the Slovenian coast (northern Adriatic Sea) (Fig. 1). The first sampling station (station A) is situated in Koper Bay between the towns of Koper and Izola. The shore consists of limestone breakwater rocks with an extent of approximately 5 km. It is exposed to wave action and open to winds from the northwest (NW) and northeast (NE). The second sampling station (station B) is situated in St. Simon Bay near Izola; it is a stretch of rocky shore with a horizontal scope of about 250 m. The area is exposed to wave action and open to winds blowing from southwest (SW) to northeast (NE). The substratum consists of limestone with alveolines and nummulites (Pavlovec, 1985). Both stations are influenced mainly by the north-north-easterly wind (known as *"burja"* or *"bora").*

During this investigation, the tidal range was about 150 cm and the sea surface temperature ranged from 8.5 °C in January to 26.2 °C in August (Tab. 1).

Tab. 1: Sea surface temperature (°C) during the investigation period (January-December 2003).
Tab. 1: Temperatura površine vode (°C) v času raziskave od januarja do decembra 2003.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp.	8.5	9.2	11.2	12.7	19.2	24.8	24.9	26.2	23.5	20.2	17.4	14.2

In total, 36 samples were collected from January to December 2003. At each station, three quantitative samples were collected monthly and randomly from the hard substrata by direct method from the upper midlittoral zone. All algae were removed from 100 cm^2 (10 cm x 10 cm) squares chosen in the areas where the community was detectable by the naked eye. Care was taken to collect samples at least 1 m away from each other. The collected material was stored in 4% seawater-formalin solution and examined in the laboratory using a microscope to determine algal species and to estimate the cover of each species. Abundance of species was expressed as percentage cover. A 10 x 10 cm square was divided into 100 sub-squares and the sum of the sub-squares covered by single species was treated as the percentage cover for that particular species. Voucher specimens were made and kept in personal herbarium.

Following Boudouresque (1971) and in order to better define the community's structure, the species number (N), percentage cover (Ri) and Shannon-Weaver diversity index (H') were calculated for each month and each season for each sample. Moreover, the quantitative dominance (DR % = Ri/Rt x 100) was calculated for *B. atropurpurea*. To evaluate the similarity on the basis of floristic composition between the two stations, the Soerensen's index (SQ) was calculated as well.

The reproductive phenology of *B. atropurpurea* was also studied throughout the year, noting the occurrence in different months of non-reproductive filaments (uniseriate and pluriseriate), male gametophytic filaments with spermatia, female gametophytic filaments with carpogonia, and zygotospores and filaments with monospores.

Algal nomenclature of Drouet (1981), Ribera *et al.* (1992), Gallardo *et al.* (1993) and Silva *et al.* (1996) was used.

To delineate phytogeographic regions of benthic algae, the following scheme was used: Atlantic **A** (including **Ab** – Atlantic-boreal, **Abt** – Atlantic boreo-tropical, **AP** – Atlanto-Pacific, **APct** – Atlanto-Pacific cold temperate, **At** – Atlantic tropical, **IA** – Indo-Atlantic, **IAt** – Indo-Atlantic tropical, **IAct** – Indo-Atlantic cold temperate taxa); Cosmopolite **C** (also including **SC** – Subcosmopolitan); **CB** – Circumboreal; **IP** – Indo-Pacific; **M** – Mediterranean and **P** – Pantropical (Furnari *et al.*, 1999).

RESULTS AND DISCUSSION

Floristic composition

The results revealed that at the two stations the floristic composition of the *B. atropurpurea* communities was basically the same. It consisted of 14 species: Cyanobacteria dominated with 7 species, Chlorophyceae were represented by 4 species, Rhodophyceae were present with 2 species, while the Fucophyceae were represented by the smallest number of species, *i.e.* one species only at station B (Tab. 2).

Tab. 2: Floral numerical and percentage composition at sampling stations.
Tab. 2: Število in odstotek taksonov na vzorčevalnih postajah.

