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The development of postglacial vegetation in coastal Croatia

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A review of postglacial vegetation development in the coastal region of Croatia is based on a synthesis of previous and the most recent archaeobotanical research, including pollen analysis, and analysis of plant macro-fossils. Changes in vegetation through individual postglacial periods are shown systematically, particular attention being devoted to anthropogenic impacts on the vegetation.

Key words: vegetation, anthropogenic impact, postglacial, coastal, Croatia

Introduction

Today's vegetation in Croatia, like that in other European countries, is the result of the reciprocal activity of natural and anthropogenic factors that have lasted over a long period of time. Croatia belongs to the refugium area and reveals a great diversity and richness of taxa, and it was difficult to define simple development. Most of the existing palynological sources for the inland part of Croatia are quite old; some of them have been analysed in very general terms and without direct dating, which makes the review to some extent a hypothesis, waiting confirmation or denial with new investigations and revisions.

Even though the coastal vegetation of Croatia is very rich in different plant species, compared with the inland area it shows more or less clear basic line of postglacial development, as confirmed by different investigations. Palynological sources for the coastal region give more precise and complex data. Some localities, like the island of Mljet, even have very recent revisions (JAHNS and BOGAARD 1998).

The earliest reconstruction of postglacial vegetation development in the coastal region of Croatia was made by BEUG (1967) and was based on the earliest palynological research of this region – the lake deposits of the lake Malo Jezero on the island of Mljet (BEUG 1962). This author returned several times later to the postglacial vegetation history of the Croatian coast from different points of view (BEUG 1975a, 1975b, 1982), but the basic outlines of vegetation development remained the same. BEUG (1967) distinguished four forest periods: Period A – the period of deciduous oak forest (about 7000–5600 BC), Period B – the *Juniperus-Phillyrea* period and beginning of true Mediterranean climate conditions

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(5600–4300 BC), Period C – the *Quercus ilex* period (4300–about 200 BC) and Period D – the *Pinus-Quercus ilex* period.

The review of vegetation development of the coastal area of Croatia presented in this work is restricted to the postglacial period (ca 8000 BC–modern times), and it is based on a synthesis of previous and the newest archaeobotanical investigations, including the results of palynological (BEUG 1962, 1977; BRANDE 1973; GRÜGER 1996; JAHNS and BOGAARD 1998) and macrofossil (HÄNSEL et al. 1997; KARG and MÜLLER 1990; ŠOŠTARIĆ 2003; ŠOŠTARIĆ and KÜSTER 2001) analysis from nine different sites (Fig. 1).

As particular attention is devoted to human impacts on the vegetation, historical ages (like Neolithic and Bronze Age, according to DIMITRIJEVIĆ et al. 1998) are also included in this review.

Reconstruction of vegetation changes

The oldest available information on the basis of which it is possible to reconstruct the development of the coastal area vegetation of Croatia goes back to the Boreal period, approximately 8000 cal BC (according to JAHNS and BOGAARD 1998). In the period of approximately 8000–6000 cal BC the island of Mljet was covered with forest vegetation dominated by deciduous oaks of the *Quercus pubescens* type, mingled with other deciduous taxa such as *Corylus, Ulmus, Carpinus orientalis/Ostrya carpinifolia* and *Fraxinus ornus.* To a lesser extent, there were also taxa such as *Tilia, Acer, Fraxinus excelsior* and *Carpinus betulus* present. *Pinus* is to be found in a considerable percentage, but it is not sure whether the pine pollen derives from the typical Dalmatian black pine (*Pinus nigra* subsp. *dalmatica*) indigenous to Dalmatia, or whether the wind brought this pollen from the pine forests of the inland area. There are also evergreen Mediterranean-proper taxa present in traces, such as *Quercus ilex, Phillyrea, Pistacia* and others, and the pollen of beech (*Fagus*), which was most likely brought by wind from the inland area.

In the period of approximately 6000–4400 cal BC (according to JAHNS and BOGAARD 1998), true Mediterranean mixed oak forests were replaced by evergreen vegetation in which *Phillyrea* and *Juniperus* predominated. Although from the period there are no finds of Neolithic communities on the actual island of Mljet, there are some items of archaeobotanical evidence of there being agricultural activity in the area of the south Adriatic (KARG and MÜLLER 1990). However, it is considered that the anthropogenic impact was too small to have brought about this kind of vegetation change, and it is rather ascribed to climatic changes (BEUG 1962, JAHNS and BOGAARD 1998). The Atlantic period (ca 7050–3800 cal BC) brought a mild warming with more arid summers and milder winters (LANG 1994) which aided the spread of true Mediterranean species.

