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ANTHESIS AND POLLINATION OF SOME TREES IN THE SURROUNDINGS OF TRIESTE

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Abstract. The transported and deposited pollen curves of 12 tree taxa in the outskirts of Trieste are reported. Meteorological data, the frequency of the taxa in the survey area, and phenologic observations on the anthesic periods have been used for the interpretation of the pollen curves.

There is a generally good correspondence between pollination and deposition peaks, and the anthesic periods. The pollination curves allow to distinguish the contributions of sources at different distances from the trap. There are some correlations between meteorological factors and quantitative variation of airborne pollen.

Introduction

The study of the airborne biological material provides information for various purposes. Many aerobiological researches examine the airborne allergenic pollen content and compile pollen calendars for the diagnosis and prevention of pollinosis. Other studies aim at the acquisition of more general data, to clarify the ways of dispersion and of transport of the pollen in the atmosphere (Subba Reddi and Reddi, 1985; Mandrioli et al.; 1980), also in relation to: meteorological factors (Mandrioli, 1987; Mercuri et al., 1982; Andersen, 1974; Liem and Grot, 1973), the relation between pollen production, anthesis and atmospheric content (Zerboni et al., 1988) and pollen deposition (Benninghoff, 1987), the relations between vegetation, aerobiological content (Zerboni et al., 1987; Hibino, 1976) and the recent and fossil pollinic spectra (Heim, 1970; Montanari, 1986; Birks, 1980).

In this study, the airborne pollen content of some tree taxa, and the pollen deposition in a peripheral zone of Trieste are analyzed; the results are interpreted on the basis of phenological and meteorological data. The pollen content of the urban atmosphere of Trieste has been already studied, so that the pollination curves of the main allergenic taxa and the pollen calendar are known (Rizzi Longo and Cristofolini, 1987).

Trieste is located at the eastern extremity of the Gulf of Trieste, in a zone of phytoclimatic boundary between the Mediterranean and Euro-siberian regions. The town is poor in green areas: parks and gardens are few and small, avenues are rare. In the suburbs, ont the sandstone hills, there is a small cultivated area, mostly with vineyards and orchards, followed by oak-woods. The strip of hills is rather narrow, being cut-off by the edge of the Karst Plateau (average height 250 m) which constitutes an important phytoclimatic barrier (Poldini, 1971).

Materials and Methods

Twelve of the most representative natural and introduced trees were considered. During 1979, periodic observations on the phenology of trees and on the airborne and deposited pollen were carried out. The phenological observations refer exclusively to the anthesic period, using Marcello's scale (1935); they were carried out on different samples of the same species, located, when possible, near the pollen trap.

The airborne pollen has been collected through a COUR trap (1974) located on the roof of the building of the Biology Department, at 20 m from the ground on the downhill side, and at about 3 m on the uphill side (Fig. 1). The Biology Department, in the north-western outskirts of the city, is built on the southern slope of the sandstone hills surrounding the urban nucleus at an elevation of 124 m. Downhill there is the University campus followed by the urban area; uphill there are the woods of M. Fiascone (213 m). Towards the west the sampling point faces a small valley with houses and orchards, separating Monte Fiascone from the woody hill of Scorcola. For the particular ubication of the trap, so close to the emitting source, it is possible to obtain data on the pollen release and on its deposition.

Two COUR traps were used, one with two vertical (VFU), the other with one horizontal filtering units (HFU). The VFUs, made of 5 hydrophylic gauze layers (mesh 10/7) soaked in silicone oil (viscosity 1000 csk) and in turpentine oil, are vertically placed within 2 squares of 20 cm, and always kept against the wind by means of a calibrated rudder. The HFU, made of 8 hydrophylic gauze layers treated as the former ones, is fixed within squares of 20 cm, placed horizontally, and collects the deposited material. The filtering units are changed every week.

The trapped pollen is freed, according to the methodology of Cour (1974), by a series of chemical treatments of the filtering units, which allow: the destruction of the hydrophylic gauze (70% HF), the elimination of other inorganic components (20% HCI), the destruction of the plasmatic content (acetolysis according to Erdtman, 1969) and the coloration of the acetolyzed pollen with basic fuchsin. Through the volumetric measure of the precipitate and through an accurate preparation and lecture of the microscopic slides (Cour, 1974), data with standard procedure are obtained. From the basic data (number of pollen grains in a given slide), through formulas (Cour, 1974), the number of pollen grains per square meter per day (average weekly value) is obtained. The quantity of pollen intercepted by the HFU is much lower than the one intercepted by the VFU; consequently different scales are used for the graphic representation.

