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INTER- AND INTRA-SPECIES RELATIONSHIPS OF SESSILE BIVALVES ON THE EASTERN COAST OF THE ADRIATIC SEA

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The paper reviews data published over a long period of time about the Adriatic sessile bivalves attached to living organisms, to various substrates and objects in the sea. A total of 49 species of sessile bivalves from 22 families are recorded, mostly from the subclass Pteromorphia. Interesting examples of their settlement on various substrates and cases of settlement of other macrofaunal species on bivalve shells are discussed.

Key words: Sessile bivalves, eastern Adriatic coast

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U radu se iznose višegodišnji podaci o jadranskim sesilnim školjkašima prihvaćenim na živim organizmima, raznim predmetima i konstrukcijama u moru. Zabilježeno je 49 vrsta sesilnih školjkaša iz 22 porodice koje većinom pripadaju skupini Pteromorphia. U raspravi se navode zanimljivi primjeri o naseljavanju sesilnih školjkaša na razne podloge kao i nekih makrofaunalnih vrsta na ljušture školjkaša.

Ključne riječi: sesilni školjkaši, istočna obala Jadranskog mora

1. INTRODUCTION

In the course of their long evolution, bivalves developed several modes of life as sessile, semi-sessile, free-living, burrowing, and buried organisms, or as a combination of these (YONGE & THOMPSON, 1976; MORTON 1991; POPE & GOTTO, 1993).

A sessile mode of life is attained in bivalves either by byssal attachment or by valve fixation to hard substrates. It is well known that settling bivalve larvae first

Tab. 1. Check list of sessile bivalve species recorded on the eastern coast of the Adriatic Sea (see: Table 2, 3).

Subclass	PTEROMORPHIA Beurlen, 1944
Family	ARCIDAE Lamarck, 1818
	Anadara inaequivalvis (Bruguière,1789)
	Anadara polii (Mayer, 1868)
	Arca noae Linnaeus, 1758
	Arca tetragona Poli, 1795
	Barbatia barbata (Linnaeus, 1758)
Family	NOETIDAE Stewart, 1930
	Striarca lactea (Linnaeus, 1758)
Family	MYTILIDAE Rafinesque, 1815
	Brachidontes pharaonis (Fisher P., 1870)
	Idas simpsoni (Marshall, 1900)
	Modiolarca subpicta (Cantraine, 1835)
	Modiolula phaseolina (Philippi, 1844)
	Modiolus barbatus (Linnaeus, 1758)
	Musculus costulatus (Risso, 1826)
	Mytilus galloprovincialis Lamarck, 1819
	Mytilaster lineatus (Gmelin, 1791)
	Mytilaster minimus (Poli, 1795)
Family	PINNIDAE Leach, 1819
	Atrina pectinata (Linnaeus, 1767)
	Pinna nobilis Linnaeus, 1758
Family	PTERIIDAE Gray J.E., 1847
	Pinctada radiata (Leach, 1814)
	Pteria hirundo (Linaeus, 1758)
Family	PECTINIDAE Rafinesque, 1815
	Aequipecten opercularis (Linnaeus, 1758)
	Chlamys flexuosa (Poli, 1795)
	Chlamys glabra (Linnaeus, 1758)
	Chlamys varia (Linnaeus, 1758)
	Crassadoma multistriata (Poli, 1795)
	Lissopecten hyalinus (Poli, 1795)
	Pecten jacobeus (Linneaus, 1758)
Family	SPONDYLIDAE Gray J.E., 1826
	Spondylus gaederopus Linnaeus, 1758
Family	ANOMIIDAE Rafinesque, 1815
	Anomia ephippium Linnaeus, 1758
	Pododesmus patelliformis (Linnaeus, 1761)

Family	LIMIDAE Rafinesque, 1815
	Lima lima (Linnaeus, 1758)
	Limaria hians (Gmelin, 1791)
	Limaria tuberculata (Olivi 1792)
Family	OSTREIDAE Rafinesque, 1815
	Crassostrea gigas (Thunberg, 1793)
	Ostrea edulis Linnaeus, 1758
	Ostreola stentina (Payraudeau, 1826)
Family	GRYPHAEIDAE Vyalov, 1936
	Neopycnodonte cochlear (Poli, 1795)
Subclass	HETERODONTA Neumayr, 1884
Family	CHAMIDAE Blainville, 1825
	Chama gryphoides Linnaeus, 1758
	Pseudochama gryphina (Lamarck, 1819)
Family	GALEOMMATOIDEA Gray J.E., 1840
	Galeomma turtoni Sowerby G:B.I in Turton, 1825
Family	KELLIIDAE Forbes & Hanley, 1848
	Kellia suborbicularis (Montagu, 1803)
Family	LASAEIDAE Gray J.E., 1842
	Lasaea rubra (Montagu, 1803)
Family	MONTACUTIDAE Clark W., 1852
	Montacuta substriata (Montagu, 1808)
Family	CARDITIDAE Fleming, 1828
	Cardita calyculata (Linneaus, 1758)
Family	CARDIIDAE Lamarck, 1809
	Laevicardium oblongum (Gmelin, 1791)
Family	CORBULIDAE Lamarck, 1818
	Corbula gibba (Olivi, 1792)
Family	HIATELLIDAE Gray J.E., 1824
	Hiatella arctica (Linnaeus, 1767)
	Hiatella rugosa (Linnaeus, 1767)
Subclass	ANOMALODESMATA Dal, 1889
Family	THRACIIDAE Stoliczka, 1870
	Thracia distorta (Montagu, 1803)
Family	CLAVAGELLIDAE D Orbigny, 1843
	Clavagella sp.

attach themselves with byssus to various living and nonliving substrates. Such attachments are never permanent as the animal can break off their byssus filaments, move to another place and make a new byssus attachment. Most bivalves remain byssally attached throughout their life (a neoteny process, YONGE & THOMPSON, 1976). However, many species are byssally attached only in the juvenile stage, until they reach a certain size, and afterwards become free living animals. Some other species display a combination of crawling free with occasional byssal attachment (YONGE & THOMPSON, 1976; GOFAS, 1991). Finally, some sessile bivalves fix themselves permanently with one valve to a substrate without any possibility of changing the place of attachment.

This paper is an attempt to summarise the present knowledge about sessile bivalves on the eastern coast of the Adriatic Sea, using data scattered in various publications as well as some unpublished data.

2. MATERIAL AND METHODS

Sessile bivalve species are identified at species level according to the publications of TEBBLE (1966), NORDSIECK (1969) and POPE & GOTTO (1993). Checklists: Mediterranean (SABELLI *et al.*, 1990), and European bivalves (COSTELLO *et al.*, 2001), as well as the checklist of CLEMAM (Check List of European Marine Mollusca) of the Muséum national d'Histoire Naturelle, Paris are used to establish the valid names. The scientific names of species mentioned in older publications, today synonyms, are cited in the present publication under their valid names.

3. RESULTS

The taxonomic survey of eastern Adriatic sessile bivalve species showed that the majority belong to the subclass Pteromorphia, several to the subclass Heterodonta, two to the subclass Anomalodesmata, and none to the subclass Protobranchia. Altogether a total of 49 sessile species belonging to 22 families are recorded along the eastern Adriatic coastline, stretching from the Savudrija Cape to Mljet Island (Tab. 1, 2, 3).

