THE SYNTAXONOMY AND SYNGENESIS OF THE ELYNO-SESLERIETEA BR.-BL. 1948 IN THE BALKAN PENINSULA*

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ABSTRACT - High mountain vegetation on calcareous geological foundation is prevalent in the alpine and subalpine belts of mountains on the Balkan peninsula. The class *Elyno-Seslerietea* is represented in alpine and subalpine communities of meadows and pastures in these communities, species from Dinaric, Balkan, Illyrian, and the south-eastern European floral element play dominant role. In the investigation area, the class is differentiated into the following orders: Seslerietalia juncifoliae (=tenuifoliae) Horvat 1930 with alliances Seslerion juncifoliae (=tenuifoliae) Horvat 1930 in alpine belts and Festucion bosniacae (=pungentis) Horvat 1930 in the subalpine belts and Festucion paniculatae calcicolum (Redzic, Lakusic et al., 1984) Redzic in North-western part; Onobrychydo-Seslerietalia Horvat 1949 with alliances Onobrycho-Festucion Horvat 1936, Festuco-Knaution longifoliae Horvat 1949, Edraiantho-Seslerion Horvat 1949, Seslerion rigidae Zolyomy 1939 and Seslerio-Festucion xanthinae Horvat 1949 in the eastern and southern part; Order Crepidetalia dinaricae (=urumovii) Lakusic 1966 with alliances Campanulion linifolii Lakusic 1964, Festucion pseudoxanthinae Lakusic 1968, Oxytropidion dinaricae (=urumovii) Lakusic 1966 in the south-eastern Dinaric Alps; order Edraintho-Seslerietalia robustae Ordo nov prov. with alliances Seslerion robustae (Lakusic et al. 1982) and Seslerio-Edraianthion pumilii Redzic all. nova prov. in the coastal side of oro-mediterranean region of Balkans.

KEY WORDS - Balkans, Dinaric Alps, *Elyno-Seslerietea*, European Vegetation Survey, High mountain vegetation, Syngenesis, Syntaxonomy.

NOMENCLATURE - Tutin et al. (1964-1980), Hayek (1924-1933).

INTRODUCTION

The vegetation class *Elyno-Seslerietea* is significantly represented and well developed in the region of the Balkan peninsula. Its presence is enterly caused

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primarely by orografic and climate conditions, and to some degree, by geological and pedological conditions at many areas.

Generally, vegetation of this class is developed on all high mountain ranges from the northwestern towards the southeastern and eastern part of the Balkan peninsula. It prefers mountain and alpine belts, although significant areas are developed in the belt of forest vegetation and vegetation of dwarf pine.

There is also an pattern in elevational this vegetation from the nothwestern part of the Balkan peninsula (Croatian mountains) towards the southeast and east. On some Croatian mountains (northwestern part), vegetation of this class is developed at only 1.000 m altitude a. s. l., while in the central and eastern part, this vegetation reaches considerable higher altitudes.

Ivo Horvat presence of mountain vegetation forms on such a low altitudes attributes to vicinity of the Adriatic sea, and penetration of the elements of Mediterranean climate, as well as to certain karst elements of relief, such as numerous depressions in which temeperature inversion is present.

However, the main vegetation of this class is developed today above the belt of forest vegetation – association *Pinetum mugi* s. lat., and in some cases above the discontinuited belt of submountain beech forest *Fagetum subalpinum* (incl. *Aceri-Fagetum subalpinum* s. l.), and on the continental part of Dinaric Alps and above the belt of submountain spruce forests *Piceetum subalpinum* s. lat.

Transformation of subalpine forest communities in the past have iniciated development of subalpine meadows, which play more dominant role on certain places in relation to typical alpine pastures. Investigations of mountain vegetation on Balkan peninsula started a long time ago. According to Horvat (1930) they date from the period when Adamovic (1912) and Beck presented the general pattern of distribution of certain vegetation types within their biogeographical studies of vegetation of Balkan countries.

However, recent studies of this vegetation by the Zürich-Montpellier school (Braun-Blanquet, 1964), have started with investigations carried out by Ivo Horvat, one of the doyens in the field of Balkan phytocoenology and complex vegetation science (Horvat, 1930; 1934; Horvat and Pawlovsky, 1939). Horvat paid particular attention to the investigations of floristic organisation of high-mountain vegetation in the northwestern part of the Balkan peninsula (Kusan 1956; Horvat, 1962; Horvat et al. 1974), and later to investigations of high-mountain vegetation in the southeastern part of the Balkan peninsula, carrying out investigations on mountains in Macedonia (Horvat, 1960-a).

After affirmation of studies by the Zürich-Montpellier, Balkan region, other scientists began to carry out investigations of high-mountain vegetation in the southeastern Dinaric Alps (Lakusic 1966, 1970-a), continental part of Dinaric Alps (Grebenscikov 1941; Jovanovic-Dunjic 1955, 1956, Randjelovic and Rexhepi 1984), as well as the central and northwestern parts of the Dinaric Alps (Bjelcic 1966; Lakusic et al. 1969; Dizdarevic et al., 1979; Lakusic et al. 1982; Misic 1984; Redzic et al. 1984; Redzic 1990; Redzic et al. 1992-95).

Previous studies mainly focused on analysis of spatial and floristic organisation of high-mountain vegetation, and later on investigations of structure and dynamics (Lakusic et al. 1979; Lakusic, Redzic et al. 1987; Lakusic, Misic et al. 1987) and syngenesis and syndynamics (Redzic 1984; Lakusic et al. 1984; Redzic 1998). Numerous data were collected on various sites from the vertical profile of coastal, northwestern, central, southeastern and continental Dinaric Alps.

Recent comparative studies undobtely point out that is necessary to make a synthesis and revision of obtained results, and particularly from a syntaxonomic standpoint, taking into account modern achievements in the field of vegetation classification and approaches to vegetation science in other geographical regions. In processes of analysis of adequate ecological and coenological differentiation of high-mountain communities from the class *Elyno-Seslerietea,* particular attention was paid to investigation of syngenesis of both dominant and subdominant and locally restricted communities in order to establish a general syngenesis of certain syntaxa and to more precisely define these communities in the spatial system of ecosystems in this very heterogenous region.

MATERIAL AND METHODS

Investigations of syntaxonomy and syndynamics of calcareous alpine and subalpine meadows and pastures from the class *Elyno-Seslerietea* was very intensively carried out in the period 1980-1991 and 1996-1999, on both vertical and horizontal profiles of the western and the central part of the Balkans, with frequent field trips to the east and the Southeast. The classic method of Braun-Blanquet (1964) was entirely implemented. During the study, more than 500 original phytocoenological recordings were made. A similar number of releves made in the broader region of the Balkans by other authors (around 500) were covered by comparative analysis.

In the description and understanding of communities, of the Code of Phytosociological Nomenclature (Barkman et al., 1986) was implemented.

Several hundred recordings from various communities of this class from other parts of its distribution (western, central and south-western Europe) were also analysed. On the basis of achieved results, syntaxonomy of this class in this region is given.

Establishment and definition of syngenetic patterns on certain profiles within the class was carried out through a long period, with implementation of slightly modified Braun-Blanquet method, as well as with use of methodology of permanent plots. Basic syngenetic indicator values of certain plant species, such as progressive, regressive and neutral species have been analysed in the definition of certain stages of development and mutual relationships among communities of this vegetation.

