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DISTRIBUTION OF ECHINODERMATA IN THE NORTH ADRIATIC INSULAR REGION

RASPROSTRANJENOST BODLJIKAŠA U OTOČNOM PODRUČJU SJEVERNOG JADRANA

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The author collected echinoderms at more than 300 coastal and offshore stations using various sampling devices, and at diving. 52 species were identified; of them, five were not recorded previously in the area investigated. Thus, in total, 59 echinoderm species are now known from this area. Previous records, sampling locations, bathymetric data and habitats are given for each species. The relations of several species to the type of the bottom, and to the pollution of the environment are discussed.

INTRODUCTION

The aquatorium between the Učka mountain and the Istrian peninsula in the northwest, and the lowland and Zadar archipelago in the southeast, is one of the most intersected and ecologically most varied areas in the Adriatic Sea and the Mediterranean. It spreads about 120 kilometers in length and covers an area about 7.700 square kilometers. In this area two strings of some 100 large and small islands, and numbers of islets and cliffs extend in the main direction form northwest to southeast, thus dividing the aquatorium into several large units such as: the Kvarner (Quarner Gulf), Riječki zaljev (Rijeka Bay), Kvarnerić, Virsko more, and, along the mainland, Velebitski kanal (Figure 1.).

The coastal line in the area is very intersected and rich with small bays, coves, straits and gorges. The greatest depths of single aquatorium units vary mostly between 65 and 100 meters. The bottom is generally silt and sand. The steep rocky and stony bottoms, which are sometimes rich in underwater caves and springs of fresh water, are limited only to the narrow coastal line. More details on sedimentological and hydrographical characteristisc of the area are given in the papers resulting from cruises of the RV »Bios« in 1967—1971 (Alfirević 1968, Alfirević *et al.* 1969, Gamulin-Brida *et al.*, 1971) and in the reports of the »Vila Velebita« expeditions in 1913—14 and 1973—74 (Gavazzi *et al.*, 1914, Škrivanić&Barić, 1979, Škrivanić&Magdalenić, 1979).

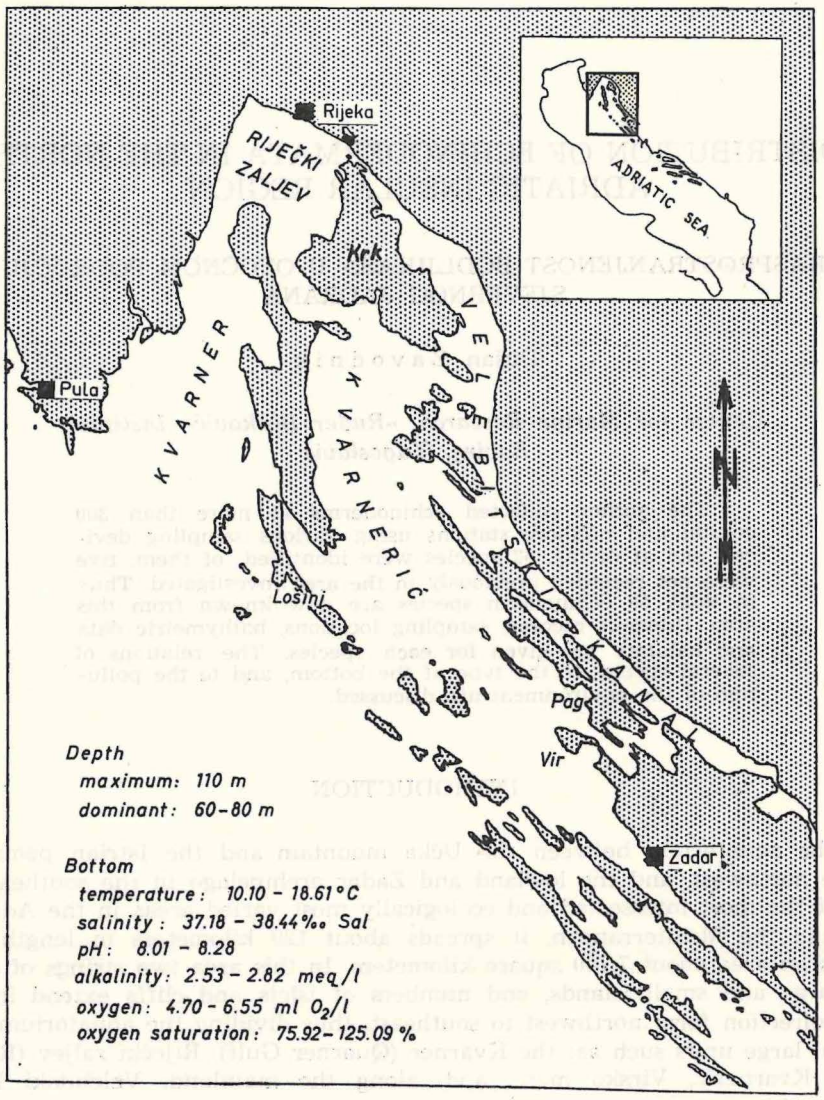


Fig. 1. Investigated area. Ranges of several environmental parameters are indicated.

The echinoderms in this area have been reported from the very first biological investigations in the Adriatic Sea. Thus already Olivi (1972) had noted *Asterias aculeata* L. in the Kvarner Gulf. In 1840 Grube cited further two species in the area: *Holothuria tubulosa* and *Echinus saxatilis* (= *Paracentrotus lividus*). Two decades later (1861, 1864), the same author has already determined 27 echinoderm species in the Kvarner area. In 1863 appeared a major work of Lorenz who listed 22 species from the investigated area, and provided important data on their ecology, bathymetric distribution, and

biological relations. A few years later, Heller (1868) recorded already 32 species in this area, and the research of Stossich (1883) increased this number to 34; all existing data were compiled by Carus (1885). With these papers a »golden age« of echinoderm studies in the area was finished; no more research was reported in the North Adriatic insular region for several decades.

At the beginning of the twentieth century, some data on echinoderms were providet by Brusina (1907) and Car&Hadži (1914 a, b). In 1924, Vatova initiated extensive benthological investigations in the northern and the middle Adriatic Sea. During twelve years, he visited more than 500 stations, 64 stations were in the area treated in this paper (Vatova 1942, 1949). The Holothuries collected by Vatova were specially studied by Mayer (1937). It should be emphasized, that Vatova's papers are the first in which exact quantitative data on echinoderm populations in the Adriatic Sea are given. Just before the 2nd World War, also Kolosvary (1939, 1940) reported on echinoderms from this area. At the same time, while studying the littoral communities in the Velebitski kanal, Zalokar (1942) provided useful informations on the ecology of several species common in this zone. Later Zei (1949) and Crnković (1970) noted, in their trawling ground research reports, most conspicuous species from silty bottoms. Zavodnik reported on the echinoderms from the islands Krk (1960 a, b) and Vir (1977 a), Legac (1974) listed 19 echinoderm species from the island Rab, and Salvini-Plawen (1977) recorded findings of *Labidoplax buski* and *Myriotrochus geminiradiatus* in the Kvarnerić.

Many data on the distribution of echinoderms in the offshore archipelagical part of this area, especially on deeper sedimentary bottoms of Velebitski kanal, Kvarnerić, and Virsko more, provided extensive biocoenological researches which were, during the past fifteen years, conducted by Yugoslav research institutions in Portorož (by the boat »Argonavt«), Rovinj (by RV »Vila Velebita«) and Split (by RV »Bios«). These surveys were part of several national and international research projects studying silty bottoms inhabited by Norway lobster *(Nephrops norvegicus),* and of fundamental ecological and pollution studies, which were primarily conducted in the Riječki zaljev. Unfortunately, from various reasons, only few results on enchinoderms were published until now (Zavodnik, 1973 b, 1976, 1977 a; Zavodnik&Zavodnik, 1978; Zavodnik *et al.* 1978). It is the aim of this paper to fill the gap with regard to distribution of echinoderms in the investigated area.

MATERIAL AND METHODS

Biological material was sampled by the author with skin and SCUBA diving at several coastal localities, and by means of various sampling devices (grabs, dredges, trawl nets) at offshore stations. The following collections are treated in the present paper:

1. Researches of the RV »Bios« which were conducted in the summer months of 1965—1971. Echinoderms were sampled at 121 stations by means of Petersen grab samplings (82 stations) otter trawl tows (22 stations, 10 of them being visited 2—4 times), triangular biological dredge tows (2 stations) and by diving (15 stations).

2. Researches of the RV »Vila Velebita« between 1972 and 1979, the jubilee cruises 1973—74 included. The echinoderms were sampled by the Petersen and van Veen grabs (79 stations), by biological dredge of the type »mušular« (8 stations), and by SCUBA diving (84 stations).

3. The voyage of the MB »Dagnja« in autumn 1970. Four stations were visited and the sediment samples were collected by Petersen grab.

4. Research cruises of the MB »Argonavt«, which were conducted in 1968 by the staff of Marine Biological Station in Portorož, at 11 coastal transects by SCUBA divers, or by means of a biological dredge. The author received the material through the ex Mediterranean Marine Sorting Center, Khereddine, Tunisia. (NB: This is the only material treated in this paper which was not sampled and processed by the author personally).

5. Sampling, by the author, at 117 coastal locations on the mainland and on several islands. The sampling, and »in situ« observations, were conducted by skin and SCUBA diving.

In general, the following devices were used for the sampling of biological material:

a. Petersen grabs of 0.05, 0.1 and 0.2 m^2, and a van Veen grab of 0.1 m^2. The gear was used one to five times for each collection.

b. Biological dredge, type »mušular«. The tows were made at the speed of 0.5 knots and lasted 15—20 minutes each.

c. Biological triangular dredge, all sides 80 cms long. The tows were at a speed below 0.2 knots for 10 minutes.

d. Commercial otter trawl. One hour tows were made at a standard speed of 2 miles per hour.

e. SCUBA dives, were made to depths up to 45 meters, depending on the locality.

The sediment taken by grabs was processed immediately after sampling through a series of sieves up to 1 mm mesh. The separated echinoderms were preserved in 60% alcohol or in 4% buffered formol solution. Identifications were accomplished in the Laboratoy for Ecology and Systematics od the Center for Marine Research in Rovinj.

It should be added that the locality data cited in this paper, or plotted on the maps, have not been published in previous papers of the author, except for some stations around the islands Krk and Vir, those dealing with rare species *(Amphiura securigera, Ophioconis forbesi, Echinocardium flavescens),* and partly with other species of the family Amphiuridae. The locality marks plotted on the maps cover, due to the diminituion scale, about 20 square kilometers of the sea surface. Therefore a single mark often does not indicate only one sampling location but more of them — up to 28 stations maximum.

RESULTS

CRINOIDEA

Antedon mediterranea (Lamarck, 1816) (Fig. 2)

Pervious records: Crube. 1861, 1864 *(Alecto europea);* Heller, 1868 *(Comatula);* Stossich, 1883 *(Comatula);* Carus, 1885 *(rosacea);*

Kolosvary, 1940 a *(adriatica);* Zalokar, 1942; Zei, 1949; Zavodnik, 1960 b, 1977 a; Crnković, 1970; Legac, 1974.

