

STRUCTURE AND BIODYNAMICS OF LAGUNAR TRAVERTINE IN N. DALMATIA

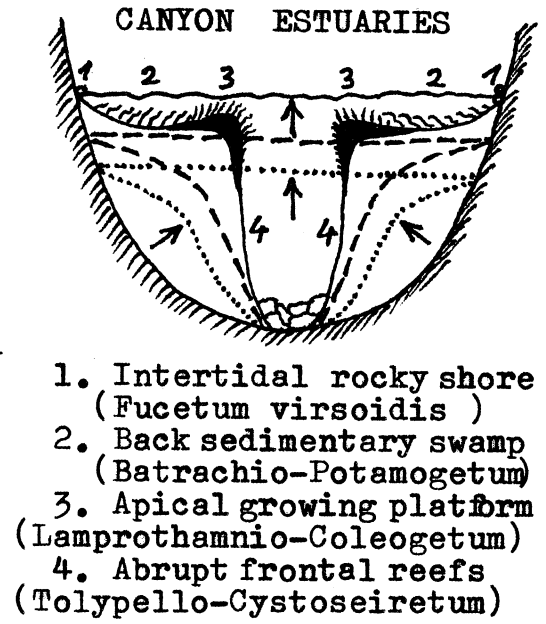
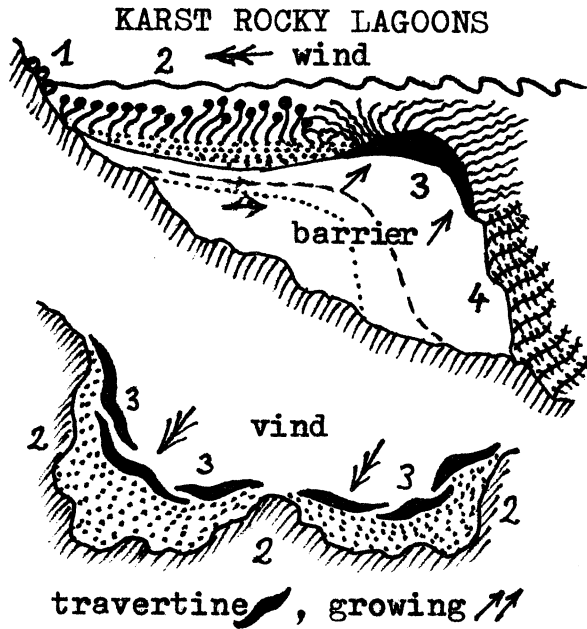
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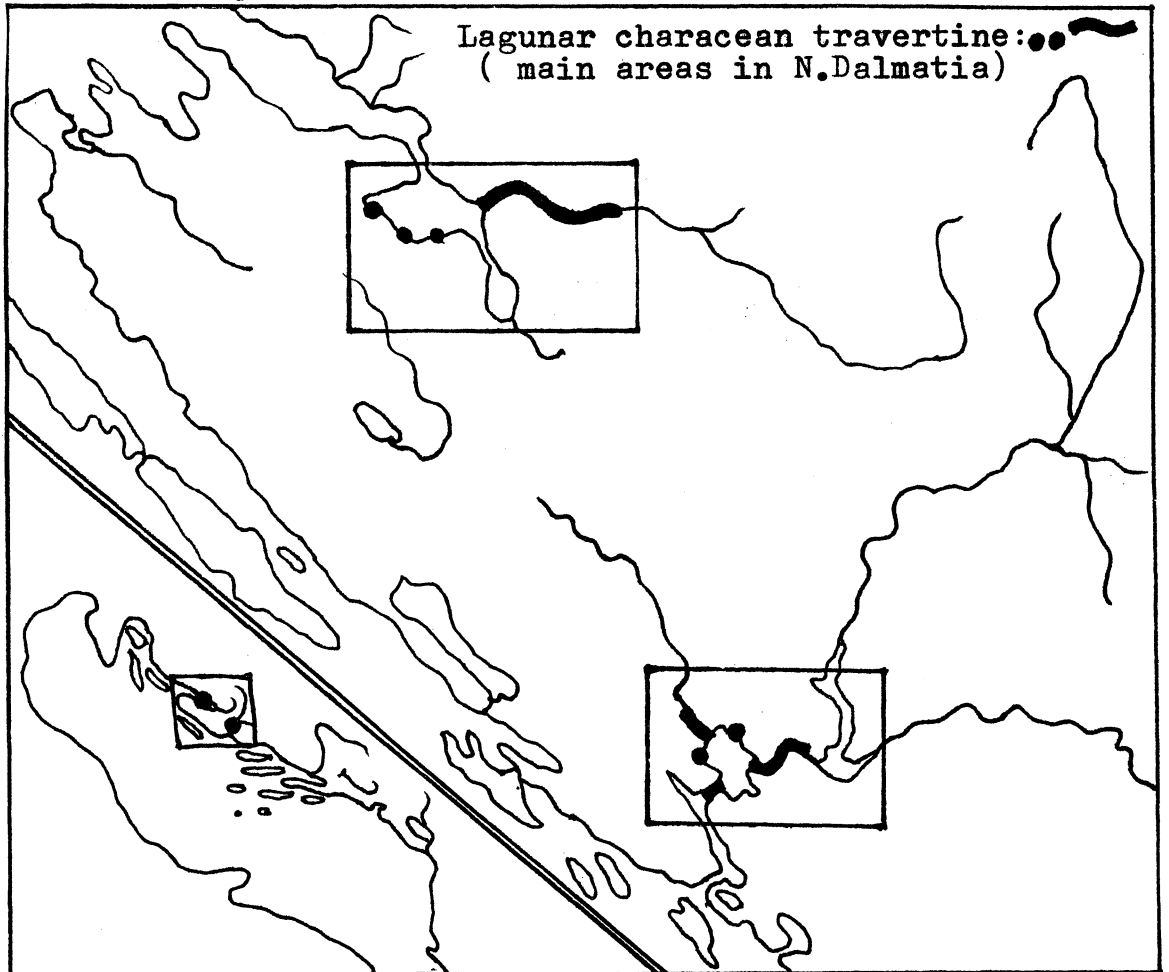
Abstract. E. Adriatic coastal Karst has almost rocky lagoons and canyon estuaries with a special karstic benthos of lagunar stony bottoms. One studied there a new coastal ecosystem: biogenic travertine barriers and reefs of the calcifying maritime Characeae, resembling characean sediments of Para-Tethys, and with a rich flora and fish fauna.

