

VEGETATION OF FOREST EDGES IN THE CENTRAL PART OF ISTRIA (ISTRIA, NORTHWESTERN CROATIA)

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In the research area (grey Istria) the bedrock consists of argyle, sandstones and marl. A new association was described as the *Knautio illyricae-Melampyretum carstiense* ass. nova. It is classified within the *Dictamno-Ferulagenion* van Gils *et al.* 1975, *Geranion sanguinei* R. Tx. in T. Müller 1962, *Origanetalia vulgaris* T. Müller 1962 and *Trifolio-Geranietaea* T. Müller 1961.

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Istraživano područje (siva Istra) leži na glini, pješčenjaku i laporu. Nova asocijacija je opisana kao *Knautio illyricae-Melampyretum carstiense* ass. nova. Smještena je unutar *Dictamno-Ferulagenion* van Gils *et al.* 1975, *Geranion sanguinei* R. Tx. u T. Müller 1962, *Origanetalia vulgaris* T. Müller 1962 i *Trifolio-Geranietaea* T. Müller 1961.

Ključne riječi: rub šume, *Dictamno-Ferulagenion*, *Trifolio-Geranietaea*, vegetacija, Istra, Hrvatska

INTRODUCTION

In Europe, some regional studies of the *Trifolio-Geranietaea* have already been made (DIERSCHKE, 1974; MÜLLER, 1978; MUCINA & KOBLEK, 1993) as well as some large scale syntheses (DE FOUCAULT *et al.*, 1983; DIERSCHKE, 1974). Certain studies have also been carried out in the region concerned (VAN GILS *et al.*, 1975; ČARNI, 1997; ČARNI, 1999). In the continental part of Croatia, this type of vegetation is already under elaboration (ČARNI *et al.*, 2001).

Although the saum vegetation has already been studied in Istria, it has been neglected in its central part. The communities have been studied mainly in the so called white Istria, in the eastern part, where the bedrock consists mainly of limestone.

The ecological characteristics of this class include a gradient from forest edge to grassland where many characteristic species are either forest indicators adapted to higher light levels or grassland indicators adapted to certain degree of shade. Although the ecological profiles of the associations belonging to this class are scarcely differentiated, the chorological characterisation of the class as a Eurasian syntaxon is quite clear (PIGNATTI *et al.*, 1995). WESTHOFF & VAN DER MAAREL (1973) treated such transition as limes divergens, or divergent limit, which is characterised by numerous small-scale boundaries in phytocoenoses merging continuously into each other, with many species generally represented by few individuals in a fine-grain pattern. The correspondent environment is stable and determined with a gradient.

The climate in these communities is of the transitional type between grassland and forest. The light conditions are between 30 and 50 % of those in the open area. However, it is more an ecological than a physiological optimum. Forest edge species can be considered better competitors under lower light conditions than species from open grassland. The same applies to the temperature regime, where the lower temperatures are mainly due to neighbouring forests (DIERSCHKE, 1974).

The structures on the forest edges and their biological richness result from long lasting human impact in the same way and on the same surface. The stability is a result of the traditional land use. The traditional farming system had the same impact for centuries and facilitated the formation of these structures with a great biodiversity. The reduction of the traditional land use system has two consequences. The first is the liberation of the natural dynamics and the spread of saum species over entire surfaces subsequently flooded by the shrub species of the *Rhamno-Prunetea*. So the process of reforestation begins (KALIGARIČ & ČARNI, 1991). On the other hand, the intensification of the modern farming system has a tendency to suppress the contact surfaces, eliminating the forest edge.