The results of syngenesis illustrate a very high level of heterogenity in structure and spatial organisation of certain phytocoenoses. Established relationships within up to date known as well as newly established syntaxa have certainly contributed to understanding of adequate syntaxonomy of this very complex vegetation.

GENERAL CHARACTERISTICS OF INVESTIGATED AREA

INVESTIGATED AREA IS LOCATED BETWEEN 40° AND 46° LATITUDE AND BETWEEN 12° AND 22° LONGITUDE.

Geology. The region of Central and Western Balkans is very heterogeneous as regards geological and petrographic characteristics.

Mesozoic limestone sediments dominate in the whole region. In hilly-mountain belt towards Pannonia dominant role play Jurassic and Triassic.

A largest part of the alpine belt of Balkan mountains was under strong influence of the last glatiation. This has also significant impact on the structure and dynamics of high-mountain vegetation.

Orography. From the orographic standpoint, this is very dynamic hilly-mountain region with basic direction of mountain ranges from the north-west to the south-east. The region is intersected with numerous river valleys with the direction the north-the south.

Vertical profile from the Adriatic sea towards peaks of littoral mountains is around 2.400 meters.

Numerous karst fields and depressions on the plateaus surrounded by dynamic relief point to specific orogenesis of this region. There are clearly differentiated belts on this relatively short profile: Eu-mediterranean, Sub-mediterranean, hills, mountain belt, subalpine, alpine and sub-nival to nival belt.

High-mountain region has numerous peaks, with more-less steep slopes which mostly end with karstic depressions. Glacial lakes are situated in numerous karstic depression and they have significant influence on determination of the vegetation in this belt.

Ecoclimate. This region is very heterogeneous and dynamic as regards ecoclimate, too. On the profile of around 2.400 meters on littoral side, there is regular succession of several ecoclimatic types in each belt from Eu-mediterranean towards sub-nival and nival type. This is region with the highest temperature extremes, and dynamics and precipitation in Europe.

Average annual temperature in alpine belt is between 2 °C and 0 °C, and in Sub-alpine belt from 4 °C to 2 °C and in sub-nivale from 0 °C to -4 °C (Lakusic 1975). Absolute maximal temperature in alpine region is 25 (30) °C, and absolute minimal temperature in mountain belt are up to -35 0 °C. During the year certain places (Gorski Kotar, Orjen, etc.) receive more than 3 000 mm of precipitation, mostly in the early spring and late fall. On other places precipitation are some lower (1000 - 1700mm).

According to the data from Hydrometeorological institute, average annual air temperature, in the alpine belt of Central Dinaric Alps (the peak of mountain Bjelasnice, 2 067m) is 1,3 °C. During six months in the year average monthly temperature is below 0 °C. Average monthly temperature are below 10 °C during the summer.

In this region, there are 193 days with frost, including all months in the year. There are almost 80 days with snow in the year. Snow layer is present almost 180 days in the year.

Average annual cloudiness vary around 66% (from 61% in October to 75% in December).

The highest insolation have summer months (cca. 233 hours). Annual values are around 1750 hours.

Wind is very dominant factor and it mostly blows from the South and North.

Soil conditions. Dynamic orography of high-mountain region as well as geological and petrographical structure caused development of very dynamical system of pedogenetical processes. In general, in whole region of mountain and sub-mountain belt, humous accumulative soils from the class A-C profile are present as climatogenous soils. They have also zonal character in this region (Lakusic 1975). Their development

and the state, as well as future trends are in direct correlation with hydrothermical regime, and wind exposure.

The main pedogenetic factors in this region are wind, snow cover, humidity and temperature. In the series of the soils on limestone and dolomites, on a larger number of mountains on Balkan peninsula, dominant role play soils from three classes:

- Class of non-developed or weakly developed soils (A)-C profile,
- Class of humous-accumulative soils with A-C profile and
- Class of cambic soils with A (B) C profile.

From the class of non-developed soils in this region are present calcosirozem, and limestone colluvial soil. The class of humous-accumulative soils is represented with several variants of two main soil types: Rendzine, on loosy bedrock type (with sub-types rendzine on soft limestone, rendzine on colluvial limestone-dolomite detritus and rendzine on dolomitic sand). Black soil or calcomelanosol, on solid limestone rocks with sub-types: Organogenous black soil, organomineral black soil and brownish black soil.

Cambic soils - calcokambisols, are developed only in depressions of subalpine belt and in the upper part of high-mountain belt, on small slopes.

Rendzine. Depth of pedological profile vary between 10-25 (30) cm. Sceleton is developed throughout the profile. Considering mechanical composition, rendzine are sandy clays and clays with and without skeleton. Soil reaction is mainly neutral and weakly acidic (pH = 6.4-8). Percentage of humus is between 2.83-10.13%.

Calcomelanosols are developed on compact limestone rocks. The depth of profile is between 15-25 (30) cm, depending on slope and aspect. In some varieties, the percentage of humus is very high (up to 40%). This is in direct connection with microbiological processes. Soil reaction is weakly acidic or alkaline (pH = 5.6 - 7.8).

Brown limestone soils are rarely represented. The depth of profile vary between 35 and 50 cm. They contain relatively high percentage of humus (up to 45%). Soil reaction is medium acidic to neutral (pH = 5.5-6.8).

Phytogeography. High mountain region of Balkan area from phytogeographical standpoint belongs mainly to High-Nordic province of Alpine-High Nordic region (Horvatic 1964; Blecic and Lakusic 1976; Lakusic 1969-a). Particular characteristics of this region are numerous endemic and relic plant species which give special floristic and vegetational, as well as biogeographical features to this region (Segulja 1969; Lakusic et al. 1978; Jovanovic et al. 1986; Sugar and Plazibat 1988).

On the basis of characteristics of the flora and vegetation, alpine belt of Balkan is differentiated in several phytogeographical sectors. Each sector is characterised by endemic plant communities and characteristical endemic species. This was the reason for the phytogeographical differentiation of the Dinaric Alps into following parts:

- the north-western (with domination of communities from order *Seslerietalia tenuifoliae*;
- the continental with domination of *Onobrichydi-Seslerietalia*,

the south-eastern and central, with domination of order *Crepidetalia dinaricae* (=*urumovii*) and

- the coastal oro-mediterranean with domination of order *Edraiantho-Seslerietalia robustae*.

From the lower part, towards Illyrian and Moesian province of Boreo-American region, alpine and subalpine pastures are linked to the vegetation of dwarf pine *Pinetum*

mugi (*calcicolum*) Lakusic et al. 1973, and on some mountain ranges to the vegetation of subalpine beech *Fagetum subalpinum*, and *Pinetum heldreichii* Auct.

From the upper part, the class *Elyno-Seslerietea* is tightly linked with the vegetation around snow from the order *Salicetalia retusae-serpyllifoliae* Lakusic 1968.

RESULTS

SYNTAXONOMY

In intensive comparative investigations of ecological and floristic differentiation of vegetation of alpine and subalpine pastures on limstones from the class *Elyno-Seslerietea* on Balkan peninsula about 1,000 taxa, and about 150 communities on the level of association, subassociation, alliance and order were found.

Floral-genetics analysis shows a very high level of endemic species which significantly differentiates these communities from other communities of this class from other regions. Dominant endmic species belong to the Dinaric and Balkan (that is) Illyrian floral clement.

