Acta Adriat., 25 (1/2): 11—27 (1984) YU ISSN: 0001—5113
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BIOTIC ACTION IN FOULING COMMUNITIES ON EDIBLE SHELLFISH — OYSTERS (*OSTREA EDULIS* LINNAEUS) AND MUSSELS (*MYTILUS GALLOPROVINCIALIS* LAMARCK) IN THE NORTHERN ADRIATIC

BIOTIČKA AKCIJA U OBRAŠTAJNIM ZAJEDNICAMA NA JESTIVIM ŠKOLJKAMA — KAMENICE (*OSTREA EDULIS* LINNAEUS) I DAGNJE (*MYTILUS GALLOPROVINCIALIS* LAMARCK) U SEVERNOM JADRANU

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On marked oysters and mussels during 2 and 3 years were observed »in situ« characteristics and changes of epibionts from their occurrence until their death. On the basis of these characteristics (occurrence, habit, manner and rate of growth, vitality, relation to substratum and season, affinity of individuals of the same species, relation imigration-emigration, and particularly the process of direct and indirect biological exclusion) all organisms were classified into 5 different types (from superior to subordinate epibionts). The same epibionts were further on divided into active, inactive and subordinate organisms according to their biological activity (participation in the process of biological exclusion).

Besides the division of epibionts, some other analytical marks were elaborated for the same organisms: frequency, abudance and covering rate.

INTRODUCTION

Biotic action in fouling communities on organisms is an almost unknown phenomenon. Only the prey-predator relationship between the oyster as host (prey) and Turbellaria (predator) has been studied (Staed, 1907; Danglade, 1919; Block, 1925; Palombi, 1931; Bytinski-Salz, 1935). In addition, numerous investigations have been made concerning the relationships in communities of fouling organisms on different substrates. In most cases the prey-predator relationship was examined, the predators being Turbellaria (Lewis, 1954, 1964; Hatton, 1938; Pearse and Wharton, 1938; McDougall, 1934; Lock and Reynoldson, 1976), limpets (Lewis, 1954, 1964; Hatton, 1938; Southward, 1956; Connel, 1961; Dayton, 1971; Bastida et al., 1971; Harger, 1972; Luckens, 1975), sea stars (Harger, 1972; Paine, 1974; Luther, 1977), crabs (Harger, 1972), urchins (Dayton, 1975) and sometimes fish (Miyazaki, 1934; Foster, 1975).

Direct or indirect competition for survival factors (space, food, oxygen) has ben studied fairly frequently. Some organisms influenced the others by fouling and smothering them, either because of flat growth (Redfield and Deevi, 1952; Nikolić, 1959; Hoshiai, 1960; Cory, 1967; Režničenko, 1967; Haderlie, 1969; Zavodnik and Igić, 1968; Igić, 1972; Southerland and Karlson, 1972), great abundance and intensive growth (Hoshiai, 1959, 1960; Connel, 1961a, 1961b; Clarke, 1965; Dimov et al., 1970; Persoone, 1971; Luckens, 1975), or else they devour the spores and larvae of the fouling organisms (Dayton, 1971, 1973; Foster, 1975). Indirectly, some organisms have influence on others by virtue of their elevated growth, functioning as a »natural isolation filter«* (Loosanoff, 1965; Turpaeva, 1967). In addition, filter-feeder organisms and toxic substances excreted by some foulers have a restrictive effect on the settlement of others (Goodbody, 1961; Turpaeva, 1967).

Investigations concerning the relationships in communities have produced rather simplified interpretations. They are usually limited to descriptions of inter and intraspecific competition, i.e. the negative consequences of the influence of some organisms upon others. No detailed analyses have been made of the mutual relationships, nor have the organisms been classified according to the degree of their activity. Only Kawahara and Iizima (1960) divided the macroorganisms into three groups in order to provide a better interpretation of the fouling mechanisms; later, Kawahara (1962) and Bastida (1972) divided them into six groups, also according to their manner of growth and life-span in the community. A more detailed analysis of relationships within a community inevitably requires data on a very large number of characteristics of the foulers in order to determine their importance on the basis of their activity in the community.

The present paper is not concerned with intra- and interspecific relationships in fouling communities on shellfish, since their relationships are to be examined in a further study of the dynamics of these communities.

The aim of this study is to determine the position and activity within the relationships in the community of each species, on the basis of all properties which were possible to observe *in situ*.

It is of particular importance to note that these relationships are manifested on a small area, such as that of shells of oysters and mussels.

MATERIAL AND METHODS

Fouling communities in breeding grounds in Limski kanal, and in the port of Rovinj were studied for two years, and in the breeding grounds at Pomer for three years, all situated in the northern Adriatic on the Istrian coast.