In Europe, the investigation of forest edge vegetation according to the standard central European method begun in the 1960s. (MÜLLER, 1961; 1962). After a long discussion about the individuality of the higher syntaxa (JAKUCS, 1970), this vegetation is nowadays mostly recognized and classified within the class *Trifolio-Geranietea*. The *Trifolio-Geranietea* is divided into two orders, the *Melampyro-Holcetalia* Passarge 1979 and *Origanetalia vulgaris* T. Müller 1961. The later one is further divided into four alliances: *Geranion sanguinei* R. Tx. in T. Müller 1961 growing in warm sites, *Trifolion medii* T. Müller 1961 found in mesic sites, *Galio littoralis-Geranion sanguinei* Géhu *et al.* 1983 found on the cliffs of the Atlantic part of Europe and *Linarion triornithophorae* Rivas-Martínez *et al.* 1984 found in the Pyrenees.

The vegetation of the forest edges of the sub-Mediterranean region of the eastern part of the Adriatic coast is classified within the *Geranion sanguinei* R. Tx. in Müller 1961 and the suballiance *Dictamno-Ferulagenion* van Gils *et al.* 1975. It is characterised by the species of the Illyrian distribution pattern such as *Knautia illyrica*, *Ferulago galbanifera*, *Paeonia officinalis*, *Knautia drymeia* subsp. *tergestina*, *Libanotis daucifolia*, to mention only the most common ones and differential species of the dry grasslands of the *Scorzoneretalia villosae*, forests of the *Ostryo-Carpinion orientalis* and shrub communities of the *Fraxino orni-Berberidenion* (ČARNI, 1997).

METHODS

The vegetation was sampled and elaborated by the standard central European method (BRAUN-BLANQUET, 1964). The nomenclature of plant species follows Index florae Croaticae (NIKOLIĆ, 1994, 1997, 2000).

DESCRIPTION OF THE RESEARCH AREA

The central part of Istria (Fig. 1) is also called grey Istria because the bedrock consists of argyle, sandstone and marl. It is situated between white Istria (Učka and Ćićarija), where the bedrock consists of limestone, and red Istria in the west, with its typical reddish soils over a limestone bedrock (RIĐANOVIĆ, 1975; ŠENTIJA, 1977).

The nearest climatic station is located in Pazin. Whilst the annual precipitation on the coast in Opatija is about 1700 mm, on Učka as much 3000 mm, in Pazin there is only 1200 mm of precipitation a year. The mean annual temperatures are 14.0 °C in Rijeka and 11.7 °C in Pazin. The climate is of the transitional type Cfb (moderate warm and humid with warm summers), but it is on the boundary with a Cfa climate (moderate warm humid climate with hot summers) (ŠEGOTA & FILIPIĆ, 1996; WALTER & LIETH, 1960).

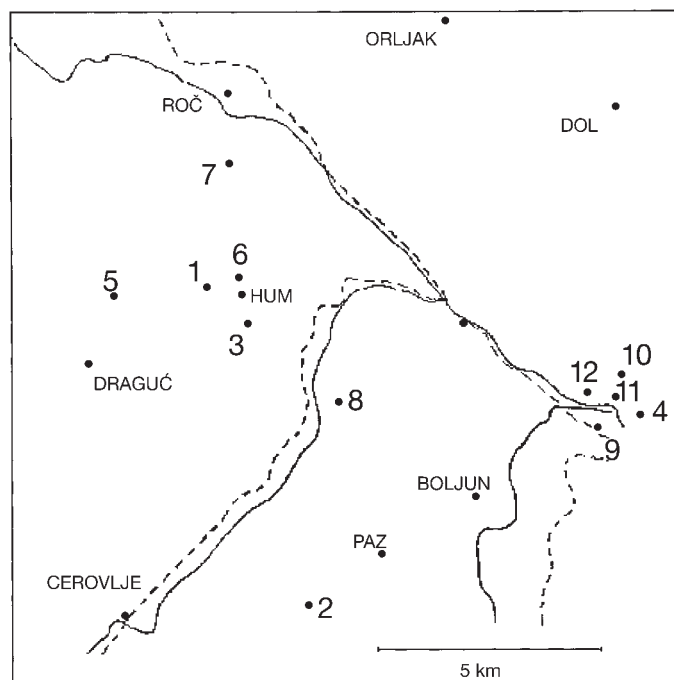


Fig. 1. Research area. The numbers correspond to those in Tab. 1.