On the basis of the results and their revision in the context of modern investigations in vegetation science, the following syntaxonomic differentiation of the vegetation of class *Elyno-Seslerietea* on Balkan peninsula is proposed:

ELYNO-SESLERIETEA Br.-Bl. 1948
(=FESTUCO-SESLERIETEA Barbero et Bonin 1969 p.p.)
SESLERIETALIA JUNCIFOLIAE Horvat 1930

SESLERION JUNCIFOLIAE Horvat 1930
(=Seslerion tenuifoliae Horvat 1930)
Seslerietum juncifoliae Horvat 1930
Caricetum firmae illyricum (=croaticum) Horvat 1930
Laevi-Helianthemetum alpestris Horvat 1930
Edraiantho croatici-Dryadetum octopetalae Lakusic et al. 1984
Seslerio-Caricetum humilis Horvat 1930
Gentiano-Edraianthetum nivei Lakusic et al. 1976
Potentilla aurea-Agrostis rupestris Horvat 1941
(=Agrosti-Potentilletum aureae Horvat 1941)
Festuca panciciana-Dianthus brevicalyx Horvat 1934
Festucetum pancicianae Horvat 1960
Scabiosetum silenifoliae Lakusic et al. 1982
(Syn.: Festuco-Scabiosetum silenifoliae Lakusic et al. 1978;
Festuco-Scabiosetum silenifoliae Lakusic et al. 1976)
Seslerio-Gentianetum dinaricae Lakusic et al. 1982
(Syn.: Seslerietum juncifoliae bosniacum gentianetosum dinaricae

Lakusic et al. 1982)
Arctostaphylletum uvae-ursi Lakusic 1964

FESTUCION BOSNIACAE Horvat 1930
(= Festucion pungentis Horvat 1930)
Festucetum pungentis Horvat 1930
Carici sempervirenti-Seslerietum juncifoliae Hovat 1956
Festuca pungens-Centaurea kotschyana Horvat 1960
Koelerio-Festucetum amethystinae Horvat 1956
Anthyllidetum alpestris Horvat 1960
Bromo-Centauretum kotschyanae Horvat 1960
Gentiano symphyandrae-Genistetum radiatae Lakusic 1975
Festuco bosniacae-Gentianetum symphyandrae Lakusic 1975
Ranunculetum scutati Lakusic 1975
Ranunculo-Crepidetum pontanae Horvat 1960
Ranunculus thora-Linum extraaxilare Horvat 1941
Armerio-Festucetum variae Randjelovic et Rexhepi 1984
Carici-Seslerietum latifoliae Randjelovic et Rexhepi 1984
Helianthemo-Ranunculetum scutati Lakusic et al. 1979
H.-R.c. subas. potentilletosum crantzii Misic 1984
Festucetum pungentis vranicensis Lakusic et al. 1979
Calamagrostio-Centauretum pseudophrigiae Horvat 1956
Ranunculus thora-Astrantia major Horvat 1941

CARICI-FESTUCION PANICULATAE (=SPADICEAE) CALCICOLUM
(Redzic, Lakusic et al.1984) Redzic 2003
Hypochoeri-Festucetum amethystinae Horvat 1960
H.-F. amethytinae subas. festucetosum paniculatae (=spadiceae) Redzic, Lakusic et al. 1984
Festucetum paniculatae (=spadiceae) calcicolum Redzic, Lakusic et al. 1984
Danthonio-Festucetum paniculatae (=spadiceae) Redzic, Lakusic et al. 1984
Hyperico-Caricetum ferrugineae Horvat 1956
Carex sempervirens-Pulsatilla alpina Horvat 1941

ONOBRYCHIDO-SESLEREIETALIA Horvat 1949

EDRAIANTHO-SESLERION Horvat 1949
Edraiantho-Helianthemetum alpestris Horvat 1935
Cariceto-Helianthemetum balcanici Horvat 1935
(= Edraiantho-Helianthemetum balcanici /Horvat 1935/ Horvat et al. 1974;
Edraiantheto-Helianthemetum balcanici /Horvat 1935/ Horvat 1960)
Helianthemo-Seslerietum Horvat et al. 1974
Carici rupestri-Seslerietum klasterskyi Simon 1957
Achilleo aizoonis-Seslerietum klasterskyi Simon 1957
Edraiantho-Elynetum Horvat 1936
Diantho jakupicensis- Elynetum Horvat 1949
Trifolio norici-Caricetum Horvat 1935

Edraiantho-Oxytropetum Micevski 1994
Carex laevis-Poa molinierii L. Rajevski 1960
Carex laevis-Heliantheum vineale L. Rajevski 1960
Carex laevis-Carex sempervirens M.Jankovic 1982
Festuco-Caricetum laevis Randjelovic et al. 1979
Astragalo-Calaminthetum alpinae Horvatic et Randjelovic 1979

ONOBRYCHO-FESTUCION Horvat 1936
(=Onobrychido-Festucion Horvat 1960)
Asyneumo-Stipetum mediterraneae Horvat
Onobrycho-Festucetum variae Horvat 1936 emend. Micevski 1994
(=Helianthemum grandiflorum-Onobrychis montana subsp. scardica Horvat 1936; Onobrychidi-Festucetum cylleniacae /Horvat 1936/ Horvat 1960; Onobrycho-Festucetum variae /Horvat 1936/ Horvat et al. 1974)
Senecioni-Festucetum bosniacae (Horvat 1949) Micevski 1994
(= Senecioni-Festucetum variae Horvat 1949)
Festuco piriensis-Seslerietum klasterskyi Simon 1957
Seslerietum wettsteinii Horvat 1937
Campanula limonifolii-Stipetum mediterraneae Horvat 1960
Stipo-Festucetum Micevski 1994
(= Asyneumo-Stipetum Horvat 1960 p.p. max.)
S.-F. subas. caricetosum caryophylleae Micevski 1994
Geranio-Brometum riparii Micevski 1994
Festucetum bistrae Micevski 1994
Seslerietum korabiensis Micevski 1994
Sesleria wettsteinii-Onobrychis montana L. Rajevski 1960
Festuca adamovici-Helianthemum grandiflorum L. Rajevski 1960
Carex rupestris-Anemone narcissiflora Horvat 1941

SESLERION RIGIDAE Zolyomy 1939
Anthylli-Seslerietum rigidae Jovanovic-Dunjic 1955
Carici-Dryadetum Jovanovic-Dunjic 1955

FESTUCO-KNAUTION LONGIFOLIAE Horvat 1949
Sileno-Festucetum nigrescentis Jovanovic-Dunjic 1955
Knautio-Festucetum paniculatae Jovanovic-Dunjic 1955
Helianthemum grandflorum-Festuca duriuscula Horvat 1960
Nardus stricta-Helianthemum grandiflorum L. Rajevski 1960

SESLERIO-FESTUCION XANTHINAE Horvat 1949
Lamio garganicae-Brometum erecti Jovanovic-Dunjic 1955
Festucetum xanthino-variae Jovanovic-Dunjic 1955
Carici sempervirenti-Seslerietum nitidae Jovanovic-Dunjic 1955

E D R A E A N T H E N E A Lakusic 1968

CREPIDETALIA DINARICAE Lakusic 1966

EDRAIANTHION NIVEI Lakusic et al. 1979
Scabiosetum silenifoliae (vranicensis) Lakusic et al.1979
Laeveto-Helianthemetum alpestris Ht 1930 vranicensis Horvat, Pawlovsky, Lakusic et al. 1978
Gentiano-Homogynetum discoloris Horvat, Pawlovsky, Lakusic et al. 1979
Gentiano-Edraianthetum nivei Lakusic et al. 1976

