CLIMATIC FACTORS AND ESTABLISHMENT OF *QUERCUS ILEX* - COMMUNITIES IN TRIESTE PROVINCE (NE ITALY)

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ABSTRACT - In the coastal area called "Cernizza" (near Duino, ca 15 km NW from Trieste), at an altitude between 0 and 40 m, is located a wood vegetation complex characterized by *Quercus ilex* and *Carpinus orientalis*. The bedrocks of this site is carbonatic. This wood vegetation does not occur in other sites of the Trieste province, where deciduous oak woods (*Q. pubescens*, *Q. petraea* s.l.) are dominant both on arenaceous and on carbonatic rocks. Other *Quercus ilex* communities are occurring only as scrubs on the calcareous coastal cliffs characterized by primitive lithosoils. In order to detect if this wood community might be an expression of the climate dominating this particular zone, some Duino's climatic data, relative to a record period of 9 years, have been compared with the Trieste's ones. The analysed parameters were the following: air temperature, rainfall, evaporation, wind speed and relative humidity. From the comparison of these paramenters it emerged that the Duino's climate is more humid than the Trieste's one. Only in springtime Duino is less rainy than Trieste according to the analysis of the monthly mean values of precipitation. From the ecophysiological point of view, a study on the seasonal changes of the root hydraulic conductance in some forest trees (Nardini *et al.*, 1998) has pointed out the superiority of *Quercus ilex* compared to *Quercus pubescens*, as regards the competitive ability of the seedlings during the spring. For this reason, the smaller spring rainfall could explain the occurence of *Quercus ilex* stands not only in the neighbourhood of Duino but also at the beginning of the large valleys characterized by S-N direction in the South Eastern Alps.

KEY WORDS - *Quercus ilex*, holm-oak, vegetation, climate, plant ecology, Trieste province.

INTRODUCTION

The climate of the NE-Italian coasts is characterised by a summer which is not particularly dry: for this reason the wood vegetation of the rocky coasts consists there of a sub-Mediterranean deciduous forest with oaks (mainly *Quercus pubescens*). This formation replaces the Mediterranean evergreen forest (*Quercetum ilicis* s.l.) that is stretched along the majority of Italian coasts. In NE Italy *Quercus ilex* seems to colonise only the steep rock surfaces, where a dry summer habitat results probably from runoff of the larger part of the rainwater (Breckle, 2002).

The Trieste's general climate (FIGURE 1) is humid with equinoctial rainfalls and cold winters. In accordance with the above mentioned facts, in the Trieste province deciduous oak woods (*Quercus pubescens*, *Q. petraea* s.l.) are dominant both on sandstone and on limestone; *Quercus ilex*-communities are occurring only as scrubs on the calcareous coastal cliffs characterised by primitive lithosoils. Despite this, a wood vegetation complex characterised by *Quercus ilex* and *Carpinus orientalis* grows in a gently undulated land near Duino, ca 15 km from Trieste in direction NW at an altitude between 0 and 40 m, in the locality called «Cernizza» (FIGURE 2). The name of this locality derives from Slovenian word «črn» that means black, probably related to the bark and canopy colour of the holm-oak. The bedrock of this site is calcareous and their origin dates from the Upper Cretaceous (Calligaris, 2001). Some climatic data of Cernizza area have been compared with the Trieste's ones in order to detect if this wood community might be an expression of the climate dominating this particular zone. The results of this comparison are being presented in this study, whose aims have been:

1) to analyse the floristical variation in the wood vegetation complex of Cernizza;

2) to relate this variation to possible environmental differences;

3) to interpret in climatic terms the establishment of a *Quercus ilex*-community in a habitat type usually colonised by deciduous oaks.