Material: About 70 specimens collected and observed.

Habitat: Rocky, sandy, and detritic bottoms. At several localities common among large seaweeds (especially *Cystoseira* and *Sargassum)* and eelgrasses *(Posidonia oceanica, Cymodocea nadosa).* Near cape Prutna (island Pag) observed while crawling on *Eunicella cavolinii.* Collection depths: 4—55 m.

Remark: It seems that coloration patterns are not related to the habitat, in spite of some indications that mottled animals are somewhat more common in eelgrass communities, while those uniformly coloured prevail among seaweeds and at larger depths.

HOLOTHURIOIDEA

Holothuria tubulosa Gmelin, 1788 (Fig. 2)

Previous records: Grube, 1840, 1861, 1864; Lorenz, 1863; Heller, 1868; Stossich, 1883; Carus, 1885; Brusina, 1907; Kolosvary, 1936. 1940 a; Zavodnik, 1960 b, 1977 a; Pérès i Gamulin-Brida, 1973; Legac, 1974; Zavodnik *et al.,* 1978.

Material: More than 1500 specimens recorded at diving and collected by dredges.

Habitat: This is a species of wide ecological distribution, which is common in the communities of high photophilic algae, on fine well calibrated sand, on coarse sands and fine gravels, and in eelgrass communities of *Posidonia oceanica* and *Cymodocea nodosa.* Rarely the specimens were observed also on bare rochy terraces some ten meters distant from sedimentary bottom. Collection depths: 0—45 meters.

Remark: Maximum population density observed was about 2 animals per square meter. Many times the animals were masked by a sandy film, small pebbles, gastropod shells, and pieces of algae and eelgrass.

Holothuria polii Delle Chiaje, 1823 (Fig. 3)

Previous records: Stossich, 1883; Carus, 1885 (all *Polii*); Kolosvary, 1936, 1940 a (*Poli*); Zavodnik, 1960 b; Zavodnik *et al.,* 1978.

Material: About 20 specimens recorded at diving.

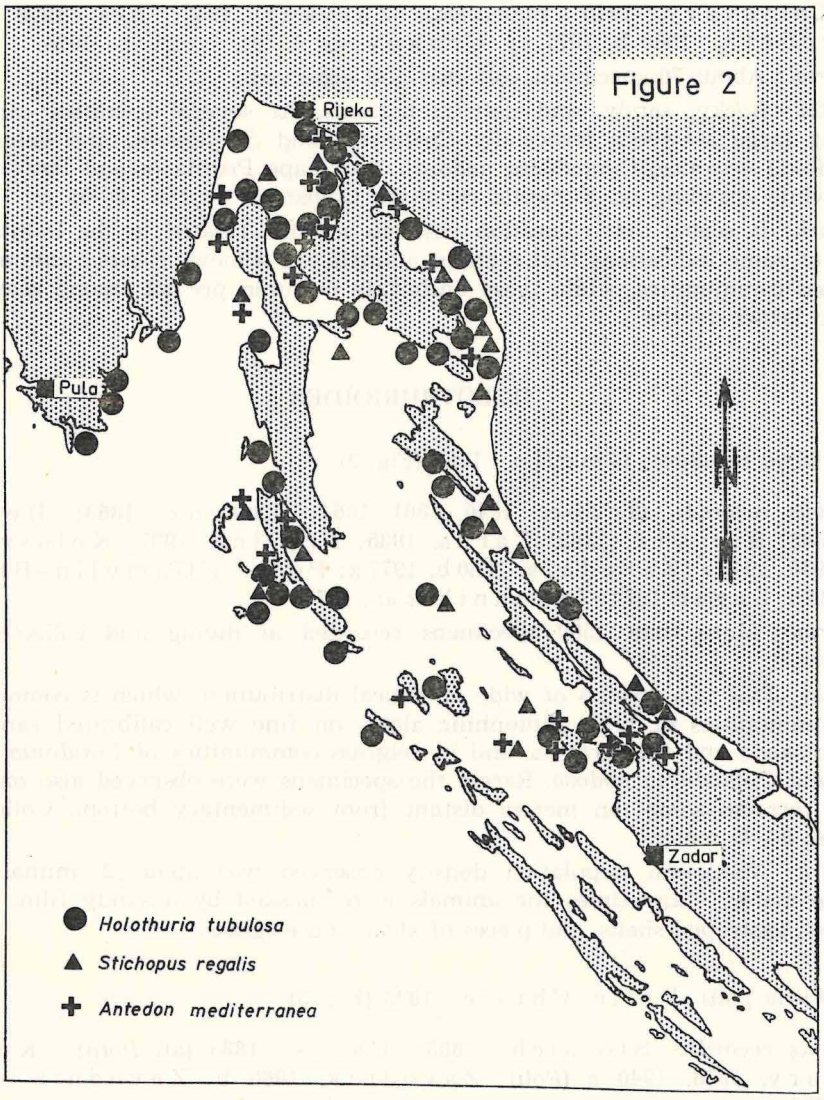
Habitat: Pure sandy bottoms, bare ones or those not densely covered by meadows of *Cymodocea nodosa.* Capture depths: 3—19 meters.

Holothuria helleri v. Marenzeller, 1878

Previous records: Stossich, 1883 *(Helleri);* Carus, 1885 *(Helleri);* Kolosvary, 1936; Tortonese, 1965.

Material: None.

Habitat: No data for the area.

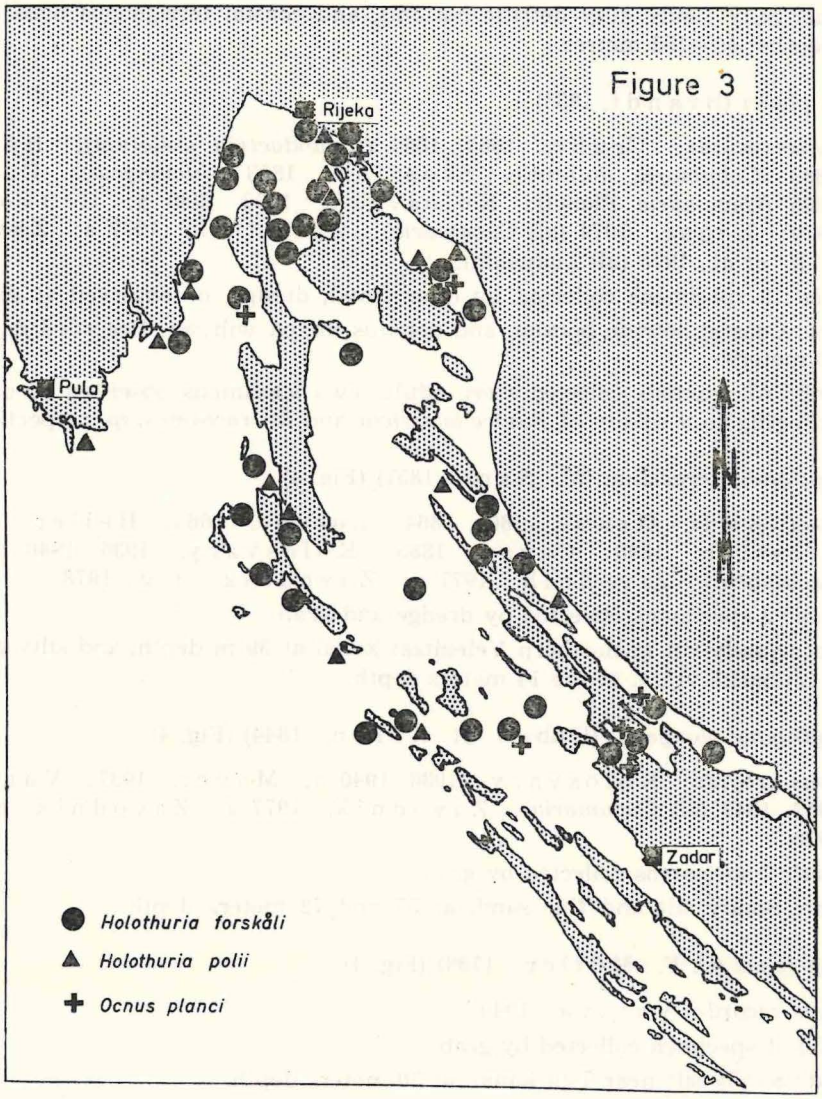


Holothuria forskåli Delle Chiaje, 1823 (Fig. 3)

Previous records: Grube, 1864; Heller, 1863 (all *catanensis*); Stossich, 1883 *(Catanensis);* Carus, 1885; Kolosvary, 1936 (all *catanensis*); Zavodnik, 1960 b, 1977 a; Zavodnik *et al.*, 1978.

Material: About 600 specimens collected by grabs, dredges, otter trawl, and recorded at diving.

Habitat: Sands, pure and those mixed with ooze, detritic bottoms, and coastal terrigenous ooze. The animals prefer bottoms deprived of vegetation. Collection depths: 13—102 meters.



Remark: Usually the population density on shallow sandy bottom does not exceed 10 specimens per square meters.

Stichopus regalis (Cuvier, 1817) (Fig. 2)

Previous records: Grube, 1861, 1864; Lorenz, 1863; Heller, 1868 (all *Holothuria*); Stossich, 1883; Carus, 1885; Car&Hadži, 1914 a, b; Kolosvary, 1936, 1940 a; Zei 1949; Crnković, 1970; Legac, 1974; Zavodnik, 1977 a.

Material: 334 specimens collected most by otter trawl.

Habitat: Silty sands, silty detritic bottoms, and coastal terrigenous ooze. Capture depths: 46—102 metres.

Ocnus planci (Brandt, 1835)

Previous records: Grube, 1861, 1864 *(Cladodactyla doliolum);* Heller, 1868 *(Cucumaria dolilum);* Stossich, 1883 *(Cucumaria);* Carus, 1885 *(Cucumaria Planci);* Kolosvary, 1936, 1940 a; Crnković, 1970; Legac, 1974 (all *Cucumaria*); Zavodnik, 1977 a; Zavodnik *et al.*, 1978 (all *Ludwigia*).

Material: 9 specimens collected by otter trawl, dredge, or observed at diving.

Habitat: Coastal detritic bottom, and detritus mixed wih silt. Recorded depths: 12—63 meters.

Remark: All animals colected were adult. Two specimens observed at diving were clinging to a colony of *Eunicella stricta* and *Microcosmus sp.* respectively.

Trachythyone tergestina (M. Sars, 1857) (Fig. 4)

Previous records: Grube, 1861, 1864; Lorenz, 1863; Heller, 1868; Stossich, 1883; Carus, 1885; Kolosvary, 1936, 1940 a (all *Cucumaria);* Zavodnik, 1977 a; Zavodnik *et al.*, 1978.

Material: 2 specimens collected by dredge and grab.