In each investigated site a sample of 108 oysters and 112 mussels was studied. At the beginning of the observation period the oysters were aged

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* According to Turpaeva (1967)

about 10 months, the mussels about 8 months, while the average lengths in the individual localities were 34.50 mm, 42.38 mm, and 53.50 mm respectively for oysters, and 31.74, 33.31, and 34.88 mm respectively for mussels. Before observation, the shellfish were thoroughly cleaned and placed in wooden crates, the top and the bottom of which consisted of zinc-plated wire mesh, The crates were divided into compartments, each containing one shell, which was thus marked. The crates were immersed at a depth of about 150 cm.

Observations were made on each shell at montly intervals concerning all characteristics and changes in each individual in the host community from the moment of the first observation to the death of the epibiont.

In each sample of oysters and mussels taken in all three localities the organisms present were treated in the following manner: a count was made for each month of the number of hosts on which the epibiont was present, i.e. of the *frequency of occurrence;* the arithmetic mean of the total number of the settled epibionts, i.e. *abundance,* was calculated; and also, the area of the fouled valves of the hosts, i.e. the covering was determined.

The *abundance* of each species was expressed in terms of the grade of abundance according to P é r è s and G a m u l i n - B r i d a (1973) on the basis of the average number of specimens (colonies).

Grade of abundance	Average number of specimens (colonies)	Characteristics of abundance
1	from 0 to 0.49	rr (very rare species)
2	from 0.5 to 0.99	r (rare species)
3	from 1 to 9.99	+ (usually present species)
4	from 10 to 99.99	C (frequent species)
5	from 100 to 499.99	CC (very frequent species)
6	over 500	CCC (great abundance)

The amount of *covering* was analysed by phytocenological methods and according to R e v e r d a t t o (1927). It was classified and represented as *real covering* for all organisms which were attached considerably or completely to the substrate. In the case of organisms which were attached only slightly to the substrate (e. g. algae, hydroids, buch-like bryozoans), *projective covering* was taken into account.

5	= irrespectively to the number of specimens the species covers	75—100%
4	= irrespectively to the number of specimens the species covers	50—75%
3	= irrespectively to the number of specimens the species covers	25—50%
2	= very abundant covering	10—25%
1	= abundant, small covering	1—10%
+	= small number, slight covering	

The analytical characteristics (frequency, abundance, covering) are presented in Table 1, showing the average values for all analysed months and investigated localities.

The analysis included sessile and semisessile organisms, as well as Turbellaria, whose frequency of occurrence was over 3%. Other mobile animals were not analysed, since they are not suitable for continuous observations of the dynamics, and also because they are rare members of the fouling communities in the northern Adriatic.

RESULTS

The fouling communities on oysters and mussels inhabiting the northern Adriatic on the Istrian coast are rather heterogeneous in the composition of their species. The largest number of species is found in the less polluted breeding ground at Pomer. It is especially rich in algae, sponges and synascidians, whereas barnacles are totally absent. In the relatively unpolluted breeding ground in Limski kanal, the community is less rich in species; among them, the most frequent are bivalves, the least density settled are algae. In the port of Rovinj, which is polluted by urban wastes and effluents from the fish cannery, the community is fairly rich in species, some of which are abundant (bivalves, barnacles).

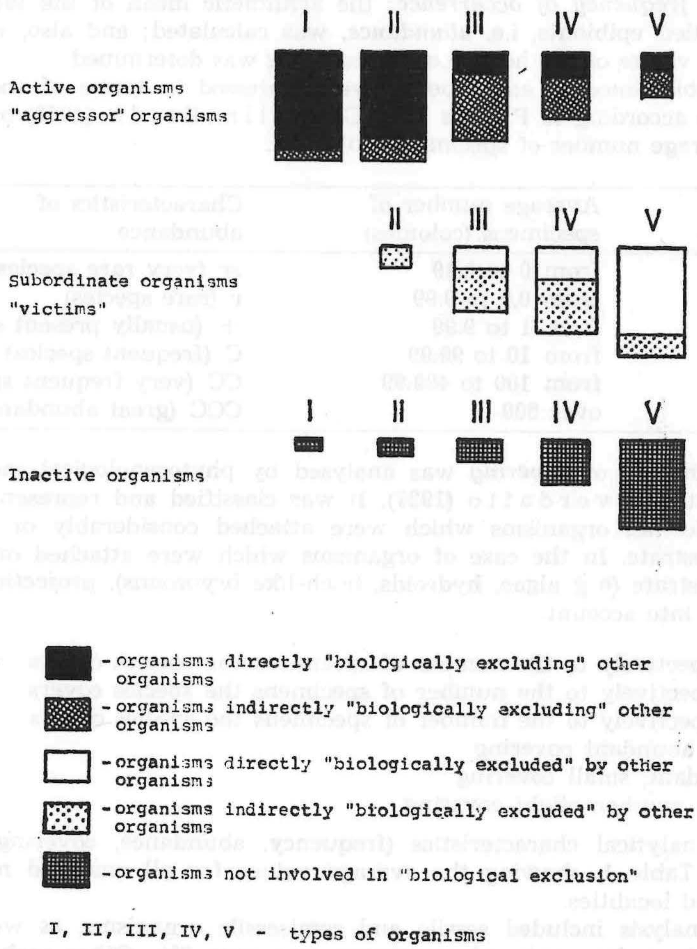


Fig. 1 — Classification of organisms according to their activity in the fouling community on oyster (*Ostrea edulis* Linnaeus) and mussel (*Mytilus galloprovincialis* Lamarck)