In the subsequent period, about 4400 cal BC to 0 AD vegetation changed again (JAHNS and BOGAARD 1998), and the true Mediterranean oak *Quercus ilex* became dominant. The percentage of *Phillyrea* fell after the rise in the presence of oak, while *Juniperus* survived in conjunction with oak somewhat longer. This *Quercus ilex*-period can be divided into three sub-periods. The curve of *Quercus ilex* remains relatively constant through all three sub-periods, but associated vegetation changed several times. In first sub-period (ca 4400–3100 cal BC) the *Juniperus* values are still high, but then *Juniperus* decreased and *Erica* spread in the second sub-period (ca 3100–1300 cal BC). The third sub-period (started

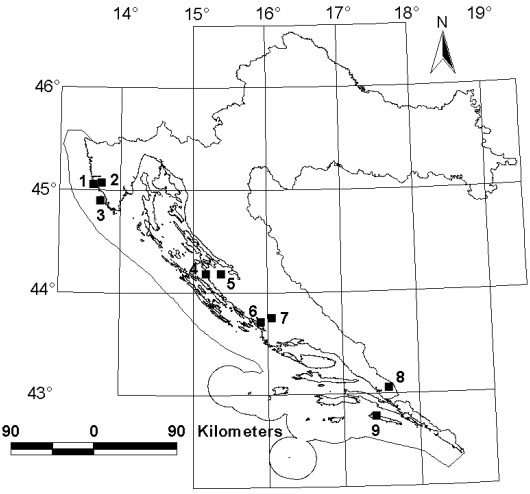

Fig. 1. Sites from which the archaeobotanical data used in the reconstruction of the vegetation development of the coastal area of Croatia in the postglacial period were obtained (P – pollen analysis, MF – analysis of plant macro-fossils): 1. Palu Lake near Rovinj, P (BEUG 1977); 2. Monkodonja, MF (HÄNSEL et al. 1997); 3. Veli Brijun, MF (ŠOŠTARIĆ and KÜSTER 2001); 4. Zaton near Zadar, MF (ŠOŠTARIĆ 2003); 5. Bokanjačko blato, P (GRÜGER 1996); 6. Danilo, MF (ŠOŠTARIĆ 2003); 7. Pokrovnik, MF (KARG and MÜLLER 1990); 8. Neretva River by Metković, P (BRANDE 1973); 9. Island of Mljet, P (BEUG 1962, JAHNS and BOGAARD 1998).

ca 1300 cal BC) was characterised by the spread of *Pinus,* higher values of *Juglans* and *Olea* and the appearance of *Ceratonia*. More favourable conditions for the development of holm oak (*Quercus ilex*) had existed in the previous period (6000–4400 cal BC), and the question inevitably arises as to whether the spread of it is connected with some anthropogenic influence. The dissemination was spontaneous and the result of the speed and potential for expansion of some of the taxa (BEUG 1962, JAHNS and BOGAARD 1998). Still, the rise in the proportion of *Erica* in the middle of this period should indicate enhanced anthropogenic influence due to burning and grazing during the Eneolithic and Bronze Age. A rise in the proportion of pine (*Pinus*) at the end of the period is ascribed to the introduction of the Aleppo pine (*Pinus halapensis*) by the Greek and/or Roman colonists. Clear evidence for human influence on the island of Mljet exists from ca 1300 cal BC, when *Pinus* and *Juglans* increase (JAHNS and BOGAARD 1998). Authors connect the date ca 1300 cal BC with the carbonate in the sediments, because it seems to be too old to be the anthropogenic impact of classical times, as compared with other pollen records: about 200 cal BC for Mljet (BEUG 1962, 1967), Neretva Lowlands (BRANDE 1973) and Bokanjačko Blato (GRÜGER 1996). Still, the area of present-day Croatia was located on the edge of the advanced Mediterranean civilizations and recent archaeological investigations show without a doubt that almost regular contacts between the Croatia of that time and the Greek and Italic cultures existed from ca 7th century BC. For example, the Liburnians (tribes of the north part of the east Adriatic coast) represented a significant maritime power in the Adriatic, with the greatest extent of their thalassocracy during the 8th and 7th centuries BC (Early Iron Age). Already at that time, connections between the west and east Adriatic coasts ex-

isted, which had an influence on the culture of both sides. Greek pottery was imported into Liburnian settlements from the 7th century BC and products of the Greek workshops of Asia Minor also appeared (MAJNARIĆ-PANDŽIĆ 1998). From this point of view it is possible that early appearance of *Pinus halepensis, Juglans, Ceratonia, Castanea,* and *Punica* also reflected the early influence of Greek and Italic (agri)culture, introduced through trade. None of those plants are complicated either to transport (fruits or seeds) or to cultivate.