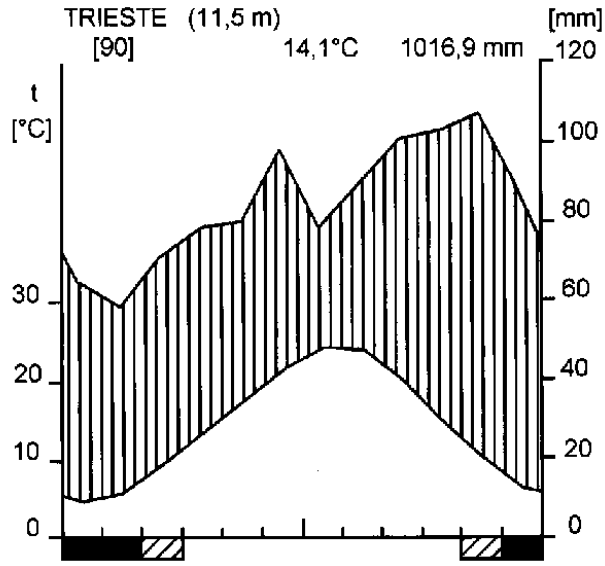

FIGURE 1 - Climate diagram of Trieste (according to Walter, 1984).

MATERIALS AND METHODS

The vegetation survey was carried out following the Braun-Blanquet's method (1964). 55 phytosociological relevés (FIGURE 2) were taken on a homogeneity cri-

terion in order to describe all the vegetational variation as far as possible. The area of each relevé was 20-30 m^2.

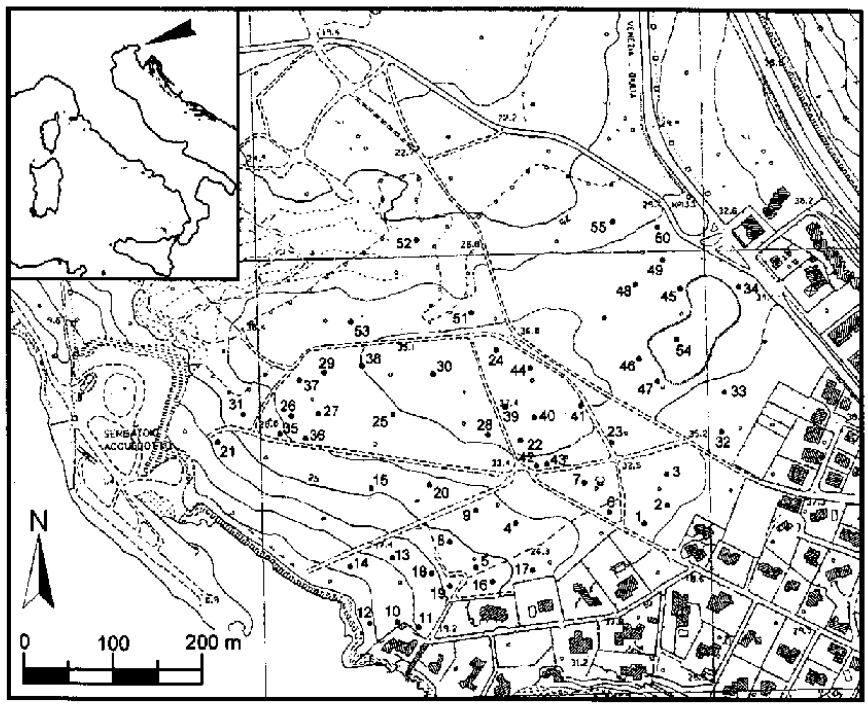

FIGURE 2 - Map of the studied area and location of the phytosociological relevés.

The relevés were classified on the binary data of the species (presence/absence), in order to analyse the compositional variation in the data set and to detect the major ecological factors related to it. It was applied a non-hierarchical clustering method based on the fuzzy logic with *a priori* specification of the cluster number (c=2) for the purpose of stressing the greatest floristic variation. The algorithm used was *c-means clustering* (Podani, 1994) with a coefficient of fuzziness f=1.1. The relevés characterised by high affinity to one or the other cluster (membership weight u>0.90) formed the simplified model towards an indirect ecological analysis.

The characteristics of the Cernizza topoclimate were studied on the basis of a comparison between climatic data of this area and the Trieste's ones. In particular the comparison was carried out on the following data sets:

a) Adjusted normal monthly data of air temperature and rainfall for the period 1931-1960 relative to Trieste (Polli, 1970) and Peschiera del Timavo (Stravisi, 1980), a locality situated next to the Cernizza's area. On the basis of these data, the water balance was computed for these two stations according to the Thornthwaite's method (1948) on the assumption that the water capacity of the soil is constant (WC=100 mm).

b) Climatic data relative to Trieste and Peschiera del Timavo recorded over a 9-year period (1958-1966: Istituto Talassografico di Trieste-C.N.R.). The analysed

parameters were evaporation, air temperature, wind speed, relative humidity and rainfall. The mean monthly values of these parameters have been calculated for the two stations on the basis of above mentioned data.

