

## BIOCENOTICAL ECOZONATION IN MEDITERRANEAN KARST OF W. DINARIC ALPS, ADRIATIC ISLANDS, AND SEA BOTTOMS

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### I - INTRODUCTION

In continuation to the classic explorations of the Karst vegetation by HORVAT and HORVATIC, one studied recently the distribution and diversity of the complementary coenopopulations of terrestrial and submarine vegetation and fauna in relation to their altitudinal zonation, humidity, winds, and different substrata as moderata merokarst, true holokarst, and extreme ultrakarst-all in limestones, then dolomites, ophiolites, silicates, gypsum, salt marshes, etc... One analysed also the landscape syndromes and vegetation mosaics (KRAU-SE), and the correlations of altitudinal series in plurizonal macrocomplexes. By the phyto-alpinistic expeditions one explored directly the up to recently few known rockbush in giant kilometric escarpments of abrupt maritime and insular mounts. A rather detailed knowledge of the diversity, distribution and zonation is obtained by a dense net of 2 870 macrotransects of sea-mounts direction, from bottoms to coastal and insular peaks, including the vascular flora, lichens, marine algae, terrestrial vertebrata, and sessile benthic invertebrata. Due to this, the actual contribution is the first general synthesis of the actual knowledge of ecozonation and diversity of E. Adriatic coastal and marine biocenoses.

### II - MEDITERRANEAN ECOZONATION IN COASTAL AND INSULAR DINARIDES

Despite its northern position, the Adriatic is not only a marginal Submediterranean area at the Mediterranean basin, but this satellite basin is just a miniature model of the complete Mediterranean zonation with Infra-, Thermo-, Meso-, Supra-, Oro-, Alti-Mediterranean belts, and even a specific supreme Acromediterranean belt (cf. in-

fra). Near all their xeric, mesic, and humide variants there are also developed, resulting by an astonishing diversity of synecosystems, vegetations, and biocenoses filled by paleoendemics and relics. This little basin is an ideal natural laboratory for the study of different problems concerning the Mediterranean biota. The submarine vegetation presents also a well diversified horizontal macrozonation with Thermo-Eu, and Sub-Mediterranean benthic zones. The whole zonation in rather low coastal and insular mounts is very condensed, also as the insular and submarine horizontal diversity. In a transect from the Palagruža archipelago in central Adriatic to the Kvarner Gulf in NE., it is comparable to 6 X larger Mediterranean zonation from the Egypt up to Crimea, and the altitudinal belts of maritime Dinarides not surpassing 1 900 m are well comparable to twice higher ranges as Atlas and Taurus.

Due to a condensed and very lowered upper belts, specific Karst substrata, and excessive Bora hurricanes, the Altimediterranean is not there a supreme belt, but it is even overtoped, in prominent peaks and very exposed slopes -especially in highest Submediterranean Dinarides surpassing 2 000m, by an additional, apical Acromediterranean belt (Mediterranean-Alpine) that is elsewhere in Mediterranean absent or fragmentary, as *Platycapnion* in Atlas, and *Alopecurion lanati* in Anatolian peaks. It includes the very recently studied stormy Karst rockfields (*Edraianthetea* LAK) filled by paleoendemic *Edraianthus* and *Centaureae*: *E. serpyllifolius*, *E. pumilio*, *E. niveus*, *E. croaticus*, *E. montenegrinus*, *E. jugoslavicus*, *E. murbeckii*, *Centaurea atrata*, *C. lanceolata*, *C. berinii*, *C. biokovensis*, *C. dinarica*, then *Oxytropis dinarica*, *Euphrasia dinarica*, *Crepis dinarica*, *Armeria majellensis*, *Polygala croatica*, *Thymus balcanus*, etc... This is one of the most interesting high alpine

series, being the unique European rest of a paleo-glacial flora developed in the Messinian glaciations (late Miocene) of S. hemisphere and Mediterranean mountains.

Such a condensed horizontal and altitudinal diversity is well correlated to the excessive bioclimatic and edaphic diversities of area. SE. Adriatic is the far wettest area of Europe (up to 5 500 mm), and just in vicinity of this is one of the driest European areas in Palagruža isle with 260 mm only. The same Palagruža is the warmest in Adriatic (mean minimum at +8°C), and in N. end of the same Adriatic archipelago, the isles of Senj archipelago are the coldest of Mediterranean islands, with regular winter snow and freezing, and even a periodical icing of the sea at shores (elsewhere in Mediterranean this is often only in N. Black sea). These NE. isles are also among the most stormy and aerosaline areas in world, with hurricanes up to 15-16 Bf, and the maritime halophytes there reach even to 470 m high, contacting directly the Subalpine balds that also descend by these hurricanes. The contrasting effects of both frequent and stormy dominating winds of Adriatic: the cold continental Bora (NE) provokes the descending of upper belts, and the warm maritime Sirocco results by an elevation of lower belts in S. coasts. This is also one of the largest and most extreme limestone Karst areas in world, with excessively diversified mountain and lowland relief, resulting in very contrasting local climates. Recent studies there indicate also a very long and durable human history and urbanizing, even to before 6 500 years :from prehistoric Paleomediterranean Hamites, followed by protohistoric Liburnians, then Illyrians, antic Romans, and medieval and actual Slaves. Such old and perpetual land use and degradation resulted also by an early increasing and recent decreasing of natural diversity, reflected also in fossil pollens. The subsequent regeneration of more xeric synecosystems related to altered and eroded Karst soils provoked that the majority of actual so called "zonal climaxes" of E. Adriatic almost present the secondary man-made subclimaxes, regenerated after the destruction of the primary and natural, more widespread humide series. Therefore just the secondary mesic series, and not the xeric ones, in E. Adriatic have a respectively poorest flora and lack of true Karst endemics.