In the last period (about 0 AD–modern times) pollen diagrams from Mljet show the domination of *Pinus halepensis*, followed by *Quercus ilex* and *Pistacia* (JAHNS and BOGAARD 1998).

Palynological investigations from two inland sites – the Neretva River by Metković (BRANDE 1973) and Bokanjačko blato by Zadar (GRÜGER 1996) in their basic outlines tend to confirm the vegetation development described above especially in the coastal part of the mainland area. Further inland, from the beginning of the record at about 7000 BP (5050 cal BC), there is an unbroken dominance of sub-Mediterranean deciduous oak forests with *Quercus pubescens*, *Carpinus orientalis/Ostrya carpinifolia* and *Fraxinus ornus* as the dominant tree species (BEUG 1982).

According to BRANDE (1973), sure indications of anthropogenic impact on the vegetation of the Neretva site are recorded only from Roman times. Radioactive carbon dating has shown that the chestnut (*Castanea*) and walnut *(Juglans)* were introduced into the area in Roman times, as was the cultivation of the olive (*Olea*) and the grape vine (*Vitis*). A degradation of the environment can be also seen in Roman times, because the pollen counts of maquis and garrigue species (*Juniperus, Paliurus, Cistaceae*) clearly rose proportionately. Most of the Middle Ages was a phase in which the forest cover was regenerated.

Bokanjačko blato near Zadar shows a very similar vegetation development (GRÜGER 1996), with the difference that the anthropogenic impact is visible as early as the Eneolithic and in the early Bronze Age (about 3000–2000 cal BC). There are no signs of agriculture, or they are very slight, but there are indications of grazing, i.e., of a pastoral economy. This locality also gave clear signs of intensive development of typical Mediterranean crops (*Olea, Vitis*) during the period of antiquity.

GRÜGER (1996) mentions traces of pollen of the *Cerealia* type, in the layers spanning the later Bronze Age to modern times, but in very low values. The same is true of the Mljet (BEUG 1962, JAHNS and BOGAARD 1998) and Neretva sites (BRANDE 1973). Since cultivated cereals produce a relatively small amount of pollen, which can usually be dispersed for just a few kilometres (LANG 1994), while the analysis of plant macro-fossils from the Neolithic site of Pokrovnik in the Dalmatian interior hills shows that cereals were cultivated as early as the Neolithic (KARG and MÜLLER 1990), perhaps these traces of primary human activity ought to be ascribed more significance.

Macro-fossil remains in Zaton near Zadar (ŠOŠTARIĆ 2003) confirm a strong anthropogenic impact on the vegetation in the environs of the settlement and harbour during Roman times and show that typical Mediterranean crops (like *Olea europaea, Vitis vinifera, Ficus carica, Pinus pinea*) were not only grown in this area for local requirements, but also traded.

The Roman site of Danilo to the rear of Šibenik (ŠOŠTARIĆ 2003) shows that in Roman times, besides typical Mediterranean crops on the coast, in the interior of the mainland the cultivation of various cereals (like *Avena, Hordeum vulgare, Triticum aestivum, T. spelta*)

was quite well developed. The indigenous Illyrian population had a largely pastoral economy before the arrival of the Romans, and under the influence of Romanization they probable enlarged the fertile fields and started dealing more intensively with arable farming.

Palaeo-vegetation investigations in the north of the Adriatic (Palu Lake, Istria) have covered periods back to about 5000 BP (3800 cal BC) (BEUG 1977). In the period from approximately 3800 cal BC to the arrival of the Romans, the Istrian peninsula was dominated by deciduous sub-Mediterranean oak forests, while the evergreen Mediterranean-proper forests were of lesser importance, and stretched only along the coastline, in a band about 20–30 metres wide. The author considers that at that time there were no traces of anthropogenic impact on the vegetation and that these were natural forests. The first certain signs of human activity are visible from the beginning of Roman colonisation of the peninsula in about the 2nd century BC, when the pollen curves of the walnut (*Juglans*) and the chestnut (*Castanea*) appear. After that come the continuous curves of *Secale* and *Cerealia* pollen types, which are sure signs of arable farming. Simultaneously, the share of evergreen Mediterranean woody taxa, such as *Phillyrea* and *Juniperus* increase. The author explains this by the clearing of the sub-Mediterranean forests, for the sake of obtaining cultivable areas, which made possible the spread of evergreen species farther into the interior and the formation of maquis.

