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THE INFLUENCE OF SOME ABIOTIC PARAMETERS ON GROWTH INCLINATION IN ASCIDIAN *HALOCYNTHIA PAPILLOSA* (LINNAEUS, 1767) FROM THE NORTHERN ADRIATIC SEA (CROATIA)

M. ŠANTIĆ[1], BILJANA RAĐA[1], ANTONELA PALADIN[1] and G. PLESLIĆ[2]

1 University of Split, Faculty of Science, Department of Biology, 21000 Split, Croatia
2 Blue World Institute of Marine Research and Conservation, 51551 Veli Lošinj, Croatia

Abstract - This study investigated the relationships between growth orientation, body height and depth on sampling sites. The survey was carried out during 2008 in the area of the island Mali Lošinj. A total of 46 specimens of *Halocynthia papillosa* (Linnaeus, 1767) were analyzed. The growth orientation varied from 60° to 80° and body height was in the range of 20 mm to 110 mm. Pearson's correlation coefficient shows the positive correlation between growth orientation and body height and the same correlation is determined between depth and body height. The Spearman rank correlation coefficient shows a more positive correlation neither between growth orientation and body height nor growth orientation and depth.

Key words: Adriatic Sea, ascidians, *Halocynthia papillosa*, growth inclination

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INTRODUCTION

Halocynthia papillosa (Linnaeus, 1767) is an endemic Mediterranean species which also occurs in the eastern Atlantic within an area which extends from the Canary Islands to the Berlengas Islands of Portugal (Ramos-Esplá et al., 2008). It is one of the most common solitary species on the rocky littoral of the Mediterranean Sea (Turon, 1990). In the Adriatic Sea, it inhabits depths between 5 and 40 m (Novosel et al., 2002; Pleslić, 2010). *H. papillosa* is a hermaphroditic species that reproduces once per year in late summer. Ascidians, as sessile suspension feeders, are nutritionally dependent on the surrounding water. They are considered to be non-selective filter-feeders (Jørgensen, 1955; Stuart and Klumpp, 1984). Very little is known about the biology and ecology of this species in the Adriatic Sea. Arko-Pijevac et al. (2001) and Novosel et al. (2002) generally noted *H. papillosa* as a part of the benthic community of the northern Adriatic. Literature referring to other zones is not extensive. In the western Mediterranean, Naranjo et al. (1996) investigated the effects of environmental stress, while Ribes et al. (1999) analyzed the seasonal variation of feeding rates.

On the Mediterranean coralligenous communities, Luna-Pérez et al. (2010) noted that individuals of *H. papillosa* are very sensitive to the adverse effects of SCUBA diving. Kott (1989) reported on the growth orientation of this species on rocky bottoms. The ecophysiology of active zoobenthic filter feeding, including ascidians, was determined by Riisgărd and Larsen (2001). This study investigated the relationships between growth orientation, body height and depth on sampling sites. However, there are no published data about the relationship between body height of *H. papillosa* and depth.

MATERIAL AND METHODS

Study area

The present study was carried out during 2008 in the area of the island Mali Lošinj, situated on the northern part of Adriatic Sea. The samples were collected at four localities: Poljana, Privlaka, Kriška

Table 1. Stations, coordinates, date, depth and substrate of *Halocynthia papillosa* sampling.

Station	Coordinates	Date	Depth (m)	Artificial Substrate
Poljana	N 44°33491 E 14°27711	24. 08. 2008.	5.2 - 10.5	rock bottom
Privlaka	N 44°33767 E 14°26695	26. 08 2008.	4.6 - 6.9	rock bottom
Kriška	N 44°29865 E 14°32191	23. 08 2008.	4.7 - 9.2	rock bottom
Rovenska	N 44°34876 E 14°28215	26. 05 2008.	6.1 – 8	vertical rock surfaces

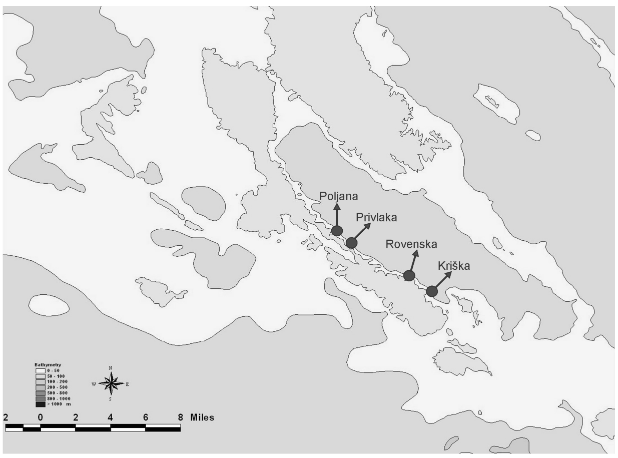

Fig. 1. Sampling locations of ascidians.

and Rovenska (Fig. 1). The stations, coordinates, date, depth and type of substrate of the *H. papillosa* sampling are presented in Table 1.

