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Flowering phenology and airborne pollen occurrence of *Corylus* and *Castanea* in Trieste (Italy), 1991–2004

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The flowering season and the pollen season of *Corylus* and *Castanea* were analyzed and compared in Trieste over a period of 14 years (1991–2004). A great variability in the flowering phenophase progression was found both among plants and from year to year. The pollen seasons of *Corylus* and *Castanea* were longer than the respective flowering seasons. A lack of correlation between the maximum flowering and the maximum pollen concentration was observed, the highest airborne pollen counts occurring two or more weeks after the maximum flowering. Given the geographical complexity of the area around Trieste, the onset of the flowering of *Corylus* and *Castanea* does not occur at the same time everywhere, and grains coming from different local and extra-local sources, characterized by a late blooming, were also found. Medium-long range transport from Slovenia should also be considered.

Keywords: Aerobiology, *Corylus*, *Castanea*, flowering, phenology, Italy, Trieste

Introduction

Phenology is the study of the timing of the biological phases recurring in the annual cycles of plants and animals. As regards plants, the biological events include sprouting, flowering and fruit ripening. Phenological models are considered suitable for studying the response of plants and ecosystems to climate changes and global warming (MENZEL 2000, SPARKS et al. 2000, AHAS et al. 2002, MENZEL et al. 2006); in order to evaluate a possible response of plants to the recent increase in temperature, the climatic impact on plant flowering has also been studied by using the data from pollen monitoring in correlation with temperature data (JÄGER et al. 1996; EMBERLIN et al. 1997, 2002, 2007; FREI 1998, TEDESCHINI et al. 2006, BONOFIGLIO et al. 2009, ORLANDI et al. 2009). Studies on flowering phenophases may also be useful for interpreting aerobiological data and for discovering the sources of airborne allergenic pollen; for this reason, phenological studies have been carried out in order to evaluate the relationships between the flowering of allergenic plants and the occurrence of airborne pollen (PUPPI BRANZI and ZANOTTI 1992; LATORRE 1997, 1999; LATORRE and BIANCHI 1998; JATO et al. 2002). In Italy, the Phenological Working Group of the Italian Association of Aerobiology founded a phenological network in 1991, with the purpose of comparing

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the phenophase progression of *Castanea*, *Corylus* and Gramineae in different Italian sites (ZANOTTI et al. 1998).

In Trieste, aerobiological monitoring and phenological observations have been carried out since 1978 (MANDRIOLI et al. 1980; RIZZI LONGO and CRISTOFOLINI 1987; RIZZI LONGO 1990, 2003; PUPPI et al. 1994; RIZZI LONGO et al. 2007). The distribution and frequency of pollen sources as well as the sensitization to some allergenic taxa in Trieste have also been investigated (LARESE et al. 1992, 1998, 2000; PIZZULIN SAULI et al. 1992; POLDINI et al. 1997/1998; RIZZI LONGO and MARTINI 2000; MARTINI et al. 2002; RIZZI LONGO et al. 2003).

Trieste is located at the northern end of the Adriatic Sea (Fig. 1), on the border between the Mediterranean and the continental climate. The annual mean temperature in Trieste is 15.1 °C, with monthly means ranging from 6.4 in January, to 24.9 in August (Tab. 1), and the total precipitation is about 1000 mm (STRAVISI 2006). Local coastal sea (NW) and land breezes (E) prevail during the warm season and make weather conditions stable (STRAVISI 1977). The mesoscale flow is dominated by the continental dry wind the »bora« (ENE), which blows at higher speed and frequency during the cold season; secondary events are represented by moist SE winds across the Adriatic Sea, mainly the »sirocco« (Fig. 2). The town lies on sandstone hills, which are surrounded by the steep slope of the Karst plateau, with a mean elevation of 250 m a.s.l. Woody coenoses, mainly oak woods, are frequent in the area of Trieste.

The aim of this study was the analysis of the flowering phenological behaviour and the occurrence of airborne pollen in two allergenic taxa in Trieste: *Corylus* and *Castanea*. *Corylus avellana* L., a winter-flowering taxon, is frequent in shrub thickets and in Karst