Habitat preference of each sessile species, as recorded in literature sources (TEBBLE, 1966; YONGE & THOMPSON, 1976; POPE & GOTTO, 1993; HRS-BRENKO, 1997), and the mode of their attachment to various substrates are summarized in Tab. 2. Hard substrates include rocks, loose stones, empty molluscan shells and their fragments, worm tubes, crab carapax, echinoderm tests, other calcium formations as well as various objects and materials (wood, glass, plastic, metal), solid wastes, and ship wreck. Attachments to floating and underwater constructions in harbours, marinas and areas of shellfish cultivation were also taken into account. Sessile species attached to living organisms, such as algae, phanerogams, bivalves, and other macrofaunal species, are presented in Tab. 3.

Tab. 2. The list of sessile bivalve species in natural habitat. Natural habitat description: (A) Tebble (1966); (B) Yonge & Thompson (1976); (C) Pope & Gotto (1993); (D) Hrs-Brenko (1997). Authors in brackets see: Table 4. Authors of unpublished data: Hrs-Brenko*, Jaklin**, Legac M.***, Nerlović****.

		attachment		
	natural habitat	mode	on or in hard substrate	miscellaneous
Subclass PTEROMORPHIA				
Family ARCIDAE				
Arca noae L.	Rocks covered with algae, in rocky crevices, holes, loose stones and gravels in meadows, on phanerogam rhizomes, sponges, molluscan shells, tunicates (C,D).	byssus plate	natural habitat (18,21,30,34,35,45) marine caves (10,39) multi-species clamps (15,17,35,43) coralligene bottoms (30)	on amphoras (22)
Arca tetragona Poli	Rock crevices, among stones, sponges, in molluscan shells, frequently encrusted with calcareous algae and serpulid polychaetes (A,C,D).	byssus plate	natural habitat (30) marine cave (36) coralligene bottoms (30)	on amphoras (18,21,22) cooling water system (30)
Barbatia barbata (L.)	Rocks covered with algae, in rocky crevices, under stones, on sponges and other hard substrates among algae and phanerogams (C,D).	byssus	natural habitat (9,29,30,32,35,45) marine cave (10,36,39) *Lithophaga* burrows (9,21,34) coralligene bottoms, in clamps (30,35)	—
Anadara polli (Mayer)	Ancored with small palletes on end of byssus filaments in mixed bottoms (C,D).	byssus	mixed bottoms (29,30,35,45)	—
Family NEOTIDAE				
Striarca lactea (L.)	Rocks with algae, crevices, caves, under stones between algae and phanerogam; on phanerogam stems (C,D).	byssus	natural habitat (9,21,29,30,32,35) marine cave (10) precoralligene clumps (35)	on amphoras (21,22) cooling water system (30)

Family MYTILIDAE				
Mytilus galloprovincialis Lam.	Rocks, cliffs, loose stones, other hard substrates predominantly covered with algae, in phanerogam meadows, polluted harbours, estuaries, near fresh water (C,D).	byssus	natural habitat (18,25,28,29,32,34) marine cave entrance (***) marine caves (10,36,39) marine springs (27) marine lake (33) mussel clumps (28,32)	buoys, chains, floats, anchors, propellers, tube, underwater objects (24,27,31,45,***) ship-wrek (23) cooling water system (34) experimental plates and collectors (41)
Mytilaster minimus (Poli) and *M. lineatus* (Gmel.)	Tidal rock crevices, holes, mussel clumps among algae in exposed locatities (C,D).	byssus	natural habitat (7,18,21,25,26,29,34,45) marine cave (10) marine lake (33) mussel clumps (18,26,28,29,34)	—
Modiolarca subpicta (Cant.)	Rocky shores, under stones, in empty molluscan shells, among holdfasts of brown algae, echinoderms, often in the test of tunicates (A,B).	byssus nest	natural habitat (45,*) marine cave (39) multi-species clamps (43)	cooling water system (***)
Musculus costulatus (Risso)	Rocky shores, under stones, on bivalves, among algae and phanerogams in rocky and sandy bottoms (A,C,D).	byssus	natural habitat (26) marine cave (10) mussel clamps (34)	—
Modiolus barbatus (L.)	Rock crevices, under stones, sponges, empty molluscan shells, tunicates among algae and phanerogams (A,D).	bissus	natural habitat (32,45) marine cave (10) mussel clumps (28) multi-species clamps (15,32,35) coralligene clumps (32)	on amphoras (22) cooling water system (34) experimental plates and collectors (41)
Idas simpsoni (Marsh.)	In sutures of whale skulls (A,C).	byssus	in bone sutures (42)	—
Modiolula phaseolina (Phil.)	Hard substrates, molluscan shells, on base of algae in various bottoms of deeper zones (C,D).	byssus	natural habitat (32)	—
Family PINNIDAE				
Pinna nobilis L.	Sandy bottoms in phanerogam medows, among hard substrates covered with algae (C,D).	byssus	natural habitat(32,45)	—
Atrina pectinata (L.)	In muddy bottoms (C).	byssus	natural habitat (38)	ship-wreck (23)

Family PTERIIDAE				
Pteria hirundo (L.)	Rocks and cliffs and other hard substrates, particularly on some species of anthozoas and hydrozoans (B,C,D).	byssus	natural habitat (32) marine cave (10,39)	ship-wreck (23)
Family PECTINIDAE				
Pecten jacobeus (L.)	Juveniles attach to hard substrates covered with algae. Adults swim or rest on the bottom (C,D).	byssus	natural habitat (32,45) marine cave (39)	—
Aequipecten opercularis (L)	Juveniles attach to hard substrates, algae, and other sessile organisms. Adults swim (A,C,D).	byssus	natural habitat (32,45,****)	amphoras (22) plastic slipper (****) plastic slipper (****) old rope (****)
Lissopecten hyalinus (Poli)	Rocks, stones, corals, sponges, on phanerogame rhisoms in coarse sand among algae and phanerogame (C,D).	byssus	natural habitat (32,34,35)	on amphoras (21,22)
Crassadoma multistriata (Poli)	Rock crevices among algae, on sponges, molluscan shells and other sessile organisms, in organogenic clumps, on hard substrates in various bottoms (C,D).	byssus	natural habitat (21,29,32) marine cave (39) *Lithophaga* burrows (21,34) coralligenous bottoms and clumps (32,35)	on amphoras (21,22)
Chlamys flexuosa (Poli)	Juveniles attach to hard substrates covered with algae. Adults on gravel, sandy and muddy bottoms (C).	byssus	natural habitat (9,***)	—
Chlamys glabra (L.)	Juveniles attach to hard substrates. Adults on various types of infralittoral bottoms (C).	byssus	natural habitat(32,****)	experimental plates and collectors (41) bricks (****)
Chlamys varia (L.)	Rocks, cliffts, coralligenous clumps, sponges, molluscan shells, bryozoans, among algae and in phanerogam meadows. Either attached or free (A,C,D).	byssus	natural habitat (21,35,45) marine caves (36,39) *Lithophaga* burrows (21,35) multi-species clumps (15,25,35) coralligenous clamps (25)	on amphoras (21,22) ship-wreck (23) experimental plates and collectors (41)