Results and Discussion

The results of the *c-means cluster analysis* of relevés on floristic data are in Figure 3. In this diagram are reported the membership weight of the relevés for the two fuzzy clusters A and B. The arrangement of the relevés in the scatter diagram of Figure 3 shows that the floristic variation in the vegetation cover is gradual, as already pointed out in a previous phytogeographic study (Tretiach & Bolognini, 1993). Table 1 contains the cover values of the species in the relevés characterised by a membership weight $u>0.90$ for the fuzzy clusters A and B (closed circles in Figure 3). On the basis of Table 1, the two fuzzy sets of relevés can be typified as follows:

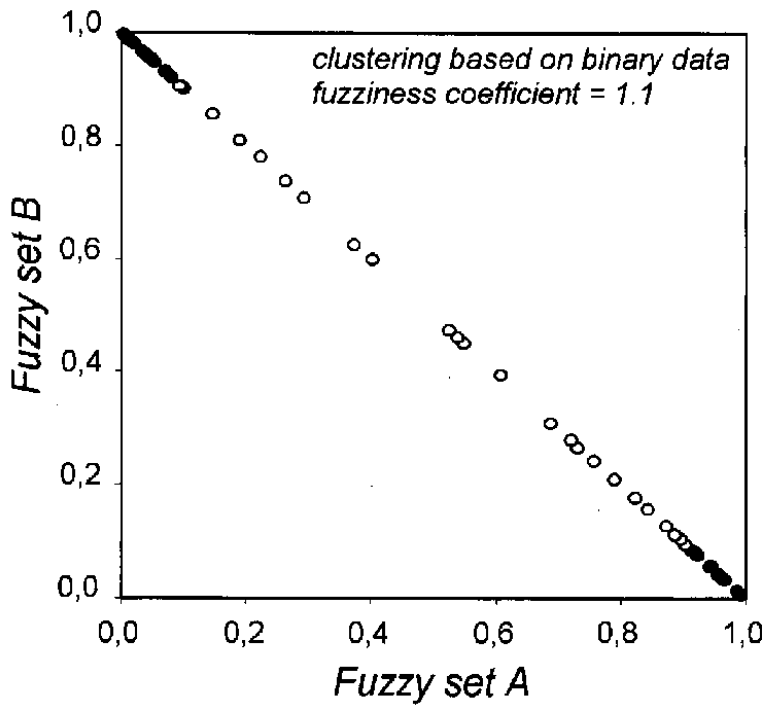

Figure 3 - Membership weight of the relevés for the fuzzy clusters A and B. Closed circles indicate the relevés with a membership weight u>0.90 for the fuzzy sets A and B. Further explanation in text.

Fuzzy set A: These relevés are characterised by high cover values of *Quercus ilex* and by presence of some creeper (*Smilax aspera, Clematis flammula, Rubia peregrina/longifolia*). *Fraxinus ornus* and *Phillyrea latifolia* are frequent in all the vegetation layers, whereas *Carpinus orientalis* is present only as undergrowth. The following deciduous species are also frequent: *Acer monspessulanum, Cotinus coggygria* and *Hippocrepis emerus/emeroides*. It is noteworthy the presence of a large

number of *Prunus mahaleb* and *Rubia peregrina/longifolia* seedlings at soil. The relevés of this fuzzy set can be attributed to the association *Orneto-Quercetum ilicis* (Lausi & Poldini, 1962).

Fuzzy set B: These relevés are characterised by high cover values of *Carpinus orientalis* in the tree dominant layer, whereas *Quercus ilex* and *Fraxinus ornus* are less frequent and play only a secondary role. *Ruscus aculeatus* and *Hedera helix* are dominant in the undergrowth; *Melittis melissophyllum* and *Mercurialis ovata* are frequent in the herb layer. In the tree layer *Quercus pubescens*, *Ostrya carpinifolia* and *Acer campestre* are also frequent. The relevés of this fuzzy set can be attributed to the association *Carpinetum orientalis* (Poldini, 1989).