The meteorological data have been taken from the 1979 records of the Istituto Talassografico di Trieste. They are summarized in fig. 3.

The nomenclature is from Poldini (1980). The chorological and phytosociologi-

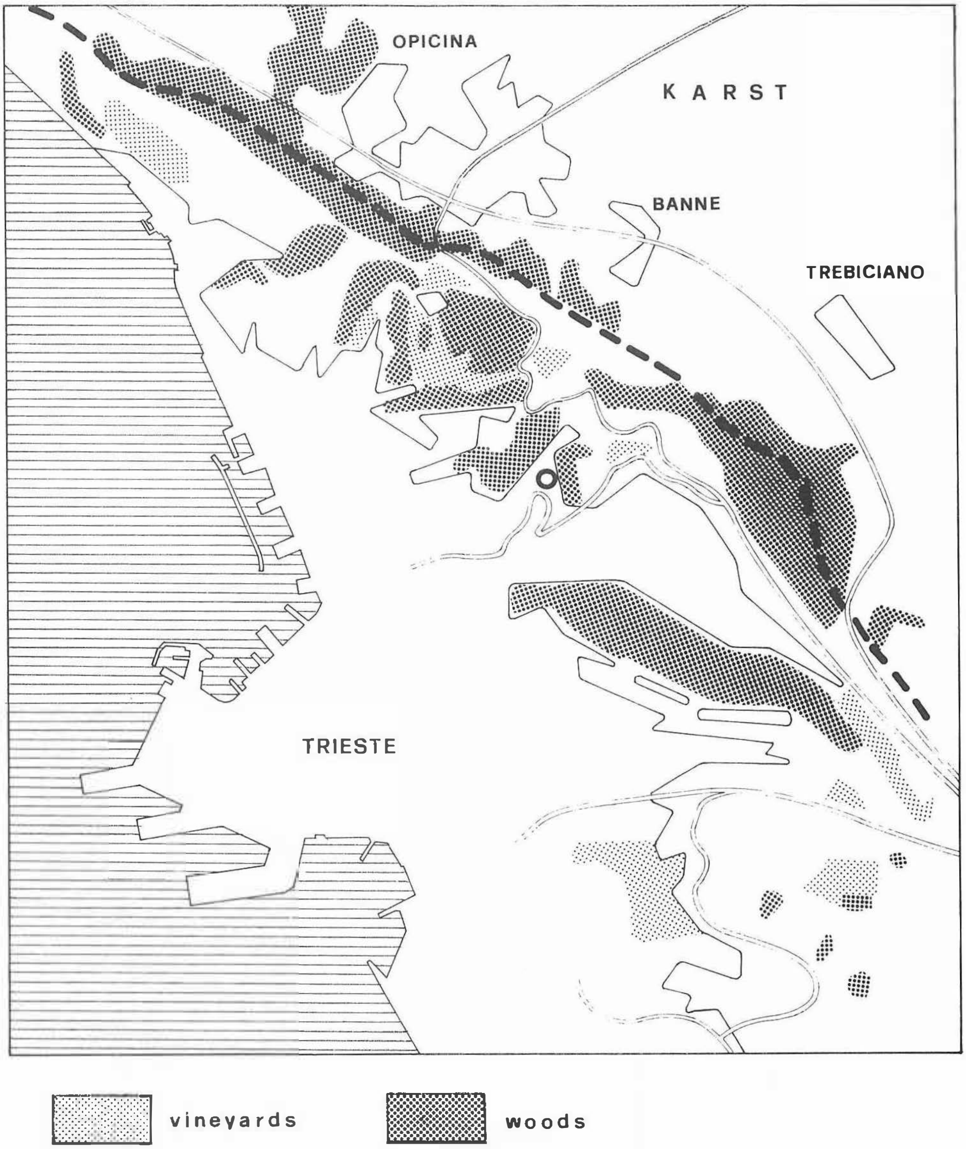