Résumé. Le Karst littoral adriatique a les lagunes rocheuses et estuaires en canyon, à un benthos spécifique karstique des fonds pierreux lagunaires. On y a étudié un nouvel écosystème littoral des barrières biogènes à travertin lagunaire construit par les characées calcifiantes maritimes et halophiles, à macrovégétation et ichthyofaune luxuriantes et une zonation de 3 biocénoses spéciales : celle frontorecifale profonde (Tolypello-Cystoseiretum), épirecifale des plaques-formes apicales (Lamprothamnium - Coleogetum) et postrecifale des étangs sédimentaires (Batrachio-Potamogetum), tout ce complexe ressemblant les sédiments à characées de la Paratéthys tertiaire.

The brackish waters in coastal Karst of eastern Adriatic present some specific karstic habitats rather different from the comparable brackish areas elsewhere in Mediterranean: the rocky lagoons in submerged karst dolines (crypto-depressions), and the cliffy canyon estuaries of rias type. There occur an endemic coastal ecosystem viz. the biogenic barriers and reefs of a special lagunar travertine (brackish water pseudo-coralligene) being produced by the calcifying maritime and halophilic Characeae as are e.g. *Chara rabenhorstii*, and especially *Lamprothamnium mediterraneum*. The other not calcified algae presented are *Tolypella*, *Charopsis*, *Nitellopsis*, *Cystoseira*, associated to a canopy of lagunar benthic grasses as are *Coleogeton*, *Zosterella*, *Ruppia*, *Althenia*, *Najas*, *Batrachium*, etc. The indispensable conditions of their development are the rocky lagunar bottoms, a pure brackish water rich in dissolved carbonates being transported from the inland karst rivers, and a certain brackish water dynamism, e.g. by the Bora storms in lagoons, or by the river flow in estuaries. This travertine formation is a terminal biocenological climax of the natural biogenic succession in undisturbed brackish waters of the Karst coast.