According to Del Favero & Poldini (1998), the vegetation type *Orneto-Quercetum ilicis* is linked to a shallow *rendzic leptosol* characterised by a superficial dark horizon of carbonatic humus with alkaline reaction (pH=7.5). On the contrary, the association *Carpinetum orientalis* grows on a deep *chromic cambisol* (*"terra rossa"*) that has a clayey-loam structure and a sub-acid reaction (pH=6-6.5). These different kinds of soils have a different relative field capacity subject to a seasonal variation: probably, according to Walter (1960), the field capacity of the stony-loam *rendzic leptosol* is higher than the one of clayey-loam *chromic cambisol* in a arid season, whereas it is lower in a humid season.

The water balances of Trieste and Peschiera del Timavo, according to Thornthwaite (1948), are shown in FIGURE 4. From the comparison of the diagrams in FIGURE 4 the climate of Peschiera del Timavo results more humid than Trieste's one, mainly in terms of summer water-deficiency as regards the soil moisture. The diagrams in FIGURE 5 seem to confirm that the climate of the studied area is more humid than Trieste's one. In particular, FIGURE 5 points out the following facts:

- in the studied area the evaporation is lower than in Trieste, probably because it's situated in a less windy zone;
- the mean monthly relative humidity is always higher than 60%;
- the summer rainfalls in the studied area are higher than in Trieste.

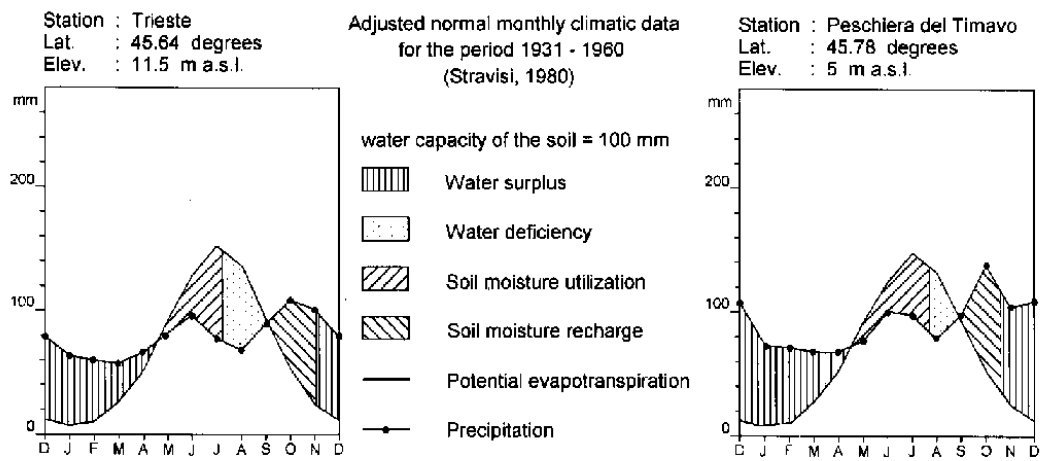

FIGURE 4 - Water balance of Trieste and Peschiera del Timavo according to Thornthwaite (1948).

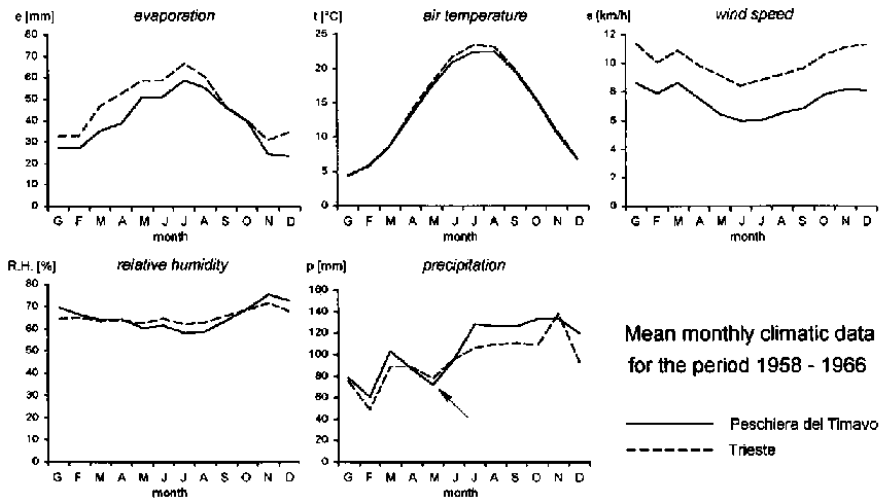

FIGURE 5 - Annual variation of some climatic parameters in Trieste and Peschiera del Timavo. Further explanation in text.