CAMPANULION LINIFOLII Lakusic 1964
(Syn: Campanulion albanicae Lakusic 1964; Festucion albanicae Lakusic 1967)
Poeto-Potentilletum montenegrinum Lakusic 1964
Crepidi-Centauretum kotschyanae Lakusic 1964
Seslerietum giganteae Lakusic 1966
Scutellario - Achilleetum montenegrinae Lakusic 1967
Ranunculo-Helianthemetum nitidae Lakusic 1967
Diantho-Anthyllidetum aureae Lakusic 1967
Festucetum albanicum Lakusic 1968

FESTUCION PSEUDOXANTHINAE Lakusic 1968
Stachydi-Festucetum pseudoxanthinae Lakusic et al. 1968
Festuco-Seslerietum coerulentis Misic 1984
Alcbemillo velebiticae-Gentianetum dinaricae Misic 1984
A.v.-G.d. subas. trifolietosum norici Misic 1984

OXYTROPIDION DINARICAE (=URUMOVII) Lakusic 1966
Carici-Crepidetum dinarici Lakusic 1964
C.-C.d. helianthemetosum nitidae Lakusic 1964
C.C.d. trifolietosum norici Lakusic 1964
C.-C.d. helianthemetosum nitidae Misic 1984
Seslerietum juncifoliae montenegrinum Lakusic 1964
S.j.m. potentilletosum tridentinae Lakusic 1964
S.j.m. globularietosum bellidifoliae Lakusic 1964
Festuco-Alchemilletum serbicae Lakusic 1964
Edraiantho-Dryadetum Lakusic 1967
Elyno-Edraianthetum serpyllifolii Lakusic 1967
Elyno-Edraianthetum alpini Lakusic 1967
Edraiantho-Helieanthemetum bjelasicense Lakusic 1964
Edraiantho-Festucetum pancicianae Lakusic et al. 1982
Seslerietum juncifoliae hercegovinum Lakusic 1969
Potentillo-Caricetum sempervirentis Lakusic et al. 1973
Poeto-Caricetum caryophylleae Lakusic et al. 1973
Asperulo-Festucetum pancicianae Lakusic et al. 1973
Edraiantho-Veronicetum satureoidis Lakusic et al. 1973
Minuartio handelii-Caricetum pollicensis Bjelcic et Silic 1979
Elyno-Leontopodietum nivalis Lakusic 1970
Edraiantho-Helianthemetum balcanici Lakusic 1960
Carici-Edraianthetum caricini Lakusicet al. 1984

EDRAIANTHO-SESLERIETALIA ROBUSTAE Ordo novus

SESLERION ROBUSTAE (Lakusic et al. 1982) Redzic 2003
(=SESLERION NITIDAE /Horvat/ Lakusic et al. 1982)
Seslerietum robustae Redzic nomen. nov.
(= Seslerietum nitidae Lakusic et al. 1975
=Seslerietum argenteae Horvat 1941)
Carici-Seslerietum robustae Tomic-Stankovic 1970
Trifolio-Armerietum canescentis Tomic-Stankovic 1970

SESLERIO-EDRAIANTHION PUMILII All. nova
Laevi-Helianthemetum balcanici Horvat 1930
Ephedro-Astragaletum biokovensis Kusan
Edraiantho-Seslerietum juncifoliae Horvat
Festuco pancicianae-Edraianthetum pumilii Horvat 1962
(=Minuartia clandestina-Saxifraga corriophylla Horvat 1944)
Genisto-Centauretum longicuspidis Lovric 1987

SYNGENESIS

Development of certain communities of mountain and submountain meadows is directly influenced by both egsogenous and endogenous factors. Dominant among egsogenous factors are: wind intensity and direction, slope and aspect, and soil charactersitics. The system of development of vegetation, more precisely its syngenesis, is in correlation with pedogenesis. Both syngenesis and pedogenesis are very compatible and complementary processes. Formation of more developed soils is one of the essential prerequisites for the development of more complex communities. The specific syndynamic and syngenetic processes take place in specific habitat conditions. In that way, in the region of mountains of the northwestern part of the Dinaric Alps, mountain meadows from the alliance *Seslerion juncifoliae* are developed on the most shallow and the most alkaline soils. These habitats are under strong influence of severe mountain winds. Communities of this alliance, in conditions of even stronger winds, establish syngenetic continuum with communities in rock fisures of alliance *Potentillion caulescentis* and *Micromerion croaticae*, and on loose soils that belong to sirosem type with communities of alliance *Bunion alpini* (Fig. 1).

On the other hand, on habitats which are significantly protected from impact of the wind, the system of pedogenesis is more suitable. In this conditions, the communities of the mountain meadow alliance *Seslerion juncifoliae* gradually transition into communities of submountain meadows of alliance *Festucion bosniacae*, which is on deeper and more acid soils connected with subalpine and montane meadows of alliance *Poion alpinae*, and *Festucion paniculatae (=spadicae) calcicolum.* In warmer habitats, ecological continuum an is established with thermophyllous meadows of alliance *Mesobromion erecti (subalpinum).*

Thesc communities, towards the Alps, are connected with submountain meadows of alliance *Caricion ferruginae* which links mountains meadows from Central Europe with those on the Balkan peninsula from the same class.

The vegetation of alliance *Edraiantho-Seslerion* is developed in the region of the

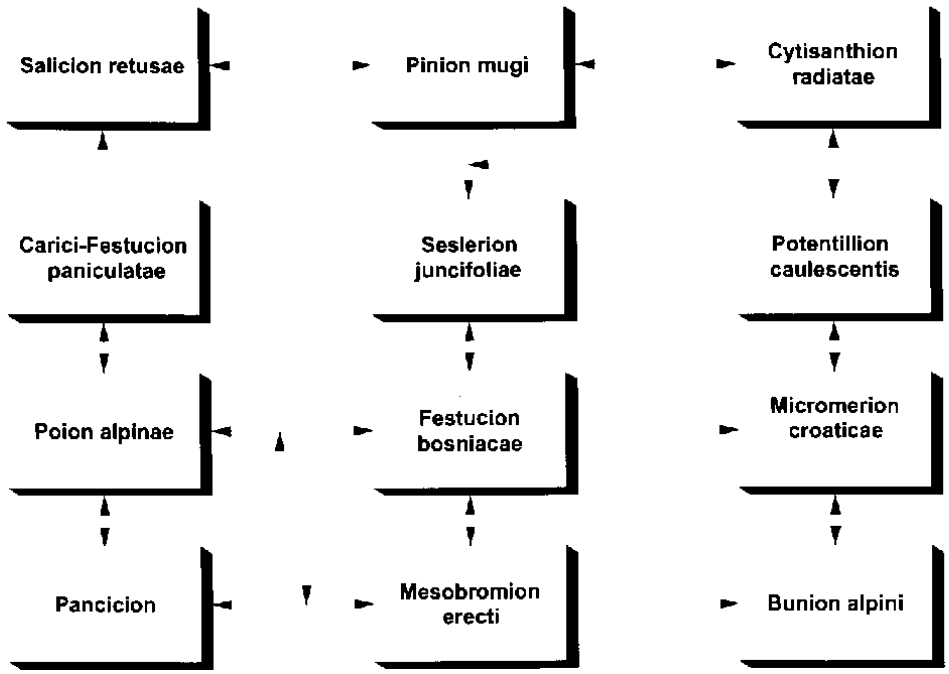

Fig. 1 - Rules of the syngenesis of the high mountain vegetation on the western part of the Balkan peninsula