The structure of the fouling communities on both hosts is basically the same, except that the flat sponges in colonies do not attach to mussels (Table 1). Greater distinctions were found between the two hosts in regard to the frequency of occurrence and covering, lesser ones in regard to the relative abundance of epibionts. On the whole, all organisms settle more frequently on oysters, which is espicially significant in the case of algae (with the exception of Melobesiaceae), and hydroids, whereas mussels are more frequently settled upon by barnacles (except for *Balanus amphitrite*) and flat bryozoans *(Schizoporella)*.

The abundance was not high in any of the species found, ranging on the average from 1 to 10 individuals (colonies) per host. Exceptionally abundant in settling was the species *Mytilus galloprovincialis;* it settled in significantly higher numbers on oysters (33—53 individuals per host) than on mussels (17—36). Another very abundant fouler was *Polysiphonia;* however, it was found in equal number on both hosts (Table 1).

Real covering on oysters was greater in the case of synascidians *(Diplosoma listerianum)*, sponges *(Leucosolenia botryoides)*, bivalves *(Ostrea edulis, Mytilus galloprovincialis);* projective covering — in the case of algae *(Polysiphonia)*. On mussels, whose valves are of smaller dimensions than these of oysters, there was more overlapping in most of the foulers (sessile, bivalves, ascidians).

Table 1. Analytical characteristics of organisms in the fouling communities on oyster (*Ostrea edulis* Linnaeus) and mussel (*Mytilus galloprovincialis* Lamarck)

	Oyster			Mussel		
	F	A	C	F	A	C
Type I — superior organisms 1st range (predators)						
Turbellaria indet.	(4)	1	2			
Type II — superior organisms 2nd range (flat and slightly elevated sessile organisms)						
Hamigera hamigera (Schmidt)	(7.7)	1	3			
Lissodendoryx isodictyalis (Carter)	(4.3)	1	3			
Halichondria panicea (Pallas)	(8.6)	1	3			
Hymeniacidon sanguinea (Grant)	(3)	1	3			
Raniera sp.	(5.5)	1	3			
Diplosoma listerianum (Milne-Edwards)	67.3	2	4	60.7	2	3
Lissoclinum pseudoleptoclinum Drache	(4.3)	1	3			
Botryllus schlosseri (Pallas)	33.1	2	3	28.6	1	3
Botryllus schlosseri forma aurea	9.3	1	3	5.2	1	3
Type III — superior organisms 3rd range (erect and ramified sessile organisms)						
Enteromorpha sp.	20.2	3	1	6.7	3	1
Ulva rigida C. Ag.	32.4	3	2	7.9	3	2
Acetabularia mediterranea Lamouroux	49.6	3	3	14.8	2	+
Bryopsis sp.	(11.5)	3	+	—		
Ectocarpus sp.	(9,6)	3	1	(4.4)	3	1
Laurencia obtusa (Hudson)	(4)	3	1	(5.7)	3	1
Polysiphonia spp.	(42)	4	3	(24.5)	4	2
Leucosolenia botryoides (Ellis & Solander)	9.3	3	3	(6.8)	3	2
Sycon ciliatum (Fabricius)	(56.8)	3	1	(19.8)	3	1
Hydroidea indet.	42.8	3	1	5.8	3	1
Bugula simplex Hincks	14.5	3	1	3.9	3	1