	Station A	**Station B**
Cyanobacteria	7 (53.8%)	7 (50.0%)
Rhodophyceae	2 (15.4%)	2 (14.3%)
Fucophyceae	–	1 (7.1%)
Chlorophyceae	4 (30.8%)	4 (28.6%)
Total	**13**	**14**

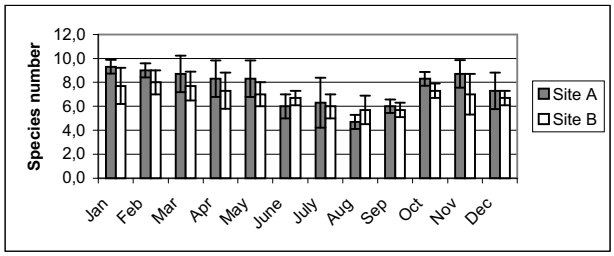

Fig. 2: Monthly variation of means (± SD, n=12) of species number at sampling stations.
Sl. 2: Mesečne variacije srednje vrednosti števila vrst (± SD, n=12) na vzorčevalnih postajah.

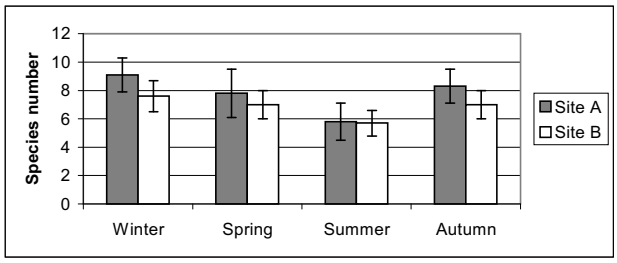

Fig. 3: Seasonal variation of means (± SD, n=9) of species number at sampling stations.
Sl. 3: Sezonske variacije srednje vrednosti števila vrst (± SD, n=9) na vzorčevalnih postajah.

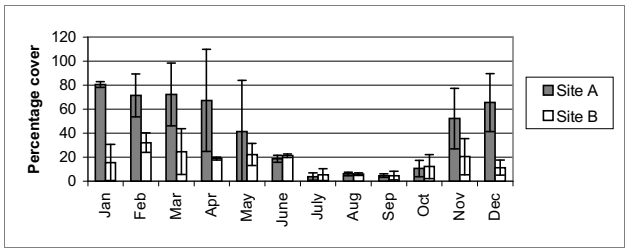

Fig. 4: Monthly variation of means (± SD, n=12) of percent cover of algae at sampling stations.
Sl. 4: Mesečne variacije srednje vrednosti pokrovnosti alg (± SD, n=12) na vzorčevalnih postajah.

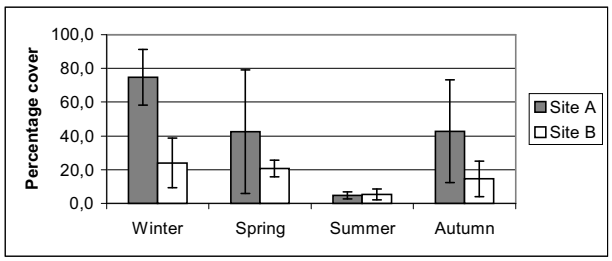

Fig. 5: Seasonal variation of means (± SD, n=9) of percent cover of algae at sampling stations.
Sl. 5: Sezonske variacije srednje vrednosti pokrovnosti alg (± SD, n=9) na vzorčevalnih postajah.

Seasonal variations

At station A, the mean species number decreased slightly from January to August, then increased from August to November, and eventually decreased again in December. At station B, the situation did not follow the same trend. It increased slightly from January and then decreased by September; it increased again in October and then decreased by December (Fig. 2). Seasonal variations of the mean species number for both stations showed the same trend: it decreased from winter to summer and then increased by autumn. Although the mean species number at station A was slightly higher than at station B, the analysis showed basically the same values for both stations in the summer months, 5.7 at station A and 5.8 at station B (Fig. 3).

Community structure

The mean percentage cover at station A was markedly higher (41.2%) then at station B (16.2%) (Tabs. 3 and 4). Temporal fluctuation of the mean percentage cover at station A decreased markedly from January to July, then increased slightly by October, and eventually increased markedly by December. The algal cover at station B did not follow the same trend. It increased from January to February and then decreased slightly by September. After that, a slight increase was observed till November, while in December the cover decreased markedly (Fig. 4). Seasonal variation of the mean percentage cover at station A showed the highest values during the spring and autumn, *i.e.* 74.8% and 42.8% respectively. The algal cover decreased markedly from winter to spring and then increased from summer to autumn. The lowest values were calculated in the summer, only 4.8%. At station B, the situation followed the same trend, although the values were basically lower than at station A. It should be noted that the cover values at both stations in the summertime were very similar, *i.e.* 4.8% at station A and 5.3% at station B (Fig. 5).