Habitat: Sandy silt in northern Velebitski kanal at 39 m depth, and silty detritus in Ljubačka vrata, at the 14 meters depth.

Trachythyone elongata (Düben et Koren, 1844) (Fig. 4)

Previous records: Kolosvary, 1936, 1940 a; Mayer, 1937; Vatova, 1942, 1949 (all *Cucumaria*); Zavodnik, 1977 a; Zavodnik *et al.*, 1978.

Material: 2 specimens collected by grab.

Habitat: Sandy silt and fine sand, at 57 and 72 meters depth.

Thyone fusus (O. F. Müller, 1788) (Fig. 4)

Previous record: Vatova, 1949

Material: 1 specimen collected by grab.

Habitat: Sandy silt near Tihi kanal, at 50 meters depth.

Thyone cherbonnieri Reys, 1959 (Fig. 4)

Previous records: None.

Material: 1 specimen collected by grab.

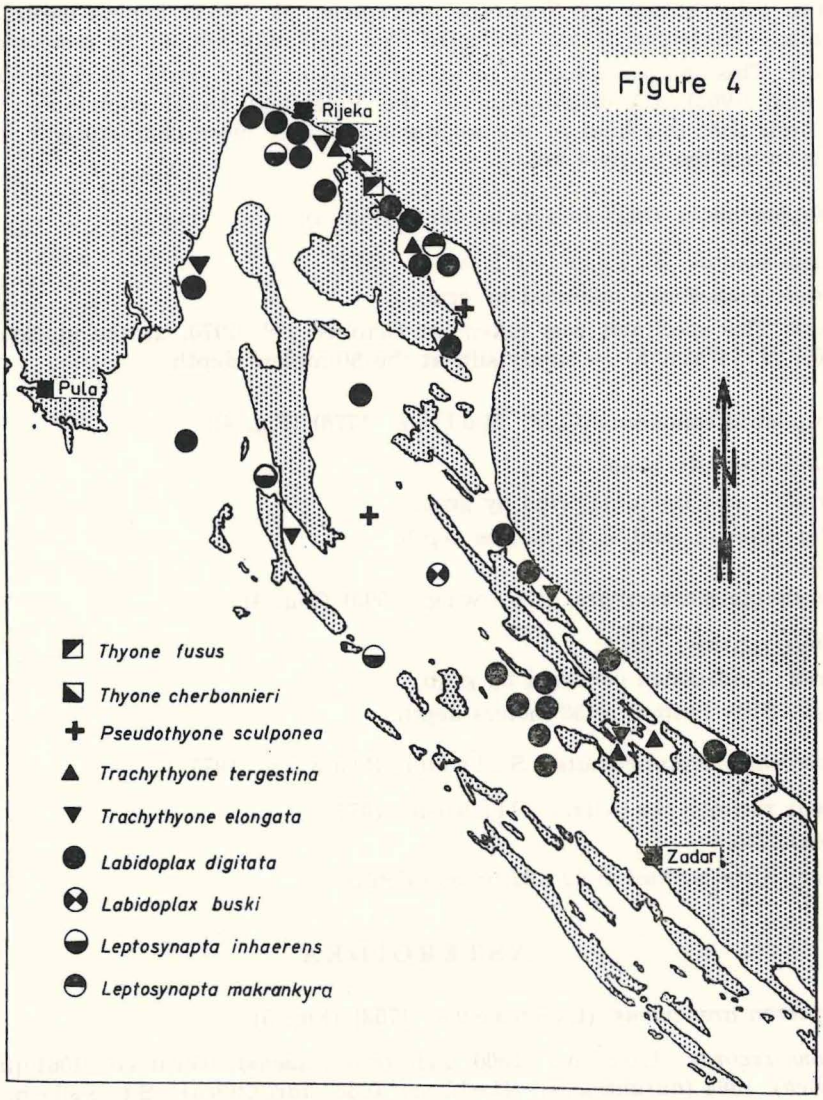
Habitat: Silty bottom in Tihi kanal, at 50 meters depth.

Pseudothyone sculponea Cherbonnier, 1958 (Fig. 4)

Previous records: None.

Material: 2 specimens collected by grab.

Habitat: Fine sand and sandy silt. Colection depths 54 and 68 m.



Remark: By their ossicles, both specimens largely corresponded to description of Mayer (1937) for *P. raphanus*. According to *Froglia* (1975), *Mayer's* description refers in fact to *P. sculponea*.

Labidoplax digitata (Montagu, 1815) (Fig. 4)

Previous records: Heller, 1868 *(Synapta);* Kolosvary, 1936, 1940 a, b *(Becheria);* Mayer, 1937; Vatova 1942 *(Synapta),* 1949; Legac, 1974 *(Labidoplax);* Zavodnik 1973 b, 1977 a; Zavodnik & Zavodnik, 1978; Zavodnik *et al.,* 1978 (all *Oestergrenia).*

Material: 44 specimens taken by grab.

Habitat: Silty bottom of *Nephrops norvegicus*, at 39—83 meters depth. Near Starigrad—Paklenica, it was collected also on sandy silt, at 28 meters depth.

Remark: This species is exclusive to the biocoenosis of coatal terrigenous ooze (Picard 1965). Its distribution in the Velebitski kanal contribute to the hypothesis that this kind of the sediment is rather more characteristic for the area than are the bathyal muds.

Labidoplax buski (Mc Intosh, 1866) (Fig. 4)

Previous record: Salvini-Plawen, 1977

Material: 1 specimen collected by grab.

Habitat: The specimen was taken on October 2nd, 1970, at the station K-II (44°36.1' N, 14°43.3' E) on sandy silt, at the 80 meters depth.

Leptosynapta inhaerens (O. F. Müller, 1776) (Fig. 4)

Previous records: None.

Material: 1 specimen collected by grab.

Habitat: Coarse sand at 47 meters depth.

Leptosynapta makrankyra (Ludwig, 1898) (Fig. 4)

Previous records: None.

Material: 1 specimen collected by grab.

Habitat: Silty bottom at 58 meters depth.

Myriotrochus geminiradiatus Salvini-Plawen, 1977

Previous record: Salvini-Plawen, 1977

Material: None.

Habitat: Silty bottom at 49—82 meters depth.

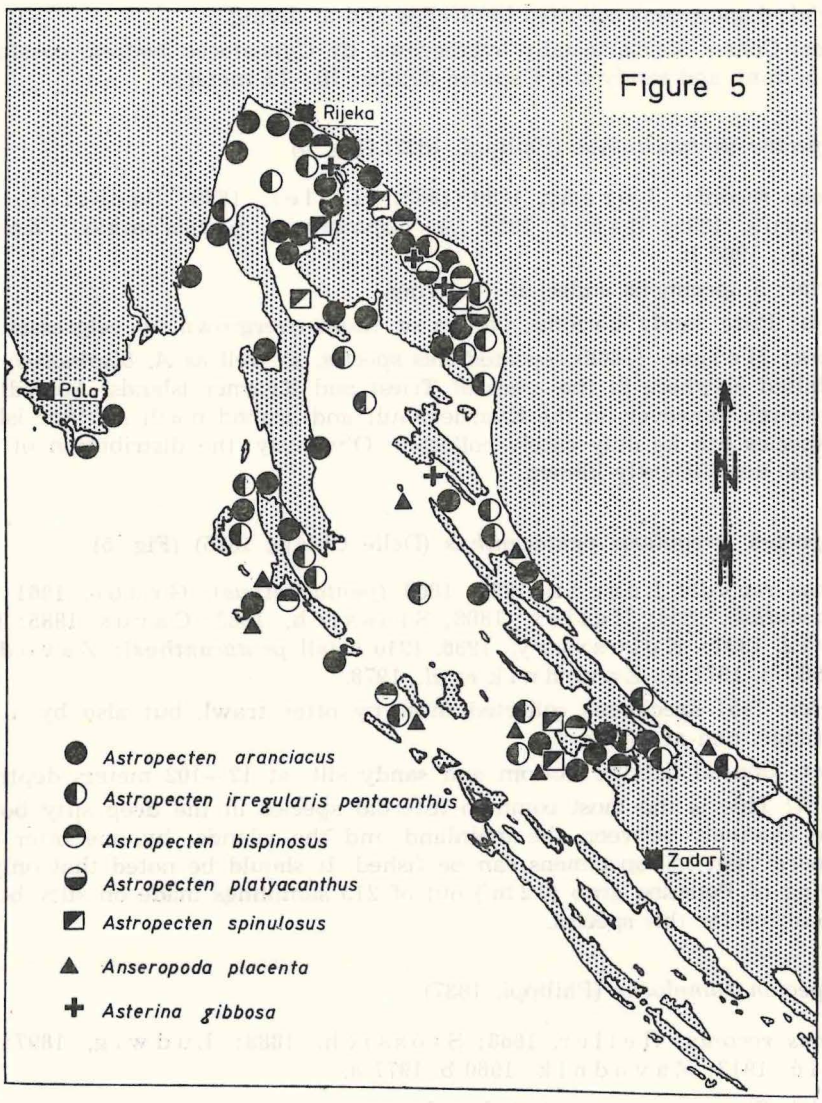
ASTEROIDEA

Astropecten aranciacus (Linnaeus, 1758) (Fig. 5)

Previous records: Lorenz, 1860, 1863 *(aurantiacus);* Grube, 1861 *(aurantiaca),* 1864 *(aurantiacus);* Heller, 1868 *(aurantiaca);* Stossich, 1883; Carus, 1885 (all *aurantiacus);* Ludwig, 1897 *(aurantiaca);* Kolosvary, 1940 a; Vatova, 1942; Zalokar, 1942 (all *aurantiacus);* Zavodnik, 1960 b, 1977 a; Crnković, 1970; Legac, 1974 *(auranciacus);* Zavodnik *et al.,* 1978.

Material: About 240 specimens collected by otter trawl and dredge, or noted at diving.

Habitat: Fine well calibrated sands, coarse sands and fine gravels under the influence of bottom currents, and coastal deritic bottom. Common in the communities of eelgrasses, especially among *Cymodocea nodosa.* Only exceptionally it was found on rocky bottom, within the biocoenosis of photophilic algae. Collection depths: 0.5—68 meters.



Astropecten jonstoni (Delle Chiaje, 1825)

Previous record: Babić, 1913
Material: None.
Habitat: No data for the area.

Astropecten bispinosus (Otto, 1823) (Fig. 5)

Previous records: Grube, 1864; Heller, 1868; Stossich, 1883; Carus, 1885; Ludwig, 1897; Babić, 1913; Kolosvary, 1940 a; Zavodnik, 1960 b, 1977 a; Zavodnik *et al.*, 1978.

Material: 4 specimens collected by dredge and at diving.

Habitat: Coarse sands, usually overegrown by *Cymodocea nodosa,* coastal detritic bottom, and sandy silt. Capture depths: 10—12 meters.

Astropecten platyacanthus (Philippi, 1837) (Fig. 5)

Previous records: Lorenz, 1860, 1863; Heller, 1868; Stossich, 1883; Carus, 1885; Babić, 1913 *(A. bispinosus f. platyacanthus);* Zavodnik, 1960 b.