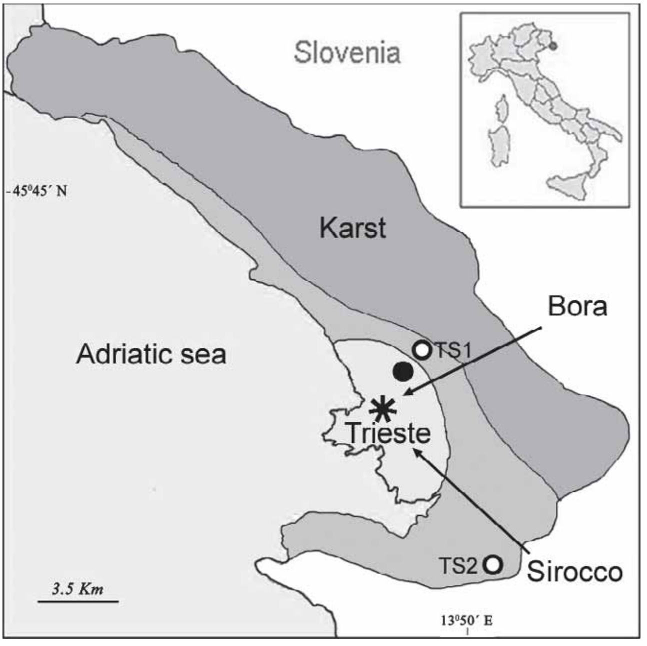

Fig. 1. Study area and location of the pollen sampling site in Trieste (✱); location of the phenological stations for *Castanea* (●) and *Corylus* (○), where phenological surveys were performed.

Tab. 1. Monthly temperatures for Trieste (1991–2004).

Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	mean
1991	5.7	4.7	12.0	12.5	14.3	20.5	25.1	24.8	21.9	14.1	10.3	5.6	14.4
1992	5.5	6.6	9.0	13.2	19.4	21.2	24.0	26.4	20.9	15.0	12.3	7.7	15.1
1993	5.7	6.8	7.5	13.3	20.0	22.5	23.0	24.8	19.5	15.9	8.3	8.5	14.7
1994	8.9	6.5	12.2	13.4	17.9	21.9	26.8	25.9	20.8	14.9	13.1	8.1	15.9
1995	6.1	8.6	8.9	12.7	17.4	19.9	25.9	23.2	18.5	17.2	10.6	7.2	14.7
1996	6.7	5.1	7.6	13.7	18.4	22.4	22.9	23.3	17.4	15.6	12.2	6.6	14.4
1997	7.4	8.1	11.6	11.2	18.4	21.9	23.4	24.0	21.2	14.6	11.1	8.3	15.1
1998	7.3	9.1	9.3	13.2	18.3	22.6	24.8	25.7	19.6	15.7	8.9	6.2	15.1
1999	6.3	5.7	10.3	13.9	18.9	22.4	24.5	24.5	22.0	16.1	9.6	6.8	15.1
2000	4.8	7.7	9.9	15.0	19.8	23.5	22.9	25.3	20.8	17.3	13.1	9.7	15.8
2001	7.9	8.7	11.9	13.0	20.2	21.3	24.7	26.2	18.0	18.3	10.4	4.9	15.5
2002	5.4	7.6	11.7	13.6	18.8	23.5	24.7	23.8	19.5	16.4	14.0	7.9	15.6
2003	5.8	4.4	10.1	13.0	20.3	25.8	26.1	27.9	19.8	13.8	12.2	8.5	15.7
2004	5.1	5.7	8.7	13.6	16.4	21.6	24.3	24.6	20.7	16.8	11.7	9.0	14.9
mean	6.4	7.0	10.2	13.2	18.5	22.1	24.4	24.9	20.0	15.9	11.3	7.4	15.1

dolines; *Castanea sativa* Mill., a spring-summer flowering tree, grows in oak woods (POLDINI 1989). The relationships between the flowering phenophases and the pollen curves were also investigated.

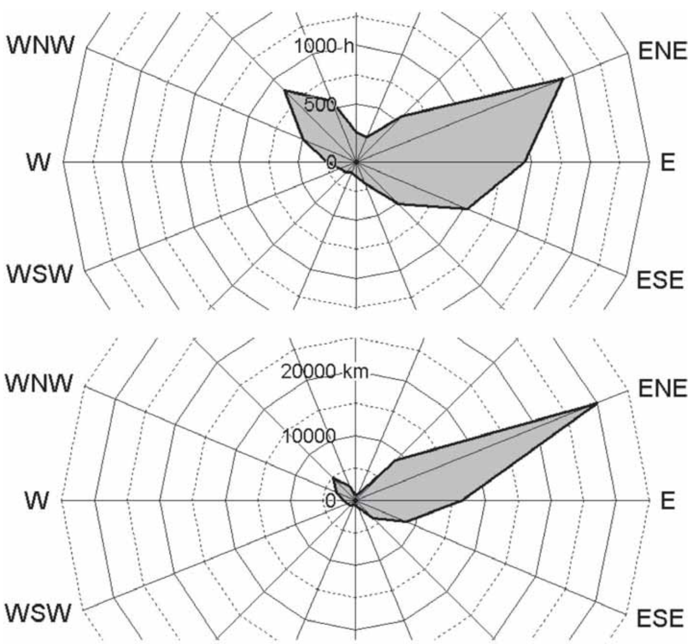

Fig. 2. Trieste (1990–2004): mean distributions of the annual wind duration (in hours) and wind run (in kilometers).