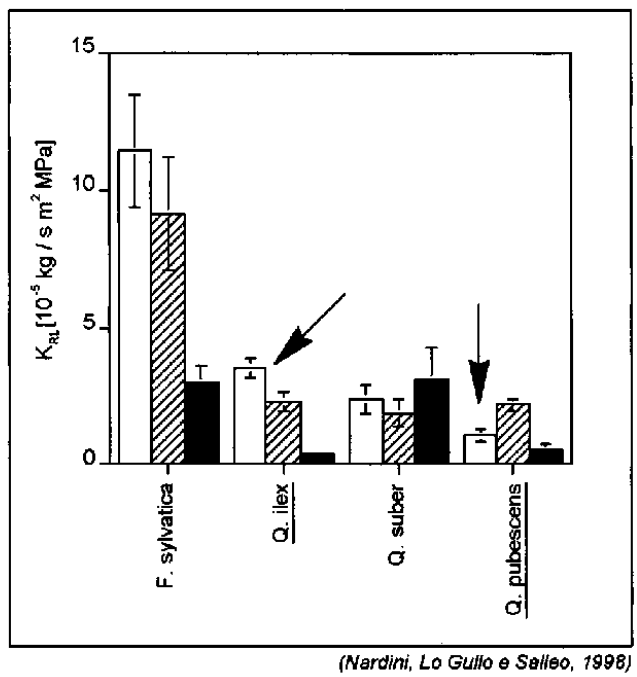

FIGURE 6 - Root hydraulic conductance per unit leaf surface area (KRL, n=6) of some tree species in May (white columns), August (dashed columns) and November (dark columns) (Nardini *et al.*, 1998). Further explanation in text.

It is noteworthy that the site characteristics of the Cernizza do not cause a strong runoff of the rainwater. The landform is nearly flat and, probably, the groundwater is relatively shallow-lying (site at low altitude and near a river mouth).

Why does a sclerophyllic xerophyte, as *Quercus ilex*, grows in a topoclimate with a relative humid summer on a site characterised by low water runoff? The answer could be in the follows down of precipitation during May (arrow in FIGURE 5). Nardini *et al.* (1998) studied the seasonal changes of the root hydraulic conductance in some forest trees from an ecophysiological point of view. These authors pointed out the superiority of *Quercus ilex* compared to *Quercus pubescens* as regards the competitive ability of the seedlings during May (arrows in FIGURE 6). The competitive ability of the seedlings is one of the principal factors determining the establishment of the tree species in a woodland and therefore its occurrence in the floristic composition of the canopy layer.

CONCLUDING REMARKS

The smaller spring rainfall could explain the occurrence of *Quercus ilex*-stand not only in the neighbourhood of Duino but also at the beginning of the large valleys characterised by S-N direction in the SouthEastern Alps. In spring the humid air masses are warmer than in autumn. They flow in the pre-alpine valleys, but to reach the dew point they have to go up much higher than in autumn. For this reason the spring rainfall is reduced at the beginning of these valleys. An example is the holm-oak-stands in Peonis (UD, Italy): there, according to Gentilli (1964), the annual average rainfalls amount at 2000 mm, but in May there are not a lot of rainy days (average number of rainy days in May=13) and rainfalls during springtime are relatively few (ca 600 mm).