Material: 5 specimens collected at diving.

Habitat: Pure sandy bottoms, barren or those overgrown by eelgrasses.

Remark: Heller (1868) reported this species, as well as *A. bispinosus,* to be distributed elswhere in the areas of Triest and Kvarner islands. According to our research, however, in the Kvarner Gulf and around north Adriatic islands, both species can be only rarely collected. Obviously, the distribution of them is far too insufficiently known.

Astropecten irregularis pentacanthus (Delle Chiaje, 1825) (Fig. 5)

Previous records: Lorenz, 1860, 1863 *(pentacanthus);* Grube, 1861 *(pentacantha),* 1864; Heller, 1868; Stossich, 1883; Carus, 1885; Ludwig, 1897; Kolosvary, 1936, 1940 a (all *pentacanthus);* Zavodnik, 1960 b, 1977 a; Zavodnik *et al.,* 1978.

Material: 1651 specimens collected most by otter trawl, but also by a grab, dredge, and at diving.

Habitat: Coastal detritic bottom and sandy silt, at 12—102 meters depth.

Remark: This is the most common asteroid species in the deep silty bottoms in the channels between the mainland and the islands: by one otter trawl tow more than 150 specimens can be fished. It should be noted that only one sampling of Petersen grab (0.2 m^2) out of 215 samplings made on silty bottom, was positive for this species.

Astropecten spinulosus (Philippi, 1837)

Previous records: Heller, 1868; Stossich, 1883; Ludwig, 1897; Babić, 1913; Zavodnik, 1960 b, 1977 a.

Material: Five specimens collected at diving.

Habitat: Rough sands and fine gravels occupied by meadows of *Posidonia oceanica.* Most rarely the animals can be found while crawling on the thalli of big *Cystoseira.* Capture depths: 7—17 meters.

Remark: Perhaps the reason for seldom collections in the area is a pretty scarce knowledge of *Posidonia oceanica* meadows which are the most characteristic habitat of this asteroid species.

Anseropoda placenta (Pennant, 1777) (Fig. 5)

Previous records: Lorenz, 1860, 1863; Heller, 1868 (all *Asteriscus palmipes);* Stossich, 1883; Carus, 1885; Ludwig, 1897 (all *Palmipes*

membranaceus); Kolosvary, 1936, 1940 a *(membranacea);* Crnković, 1970; Legac, 1974; Zavodnik, 1977 a.

Material: 10 specimens collected by otter trawl, grab, and dredge.

Habitat: Rough sand and detritic bottom, at 40—70 meters depth.

Asterina gibbosa (Pennant, 1777) (Fig. 5)

Previous records: Lorenz, 1860 *(Asteriscus verruculatus),* 1863 *(Asteriscus ciliatus);* Grube, 1861 *(A. verruculata),* 1864; Heller, 1868; Stossich, 1883 (all *A. verruculatus);* Carus, 1885; Ludwig, 1897; Babić, 1913; Kolosvary, 1936, 1940 a; Zavodnik, 1960 b; Legac, 1974.

Material: 12 specimens collected at coastal research.

Habitat: Among loose stones in littoral zone, 0—1 meter depth.

Remark: Few localities of this species indicate that its typical habitat was not studied enough in the area explored.

Asterina pancerii (Gasco, 1870)

Previous record: Babić, 1913 *(A. gibbosa var. pancerii)*

Material: None.

Habitat: No data for the area.

Echinaster sepositus (Retzius, 1783) (Fig. 6)

Previous records: Lorenz, 1860, 1863; Grube, 1861 *(seposita),* 1864; Heller, 1868; Stossich, 1883; Carus, 1885; Ludwig, 1897; Kolosvary, 1936, 1940 a; Zalokar, 1942; Zavodnik, 1960 b, 1977 a; Crnković, 1970; Legac, 1974; Zavodnik *et al.,* 1978.

Material: About 140 specimens collected by otter trawl and dredge, and collected or noted at diving.

Habitat: Rocky bottom overgrown by photophilic algae, rough sands and gravels, bare ones or those occupied by meadows of *Cymodocea nodosa* and *Posidonia oceanica,* coastal detritic bottom, and also the bottom of pebbles and steep slopes of loose stones. Collection depths: 2—63 meters.

Remark: Near Lošinj, two six-armed animals were collected.

Coscinasterias tenuispina (Lamarck, 1816) (Fig. 6)

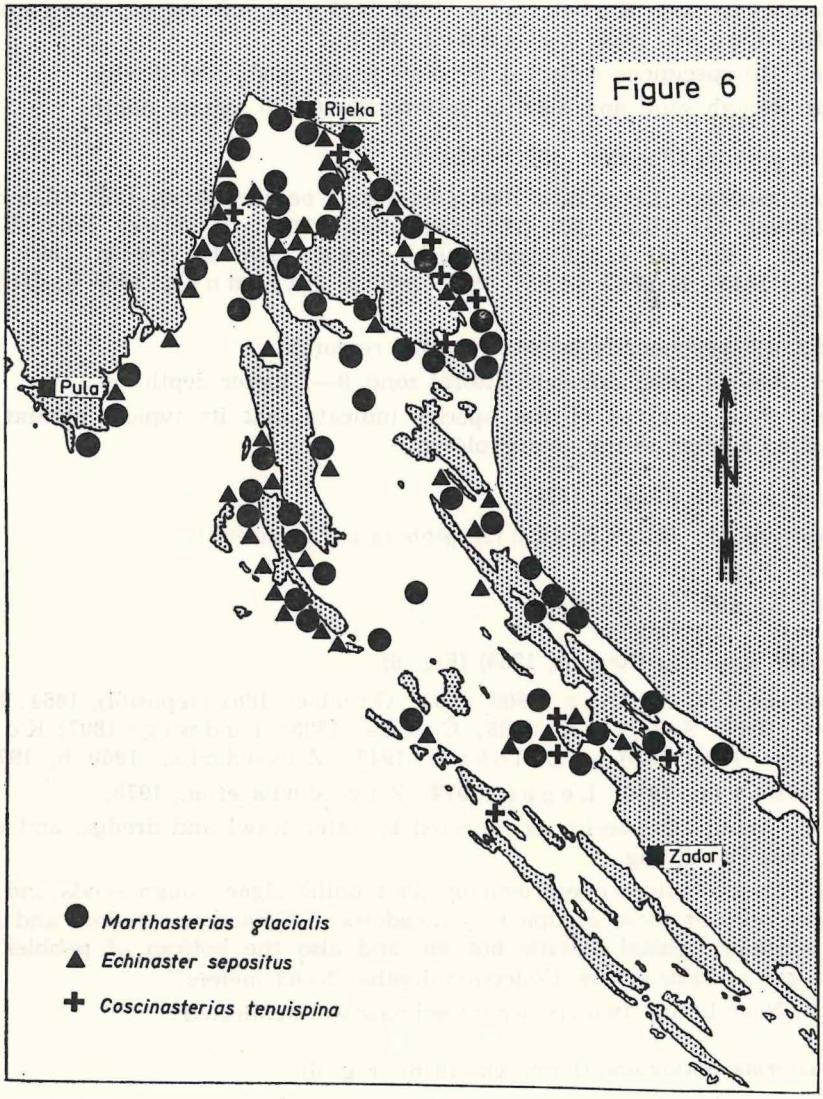
Previous records: Lorenz, 1860; Heller, 1868 (all *Asteracanthion tenuispinus);* Stossich, 1883 *(Asteracanthion);* Carus, 1885; Ludwig, 1897 (all *Asterias);* Kolosvary, 1936, 1940 a; Zalokar, 1942; Zavodnik, 1960 b, 1977 a; Legac, 1974; Zavodnik *et al.,* 1978.

Material: 12 specimens collected or recorded at diving.

Habitat: Rocky bottom and under loose stones, at 0—3 meters depth.

Marthasterias glacialis (Linnaeus, 1758) (Fig. 6)

Previous records: Lorenz 1860, 1863 *(Asteracanthion);* Grube 1861 *(Asterias);* Heller, 1868; Stossich, 1883 (all *Asteracanthion);* Carus, 1885; Ludwig, 1897 (all *Asterias);* Kolosvary, 1936, 1940 a; Zalokar,



1942; Zavodnik, 1960 b, 1977 a; Crnković, 1970; Zavodnik, *et al.*, 1978.

Material: About 200 specimens collected by grab, otter trawl, dredge, and collected or noted at diving.

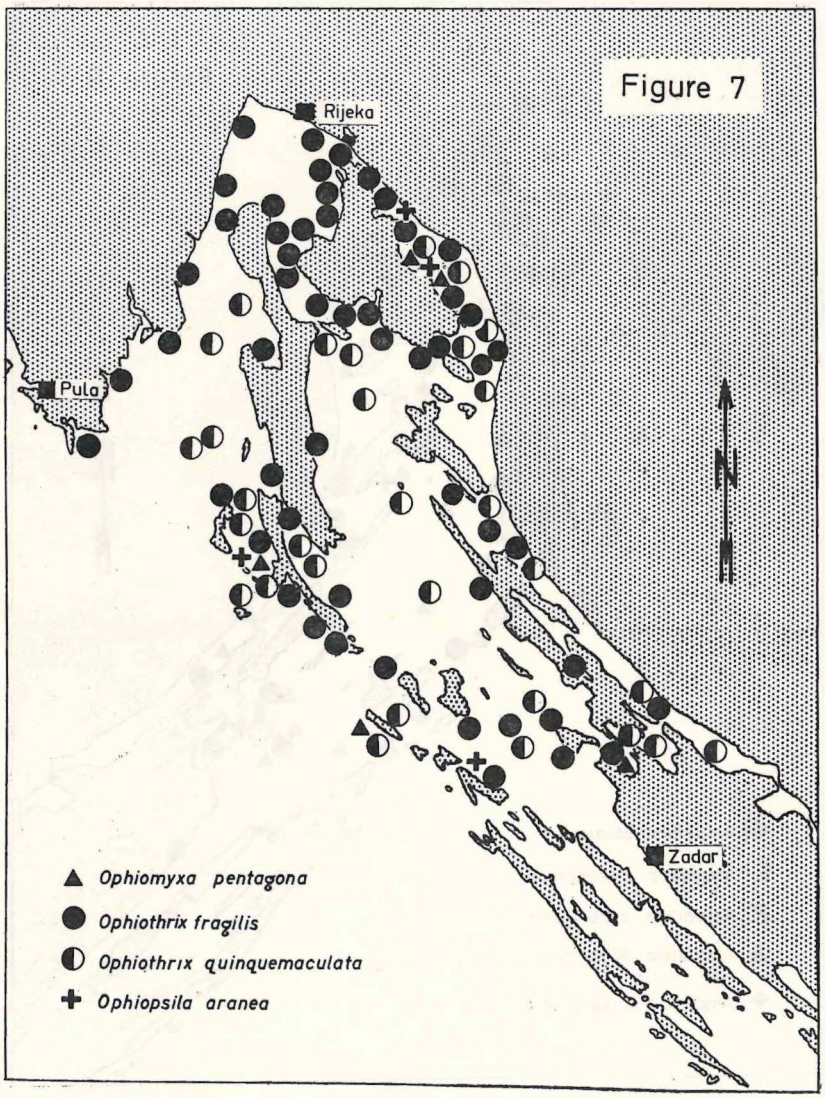
Habitat: Species of wide ecological distribution which is common on rocky bottom within the biocoenosis of high photophilic algae, under loose stones, on sands and gravels, in the meadows of *Posidonia oceanica,* in the communities of coastal detritic bottoms. Once, two animals were observed on a big live pen-shell *Pinna nobilis.* It is noted also in polluted harbour waters. Collection depths: 0—112 meters.