1. Intertidal rocky shore
(*Fucetum virsoidis*)
2. Back sedimentary swamp
(*Batrachio-Potamogetum*)
3. Apical growing platform
(*Lamprothamnio-Coleogetum*)
4. Abrupt frontal reefs
(*Tolypello-Cystoseiretum*)



It is the best developed in exposed rocky lagunar bays with the semilunar travertine reefs, and also in the deep and narrow estuarine canyons: along the both river sides this travertine forms the increasing parallel barriers up to a formation of underwater micro-canyons. The most luxuriant and largest characean barriers exist in the Zrmanja canyon estuary, being ca. 11 km long and large to 150 m, thus presenting one of the biggest active biogenic constructions in the recent Mediterranean. Other active travertine reefs occur in the adjacent Novigrad lagoon, and in the Krka estuary, but the comparable subfossil formations are almost widespread in rocky bottoms of the Karst brackish waters, e.g. in the Prokljan, Karin, and the similar karst lagoons, and also in Velarika (SE. Krk), Guduša, Cetina, and other canyon estuaries, being possibly eliminated by the recent river regulations and by an increasing pollution.

These lagunar barriers present a very interesting structure and zonation being somewhat comparable to this one in the marine coral barriers and atolls. They have also an abrupt frontal reef being exposed to the Bora storms or to river course, and convenient to a special circumlittoral belt of the deepest lagoons (=Halo-Charion canescentis), and presenting the sciophilic lagunar vegetation of the Tolypello - Cystoseiretum myriophylloidis Lov. Above is an apical travertine platform being the main zone of barrier growth, and convenient to the lower infralittoral area of the deep lagoons (= Ruppion cirrhosae) with a photophilic lagunar vegetation of Lamprothamnio-Coleogetum zosteracei Lov., and then followed in back by an internal sedimentary swamp convenient to the upper infralittoral fringe and with a superficial vegetation of Batrachio - Potamogetum siculi Lov., and only this last interior belt may be comparable to the standard lagunar phytobenthos (= Ruppion maritimae) of the other shallow and muddy brackish waters elsewhere in the Mediterranean. The emerging reef peaks and also the surrounding rocky shores include a brackish mediolittoral belt with the Adriatic intertidal vegetation of the Fucetum virsoidis (Zal.) Pign.

This lagunar pseudo-coralligene is actually restricted only to N. Dalmatian brackish waters, and no other comparable formations have been reported from elsewhere, except a considerable ressembling of the fossil characean sediments from the Tertiary brackish seas of the Para-Tethys area, and therefore it is possibly the last active successor of such Tethyan formations.

These specific habitats have been so far very important areas of the natural fish reproduction, and thus reputed in the traditional lagunar fisheries of Dalmatia. Therefore they may be also important and promissive for a further

lagunar aquaculture, and their preservation and prevention of pollution and destroying may be urgent and imperative both for the scientific and applied purposes, especially in the cases of the last active barriers in the Krka and Zrmanja estuaries, and their adjacent lagoons.

Characteristic species and zonation in the lagunar travertine barriers of Dalmatia. Symbols used: 1 - 10 = biomass domination in typical reefs of Zrmanja, I - V = general frequency in Dalmatian brackish travertines.