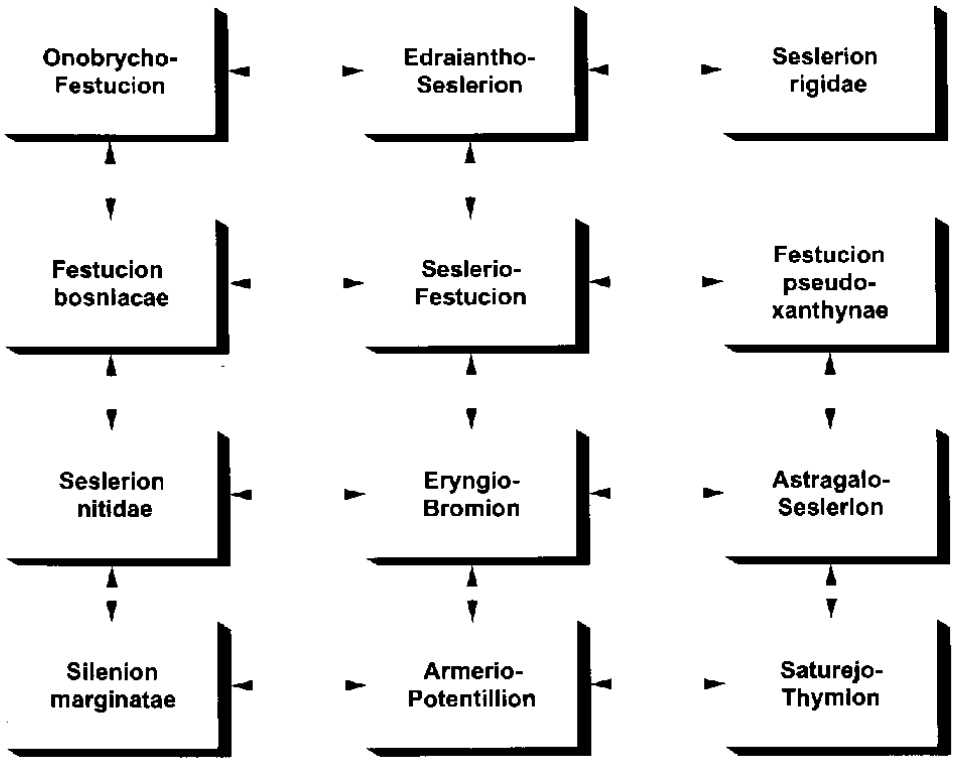

Fig. 2 - Rules of the syngenesis of the high mountain vegetation on the eastern and the southern part of Balkan peninsula

central and southeastern part of Balkan peninsula, on the highest mountain peaks. This community, on warmer and wind exposed places on mountains in Macedonia, establishes syngenetic continuum with communities of alliance *Onobrycho-Festucion*, as well as with some communities of *Seslerion rigidae* on mountains in Bulgaria (Fig. 2).

Towards the northwestern colder part of Dinaric Alps, the above mentioned community establishes syngenetic continuum through numerous intermediary

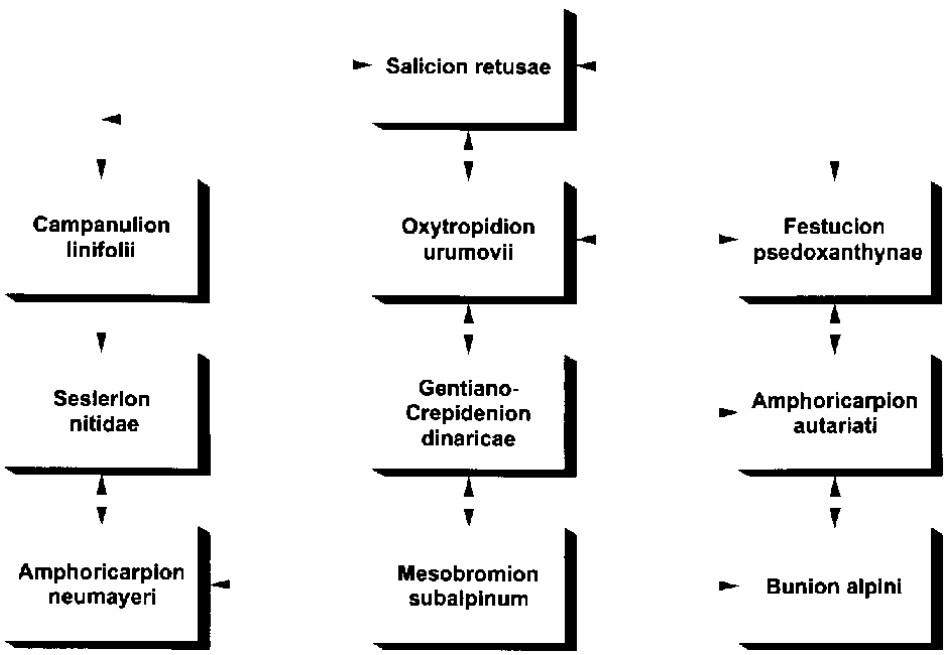

Fig. 3 - Rules of the syngenesis of the high mountain vegetation on the central and the southeastern Dinaric Alps

communities with communities from order *Seslerietalia juncifoliae*, and on more pronounced slopes and shallow soils with communities of alliance *Silenion marginatae*.

On the southeastern and central part of Dinaric Alps, the highest peaks are covered by the communities of alliance *Oxytropidion urumovii*, which on better sheltered habitats and on more acid soils is established a syngenetic continuum with communities of alliance *Campanulion albanicae*, *Seslerion robustae*, and with communities of alliance *Festucion pseudoxanthinae* on colder habitats.

Syndynamic connection of the community *Oxytropidion urumovii* with communities of thermophyllous meadows in montane belts is established through the communities of suballiance *Gentiano-Crepidenion dinaricae*. Detailed syngenetic relationships are presented in Fig. 3.

The highest peaks of continental part of Dinaric Alps are covered with communities of alliance *Edraianthion nivei*, which are linked with the communities of alliance *Oxytropidion urumovii* on warmer habitats, and with the communities of alliance *Seslerion juncifoliae* on colder habitats (Fig. 4).

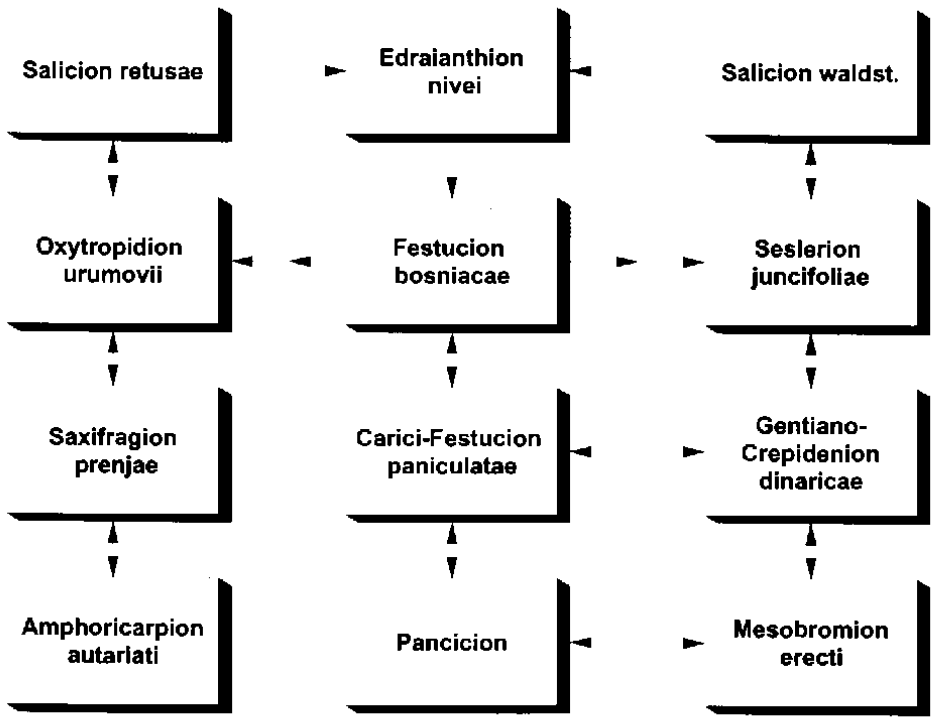

Fig. 4 - Rules of the syngenesis of the high mountain vegetation on the continental Dinaric Alps (central and northwestern part of Balkan peninsula)