Remark: Shallow water specimens are always uniformly dark-green or brown-greenish coloured, while specimens from deeper detritic bottoms are usually vividly coloured, more light, and can exceptionally be totally yellow.

OPHIUROIDEA

Ophiomyxa pentagona (Lamarck, 1816) (Fig. 7)

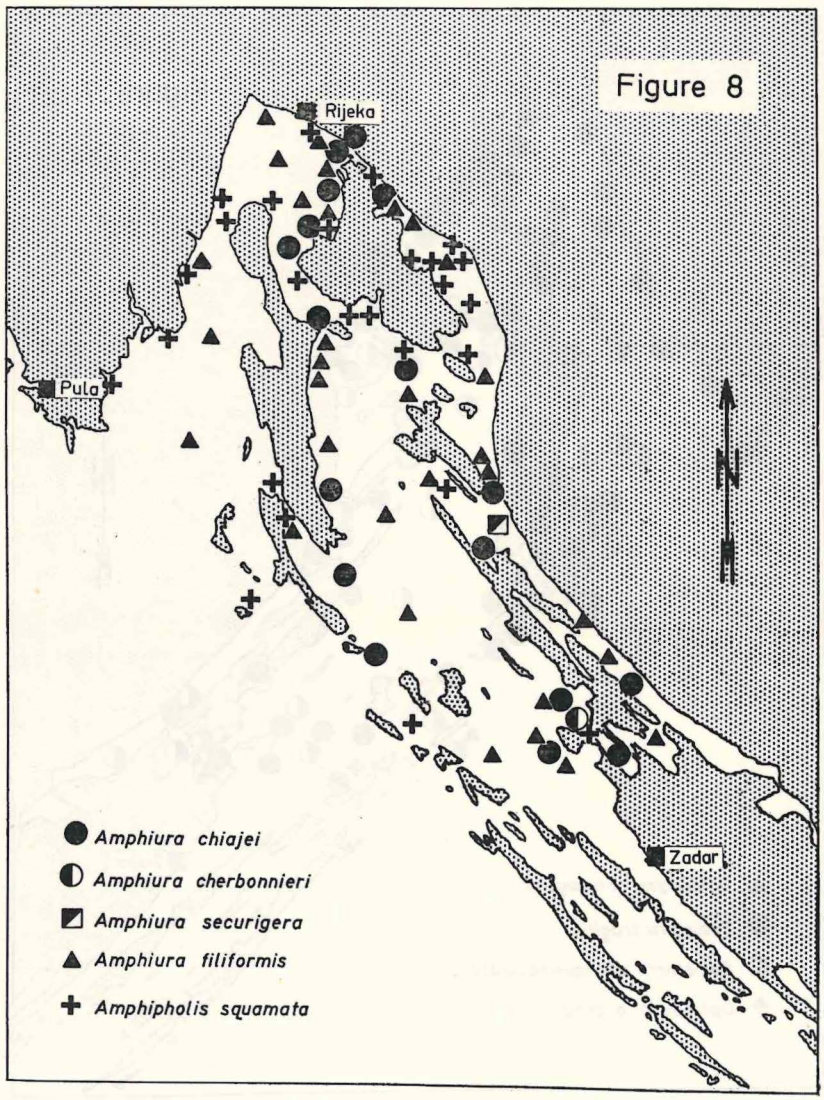
Previous records: Lorenz, 1860, 1863; Grube, 1861, 1864; Heller, 1868; Stossich, 1883; Carus, 1885; Kolosvary, 1936, 1940 a; Zavodnik, 1960 b, 1977 a.



Material: 20 specimens collected by dredge.
Habitat: Coastal detritic bottom, at 12—56 meters depth.

Ophiopsila aranea Forbes, 1843 (Fig. 7)

Previous records: Grube 1864; Heller, 1868; Stossich, 1883; Carus, 1885; Kolosvary, 1936, 1940 a; Vatova, 1949; Zavodnik, 1960 b. 1977 a; Tortonese, 1965.
Material: 12 specimens collected by grab and dredge.
Habitat: Sandy bottom. Collection depths: 45—56 meters.



Amphiura chiajei Forbes, 1843 (Fig. 8)

Previous records: Lorenz, 1863 *(Ophiolepis sundevalli);* Marktanner-Turneretscher, 1887; Kolosvary, 1936, 1940 a (all *Chiajei);* Vatova, 1942, 1949; Zavodnik, 1972 a, 1977 a; Zavodnik *et al.,* 1978.

Material: 26 specimens captured by grab and dredge.

Habitat: Fine sands, sandy detritus, sandy silt, and coastal terrigenous ooze. Collection depths: 13—102 meters.

Amphiura cherbonnieri Guille, 1972 (Fig. 8)

Previous records: None.

Material: 1 specimen collected at Ljubačka vrata at diving.

Habitat: Detritus sand at 30 meters depth.

Amphiura filiformis (O. F. Müller, 1776) (Fig. 8)

Previous records: Grube, 1861, 1864; Heller, 1868; Stossich, 1883; Carus, 1885; Kolosvary, 1936, 1940 a; Vatova, 1949; Zavodnik, 1972 a, 1977 a.

Material: 45 specimens taken by grab.

Habitat: Fine sands, sandy silt, and coastal terrigenous ooze, at 39—105 meters depth.

Amphiura securigera (Düben et Koren, 1846) (Fig. 8)

Previous records: Zavodnik, 1972 a, 1973 a.

Material: 1 specimen collected by grab.

Habitat: Sandy bottom at 61 meters depth.

Remark: Until now, this species is not known from other locations in the Adriatic Sea.

Amphipholis squamata (Delle Chiaje, 1828) (Fig. 8)

Previous records: Zavodnik, 1960 a, b, 1972 a, 1977 a.

Material: 47 specimens collected at coastal research and diving survey.

Habitat: Among seaweeds and holdfasts and leaves of *Posidonia oceanica.* Capture depths: 0—30 meters.

Remark: This tiny amphiurid is surely much more distributed in the area than it is seen from the mapped localities. Obviously, I have overlooked it many times at routine underwater biocoenological survey.

Ophiothrix fragilis (Abildgaard, 1789) (Fig. 7)

Previous records: Lorenz, 1860 *(fragilis + alopecurus),* 1863; Grube, 1861, 1864; Heller, 1868; Stossich, 1883; Carus, 1885; *Marktanner*-Turneretscher, 1887 *(alopecurus);* Kolosvaary, 1936, 1940 a *(fragilis echinata);* Zalokar, 1942; Zavodnik, 1960 b, 1977 a; Legac, 1974.

Material: More than 1000 specimens captured by grab, dredge, otter trawl, and collected or noted at diving.

Habitat: All kinds of rocky and stony bottom, under loose stones, in crevices, and similar. Very common among algae and in beds of *Posidonia oceanica.* Also found on seaweeds, sessile animals, and hard objects on sandy bottoms. Collection depths: 0—63 meters.

Ophiothrix quinquemaculata (Delle Chiaje, 1828) (Fig. 7)

Previous records: Vatova, 1949; Legac, 1974; Zavodnik, 1977 a.

Material: Some thousands specimens collected by grab, otter trawl, dredge, and noted at diving.

Habitat: Very common on coastal detritic bottom and silty detritus. It seems that on oozy bottoms inhabited by *Nephrops norvegicus* the animals stay before all on hard objects — epipelic shells, echinoid tests, and on dendritic sponges *Axinella polypoides* and *Axinella cannabina.* Capture depths: 18—102 meters.

Remark: On sponges mostly young animals settle: maximum about 100 specimens were found on a moderately large *Axinella.*

Ophioderma longicaudum (Retzius, 1805) (Fig. 9)

Previous records: Grube, 1840 *(Ophiura lacertosa),* 1861, 1864; Lorenz, 1860, 1863; Heller, 1868; Stossich, 1883; Carus, 1885; Kolosvary, 1936, 1940 a (all *longicauda);* Zalokar, 1942 *(lacertosum);* Zavodnik, 1960 b, 1977 a; Legac, 1974; Zavodnik *et al.,* 1978.

Material: About 320 specimens collected by dredge and noted at diving.

Habitat: Rocky bottom overgrown by high photophilic algae, gravels among the stone no more than 20 centimeters in diameter. Collection depths: 0.5—12 stones and other hard objects. Several times 2—3 animals can be found under the stone no more than 20 cetimeters in diameter. Collection depths: 0.5—12 meters.

Remark: Very variable in colouring.

Ophioconis forbesi (Heller, 1863) (Fig. 9)

Previous records: Grube, 1864 *(Pectinura Forbesii);* Heller, 1868 *(Pectinura);* Stossich, 1883; Carus, 1885 (all *Forbesii);* Zavodnik, 1977 b.

Material: 8 specimens collected by grab and dredge.