### 1 - Mediterranean Dinarides :

Despite often abundant winter rainfall, an evident summer dryness reach up to their peaks, and the altitudinal belts of Mediterranean types occupe the whole transect, at least

in SW. slopes. A complete Mediterranean zonation in Yugoslavia is restricted in only two areas. The first is the driest coastal range of Biokovo in central Dalmatia. The second one occur in the peninsular mountain of Galičica on the inter-lacustrine isthmus between Ochrida and Prespa lakes in SW. Macedonia : a very mild climate in comparison to other surrounding subcontinental mountains there is provoked by a temperating effect of both lakes, resulting by this Mediterranean enclave far from the sea. The incomplete Mediterranean zonation without apical belts occur also in many lower maritime mounts of Dalmatia as in Poštak, Promina, Mosor, Dovanj, Rilic, and Sniježnica, and also in some highest islands : Krk, Prvic, Brač, Hvar, Pelješac. The SW. slopes of such mounts include a belt of xeric montane conifers, and the apical balds of interior continental Dinarides (*Seslerietalia juncifoliae*) here are almost replaced by a xeric Altimediteranean belt of maritime Dinarides, including the specific tragacanthic espinals (*Astragalo-Daphnion* GREB., *Astragalo-Acantholimetalia* HORV.= *Koelerietalia* HIC. p.p.), registered at least by 5 diverse vicarious associations from C. Dalmatia and S. Montenegro up to westernmost Macedonia (mt. Galičica). The floristic data indicate that the probable developing center of this series may be in the few studied mountains of C. Albania. This group initially included all xeric Altimediteranean balds in Balkans, but subsequently these southern of Greece are separated as *Daphno-Festucetalia* QUEZEL, and the eastern ones in Macedonia, and in Bulgaria as *Onobrychi-Seslerietalia* HORV. They all present three vicariads in W, S, and E. Balkans, belonging to the same Altimediteranean series of Balkanic xeric balds (*Daphno-Festucetea* QU.= *Astragalo-Acantholimetalia* s. ampl.), and their triple limit is at mt. Pelister (Baba) in Macedonia. In Dalmatia and Montenegro they are almost dominated by spiny echinate Leguminosae : *Astragalus angustifolius*, *A. pastellanus*, *Genista dalmatica*, *G. sericea*, *Chamaecytisus alaventi*, *Cytisanthus holopetalus*, *Ononis pusilla*, then *Berberis illyrica*, *Crataegus brevispina*, *Prunus prostrata*, *Rhamnus prunifolia*, *Euphorbia spinosa*, *Eu. barrelieri*, *Ephedra major*, *Daphne alpina* s.l., *Sesleria coerulea*, *S. argentea*, *S. nitida*, *S. robusta*, *Onobrychis laconica*, *Globularia meridionalis*, *Anthyllis aurea*, *Galium firum*, and in W. Macedonia also *Acantholimon androsaceum*, *Astragalus pungens*, *A. tymphreus*, *A. mayeri*, *Festuca cyllenea*, *Thymus degenii*, *Erodium guicciardii*, *Gnaphalium galicicae*, etc... Such espinals are correlated to warm-humide mounts dominated by the maritime Sirocco wind. More westwards in N. Dalmatia, Liburnia (Kvarner), and Lika highland, in dry-cold mounts exposed to the conti-

mental Bora storms, they are replaced by xeric bare balds (*Festucion illyrica* HORV.), developed optimally in montane xero-alkaline substrata as dolomites and gypsum. The westernmost limits of the *Daphno-Festucetea* xeric balds occur in very stormy aerosaline mounts of the Senj archipelago.

2 - *Submediterranean Dinarides* present a certain summer dryness and related belts only in lower slopes, and in their peaks both are absent and replaced by the continental Euro-montane series. This zonation type includes the majority of Yugoslav coastal ranges, from Slovenian coast up to Macedonia, and N. Albania.