The above mentioned communities, in better sheltered places and on deeper soils are linked with *Festucion bosniacae*, that is with montane meadows of the alliance *Pancicion*, which is tightly linked with the communities of alliance *Gentiano-Crepidenion dinaricae*, and *Mesobromion erecti (subalpinum)*.

Discussion

The results of previous studies indicate that the vegetation of alpine and subalpine meadows on limestone of the class *Elyno-Seslerietea* is distributed on all high mountains from the north to the southern part of Europe. In the northern part it is developed at the altitudes between 40-600 m, and in the southern part, e. g. on some mountains in Greece, at the altitudes over 3000 m (Lakusic 1966, 1970-a; Shimwell 1971).

However, on the basis of recent studies of the vegetation of meadows in Europe, it is possible to differentiate into several vegetation classes: *Carici rupestris-Kobresietea bellardi* Ohba 1974, which includes mountain and subalpine meadows and vegetation of low shrubs in the northern part of Europe and in the Caucasus (Mucina 1997; Oberdorfer 1983). The class *Festuco-Seslerietea* includes alpine and subalpine pastures in the Apennines, and the class *Seslerietea albicantis* includes the vegetation of alpine and subalpine meadows in the Alps and the Pyrenees. The class *Daphno-Festucetea* includes the vegetation of pastures on limestone and low shrubs in mediterraneo-montaneous belt of Dinaric Alps and in mountains

in Greece (Quezel 1964). The class *Elyno-Seslerietea* today includes vegetation of alpine and subalpine and sub-alpine meadows on limestone on the mountains of Balkan peninsula, Apennines, a part of the Pyrenees, Alps, and Carpathian mountains (Horvat et al. 1974; Grabherr 1993). The vegetation of mountain meadows of the class *Elyno-Seslerietea* on the Balkan peninsula is floristically and ecologically very differentiated from all other communities of this class. It is characterised by the presence of numerous endemic and relic plant species, distributed on Balkan and the Dinaric Alps.

The climate is one of the crucial factors for determination and distribution of alkaline high-mountain vegetation. According to Petriccione (1995) in four main climate regions distributed between 37 and 70 degrees of latitude, high-mountain vegetation is divided into four classes: *Carici rupestris-Kobresietea bellardi* Ohba 1974, with the optimum in bolarctic region (Ohba 1974), *Seslerietea albicantis* Oberd. 1978 corr 1990 in the region of Central Europe, and partially on the Alps and Carpathian mountains (Grabherr et al. 1993), *Festuco-Seslerietea*, which includes plant communities on high mountain in the Pyrenees, the Apennines, and Dinaric Alps (Barbero and Bonin 1969), and *Daphno-Festucetea* Quezel, 1964 in the south-eastern part of Balkan peninsula, from Macedonia to Peloponesus.

Although there is certain inconsistent comprehension of position and relationships with other similar types of mountain and sub-mountain vegetation, the class *Elyno-Seslerietea* has special features. It includes mountain and sub-mountain vegetation on shallow soils on limestone in the whole Europe (Braun-Blanquet 1948; Ellenberg 1986).

In the region of Spanish mountains and the south-western Alps, the class *Elyno-Seslerietea* is represented with the following orders: *Elynetalia myosuroides* Oberdorfer 1957; *Seslerietalia coeruleae* Br.-Bl. in Br.-Bl. and Jenny 1926; *Astragaletalia sempervirentis* with several alliances and associations and subassociations (Rivaz-Martinez et al. 1984, 1991; Diaz Gonzales and Fernandez Prieto, 1994).

In the Apennines, this class is represented with communities from the order *Seslerietalia apenninae* Lakusic 1968. This order, on vertical profile, is differentiated into two alliances: alpine alliance *Seslerion apenninae* Lakusic 1966, and subalpine alliance *Festucion dimorphae* Lakusic 1968 (Lakusic 1969-b). These alliances are parallel with alliances *Seslerion juncifoliae*, and *Festucion bosniacae* on the nortwestern part of Dinaric Alps, as well as with alliances *Oxytropidion urumovii* Lakusic 1966 and *Campanulion liniifolii* on the south-eastern part of Dinaric Alps.

Towards the south-eastern part of Balkan peninsula, the communities of the class *Elyno-Seslerietea* reach their limit on mountain in Macedonia and Greece (Horvat, 1960-a; Micevski 1994). In this region they alternate with the vegetation of open mountain steppes of the class *Daphno-Festucetea* which play a dominant role on mountains in Greece (Quezel, 1964). Although some authors still propose mountain meadows of this class, that is of the order *Seslerietalia juncifoliae*, recent investigations of syntaxonomy of mountain vegetation in Greece exclude presence of the communities of the class *Elyno-Seslerietea*. Similar vegetation formations of this type are included into order *Daphno-Festucetalia* Quezel 1964, from the class *Daphno-Festucetea* (Dimopoulous and Georgiadis, 1995; Papastergiadou et al. 1997).

Towards the east and the north-eastern part of Europe, mountain meadows from the class *Elyno-Seslerietea* are represented with communities from the order *Seslerietalia calcareae* (Br.-Bl. 1926) Klika and Hadac 1944 and with alliance *Seslerion bielzii* Pawl. 1935 emend. A. Nyarady 1967 on Carpathian mountains (Resmerita 1983), that is with the alliance *Alchemillo-Festucion supinae* Guinochet 1984, from the order *Campanulo tridentatae-Caricetalia tristis* Guinochet 1984 on the central part of Caucasus (Korotkov et

al. 1991). In the region of the northern European part of Russia, there are mainly communities from the class *Carici rupestris-Kobrisietea* (Solomakha 1996).

The highest degree of biodiversity of alpine meadows on limestone from the class *Elyno-Seslerietea* is present on Balkan peninsula. High level of floristic differentiation and presence of numerous endemic and relic species of Dinaric and Illyrian floral element contributes to such a situation, besides very heterogeneous climate and geological and pedological, as well orographic conditions. A large number of endemic species is characteristic of numerous communities from this class and it differentiates them from similar communities from adjacent regions. Very important diagnostic significance have the species from the genus *Sesleria* Scop., which are represented with numerous species on Balkan peninsula (Deyl, 1980; Gazi-Baskova 1970; Strgar 1981), as well as the species from the genus *Edraianthus* DC (Lakusic 1974). After this genus Lakusic (1970-a) differentiated special sub-class *Edraianthenea* Lakusic 1970. A very important role also play species from genera *Gentiana* L. (Misic 1965), *Silene L.*, *Scabiosa* L. (Lakusic, 1965; Abadzic, 1992-95). Similar indicator values some species of genus *Sesleria* have on other calcareous regions, too (Pignatti and Pignatti 1975).