Family SPONDYLIDAE				
Spondylus gaederopus L.	Rocks, cliffs, stones covered with algae, hard substrata, under sponges among algae and phanerogams (C,D).	cemented with valve	natural habitat (25,29,34) marine cave (36) coralligenous clamps (25)	—
Family ANOMIIDAE				
Anomia ephippium L.	All types of hard substrata, on live orgamisms, empty molluscan shell, on algae (A,B,C,D).	calcified byssus	natural habitat (21,***) marine caves (36)	on amphoras (21,22) commercial shellfish collectors (*) cooling water system (***) experimental plates and collectors (41) ship-wreck (23) wooden pillars (21)
Pododesmus patelliformis (L.)	On hard substrates, empty shells, live organisms on gravel and rocky bottoms in deeper zones (A,C,D).	calcified byssus	natural habitat (*)	plastic bag (18) ship-wreck (23)
Anomia sp.	—	calcified byssus	natural habitat (****)	bricks (****) terracotta pipes (****) plastic slipper (****)
Family LIMITIDAE				
Lima lima (L.)	On rocks, cliffs, in crevices, under stones covered with algae, in sponges and ascidians (C,D).	byssus	natural habitat (29,32,35,45) marine cave (10,36,39) *Lithophaga* burrows (***) coralligenous bottom (32,34)	experimental plates and collectors (41)
Limaria tuberculata (Olivi)	Rock cavities, clifts covered with algae, corals and sponge (D).	byssus nest	natural habitat (*) marine cave (39)	—
Limaria hians (Gmel.)	Nests in rock holes, among loose stones, algae, phanerogam rhizomes, molluscan shells. Swim when is outside of the nest (A,C).	byssus nest	natural habitat (24,29,45) marine cave (39)	on amphoras (***)
Family OSTREIDAE				
Ostrea edulis L.	Rocks, cliffs, loose stones with algae, coraligenous clumps,	cemented with valve	natural habitat (21,32,34,45) marine cave (10)	chains, floats anchors (31,***) commercial shellfish collectors (*)

	molluscan shells, and various artificial hard substrata (D).		in marine lake (33) caralligenous clamps (25)	experimental plates and collectors (41) cooling water system (34,***) metal objects (21), wood (4) plastic bag (18) underwater objects (***)
Crassostrea gigas (Thun.)	In shallow water, below low tide line, on rocks and hard substrata in muddy bottoms (C).	cemented with valve	natural habitat (*)	commercial shellfish collectors (*)
Family GRYPHAEIDAE				
Neopycnodonte cochlear (Poli)	Cliffs, in caves, on secundary hard substrata, corals, on muddy gravel bottoms in deeper zones (C,D).	cemented with valve	natural habitat(*) cliffs (32) marine cave (36,39)	ship-wreck (23)
Subclass HETERODONTA				
Family CHAMIIDAE				
Chama gryphoides L.	Rocks, stones, sponges, molluscan shells among algae (D).	cemented with valve	natural habitat (9,21,25,35) marine cave (10,36) multi-species clumps (35)	on amphoras (21,22)
Pseudochama gryphina(Lam)	Hard substrates, molluscan shells in phanerogam meadows (D).	cemented with valve	natural habitat (21,25,35) marine cave (36) multi-species clumps (35)	rough lump of dross (***)
Family GALEOMMATIDAE				
Galeomma turtoni Sowerby	Rocks, cliffs, inside crevices with algae, under stones, in sponges (B,D).	byssus and crowl free	natural habitat (29,32,35,***)	—
Family LASAEIDAE				
Lasaea rubra (Mont.)	In masses in rock crevices, mussel clumps, empty barnacles, molluscan shells among algae in the tidal zone (A,D).	byssus	natural habitat (29,32) mussel clumps (28,29,34)	—
Family CARDITIDAE				
Cardita calyculata (L.)	Under or in hard substrata (D).	byssus	natural habitat (9,21,34) marine cave (10) mussel clumps (28,34)	—

Family CARDIIDAE				
Laevicardium oblongum (Gmel.)	Juveniles attach to hard substrates, algae, other sessile organisms. Adults buried in the sediment (C).	byssus	natural habitat	—
Family CORBULIDAE				
Corbula gibba (Olivi)	Hard objects in silty sand and muddy bottoms with gravel (D).	byssus	natural habitat (*)	in amphoras (22)
Family HIATELIDAE				
Hiatella arctica (L.) and *H. rugosa* (L.)	In rocky crevices and bored holes by other species, empty molluscan shells, and various organisms (A,B,C,D).	byssus without it	natural habitat (18,***) marine cave (10,36,39) *Lithophaga* burrows (***) multi-species clumps (43) coralligenous clamps (25,32)	on amphoras (22) cooling water system (34) experimental plates and collectors (41).
Subclass ANOMALODESMATA				
Family THRACIIDAE				
Thracia distorta (Mont.)	In crevices and holes in rocks made by other bivalves (A,B,C).	byssus	natural habitat (***) *Lithophaga* burrows (***)	—
Family CLAVAGELLIDAE				
Clavagella sp.	In rocks in shallow water (C).	cemented with valve	natural habitat (**)	—

Tab. 3. The list of sessile bivalves attached to various benthic species. Numbers in brackets are authors: see Table 4. Authors of unpublished data: Hrs-Brenko *, Jaklin **; Legac M. ***, Nerlović ****. According to Dijkstra (pers. comm.) (A) *Chlamys glabra* = *Flexopecten glaber*, (B) *Chlamys flexuosa* = *Flexopecten flexuosus*

	attachment				
	mode	algae	phanerogams	bivalves	macrofauna
Subclass **PTEROMORPHIA**					
Family **ARCIDAE**					
Arca noae L.	byssus plate	*Stypocaulon scoparia* (30) in *Peyssonnelia polymorpha* clumps (30)	in phanerogam meadows (18,26,30,35) on *Posidonia* rhisoms (18)	*Mytilus galloprovincialis* (*) *Pinna nobilis* (12,40) *Spondylus gaederopus* (30,***)	*Geodia cydonium* (6) *Hippodiplosia folliacea* (8) *Microcosmus* sp. (14,30)
Barbatia barbata (L.)	byssus	among algae (29,32)	among phanerogames (29)	—	*Geodia cydonium* (6)
Family **NEOTIDAE**					
Striarca lactea (L.)	byssus	*Neurocaulon* sp. (35) on *Osmundaria volubilis* (18,35) *Rytiphloea tinctoria* (35) among *Cystoseira* sp. (35)	on *Posidonia* steams (18,32) among phanerogams (29)	—	*Acanthella acuta* (35) *Geodia cydonium* (6) *Schizobrachiella sanguinea* (35)
Family **MYTILIDAE**					
Mytilus galloprovincialis Lam.	byssus	among *Cystoseira stricta* (25) *Fucus virsoides* (13) *Lithophyllum tortuosum* (20,32)	—	*Mytilus galloprovincialis* (16,19,28) *Ostrea edulis* (16,19)	—
Mytilaster minimus (Poli) and ***M. lineatus*** (Gmel.)	byssus	*Catenella opuntia* (11) *Fucus virsoides* (13) *Lithophyllum tortuosum* (20,32)	—	—	—
Modiolarca subpicta (Cant.)	byssus nest	*Ulva laetevirens* (***)	—	—	*Phallusia mammillata* (2)