The mean Shannon-Weaver index value at station A was slightly lower (0.7) than at station B (1.0) (Tabs. 3 and 4). The analysis of temporal fluctuation of diversity mean values indicated some differences between the two florae. In general, the values at station A were slightly lower than at station B during all months, except in July when the value at station A was markedly higher (1.2) than at station B (0.8) (Fig. 6). The mean diversity seasonal fluctuation at station A showed the highest value in the summer (1.0) and the same values during the winter

Tab. 3: *B. atropurpurea* ***community of the Koper-Izola coast. The reproductive phenology is reported only for*** *B. atropurpurea* ***as: m = male gametophyte, f = female gametophyte, j = juvenile stage. (For the names of species see Annex – check list.) *Cover abundance values (see Table 4)***

Tab. 3: Združba z vrsto *B. atropurpurea* ***vzdolž obale Koper – Izola. Reproduktivna fenologija je prikazana le za vrsto*** *B. atropurpurea* ***in sicer: m = moški gametofit, f = ženski gametofit, j = začetni štadij razvoja. (Za imena vrst glej Annex – check list.) *Vrednosti pokrovnosti (glej Tabelo 4)***

Sub-area	**8**			**4**			**5**			**6**			**12**			**2**		
Month	January			February			March			April			May			June		
Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Season	**Winter**									**Spring**								
Surface/cm²	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Depth/cm	40	35	40	45	35	40	35	30	30	35	45	45	30	40	30	40	45	30
Exposition	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Characteristic species																		
B. atropurpurea	4mf	4mf	4mf	4mf	3mf	3mf	4f	5f	3f	5f	5f	2f	5f	2f	2f	2f	2f	2f
U. flacca	2	2	2	1	3	+	1	1	+	1	1	+	-	1	+	-	1	-
Others species																		
C. crustacea	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
M. lyngbyaceus	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
E. deusta	+	+	1	+	+	1	+	+	1	+	+	+	+	+	+	+	+	1
B. minima	1	+	+	+	2	2	2	1	1	+	1	1	1	+	+	-	1	1
E. conferta	+	+	+	+	+	+	+	+	+	+	-	+	-	+	+	-	+	-
P. leucosticta	+	+	+	1	+	-	+	+	-	+	+	-	+	+	-	-	-	-
U. compressa	1	+	+	+	-	+	-	+	-	+	-	-	+	+	+	-	-	-
A. dimidiata	+	-	-	-	+	-	-	+	-	+	-	+	-	+	-	+	-	+
S. calcicola	-	-	-	-	+	-	-	-	-	+	-	-	-	-	-	+	-	-
U. clathrata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. quojii	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-
% Cover	83.1	78.2	80.6	68.2	90.6	55.5	80.5	93.3	42.9	90.8	92.9	18.1	90.5	18.3	15.7	15.4	20.4	20.3
Diversity (H')	0.8	0.6	0.7	0.4	1.1	0.8	0.7	0.3	0.5	0.2	0.3	0.6	0.2	0.7	0.3	0.2	0.8	0.8
Species number	10	9	9	10	10	8	8	11	7	11	7	8	7	10	8	6	7	6
Evenness (J)	0.3	0.3	0.3	0.2	0.5	0.4	0.3	0.1	0.3	0.1	0.2	0.3	0.1	0.3	0.1	0.1	0.4	0.5