3 - *Mediterranoide Dinarides* have no dryness nor Mediterranean belts, except a mild warmer bioclimate and related Submediterranean vegetation only at the SW. foots, but all other is quite continental, of Mid-European type. These are the limiting ranges of Mediterranean area in Dinarides, as Nanos, Snežnik, Obruč, Bitoraj, Kapela, Plješivica, Osječenica, Lunjevača, etc... The comparable, isolated Mediterranean mounts occur also in far continental inlands in special edaphic conditions (foehn, dolomites, ophiolites, etc...).

#### 4 - *Submarine Karst Dinarides* :

Due to an early pre-glacial geotectonical subsiding of insular Dinarides correlated to the continental drifting of Adriatic microplate, and an additional post-glacial sea rising in Adriatic archipelago, the submerged fossil Karst relief in E. Adriatic is a submarine prolongation of maritime Dinarides. Therefore the shores there are almost abrupt, rocky, and cliffy, and the horizontal bottoms are often under the marine vegetation limits, except in alluvial shallows of NW. Adriatic. Thus this abrupt profundal zonation is presentable almost only in medium scales, and the small ones are convenable only for the horizontal biogeographical macrozonation in benthos that is parallel to the coastal forests: a Submediterranean benthos in NE. coast and N. isles, a widespread Eumediterranean, and a Thermomediterranean (subtropical) benthic zone at SE. coast and pelagic isles of C. Adriatic (cf. Table 1).

Due to the considerable thermic and humidity variations along E. Adriatic coast and islands, and to a parallel diversity of temperature and salinity in adjacent sea bottoms, four main plurizonal complexes of altitudinal-profundal zonations there are registered. The typical, widespread mesic macrocomplex has been previously presumed as the unique climax zonation of E.

Adriatic, but more detailed recent studies defined also other coexisting plurizonal macrocomplexes in different bioclimates and substrata along E. Adriatic : xero-alkaline one in dry C. Adriatic, one humide in SE. coast, and a special stormy one in NE. The additional edaphic plurizonal complexes exist in cliffy kilometric escarpments of abrupt maritime mounts, and in Mediterraneoide enclaves of continental inlands (Tables 1-3).

### III - TYPICAL MESIC SERIES OF EASTERN ADRIATIC (Megacenose $\Omega$ Seslerio-Ostryetum/Orno-Quercetum).

This zonation complex is widespread at average precipitations and typical holokarst substrata of E. Adriatic, especially in Istra and N. Dalmatia. It includes the well known upper Seslerio-Fagetum, then Oromediterranean Seslerio-Ostryetum, Supramediterranean *Carpinetum orientalis*, and Mesomediterranean Orno-Quercetum *ilicis*, and the related replacing shrublands and grasslands. The recently studied, warmer lower belts include the natural carobwoods (*Ceratonio-Pistacietum lentisci*) with related subtropical fauna, and in warmest pelagic isles the summer-deciduous, Inframediterranean xeric shrublands (*Lavatero-Capparetum* LOV.) with *Capparis orientalis*, *Lavatera maritima*, *Coronilla juncea*, *Convolvulus cneorum*, *Lotus creticus*, *Teucrium capitatum*, etc.

### IV - XERO-ALKALINE SERIES OF CENTRAL DALMATIA (Megacenose $\Omega$ *Erico-Pinetum/Obiono-Suaedetum*).

These series occur both in driest C. Adriatic with only 250-700 mm at seashore, and on alkaline substrata as gypsum and dolomite they occur also in mesic climates. This area includes the dry pelagic archipelagos of Vis, Lastovo, and Palagruža, reaching up to Biokovo and adjacent dry maritime mounts. The Submediterranean gypsum areas of S. Croatia (Lika, Dalmatian Zagora) are among the largest in SE. Europe, presenting a convenable xeric vegetation. Due to restricted precipitations, the corrosive karstification there is scarce, and in limestones dominate a moderate merokarst. The excessively dry Palagruža archipelago (250-300 mm) has the most interesting Inframediterranean series of crassulescent semi-desert shrublands (*Obiono-Suaedetum* LOV.) on yerma crust soil, with *Obione australis*, *Suaeda vera* ssp. *deserti*, *Lycium intricatum*, *Artemisia arborescens*, *Mesembryanthemum nodiflorum*, and also

Table 1 - ECOZONATION OF VEGETATION AND FAUNA IN GENTLE MARITIME SLOPES OF E. ADRIATIC MOUNTS

Legend: The faunistic communities parallel to phytocoenoses are in parentheses. Third row presents the variation of precipitations at seashore, and in mounts. In each belt is indicated the variation of its upper limit from N. to S. Yugoslav coasts, and the limiting mean minimal temperatures of coldest month.