	Oyster			Mussel		
	F	A	C	F	A	C
Scrupocellaria reptans Linnaeus	(5)	3	2	—		
Styela partita (Stimpson)	(12.7)	2	2	(5.7)	1	3
Styela plicata (Lauseur)	(9.5)	2	3	(10.5)	2	4
Phallusia mammilata (Cuvier)	(13.8)	2	3	(4.8)	1	4
Phallusia fumigata Grube	9.5	2	3	1.4	2	4
Ascidiella aspersa (Müller)	15.8	2	3	6.1	2	4
Polycarpa violacea Alter	(3.4)	1	2	—		
Pyura microcosmus (Savigny)	10.4	2	2	3.4	2	3
Ciona intestinalis (Linnaeus)	10	2	2	3.7	2	3
Type IV — superior organisms 4th range (semisessile emigrating org.)						
Anthozoa indet.	14.5	2	1	3	1	1
Modiolus barbatus (Linnaeus)	59.4	2	2	14.2	1	1
Mytilus galloprovincialis Lamarck	93	4	4	75	3	3
Musculus sp.	21.5	2	1	9.2	2	1
Saxicava arctica (Linnaeus)	40	2	1		2	1
Lima inflata (Chemnitz)	(6.7)	2	2	—		
Lucina reticulata Poli	4.1	2	1			
Irus irus (Linnaeus)	4	1	2	—		
Chiton olivaceus (Sprengler)	(4)	1	2			
Type V — subordinate organisms (flat and slightly elevated sessile organisms)						
Valonia utricularis (Roth.) C. Ag.	(10.9)	3	1	—		
Melobesiaceae	5.4	3	1	16.4	3	1
Anomia ephippium Linnaeus	42.3	2	2	59	2	3
Monia patelliformis (Linnaeus)	13.4	2	1	12.6	2	2
Ostrea edulis Linnaeus	92	2	4	72.6	2	4
Filograna implexa (Berkeley)	7.4	2	1	(9.2)	2	1
Pomatoceros triqueter (Linnaeus)	55	3	1	41.6	3	1
Spirorbis sp.	(3)	3	+	—		
Balanus amphitrite (Darwin)	(63.5)	3	1	(54.8)	3	1
Balanus eburneus (Gould)	(63)	3	1	(93)	3	1
Balanus perforatus (Brug)	(26.1)	3	1	(29.8)	3	1
Balanus trigonus Darwin	(15.2)	3	1	(29.5)	3	1
Schizoporella sp.	46.4	2	3	61.8	2	3

F — frequency of occurence (%)
A — grade ob abundance
C — average values of real and projective covering
() — frequency of epibionts for one or two localities, (frequency without brackets is for three localities)

DISCUSSION

Kawahara and Iizima (1960) were the first to classify the fouling organisms according to growth and life-span, into the following three groups:

»incrusting forms« — flat bryozoans
»erecting forms« — bryozoans, ascidians
»block forms« — tubeworms, barnacles

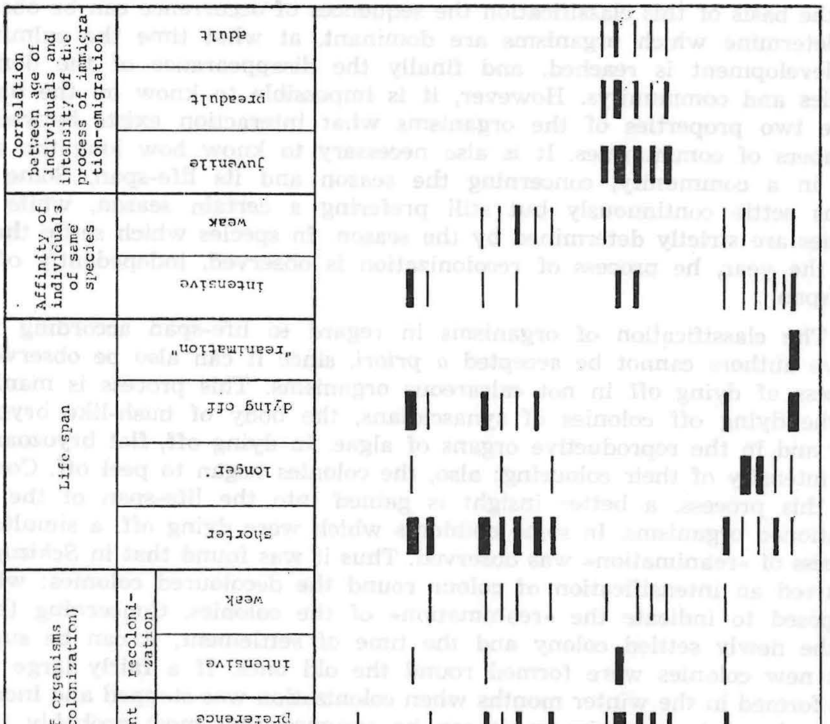
According to these authors, »incrusting forms« have the shortest life-span, followed by »erecting forms«, while »block forms« have the longest life-span.

On the basis of this classification the sequences of occurrence can be observed, to determine which organisms are dominant, at what time the culmination of development is reached, and finally the disappearance of the dominant species and communitys. However, it is impossible to know on the basis of these two properties of the organisms what interaction exists between the members of communities. It is also necessary to know how long the species live in a community, concerning the season and its life-span. Some organisms settle continuously but still prefering a certain season, while other species are strictly determined by the season. In species which settle throughout the year, he process of recolonization is observed, indepedently of their life-span.