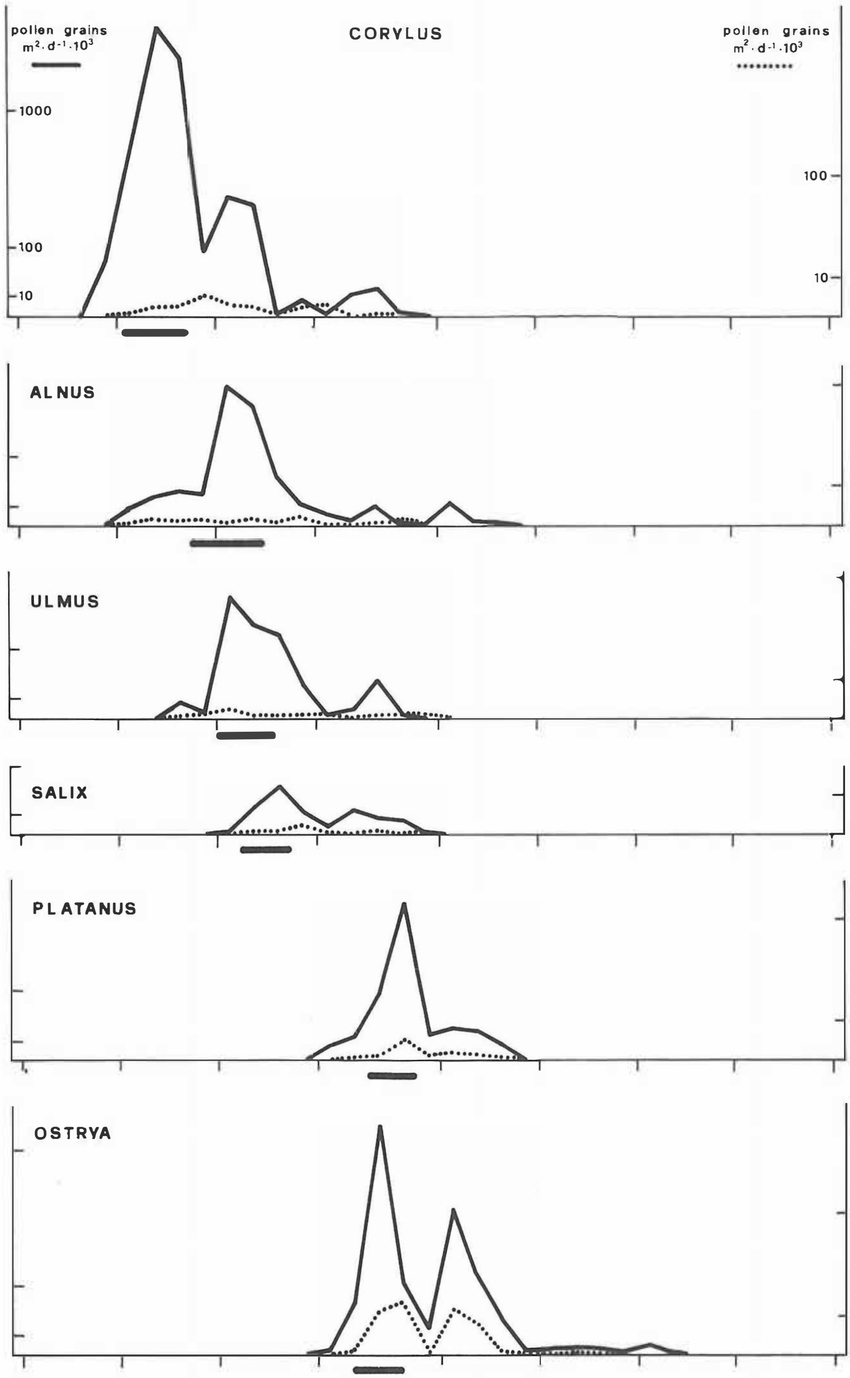


Fig. 1 — Location of the pollen trap (o) within the town of Trieste (after Poldini, 1977, modified).

cal data are from Oberdorfer (1979), Pignatti (1982), and Poldini (1988).