Research of the proto-urban site of Monkodonja near Rovinj, from the Old and Middle Bronze Age shows that the early inhabitants of the peninsula were involved in agriculture (*Avena, Lathyrus sativus, Vicia faba, Vitis*) (HÄNSEL et al. 1997). In BEUG'S pollen diagram of 1977 one can see the occasional appearance of *Cerealia* pollen types even before the coming of the Romans. Considering the presence of many prehistoric settlements in the general area of Istria, the configuration of the land and the macro-fossil findings, doubt must be cast on BEUG'S (1977) claim that until the coming of the Romans the forest vegetation was natural and devoid of anthropogenic influence. The olive curve is also negligible (BEUG 1977) but archaeological and macro-fossil findings (ŠOŠTARIĆ and KÜSTER 2001) show beyond any doubt that the cultivation of the olive was extremely well-developed in the Roman times, as well as of other Mediterranean crops (*Vitis vinifera, Ficus carica, Pinus pinea*).

If a comparison is made of the proportion of arboreal pollen (AP) and non-arboreal pollen (NAP) in the pollen diagram, it can be seen that arboreal taxa were predominant until about Roman times. After Roman times there were successive alternations of phases of rises and declines in the share of arboreal pollen, which reflects strong anthropogenic impact on the natural vegetation and its phases of occasional regeneration and repeated devastation.

Conclusion

The review of vegetation development in the Croatian coast is based on a synthesis of previous and the newest archaeobotanical research, including pollen analysis and analysis of plant macro-fossils, and it is restricted to the postglacial period (ca 8000 cal BC–modern times). The postglacial vegetation history of the Croatian coast (islands of Dalmatia and coastal part of mainland area) can be divided in four periods (Tab. 1). In first period (ca 8000–6000 cal BC) the coastal area was covered with mixed deciduous forests in which

Tab. 1. Simplified summary of the vegetation development of the coastal region of Croatia during the postglacial period. The dark lines in the table show duration of individual vegetation phases according to accessible data

Time scale (BC/AD)	Historical ages	North Adriatic	Islands of Dalmatia and coastal part of mainland area	Further inland of Dalmatian mainland
	Antiquity	+ *Juglans, Castanea, Cerealia, Olea, Vitis, Phillyrea, Juniperus*	+ *Pinus halepensis, Castanea, Juglans, Olea, Vitis, Cerealia, Ceratonia, Punica, Juniperus, Pistacia, Paliurus, Cistaceae*	+ *Castanea, Juglans, Olea, Vitis, Cerealia, Juniperus, Paliurus, Cistaceae*
0	Iron Age			
1000	Bronze Age	*Quercus pubescens* + *Carpinus orientalis/ Ostrya carpinifolia, Fraxinus ornus*	*Quercus* + *Erica*	
2000	Eneolithic	(*Quercus ilex* + *Phillyrea, Pistacia, Juniperus*)	*ilex*	*Quercus pubescens* + *Carpinus orientalis/ Ostrya carpinifolia, Fraxinus ornus*
3000			+ *Juniperus*	
4000	Neolithic			
5000			*Phillyrea, Juniperus* + *Quercus ilex*	
6000			*Quercus pubescens* + *Corylus, Ulmus,*	
7000			*Carpinus orientalis/ Ostrya carpinifolia, Fraxinus ornus*	
8000				

Quercus pubescens prevailed, mixed with other thermophile deciduous species, like *Carpinus orientalis*/*Ostrya carpinifolia*, *Fraxinus ornus*. The climate was either colder in winter or more humid in summer than that of today. In the period of approximately 6000–4400 cal BC deciduous oak forests were replaced by evergreen vegetation in which *Phillyrea* and *Juniperus* predominated. This vegetation change was probable caused by climate change that brought about true Mediterranean conditions. In the subsequent period (ca 4400 cal BC–0 AD) the vegetation changed again and *Quercus ilex* became dominant. There is no evidence that this vegetation change was caused by changes in the climate and the human influence of the early Neolithic communities was probable insufficient, so at the beginning it was presumably the result of the potential for expansion of the given species. *Quercus ilex* remained more or less dominant through all the period (ca 4400 cal BC–0

AD), but the associated vegetation changed several times. In first sub-period (ca 4400–3100 cal BC) the *Juniperus* values were still high, but in the second sub-period (ca 3100–1300 cal BC) *Juniperus* decreased and *Erica* spread. This *Erica*-vegetation change is most likely a result of anthropogenic influence, due to burning and grazing during the Eneolithic and Bronze Age. In the last sub-period (ca 1300 cal BC–0 AD) the proportion of *Pinus halepensis* and *Juglans* rose, *Ceratonia, Castanea, Punica* and other species appeared, which changes are beyond any doubt the result of human activities. Strong anthropogenic influence, starting in the last sub-period, caused great changes in the natural vegetation.