Musculus costulatus (Risso)	byssus	*Caulerpa taxifolia* (37) *Fucus virsoides* (13)	on *Cymodocea* leaves (14)	*Mytilus galloprovincialis* (***) *Pinna nobilis* (12)	—
Modiolus barbatus (L.)	byssus	*Caulerpa taxifolia* (37) *Fucus virsoides* (13)	—	*Mytilus galloprovincialis* (19) *Ostrea edulis* (16,19)	*Microcosmus sulcatus* (14,*)
Modiolula phaseolina Phil.	byssus	—	—	*Chlamys pesfelis* (***) *Chlamys* sp. (29,32)	—
Family **PINNIDAE**					
Pinna nobilis L.	byssus	—	in phanerogam meadows (32,34,35)	—	in hole bellow *Cladocora caespitosa* (35)
Family **PTERIIDE**					
Pteria hirundo (L)	byssus	—	—	—	*Aglaophenia* sp. (1,4) *Antipathes* sp. (18,34) *Cidaris cidaris* (35,46) *Eunicella singularis* (34) *Eunicella cavolini* (21,34) *Lytocarpia myriophyllum* (18,34) *Paramuricea clavata* (29,34,***)
Family **PECTINIDAE**					
Pecten jacobeus (L.) juvenile.	byssus	macroaslgae (45)	on *Cymodocea nodosa* (***)		*Hippodiplosia foliacea* (8) *Phalusia mamillata* (****)
Aequipecten opercularis (L.) juvenile.	byssus	among algae (32)	—	*Atrina pectinata* (15, 38) *Ostrea edulis* (****)	*Aplidium conicum* (****) *Aplysina aerophoba* (****) *Geodia cydonium* (****) *Microcosmus sulcatus* (****) *Phallusia mamillata* (****) *Tethya aurantium* (****)
Lissopecten hyalinus(Poli)	byssus nets	among algae (32)	on *Posidonia oceanica* (***) in phanerogam meadows (32 ,35)	—	—
Crassadoma multistriata (Poli)	byssus	*Codium bursa* (44) *Pseudolithophyllum expansum* (35) among algae (25,29,32)	among phanerogams (29,32)	*Acanthocardia paucicostata*(***) *Pinna nobilis* (21)	*Cellaria* sp. (18) *Myriapora truncata* (7)
Chlamys flexuosa (Poli)	byssus	—	in *Posidonia* meadows (35)	—	—

Chlamys glabra (L.) (A)	byssus	—	on *Cymodocea nodosa* (18)	—	*Microcosmus sulcatus* (****) *Tethya aurantium* (****)
Chlamys varia (L.)	byssus	—	—	*Atrina pectinata* (38) ***Chlamys glabra*** (****) *Ostrea edulis* (24) *Pinna nobilis* (12,21,40)	*Cellaria fistulosa* (35) *Cladocora caespitosa* (35) *Clathria coralloides* (****) *Geodia cydonium* (6) *Hippodiplosia foliacea* (8) *Ocnus planci* (****) *Suberites domuncula* (****)
Family **SPONDILIDAE**					
Spondylus gaederopus L.	cemented with valve	on stones among algae (25)	on stones in *Posidonia* oceanica meadows (29)	*Pectunculus* sp. (7) *Pinna nobilis* (12)	—
Family **ANOMIIDAE**					
Anomia epphipium L.	calcified byssus	*Caulerpa taxifolia* (37) *Codium bursa* (2,18) *Udotea* sp. (5)	—	*Acanthocardia echinata* (18) *Aequipecten opercularis* (3,4,14) *Arca noae* (7) *Atrina pectinata* (18,26,38,***) *Chlamys glabra* (***) (A) *Glossus humanus* (18) *Mytilus galloprovincialis* (19,28) *Ostrea edulis* (16,19) *Pinna nobilis* (12,21,40) *Tellina balaustina* (7)	*Ceritium vulgatum* (18,21) *Gibbula magus* (7) *Jujubinus striatus* (4) *Zonaria pyrum* (7)
Pododesmus patelliformis (L.)	calcified byssus	—	—	*Acanthocardia echinata* (18) *Aequipecten opercularis* (*) *Atrina pectinata* (*, ***) *Callista chione* (18) *Chlamys flexuosa* (4) (B) *Chlamys glabra* (21) (A) *Glossus humanus* (18) *Laevicardiun oblongum* (***) *Mytilus galloprovincialis* (19) *Ostrea edulis* (19)	*Gibbula magus* (5) *Nephrops norvegicus* (18,34)

Anomia sp.	calcified byssus			*Aequipecten opercularis* (****) *Atrina pectinata* (****) *Chlamys glabra* (***) (A) *Ostrea edulis* (****) *Pecten jacobeus* (****)	*Bolinus brandaris* (****) *Hexaplex trunculus* (****) *Microcosmus sulcatus* (****) *Tonna galea* (****)
Family **LIMIDAE**					
Lima lima (L.)	byssus	*Codium bursa* (44)	—	—	*Geodia cydonium* (6) *Hippodiplosia foliacea* (8) *Microcosmus* sulcatus (*) *Verongia aerofoba* (29,32)
Limaria tuberculata (Olivi)	byssus nest	*Codium bursa* (44)	—	*Ostrea edulis* (19)	*Geodia cydonium* (6)
Family **OSTREIDAE**					
Ostrea edulis L.	cemented with valve	*Fucus virsoides* (13)	—	*Mytilus galloprovincialis* (16,19,28) *Pinna nobilis* (12,21,26,40) *Atrina pectinata* (*) *Ostrea edulis* (16,19) *Acanthocardia echinata* (*) *Acanthocardia tuberculata* (***)	*Bolinus brandaris* (***, ****) *Cerithium vulgatum* (18,21) *Geodia cydonium* (6)
Family **GRYPHAEIDAE**					
Neopycnodonte cochlear (Poli)	cemented with valve	—	—	*Atrina pectinata* (*) *Neopycnodonte cochlear* (29) *Pteria hirundo* (**)	—
Subclass **HETERODONTA**					
Family **CHAMIDAE**					
Chama gryphoides L.	cemented with valve	among algae (25)	—	*Glycymeris pectunculus* (7) *Pinna nobilis* (*) *Spondylus* sp. (4)	*Cerithium vulgatum* (***)
Pseudochama gryphina (Lam.)	cemented with valve	—	on stone in *Posidonia oceanica* meadows (29)	*Pinna nobilis* (12,25) *Spondylus* sp. (4)	—

Family **GALEOMMATIDAE**	byssus and	*Codium bursa* (44)	—	—	—
Galeomma turtoni Sowerby	crowl free				
Family **KELLIIDAE**					
Kellia suborbicularis (Mont.)	byssus and creeping	—	—	—	*Petrosia ficiformis* (34)
Family **LASAEIDAE**		*Lithophyllum tortuosum* (20,29,32)			
Lasaea rubra (Mont.)	byssus	*Peyssonellia* sp. (***) *Ulva laetevirens* (***)	—	—	—
Family **MONTACUTIDAE**					
Montacuta substriata(Mont.)	byssus to anal spines	—	—	—	*Spatangus purpureus* (32,34)
Family **CARDIIDAE**					
Laevicardium oblongum	byssus	—	*Cymodocea nodosa* (18,***)	—	*Hippodiplosia foliacea* (8)
(Gmel.) - juvenile					
Family **HIATELLIDAE**					
Hiatella arctica (L.) and ***H. rugosa*** (L.)	byssus	*Caulerpa taxifolia* (37) *Peyssonellia polymorpha* (***) *Peyssonellia squamaria* (***) *Codium bursa* (***)	—	*Acanthocardia echinata* (***) *Acanthocardia tuberculata* (18,21,***) *Glossus humanus* (18,21) *Mytilus galloprovincialis* (16,19) *Ostrea edulis* (16,19) *Pecten jacobeus* (18,21) *Pinna nobilis* (40)	*Cladocora caespitosa* (18,21) *Fasciospongia cavernosa* (7) *Geodia cydonium* (6) *Hippospongia communis* (18,21) *Ircinia muscarum* (18)

Tab. 4. The list of the author's publications used in the Tab. 2 and Tab. 3.