The classification of organisms in regard to life-span according to the above authors cannot be accepted *a priori,* since it can also be observed the process of dying off in not calcareous organisms. This process is manifested in the dying off colonies of synascidians, the body of bush-like bryozoans, talli and in the reproductive organs of algae. In dying off, flat bryozoans lost the intensity of their colouring; also, the colonies began to peel off. Considering this process, a better insight is gained into the life-span of the above mentioned organisms. In some epibionts which were dying off, a simultaneous process of »reanimation« was observed. Thus it was found that in *Schizoporella* occurred an intensification of colour round the decoloured colonies; which is supposed to indicate the »reanimation« of the colonies. Concerning the size of the newly settled colony and the time of settlement, it can be supposed that new colonies were formed round the old ones. If a fairly large colony was formed in the winter months when colonization was stopped and increment was reduced to a minimum, it can be assumed that most probably the old colony became »reanimated«. D r a c h (1952) stated that such bryozoans spreaded out on the surface in order that the species should preserve the space it had won. The same author described the process of »reanimation« as consisting in the budding of new individuals from surviving tissue, taking place of the old zoaecia. As a result of this phenomenon, these »incrusting forms«, though dependent on the season, were found in the investigated communities throughout the year (Table 2), and some colonies lived about 12—14 months without the process of »reanimation«.

Nearly all epibionts had a shorter life-span in these communities on both hosts; about six months from the first observation till their death. The longest life-span was observed in calcareous organisms, particularly of bivalves, *Ostrea edulis* (maximum 21 months), some individuals of *Anomia ephippium* and *Monia patteliformis* (maximum 9 months). The »block forms« also had a fairly long life-span, the species *Pomatoceros triqueter* up to 14 months, *Balanus amphitrite* 7 months, *B. eburneus* 8 months, *B. trigonus* and *B. perforatus* (10 months). The »erect forms« were considerably shorter-lived, especially algae and hydroids, although some ascidians lived up to 8 months *(Phallusia fumigata)*, 9 *(Phallusia mammilata)* or 10 months *(Styela partita)*. Synascidians also had a shorter average life-span in the communities examined (Table 2). Nevertheless, there was a case recorded for a colony of species *Botryllus schlosseri* which lived for six months owing to a very slow process of dying off. All the above examples are extremes, referring to one or two specimens (colonies), whereas in all the species mortality occurred already in the new-settled individuals (colonies), i.e. within 30 days.

Table 2. Ecological and physiological characteristics of organisms in fouling community on oyster (Ostrea edulis Linnaeus) and mussel Mytilus galloprovincialis Lamarck)



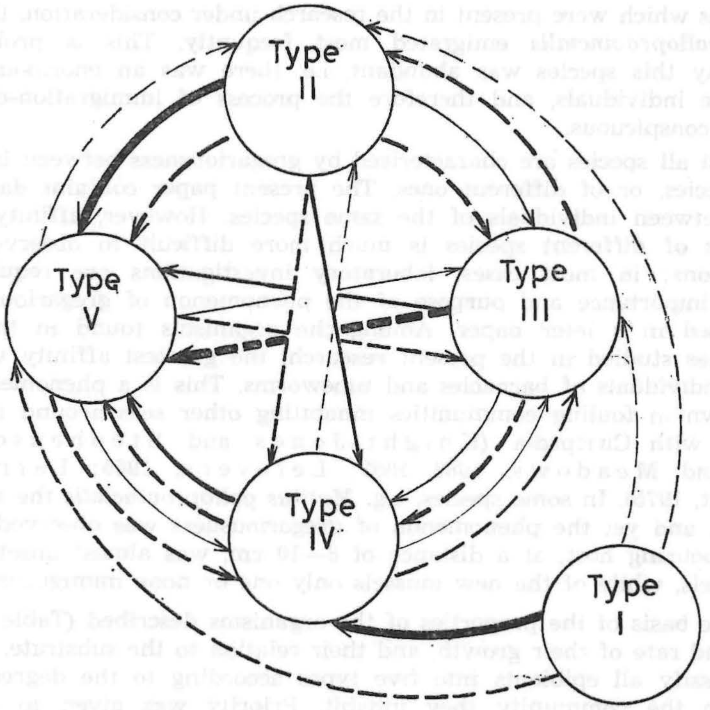
Note: most highly significant characteristic (▬), highly significant characteristic (▬), significant characteristic (—), slight characteristic (—).

In semisessile organisms it was impossible to make observations of the life-span because of emigration, and therefore observations were made for the correlation between the age of indivduals and the intensity of the process of immigration-emigration (Table 2). Emigration was observed most frequently in juvenile forms, while in adult individuals this process was slowest. From all bivalves which were present in the research under consideration, the species *Mytilus galloprovincialis* emigrated most frequntly. This is probably the reason why this species was abundant, i.e. there was an enormous number of juvenile individuals, and therefore the process of immigration-emigration was more conspicuous.