The main forest type is *Ostryo-Quercetum pubescentis*, a climazonal community of the epi-Mediterranean zone of the Mediterranean-montane vegetation belt. It occupies the belt at an altitude between 350 and 950 m. Most frequently it is developed as a low forest with *Ostrya carpinifolia* as the dominant species. However, because of strong human influence it is in places degraded and reduced to only one dominant species, to the secondary plant community, *Seslerio autumnalis-Ostryetum*. It develops on brown soils and rendzinas over limestone and dolomites, occasionally on flysch (ŠUGAR, 1986, 1992; POLDINI, 1989). In Slovenia, the communities on flysch are sometimes treated as an independent association (ZUPANČIČ, 1999; MARINČEK & ČARNI, 2002).

The main grassland type is *Danthonio-Scorzoneretum villosae* Ht et H-ić (1956) 1958, which is a widespread association in the sub-Mediterranean part of Croatia. This meadow community that is found on deeper soils consists of more or less washed out cambisol. Waste surfaces are found in Istria that are cut in summer but also used as pastures (ROGOŠIĆ, 2000).

Syntaxonomic scheme

Trifolio-Geranietaea T. Müller 1961

Origanetalia vulgaris T. Müller 1962

Geranion sanguinei Tx in T. Müller 1961

Dictamno-Ferulagenion van Gils *et al.* 1975

Knautio illyricae-Melampyretum carstiense Čarni 2003

DESCRIPTION OF THE COMMUNITY

Knautio illyricae-Melampyretum carstiense ass. nova hoc loco

Holotypus hoc loco: Tab. 1, rel. 7

These communities develop on fringes of *Ostryo-Quercetum pubescentis*. They attain the optimum development at the end of May and at the beginning of June when they are very visible because of the significant colour of the flowers of the dominant species.

The communities are dominated by *Melampyrum barbatum* subsp. *carstiense*. This is a species of the Illyrian distribution pattern, found in ruderal places and on forest edges. In this area, the species replaces *Melampyrum barbatum* s. str. (PIGNATTI, 1982a).

Within this association there appear the following species of *Dictamno-Ferulagenion*: *Knautia illyrica*, *Centaurea weldeniana* and *Ferulago galbanifera*.

Knautia illyrica is a typical species of the forest edges of the karstic region of Croatia, Slovenia and Italy. It is closely related to *Knautia purpurea*, found in France, Italy, Switzerland and Spain (EHRENDORFRER, 1976). *Centaurea weldeniana* is a species of the Illyrian region and is spread among the scrubs and on dry grasslands of the Illyrian region (PIGNATTI, 1982b). *Ferulago galbanifera* is a species of the dry grass-