Materials and methods

Flowering phenophase monitoring

Phenological observations of the flowering period of *Corylus* and *Castanea* were carried out in Trieste over a 14-year period, from 1991 to 2004. During the whole period two survey stations were observed (Fig. 1): one for *Castanea* (in Vicolo delle Rose, at 150–170 m) and one for *Corylus* – named TS1 – (in Via Commerciale, at 260 m). The examined plants of these survey stations grow in disturbed oak woods, together with *Quercus petraea* Liebl., *Robinia pseudacacia* L. and *Sambucus nigra* L. From 1992 to 1995, another survey station (named TS2) was considered in order to study the flowering of *Corylus*. TS2 was located in Bosco Vignano near to Muggia, in the south-eastern area of the province of Trieste, on the border with Slovenia, at 70 m a.s.l. (Fig. 1): here *Corylus* plants grow in a semi-natural oak wood together with *Carpinus betulus* L., *Castanea sativa* and *Quercus petraea*.

The phenophase progression was monitored according to the standard method adopted by the Italian Phenological Network (ZANOTTI et al. 1998). Phenological observations were carried out once a week; a sample of five plants was used in each population. Only the following steps of the phenological cards, corresponding to some of the stages of the phenological key proposed by MARCELLO (1935), were considered in this paper: lengthened catkins with closed anthers (stage +00); catkins with some open anthers releasing pollen (stage ++0); catkins with some exhausted anthers (stage +++); catkins with open and exhausted anthers (stage 0++); catkins with only exhausted anthers (stage 00+). The stage +++ corresponds to the stage 65 of the extended BBCH-scale (MEIER 1997). The beginning of the flowering season was defined as the moment when at least one of the five examined plants showed long catkins with closed anthers (stage +00); the time when all the examined plants displayed catkins with closed, open and exhausted anthers (stage +++) was considered the moment of full flowering; the end of the flowering season was defined as the moment when all the examined plants showed catkins with only exhausted anthers (stage 00+).

Airborne pollen sampling

Daily airborne pollen records of *Corylus* and *Castanea* were collected over a 14-year period (1991–2004). During this period, a Hirst type 7-day volumetric spore trap (Burkard until 1999, VPPS 2000 Lanzoni from 2000) was operating at about 20 m above ground level on the Bastione Fiorito of San Giusto Castle, in the town centre (Fig. 1). Sampling method, slide preparation and data interpretation were performed according to the standard method adopted by the Italian Aeroallergen Network (MANDRIOLI 1990). The pollen counts were expressed as pollen grains per cubic meter of air (p/m^3). For each year, the main pollen season (MPS) of each taxon was determined by taking 90% of the annual total pollen concentration, using cumulative values (NILSSON and PERSSON 1981). The start date of the MPS was set in correspondence to the day when the sum of the daily concentrations reached 5% of the total sum; the end date of the MPS was made to correspond to the time when that sum reached 95%. For each year, the total annual pollen amount, the peak day and the peak value were also considered.

Since phenological observations were carried out once a week, daily pollen counts of 7-day periods were summed in order to compare the phenological and the aerobiological data. In order to compare these two sets of data, the full flowering in the survey stations was considered correspondent to the time of maximum pollen production. The period from the start of the season to the maximum pollen production was considered the ascendant phase, whereas the period from the maximum pollen production to the end of the season was considered the descendant phase. In the graphic presentation, the weekly pollen variations of each year have been presented from January to late June for *Corylus*, from late April to the end of September for *Castanea*. These periods were chosen on account of the fact that very small amounts of pollen grains of the examined taxa were found during the rest of the year (RIZZI LONGO et al. 2005, 2007). Moreover, both the weekly sums of the daily pollen concentrations calculated for each year and the phenological data were averaged out over the 14 years (1991–2004).