Sampling procedures

The survey was conducted by scuba diving at depths from 4 to 11 m. Measurements were made *in situ*. During the diving, the localities were chosen according to their similar community, depth, orientation, slope and type of substrate. Body height (in centimeters) and growth orientation (in degrees) were measured by protractor. The degree of growth orientation of each specimen was determined in relation to the Earth surface (Fig 2). The data set on surface sea currents was taken from the data base of Hydrographic Institute Croatia.

Statistical analysis

All statistical analysis was made using STATISTICA 8.0 software. The correlation between body height, growth orientation and depth was tested by Pearson's and Spearman correlation coefficients. For every data set average and mean values were calculated.

RESULTS

A total of 46 specimens of *H. papillosa* were analyzed. The growth orientation varied from 60° to 80°. Body height was in the range of 20 mm to 110 mm. The average growth orientation was 100.32° and that of body height was 69.36 mm (Tab. 2). The major number of individuals (N = 13) had a growth orientation between 80° - 90° (Fig. 3). The average body height revealed the lowest range at the station Rovenska (from 52 mm to 83 mm) (Fig. 4). Correlation analysis using Pearson's coefficient shows the positive correlation between growth orientation and body height ($r = 0.2557$, $p < 0.05$). The same correlation is determined between depth and body height ($r = 0.02351$, $p < 0.05$). The Spearman index shows a more positive correlation neither between growth orientation and body height ($r = 0.6836$, $p = 0.426$) nor between growth orientation and depth ($r = 0.339$, $p < 0.05$) (Fig. 5).

The maximum measurement of current velocity was 19 cm/sec through a water column (from 3 to 65 m). The main current velocity was in SE (29.8%), E (15%) and W (12.2%) directions. From those results it is obvious that current velocities are unstable and slow. Therefore, they are favorable for ascidian growth.

DISCUSSION

The physical parameters, predation and competition are considered to be the most important fac-

Table 2. Total number of individuals per location, height and growth orientation of investigated specimens

Station	Number of individuals	Height (mm)	Growth orientation (°)
Poljana	1	23	80
	2	65	80
	3	45	95
	4	95	90
	5	97	105
	6	36	90
	7	93	140
	8	65	110
	9	107	60
	10	93	90
	11	63	120
Privlaka	1	67	90
	2	60	100
	3	73	150
	4	110	180
	5	63	90
	6	47	105
	7	80	130
	8	90	140
Kriška	1	76	100
	2	80	80
	3	97	95
	4	40	90
	5	67	95
	6	85	100
	7	100	65
	8	90	145
	9	90	65
	10	27	90
	11	55	60
Rovenska	1	66	105
	2	83	115
	3	79	100
	4	80	95
	5	72	135
	6	77	90
	7	52	135
	8	83	105

tors in benthic communities influencing the abundance and distribution of the species. The substrate type, as well as the relationship between environment and larvae, is added to the above elements (Naranjo et al., 1996).

Kott (1996) noted that the growth orientation measurements show that not a single species grows under the angle of 90° and that this species does not grow vertically on rocky substrate. This species has also been found on protruding mainland areas and

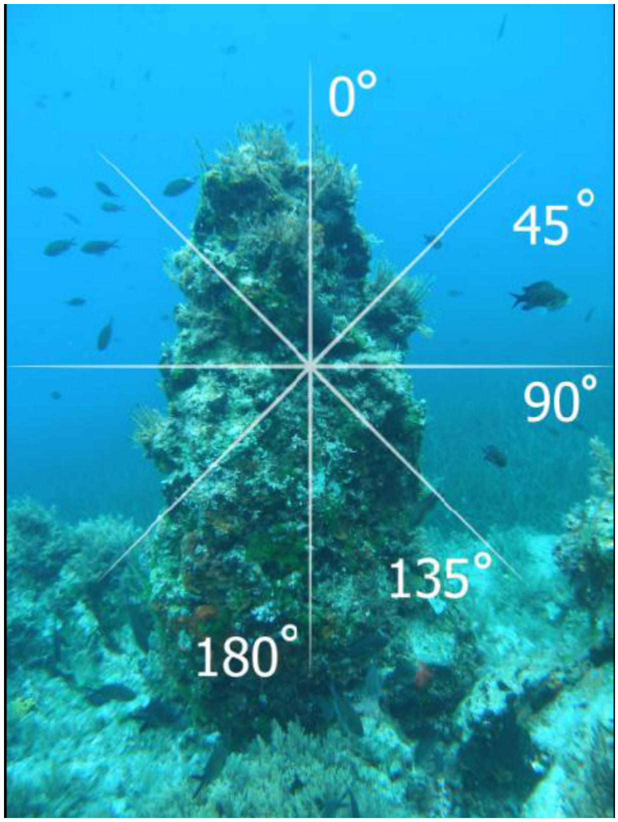

Fig. 2. Shematic scale for growth orientation measurements.

this can be connected with the stronger sea flow and continuous inflow of nutrients. Such a feeding mechanism is especially favorable to the species *Halocynthia papillosa* whose mechanism is adapted to such conditions (Riisgărd and Larsen, 2001). The sampling area is characterized by the relatively high sea clarity, this being in accordance with Moore (1997). In his research, Moore (1997) confirmed that the ascidians inhabit clear seas with lower nutritive concentration and uniform flow. Kott (1989) connects growth orientation with the adjustment of filter feeding. In fact, should ascidians grow vertically it could be possible that two large particles enter the pharyngeal region and this could disturb the feeding.