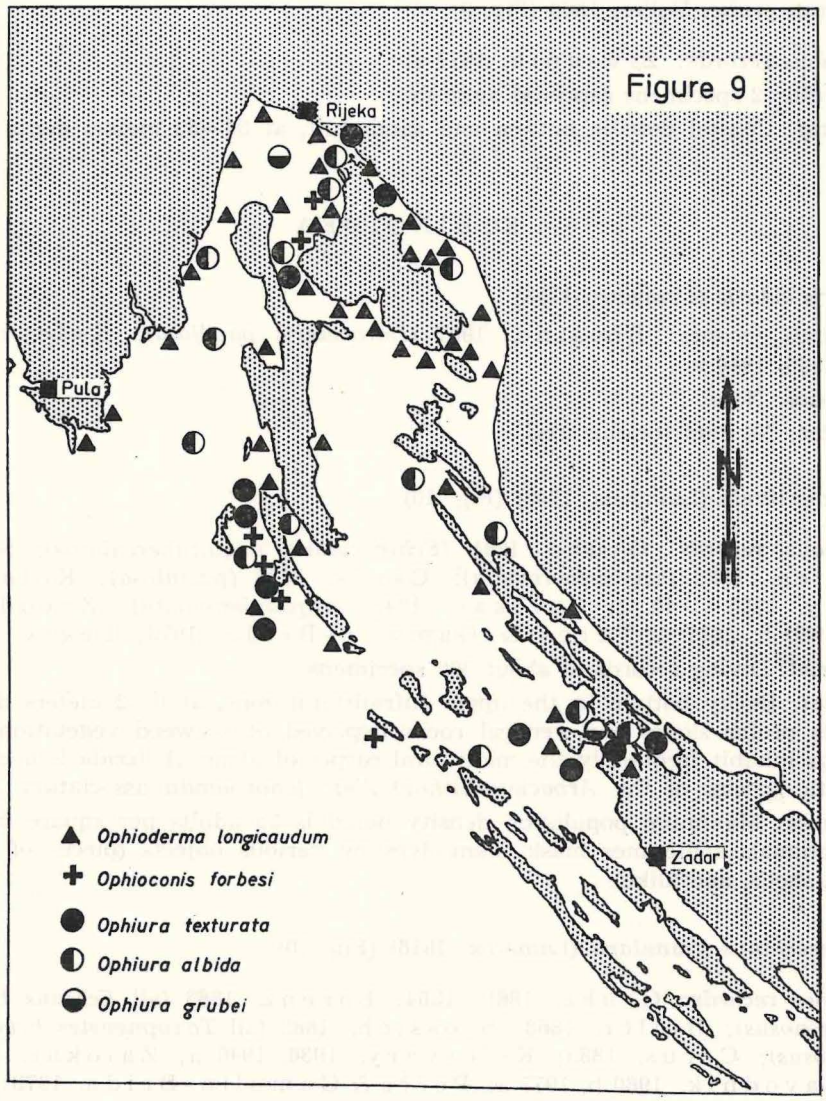
Habitat: Pure sand and coastal detritic bottom. Sampling depths: 23—59 meters.

Ophiura texturata Lamarck, 1816 (Fig. 9)

Previous records: Lorenz, 1860, 1863; Grube, 1861, 1864 (all *Ophiolepis ciliata);* Heller, 1868; Stossich, 1883 (all *Ophioglypha);* Carus, 1885 *(Ophioglypha lacertosa);* Kolosvary, 1936, 1940 a; Zei, 1949; Zavodnik, 1977 a; Zavodnik *et al.,* 1978.

Material: 104 specimens collected by otter trawl, dredge, or by diver.

Habitat: Coastal detritic bottom at 12—63 meters depth.



Ophiura albida Forbes, 1839 (Fig. 9)

Previous records: Grube, 1864 *(Pectinura Forbesii);* Heller, 1868 *(Pecti-* 1885; Marktanner-Turneretscher, 1887 (all *Ophioglypha);* Vatova, 1949; Zavodnik, 1977 a; Zavodnik *et al.,* 1978.

Material: 57 specimens collected by grab, dredge, and at diving.

Habitat: Fine sand and sandy silt, common on coastal detritic bottom. Collection depths: 12—102 meters.

Remark: Near Lošinj, two four-armed specimens were collected.

Ophiura grubei Heller, 1863 (Fig. 9)

Previous records: Zavodnik, 1977 a.

Material: 2 specimens captured by grab.

Habitat: Coastal detritic bottom and sandy silt, at 30—62 meters depth.

ECHINOIDEA

Cidaris cidaris (Linnaeus, 1758)

Previous records: Brusina, 1907 *(Dorocidaris papillata);* Kolosvary, 1936, 1940 a.

Material: None.

Habitat: No data for the area.

Arbacia lixula (Linnaeus, 1758) (Fig. 10)

Previous records: Grube, 1861 *(Echinocidaris aequituberculatus);* Stossich, 1883 *(aequituberculata);* Carus, 1885 *(pustulosa);* Kolosvary, 1936, 1940 a; Zalokar, 1942 *(aequituberculata);* Zavodnik, 1960 b, 1977 a; Pérès & Gamulin-Brida, 1973; Legac, 1974.

Material: Diving records of about 300 specimens.

Habitat: Rocky bottom in the upper infralittoral zone, at 0—2 meters depth. Adults prefer slopes and vertical rocks deprived of seaweed vegetation, but youngs inhabit frequently the midlittoral carpet of algae. *A. lixula* is a characteristic species of the *Arbacieto-Lithophylleto lenormandii* association.

Remarks: Maximum population density noted is 25 adults per square meter. The animals sometimes mask themselves by various objects (pieces of algal thalli, shells, and alike).

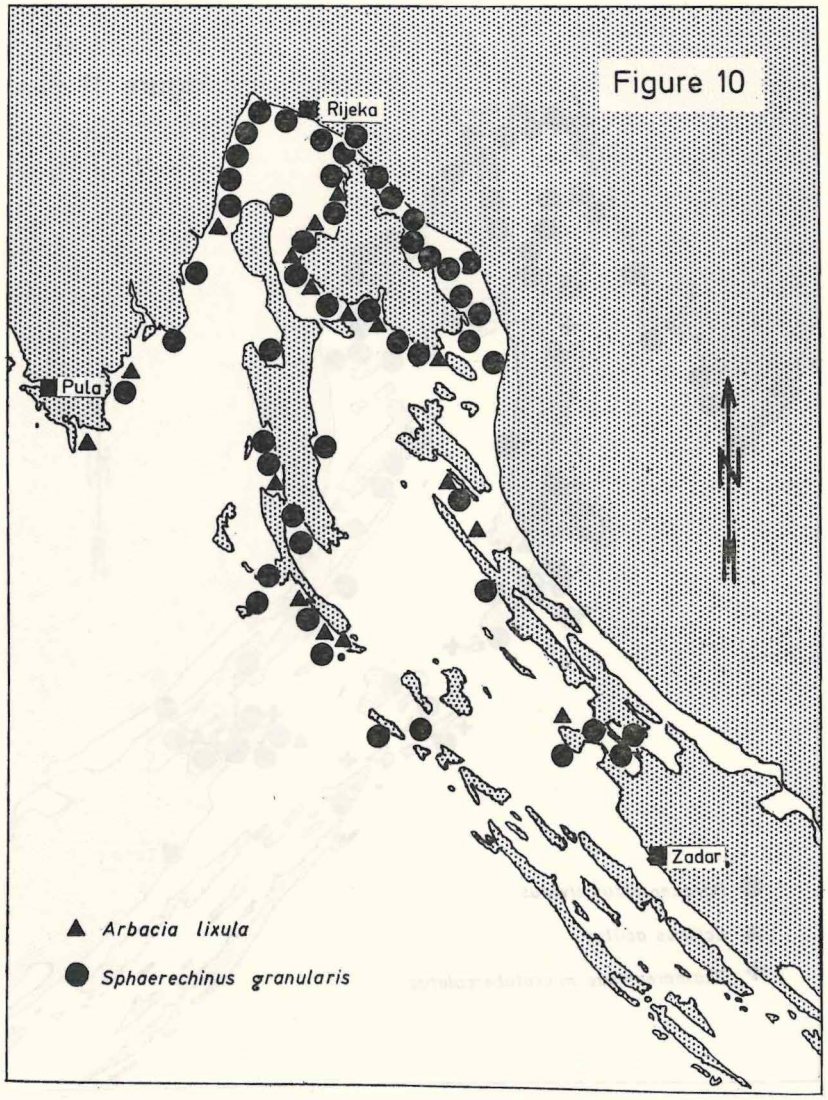
Sphaerechinus granularis (Lamarck, 1816) (Fig. 10)

Previous records: Grube, 1861, 1864; Lorenz, 1863 (all *Echinus brevispinosus);* Heller, 1868; Stossich, 1883 (all *Toxopneustes brevispinosus);* Carus, 1885; Kolosvary, 1936, 1940 a; Zalokar, 1942; Zavodnik, 1960 b, 1977 a; Pérès & Gamulin-Brida, 1973; Legac, 1974; Zavodnik *et al.,* 1978.

Material: About 500 specimens, collected by grab and dredge, and noted at diving.

Habitat: All kinds of rocky, stony, gravely, sandy, and coastal detritic bottoms. Collection depths: 5—56 meters.

Remarks: Maximum population density noted at diving is one adult per about two square meters. In Unijski kanal, on pure well calibrated sand, the Petersen grab survey resulted in 40 juveniles (3—5 cms in diameter) per one square meter. Sometimes, the adults are scarcely masked by pebbles, dead shells, end even tests of other echinoids. Colour variables seem not to be specific for localities and habitats.



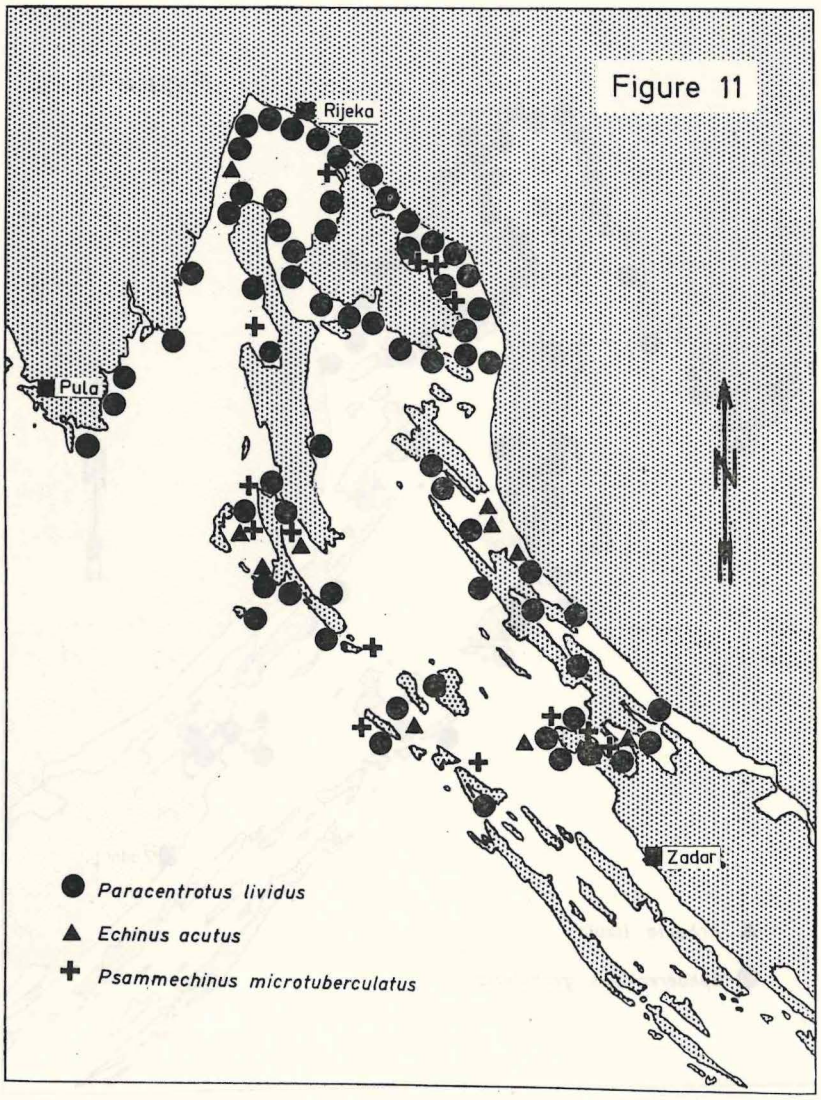
Echinus acutus Lamarck, 1816 (Fig. 11)

Previous records: Lorenz, 1863; Grube, 1864; Heller, 1868 (all *melo ?);* Carus, 1885; Car & Hadži, 1914 b *(melo)*; Zavodnik, 1977 a.