Results

The pollen curves and the anthesic periods of the 12 tree taxa are shown in Fig.


pollen grains
m²·d⁻¹·10³
CORYLUS
pollen grains
m²·d⁻¹·10³
1000
100
10
100
10
ALNUS
ULMUS
SALIX
PLATANUS
OSTRYA

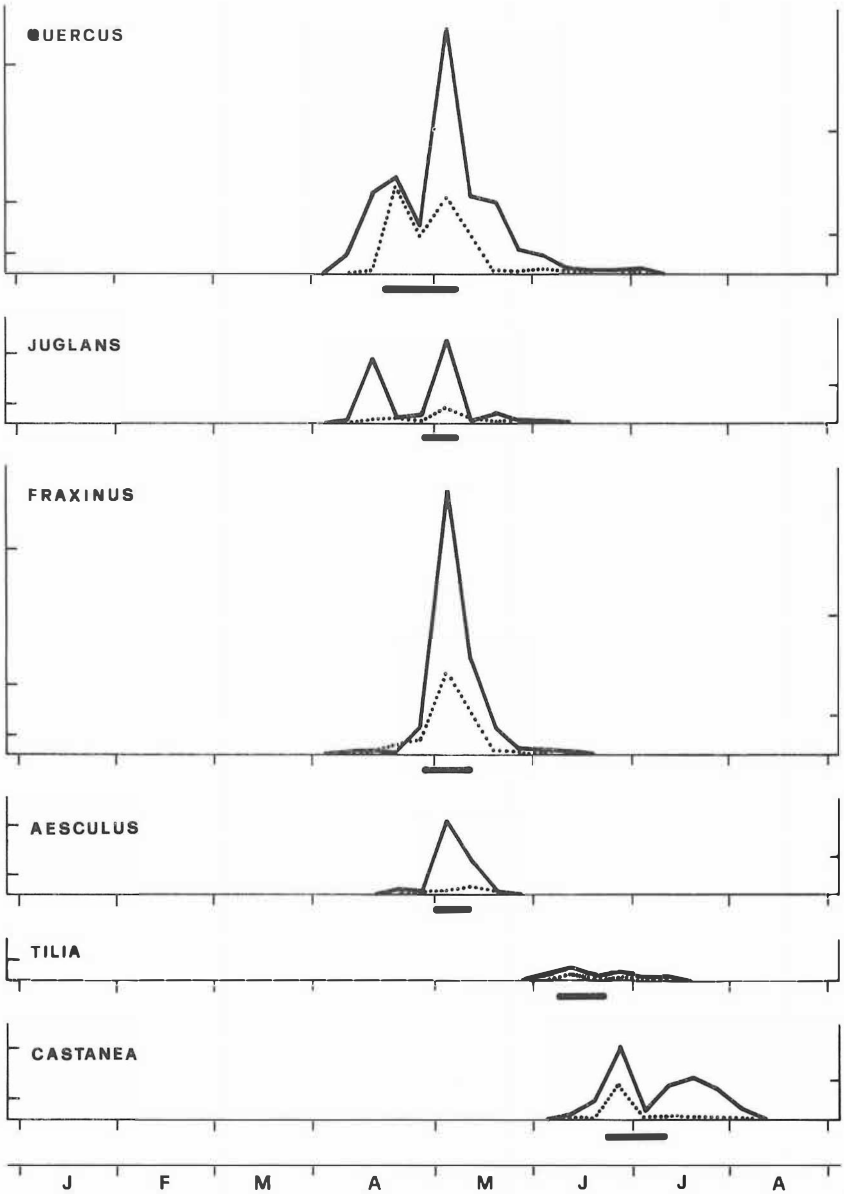


Fig. 2 – Pollination curves of different tree taxa in the survey area. Continuous line: transported pollen; dotted line: deposited pollen. The anthesic period is shown by horizontal lines below the time scales.

2. In the following, each taxon will be grifly discussed.

Corylus L.

In the region the following species occur, *C. avellana* L. and *C. maxima* Mill. The latter is cultivated.