Belts and area Limits, m°C	NE. KVARNER GULF Stormy Bora series	N. DALMATIA Typical mesic series	MIDDLE DALMATIA Xero-alkaline series	SE. DALMATIA Acide-humide series
Coastal/apical precipitations	1100 - 1400 mm 1400 - 1900 mm	600 - 1300 mm 2000 - 3000 mm	250 - 600 mm 1300 - 2500 mm	1300 - 2900 mm 3000 - 5500 mm
ALTIMEDI - TERRANEAN	Acer obtusatum - -Fagus sylvatica	Sesleria autumnalis - -Fagus sylvatica	Astragalus angustifol. -Juniperus sabina	Pinus heldreichii - -Oreoherzogia fallax
N. 1500-S. 1800 m > -7°C	(Lacerta horvathii - -Erithacus rubecula)	(Dryocopus martius - -Parus montanus)	(Lacerta mossorensis - -Monticola solitarius)	(fauna not studied)
OROMEDI - TERRANEAN	Cotoneaster nebrodensis - Pinus nigra	Quercus cerris - -Ostrya carpinifolia	Abies alba ssp. - -Ostrya carpinifolia	Viburnum maculatum - -Ostrya carpinifolia
N. 1100-S. 1400m m > -4°C	(Parus ater - Aegyptoides nigropunctatus)	(Sylvia communis - -Emberiza cia)	(Regulus ignicapillus -Nucifraga caryocactes)	(Emberiza cia - Algyro- ides nigropunctatus)
SUPRAMEDI - TERRANEAN	Ulmus dalmatica - -Ficus carica	Quercus pubescens - -Carpinus orientalis	Erica manipuliflora - -Pinus dalmatica	Petteria ramentacea -Quercus frainetto
N. 550-S. 900m m > 0°C	(Lanius senator - -Sylvia cantillans)	(Parus caeruleus - Aegithalos caudatus)	(Carduelis chloris - -Fringilla coelebs)	(Parus lugubris - -Emberiza cirius)
MESOMEDI - TERRANEAN	Euphorbia wulfenii - -Quercus virgiliana	Fraxinus ornus - -Quercus ilex	Styrax officinalis - -Pinus halepensis	Myrtus communis - -Carpinus orientalis
N. 250-S. 500m m > +3°C	(Hippolais polyglotta - -Carduelis cannabina)	(Hippolais pallida - Sylvia melanocephala)	(Hippolais pallida - -Carduelis chloris)	(fauna not studied)

<p>THERMOMEDI- TERRANEAN N.30m-S.350m m &gt; +5°C</p>	<p>Olea sylvestris - -Pistacia lentiscus (Sylvia melanocephala -Hippoleis olivetorum)</p>	<p>Cerastonia siliqua - -Pistacia lentiscus (Sylvia melanocephala -Hippoleis olivetorum)</p>	<p>Euphorbia dendroides- -Fraxium majus (Lacerta oxycephala)</p>	<p>Quercus coccifera- -Fraxinus ornus (Canis aureus - Erythropogon galactotes)</p>
<p>INFRAMEDIO- TERRANEAN N.0 - S. 60m m &gt; +7°C</p>	<p>(belt absent)</p>	<p>Levatera maritima- -Capparis orientalis (Lacerta melisellensis)</p>	<p>Obione australis - -Lycium intricatum (Lacerta sicula)</p>	<p>(belt absent)</p>
<p>Alluvia and lagoons : Vitex agnus castus - Tamarix dalmatica (Merops apiaster - Cettia cetti)</p>				
<p>MEDIO - LITTORAL (Eulittoral) N.2,5- S.1 m</p>	<p>Pylaeiella littoralis- Cystoseira tamariscif. (Arbacia lixula - -Monodonta turbinata)</p>	<p>Cystoseira spicata - -Cy. crinitophylla (Paracentrotus lividus -Monodonta turbinata)</p>	<p>Cystoseira amentacea -Cystoseira jabukae (Arbacia lixula - Monodonta turbinata)</p>	<p>Cystoseira spicata- -Cystoseira squarrosa (Paracentrotus lividus- Monodonta turbinata)</p>
<p>INFRA - LITTORAL (Sublittoral) N.30 -S.50 m</p>	<p>Zostera marina - Cystoseira barbata (Pinna nobilis - Cerianthus membranac.)</p>	<p>Sargassum salicifolium -Cystoseira schiffneri (Calyx nicaensis - -Geodia gigas)</p>	<p>Posidonia oceanica- Cystoseira flaccida (Hippocampus guttulatus-Syngnathus acus)</p>	<p>Posidonia oceanica- Cystoseira flaccida</p>
<p>CIRCUM - LITTORAL (Eulittoral) N.70-S.150m</p>	<p>Cystoseira adriatica -Cy. corniculata (Cladocora cespitosa- Halocynthia papillosa)</p>	<p>Lithothamnium calcareum -Lithophyllum solutum (Eunicella stricta- -Parazoanthus axinella)</p>	<p>Cy. zosteroides- Arthrocladia villosa (Alcyonium adriaticum- Paullusia mamillata.)</p>	<p>Cystoseira spinosa- -Valonia macrophysa (Pteroeides griseus- -Pennatula rubella)</p>
<p>EPIBATHYAL (Profundal) limit of algae N.120-S.260m</p>	<p>Vidalia volubilis - -Rytiphloea tinctoria (Virgularia multiflora -Funiculina quadrangularis)</p>	<p>(deep bottoms absent)</p>	<p>Halarachnion spathulatum -Laminaria rodriguezii (Antipathes glaberrima- Desmophyllum cristagalli)</p>	<p>(belt not studied)</p>
<p>Affinity of sea vegetation MARINE ZONES</p>	<p>Boreal affinity N.Atlantic-Baltic SUBMEDITERRANEAN benthos</p>	<p>Mediterranean affin. Central Mediterranean EUMEDITERRANEAN</p>	<p>Subtropical affinity SW.Mediterranean THERMOMEDITERRANEAN</p>	<p>Subtropical affinity SE. Mediterranean THERMOMEDITERRANEAN</p>