Horvat (1952) has also emphasised very high level of biodiversity and richness of the flora of mountain vegetation in the south-eastern Europe. In this region, numerous species from Balkan floral element meet species from alpine and arcto-alpine floral element, which deeply penetrate into the Southeast. More complex investigations of the flora of high-mountain regions have also shown presence of numerous floristic characteristics (Bjelcic 1965; Silic et Abadzic 1986).

One of the fundamental issues today, regarding understanding of chorological and floristical differentiation of certain communities of mountain meadows is the south-eastern limit of distribution of central-european high-mountain vegetation on the one hand, and the relationship with mediterranean and montane vegetation, on the other hand.

From that standpoint, taking into account geological, pedological, and eco-climate conditions, it is possible to separate two main types of spatial and ecological differentiation – longitudinal, from the Northwest towards Southeast and the Dinaric Alps, and transverse, from coastal part of the Adriatic sea towards inland.

In the far north-western part of Balkan peninsula, mountain meadows from the class *Elyno-Seslerietea* ecologically and syndynamically go over to the communities of the alliance *Caricion ferrugineae* which establishes a continuum with the communities from the order *Seslerietalia juncifoliae*. The order *Seslerietalia juncifoliae* includes mountain and sub-mountain meadows in the north-western and partly central part of Dinaric Alps, going down to the complex of mountains around Neretva – Prenj, Cvrsnica and Cabulja, mainly on the continental part of these mountains.

The order is represented with two alliances: alpine alliance *Seslerion juncifoliae* and sub-alpine alliance *Festucion bosniacae*. The alliance *Caricion ferrugineae*, was mentioned in syntaxonomic surveys (Horvat 1930, 1962; Lakusic et al. 1978; Jovanovic et al. 1986), within the order *Seslerietalia juncifoliae*. After comparative investigation with the results of other authors (Grahherr et al. 1993; Gragner 1997) it was established that it has Alpine distribution and it is not present on Balkan peninsula. Certain reserve to this alliance expressed Horvat in the survey of vegetation on mountains in the western Croatia (Horvat 1962).

More complete analysis of floristic composition, and eco-climate and pedological conditions along longitudinal gradient, enables to differentiate within this order the communities from more humid and deeper soils on limestone, often in smaller depressions

where the processes of eluviations are more pronounced. On this level of knowledge they are included in the alliance *Carici-Festucion paniculatae* (Redzic, Lakusic et al. 1984) Redzic. From syngenetic standpoint, these communities makes transition between communities of alliance *Festucion bosniacae*, *Poion alpinae* and *Seslerion comosae*, on silicate geological foundation and more acid soils.

The need for the separation of alliance of this type was stressed by Redzic et al. (1984) when they have proposed alliance *Festucion paniculatae.*

Although main part of populations of this species develops on more acid geological foundation, it has also significant distribution on deep kalkomelanosols and young kalkokambisols on limestone. Horvat (1952) stressed its intermediary ecological position and its high indicator value in diagnostics of communities.

Besides calciphyllous populations of the species *Festuca paniculata* (L.) Schniz et Thell, significant role also play *Knautia dinarica*, *Potentilla crantzii* subsp. *dinarica* and *Hypochoers illyrica*, as typical species. The community *Festucetum paniculatae calcicolum* Redzic, Lakusic et al. 1984, was taken as the nomenclature type.

Order *Crepidetalia dinaricae*, which is the endemic order on the south-eastern Dinaric Alps, is represented from central part of Dinaric Alps and southern slopes of the continental Dinaric Alps (mountains Vranica, Vlasic, Romanija, Ozren).

The most continental communities of this order are present in alliance *Edraianthion nivei* (Dizdarevic et al. 1979; Lakusic et al. 1979). Towards the south, these communities go over to communities of *Oxytropidion urumovii* in alpine belt, and to *Festucion pseudoxanthynae* and *Campanulion linifolii* in subalpine belt of the south-eastern part of Dinaric Alps (Lakusic 1966, 1970-a, 1970-b, 1970-c, 1984).

The vegetation from the order *Crepidetalia dinaricae* is discovered also on the other mountain ranges in the central part of Dinaric Alps – mountain Cvrsnica (Bjelcic and Silic 1979), Treskavica (Misic 1984), Jahorina (Bjelcic 1966), on the complexes of the mountains around Sutjeska (Lakusic et al. 1969; Lakusic, Redzic et al. 1987; Lakusic, Misic et al. 1987), Crvanj and Bjelasnica (Redzic et al. 1992-95), and partly on colder continental Dinaric Alps – mountain Vlasic (Horvat 1960b; Lakusic et al. 1982), mountain Ozren (Redzic 1990).

Further towards mountains and Macedonia and Greece, as well towards mountains in Serbia and Bulgaria, the order *Crepidetalia dinaricae* establishes syngenetic continuum with communities from the order *Onobrychido-Seslerietalia* (Horvat, 1960-a).

The communities of the alliance *Edraiantho-Seslerion* are developed in the alpine belt, on wind exposed sites. The communities of alliance *Onobrycho-Festucion* (Micevski 1994) are developed in subalpine belt on similar sites. The alliance *Seslerion rigidae* which alternates with mountain and sub-mountain "steppes" continues towards mountains in Serbia and Bulgaria (Jovanovic-Dunjic 1955, 1956; Rajevski 1960; Misic et al. 1978; Jankovic 1982; Randjelovic 1983).

Towards mountains in Greece, mountain and sub-mountain vegetation takes low-shrub form, and therefore it is included into separate class *Daphno-Festucetea* (Quezel 1964).

Regarding differentiation of the vegetation from the class *Elyno-Seslerietea* on transverse profile of Dinaric Alps, from coastal part towards mountain peaks of mountains Biokovo and Orjen, there is certain differentiation in relation to the differentiation on longitudinal profile.

A very strong influence of Mediterranean climate is pronounced on the coastal part, not only in lower parts but also in montane and sub-mountain belt. This fact has a very significant impact on the structure of pastures, as well.

Important role also plays low shrubs, besides perennial herbaceous plants. This reminds to the communities from the order *Daphno-Festucetalia*. For that reason some authors tend to include this vegetation into this order (Lovric and Rac 1987; Lovric and Bedalov 1987). Above mentioned authors put all communities which develop in the oro-mediterranean zone (the mediterraneo-montaneous belt), such as *Carici-Seslerietum robustae*, *Ephedro-Astragaletum biokovensis*, *Genisto-Centauretum longicuspidis* Lovric 1987, together with the alliance *Seslerion nitidae* into above mentioned order, that is into the class *Daphno-Festucetea*.

Very high level of floristic differentiation was discovered by the comparative analysis of the communities on the north-western part of Dinaric Alps, as well as the communities on the south-eastern part of Dinaric Alps with the vegetation of coastal Dinaric Alps, and by authors research in the field. This fact stresses the need for the clearer definition of this vegetation in the light of modern vegetation science.

Even Horvat (1941) pointed out to the significant differences between mountain Biokovo and other mountains on the north-western part of Dinaric Alps. He documented his findings in the study of the flora and vegetation of mountain Biokovo. Although the presence of certain number of species from the order *Seslerietalia juncifoliae* and alliance *Seslerion juncifoliae* was documented, the presence of the main combinations of species of these vegetation units on mountain Biokovo was not discovered (Kusan 1969).