Almost all species are characterized by gregariousness between individuals of the species, or of different ones. The present paper contains data on the affinity between individuals of the same species. However, affinity between individuals of different species is much more difficult to observe in field investigations; in most cases, laboratory investigations are required. The biological importance and purpose of the phenomenon of gregariousness will be discussed in a later paper. Among the organisms found in the fouling communities studied in the present research, the greatest affinity was found between individuals of barnacles and tubeworms. This is a phenomenon generally known in fouling communities inhabiting other seas around the world, especially with Cirripedia (Knight-Jones and Stephenson, 1950; Crisp and Meadows, 1962, 1963; Lefevere, 1965; Larman and Gabbott, 1975). In some species, e.g. *Mytilus galloprovincialis* the abundance was great, and yet the phenomenon of gregariousness was observed. Namely, the neighbouring host, at a distance of 8—10 cm, was almost unsettled, with 1—2 mussels, while of the new mussels only one or none immigrated.

On the basis of the properties of the organisms described (Table 2), of the manner and rate of their growth, and their relation to the substrate, I attempted to classify all epibionts into five types according to the degree of their activity in the community they inhabit. Priority was given to organisms which exclusively or more directly influenced the phenomenon of »biological exclusion« (Harris, 1946). Thus Type I includes predators now denoted as 1st range superior organisms. Sessile and semisessile organisms are much more difficult to assess for their interaction. The struggle between them is a »quiet« one. They destroy one another directly by fouling them, or by settling on them abundantly, thus causing their smothering. Their indirect effect on the community members is in their presence, since they deprive the vital requirements (oxygen, food, space, etc.). Sessile and semisessile organisms are divided here into the following four types: Type II-2nd range superior organisms; Type III-3rd range superior organisms; Type IV-4th range superior organisms; and Type V- subordinate organisms. Depending on whether the organisms are active in their community, all epibionts are divided into *active, subordinate,* and *inactive.* Fig. 1 shows types according to the degree of activity, and to the degree of their influence, direct or indirect, on the phenomenon of »biological exclusion«. Fig. 2. presents the interaction between all types in the community.

Type I. The present research was the first to give observations of the predator-prey relationships in the investigated area. Turbellaria devoured a small number of mussels in 2—10% of the cases observed, as well as a few individuals of *Modiolus* on only two hosts. Earlier research, carried out through a period of several years in the northern Adriatic concerning fouling communities of different test substrata, never recorded the presence of predator-prey relationships, although in some cases a few indivduals of Turbellaria or sea-urchins were present. Recently, a considerable number of sea-urchins were



——— organisms directly "biologically excluding" other organisms

— — — organisms indirectly "biologically excluding" other organisms

thick lines indicate intensive influence

Fig. 2 — Interaction of organisms in fouling communities on oyster (*Ostrea edulis* Linnaeus) and mussel (*Mytilus galloprovincialis* Lamarck).

found in plastic boxes together with oysters in the breeding ground in Limski kanal; there were no grazed algae, though sea-urchins are well-known as grazers (Dayton, 1975; Forster, 1976). Other predators, listed in the Introduction, were not observed. One of the reasons is the fact that the shellfish were placed in crates behind a wire mesh, denying access to the larger predators (sea stars, fishes). On the accessible test substratum, no predators were found either in the communities, due probably to environmental characteristics, the nature of the substratum, separation from the bottom, and other factors.

Type II. These are organisms of flat or slightly elevated growth which overlap other members of the community. This type includes synascidians and sponges (Table 1). Synascidians are particularly important as »aggressors«, since they have better consistency and the colonies are rarely torn away, unlike colonies of sponges. Colonies of synascidians grow very rapidly, occupying a maximum of space in a minimum of time. These organisms are 1st grade epibionts, and if the substratum is alive, they smother the host. This phenomenon has been observed for the last few years in the breeding ground at Pomer, when the species *Diplosoma listerianum* overlapped completely and smothered some 40% of juvenile and preadult oysters as host, on which there had been hardly any settled organisms (I g i ć, 1972). In other breeding grounds, e.g. in Japan, synascidians joined to other fouler may be fatal to their hosts (M i y a z a k i, 1938). In breeding grounds in the Netherlands the species *Botryllus schlosseri* often smothers young oysters as hosts; it is therefore called »the pest« by oyster breeders (K o r r i n g a, 1951). If these organisms settle as epibionts of the 2nd or nth grade in this kind of »all animal warfare« (C l a r k e, 1965), the result is destruction of the ones by the others. Negative effects may also be manifested in other ways. Thus D o l g o p o l s k a j a (1954) describes the way in which colonies of *Botryllus* foul mussels, which makes the mussels drop from the substratum as a result of their weight. Synascidians have an important defence mechanism (D r a c h, 1952): a smooth surface, which does not permit the settling of any organisms above their colonies while they live. For this reason live synascidians are never directly subject to »biological exclusion« (Fig. 2). Sponges of flat or slightly elevated growth have the ability, like synascidians, to settle on the organisms present in a very short time. Sometimes they even destroy the hosts if they are densely settled, as M o e b i u s (1877) noted the oysters which had been smothered in great numbers by colonies of the species *Halichondria panicea*. In the present research this phenomenon was not observed either in hosts or in epibionts, since they were less thickly settled (Table 1) and of smaller dimensions as a result of hard competition for space.