frutescent *Centaurea friderici*. The xeric Thermo- and Mesomediterranean include *Euphorbia dendroides*, *Colutea orientalis*, *Anthyllis aegaea*, *Styrax*, *Anagyris*, *Coridothymus*, *Sarcopoterium*, *Ptilostemon*, *Bellardia*, *Scaligeria*, *Leuzea*, *Urginea*, etc... The zonation is generally marked by xeric Mediterranean conifers in all altitudinal belts: Mesomediterranean *Pinus halepensis*, Supramediterranean *P. Nigra* ssp. *dalmatica*, and Oromediterranean *Abies alba* ssp. *dinarica* SV. (*A. biokovenski* KUŠ.) comparable to Greek *A. borisi-regis* and Anatolian *A. equi-trojani*, with a pre-glacial Paleomediterranean subendemic flora in understory: *Bielzia*, *Moltkia*, *Aurinia*, *Hiacynthella*, *Erica*, endemic *Centaureae*, and rare orchids. More upwards occur Altimediterranean epinals (*Astragalus angustifolius-Ephedra major*) and the apical Acromediterranean stormy rockfields of *Edraianthus serpyllifolius* - *Oxytropis dinarica*.

#### V - ACIDE-HUMIDE SERIES OF SOUTHEASTERN ADRIATIC

(Megacenos  $\Omega$  *Petterio-Quercetum/Orno-Cocciferetum*).

This zonation type includes very humid Dubrovnik coast and S. Montenegro, with 1 300 - 2 900 mm at seashore and up to 5 500 in mounts, but it occurs also in acide substrata of mesic areas, as in flysch, schistes, eruptives, etc... Due to excessive precipitations and related very intense Karst corrosion, in limestone areas there dominate the extreme ultrakarst substrata. The zonation is generally presented by diverse luxuriant rainforests comparable to these ones of Colchis and Hyrcania. The humid Thermomediterranean includes sempervirent subtropical rainforest (*Orno-cocciferetum* HIC) with *Quercus coccifera*, *Arbutus andrachne*, *Myrtus tarentina*, *Pinus pinea*, *Smilax nigra*, *Nerium*, etc..., followed by a colline mixed half-sempervirent pseudomaquis (*Rusco-Carpinetum* LAK.) including *Carpinus orientalis*, *Myrtus communis*, *Erica arborea*, *Rhamnus alaternus*, *Quercus trojana*, *Spartium*, many mosses and lianas. The ultrahumide Submediterranean is marked by excessively rich (to 46 taxa of trees and shrubs) suboceanic rainforests of *Petterio-Quercetum* LOV. with *Quercus frainetto*, *Q. oxycarpa*, *Celtis tournefortii*, *Cercis siliquastrum*, *Petteria*, *Punica*, *Mandragora*, and many endemic herbs. The humid Oromediterranean rockwoods (*Viburno-Ostryetum* LOV.) include *Ostrya*, *Viburnum maculatum*, *Rhamnus orbiculata*, *Chamaecytisus tommasinii*, and other endemics. The Altimediterranean timberline is presented by frutescent garides (*Lonicero-Rhamnion* FUK.) with the unique tree *Pinus heldreichii*, and among shrubs *Lonicera glutinosa*, *L. borbasiana*, *L. alpigena*,

*Ribes alpinum* s.l., *Cotoneaster integririma*, *C. nebrodensis*, *Juniperus sabina*, *Oreohertzogia fallax*, *Taxus*, terminated by the apical, Acromediterranean stormy rockfields (*Oxytropidion dinaricae* LAK.).