Sub-area	**7**			**10**			**1**			**9**			**3**			**4**					
Month	July			August			September			October			November			December					
Sample	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36			
Season	**Summer**									**Autumn**											
Surface/cm²	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100			
Depth/cm	45	35	45	40	45	35	40	30	30	30	45	40	35	40	35	40	30	40			
Exposition	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N			
Characteristic species																			Ri	P	Clas-ses
B. atropurpurea	1f	+f	-	-	-	-	-	-	-	1j	+j	+j	2f	4f	3f	3mf	5mf	4mf	32.6	29	IV
U. flacca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+		16	III
Other species																					
C. crustacea	+	+	+	+	1	1	+	1	1	+	1	1	+	+	+	+	+	+		36	V
M. lyngbyaceus	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		36	V
E. deusta	+	+	+	1	+	1	1	+	+	1	+	1	1	+	1	+	+	1		36	V
B. minima	+	1	-	1	-	-	+	+	+	+	2	1	2	2	1	+	+	-		31	V
E. conferta	1	1	+	1	1	+	1	1	-	+	+	+	+	+	+	-	+	+		30	V
P. leucosticta	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	1	+	1		19	III
U. compressa	+	+	-	-	-	-	+	-	-	-	+	-	-	1	+	-	+	-		17	III
A. dimidiata	-	+	-	-	+	-	-	+	+	+	-	+	-	+	-	-	+	-		16	III
S. calcicola	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	+	-		6	I
U. clathrata	-	-	-	-	-	-	-	-	-	+	+	-	+	+	-	-	-	-		4	I
B. quojii	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-		3	I
% Cover	5.5	5.6	0.4	7.7	5.3	5.2	5.4	5.4	3.0	5.6	18.2	8.0	33.0	80.7	43.0	40.4	88.3	67.9	41.2		
Diversity (H')	1.1	1.2	1.4	1.2	0.9	0.9	1.0	1.0	0.6	1.2	0.6	1.4	1.0	0.7	0.5	0.3	0.1	0.4	0.7		
Species number	7	8	4	5	6	4	6	6	6	8	10	8	8	10	8	6	10	7	7.6		
Evenness (J)	0.6	0.6	1.0	0.7	0.6	0.6	0.6	0.6	0.3	0.6	0.3	0.7	0.5	0.3	0.2	0.2	0.05	0.2	0.4		

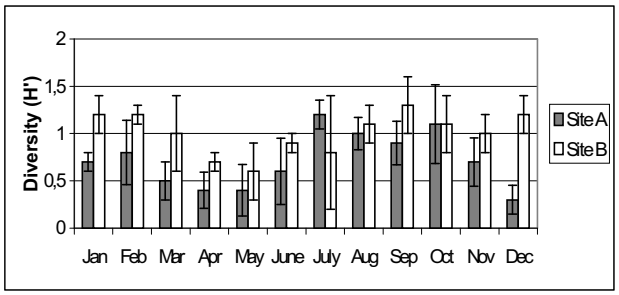

Fig. 6: Monthly fluctuations of means (± SD, n=12) of the Shannon-Weaver diversity index (H') of florae at sampling stations.
Sl. 6: Mesečne variacije srednje vrednosti (± SD, n=12) Shannon-Weaverjevega diverzitetnega indeksa (H') na vzorčevalnih postajah.

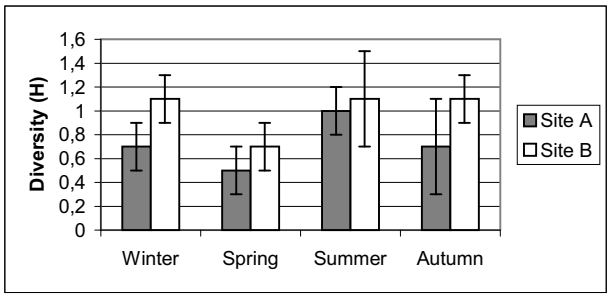

Fig. 7: Seasonal fluctuations of means (± SD, n=9) of the Shannon-Weaver diversity index (H') of florae at sampling stations.
Sl. 7: Sezonske variacije srednje vrednosti (± SD, n=9) Shannon-Weaverjevega diverzitetnega indeksa (H') na vzorčevalnih postajah.

and autumn months. Conversely at station B the value was the same (1.1) throughout the seasons, except in spring when it reached the minimum value (0.7) (Fig 7).

The mean evenness value at station A (0.4) was slightly lower than at station B (0.5) (Tabs. 3 and 4). Temporal variations were basically constant at both stations during all months, although the values at station B were slightly lower than at station A. The analysis showed that only in July the value at station A was slightly higher than at station B (Fig. 8). Conversely, the seasonal mean values of evenness decreased slightly from winter to spring at both stations and then increased markedly by summer reaching the same value (0.6). From summer to autumn, the values remained the same at station B, while at station A they decreased markedly by autumn (Fig. 9). The low evenness values throughout the study period indicate a dominance of a small number of species at both stations particularly in the winter, spring and autumn months due to the presence of gametophytic phase of *B. atropurpurea.*

The results of the study revealed that at both stations the species *B. atropurpurea* was well developed in the upper midlittoral zone of the examined area, forming a belt of dense turf, with a very patchy and irregular distribution. The mean total cover value of *B. atropurpurea* at station A (32.6%) was markedly higher than at station B (8.3%) (Tabs. 3 and 4). The comparison of the percentage cover of this species at the two stations throughout the year showed basically the same trend, although the values at station A were markedly higher than at station B (Fig 10). The percent cover means of *B. atropurpurea* showed great seasonal variations at both stations; the values decreased markedly from winter to spring, reaching the minimum in the summer months and then increased by the autumn (Fig. 11).