Tab. 1. Analytical table of the *Knautio-Melampyretum carstiense*

Number	1	2	3	4	5	6	7	8	9	10	11	12	Presence
Surface (in m ²)	7	10	10	10	10	7	10	10	10	10	10	15	
Altitude (in m)	310	366	320	504	420	300	264	426	444	487	443	450	
Aspect	SE	-	W	-	NE	E	-	S	S	S	SW	SW	
Inclination (in °)	5	0	2	0	2	2	0	2	5	5	2	15	
Number of species	29	38	30	37	20	26	25	29	29	36	36	32	
Ass. char. species													
<i>Melampyrum barbatum carstiense</i>	2	2	3	2	2	3	3	4	4	3	4	4	12
Dictammo-Ferulagenion													
<i>Knautia illyrica</i>	+	+	1	+	+	+	+	+	+	+	+	1	12
<i>Centaurea weldeniana</i>	.	.	+	+	+	1	+	+	+	+	+	+	10
<i>Ferulago galbanifera</i>	.	.	.	.	1	.	1	.	.	.	.	.	2
Trifolio-Geranietea													
<i>Medicago falcata</i>	.	+	+	+	+	+	+	+	+	+	+	+	11
<i>Trifolium rubens</i>	.	+	2	+	+	1	+	+	+	1	+	+	11
<i>Carex hallerana</i>	+	+	+	+	.	+	.	+	+	1	+	+	10
<i>Teucrium chamaedrys</i>	+	+	+	+	+	+	+	.	+	+	+	.	10
<i>Dorycnium herbaceum</i>	.	1	2	1	1	+	.	1	1	+	+	.	9
<i>Lathyrus megalanthos</i>	.	.	1	1	1	+	+	+	.	+	.	.	7
<i>Scabiosa triandra</i>	+	.	.	.	.	+	+	.	.	+	+	.	5
<i>Bupthalmum salicifolium</i>	.	+	+	+	.	1	.	.	.	+	.	.	5
<i>Viola hirta</i>	.	+	.	+	.	.	+	.	.	.	+	+	5
<i>Hieracium piloselloides</i>	.	.	.	+	.	.	+	+	.	+	+	.	5
<i>Chamaecytisus hirsutus</i>	.	+	.	.	+	.	.	.	.	2	.	+	4
<i>Vicia angustifolia</i>	.	.	.	.	.	.	.	.	+	+	+	+	4
<i>Genista tinctoria</i>	.	+	+	.	.	.	.	.	+	.	.	.	3
<i>Senecio jacobaea</i>	.	.	.	.	.	+	.	+	.	.	.	+	3
<i>Muscari comosum</i>	.	.	.	.	.	.	.	+	1	.	.	+	3
<i>Genista germanica</i>	+	.	.	.	.	.	+	.	.	.	.	.	2
<i>Peucedanum cervaria</i>	+	.	.	.	.	.	+	.	.	.	.	.	2
<i>Trifolium alpestre</i>	.	.	.	.	.	.	.	+	.	+	.	.	2
Thero-Brachypodietea													
<i>Eryngium amethystinum</i>	+	+	+	+	+	+	+	+	+	+	+	+	12
<i>Galium corrudifolium</i>	1	.	+	+	1	+	.	+	1	.	+	1	9
<i>Trifolium campestre</i>	.	+	+	.	.	.	.	+	+	.	.	+	5