C. avellana is a subatlantic element, characteristic of the *Querco-Fagetea* vegetation class; in the South of the Alps, it is associated with the *Carpinion* alliance (Poldini, 1988). It is a species of forest edge, of underwoods, growing in the Karstic dolines, and in shrub thickets. Near the trap, there are a few individuals of *C. avellana.*

The pollination peak, around mid-February, fully corresponds to the anthesic period. A second peak, in the first half of March, is due to the blooming of the Karst populations; the increase of atmospheric pollen around mid-April could be due to the blooming of the populations in the interior Karst mountains. The presence of *Corylus* pollen before the anthesis is due to individuals of lower, more protected and sunny sites, with early blooming. The pollen of *Corylus* is easily transported (Gambarelli et al., 1985, give a free fall value of 5,51 cm/sec) and remains for a long time in the atmosphere; the shrubs next to the trap have a limited pollen production so that the HFU values are low.

Alnus Mill.

In the Trieste region there is only *A. glutinosa* (L.) Gaertn., a suboceanic-submediterranean Eurasiatic species, frequent in the riparian woods and in the *Alno-Ulmion* communities. It is not frequent in the area, because of the scarcity of rivers.

The pollination peak, around mid-February, is delayed with respect to the beginning of the anthesis. This is related with the distance of the emitting sources, located at the extreme east of the city (Val Rosandra). The other peaks are due to specimens of montane alders (*A. incana* (L.) Moench and *A. viridis* (Chaix) DC.) of the interior Karst (mid-April) and of the Julian Alps (beginning of May).

Also the pollen deposition is rather scarce and the pollination curve remains low and uniform. A higher pollen deposition occurs at the end of March, as an effect of rain.

Ulmus L.

Only *U. minor* Mill. is present in the area. It is a submediterranean element, growing in humid woods and shrublands, at the edges of *Quercus pubescens* woods, along peripheral roads, between houses in sunny stations, and in disturbed areas.

The pollination peak at the beginning of March corresponds to the anthesic period close to the trap; the early pollen appearance, and its persistence after the end of the anthesic period, are related, the former with the early blooming of