Type III. These are erected and ramified forms which exercise their influence in the community mostly indirectly, and sometimes directly, causing »biological exclusion«. These organisms may have influence on other members of the community directly in cases when they are densely settled over flat or low foulers. Their indirect influence is nearly always present in the community (Figs. 1, 2); it can be interpreted in various ways. Thus according to L o o s a n o f f (1965) oysters which are densely settled by algae perish from the effect of the »water column«, which makes them deficient in food and oxygen. T u r p a e v a (1967) calls these forms »natural isolation filters«; and explains why hydroids have a negative effect on barnacles in the community. Hydroids are zooplanktophagous, while barnacles are phytoplanktophagous, so there is no competition for food between them. However, phytoplankton is retained on hydroids, and therefore the amonut of food and oxygen which reach barnacles becomes insufficient, because a part of them has been previously consumed by hydroids.

My opinion is that these forms undoubtedly exercise a negative influence on organisms of lower growth, in the manner as interpreted by earlier authors, if they are densely settled, and if their sizes are large (e.g. ascidians) and the substratum is small. Still, such organisms, especially algae of the larger thalli (e.g. *Ulva*) are capable of building up an »upper floor« which produces a big shade (H u v é, 1952), or of forming a shelter for predators and a habitat for larvae of mussels (L u c k e n s, 1975). Where thalli algae are large and densely settled, the substratum is suitable for shade seeking organisms, and unsuitable for phototrophic ones taking into consideration only the intensity of illumination as such. In communities, this type of organisms has the most profitable position, since it is in contact with water in rapid motion, thus achieving better food and oxygen supply (C r i s p, 1965; R i e d l, 1969; S t e b b i n g, 1971). R i e d l (1969) states that this fact may account for the erect growth of many filter-feeder organisms.

Type IV. This type is represented by semisessile organisms which emigrate rather frequently from the community. These organisms are also active, influencing other members directly or indirectly, but to a lesser extent (Figs. 1, 2). In fouling communities this type mainly includes bivalves and, less frequently limpets (Table 1). Some bivalves attach to the ground by means of byssuses, hence competition for space is not their top priority. They have directly negative effect on other foulers when their abundance and intensity of growth are high. Since these are mainly filter-feeding animals, they may have a restricting effect on the fixation of larvae (V o s k r e s e n s k i j, 1948; M i r o n o v, 1948). Larvae and spores of fouling organisms can be devoured by filtration (D a y t o n, 1971, 1973; F o s t e r, 1975). It is known that mussels are the dominant foulers, developing thick layers and dispersing other organisms by powerful filtration work. An example of this phenomenon is that in the Bay of Sevastopol; all underwater constructions are covered with mussels only (V o s k r e s e n s k i j, 1948; M i r o n o v, 1948). G o o d b o d y (1961) supposes that the high filtration rate of sponge community could deplete the surrounding of food for the young primary colonizers, or the secretion of chemical toxins might kill the young stages. Otherwise, if these organisms have settled in a small number, or if juvenile forms are dominant, competition is probably not very great. Greater negative influence on other foulers is expected if the abundance is higher, and if preadult and adult individuals predominate.

Type V. These are mainly I grade epibionts of smaller dimensions, of flat or slightly elevated growth, which are mostly the »victims« of the other members of the community. These organisms are sometimes »aggressors« (Figs. 1, 2), depending on whether they are II grade epibionts, thus overlapping some smaller forms and smothering them. Particularly interesting is the bryozoan *Schizoporella,* very frequently found in fouling communities, of intensive and flat growth, often covering large areas. According to these characteristics, it should be classified as Type II. However, in the investigations carried out hitherto *Schizoporella* was found to be a passive rather than an active member of the community. As a result of competition, the colonies were not very large, and mortality ensued generally early, already after 30 days; that is why this fouler was frequently »biologically excluded«, especially by colonies of *Diplosoma* (1—39% of cases during one month). Foulers such as *Schizoporella* permit other species to overlap them only when they are dead. Living colonies have active defence mechanisms (avicular and vibracular organs); they repel undesirable material from the colonies (M c G i n i t i e, G. and M. M c G i n i t i e, 1968), or else limit the settlement of larvae and spores of fouling organisms (M e a d o w s, 1969). Besides organisms like *Schizoporella* are fragile and break easily; as a consequence, the water dynamics eliminate them from the community in a relatively short period of time.

As shown in Fig. 1, organisms of all five types can also be inactive. This refers only to cases in which they do not participate actively in causing the phenomenon of »biological exclusion«. Apart from this, interaction between the members of the community, the host and the environment is always present.

CONCLUSIONS

In fouling communities on edible shellfish (oysters and mussels) in the northern Adriatic all organisms have been divided into five types according to the following factors: occurrence, type of tegument, manner and rate of growth, vitality, relation to substratum and season, and affinity of individuals of the same species.

