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Contribution to the ecology of the sponge *Suberites domuncula* (Olivi, 1792): A field study (northern Adriatic Sea, Croatia)*

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Abstract

Background and Purpose: *Through centuries sponges and other marine invertebrates have been widely affected by their use in commercial trade and for human benefit, including usage for public aquaria and in scientific research. Sponge populations are also affected by bottom fishing and by pollution. Due to the limited knowledge about the extent of these factors, the main objective of this study was to estimate the population abundance and color variations of the sponge species* Suberites domuncula *near Rovinj (northern Adriatic Sea, Croatia).*

Materials and Methods: *Specimens of* S. domuncula *were studied in situ and collected by SCUBA diving.*

Results and Conclusion: *During a 16 month period from June 2004 to September 2005, a total of 768 specimens were recorded. We determined for the first time the abundance of* S. domuncula *as one individual per* 2.8 ± 0.9 m^2. *During the research period we observed sponges of different colors: red-orange, blue, yellow, brown, and white, as well as combinations thereof with differing patterns. There was a great prevalence of the red-orange color variety, i.e.* $85.2 \pm 4.4\%$. S. domuncula, *with an abundance of 34 to 96 specimens per 150* m^2 *at the investigated site, did not appear as a threatened species, moreover, according to the data given by Zavodnik and Šimunović (28), it appears to be more common in Rovinj area than in the rest of the northern Adriatic.*

INTRODUCTION

The number of sponge species in the Mediterranean Sea is estimated to be 649 and represents one of the highest diversity of sponges in the world *(1, 2)*. Focusing on the Adriatic Sea, reports described sponges as the predominant and prevalent taxon within their biotopes and gave the illustrative descriptions decisive for a systematic compilation *(3–8)*. The region around Rovinj was repeatedly investigated during the 20th century and so far 151 sponge species have been identified out of the total of sponges 201 in the Adriatic Sea *(9–13)*. Our species of interest, *Suberites domuncula* (Olivi, 1792) (Porifera, Demospongiae, Tetractinomorpha, Hadromerida, Suberitidae) *(14, 15)*, has been used for public aquaria, bioactive substance screening, isolation of symbiotic bacteria, biomonitoring purposes *(16–23)*, etc.

* In Memoriam to Prof. Vera Gamulin, Ph.D (1948–2006)