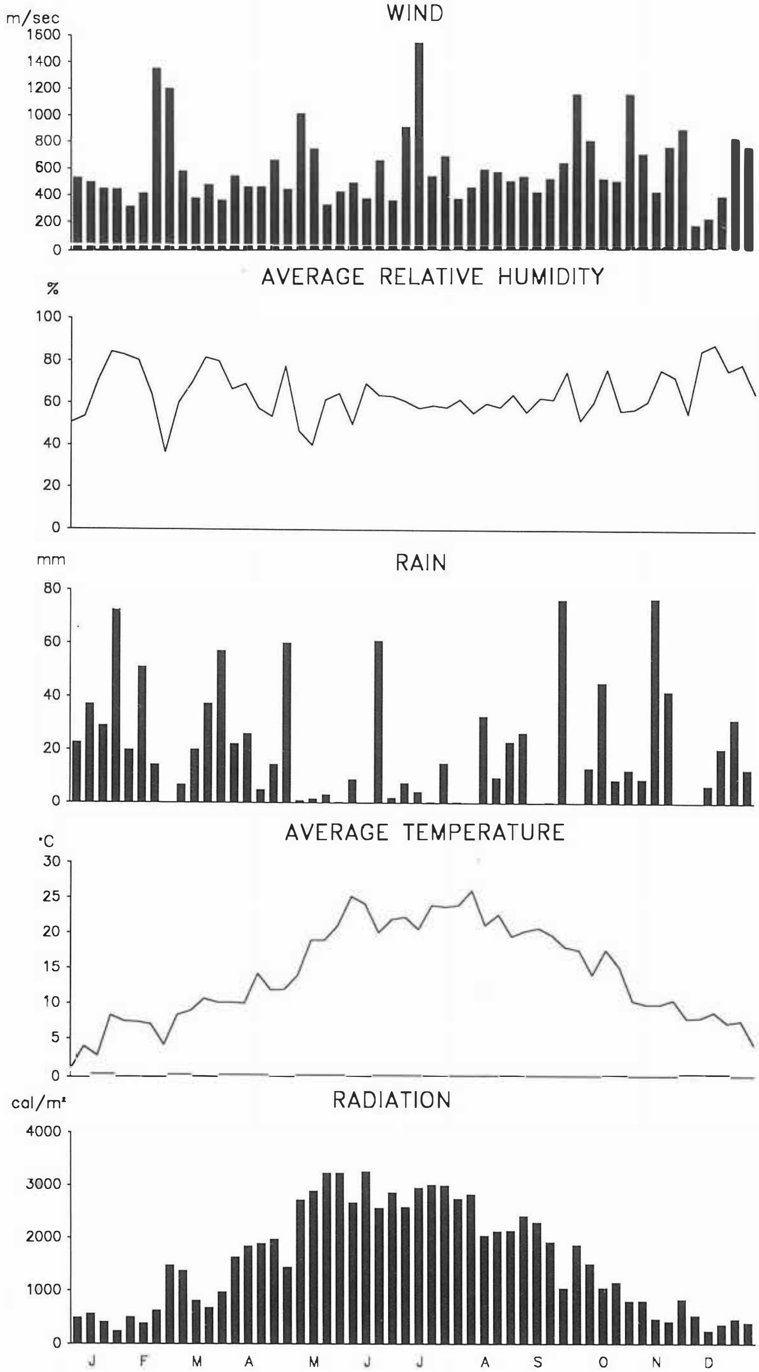


Fig. 3 — Weekly trends of wheather conditions in the survey area.

individuals of lower zones (town center), the latter to the delayed blooming of individuals at higher altitudes (Karst). The further increase at mid-April is due to the blooming in the interior Karst.

There are no elms in the proximity of the trap; the pollen found in HFU is deposited aerotransported pollen. The HFU pollination curve is rather weak and uniform. Nevertheless, there is a correspondence between the peaks of atmospheric and of deposited pollen.

Salix L.

Willows grow in humid places, such as river shores, lakes and ponds. In the region of Trieste, they are not common, due to the scarcity of surficial waters. They occur in the eastern sector, along the short waterways of the Rosandra and Ospo Rivers, with the species *S. alba* L., *S. eleagnos* Scop., and *S. purpurea*.

Less frequent are willows of the *S. caprea* group (*S. cinerea* L., *S. caprea* L.), that grow in humid woods, in pioneer shrub thickets, and on deep and humid soils.

The pollination curve of *Salix* shows a small peak around mid-March, more or less in correspondence with the anthesis of *S. caprea* from the hill belt, and a second period of minor importance, in April, which is due to the willows of the interior Karst with delayed blooming. Willows are partially entomophylous: also considering their scarcity in the survey area the amount of airborne pollen in high.

The pollen deposition is scarce, with a peak at the end of March, corresponding to intense precipitations.

Platanus L.

In the region, only *P.x hybrida* is present; it is a cultivated tree, frequent in parks, gardens and avenues.

The pollination curve presents only one peak, corresponding to the anthesic period and to the maximum of deposited pollen. In spite of the rarity of plane-trees, its pollen is well represented, also because some trees grow near the trap.

Ostrya Scop.

Ostrya carpinifolia Scop., an eastern mediterranean element, is abundant in the survey area. It is dominant in open woodlands belonging to the *Ostryo-Carpinion orientalis* alliance, characterizing the transition between oak-woods and Karstic open woodland, and between the latter and the pine-woods (Poldini, 1982)). It is a differential species of the Mediterranean maquis, which is a relict formation along the Trieste coasts (*Ostryo-Quercetum ilicis;* Trinajstić 1975).

The pollination curve has two important peaks, the first at mid-April, of 1.264.116 pollen grains m^2/d, corresponding to the blooming of populations of the same altitudinal belt at the trap, and a second one, at the beginning of May, of 680.022 pollen grains m^2/d, due to the anthesis in the Karst.

The pollen of *Ostrya* is also abundant in the HFU, with a peak of 19.234 pollen grains m^2/d, corresponding to the peak in the VFU.

Quercus L.

Q. ilex L., a stenomediterranean element, characteristic of the *Quercetalia ilicis* order, is common along the coasts, in the Mediterranean maquis. It is also cultivated in avenues and parks, mostly along the coasts.

Q. cerris L., an eastern Mediterranean element, grows on deep, humid soils, mostly in dolines and small humid valleys.

Q. petraea (Matt.) Liebl., a subatlantic-submediterranean element, characteristic of the *Querco-Fagetea* class, forms extensive woods on sandstone slopes with acid soils that surround the town *(Seslerio-Quercetum petraeae;* Poldini, 1982). *Q. daleschampii* Ten., a very similar species, occurs in the Karst Plateau.