1. Danilo & Sandri, 1855	**24.** Marguš *et al.*, 1991
2. Grube, 1864	**25.** Grubelić, 1992
3. Stossich M., 1880	**26.** Hrs-Brenko & Legac M., 1992
4. Brusina, 1891	**27.** Petricoli *et al.*, 1995
5. Odhner, 1914	**28.** Emrić, 1996
6. Santucci, 1922	**29.** Hrs-Brenko, 1996
7. Vatova, 1928	**30.** Hrs-Brenko & Legac M., 1996
8. Nikolić, 1956	**31.** Petricioli *et al.*, 1996
9. Horvath, 1963	**32.** Hrs-Brenko, 1997
10. Riedl, 1966	**33.** Bakran-Petricioli *et al.*, 1998
11. Zavodnik D., 1967a	**34.** Hrs-Brenko *et al.*, 1998
12. Zavodnik D., 1967b	**35.** Žerlić, 1999
13. Zavodnik D., 1967c	**36.** Arko-Pijevac *et al.*, 2001
14. Zavodnik D., 1971	**37.** Ivesa, 2001
15. Hrs-Brenko, 1979	**38.** Šimunović, 2001
16. Igić, 1981a	**39.** Novosel *et al.*, 2002
17. Fedra *et al.*, 1976	**40.** Šiletić & Peharda, 2003
18. Legac M. & Hrs-Brenko, 1982	**41.** Bratoš, 2004
19. Igić, 1984	**42.** Bolotin *et al.*, 2005
20. Zavodnik D. & Zavodnik N., 1985	**43.** Stachowitsch, 1991
21. Legac M., 1987	**44.** Passamonti *et al.*, 1993
22. Legac M. & Legac I., 1989	**45.** Marguš, 1998
23. Petricioli & Bakran-Petricioli, 1989	**46.** Zavodnik D., 2003

4. DISCUSSION

4.1. Bivalves as epibionts on various substrates

In the Adriatic Sea, sessile and semi-sessile bivalve species mostly inhabit rocky coastal zones, covered with algae, where they attach by byssus threads and plates, calcified byssus, or are cemented by valves. In such a manner, the animals can easily withstand strong dynamic effects of waves and sea currents. On soft bottoms, the opportunities for bivalve settlements are restricted to dispersed hard substrata lying on the bottom surface, such as loose stones, empty molluscan shells, various organogenic debris, multi-species clumps, coralligenous clumps, or other hard objects buried shallowly in the sediment.

Sessile bivalves attach either as solitary organisms or in masses associated with species belonging to other systematic groups in bottom communities. For example, when ***Mytilus galloprovincialis*** attaches to rocks in masses within interwoven byssal threads, small benthic species find convenient and protective niches from desiccation and high temperatures during low tides. Sessile bivalves in such mussel clumps include ***Mytilaster*** sp. (***minimus or lineatus***), ***Musculus costulatus, Mo-***

diolus barbatus, Lasaea rubra, Cardita calyculata, and ***Irus irus*** (LEGAC M. & HRS-BRENKO, 1982; HRS-BRENKO & LEGAC, 1992; EMRIĆ, 1996; HRS-BRENKO, 1996; HRS-BRENKO *et al.*, 1998). Close intra- and inter-species relationships are evident in mussel clumps. EMRIĆ (1996) observed that dense populations of ***Mytilaster*** sp. were always present below large-sized ***M. galloprovincialis***. Similarly, in the low mediolittoral zone, in rocky crevices filled with fine sand, there was an abundance of ***Lasaea rubra*** associated with ***Mytilaster*** sp. and ***M. galloprovincialis*** populations (EMRIĆ, 1996). ***L. rubra*** together with ***Mytilaster*** sp. and ***M. gallorovincialis***, is a frequent inhabitant in bolsters of calcified algae *Lithophyllum tortuosum* (ZAVODNIK D. & ZAVODNIK N., 1985; HRS-BRENKO, 1996, 1997). YONGE & THOMPSON (1976) claim that the aggregation behaviour of ***L. rubra*** is the result of convenient microhabitat and the ***Lasaea*** mode of reproduction. That is, the species produces a limited number of eggs, incubates them in the pallial cavity, and releases developed juveniles, which shortly after their release attach themselves with byssus in the vicinity of the adults.

Sessile bivalves make an important structural component in multi-species clumps, i.e. biogenic structures, in soft-bottom communities. The clumps are composed of sessile and mobile invertebrates, closely associated with molluscan shells, their fragments, crab carapax, echinoderm tests, polychaete tubes, sponges, bryozoans, calcareous algae, and other small hard bottom elements (FEDRA *et al.*, 1976; STACHOWITSCH, 1986). In multi-species clumps sessile bivalves include live individuals and their shells of the following species: ***Arca noae, Modiolarca subpicta, Modiolus barbatus, Crassadoma multistriata, Chlamys varia, Chama gryphoides, Pseudochama gryphina, Hiatella arctica*** (ZAVODNIK, 1971; FEDRA *et al.*, 1976; STACHOWITSCH, 1991; HRS-BRENKO, 1997; ŽERLIĆ, 1999). The frequent hypoxic events in the northern Adriatic Sea kill sensitive benthic species, including the inhabitants of multi-species clumps, and later, during community recovery, clump remains become convenient bases for new settlements of many benthic species (STACHOWITSCH, 1991). After a mortality event in 1983, STACHOWITSCH (1991) recorded successful settlement of ***M. subpicta*** on the tunics of ascidians and that of ***H. arctica*** in shelters in newly developed multi-species clumps. Both species, ***M. subpicta*** and ***H. arctica,*** together with numerous juveniles of ***Modiolula phaseolina***, ***Atrina pectinata, Pecten jacobeus, Aequipecten opercularis, Limaria hians, Anomia*** sp., ***Laevicardium oblongum***, and ***Corbula gibba*** occurred a couple of months after the 1989 benthic catastrophe in the Croatian part of the northern Adriatic Sea (HRS-BRENKO *et al.*, 1994). The majority of these juveniles were small-sized and opportunistic species, important members of early recovery communities (HRS-BRENKO, 1998). Juveniles of relatively large sized bivalves are sessile until they reach a certain length, when a shift from sessile to free mode of life occurs. Such a mode of life was shown by ***P. jacobeus*** juveniles of which, between 5 and 10 mm in length, were found attached with byssus to macroalgae (MARGUŠ, 1998), and ***L. oblongum*** on *Cymodocea nodosa* (LEGAC M. & HRS-BRENKO, 1982). Also ***A. opercularis,*** with 38 juveniles, between 3 and 13 mm in length, was recorded on an empty shell of ***A. pectinata*** (HRS-BRENKO, 1979), rarely on live individuals (ŠIMUNOVIĆ *et al.*, 2001), and on experimental plates (IGIĆ, see: HRS-BRENKO, 1979).