Number	1	2	3	4	5	6	7	8	9	10	11	12	Presence
<i>Medicago prostrata</i>	.	.	.	+	.	.	.	.	.	.	+	+	3
<i>Genista sylvestris</i>	.	.	.	.	.	.	.	+	+	.	.	+	3
<i>Medicago minima</i>	.	.	.	.	.	.	+	.	.	.	.	+	2
<i>Sedum sexangulare</i>	.	.	.	.	.	.	.	.	+	.	+	.	2
Festuco-Brometea													
<i>Brachypodium rupestre</i>	+	+	1	2	1	+	1	+	+	1	+	+	12
<i>Bromus erectus</i>	1	1	1	1	1	1	1	1	2	1	2	2	12
<i>Helianthemum ovatum</i>	+	+	1	1	+	+	+	2	1	+	+	+	12
<i>Scorzonera villosa</i>	1	+	1	+	2	+	2	2	3	2	1	2	12
<i>Festuca rupicola</i>	+	+	1	.	+	+	+	+	+	+	+	+	11
<i>Carex flacca</i>	+	+	+	1	+	.	1	+	1	1	+	1	11
<i>Hippocrepis comosa</i>	1	1	1	1	+	.	+	+	+	+	+	+	11
<i>Thymus longicaulis</i>	+	+	+	+	+	.	+	+	+	+	+	+	11
<i>Trifolium montanum</i>	+	.	+	+	+	.	+	.	+	+	+	+	9
<i>Chrysopogon gryllus</i>	+	+	+	.	+	+	.	+	+	.	+	.	8
<i>Asperula cynanchica</i>	+	+	+	+	+	+	.	.	.	+	+	.	8
<i>Euphorbia cyparissias</i>	.	+	.	+	.	+	.	+	+	+	+	+	8
<i>Salvia pratensis</i>	.	.	.	+	.	+	+	+	1	1	+	1	8
<i>Polygala nicaeensis mediterranea</i>	+	+	+	+	.	.	.	.	+	+	+	.	7
<i>Thesium divaricatum</i>	+	+	.	+	.	.	.	+	+	+	.	+	7
<i>Plantago holostium</i>	.	+	+	+	+	.	.	+	+	.	+	.	7
<i>Koeleria pyramidata</i>	.	.	.	1	+	+	+	+	.	+	+	.	7
<i>Globularia elongata</i>	+	+	+	+	.	.	+	.	+	.	.	.	6
<i>Onobrychis arenaria tommasinii</i>	.	.	.	+	.	.	.	+	+	1	1	1	6
<i>Fumana procumbens</i>	1	+	+	+	+	.	.	.	.	.	.	.	5
<i>Sanguisorba muricata</i>	+	+	+	.	.	.	.	.	.	+	+	.	5
<i>Linum trigynum</i>	1	.	.	+	.	.	.	.	+	+	+	.	5
<i>Plantago media</i>	.	.	.	+	.	.	+	.	+	.	+	+	5
<i>Leontodon crispus</i>	.	.	.	.	+	+	+	.	+	+	.	.	5
<i>Filipendula hexapetala</i>	.	.	.	.	.	.	+	+	+	+	.	2	5
<i>Asperula purpurea</i>	+	.	+	+	.	+	.	.	.	.	.	.	4
<i>Leontodon crispus</i>	+	.	+	+	.	.	.	.	+	.	.	.	4
<i>Centaurea rupestris</i>	.	+	.	+	.	.	.	+	.	.	+	.	4
<i>Dianthus sanguineus</i>	.	.	.	.	.	.	.	+	.	+	+	+	4
<i>Teucrium montanum</i>	+	.	+	+	.	.	.	.	.	.	.	.	3
<i>Briza media</i>	.	.	.	+	.	.	.	.	.	+	+	.	3
<i>Centaurea triumfettii</i>	.	.	.	+	.	.	.	+	.	+	.	.	3
<i>Leucanthemum liburnicum</i>	.	.	.	.	.	.	+	.	+	+	.	.	3

Number	1	2	3	4	5	6	7	8	9	10	11	12	Presence
<i>Danthonia calycina</i>	+	+	.	1	.	3
<i>Linum tenuifolium</i>	+	+	2
<i>Prunella laciniata</i>	.	+	.	+	2
<i>Euphorbia nicaeensis</i>	.	.	+	+	2
<i>Scorzonera austriaca</i>	.	.	+	.	+	2
<i>Epipactis helleborine</i>	.	.	.	+	.	+	2
<i>Anacamptis pyramidalis</i>	+	.	.	.	+	.	2
<i>Ranunculus bulbosus</i>	+	.	+	2
Quercus-Fagetea													
<i>Quercus pubescens</i>	.	+	.	+	+	+	+	+	.	.	.	+	7
<i>Sesleria autumnalis</i>	.	.	1	.	.	+	+	.	.	+	1	.	5
<i>Cotinus coggygria</i>	+	+	+	.	3
<i>Hedera helix</i>	.	+	+	.	.	+	3
<i>Fraxinus ornus</i>	.	+	+	+	3
<i>Cephalanthera longifolia</i>	.	+	.	+	.	+	3
<i>Picris hieracioides</i>	.	+	.	.	.	+	.	.	.	+	.	.	3
<i>Juniperus communis</i>	.	+	+	.	+	.	3
<i>Lembotropis nigricans</i>	.	+	.	+	2
<i>Helleborus istriacus</i>	.	+	.	.	.	+	2
<i>Hieracium racemosum</i>	.	.	.	+	+	.	.	2
Other species													
<i>Dactylis glomerata</i>	+	+	+	+	+	1	+	+	+	+	+	+	12
<i>Lotus corniculatus</i>	+	+	+	.	.	+	+	.	.	+	.	.	6
<i>Ornithogalum sphaerocarpum</i>	.	+	.	.	.	+	+	+	+	.	.	.	5
<i>Achillea collina</i>	.	+	+	+	3
<i>Genista sagittalis</i>	+	.	+	+	+	+	5
<i>Plantago lanceolata</i>	.	+	+	+	+	4
<i>Trifolium pratense</i>	+	+	2