Type I (1^{st} range superior organisms) are predators; Type II (2^{nd} range superior organisms) have flat and intensive growth; Type III (3^{rd} range superior organisms) are erect and ramified epibionts; Type IV (4^{th} range superior organisms) are semisessile emigrating foulers; Type V are subordinate organisms, of flat and slightly elevated forms, mostly of smaller dimensions and mainly 1^{st} grade epibionts.

All five types behave in their communities as *active*, *inactive* and *subordinate* (except of I type) members in the process of occurrence of »biological exclusion«.

Organisms interact directly or indirectly in response to the phenomenon of »biological exclusion«. Type I nearly always acts directly, Type II mostly directly, Type III nearly always indirectly, Type IV somewhat more indirectly, while Type V is the most seriously threatened in the community. All types except I and II can be directly »biologically excluded«, while this may happen indirectly to all types, except Type I.

Mutual relationships of organisms in communities are less closely correlated with the kind of substratum (valves of oysters or mussels), and more closely with the locality, the structure of the community, and the ecological and physiological characteristics of the foulers.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the financial support provided by the Self-Management Community of Interest for Scientific Research of S. R. Croatia for work on this project.

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Received: May 10, 1979

BIOTIČKA AKCIJA U OBRAŠTAJNIM ZAJEDNICAMA NA JESTIVIM ŠKOLJKAMA — KAMENICE (*OSTREA EDULIS* LINNAEUS) I DAGNJE (*MYTILUS GALLOPROVINCIALIS* LAMARCK) U SEVERNOM JADRANU

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KRATKI SADRŽAJ

Biotička akcija između članova obraštajnih zajednica u Jadranu skoro je nepoznata, a njezino poznavanje je značajno posebno kod uzgoja školjaka, jer ih biogena komponenta neretko može uništiti. Zato se pokušalo na osnovu svih karakteristika obrašćivača (prisutnost, vrsta habitusa, način i brzina rasta, vitalnost, proces odumiranja i oživljavanja, odnos ka supstratu i sezoni, afinitet individua iste vrste, odnos imigracije—emigracije i posebno proces direktnog i indirektnog biološkog isključenja), koje je bilo moguće pratiti »in situ«, da se organizmi izdiferenciraju po stepenu aktivnosti. Tako su epibionti klasificirani u 5 sledećih tipova: *I tip — nadmoćni organizmi prvog ranga* (superior organisms 1st range) (predatori), *II tip — nadmoćni organizmi drugog ranga* (superior organisms 2nd range) (pljosnati i slabo izdignuti organizmi), *III tip — nadmoćni organizmi trećeg ranga* (superior organisms 3rd range) (uspravni i razgranati sesilni epibionti), *IV tip — nadmoćni organizmi četvrtog ranga* (superior organisms 4th range) (semisesilni emigrirajući organizmi), *V tip — podređeni organizmi* (subordinate organisms) (pljosnati i slabo izdignuti epibiont). Nadalje su epibionti podeljeni na *aktivne* (»agresore«), *neaktivne* i *podređene* (»žrtve«) po tome da li direktno ili indirektno utiču na pojavu »biološkog isključenja« (biological exclusion — Harris, 1946).

U obraštajnoj zajednici su najaktivniji predatori (I tip) i to Turbellaria koji među epibiontima najčešće uništavaju dagnje i dlakave dagnje. Od sesilnih organizama najviše ugrožavaju druge članove u zajednici sinascidije i spužve (II tip) zbog vrlo brzog i pljosnatog rasta kolonija. Uspravne forme (III tip) (alge, spužve, hidroidi, žbunasti briozoji) uglavnom deluju indirektno na pojavu »biološkog isključenja« na epibionte koji su ispod njih. Semisesilni organizmi (puževi, školjke) (IV tip) također utiču direktno i indirektno na druge članove, ali u manjoj meri, jer često emigriraju iz zajednice. Podređeni organizmi (pljosnate alge, sesilne školjke, sesilni poliheti, balanidi, pljosnati briozoji) (V tip) su najčešće »žrtve« u zajednici jer su uglavnom epibionti prvog stupnja, manjih dimenzija, pljosnatog ili nešto izdignutog rasta. Svi tipovi osim I i II mogu biti na direktan način »biološki isključeni«, a na indirektan način svi organizmi osim predatora.

Međuodnosi u zajednicama su u manjoj korelaciji s karakterom supstrata (valve kamenica, daganja), a više s lokalitetom, strukturom zajednica, ekološkim i fiziološkim svojstvima obrašćivača. Tako je u rovinjskoj severnoj luci (zagađena uglavnom otpadnim organskim materijama urbanog i industrijskog porekla) bila najintenzivnija i najčešća biotička akcija, prioritetno zbog prisustva predatora, kao »agresora« školjaka, a i jače ekspanzije kolonija sinascidije *Diplosoma listerianum*, preko podređenih epibionata V tipa, posebno kamenica, juvenilnih i preadultnih balanida.