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RIASSUNTO

Nella località costiera chiamata "Cernizza" (presso Duino, ca. 15 km a NW di Trieste), ad una quota compresa tra 0 e 40 m s.l.d.m., cresce un complesso di vegetazione forestale caratterizzato da *Quercus ilex* e *Carpinus orientalis*. Il substrato roccioso è calcareo. Tale formazione vegetale non è riscontrabile in altri siti della provincia di Trieste, nella quale boschi a querce caducifoglie (*Q. pubescens*, *Q. petraea* s.l.) dominano sia su roccia silicea che carbonatica. In tale area sono presenti solo comunità arbustive a *Quercus ilex* limitatamente alle impervie falesie costiere su suoli pietrosi primitivi. Per indagare se la vegetazione forestale della Cernizza può essere considerata espressione del particolare topoclima della zona, sono stati confrontati alcuni dati climatici di questa area con quelli di Trieste. I dati analizzati sono relativi ad un periodo di 9 anni. I parametri considerati sono i seguenti:

temperatura dell'aria, precipitazioni, evaporazione, velocità del vento ed umidità relativa. Dalla comparazione di questi parametri è emerso che il topoclima dell'area di studio è più umido di quello di Trieste. Solo l'analisi dei valori medi mensili delle precipitazioni indica che in primavera l'area di Duino è meno piovosa rispetto a Trieste. Dal punto di vista ecofisiologico, uno studio sulle variazioni stagionali della conduttanza idraulica delle radici in alcune specie arboree di interesse forestale (Nardini *et al.*, 1998) ha evidenziato la superiorità di *Quercus ilex* rispetto a *Quercus pubescens* per quanto concerne la capacità competitiva dei semenzali durante la primavera. Per tale motivo, le minori precipitazioni primaverili potrebbero spiegare la presenza di formazioni a *Quercus ilex* non solo nella zona di Duino ma anche allo sbocco delle grandi valli con direttrice S-N nelle Prealpi Orientali.

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TABLE 1 - Cover values of the species in the relevés characterised by a membership weight u>0.90 for the fuzzy clusters A and B (closed circles in FIGURE 3). Data of the relevés and sporadic species (those occuring less than three times within both relevé groups) are in Appendix. Further explanation are in Appendix.

		Fuzzy set A														*Fuzzy set B*											
		9	**20**	**26**	**35**	**30**	**18**	**10**	**27**	**33**	**21**	**8**	**11**	**14**	**38**	**4**	**51**	**6**	**12**	**13**	**55**	**22**	**46**	**47**	**5**	**28**	**34**	**45**
Clematis flammula		r		r		r	+	+					r		+													
Acer monspessulanum				+	+				+		1	r																
Cotinus coggygria					1		+	1		+					1													
Hippocrepis emerus / emeroides					1		+	+			+																	
Carpinus orientalis		1						1						r														
Rubia peregrina / longifolia			1	+	+	+			1	+	+								1									
Carpinus orientalis		1	2				3	1				1	3				1											
Phillyrea latifolia					1				2			1		1								1						
Prunus mahaleb	s	+	+	r	r	+	+	+	r	+		1	+	+				r					+	1				
Fraxinus ornus		1	+	1		r	+			+		+			+	1		+						1				
Fraxinus ornus		1		+				1	1	1	1	1		1	1		+	+							1	1		
Carpinus orientalis						5							4			1	3	3	1	5	2	4	3	1	5	3	4	4
Melittis melissophyllum								1	r								r			+	r		1	1			+	2
Hedera helix														1		1		+	1		1			1	1	1	1	+
Lonicera etrusca							1										r	+	+					+	r			
Acer campestre s.l.	s							1														r	r	1				
Mercurialis ovata																+	r	+	r	+	+	1	1	1	+	+	r	1
Quercus pubescens																r		r							r	r	+	
Rubus caesius																r					r	+						
Quercus pubescens																	1						1	1				
Ostrya carpinifolia																					2			1		2		
Quercus ilex		4	4	3	2			4	4	4	4	3		3	4	5	2	3	2	1	1	1	1	1	1	2	1	1
Quercus ilex		1	1	1	1	+	1	2	1	1		1	1		1	1		+	1		1	1				1		
Quercus ilex		2	4	2	1	+	1	3	2	2	1		+	2	1	2	1	1	2	1	1	1		+	1	1	1	+
Phillyrea latifolia		+		1	1	r		1			+	1	1	2		1			1	1		1			1			
Fraxinus ornus				2	1		1	1		1	1		1	1		1	1			1		1	1		1			
Smilax aspera		r	1	1	1	+	1	1	2		2	1	+	1		+			1	+				1		1		
Asparagus tenuifolius		r	+		r			+	+	+	+	+	+				+	+			r				+			
Ruscus aculeatus		1	2	1	1	5	4	1	3	2	+	3	+	3	3	4	3	2	3	5	4	5	1	1	5	4	5	4
Hedera helix		+		1			+	+			r	+	+			2	1	1	1	1	2	2	1	3	2	2	2	2
Asparagus acutifolius		+	+	1	1	+	+	1	1	+	+	+	+	1	+	1	1		+	+	+	1			1	1		1
Rubia peregrina / longifolia		1			1		1	1	2		+	+	+	1	+	1	1	+	1	+		r		+	+	1		+
Acer monspessulanum	s	1	1			r					1	1	1	1			3	+	r				+	1	r			1
Cyclamen purpurascens		+	+	+		+	1	+	1	+			1	+		1	1		+	+	1	2				1		1
Celtis australis	s			+					+	+		+	+		r	r	+		r	1		r		+		r	r	+
Laurus nobilis	s							+		1		r	1	+				+				+	r	+		+	r	
Sesleria autumnalis		+		+		+	1			+			3	+			1	+			+							+
Viola alba / scotophylla				+	+	+								1		+	+		r		+		+		+	1		1
Viola cfr. *hirta*				+	+		1			r		+	+			+		+				+		1	+		+	1
Euonymus europaea	s	1	+	r	r			+				1	+	+							2		+	+				1
Laurus nobilis			1						+							+			+						+			
Crataegus monogyna	s		r	r					r							r	+											
Osyris alba				1	+								+			r									+			