Results

Corylus

Flowering season

During the 14-year period, several differences in the timing of the flowering phenophases were recorded for hazel plants observed in the survey station named TS1 (Tab. 2). The earliest start of the flowering of *Corylus* was recorded in 1994 and in 2001 (2nd January), the latest one was recorded in 1995 and in 1996 (28th January), with a difference of 26 days. The earliest end of the flowering time was observed in 1994 (13th February), the latest one in 2003 (30th March), with a difference of 45 days. The flowering season lasted on average seven weeks, the longest one was recorded in 2003 (63 days) and the shortest one in 2000 (35 days). The course of the flowering of hazel plants observed in the survey station named TS1 differed greatly over the years (Fig. 3). In several years, *Corylus* began flowering in the fourth week of January and finished flowering between late February and late March. The full flowering usually occurred in February. In some years, the full flowering lasted two weeks. A long descendant flowering phase was frequently observed and attributed to the irregular course of meteorological parameters, which brought about an interruption and a subsequent restarting of the blooming (STRAVISI 2006). In 1994, the flowering of *Corylus* was anomalous: both the beginning and the full flowering occurred within the first week of January, catkins being not yet lengthened in the previous week and already almost exhausted in the following one.

The flowering behaviour of *Corylus* was examined from 1992 to 1995 in survey station TS2, too. In these years, the flowering phenophase progression differed between the two studied populations (TS1 and TS2) and showed a constant delay of the flowering season in TS2 in comparison with TS1 (Fig. 3). *Corylus* began flowering 10 to 15 days earlier in TS1 than in TS2 in 1992, 1994 and 1995, and a month earlier in 1993 (Tab. 3). The flowering season was longer in TS2 than in TS1 in 1992 and 1994.

Pollen season

During the 14-year period, significant differences were recorded in the MPS dates and in the annual pollen totals of *Corylus* (Tab. 2). The mean start date of the main pollen season (MPS) fell at the beginning of February; an early start was recorded in 1994 (8th January), a late one in 1996 (1st March). The main pollen season was very short in 1991 and in 1992 (35 days), and very long in 1994 (84 days). On average, the MPS of *Corylus* lasted about two months, from early February to early April. Different annual totals of *Corylus* were recorded over the years, the lowest in 2000 (197), and the highest in 1998 (1796). The highest daily pollen values also varied over the years. The earliest daily peak occurred in 2001, on 6th February, and the latest one was recorded in 1996, on 28th March. The mean daily maximum was 83 p/m^3, with the highest value of 324 in 1998, and the lowest value of 24 in 2000. The course of the weekly pollen concentrations was rather different over the years (Fig. 3). In 1991, 1992, 1998 and 2000, only one peak was recorded; in 1995, 1996, 1997, 1999, 2001 and 2004, two or more peaks (variable as for the pollen amount) were observed. In the other years (1993, 1994, 2002, 2003), no evident peak was found. Long ascendant phases were observed, particularly in 1992, 1999 and 2004. The weekly peaks usually occurred in late February or in March. In 1998, an exceptionally high weekly amount of hazel airborne grains was recorded.

Tab. 2. Flowering and pollen seasons of *Corylus* in Trieste at station TS1 (1991–2004). Flowering season column data refer to mean data; the pollen season column data refer to 90% pollen concentration method. The start of the pollen season was chosen as the day when the cumulated daily counts reached 5% of the annual sum; the end as the day when the cumulated daily counts reached 95%.

Years	Flowering season			Pollen season			annual total	peak value (p/m^3)	peak-date
	start	end	length	start	end	length			
1991	20/1	10/3	49	19/2	26/3	35	518	65	26/2
1992	19/1	8/3	49	13/2	19/3	35	803	137	1/3
1993	24/1	14/3	49	28/1	30/3	61	347	28	19/3
1994	2/1	13/2	42	8/1	2/4	84	816	39	4/3
1995	28/1	11/3	42	5/2	19/4	73	577	38	22/2
1996	28/1	17/3	49	1/3	24/4	53	829	108	28/3
1997	26/1	16/3	49	2/2	5/4	62	692	71	4/3
1998	4/1	1/3	56	12/2	5/4	52	1796	324	15/2
1999	10/1	28/2	49	2/2	8/4	65	1244	125	14/3
2000	23/1	27/2	35	1/2	2/4	61	197	24	28/2
2001	2/1	26/2	55	16/1	6/4	80	758	87	6/2
2002	27/1	10/3	42	10/2	5/4	54	432	36	23/2
2003	26/1	30/3	63	17/2	24/4	66	333	25	12/3
2004	25/1	22/3	57	19/2	28/4	67	928	56	17/3
mean	19/1	9/3	49	6/2	8/4	61	734	83	4/3

Tab. 3. *Corylus* flowering seasons mean data at stations TS1 and TS2 (1992–1995).