Kott (1989) and Armsworthy (1996) quote that besides the growth orientation the siphon aperture has a defending function since it is directed

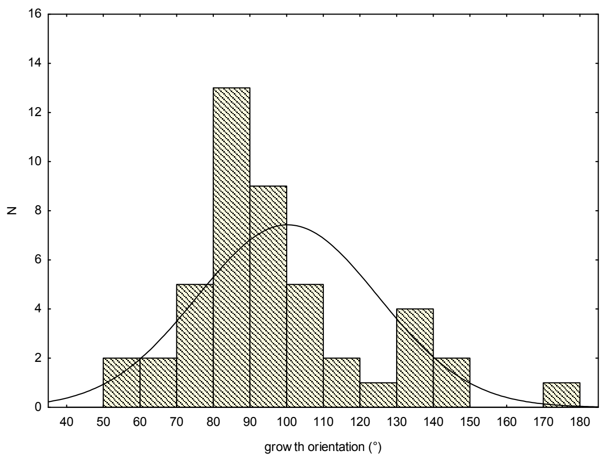

Fig. 3. The growth orientation in the whole sample.

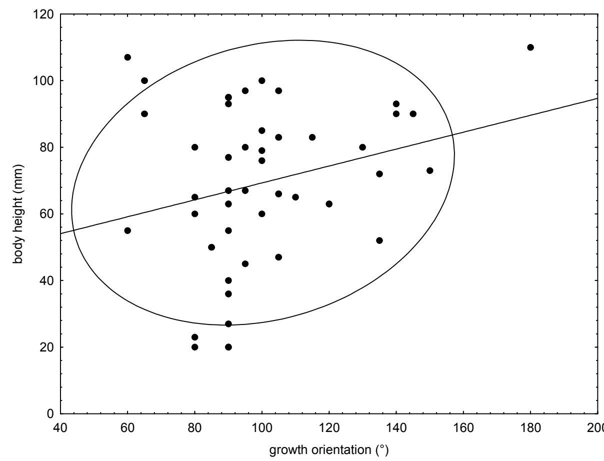

Fig. 5. Correlation between growth orientation and body height.

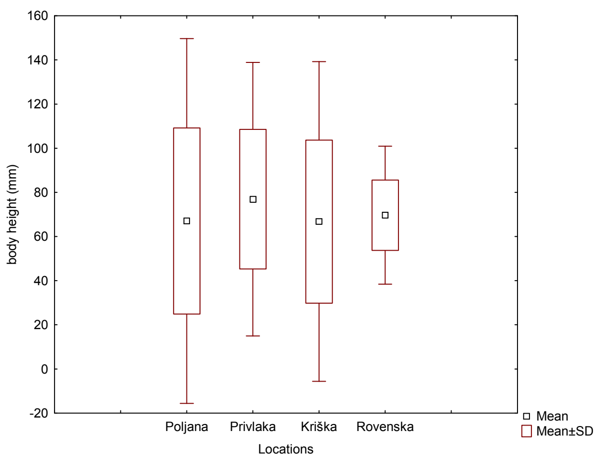

Fig. 4. The average values of body height on four sampling stations..

horizontally or downwards. The same has been established in the present study. Naranjo et al. (1996) states that this species has not been found in habitats of high turbidity or in those under human influence. Therefore, Naranjo et al. (1996) and Luna-Pérez et al. (2010) consider this species to be a clear sea bioindicator.

The average body weight of the investigated species is in accordance with the average body size of the Mediterranean *H. papillosa* (Luna-Pérez et al. (2010). The correlation between depth and body height has been established where larger samples were found in bigger depths. This could be connected to the different velocity of sea currents and the quality of the food they carry. The sea currents in smaller depths show considerable oscillation and this does not comply with the feeding mechanism of ascidians (Naranjo et al., 1996). In greater depths the currents are more uniform, as is the bringing in of food. This suits the species since they feed as active filter feeders with a low energy-pump system which is capable of running continuously (Riisgărd and Larsen, 1996). This fact could be the reason why the body growth is greater than those of the species in shallower depths.

Armsworthy (1996) reports that the pumping frequency of ascidians is in proportion with the food concentration. This means that it depends on the quantity and not the quality of particles.

Also, the positive correlation between depth, body height and growth orientation has been established and this confirms the connection of the above-mentioned parameters with environmental factors such as sea currents and food. There are no published data on the connection between body height and the depth in which *H. papillosa* lives. For instance, Young and Braithwaite (1980) report for the species *Styela montereyensis* that it is oriented as regards the substrate in the direction of the sea current. Comparing the body heights of the samples collected in the bay and in places exposed to intense sea currents, it has been established that the samples from the protruding areas are bigger than those in the bay. Therefore this species prefers the habitats exposed to intense current velocities (Young and Braithwaite, 1980).

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