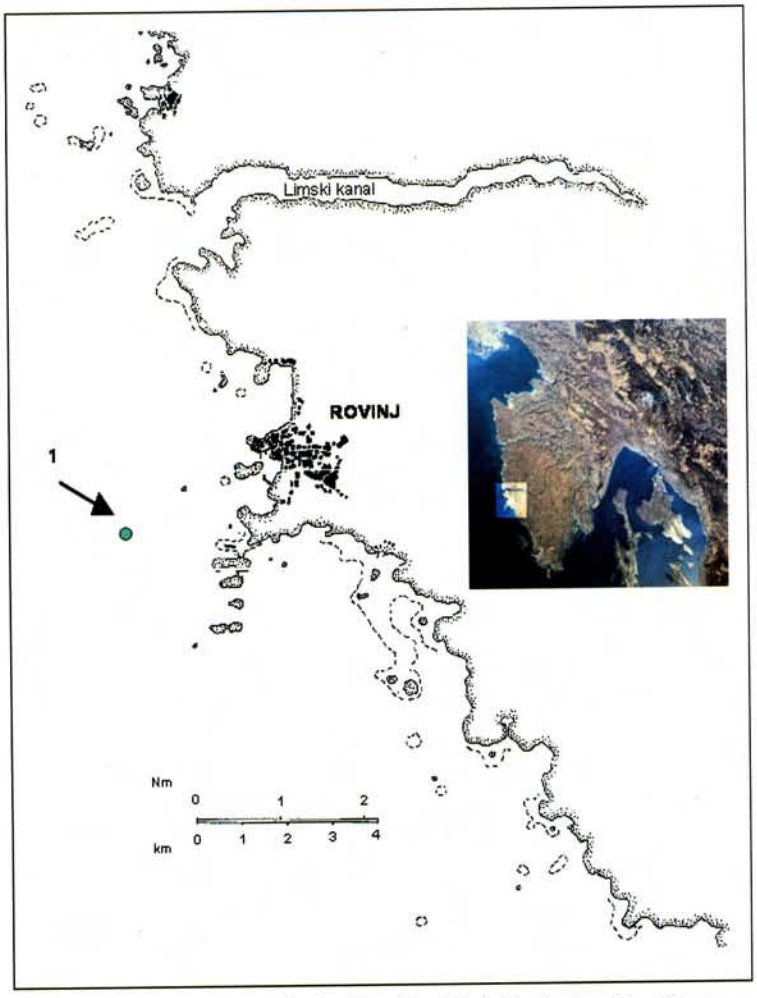

Figure 1. *Investigated site off Rovinj coastal area (northern Adriatic, Croatia) with the fixed point of 3 x 50 m transects.*

In the index of marine fauna in Rijeka Bay (Adriatic Sea, Croatia) Zavodnik and Kovačić *(24)* provided the following information on *S. domuncula* on the basis of their own records and literature reports: General distribution – Atlantic-Mediterranean; Ecological distribution – circalittoral zone; Abundance in the area – common species *(25–27)*. Zavodnik and Šimunović *(28)* gave only a descriptive record for northern Adriatic Sea: 1hr trawling resulted in 750 collected *S. domuncula* specimens and abundance from the northern to southern Adriatic declined to ten specimens per one hour trawling. Autecology of most sponge species, including *S. domuncula* in the Adriatic Sea is still unknown although recent research, using molecular biological methods, enabled distinction of sponge populations of Limski kanal and Rovinj area on the basis of markers that are related to the immune status of *S. domuncula (29)*. Hamer *et al. (30)* clarified the presence/absence of oscula *in situ* and *ex situ* of *S. domuncula* by documentation of the contraction for the first time.

Prior to this fieldwork, very little had been known about abundance and population dynamics of *S. domuncula* in the Adriatic Sea. During collection of biological material using bottom trawl (summer periods 1994–2004) for public aquaria and scientific studies, we had observed fluctuations of *S. domuncula* population density from year to year and specimen variation in coluring. Therefore, the present field research was targeted on the study of abundance and color varieties in order to provide a contribution to the knowledge on *S. domuncula*, essential for assessment and reporting on the state of environment. In general ecological and biological knowledge must be the fundamental basis of responsible and sustainable biotechnological use of marine resources. A closer look in the dynamics of benthic populations will allow a more accurate prediction of the effects of exploiting this environment, e.g. by bottom trawling.

MATERIAL AND METHODS

Research

Specimens of *S. domuncula* were studied *in situ* and collected at a site about 2.7 km off Rovinj (northern Adriatic Sea, Croatia) (Figure 1). Investigated site was characterized by sandy-muddy detritic bottom under the influence of strong currents and particulate deposition.