Years	Flowering season					
	start		end		length	
	TS1	TS2	TS1	TS2	TS1	TS2
1992	19/1	3/2	8/3	30/3	49	56
1993	24/1	20/2	14/3	10/4	49	49
1994	2/1	11/1	13/2	10/3	42	58
1995	28/1	8/2	11/3	22/3	42	42

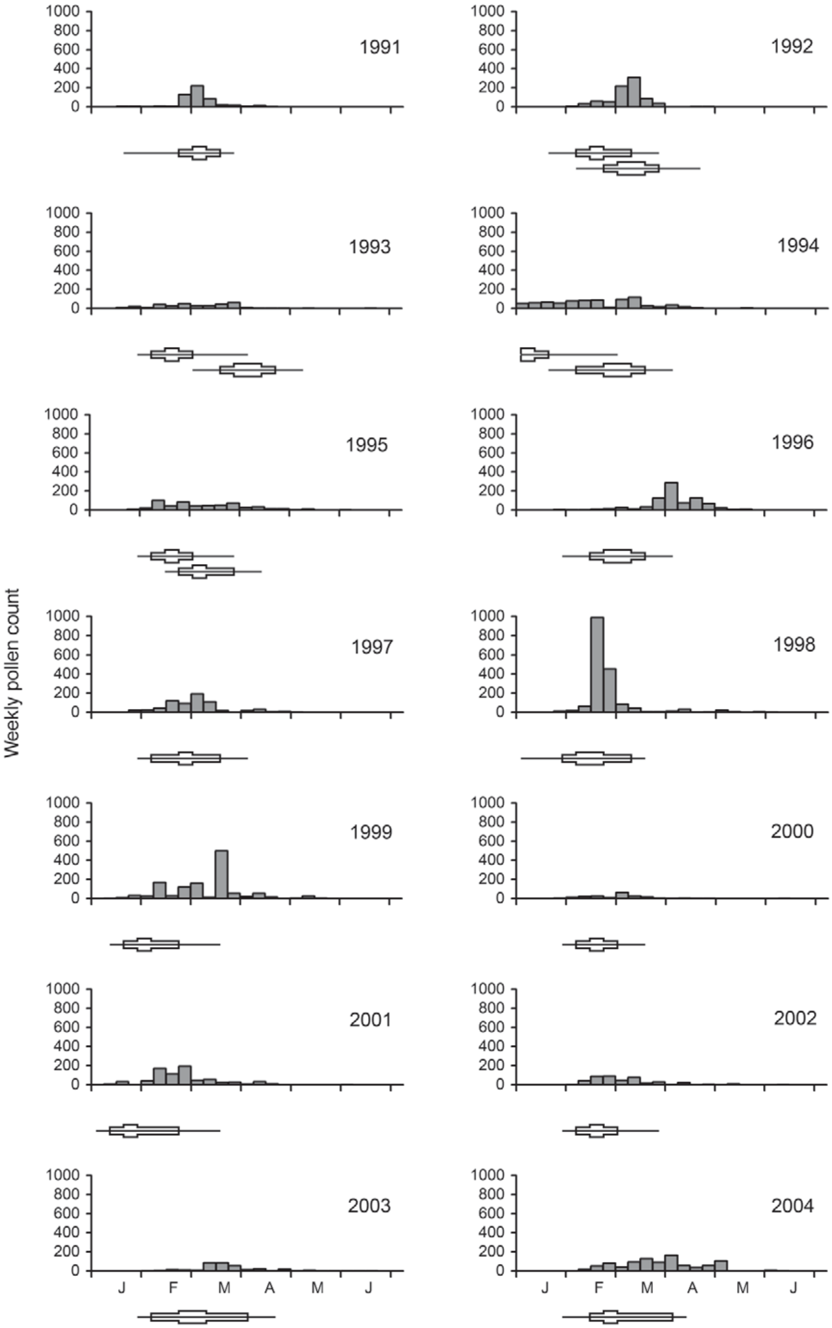

Fig. 3. Airborne pollen counts (weekly sums of the daily pollen concentrations) and mean flowering phenophases of *Corylus* in Trieste during 1991–2004. The horizontal black lines show the flowering period. For the years from 1992 to 1995, two horizontal black lines are presented, the upper line showing the flowering phenophases for TS1, the lower one showing the flowering phenophases for TS2.