Appendix to Tab. 1

1. *Argyrolobium zanonii* +, *Asparagus acutifolius* +, *Hieracium pilosella* +; 2. *Hypericum perforatum* +, *Origanum vulgare* +, *Satureja montana* +; 3. *Inula hirta* 2, *Molinia arundinacea* +; 4. *Bupleurum veronense* +, *Lonicera caprifolium* +; 5. *Blackstonia perfoliata* +; 6. *Campanula glomerata* +, *Fragaria moschata* +, *Medicago lupulina* +; 7. *Centaureum erythraea* +, *Platanthera bifolia* +; 8. *Anthyllis vulneraria* +, *Campanula rapunculus* +, *Campanula persicifolia* +, *Thlaspi praecox* +, *Trinia glauca* +; 9. *Cephalaria leucantha* +; 10. *Chamaecytisus supinus* +, *Ononis antiquorum* +, *Silene italica* +; 11. *Dianthus tergestinus* +, *Ornithogalum kochii* +; 12. *Clematis vitalba* +, *Coronilla varia* +, *Geranium columbinum* +, *Orobanche* sp. +, *Silene vulgaris* +, *Stachys subcrenata* +.

1. lat. 45°21,087', long. 14°02,574'; 2. 45°16,689', 14°04,326'; 3. 45°20,695', 14°03,158'; 4. 45°19,282', 14°10,313'; 5. 45°21,032', 14°00,661'; 6. 45°21,130', 14°02,930'; 7. 45°22,748', 14°02,759'; 8. 45°19,362', 14°09,992'; 9. 45°19,310', 14°10,015'; 10. 45°19,489', 14°10,055'; 11. 45°19,341', 14°09,948'; 12. 45°19,454', 14°09,738'.

land and forest edges of the deciduous forests of the sub-Mediterranean region (PIGNATTI, 1982a).

Among the species characteristic of the alliance, order and class, the most common are *Medicago falcata*, *Trifolium rubens*, *Carex hallerana*, *Teucrium chamaedrys*, *Dorycnium herbaceum*, *Lathyrus megalanthos*. Some of them are sometimes treated as the character species of *Scorzonerion villosae*, as they do not appear in the more thermophilous associations of *Satureion subspicata* (KALIGARIČ, 1997).

There are also some species of *Thero-Brachypodietea*, like *Eryngium amethystinum*, *Galium corrudifolium*, *Trifolium campestre*, that emphasise the thermophilic character of the communities.

The species of the dry grasslands are well presented in a table like *Brachypodium rupestre*, *Bromus erectus*, *Helianthemum ovatum*, *Scorzonera villosa*, *Carex flacca*, to mention only the most common ones.

The distribution of this vegetation type is limited by the summer drought (VAN GILS & KEYSERS, 1977). In this part of Istria, there is a boundary of *Trifolio-Geranietea*, a syntaxon of the Eurasian origin. The communities appear on the fringes, on the ecotone between dry grasslands of the *Scorzonerion villosae* and forests of the *Ostryo-Quercetum*. Although there are many species of dry grassland of the *Festuco-Brometea*, a decision was made to classify these communities into the *Trifolio-Geranietea*.

The group of forest species of *Quercu-Fagetea* is also well represented with *Quercus pubescens*, *Ornithogalum sphaerocarpum*, *Sesleria autumnalis*, *Fraxinus ornus*, to mention only the most common ones. It shows the syndynamical contact of the vegetation concerned.

CONCLUSION

The present investigation revealed the presence of the *Trifolio-Geranietea* vegetation in the central part of Istria, on the boundary of its distribution area. This vegetation is also the pool of species that play an important role in the reforestation process of dry grasslands. On the other hand, it is quite diverse, its floristic composition reflecting the historical human impact, and it is an important element of the natural heritage of the region.

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