Material: 128 specimens collected by otter trawl, dredge, and at diving.

Habitat: Coastal detritic bottom, silty sands, and sandy silt. Collection depths: 18—102 meters.

Remark: Considering our present knowledge on the distribution and ecology of this species, one can veritably suspect that several older literature citations



for *E. melo* refer in fact to the species *E. acutus*, especially if the latter is not cited in the same paper. Consequently, the distribution patterns of both *Echinus* species are fruther on an enigma not only in the area treated in this paper but also in the entire Adriatic Sea.

Echinus melo Lamarck, 1816

Previous records: Stossich, 1883; Carus, 1885; Crnković, 1970; Zavodnik, 1977 a.

Material: 2 specimens captured at diving.

Habitat: Sand and gravel at 25 meters depth.

Remark: Both specimens are young and exhibit morphological characters of *E. melo* and also *E. acutus* (Zavodnik 1977 a). The habitat in which the animals were collected is more likely to that of *E. acutus*. In spite of this finding, I suspect that the presence of *E. melo* in the area investigated is not yet satisfactorily proved.

Psammechinus microtuberculatus (Blainville, 1825) (Fig. 11)

Previous records: Grube, 1861, 1864; Lorenz, 1863 (all *Echinus*); Heller, 1868; Stossich, 1883; Carus, 1885 *(Echinus);* Car & Hadži, 1914 a; Kolosvary, 1936, 1940 a; Zavodnik, 1960 b, 1977 a; Legac, 1974.

Material: 54 specimens collected by otter trawl, dredge, and grab, and noted at diving.

Habitat: Coastal detritic bottom and the beds of *Posidonia oceanica.* Collection depths: 7—65 meters.

Paracentrotus lividus (Lamarck, 1816) (Fig. 11)

Previous records: Grube, 1840 *(Echinus saxatilis),* 1861, 1864; Lorenz, 1863 (all *Echinus);* Heller, 1868; Stossich, 1883 (all *Toxopneustes);* Carus, 1885 *(Strongylocentrotus);* Kolosvary, 1936, 1940 a; Zalokar, 1942; Zavodnik, 1960 b, 1977 a; Legac, 1974; Zavodnik *et al.,* 1978.

Material: Several thousands specimens sampled by otter trawl and the dredge, and noted at diving.

Habitat: All kinds of rocky, gravely, sandy and detritic bottoms in the infralittoral zone (0 — 46 meters). Absent on genuine silty bottoms. On sedimentary bottoms, the animals usually cluster on isolated stones, large shells and tests, and on various refuses. On rocky shore, *P. lividus* population often expands into the mediolittoral zone, and rarely the specimens can be found even in rock pools. It is common also in polluted waters.

Remarks: Between loose stones, and on the barren rocky terraces, the maximum population densities of adults often exceed hundred specimens per square meter. It seems that *P. lividus* is the most distributed echinoderm species in the Adriatic rocky littoral. At localities where *Arbacia lixula* and *Paracentrotus lividus* coinhabit the bare rocky bottom, the upper infralittoral zone (between 0 to about 1—1.5 meters depth) is occupied almost exclusively by *Arbacia,* while deeper on the genuine *Paracentrotus* population absolutely prevails. Moreover, *Arbacia* prefers steep rocky cliffs, while *Paracentrotus* population occupies more slopy parts of the sea bottom. *P. lividus* specimens are usually always masked by all kinds of objects, even in surfing localities.

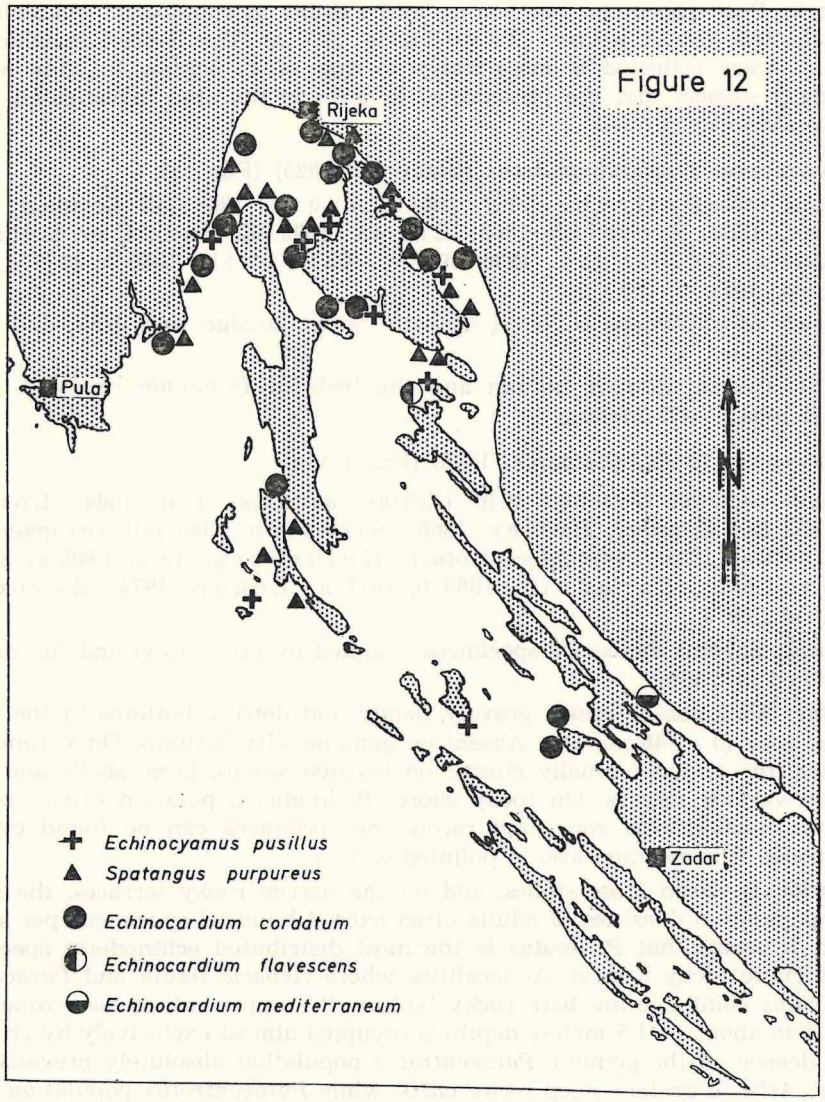
Echinocyamus pusillus (O. F. Müller, 1776) (Fig. 12)

Previous records: Grube, 1861, 1864 *(tarentinus);* Heller, 1868; Stossich, 1883; Carus, 1885; Kolosvary, 1936, 1940 a; Zavodnik, 1960 b, 1971.

Material: 12 live specimens collected by grab and at diving; about 280 tests.

Habitat: Well calibrated sand at 39 and 65 meters depth.

Remark: Many dead tests were collected or noted at diving suveys but the localities are not plotted on the map.



Echinocardium cordatum (Pennant, 1777) (Fig. 12)

Previous records: Zavodnik, 1960 b, 1971, 1977 a, 1978; Legac, 1974; Zavodnik *et al.*, 1978.

Material: 5 live specimens and about 350 tests, all collected or noted at diving.

Habitat: Pure well calibrated sand, barren or superimposed by the meadow of *Cymodocea nodosa*. Collection depths: 6 — 8 meters.

Echinocardium flavescens (O. F. Müller, 1776) (Fig. 12)

Previous record: Zavodnik, 1971

Material: 1 specimen collected by a grab.

Habitat: Sandy botom near the island Rab, at 65 meters depth.

Echinocardium mediterraneum (Forbes, 1844) (Fig. 12)

Previous records: Kolosvary, 1936; Zavodnik, 1971.

Material: 1 test collected at diving.

Habitat: Fine well calibrated sand, at 4 meters depth.

Spatangus purpureus (O. F. Müller, 1776) (Fig. 12)

Previous records: Grube, 1864; Heller, 1868; Stossich, 1883 (all *meridionalis*); Carus, 1885; Kolosvary, 1936, 1940 a; Zavodnik, 1960 b, 1971; Legac, 1974; Zavodnik *et al.*, 1978.

Material: 12 live specimens collected by grab and the divers. About 100 tests collected or noted at diving.

Habitat: Coarse sands and fine gravels under the influence of bottom currents. Very rarely found in transition zones to the coastal detritic bottom. Collection depths: 20 — 47 meters.

Br*issopsis lyrifera* (Forbes, 1841) (Fig. 13)

Previous records: Kolosvary, 1936, 1940; Vatova, 1942 *(Bryssopsis);* Crnković, 1970, Zavodnik, 1971, 1973 b.

Material: 136 live specimens and about 100 tests collected by grab and otter trawl.

Habitat: Locally common on coastal terrigenous ooze. It lives also in sandy silt, and only once it was collected in fine sand. Capture depths: 43 — 102 meters.

Remarks: Juveniles live burried only few centimeters deep in the sediment, while the adults often reach the depth of about 25 — 30 centimeters. No correlation between colour varieties, the depth, and localities could be established.

Brissopsis mediterranea Mortensen, 1913

Previous record: Kolosvary, 1936

Material: None.

Habitat: No data for the area.