Flowering-pollen relationships

Hazel airborne pollen was usually recorded in coincidence with or some days after the start of the flowering season of *Corylus avellana*, and several days after its end. On average, the start and the end of the main pollen season of *Corylus* occurred 18 days after the beginning of the flowering season and one month after its end, respectively (Tab. 2). The weekly airborne pollen peaks rarely corresponded to the full flowering of hazel plants; on the contrary they were usually recorded one or even several weeks after (Fig. 3).

Taking into consideration the whole period (1991–2004), pollen grains of *Corylus* were detected in the air of Trieste from January to mid May, and refloated grains were detected also later (Fig. 4). In the mean weekly pollen curve the descendant phase appears longer than the ascendant one. On average, the mean flowering season of *Corylus* lasted nearly three months, from January to mid March, with the maximum falling in February. On average, the highest concentration of airborne pollen was found when the flowering of *Corylus* began to diminish.

The weekly pollen sums and the phenological data collected in the two survey stations (TS1 and TS2) were averaged out over the period from 1992 to 1995 (Fig. 5). The flowering started and ended earlier in TS1 than in TS2: the full blooming usually occurred in early February in TS1, and in late February, with a delay of two weeks, in TS2. The mean pattern of the weekly pollen concentrations was bimodal, the first peak corresponding to the full blooming in TS1, and the second one occurring a month later, and not corresponding to the full flowering either in TS1 or in TS2.

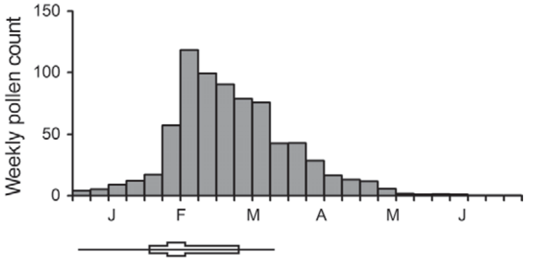

Fig. 4. Mean variation of pollen counts (weekly sums of the daily pollen concentrations) and flowering phenophases of *Corylus* in Trieste (1991–2004). The horizontal black line shows the mean flowering period.

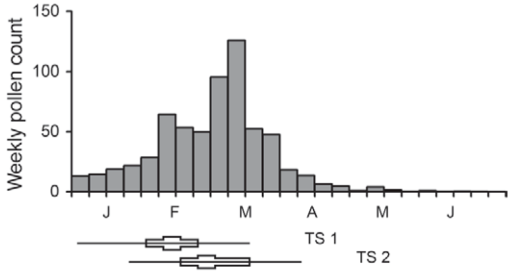

Fig. 5. Mean pattern of pollen counts and flowering phenophases of *Corylus* at stations TS1 and TS2, in the period 1992–1995. The horizontal black lines show the mean flowering periods.

Castanea
Flowering season

The timing of flowering phenophases of *Castanea* varied over the years (Tab. 4). The earliest start of flowering was recorded in 1993 (15th May), the latest one in 1991 (2nd June), with a difference of 18 days. In most cases, *Castanea* began flowering in late May and finished flowering between late June and early July. The earliest end of the flowering was observed in 2000 (17th June), the latest one in 1991 (14th July), with a difference of 27 days. The duration of the flowering season varied between 28 and 42 days. The flowering of *Castanea* usually lasted about six weeks, with a flowering course rather similar over the years (Fig. 6). Long ascendant and descendant flowering phases were observed in some years; in 1999, the full flowering of *Castanea* became suddenly exhausted.

Tab. 4. *Castanea* flowering and pollen seasons in Trieste (1991–2004). Flowering season column data refer to mean data; main pollen season column data refer to 90% method. The start of the pollen season was chosen as the day when the cumulated daily counts reached 5% of the annual sum; the end as the day when the cumulated daily counts reached 95%.

Years	Flowering season			Pollen season			annual total	daily peak (p/m^3)	peak date
	start	end	length	start	end	length			
1991	2/6	14/7	42	25/6	8/8	44	577	69	21/7
1992	16/5	27/6	42	7/6	31/7	54	417	36	27/6
1993	15/5	26/6	42	11/6	1/8	51	580	33	17/6
1994	27/5	2/7	36	9/6	13/8	65	392	26	3/7
1995	27/5	8/7	42	21/6	22/7	31	598	49	30/6
1996	29/5	3/7	35	12/6	26/7	44	638	44	1/7
1997	25/5	29/6	35	13/6	23/7	40	571	56	21/6
1998	24/5	28/6	35	12/6	20/7	38	1081	110	11/7
1999	23/5	20/6	28	10/6	22/7	42	511	36	22/6
2000	20/5	17/6	28	3/6	12/7	39	940	72	5/7
2001	20/5	1/7	42	10/6	18/7	38	619	47	16/6
2002	26/5	23/6	28	8/6	20/7	42	261	23	22/6
2003	17/5	21/6	35	8/6	18/7	40	983	93	12/6
2004	22/5	3/7	42	20/6	23/7	33	1452	180	9/7
mean	23/5	29/6	37	12/6	25/7	43	687	62	29/6