The seasonal trend of *B. atropurpurea* quantitative dominance was evident and basically the same at both sampling stations, although the values at station A were markedly higher than at station B (Fig. 12). The values reached the maximum in winter and spring, while the minimum was reached in the summer months due to the seasonal development of this species. As mentioned above, the macroscopic (gametophytic) phase begins to disappear during the summer, when the temperature of the sea is higher than 24 °C (the microscopic (sporophytic) phase has different ecology).

Reproductive phenology of *Bangia atropurpurea*

Different seasonal patterns were manifested, when the reproductive phenology of *B. atropurpurea* was taken into consideration due to the seasonality of the gametophytic phase. Gametophytic filaments appeared in the autumn months, reaching the cover maximum development and values from January to May, and then disappeared in the summer months. For this species, the non-reproductive uniseriate filaments and three types of multiseriate filaments, *i.e.* non-reproductive, female and male, were recorded during this study at both stations. We found that monospores were produced in both, uniseriate and multiseriate non–reproductive filaments, and that gametophytic thalli formed male and female reproductive structures on separate thalli.

The presence in the field of filaments with zygotospores, monospores and gametes is shown in Table 3. Although the values of species number, percentage cover and quantitative dominance of *B. atropurpurea* in different months and seasons varied slightly at both stations, it can be concluded that the examined communities were quite similar at both stations. This is supported by the fact that all the species, except *Fucus virsoides,* present at station B, were common at both stations as well as expressed by the high SQ value (0.96). The low diversity index value of both florae (0.7 at station A and 1.0 at station B) indicated a low community complexity at both stations. The seasonal fluctuation of species number and percentage

Tab. 4: *B. atropurpurea* ***community of St. Simon Bay (Simonov zaliv). The reproductive phenology is reported only for*** *B. atropurpurea* ***as: m=male gametophyte, f=female gametophyte, j=juvenile stage. (For the names of species see Annex – check list.)***

Tab. 4: Združba z vrsto *B. atropurpurea* ***pri Simonovem zalivu. Reproduktivna fenologija je prikazana le za vrsto*** *B. atropurpurea****, in sicer: m = moški gametofit, f = ženski gametofit, j = začetni štadij razvoja. (Za imena vrst glej Annex – check list.)***

Sub-area	**8**			**4**			**5**			**6**			**12**			**2**		
Month	January			February			March			April			May			June		
Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Season	**Winter**									**Spring**								
Surface/cm²	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Depth/cm	40	35	40	45	35	40	35	30	30	35	45	45	30	40	30	40	45	30
Exposition	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Characteristic species																		
B. atropurpurea	1mf	2mf	1mf	2mf	2mf	2mf	1f	2f	3f	2f	2f	2f	2f	2f	2f	2f	2f	2f
U. flacca	+	-	+	1	-	+	1	-	+	+	-	+	-	-	+	+	-	-
Other species																		
C. crustacea	+	+	+	+	1	1	+	+	1	+	+	+	+	+	+	1	1	+
M. lyngbyaceus	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
E. deusta	1	1	1	1	1	1	1	1	1	1	1	+	+	1	+	1	1	1
B. minima	1	2	+	1	1	2	+	1	1	+	1	1	+	2	+	-	1	1
S. calcicola	+	-	-	-	+	+	+	-	+	-	+	-	-	-	+	-	+	-
A. dimidiata	+	-	-	-	+	-	-	+	-	+	-	+	-	+	-	+	-	+
E. conferta	-	+	-	-	-	+	-	-	+	-	-	-	-	-	-	-	+	-
P. leucosticta	+	-	-	2	-	-	+	-	-	+	-	-	1	-	-	+	-	-
U. compressa	-	-	+	-	-	+	-	-	-	+	-	-	+	-	+	-	-	-
B. quojii	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
U clathrata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F. virsoides	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
% Cover	8.1	32.9	5.5	37.8	22.8	35.5	8.0	20.4	45.4	18.2	20.3	18.0	18.0	32.8	15.7	20.4	22.8	20.3
Diversity (H)	1.4	1.0	1.1	1.3	1.1	1.2	1.4	0.8	0.7	0.6	0.8	0.6	0.6	1.0	0.3	0.8	1.1	0.8
Species number	9	7	7	8	7	9	8	7	8	9	6	7	7	6	8	7	7	6
Evenness (J)	0.6	0.5	0.6	0.6	0.6	0.5	0.7	0.4	0.3	0.3	0.5	0.3	0.3	0.5	0.1	0.4	0.6	0.5