In coastal algal assemblages and phanerogam meadows, numerous small-sized macrofaunal species, including bivalves, juveniles and adults, search sheltered places for settlement and habitation. For example, ZAVODNIK (1967c) recorded a young specimen of ***Ostrea edulis*** cemented on phylloid and a couple of species from Mytilidae family attached with byssus to *Fucus virsoides*. Furthermore, LEGAC M. collected a few ***Modiolarca subpicta*** from *Ulva lactuca*, ***T. distorta*** from *Cystoseira sp.*, and ***Hiatella arctica*** from the basis of *Codium bursa*, as well as from thallus of *Peyssonnelia polymorpha* and *P. squamaria.* During the survey of a bottom community invaded by the introduced alga *Caulerpa taxifolia* in Malinska (Krk Island), IVEŠA (2001) noted 2–3 mm-sized juveniles of ***Musculus costulatus, Modiolus barbatus, Anomia epphipium*** and ***Hiatella arctica.*** Iveša concluded that the presence of *Caulerpa* has no harmful effect on the reproduction, settlement, and survival of most bivalve species. In phanerogam meadows, on *Posidonia oceanica*, *Cymodocea nodosa* and stones among phanerogams, sessile bivalves find convenient places for habitation. In particular, ***Arca noae*** and ***Striarca lactea*** were attached to rhizomes and stems of *P. oceanica*, and ***M. costulatus***, ***Chlamys glabra*** and ***Laevicardium oblongum*** on *C. nodosa* leaves (ZAVODNIK D., 1971; LEGAC M. & HRS-BRENKO, 1982). Besides direct attachment to algae and phanerogamae, bivalves of ***A. noae, Barbatia barbata, S. lactea, Lissopecten hyalinus, Crassadoma multistraiata, Spondylus gaederopus, Ostreola stentina, Pseudochama gryphina, Thracia distorta*** were often collected from coastal rocks, outcrops and loose stones dispersed on the bottom surface (HRS-BRENKO & LEGAC M. 1992; HRS-BRENKO, 1996, 1997; LEGAC M. unpublished data).

Two bivalve species, characteristic of a coralligenous biocoenosis, ***Chlamys pesfelis*** and ***Lima lima*** inhabit secondary organogenic solid substrates made up of coralline algae, bryozoans, serpulids, and other similar species (GAMULIN-BRIDA, 1967). In addition to these two species, recent research revealed a number of bivalve empty shells dispersed on coralligenous bottom or incorporated into coralligenous clumps such as ***Pecten jacobeus, Chlamys varia, Spondylus gaederopus, Ostrea edulis, Hiatella arctica*** (GRUBELIĆ, 1995), ***Modiolus barbatus, Pseudamussium clavatum, Crassadoma multistriata***, (HRS-BRENKO, 1997), and ***Barbatia barbata, Striarca lactea, C. multistriata*** (ŽERLIĆ, 1999). Most of the single and damaged bivalve shells of these species originated from inhabitants of the upper zones of steep rocks and cliffs from which the shells, after the death of animals, fell and were consolidated with pebbles, coarse sand, and various organogenic debris into coralligene clumps.

While the majority of sessile bivalves are attached directly with byssus to surfaces of hard substrata, some species search for a habitat in sheltered places, such as rock crevices, spaces under stones, submarine caves, temporary submarine springs (vruljas), molluscan shells, or burrows left empty after the death of burrowing animals. Thus, empty *Lithophaga* burrows are often a convenient habitat for many small macrofaunal species including the sessile bivalves ***Hiatella arctica*** and ***Thracia distorta*** noted by LEGAC M., ***Barbatia barbata*** and ***Chlamys varia*** recorded at the opening and ***Crassadoma multistriata*** in deeper parts of the burrows (HORVATH, 1963; LEGAC M., 1987; HRS-BRENKO *et al.*, 1998; ŽERLIĆ, 1999). In shallow water rock on Pelješac Peninsula JAKLIN (pers. comm.) discovered the bivalve ***Clavagella*** sp. This species lives cemented in its own tube produced by its left valve while its somewhat larger right valve excavates or enlarges the burrow (YONGE & THOMPSON, 1976). According to POPE & GOTTO (1993) ***Clavagella*** starts life as normal bivalve with two valves, but later its mantle produces a »second shell« which grows into the substrate.

Rock crevices, spaces between loose stones, empty shells of various macrofaunal species, and macroalgae are obviously convenient habitats for nesting species of ***Modiolarca subpicta***, ***Limaria hians***, ***Limaria tuberculata***, ***Hiatella arctica***, and ***Thracia distorta.*** YONGE & THOMPSON (1976) mentioned that ***M. subpicta*** lives in a byssally formed nest within empty molluscan shells, in algae, or in ascidians, which is confirmed by STACHOWITSCH (1991) who found numerous individuals in shelters of ascidian tunics on newly developed multi-species clumps, after a benthic mortality event. TEBBLE (1966) noted that ***L. hians*** builds a sort of nest by byssal filaments woven with and reinforced by fragments of shells, small pebbles and pieces of algae. The nests have two holes, one for the entrance and a second one for the exit of water currents. Such a nest probably serves as a hiding place and for animal protection. It was observed that nests of ***L. hians***, may be inhabited by a single adult or several juveniles, and it can reach sizes up to 250 mm (MARGUŠ, 1998). According to LUCAS (1976), ***L. hians*** starts building the nest at the juvenile stage, when the animal is about 6 mm in size. If the nest is destroyed, animals can build a second, and even a third one. Several individuals can be engaged in the construction of a common nest in which they live a colonial mode of life. According to YONGE & THOMPSON (1976) and POPE & GOTTO (1993) nesting ***H. arctica*** is bysally attached on or in all types of substrate. It is often found in holes previously bored by other species (LEGAC M., unpublished data). The closely related species ***Hiatella rugosa*** also lives in holes made by other bivalves or in rock crevices but this animal does not produce byssus (POPE & GOTTO, 1993). ***T. distorta***, a byssally attached epifaunal nester, is found in rock crevices and abandoned holes where it takes irregular shape in accordance with available space (YONGE & THOMPSON, 1976).

A relatively small amount of research has been carried out on the benthic macrofauna of submarine caves and temporary springs (vruljas) along the karstic eastern Adriatic coast (RIEDL, 1966; PETRICIOLI *et al.*, 1995; BAKRAN-PETRICIOLI *et al.*, 1998; ARKO-PIJEVAC *et al.*, 2001; NOVOSEL *et al.*, 2002). Data revealed only a small number of sessile bivalve species inhabiting caves in comparison with the number of species of other systematic groups. The penetration of species into the caves and springs depends on water characteristics, mostly on slow water circulation, low temperature, amount of light and availability of food. ***Mytilus galloprovincialis***, a species known for its depth tolerance, was found attached to rocks and stones at the entrance of caves, often in the vicinity of fresh water springs, but it also penetrates into the interior part of caves. In a submarine cave near Vrbnik (Krk Island), ARKO-PIJEVAC *et al.* (2001) noted three species of sessile bivalves as the most conspicuous: ***M. galloprovincialis*** in the rock crevices close to the sea surface; ***Chama*** sp. along the entire cave; and the deep water oyster ***Neopycnodonte cochlear*** at the depth of 10 m. ***N. cochlear*** was found at 15 m depth in Stražica cave on Prvić Island and was discovered earlier by Bakran-Petricioli at the depth of 10 m in a cave on Borovik Island (Kornati Islands), and at 19 m in the cave Katedrala (Premuda Island) (see: NOVOSEL *et al.*, 2002). PETRICIOLI *et al.* (1995) investigated two temporary submarine springs in Velebit Channel. In Modrič Cove sparse small ***M. galloprovincialis*** were found attached to the walls from 5 to 31 m depth. In the second one, on rocky walls in Zečica Cove a compact population of large ***M. galloprovincialis*** penetrated down to 23 m depth. BAKRAN-PETRICIOLI *et al*. (1998) investigated a small lake Zmajevo oko (Dragon's Eye) near Rogoznica, an interesting karstic phenomenon, connected with the sea through fissures in rocks and displaying small tides. In the lake, on rocky walls, a dense ***Mytilaster*** sp. population, up to 4.000 ind/m2 from 0.4 to 2 m depth, was dispersed along with rather common populations of ***M. galloprovincialis*** and ***Ostrea edulis***.