#### VI - STORMY BORA SERIES OF LIBURNIA, NE. ADRIATIC (Megacenos $\Omega$ *Cotoneastro-Pinetum/Euphorbio-Quercetum*).

The NE. coast of Kvarner Gulf and adjacent isles (Liburnia) have almost more than 180 days/year with NE. continental Bora storms, the most extreme being Senjsko Bilo mountain and the adjacent Senj archipelago with periodical coastal hurricanes to 50-60 m/sec. The amounts and distribution of precipitations, and summer dryness there are not different from these in mesic series, but with severe stormy winters, snow, freezing, coastal ice on shores. The perpetual dry continental winds by a foehn effect provoke a considerable air dryness up to the desertic excesses of 4-9 % only. Both wind and dry air provoke an excessive evapotranspiration, often surpassing the abundant precipitations, and the perpetual dry aerosaline storms (*fumarea*) reaching the insular peaks, together with winds and dry air, result in a xeric zonation despite the apparently humid climates. A narrow fragmentary Thermomediterranean maquis (*Oleo-Lentiscetum*) exists only at sheltered SW. shores, and all other coasts exposed to a quasi-permanent aerosalinity and storms, have a medium presentable, asylvatic maritime belt up to 0,5 km wide of natural bare rockfields with sparse endemic xero-halophytes (*Artemisio-Senecionetum* LOV.) including *Artemisia maritima*, *Senecio fluminensis*, *Suaeda salsa*, *Salsola pontica*, *Camphorosma nestensis*, *Chaenarrhinum litorale*, *Juncus litoralis*, resembling to the Aralo-Caspian salt deserts (*Halostachyetalia*). The next inlands present a Mesomediterranean stormy belt of often creeping, half-sempervirent mixed pseudomaquis (*Euphorbio-Quercetum* LOV.) up to 12 km wide and well presentable in small scale, including *Qu. virgiliana*, *Qu. saxicola*, *Fraxinus argentea*, *Rhamnus myrtifolia*, *Lonicera stabiana*, *Euphorbia wulfenii*, *Rumex suffruticosa* and endemic herbs. The stormy Supramediterranean has very diversified deciduous forests (*Fico-Ulmetum* LOV.) with excessively rich dendroflora - up to 48 trees and shrubs, including giant *Ficus carica* (spontaneous), *Ulmus dalmatica*, *Quercus brutia*, *Acer marsicum*, *Carpinus grandis*, *Cornus australis*, *Lycium europaeum*, *Vitex*, many endemic *Centaureae* and rare orchids. The stormy mounts and insular peaks include the pinewoods (*Cotoneastro-Pinetum* HORV.) with *P. nigra*, *P. freyeri*, *Qu. dalechampii*, *Cotoneaster nebrodensis*, *Amelanchier cretica*, *Sibi-*

raea, Erica, Bielzia, Lembotropis, and frequent endemics. Upwards occur the beech (*Acer obtusatum*-*Fagus* Stef.), then stormy bare balds (*Seslerio-Caricetum* HORV.) with *Sesleria interrupta*, *Festuca illyrica*, *Edraianthus caricinus*, *Centaurea ceratophylla*, *Asperula canescens*, *Anthyllis atropurpurea*, *Anthericum balcanicum*, and the apical hurricane rockfields of *Edraianthus croaticus*-*Helianthemum canum*. This Borragenic zonation complex includes a very rich vascular flora of ca. 2 700 taxa with a high endemism (to 9 %) resembling these in Creta.

#### VII - INLAND EDAPHIC MEDITERRANOIDE ENCLAVES (Table 2)

Due to rather narrow and low W. Dinarides, the Mediterranean influence partially penetrate also in the inlands, and therefore the SW. Pannonian margin in C. and N. Croatia presents a considerable diversity of xerothermic Mediterranean series, especially in SW. slopes and xeric substrata, including also the faunistic enclaves with Mediterranean birds. The dolomitic series of N. Croatia (Zagorje) are well known after HORVAT, and the xeric vegetation in loess hills of NE. Croatia (Slavonija) are not different from these ones in loess of N. Serbia.

The ophiolitic mounts (peridotites) of C. Croatia, Banija county, up to recently were not studied, and actual results confirm there a new NW. limite of related specific forests and endemic edaphic flora of Balkanic ophiolites: natural pinewoods (*Seslerio-Pinetum nigrae* RIT.) and xeric grasslands (*Polygonion albanici* RIT.), including *Euphorbia montenegrina*, *Polygonum albanicum*, *Cerastium moesiacum*, *Viola beckiana*, *Sesleria serbica*, *Stachys baldaccii*, *Silene staticifolia*, *Sedum serpentinum*, *Notholaena*, *Asplenium plur.*, etc... This specific vegetation was always restricted to eruptive peridotites, as also recently confirmed in Serbia and Bosnia (RITER, etc...) that have been by earlier Balkanic botanists confused as "serpentinines". The true metamorphic serpentinites of petrologists, in Yugoslavia present also poor an few specific vegetation as elsewhere in Europe, and this elucidates also the previous controversies with Balkanic "serpentinophytes", and inadequate "serpentinicum" communities.

The isolated Intra-Dinaric karst valleys and SW. Peri-Pannonian river canyons (Dobra, Mrežnica, Una) have a warm-humide zonation different of this in Adriatic, and resembling the rainforests of Colchis, also with *Juglans*, *Acer hyrcanum*, *A. obtusatum*, *Qu. brutis*, *Tilia tomentosa*, *Laburnum alschingeri*, *Ostrya*, *Oreocherzogia*,

Table 2 - MEDITERRANOIDE ECOZONATION IN XEROTHERMIC ENCLAVES AT SW. PANNONIA

Legend: The variations of upper limit in each belt are indicated (parallel fauna is in parentheses).