Q. pubescens Willd., a submediterranean element characteristic of the *Quercetalia pubescentis* order, frequently forms open woodlands on dry calcareous ground *(Ostryo-Quercetum pubescentis* Trinajstić 1974).

The pollination curve of the genus *Quercus* has several peaks. The anthesic period is generally a little out of phase in the various species: generally the earliest is *Q. petraea,* followed by *Q. pubescens* and by the late blooming by *Q. ilex.* Since *Q. petraea* and *Q. pubescens* are by far the most frequent species, the anthesic period near the trap is referred solely to them. The first pollination peak, in the second half of April, seems mostly due to the blooming of *Q. petraea:* the very high values are due to individuals growing just above the trap; this explains also the high deposition values, since a good part of tree pollen falls not far from the source (Guido, 1988). The peak of 1.429.430 pollen grains m^2/d at the beginning of May is mostly due to mass blooming of *Q. pubescens* on the Karst Plateau; this peak is also evident in the HFU, even if less pronounced because of the greater distance of *Q. pubescens* populations from the trap. In the VFU, the peak of May is followed by a tail of airborne pollen, due mainly to the delayed pollination of *Q. ilex.*

Juglans L.

Only *J. regia* L. is present in the survey area; it is an eastern Mediterranean Eurasiatic species, cultivated since antiquity and now subspontaneous, with isolated individuals in the countryside, in the outskirts of the town and in the Karst.

The pollination curve is rather discontinuous. The first VFU peak is interpreted as due to the early blooming in lower and more protected zones; the anthesic period of the trees close to the trap corresponds to the peak at the beginnings of May and to the maximum of deposited pollen in the HFU.

Fraxinus L.

F. ornus L. is widespread in the survey area, it is an eastern Mediterranean element, characteristic of thermophylous woods of south-eastern Europe, with a very broad ecological range, from the Mediterranean belt to the thermophylous beech-woods. It's abundant both in the Karstic woodland and in the understorey of pine-woods.

The pollination peak, with 1.873.130 pollen grains m^2/d, at the beginnings of May, corresponds with the mass blooming of *F. ornus* on the Karst slopes.

The pollen deposition is high, with a maximum of 39.183 pollen grains m^2/d, corresponding to the peak in the VFU; this is probably due to emitting sources close to the trap.

Aesculus L.

Ae. hippocastanum L. is frequently cultivated in avenues and parks, and is a Balcanic element. *Ae. carnea* Hayne, a North American hybrid between *Ae. hippocastanum* and *Ae. pavia* L., is less frequent.

Notwithstanding the entomophylous impollination, the airborne pollen is frequent, with a peak at the beginnings of May, in correspondence to the anthesic period. Its presence in the HFU is scarce, in spite of the relative vicinity to the trap of many individuals, that, however, are located laterally and separated from the trap by buildings.

Tilia L.

In the urban and suburban districts, *T. tomentosa* Moench and other hybrids are frequent, and are used in avenues and parks. *T. cordata* Mill., and European-Caucasian element, characteristic of the *Tilio-Acerion* alliance, and *T. platyphyllos* Scop., are sporadic in oak woods, in Karstic villages and in the countryside.

The presence of airborn pollen is scarce, due to the impollination type and to the pollen heaviness. Proportionally to this scarceness of transported pollen, the deposition appears significant, showing a scarce flight capacity.

Castanea Mill.

C. sativa Mill., a subatlantic submediterranean element, is frequent in oak woods on sandstone, mainly in humid and colder sites.

In spite of a good presence of trees behind the trap, the pollination curve is not very significant, presenting a maximum at the end of June of only 82.349 pollen grains m^2/d.

On the other hand the deposited pollen is rather noticeable (9.540 pollen grains m^2/d), even considering its small size; this might be due to the particular position of the trap, just below the emitting sources.