Sub-area	**7**			**10**			**1**			**9**			**3**			**4**					
Month	July			August			September			October			November			December					
Sample	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36			
Season	**Summer**									**Autumn**											
Surface/cm²	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100			
Depth/cm	45	35	45	40	45	35	40	30	30	30	45	40	35	40	35	40	30	40			
Exposition	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N			
Characteristic species																			Ri	P	Classes
B. atropurpurea	1f	+f	+f	-	-	-	-	-	-	-	+j	+j	1f	1f	2f	1mf	2mf	1mf	8.3	29	V
U. flacca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1	-	+		13	II
Other species																					
C. crustacea	1	1	+	1	+	1	1	+	1	1	1	1	1	+	1	+	1	1		36	V
M. lyngbyaceus	+	+	+	+	+	1	+	+	1	+	+	+	+	+	+	+	+	+		36	V
E. deusta	+	1	+	+	1	1	1	+	+	+	1	1	+	1	2	+	+	1		36	V
B. minima	-	1	-	1	-	-	1	+	+	+	2	1	+	2	1	+	+	-		30	V
S. calcicola	+	-	+	-	+	+	+	-	-	+	+	-	-	-	+	+	-	+		18	III
A. dimidiata	-	+	-	-	+	-	-	+	+	-	-	+	-	+	-	-	+	-		15	III
E. conferta	-	1	-	-	1	+	-	-	-	-	1	1	-	-	+	-	-	-		10	II
P. leucosticta	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	1		9	II
U. compressa	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-		8	II
B. quojii	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-		3	I
U clathrata	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-		1	I
F. virsoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		1	I
% Cover	5.4	10.3	0.5	5.2	5.4	7.2	7.8	0.6	5.3	3.1	22.8	10.3	5.4	20.3	35.5	5.5	17.9	10.3	16.2		
Diversity (H)	1.0	1.3	0.2	0.9	1.1	1.3	1.3	1.6	0.9	0.8	1.1	1.5	1.0	0.8	1.2	1.1	1.0	1.5	1.0		
Species number	6	7	5	5	7	5	6	6	5	8	7	7	6	6	9	7	6	7	6.9		
Evenness (J)	0.6	0.7	0.1	0.6	0.6	0.8	0.7	0.9	0.6	0.4	0.6	0.8	0.6	0.5	0.5	0.6	0.6	0.8	0.5		

Class	**% Cover**	**Average values**
+	<1	0.1
1	1.1 – 5.0	2.5
2	5.1 – 25.0	15.0
3	25.1 – 50.0	37.5
4	50.1 – 75.0	62.5
5	75.1 – 100	87.5

****Cover abundance values / *Vrednosti pokrovnosti***

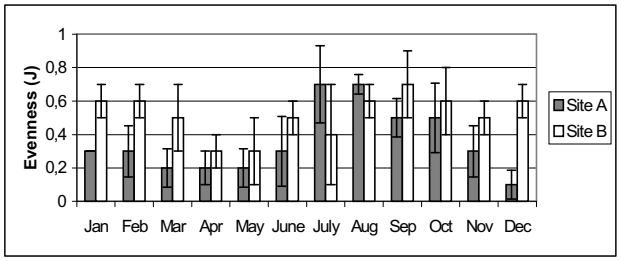

Fig. 8: Monthly fluctuations of means (± SD, n=12) of evenness (J) of florae at sampling stations.
Sl. 8: Mesečne variacije srednjih vrednosti (± SD, n=12) indeksa enakomernosti porazdelitve (J) flore na vzorčevalnih postajah.