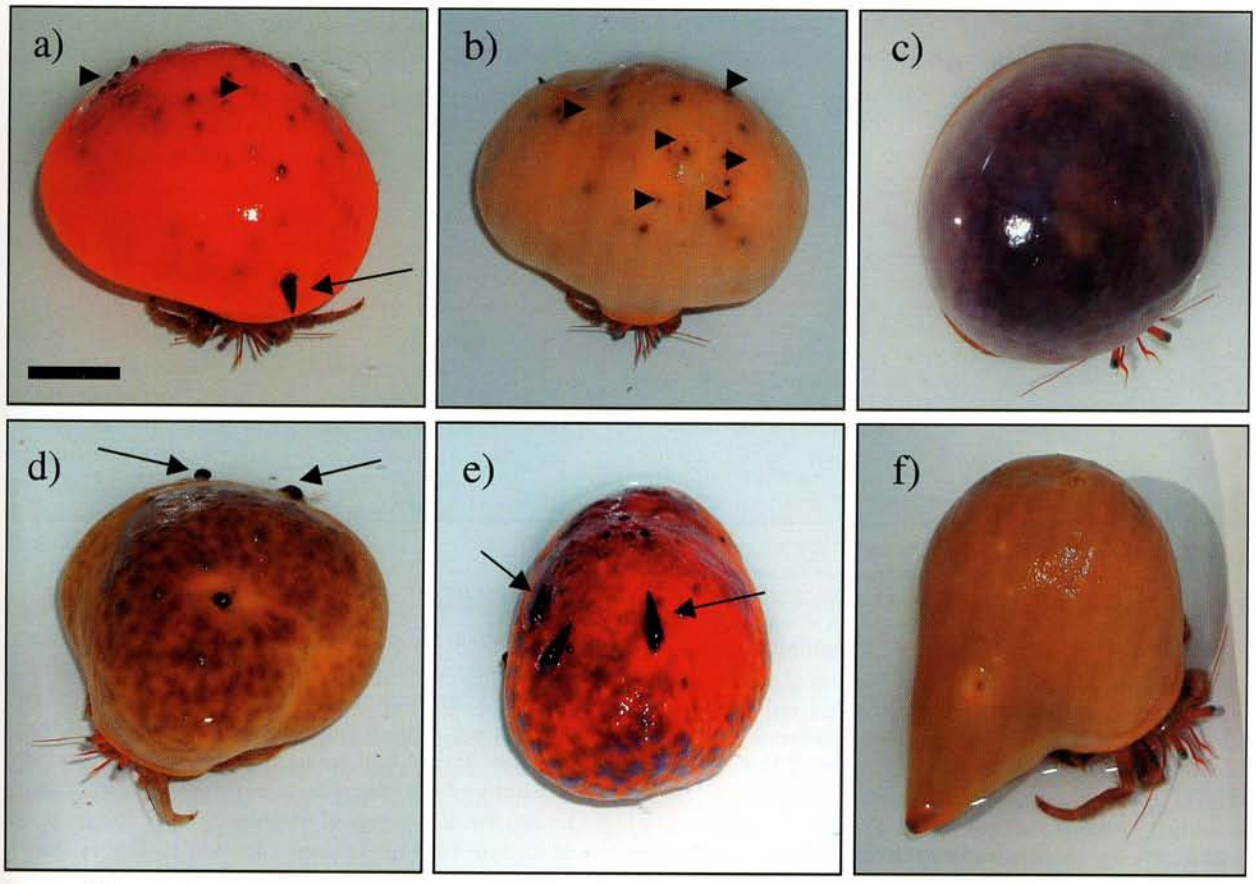

Figure 2. *Color varieties of* Suberites domuncula *with associated hermit crab: a) red-orange, b) white, c) blue, d) brown »marmorate tiger pattern«, e) red-blue and f) yellow. Note living gastropods (*Cerithiopsis *sp.) at the surface of the sponge (arrows), as well as empty shells embedded within the sponge tissue (arrowheads). Scale bar represents 1 cm.*

Material

The sponge *S. domuncula* (Olivi, 1792) generally lives on muddy sand bottoms between 5–40 m (northern Adriatic Sea) and comes to 200 m depth (southern Adriatic and south of France) *(14, 15, 28, 30–35.)*. This sponge overgrows a gastropod shell occupied by hermit crabs e.g. *Paguristes eremita* or *Dardanus arrosor.* Due to an almost obligatory symbiosis, the sponge obtains certain mobility. The collected specimens showed variation in color which may range from red-orange to blue, yellow, brown and white, as well as combinations thereof with differing patterns. Besides various colors, most of collected *S. domuncula* specimens came without visible oscula. Adult specimens are filter feeders ingesting particles through a more or less complex channel system. It was calculated that a marine sponge is able to process the amount of seawater equal to its body volume every 5 s *(36)*.