Further in the interior of the Dalmatian mainland, in the period from the beginning of the record at about 5050 cal BC to Roman times, there was an unbroken dominance of sub-Mediterranean deciduous oak forests with *Quercus pubescens*, *Carpinus orientalis/Ostrya carpinifolia* and *Fraxinus ornus* as the dominant tree species (Tab. 1).

In the north Adriatic in the period from about 3800 cal BC to the arrival of the Romans deciduous sub-Mediterranean oak forests also predominated, while the evergreen Mediterranean forests were of lesser importance and stretched only along the coastline (Tab. 1).

Until about Roman times the arboreal taxa in the pollen diagrams were predominant over non-arboreal taxa, which reflects the unbroken domination of the forests through all this long period (ca 8000 cal BC–0 AD). This means that earlier human activities did not result in the loss of forest cover, rather in some changes in the composition. In the last period, since Roman times (ca 0 AD to modern times), there were successive alternations of phases of rises and declines in the share of arboreal pollen, reflecting strong anthropogenic impact on the natural vegetation and its phases of occasional regeneration and repeated devastation.

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References

BEUG, H.-J., 1962: Über die ersten anthropogenen Vegetationsveränderungen in Süddalmatien an Hand eines neuen Pollendiagrammes vom »Malo Jezero« auf Mljet. Veröff. Geobot. Inst. Stiftung Rübel, Zürich, 37, 9–15.

BEUG, H.-J., 1967: On the forest history of the Dalmatian coast. Rev. Palaeobotan. Palynol. 2, 271–279.

BEUG, H.-J., 1975a: Changes of climate and vegetation belts in the mountains of Mediterranean Europe during the Holocene. Bull. Geol. 19, 101–110.

BEUG, H.-J., 1975b: Man as factor in the vegetational history of the Balkan Peninsula. Proc. 1 Int. Symp. Balkan Flora and Vegetation, Varna, Sofia, 72–77.

BEUG, H.-J., 1977: Vegetationsgeschichtliche Untersuchungen im Küstenbereich von Istrien (Jugoslawien). Flora 166, 357–381.

BEUG, H.-J., 1982: Vegetation history and climatic changes in central and southern Europe. In: Harding, A. F. (ed.), Climatic changes in later prehistory, 85–102. Edinburgh Univ. Press, Edinburgh.

BRANDE, A., 1973: Untersuchungen zur postglazialen Vegetationsgeschichte im Gebiet der Neretva-Niederung (Dalmatien, Herzegowina). Flora 162, 1–44.

DIMITRIJEVIĆ, S., TEŽAK-GREGL, T., MAJNARIĆ-PANDŽIĆ, N., 1998: Prapovijest. Naprijed, Zagreb.

GRÜGER, E., 1996: Vegetational change. In: CHAPMAN, J., SHIEL, R., BATOVIĆ, Š. (eds.), The changing face of Dalmatia, archaeological and ecological studies in a Mediterranean landscape 33–43. Leichester Univ. Press, Leichester.

HÄNSEL, B., MIHOVILIĆ, K., TERŽAN, B., 1997: Monkodonja, utvrđeno protourbano naselje starijeg i srednjeg brončanog doba kod Rovinja u Istri. Histria Arch. 28, 37–107.

JAHNS, S., BOGAARD VAN DEN, C., 1998: New palynological and tephrostratigraphical investigations of two salt lagoons on the island of Mljet, south Dalmatia, Croatia. Veget. Hist. Archaeobot. 7, 219–234.

KARG, S., MÜLLER, J., 1990: Neolitische Getreidefunde aus Pokrovnik, Dalmatien. Archäol. Korespondenzblatt 20, 373–386.

LANG, G., 1994: Quartäre Vegetationsgeschichte Europas, Methoden und Ergebnisse. Gustav Fischer Verlag, Jena.

MAJNARIĆ-PANDŽIĆ, N., 1998: Brončano i željezno doba. In: DIMITRIJEVIĆ, S., TEŽAK-GREGL, T., MAJNARIĆ-PANDŽIĆ, N. (eds.), Prapovijest, 161–358. Naprijed, Zagreb.

ŠOŠTARIĆ, R., 2003: Vegetacijske promjene u postglacijalu u Hrvatskoj. PhD Thesis, University of Zagreb.

ŠOŠTARIĆ, R., KÜSTER, H., 2001: Roman plant remains from Veli Brijun (island of Brioni), Croatia. Veget. Hist. Archaeobot. 10, 227–233.