The walls of numerous drainage pipelines discharging water into the sea are also convenient substrates for settling particular macrofaunal species, bivalves included. Thus, in the pipeline of an old seawater cooling system of a petrochemical plant (Rafinerija Rijeka), adults of ***Arca tetragona*** and ***Striarca lactea*** (HRS-BRENKO & LEGAC M., 1996), adults and juveniles of ***Mytilus galloprovincialis***, juveniles of ***Modiolus barbatus***, ***Anomia epphipium,*** various sized individuals of ***Ostrea edulis***, ***Chama*** sp, ***Hiatella arctica*** (HRS-BRENKO *et al*., 1998), and ***Modiolarca subpicta*** (LEGAC M., unpublished) were found as fouling elements. ***M. galloprovincialis,*** of various sizes, was also noted in the drainage pipeline of the Aquarium in Rovinj (ZAVODNIK, pers. comm.).

Data from the reviewed literature show that the majority of Adriatic sessile bivalves are not strictly selective in choosing their substrate for settlement. For example, ***Anomia ephippium,*** a known epibiont species of wide ecological distribution, is a frequent settler on various benthic organisms. Up to 7 ***Anomia*** sp. individuals were recorded on ***Atrina pectinata*** shell (HRS-BRENKO & LEGAC M., 1992), and as many as 45 on the thallus of alga *Codium bursa* (LEGAC M. & HRS-BRENKO, 1982). Likewise a closely related species ***Pododesmus patelliformis*** was found on empty shells of ***Glossus humanus***, ***Acanthocardia echinata***, and ***Callista chione*** (LEGAC M. & HRS-BRENKO, 1982), and by HRS-BRENKO up to 14 individuals on an empty shell of ***Atrina pectinata.*** On carapax, telson, and chelipeds of dredged live Norwegian lobsters (*Nephrops norvegicus*), between 14 and 17 cm long, LEGAC M, observed numerous ***P. patelliformis*** individuals, even up to 5 individuals on some chelipeds (Fig. 1) (LEGAC M. & HRS-BRENKO 1982).

Anomia epphipium, ***Mytilus galloprovincialis, Ostrea edulis***, and ***Crassostrea gigas***, often settle on pillars, anchors, mooring chains, submarine tubes, boats and ships anchored in harbours, marinas, mariculture areas, and on experimental plates (glass, metal, plastic, wood) (IGIĆ, 1972, 1982, 1986; LEGAC M., 1987; PETRICIOLI *et al*., 1996; BRATOŠ, 2004). Thus, LEGAC M. (1987) observed about ten ***A. epphipium*** on a wooden pillar used for mooring boats, while HRS-BRENKO (1986) and IGIĆ, (1986) recorded various-sized ***Anomia*** sp. on collectors used in commercial shellfish cultivation. Simultaneously, HRS-BRENKO (1986, 1989) and IGIĆ (1986) analyzed the intensity and the depth distribution of ***M. galloprovincialis, O. edulis*** and ***C. gigas*** settlers on shellfish collectors, and revealed an optimum of ***O. edulis*** settlement at the depths of 3 m. As a curiosity, an unusually dense settlement of ***O. edulis*** occurred on a shellfish collector when juvenile ***O. edulis*** completely filled up the spaces between the plastic plates, thus creating a cylinder of a compact ***O. edulis***

mass of about 40 cm in diameter. This huge collector, about 5 m long, contained more than 5.000 juvenile ***O. edulis,*** although an unknown number of ***O. edulis*** were detached and fell into the sea while the collector was being raised to the ship (HRS-BRENKO, 1986). The well-known ***M. galloprovincialis*** preference for settling close to the water surface is used by farmers, who immerse old filamentous ropes horizontally, at about 10–30 cm below the water surface, to stimulate the settlement of ***M. galloprovincialis*** larvae, which sometimes form in a thick layer around the collector ropes (HRS-BRENKO 1986, 1989). In Skradin marina, PETRICIOLI *et al*. (1995) recorded on a mooring chain a compact mass of small-sized ***M. galloprovincialis*** from the surface to an approximate depth of 2.5 m, and a mixture of large ***M. galloprovincialis*** and ***O. edulis*** further down toward the bottom. The apparent origin of the small mussels on the upper part of the mooring chain is a heavy larval settlement in water restored to normal salinity, after a strong fresh water inflow from the Krka River. The Krka River estuary is a known area with dense natural ***M. galloprovincialis*** populations and high juvenile settlements, except in the Skradin area, due to frequent »salinity shocks« (MARGUŠ & TESKEREDŽIĆ, 1986). In addition, HRS-BRENKO recorded numerous large-sized ***M. galloprovincialis*** on the mooring chains bound to a large offshore buoy anchored in the northern Adriatic Sea. PETRICIOLI & BAKRAN-PETRICIOLI (1989) studied sessile assemblages on the shipwreck of m/t »Brigitta Montanari« raised from the depth of 82 m, where it rested for about 3 years. They recorded more than 30 macrofaunal species on the wreck, including 7 bivalve species. The most abundant bivalves were ***Neopycnodonte cochlear***, up to 1000 ind./ m^2, then ***Atrina pectinata***, with about 100 individuals on the whole ship, and ***M. galloprovincialis***, on the ropes. Contrary to expectations, on amphorae and their fragments taken from sandy bottoms at depths from 17 to 31 m in the coastal areas of Rab and Sv. Grgur Islands, ***M. galloprovincialis*** were not found among the 11 sessile bivalve species (LEGAC, M. & LEGAC I., 1989).

Some bivalve species prefer to attach themselves to particular substrata. In the Adriatic Sea, divers have usually registered ***Pteria hirundo*** attached with a bunch of long byssal threads to gorgonians and hydrozoans (BRUSINA, 1891; LEGAC & HRS-BRENKO, 1982; LEGAC, 1987; HRS-BRENKO 1996; HRS-BRENKO *et al.*, 1998). Recently, ŽERLIĆ (1999) and ZAVODNIK (2003) found ***P. hirundo*** on the radioles of the echinoderm *Cidaris cidaris*. Another example of exclusive attachments to special substrate is shown by the tiny commensal epibiont ***Montacuta substriata***, which in the juvenile stage seat to spines around the anal field of *Spatangus purpureus* (YONGE & THOMPSON, 1976; HRS-BRENKO *et al.*, 1998). In addition, a highly specialized mytilid species ***Idas simpsoni***, attached with byssus in the suture of a whale skull was recently trawled up in the southern part of the Adriatic Sea (BOLOTIN *et al*., 2005).