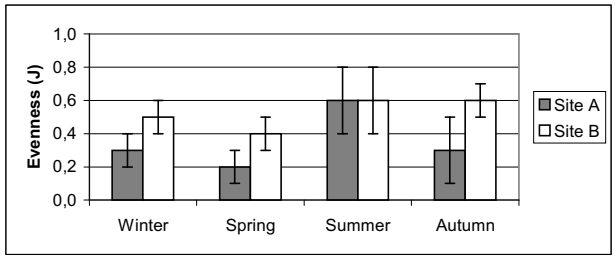

Fig. 9: Seasonal fluctuations of means (± SD, n=9) of evenness (J) of florae at sampling stations.
Sl. 9: Sezonske variacije srednjih vrednosti (± SD, n=9) indeksa enakomernosti porazdelitve (J) flore na vzorčevalnih postajah.

cover at both stations was basically the same, although the values at station A were higher. The mean evenness values were low at both stations and temporal variations of these values followed basically the same trend, although a slight increase of the values was observed during the summer months. The low evenness values indicate a dominance of a small number of species at both stations especially in the winter, spring and autumn months due to development of some seasonal algae, such as *B. atropurpurea* and *Porphyra leucosticta*. On the basis of this study, the *B. atropurpurea* community of both stations may be considered from the syntaxonomic point of view as the association *Bangietum atropurpureae* Giaccone 1993. The author put as characteristics species *B. atropurpurea* and *Ulothrix flacca* in the phytocenological table of sample made during May with the mean of species number value of 9 (Giaccone *et al.*, 1993).

In both florae, cosmopolitan (10) and subcosmopolitan (3) elements dominate, whereas the Mediterranean elements are represented by a single species *(F. virsoides,* only at station B) (Annex – check list).

Tab. 5: Presence in the field of filaments with different spore types and gametes of** B. atropurpurea **during the period January-December 2003.
Tab. 5: Reproduktivna fenologija vrste** B. atropurpurea **v času vzorčevanja od januarja do decembra 2003.

Month	Spermatangia	Carpogonia	Zygotospores	Monospores
January	+	+	+	+
February	+	+	+	+
March	-	+	+	+
April	-	+	+	+
May	-	+	+	+
June	-	+	-	+
July	-	+	-	+
August	-	-	-	-
September	-	-	-	-
October	-	-	-	-
November	-	+?	-	-
December	+	+?	-	+

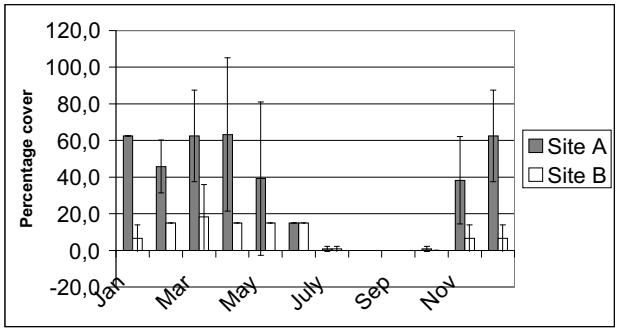

Fig. 10: Monthly variation of means (± SD, n=12) of percentage cover of** B. atropurpurea **at sampling stations.
Sl. 10: Mesečne variacije srednje vrednosti (± SD, n=12) pokrovnosti vrste** B. atropurpurea **na vzorčevalnih postajah.

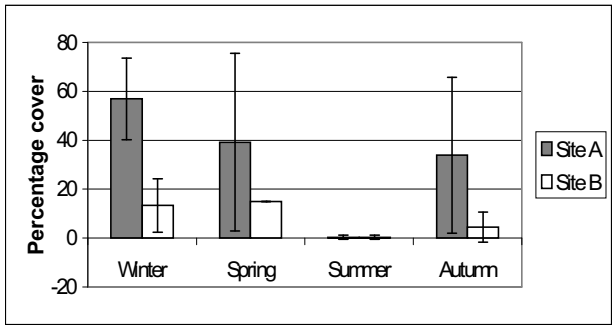

Fig. 11: Seasonal variation of means (± SD, n=9) of percentage cover of** B. atropurpurea **at sampling stations.
Sl. 11: Sezonske variacije srednje vrednosti (± SD, n=9) pokrovnosti vrste** B. atropurpurea **na vzorčevalnih postajah.