METHODS

Documentation and collection

S. domuncula specimens were recorded, documented and collected by SCUBA diving from June 2004 to September 2005 whereby SCUBA diving followed the rules of C.M.A.S. (World Unterwater Federation) and decompression dives were performed. Collected specimens were used for long-term *ex situ* investigations under different conditions in aquaria, completion of our Institute collection and analysis of different pigments. After documentation and analysis, approximately half of the collected sponges were transferred back to sea at a place 6 km southward from the studied site according to the sustainable use of marine organism's criteria. The size of sponges measured *ex situ* varied from 2 to 6 cm. During this field study, we performed comparison of the size of sponges measured *in situ* and *ex situ* after collection and established an average contraction of sponge volumes of 52.1%, which was followed by the complete disappearance of the osculum *(30)*. Water depth and water temperature were measured using Aladin diving computer (UWATEC®, Switzerland). The fixed point of transects was determined using GPS device (Garmin®, USA) with an accuracy of <20 feet. From that point, field work was performed each time by the same SCUBA diver along a 3 x 50 m transect (150 m^2 area, 32.8–33.5 m depth) which did not represent any environmental gradient. Bottom surveys were limited to 20 minutes each. During the period of research, bottom temperature varied seasonally from 7 to 17 °C.

TABLE 1

Suberites domuncula abundance: the number of specimens and percentage of different color varieties at the research site.

S. domuncula	2004					2005								
color	June	July	Aug	Sep	Oct	Nov	Feb	March	April	May	July	Aug	Sep	Total	%
Red-orange	69	79	75	65	29	41	59	32	59	40	32	38	36	654	85.2
Blue	5	6	3	3	3	5	2	2		2		1	6	38	4.9
Red-blue	4	2	3	3		1	1		5		2	1	3	25	3.3
White	3	4	4	2	2		1							16	2.1
Brown		5					8	4	3	7	2			29	3.8
Yellow						2					2		2	6	0.8
Total	81	96	85	73	34	49	71	38	67	49	38	40	47	768	100.0
Red-orange (%)	85.2	82.3	88.2	89.0	85.3	83.7	83.1	84.2	88.1	81.6	84.2	95.0	76.6		85.2
Others (%)	14.8	17.7	11.8	11.0	14.7	16.3	16.9	15.8	11.9	18.4	15.8	5.0	23.4		14.8

Color classification

There were noted several color varieties of *S. domuncula*, from red to white color, combination of colors, and some specimens were mottled with brown, red or bluish spots (so called »marmorated« form) (Figure 2). According to color, we divided the recorded *Suberites* specimens into six categories: 1) red-orange, 2) blue, 3) red-blue, 4) white, 5) brown and 6) yellow. Calculated annual average incidences for each category, and monthly ones for dominant red-orange and all other together are presented in Table 1.

RESULTS

Sponge abundance

With an aim to collect data for assessment and reporting the environmental status of *S. domuncula*, we monitored seasonal variations in the abundance of the six different color categories. A total of 768 sponges were recorded and collected in a 16-month period from June 2004 to September 2005 with gaps in December 2004, and January and June 2005 (Table 1). Annual fluctuations of population density varied from 34 to 96 specimens at the investigated site (150 m^2). The calculated mean abundance of *S. domuncula* was 1 individual per 2.8 ± 0.9 m^2.

Sponge color varieties

During the research period individuals of various colors, i.e. red, blue, yellow, brown, and white specimens were recorded. Combinations of colors and patterns were also noted. The greatest annual average incidence ($85.2 \pm 4.4\%$) was determined for the dominant red-orange color variety (Table 1; Figure 2).

DISCUSSION

Sponges (Porifera) are the most numerous sessile, multi-cellular animals found in the marine hard substrate benthos, both with respect to the number of species and biomass *(37–39)*. The present investigation was performed on soft substrate bottom, which has been far less known in this respect. Especially no *in situ* data is available for soft bottom sponges. Focusing on the Adriatic Sea, past research of sponge species diversity provided illustrative descriptions decisive for a systematic compilation. But autecology of the major part of species is still unknown, even of the most common taxa. Very little is known about abundance and population size of the common and abundant sponge *S. domuncula* in the Adriatic Sea, and there are still gaps in our knowledge of growth, migration, behavior, crab-sponge symbiosis, etc.