Brissus unicolor (Leske, 1778)

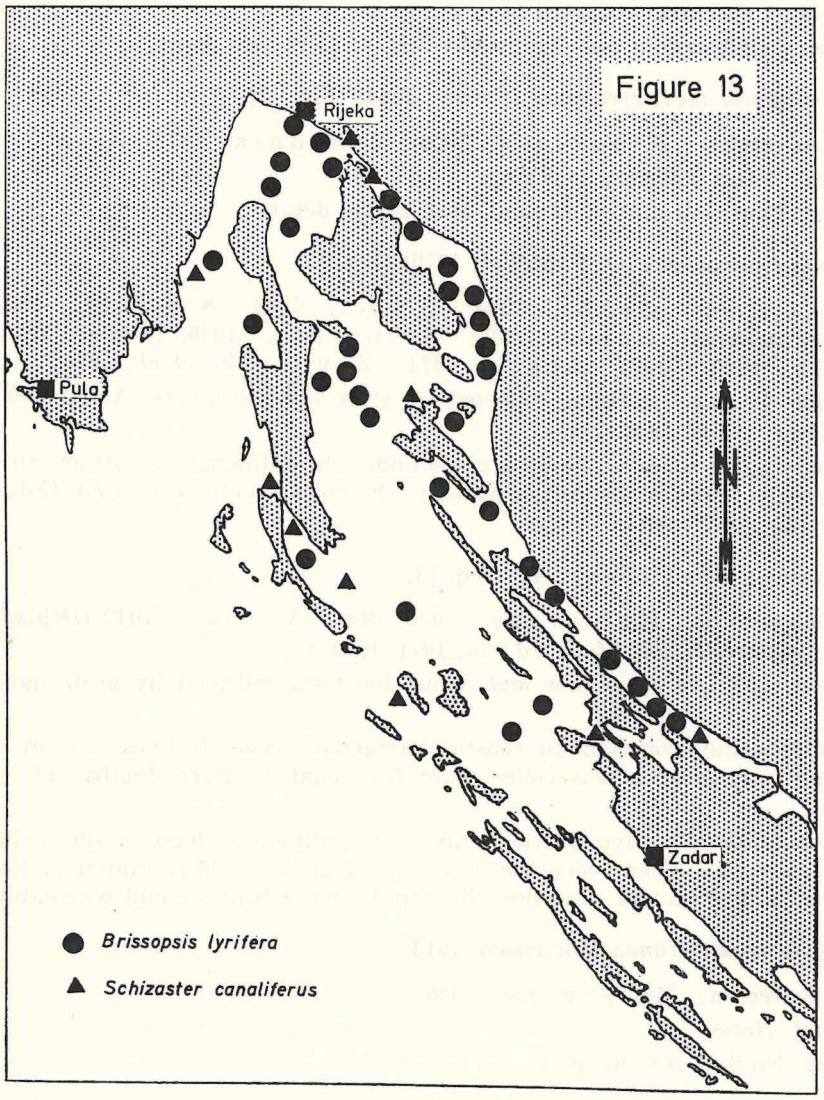
Previous records: Kolosvary, 1936, 1940 a; Zavodnik, 1971.

Material: None.

Habitat: Sand. No exact bathymetric data for the area.

Schizaster canaliferus (Lamarck, 1816) (Fig. 13)

Previous records: Grube, 1861 *(Spatangus),* 1864; Heller, 1868; Stossich, 1883; Carus, 1885; Kolosvary, 1936, 1940 a *(Ova);* Vatova, 1949; Zavodnik, 1960 b, 1971, 1977 a; Legac, 1974; Zavodnik *et al.*, 1978.



Material: 3 live specimens and 9 tests collected by grab.

Habitat: Fine well calibrated sand and silty detritic bottom. Collection depths: 43 — 80 meters.

DISCUSSION

A review of the literature revealed 54 echinoderm species reported for the Northern Adriatic insular region. To my regret, I did not suceed to collect the following 8 species which other authors have reported previously in this area:

Holothuria helleri v. Marenzeller, 1878: reported for Mali Lošinj by v. Marenzeller (1878), Carus (1885), Kolosvary (1936), and Tortonese (1965).

Myriotrochus geminiradiatus Salvini-Plawen, 1977: reported for Kvarnerić by Salvini-Plawen (1977).

Astropecten jonstoni (Delle Chiaje, 1825): reported for Rijeka by Babić (1913).

Chaetaster longipes (Retzius, 1805): reported for Senj by Babić (1913).

Asterina pancerii (Gasco, 1870); reported as *A. gibbosa var. pancerii* by Babić (1913) for Novi and Karlobag.

Cidaris cidaris (Linnaeus, 1758): reported by Brusina (1907) for Kvarnerić (as *Dorocidaris papillata*), and by Kolosvary (1940 a) for Senj.

Brissopsis mediterranea Mortensen, 1913: reported for Kanal Krušija by Kolosvary (1936) as *B. atlantica.*

Brissus unicolor (Leske, 1778): reported for Rijeka by Kolosvary (1936) as *B. brissus.*

Obviously, all the above named species are very rare in the Northern Adriatic insular region, and some of them were not rediscovered for more than half a century. I suppose that at least the thermophilic *Chaetaster longipes* does not live in this area. The record of Babić (1913) refers to a specimen which M. Padewith had found dried on the beach near Senj, but it was already Babić who supposed that the specimen was thrown away by fishermen who made a catch in another area.

The present author's data raise the number of echinoderms krown in the North Adriatic insular region to 59: *Thyone cherbonnieri, Pseudothyone sculponea, Leptosynapta inhaerens, Leptosynapta makrankyra,* and *Amphiura cherbonnieri* were not recorded previously. This approximates 44% of the echinoderms which are known from the Adriatic Sea (Zavodnik 1972 b, 1979). Only two of them have a world-like distribution *(Amphipholis squamata* and *Echinocardium cordatum),* and some seem to be endemic in the Mediterranean. Most of species, recorded in the study area have an atlantic-mediterranean distribution. Only *Brissopsis lyrifera* is distributed in the Mediterranean, along the eastern Atlantic, and (above all) in the northern seas. It is, however, common in the deep silty bottoms of the Velebitski kanal, Kvarnerić, nad also Riječki zaljev, where the temperature of bottom layer of sea water is relatively low throughout the year (Škrivanić and Barić 1979).

With regard to their bathymetric distribution, most of the echinoderms examined belong to the hypobathic and euribathic groups (Odhner 1915). This is in accordance with the relatively small depths in the area, which only rarely exceed 100 meters. Although in the depths of the Kvarner, Kvarnerić, and especially the Velebitski kanal, several bathyal faunistic elements can be found *(Virgularia mirabilis, Thenea muricata),* not one of the echinoderms studied belongs to this stock. All echinoderms which populate the deep silty bottoms in area, generally have hypobathic or eurybathic distribution, in the sense of Odhner (1915) nad Vatova (1949).

The great diversity of echinoderm fauna in the area investigated is conditioned by the diversity of bottom characters, the specific geomorphological features of the area, and the ecological tolerance of species which inhabit the

various kinds of sea bottom. The horizontal distribution of species which are strictly associated with a special kind of the bottom, is correlated with the distribution of that bottom and not with the depth zone (e. g. *Labidoplax digitata, Brissopsis lyrifera).*

A special problem is the distribution of sand living species at those coastal localities at which the primary rocky slope is covered by a thin layer of sand sometimes mixed with fine gravel and pebbles, which is hardly 10—15 centimeters thick. Such kind of the sea bottom is distributed in many shallow regions around the islands of Krk, Lošinj, Rab, and others. More rarely, this kind of bottom is found in the area also on the slope which inclination is about 10—20°. Most common on such sands are *Astropecten aranciacus, Holothuria tubulosa,* and *Echinocardium cordatum.* Of these, only *Echinocardium* is a typical infaunal species, of which the adults live 40 or even more centimeters deep burrowed in the sediment. But in the localities described above, usually only dead tests of juvenile specimens can be seen scattered on the surface of the sandy bottom. In fact, no live adult animal could be sampled by the devices used, or by divers, on such thin sandy bottoms. Probably, while growing, the joung animals migrate in search of deeper sediment, and perish if they do not find it. A similar pattern of vertical distribution of various size classes I have found also in *Brissopsis lyrifera.*

It is interesting to note that in areas with mixed sandy and rocky surfaces, the sand living species *Astropecten aranciacus* and *Holothuria tubulosa* were often found on genuine rocky terraces, even if covered by the dense carpet of seaweeds. This means that morphological and physiological adaptations of animals cannot be strict evidence for their distribution with regard to the kind of bottom and the community which occupies it.

Some echinoderms listed in this paper are considered characteristic species for selected benthic communities. So *Echinus acutus, Ophiura grubei,* and *O. texturata* are exclusive to the community of coastal detritic bottom, *Amphipholis squamata* is a characteristic species of the community of high photophilic seaweeds, and *Labidoplax digitata* is exclusive to coastal terrigenous ooze (P i c a r d 1965). But in the area investigated, the majority of echinoderms belong to the stock of species with wide ecological distribution. Regrettably, their real community distribution characteristics in this area are still imperfectly known. Namely, we can consider, that with regard to echinoderms, the communities distributed on silty and sandy bottoms, especially among *Cymodocea nodosa,* and on rocky shores, are relatively well explored. Much less is known about echinoderm fauna from *Posidonia oceanica* beds. The vertical rocky slopes of Velebitski kanal and several islands, which are rich on crevices, shaded subvertical walls, and carstic grottoes, remained until now literally unknown. Similarly, in spite of some field observations, there is no evidence on the influence of underwater springs of fresh water on surrounding benthic communities and their echinoderm populations.

Special attention should be also paid to echinoderms in polluted environment. Recent investigations by divers have shown that in the areas investigated, only *Paracentrotus lividus* and *Marthasterias glacialis* can be found on piers and on the stony or gravel bottom in moderately polluted harbours. In the sand and silt of the Rijeka harbour which is locally dark grey or nearly black because of the infuence of the H_2S, the *Amphiura chiajei* has also survived: its population density is about 3 specimens per square meter.

CONCLUSIONS

1. — In the north Adriatic insular region, echinoderms were sampled by the author at more than 300 coastal and offshore stations, in depths between 0—105 meters. In the material, 52 species were identified, all of them previously recorded from the Adriatic Sea.
2. — A review of the literature showed that at least 59 echinoderm species inhabit the area investigated. This represents about 44% of the echinoderms known from the Adriatic.
3. — Most of species belong to the group of hypobathic and eurybathic speceis in the sense of Odhner (1915), and they are most common in the area.
4. — The geographical distribution of echinoderms in the area studided is in complete accord with the kinds of bottom and benthic communities which they populate. The microdistributional patterns of sediment living *Echinocardium cordatum* and *Brissopsis lyrifera* are discussed.
5. — In moderately polluted harbour habitats the diversity of echinoderms is very low.

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RASPROSTRANJENOST BODLJIKAŠA U OTOČNOM PODRUČJU SJEVERNOG JADRANA

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KRATKI SADRŽAJ

U proteklih dvadesetak godina sakupljani su bodljikaši na više od 300 lokaliteta uz obalu i na pučini, raznim vrstama grabila, povlačnim mrežama i ronjenjem. Sabrano je ukupno 52 vrste, od kojih 5 *(Thyone cherbonnieri, Pseudothyone sculponea, Leptosynapta inhaerens, Leptosynapta makrankyra* i *Amphiura cherbonnieri)* do sada nije nađeno u području između riječko-istarske regije i područja Zadra. Time se broj vrsta koji nastanjuju to područje povećao na 59, što čini 44% svih vrsta bodljikaša do sada poznatih u Jadranskom moru.

Utvrđeno je, da geografska rasprostranjenost pojedinih vrsta ne ovisi toliko o dubinskim karakteristikama lokaliteta, koliko o rasprostranjenosti pojedinih tipova morskog dna odnosno rasprostranjenosti životnih zajednica. U istraživanom području prevladavaju euribatne i hipobatne atlantsko-mediteranske vrste širokog ekološkog rasprostranjenja.

Za svaku vrstu se navode dosadašnji nalazi u tom području, stanište te batimetrijski podaci. Za neke vrste daju se i drugi ekološki podaci. Posebno su razmotrene karakteristične »slike« lokalne rasprostranjenosti nekih najčešćih vrsta zmijača, te regularnih i iregularnih ježinaca. Također je ustanovljeno siromaštvo faune bodljikaša u zagađenoj sredini gradskih luka.