Belt and area (upper limit)	WARM KARST WALLEYS Kordun-Lika (C.Croatia)	PERIDOTITE MOUNTS Banija (C.Croatia)	DOLOMITE MOUNTS Zagorje (N.Croatia)	DRY LOESS HILLS Slavonija (NE.Croatia)
Mean limiting precipitations	Humide series 1100 - 2000 mm	Mesic series 900 - 1100 mm	Mesic series 800 - 1000 mm	Xeric series 600 - 800 mm
ALTIMEDI - TERRANOIDE (Montane) S.1000-N.600m	<i>Acer obtusatum</i> - - <i>Fagus moesiaca</i> ( <i>Erithacus rubecula</i> - <i>Sylvia atricapilla</i> )	<i>Acer obtusatum</i> - - <i>Fagus moesiaca</i> (fauna few studied)	<i>Taxus baccata</i> - - <i>Tilia cordata</i> ( <i>Phylloscopus collybita</i> - <i>Parus caeruleus</i> )	(low hills without montane belt)
OROMEDI - TERRANOIDE (Submontane) S.650-N.200m	<i>Acer hyrcanum</i> - - <i>Juglans regia</i> (fauna few known)	<i>Sesleria serbica</i> - - <i>Pinus nigra</i> ( <i>Phylloscopus collybita</i> - <i>Fringilla coelebs</i> )	<i>Erica herbacea</i> - - <i>Ostrya carpinifolia</i> ( <i>Emberiza cia</i> - - <i>Turdus merula</i> )	<i>Quercus frainetto</i> - - <i>Quercus cerris</i> (fauna few known)
SUBMEDI - TERRANOIDE (Colline) S.300-N. 0 m	<i>Laburnum alschingeri</i> - <i>Quercus brutia</i> ( <i>Emberiza cirulus</i> - - <i>Anthus campestris</i> )	<i>Fraxinus ornus</i> - - <i>Quercus cerris</i> ( <i>Aegithalos caudatus</i> - <i>Certhia brachyactyla</i> )	<i>Quercus pubescens</i> - - <i>Ostrya carpinifolia</i> ( <i>Emberiza cia</i> - <i>Carduelis cannabina</i> )	<i>Carpinus orientalis</i> - - <i>Quercus daleschampii</i> (fauna not studied)

Colutea, Daphne, Erica, and endemic herbs (Megacenoze Laburno-Quercetum/Acero-Fagetum).

VIII - KILOMETRIC MEGA CLIFFS AT  
E. ADRIATIC SHORES (Table 3)

The abrupt rocky escarpments of some maritime Dinarides are among the largest in world coasts, and they must be mapped. Someones penetrate all belts from sea bottoms to subalpine peaks, and there all forest and marine grasslands are absent, and replaced by specific rockbush, different from adjacent horizontal shrublands. The secondary herbaceous rock vegetation in E. Adriatic occur only in lower, oblique, and accessible cliffs, and in protected plots it succeeds in "petroclimax", rockbush. The highest mega-cliffs present apical subalpine rock herbs "Amphoricarpetalia LAK.) with paleoendemics as Amphoricarpus, Wulfenia, Aubrieta, Heliosperma. The Oromediterranean deciduous rockbush (Moltkietalia LAK.) includes Moltkia, Portenschlagia, Ramonda, Satureia, Edraianthus, Micromeria. The colline rockbush (Asplenietalia BR.-BL.) has a poor flora and few endemics, and the richest is the sempervirent maritime rockbush (Aurinietaalia LOV.) filled by relict shrubs as Aurinia, Seselignum, Cramboxylon, Centaurea-sect. Pterolophus, etc..., presenting one of the oldest vegetation types of Europe, comparable to these in Creta and Canarias. The parallel faunistic belts include many colonies of rare birds as Puffinus, Hydrobates, Hydroprogne, Oceanodroma, Fratercula, Ptyonoprogne, Petronia, Gyps, Neophron, Pyrrhocorax. Their abundance and related guano in sterile rocks are indispensable for a luxuriant endemic rockbush. The submarine escarpments of megacliffs have also a specific zonation of different coralligenic incrustations with rare algae and fauna. Four macrocomplexes of megacliff zonation in E. Adriatic are registered:  $\Omega$  Aurinio-Astragaletum/Micromerio-Seselietum in stormy NE. Kvarner,  $\Omega$  Aurinio-Cerinthetum/Campanulo-Moltkietum in mesic Dalmatia,  $\Omega$  Aurinio-Brassicetum/Phagnalo-Centaureetum in dry pelagic isles, and  $\Omega$  Prango-Seseli-gnetum/Moltkio-Edraianthetum in humide SE. coast. The kilometeric megacliffs (term of GUILCHER, and KING) of some maritime Dinarides are high 700 - 1 200m and go well in small scale, and the half-kilometeric megacliffs (400 - 500m) of insular escarpments and canyon estuaries are presentable at medium scale.