APPENDIX

Data of the relevés in TABLE 1. The sporadic species (**high tree layer, *low tree layer***, shrub layer, *herb layer*) are those occuring less than three times within both relevé groups. Nomenclature follows Poldini (2002).

s=seedlings

Relevé nr.	Aspect	Slope [°]	Plot size [m^2]	Sporadic species
4	SW	5	30	***Cornus sanguinea / hungarica*** (1); Acer campestre s.l. (+); Prunus avium (r); Viburnum lantana (r); *Asparagus tenuifolius* (r).
5	-	-	15	Prunus avium (r).
6	-	-	30	
8	SSW	6	25	***Cornus sanguinea / hungarica*** (1); Rubus ulmifolius (1); *Galium aparine* (+).
9	SSW	7	30	Bryonia dioica (+); *Asparagus tenuifolius* (r); *Quercus pubescens* s (r).
10	WSW	10	20	*Quercus pubescens* s (r).
11	WSW	8	20	**Acer monspessulanum** (2); **Pistacia terebinthus** (1).
12	W	12	20	**Acer monspessulanum** (2).
13	W	3	20	Pistacia terebinthus (+); Juniperus communis (r).
14	W	9	42	**Acer monspessulanum** (3); ***Acer monspessulanum*** (1); ***Pistacia terebinthus*** (+).
18	W	5	15	Cornus sanguinea / hungarica (+); *Hippocrepis emerus / emeroides* s (r).
20	S	4	36	Crataegus monogyna (+).
21	WSW	14	20	***Cotinus coggygria*** (1); Cornus sanguinea / hungarica (+).
22	SSW	3	30	Rosa canina (1).
26	WSW	3	25	**Pistacia terebinthus** (1); Pistacia terebinthus (+); *Cornus sanguinea / hungarica* s (r).
27	WSW	3	20	
28	SSW	4	25	***Pistacia terebinthus*** (+); Ostrya carpinifolia (+).
30	SW	3	20	
33	NW	3	25	Juglans regia (r); *Hippocrepis emerus / emeroides* s (r).
34	WSW	27	30	**Quercus petraea** (1); Prunus mahaleb (r).
35	WSW	3	25	***Acer monspessulanum*** (1); ***Pistacia terebinthus*** (1).
38	SW	3	25	***Cotinus coggygria*** (1).
45	SE	9	30	**Quercus petraea** (1).
46	ESE	11	30	
47	NW	16	30	**Cornus sanguinea / hungarica** (1); *Galium aparine* (1).
51	NNW	6	30	
55	-	-	30	**Acer campestre** s.l. (1); Quercus petraea (+); Prunus mahaleb (+); Acer campestre s.l. (+); *Lathyrus venetus* (1).