Discussion

The maximal presence of airborne pollen corresponds well with the anthesic periods near the trap. Generally, the pollen appears in the atmosphere some time before the anthesis and persists rather long after its end. This because the trap is located between the town and the Karst, intercepting pollen deriving from both early and late blooming populations. In the plurispecific taxa, such as *Quercus*, the pollination peaks correspond to the different anthesic maxima of the single species. Sometimes, also in monospecific taxa, secondary peaks are evident, which might be due to contributions from the Karst Plateau or from even further zones, such as the interior Karst or the Julian Alps. This is the case of most anemophytic taxa, with easily aerotransported pollen, such as *Corylus* and *Ostrya,* and/or with early blooming *(Corylus, Alnus, Ulmus, Salix);* such taxa release the pollen before the emission of the leaves, which facilitates its long-distance aerial transport. The persistence of certain pollen types may be also ascribed to re-transport of the already deposited pollen.

Generally, the studied taxa are well represented in the pollen spectra. *Corylus, Alnus* and *Platanus* are even over-represented, with respect to their frequency in the survey area, whereas the high values of *Ostrya, Quercus* and *Fraxinus* are easily explained by the massive presence in the area of these anemophilous trees. Particularly under-represented are *Tilia* and *Castanea;* the latter has a very small, easily transported pollen; these two species, however, are entomophylous.

The pollen captured by the HFU is rather scarce for all taxa. The deposition is highest in correspondence with the maxima of airborne pollen, but it is significant only for *Ostyra, Quercus, Fraxinus* and *Castanea.* This seems to be due to the presence, in the proximity of the trap, of overhanging individuals of the same taxa. On the other hand, extremely scarce is the pollen deposition of *Salix* or *Alnus,* whose first individuals are at a few kilometers from the trap. In these cases, the deposition maxima do not correspond to those of airborne pollen, and are probably due to rainfall. The pollens of *Corylus, Ulmus* and *Platanus* are very little represented in the HFU in spite of the high presence of airborne granules and the relative vicinity of the emitting sources, presumably because of their good flighting capacity.

Even for the peculiar climatic characteristics of the zone (Polli, 1970), there are no constant correspondences between quantity of transported and deposited pollens, and meteorological factors. Not always does the rain determine an accumulation of pollen in the HFU, also because its action is limited to the initial rain (Mandrioli et al., 1975). The wind does not always facilitate the pollen transport; sometimes there is (e.g. in *Corylus* at the end of February) a deposition increment corresponding to strong winds, especially when these are not constant. Other times the correspondence is noticeable, as at the end of March, when the rain produces deposition maxima for taxa located far from the trap, such as *Alnus* and *Salix,* with a corresponding drop of airborne pollen. The decrease at the end of April, which occurs betweenn two pollination peaks in VFU (e.g. *Ostrya* and *Quercus)*, corresponds with a period of weak wind, strong precipitations, and high relative humidity, that inhibit pollen release and its atmospheric dispersal.

Comparing the pollination curves of the outskirts with those of the town center (Rizzi Longo and Coassini Lokar, 1985), the importance of the position of the trap becomes evident. In the center, where the trap is rather far from the emitting sources, the pollination peaks are wider (e.g. *Quercus, Fraxinus* and *Platanus)* and more delayed in respect with the anthesic periods (e.g. in *Ostrya* and *Platanus),* since they result from the pollen contributions from all directions, and are free from the effects of neighbouring individuals. In the outskirts the peaks are sharp and narrow; the contributions from longer distances have a more limited importance. In *Corylus,* however, the pollination curves in the town and in the outskirts are perfectly correspondent: besides the good pollen dispersal this might be due to its optimal transport, the anthesis occurring when the vegetation is still bare.

Conclusions

The anthesic periods, the frequency of the taxa in the survey area and the distance of the emitting sources from the trap are important factors for the interpretation of the pollination curves. In aerobiological studies devoted to the analysis of allergenic pollens, the position of the trap has to be rigorously central with respect to the survey area and far from emitting sources. For other types of studies such as the research of correlations between vegetation and pollen spectra, or between production, release, dispersal and deposition of pollen, the trap should be located within the vegetation or at a small distance from it.

In our case, there is a generally good correspondence between local blooming and maxima of airborne pollen, and a scarce deposition. The latter is high only for trees close to the trap.

The climatic factors have a secondary importance on the interpretation of the pollination curves, especially when the traps are too close to the emitting sources; in this case the pollen production and consequent release are determinant, while the transport or the deposition rate, which are most dependent on meteorological factors, are less important.

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