Table 3 - ECOZONATION OF ROCKBUSH AND CORALLIGENE IN KILOMETRIC MEGA CLIFFS AT E. ADRIATIC SEASHORES

BELT and AREA (Variation of upper limits)	NE. KVARNER GULF Cold-stormy cliffs	MIDDLE DALMATIA Typical mesic cliffs	C. ADRIATIC ISLES Hot-xeric cliffs	SE. ADRIATIC COAST Warm-humide cliffs
SUBALPINE BELT Apical rock herbs N.1500-S.1700m	Asplenium fissum- -Silene hayekiana (Aquila chrysaetos- -Ptyonoprogne rupestris)	Minuartia graminifolia -Edraianthus pumilio (Aquila chrysaetos- -Bubo bubo)	(high cliffs absent)	Minuartia clandestina- -Amphoricarpus neumayeri (Aquila chrysaetos- - Bubo bubo)
MONTANE BELT Upper rockbush N.900-S.1200m	Micromeria kernerii- -Seseli tomentosum (Gyps fulvus - -Falco naumanni)	Campanula portenchlagi. -Moltkia petraea (Sitta neumayeri - Ptyonoprogne rupestris)	Portenschlagiella ramosissima (Circaetus gallicus -Pyrrhocorax graculus)	Moltkia petraea - -Edraianthus baldaccii (Neophron percnopterus -Hirundo daurica)

table 3, 2nd part

COLLINE BELT Middle rockbush N.500-S.700 m	Campanula istriaca- -Centaurea dalmatica (Apus melba - -Columba livia)	Aurinia microcarpa- -Cerinthe tristis (Apus melba - Pyrocorax pyrrocorax)	Phagnalon rupestre- -Centaurea ragusina (Apus pallidus - -Falco eleonorae)	Sesleria robusta - -Putoria calabrica (Apus melba - -Petronia petronia)
MARITIME BELT Lower rockbush N.350-S.300 m	Aurinia media - Astragalus dalmaticus (Fratercula arctica- Oceanodroma leucorhoa)	Plantago holosteaum- -Limonium cancellatum (Puffinus diomedea- -Chlidonias nigra)	Aurinia leucadea- -Brassica frutescens (Puffinus puffinus- -Hydrobates pelagicus)	Frangos ferulacea - -Seselignum globiferum (Hydroprogne caspia- Monachus albiventer)
MEDITERRANEAN Intertidal incrustations N.0,5-S.0,3 m	Lithophyllum hieroglyph- icum-Valonia incrustans (Mihovilia adriatica)	Enteromorpha clathrata -Fucus virsoides (Anemonia sulcata - Mytilus galloprovincialis)	Lithophyllum tortuosum -Neogoniolithon notarisii (Middendorfia caprearum -Patella aspera)	Lithophyllum tortuosum -Lith. incrustans (fauna few known)
INFRA-LITTORAL Subtidal incrustations N.15 -S. 7m	Amphirhoa beauvoisii- -Corallina squamata (Aglaophenia septifera - -Eudendrium rameum)	Ceramium ciliatum - -Corallina officinalis (Asterias glacialis- Spirographis spalanzani)	Corallina mediterranea -Lithothamnium lenorman, (Astropecten aurantiacus - Actinia aequina)	Tenarea undulosa- Lithophyllum trochanter (fauna few known)
CIRCUMLITTORAL Deep coralligene N.80 -S.120 m	Lithophyllum expansum - Halimeda tuna (Caryophyllia clavus- -Leptopsammia pruvoti)	Zenardinia prototypus - Codium bursa (Geodia cydonium - -Microcosmus sulcatus)	Lithophyllum expansum - Halimeda tuna (Caryophyllia smithi- -Madracis pharensis)	Palmophyllum crassum- Mesophyllum lichenoides (fauna not studied)
Lower cliffs degraded by man (Secondary communities)	Sesleria juncifolia- -Scorzonera austriaca (Apus - Falco tinunculus)	Cheilanthes fragrans- -Cotyledon horizontalis	Cheilanthes fragrans- Cotyledon horizontalis	Cheilanthes persica- Cotyledon chloranthus

SUMMARY.- The insular mounts and some maritime Dinaric Alps at E. Adriatic present a complete Mediterranean altitudinal zonation, from the apical Acromediterranean up to warmest Inframediterranean belts. A correlated submarine horizontal zonation from Thermo- to Submediterranean benthic vegetation exists also in Adriatic bottoms. Four different types of coastal zonations are registered: widespread mesic of E. Adriatic, xeric one in dry pelagic isles, humide one in SE. coast, and a special stormy one in NE. coast exposed to Bora. The warm intra-montane valleys, and inland dolomitic and ophiolitic mounts present also the relict Mediterraneoide ecotonations. The giant kilometric megacliffs of abrupt maritime mountains have a parallel independent zonation of specific rockbush.

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