At the present level of knowledge of high-mountain vegetation on limestone on Balkan peninsula, it is possible to speak about presence of special alliances which unify vegetation of oro-mediterranean: the alliance *Seslerio-Edraianthion pumilii* All. Nova prov. in the central part of littoral Dinaric Alps is present, while the alliances *Seslerion nitidae* and *Seslerion robustae* are present in the south-eastern part of the littoral Dinaric Alps, where it was discovered before (Lakusic et al. 1984).

The alliance *Seslerio-Edraianthion* is characterised by the presence of endemic plant species such as *Edraianthus pumilio*, *Minuartia clandestina*, *Festuca panciciana*. The association *Festuco panciciana-Edraianthetum pumilii*, was taken as the nomenclature type.

Determination of adequate position of these alliances within the order *Daphno-Festucetalia*, that is *Crepidetalia dinaricae*, or special suborder, it will be possible

At the present level of knowledge of high-mountain vegetation on limestone on Balkan peninsula, it is possible to speak about presence of special alliances which unify vegetation of oro-mediterranean: the alliance *Seslerio-Edraianthion pumilii* All. nova prov. in the central part of coastal Dinaric Alps is present, while the alliances *Seslerion nitidae* and *Seslerion robustae* are present in the south-eastern part of the coastal Dinaric Alps, where it was discovered before (Tomic-Stankovic 1970; Lakusic et al. 1984).

The alliance *Seslerio-Edraianthion* is characterised by the presence of endemic plant species such as *Edraianthus pumilio*, *Minuartia clandestina*, *Festuca panciciana*. The association *Festuco panciciana-Edraianthetum pumilii*, was taken as the nomenclature type.

Alliance *Seslerion robustae* can be found in the literature under the name *Seslerion nitidae* (Lakusic et al. 1978; Lakusic et al. 1984). However, it is completely the same community. In earlier phytocoenological and even floristic literature within species *Sesleria robusta* from western part of Balkan peninsula, there were included species *S. nitida* Ten. and *S. argentea* Savi. The studies carried out by Deyl (1980) have shown that they are completely genetically and chorologically and ecologically different species. The species *S.*

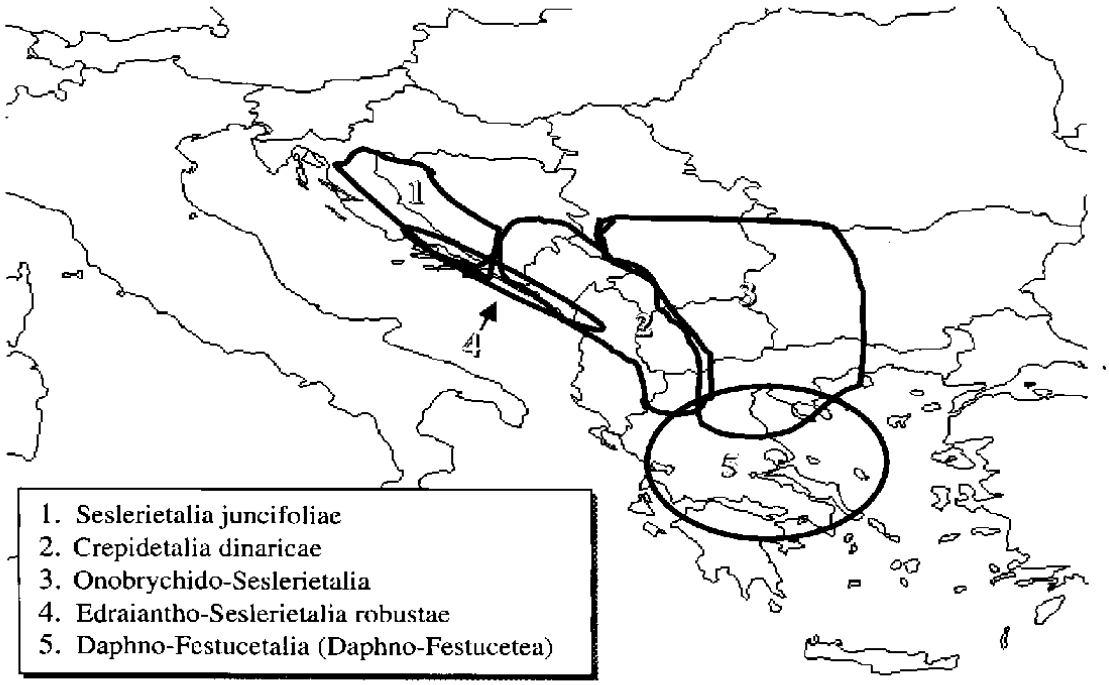

Fig. 5 - Schematic survey of chorological differentiation of orders within the class Elyno-*Seslerietea* on Balkan peninsula.

nitida is distributed on the mountains of the central and the southern Italy and Sicily. The species *S. argentea*, which is genetically closely related with the species *S. robusta* is distributed on limestone bedrock type in Italy, the south-eastern France, and the eastern Spain. On the basis of these findings, it is possible to reliably speak about communities of the alliance *S. robustae*, typical for coastal part of the central and the south-eastern Dinaric Alps.

Even communities, such is *Seslerion argenteae* represent the community *Seslerion robustae* (Horvat, 1941) Redzic, and the community *Seslerietum nitidae* Lakusic et al. represents also community of *Seslerietum robustae*, although Lakusic et al. (1984) speak about various alliances *Seslerion nitidae* and *Seslerion robustae* in the region of mountain Orjen.

This was one of the best examples how syntaxonomy must be in co-ordination with taxonomic differentiation, particularly regarding species with high diagnostic significance. Determination of syntaxonomic position of above mentioned alliances, on this level of knowledge of syntaxonomy of the class *Elyno-Seslerietea*, is very complex at the moment. Comparative analyses of ecological conditions, chorology of diagnostic species, and communities within orders *Seslerietalia juncifoliae* and *Crepidetalia urumovii*, significant differences in relation to the vegetation in oro-mediterranean belt. Comparison of floristic composition with related communities from order *Daphno-Festucetalia* from mountains in Grecee has also revealed significant differences.

This fact stress the need for the more precise ecological and syntaxonomic definition of alpine and subalpine meadows on coastal part of Dinaric Alps, which have not been precise defined. On this level of knowledge of this vegetation type, all communities from subalpine and alpine belt of coastal part of Dinaric Alps are separated into order *Edraiantho-*

Seslerietalia robustae Ordo novus prov. Besides certain differences in ecology, the order is significantly differentiated from communities of orders *Seslerietalia juncifoliae*, and *Crepidetalia urumovii*, and even from order *Daphno-Festucetalia.*

Typical species of this order are: *Sesleria robusta* subsp. *robusta*, *Edraianthus pumilio*, *Festuca panciciana*, *Minuartia clandestina*, *Astragalus biokovensis*, *Minuartia capillaceae* and *Centaurea longicuspidis.*

The alliance *Seslerion robustae* is taken as nomenclature type.

In clearing up of syntaxonomic differentiation of vegetation of this class, besides floristic and ecological differentiation, significant information were obtained by investigation of syngenesis and mutual relations of communities from three above mentioned vegetation orders.

Further comparative taxonomic investigations within the class *Elyno-Seslerietea*, which are still on going, will show suitability of established syntaxonomic differentiation.

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