Annex – check list

Cyanobacteria
Anacystis dimidiata (Kützing) Drouet & Daily **C**
Brachytrichia quojii (C. Agardh) Bornet & Flahault **C**
Calothrix crustacea Thuret **C**
Entophysalis conferta (Kützing) Drouet & Daily **C**
Entophysalis deusta (Meneghini) Drouet & Daily **C**
Microcoleus lyngbyaceus (Kützing) Drouet **C**
Schizothrix calcicola (C. Agardh) Gomont **C**

Rhodophyceae
Bangia atropurpurea (Roth) C. Agardh **C**
Porphyra leucosticta Thuret in Le Jolis **SC**

Fucophyceae
Fucus virsoides C.Agardh **M**

Chlorophyceae
Blidingia minima (Nägeli ex Kützing) Kylin **SC**
Ulva clathrata (Roth) C. Agardh **C**
Ulva compressa Linnaeus **C**
Ulothrix flacca (Dillwyn) Thuret **SC**

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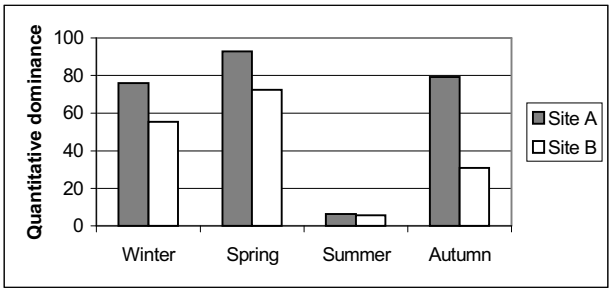

Fig. 12: Seasonal variation of quantitative dominance of** B. atropurpurea **at examined sites.
Sl. 12: Sezonske variacije količinske dominance vrste** B. atropurpurea **na vzorčevalnih postajah.

SESTAVA IN SEZONSKA SPREMENLJIVOST ZDRUŽBE Z VRSTO *BANGIA ATROPURPUREA* (ROTH) C. AGARDH (BANGIALES, RHODOPHYCEAE) SLOVENSKEGA MORSKEGA OBREŽJA (SEVERNI JA DRAN)

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POVZETEK

Prispevek obravnava floristično in fitogeografsko sestavo ter sezonske variacije združbe z vrsto Bangia atropurpurea *na dveh postajah slovenskega morskega obrežja (severni Jadran). Namen raziskave je bil opredeliti združbo z vrsto* B. atropurpurea *s floističnega vidika in sezonske spremenljivosti.*

Raziskava je potekala na dveh stalnih vzorčevalnih postajah; ena na valolomnih kamnih vzdolž obalne ceste med Koprom in Izolo (postaja A), druga pa na naravni apnenčasti podlagi v Izoli pri Simonovem zalivu (postaja B). Določenih je bilo 14 vrst, in sicer 7 cianobakterij (50,0%), 2 vrsti rdečih alg (14,3%), 1 rjava (7,1%) in 4 vrste zelenih alg (28,6%).

Raziskava je pokazala, da je združba z vrsto B. atropurpurea *dobro razvita na obeh postajah v zgornjem delu mediolitorala v obliki gostega pasu z zelo nepravilno (mozaično) razporeditvijo. Povprečna vrednost pokrovnosti vrste* B. atropurpurea *na postaji A (32,6%) je bistveno večja od vrednosti na postaji B (8,3%). Fluktuacija vrednosti v letu je na obeh postajah zelo podobna: največje vrednosti so zabeležene v jesenskem, zimskem in spomladanskem času, kar se ujema z razvojnim krogom vrste* B. atropurpurea. *Nizke vrednosti diverzitetnega indexa (H') in visoke vrednosti indeksa podobnosti (SQ=0,96) kažejo na majhno kompleksnost te skupnosti. V obeh združbah prevladujejo kozmopolitski (10) in subkozmopolistski (3) elementi, medtem ko je bila od mediteranskih vrst zabeležena le ena, in sicer* Fucus virsoides *na postaji B.*

S fitocenološkega vidika združba z vrsto B. atropurpurea *predstavlja asociacijo* Bangietum atropurpureae *Giaccone 1993.*

Ključne besede: združba z vrsto *Bangia atropurpurea*, morska vegetacija, severni Jadran

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