During this field work we determined the average abundance of *S. domuncula* at the investigated site as 1 specimen per 2.8 m^2, which is much higher than reported previously *(28)*. Annual oscillations of *S. domuncula* abundance were detected. The sponge abundance varied over the year from 34 to 96 specimens per 150 m^2. Besides an unknown anthropogenic impact, this fact might be explained by crab migrations *(40)*. Our results indicated that the population dynamics of *S. domuncula* mainly depends on the hermit crabs motility.

Sponges of different colors (red, blue, yellow, brown, white) and their combination were noticed *in situ*, with dominant red-orange color varieties (82–95%). An increase in yellow *S. domuncula* specimens from northern to southern Adriatic was reported by Zavodnik and Šimunović *(28)*. While keeping sponges in aquaria for a certain period of time we observed changes in their color, from red to lighter tints. The variation could be caused by different contents of associated micro-organisms, if they are the source of the coloration (pigments). Biodiversity and biomass of associated micro-organism is known to decrease during experimental conditions in aquaria, *(41, 42)*. There is no data available, concerning taxonomic variation of different color morphs of *S. domuncula* specimens (subspecies, form, or variety) *(14, 35)* and also color

morphs seem to have nothing to do with different species-subspecies.

There is systematic uncertainty about the sponge *S. domuncula* identity. Not every more or less spherical sponge associated with a hermit crab is necessarily *S. domuncula*, though it seems to be the most abundant epibiontic species. *S. domuncula* was originally described from the Adriatic Sea, but widespread occurrence is maybe an artefact because of a low number of discriminatory morphological characteristics *(14)*. *S. suberia* probably also occurs in the Mediterranean and the records of *S. ficus* could therefore refer to *S. suberia (14, 15, 35, 43)*. The distinguished sponge scientist Maurice Burton synonymized in 1953 many *Suberites*-species under *S. domuncula*, including *S. ficus* and *S. suberia (31)*. Solé-Cava and Thorpe *(43)* showed, however, that they could distinguish between *S. ficus* and *S. suberia* with genetical methods.

Isolation of differently colored micro-organisms (bacteria, algae, and especially fungi) from *S. domuncula* suggested microbial origin of the sponge pigments (Grebenjuk V A, personal communication). Our preliminary analysis of pigments confirmed the presence of red pigment carotene and blue pigment (carotenoprotein) *(44)* in all color morphs in different concentrations. Further research of *S. domuncula* – associated micro-organisms, color varieties and pigments is needed.

Population size is the most important information to be collected for a threatened species. Therefore trend analysis should be the major focus in species categorization and reporting on the state of environment. Species are driven to extinction by deterministic and stochastic factors *(45, 46)*. We started this preliminary study in order to predict vulnerability of *S. domuncula* population off Rovinj, with intention to continue research on long term basis and extend it to establish life cycle, sponge-crab symbiosis, growth parameters, and other unknown natural factors *(47)*. Increasing anthropogenic impact, such as scientific exploitation, bottom-fishing activities *(48, 49)* and pollution *(50–52)* can affect species abundances and community composition directly and/or indirectly *(53–55)*. However, data obtained in present field study are not sufficient to enable factor analysis and hypothesis related to future population size and trend. *S. domuncula*, with an abundance of 34 to 96 specimens per 150 m^2 at the investigated site does not appear to be a threatened species. Moreover, according to the data given by Zavodnik and Šimunović *(28)*, it appears to be more common in Rovinj area than previously described in the northern Adriatic. Combined investigations, experimental (*in vitro*) and ecological (*in situ*) of *S. domuncula* in the northern Adriatic are continued.

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