Pollen season

Over the years some differences emerged in the pollen season of *Castanea*. During the 14-year period, the start of the main pollen season varied between 3rd June – in 2000 – and 25th June – in 1991 (Tab. 4). The longest pollen season was recorded in 1994, the shortest in 1995. The annual sums of the daily pollen concentrations were rather variable, with the lowest total in 2002 (261), and the highest one in 2004 (1452). The highest daily pollen values were usually recorded in late June or at the beginning of July, with the earliest peak occurring on 12th June 2003, and the latest on 21st July 1991. The mean daily maximum was equal to 62 p/m^3, with the highest value of 180 grains in 2004, and the lowest value of 23

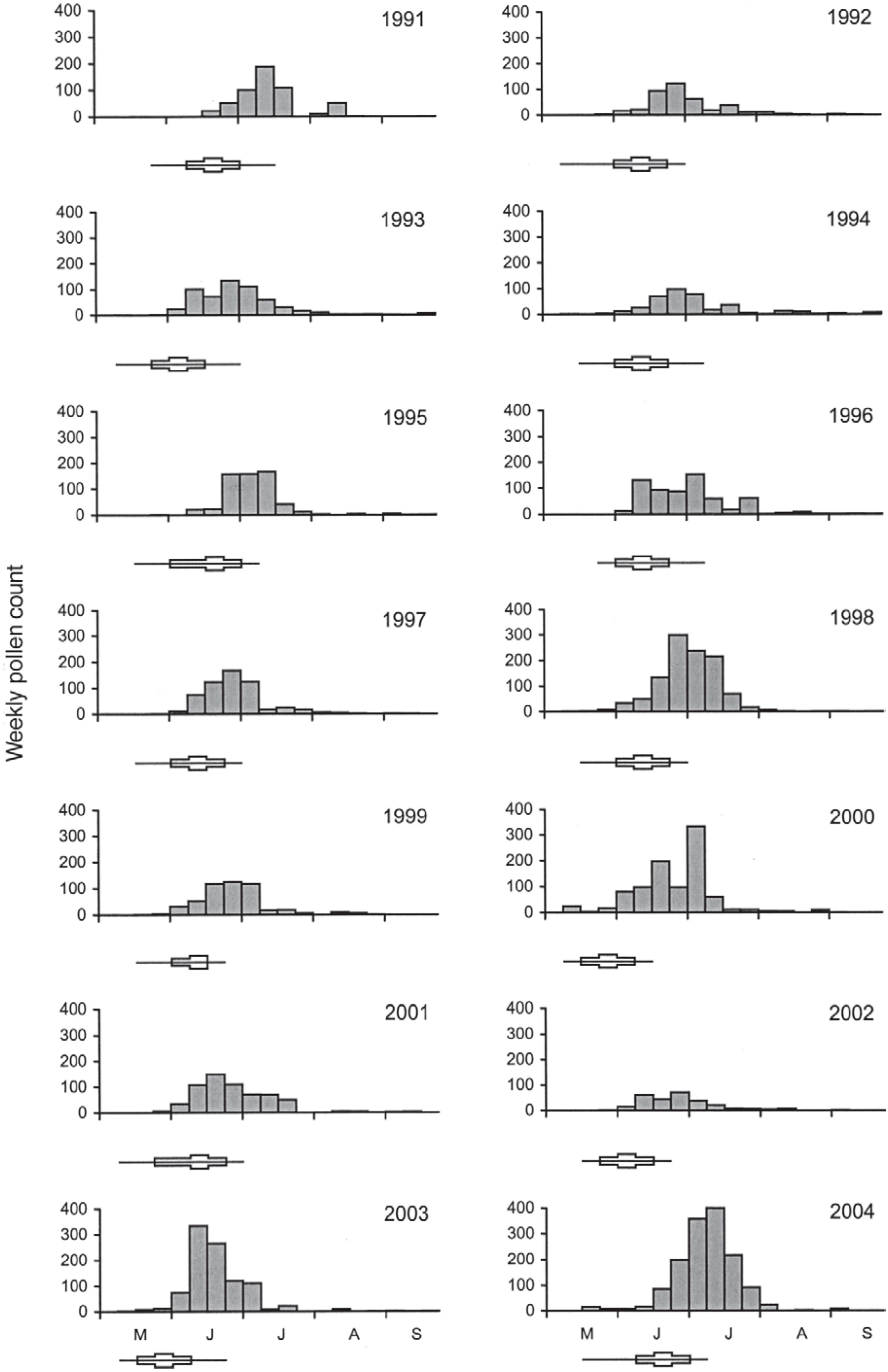

Fig. 6. Airborne pollen counts (weekly sums of the daily pollen concentrations) and mean flowering phenophases of *Castanea* in Trieste in the period 1991–2004. The horizontal black lines indicate the flowering periods.

grains in 2002. The course of the weekly pollen concentrations (Fig. 6) showed some differences over the years. In some years only one peak was found; in some cases we are dealing with a clearly recognizable peak (1998, 2001, 2003, 2004), whereas for 1995 and 1999 the peak is hardly identifiable. For the remaining years, at least two peaks were observed, though different with regard to the pollen amount; the lower peak was generally recorded two or more weeks after the main peak, less frequently before it.

Flowering-pollen relationships

The mean start date of the pollen season of *Castanea* occurred 20 days after the mean start date of the flowering season, and the mean end date of the pollen season fell 26 days after the mean end date of the flowering season (Tab. 4). The peaks of the weekly airborne pollen concentrations never corresponded to the full flowering of the observed trees, but usually occurred 2 or 3 weeks after (Fig. 6).

Taking into account the whole studied period (1991–2004), the mean weekly pollen curve displays a symmetrical pattern, in which the ascendant and the descendant phases are similar in length (Fig. 7). The pollen season of *Castanea* lasted from early June to late July, with the highest weekly peak occurring in the first week of July. On average, the flowering season of *Castanea* lasted six weeks, from mid May to late June, with the maximum in mid June; on average, the highest concentrations of airborne pollen were detected three weeks later. *Castanea* pollen was usually recorded in the air before the start of the flowering season of the examined trees, and for a long time after its end.