Based on the literature records several non-native sessile benthic species appeared in the northern Adriatic Sea, including 9 bivalves. The majority of species are of Indo-Pacific origin, introduced intentionally for aquaculture purposes or accidentally as fouling elements attached on the ships, captured in ballast waters, or penetrated through the Suez Canal into Mediterranean Sea, so-called Lessepsian immigrants (ORLANDO BONACA, 2001). The knowledge about the presence of non-native species in the coastal waters of Croatia is unsatisfactory. Only a few data exist, like the empty shells of ***Brachiodontes pharaonis,*** found on detritic bottom at the cape of Savudrija, probably originating from live specimens attached by byssus on ships coming to the petrochemical plant in Trieste (VIO & DE MIN, 1996; DE MIN & VIO, 1998). Furthermore, one valve of an adult and edible ***Anadara inaequivalvis*** was dredged in the Mirna estuary (HRS-BRENKO & LEGAC, 1996). This valve could have originated either from an already established but small population, or been discarded from yacht after a meal. Another species is ***Pinctada radiata,*** recorded in Gulf of Trieste, (VIO & DE MIN, 1996; DE MIN & VIO, 1998). A very small live and transparent specimen, dredged from below oil platform, could belong to this species (NERLOVIĆ, priv. comm.).

4.2. Bivalve shells as substrate for the settlement of various algae and sessile macrofauna

Bivalves and their empty shells, especially those belonging to large-sized species, are attractive substrates for the settlement of small algae and sessile macrofauna, making thus a special assemblage interesting for study. Unfortunately, the composition of such assemblages and the interactions between host-bivalves and sessile species attached to shell surface has been the subject of investigation in only a few papers. IGIĆ (1981 a, b, c, 1982, 1984, 1986), EMRIĆ (1996) and BRATOŠ (2004) provide information about sessile assemblages on ***Mytilus galloprovincialis*** and ***Ostrea edulis***. From these publications the most frequent bivalves are ***Modiolus barbatus, M. galloprovincialis, Anomia ephippium, Pododesmus patelliformis, Limaria tuberculata, O. edulis, Irus irus,*** and ***Hiatella arctica***, and other macrofaunal species as *Mycale macilenta, Reniera sp., Pomatoceros triqueter, Spirorbis* sp., *Balanus amphitrite, B. eburneus, B. perforatus* and *B. trigonus, Schizoporella sp., Diplosoma listerianum, Phallusia mammilata, Botryllus schlosseri, Ciona intestinalis, Styella partita,* and *Ascidiella aspera*. Reviewed publications of IGIĆ (1981a, c, 1984) showed the difference in species composition of investigated sessile assemblages between localities, and a higher epibiont biomass on larger and rougher ***O. edulis*** than on smoother ***M. galloprovincialis*** shells. These differences are related to local environmental conditions, ecological and physiological characteristics of each sessile species. Igić (pers. comm.) stated that epibionts, especially those living in calcareous tubes, on the shell surface of cultivated bivalves, may considerably decrease the market value of such bivalves. Another cultivation problem is the deleterious effect of colonial epibionts, as for example the fast growing synascidian *Diplosoma listerianum,* which can in a short period of time overgrow live ***O. edulis*** and ***M. galloprovincialis*** preventing thus the opening of valves and causing unavoidable death not only of the hosts but also of the other species in the sessile assemblages.

The large shells of ***Pinna nobilis*** are also ideal substrata for the settlement of sessile and hemisessile species, including numerous algal species, bivalves of ***Arca noae, Chlamys varia, Crassadomma multistriata, Anomia ephippium, Ostra edulis***, and various macrofaunal species including *Spongia officinalis, Verongia aerophoba, Bittum reticulatum, Ballanophylia europaea, Chiton olivaceus,, Capulus ungaricus, Vermetus arenarius, Pomatoceros triqueter, Spirorbis* sp., *Dexiospira* sp., *Serpula vermicularis,*

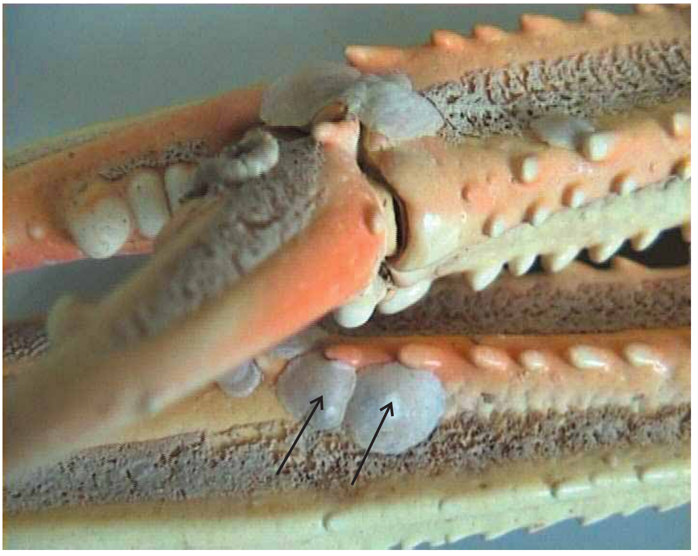

Fig. 1. Bivalve ***Pododesmus patelliformis*** (Linnaeus) attached to chelipeds of norwegian lobster (*Nephrops norvegicus* Linnaeus) (Photo: L. Bartoniček).

Schizobrachiella sanguinea, Microcosmus sp., and *Reteporella beaniana,* (ZAVODNIK, D., 1963, 1967 b; HRS-BRENKO, 1979; LEGAC M., 1987; ŠILETIĆ & PEHARDA, 2003).

The epibionts of sessile assemblages developed on shells of other bivalve species have been only occasionally mentioned due to difficulties in field observations and the small scientific interest of divers. As a matter of fact, during careful inspection of the coastal zones, especially rocks heavily overgrown with algae, divers may overlook many bivalve species covered with epibionts. The exceptions are ***Arca noae, Chlamys varia*** and ***Spondylus gaederopus***, often easily detected due to the presence of the conspicuous calcified red sponge *Crambe crambe* on their shells (ZAVODNIK, 1971; HRS-BRENKO, 1996, 1997; HRS-BRENKO & LEGAC M., 1996; HRS-BRENKO *et al*., 1998; ŽERLIĆ, 1999). Finally, as a curiosity, the finding of a double bivalve settlement (JAKLIN, pers. comm.) might be cited, in which the bivalve ***Pteria hirundo*** was first attached to the gorgonia *Paramuricea clavata*, after which several individuals of ***Neopygnodonte cochlear*** were attached to the ***Pteria***.

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SAŽETAK

Odnosi između i unutar vrsta sesilnih školjkaša istočne obale Jadrana

M. Hrs-Brenko & M. Legac

Bogatstvo školjkaša u pridnenim zajednicama Jadranskog mora potaklo je autore da preglednim radom obrade objavljene i još neobjavljene višegodišnje podatke o sesilnim školjkašima prihvaćenim na živim organizmima, raznim predmetima i konstrukcijama u moru. Obrađeno je 49 vrsta sesilnih školjkaša iz 22 porodice koje pretežno pripadaju skupini Pteromorphia. U raspravi su navedeni zanimljivi primjeri naseljavanja sesilnih školjkaša na razne podloge kao i značajnijih vrsta makrofaune na ljušture školjkaša.

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