EMERGING REEFS AND CLIFFS: <i>Fucetum virsoidis</i> (Zal.) Pign.	
<i>Fucus virsoides</i> J. Ag.	8, IV
<i>Enteromorpha clathrata</i> (Roth.) Grev.	4, III
<i>Pylaiella litoralis</i> (L.) Kjellm.	1, II
<i>Laurencia papillosa</i> (Forsk.) Grev.	2, IV
<i>Cladophora prolifera</i> (Roth.) Kütz.	1, III
<i>Ulva rigida</i> C. Ag.	2, III

BACK SEDIMENTARY SWAMP: <i>Batrachio-Potamogeton siculi</i> Lov.	
<i>Potamogeton coloratus</i> ssp. <i>siculus</i> (Tin.) MG.	6, III
<i>Coleogeton marinus</i> (L.) Lov. ssp. <i>marinus</i> s.str.	3, IV
<i>Potamogeton perfoliatus</i> ssp. <i>loeselii</i> (R. & S.) Asch. Grb.	2, II
<i>Althenia filiformis</i> Petit	1, II
<i>Charopsis stalii</i> (Vis.) Menegh. (<i>Chara</i> st. Vis.)	1, I
<i>Nitellopsis obtusa</i> ssp. <i>ulvoides</i> (Bertol.) Nor.	- I
<i>Chara polyacantha</i> ssp. <i>meridionalis</i> MG.	1, II
Sp. of brackish infralittoral fringe: <u><i>Ruppion maritimae</i> Br.</u>	
<i>Ruppia maritima</i> L. (<i>R. rostellata</i> Koch)	1, II
<i>Zosterella noltii</i> (Horn.) Giac. (<i>Zostera nana</i> p.p.)	4, IV
<i>Najas marina</i> L.	2, III
<i>Zannichellia maritima</i> Nolte (<i>Z. pedicellata</i> Wahl.)	2, V
<i>Batrachium baudotii</i> (Godr.) Schul. (<i>Ranunculus</i> b.)	1, II
<i>Enteromorpha intestinalis</i> s. lat.	1, III

APICAL TRAVERTINE PLATFORM: <i>Lamprothamnio-Coleogeton</i> Lov.	
<i>Coleogeton marinus</i> ssp. <i>zosteraceus</i> (Fries.) Lov.	9, V
<i>Najas graminea</i> Del. (<i>N. minor</i> auct. adr. p.p.)	2, II
<i>Althenia barrandonii</i> Duval-Jouve	1, I
<i>Lamprothamnium papulosum</i> ssp. <i>mediterraneum</i> MG.	6, IV
<i>Chara rabenhorstii</i> A. Br.	3, II
Sp. of lower brackish infralittoral: <u><i>Ruppion cirrhosae</i> Lov.</u>	
<i>Ruppia cirrhosa</i> (Petagna) Grande (<i>R. spiralis</i> auct.)	2, III
<i>Zosterella hornemannii</i> (Rouy) Lov. (<i>Zostera nana</i> p.p.)	4, IV
<i>Zannichellia maritima</i> ssp. <i>major</i> (Rchb.) = <i>Z. major</i> .	2, III
<i>Halopteris scoparia</i> (L.) Sauv.	1, II

ABRUPT FRONTAL REEFS, shady: <i>Tolypello-Cystoseiretum</i> Lov.	
<i>Cystoseira myriophylloides</i> Sauv. (<i>C. abrotanifolia</i> p.p.)	7, IV
<i>Cy. barbata</i> ssp. <i>crinoides</i> Fil. (<i>C. aurantia</i> Kütz.)	3, II
<i>Tolypella hispanica</i> Nord.	3, II
<i>Chara canescens</i> ssp. <i>salsa</i> MG. (<i>Ch. crinita</i> auct. p.p.)	4, III
Sp. of brackish circumlittoral: <u><i>Halo - Charion</i> Krausch</u>	
<i>Chara aspera</i> Willd.	2, II
<i>Chara galioides</i> DC.	- I
<i>Polysiphonia</i> spp. indet.	3, IV
<i>Ulva olivascens</i> Dang.	1, II
<i>Rhytiphloea tinctoria</i> (Clem.) Ag.	2, III
<i>Halymenia floresia</i> (Clem.) Ag.	1, II
<i>Vidalia volubilis</i> (L.) Ag.	- I
<i>Sphacellaria cirrhosa</i> (Roth.) Ag.	1, I