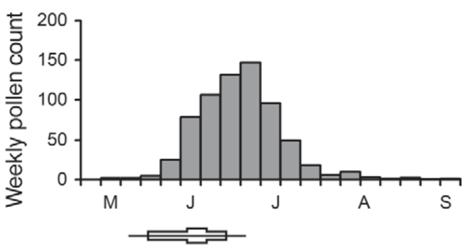

Fig. 7. Mean variation of pollen counts (weekly sums of the daily pollen concentrations) and flowering phenophases of *Castanea* in Trieste (1991–2004). The horizontal black line shows the mean flowering period.

Discussion

The flowering phenological behaviour of *Corylus avellana* and *Castanea sativa* in Trieste varied greatly over the years (1991–2004). On average, the flowering season of *Corylus* lasted from late January to early March, with the full bloom occurring in February. *Castanea* flowered later, from late May to late June, with the full bloom occurring in mid June. Interannual differences were observed both for the timing and for the length of the examined phenophases, as observed for *Betula* by JATO et al. (2002), and for *Alnus*, *Corylus* and *Betula* by KASPRZYK (2003). Phenological differences in the timing of the flowering were recorded more often for *Corylus* than for *Castanea. Corylus* flowered at the beginning of the year, when the weather is very unstable; *Castanea* flowered in late spring –

early summer, when the weather is less changeable from day to day, as well as from year to year. Meteorological parameters, particularly temperature, are known as the main variable that influences the timing of the flowering (RODRÍGUEZ-RAJO et al. 2006, EMBERLIN et al. 2007). In Trieste and especially in winter, daily temperatures are very changeable, because of the peculiar climate of this area, strongly influenced by two dominant winds, the »bora« (ENE) and the »sirocco« (SE).The »bora« causes sudden drops in temperature, whereas the »sirocco« brings about significant increases in temperature (STRAVISI 2006). Given the remarkable effect of chilling and post chilling temperatures on the flowering of *Corylus* (FRENGUELLI et al. 1992, 1997), the flowering behaviour of this plant was very variable over the years, in accordance with the course of the temperature during late autumn and early winter (STRAVISI 2006).

Between the two examined populations of *Corylus*, differences in the flowering period were also observed: a constant delay was found in the full bloom of the plants growing in the colder and more humid site TS2. As already observed by CHUINE et al. (2000), who found significant differences in the phenological response to temperature among *Corylus* populations, the phenological behaviour of this temperate woody taxon seems to adapt locally to microclimate. In TS2, a fifteen-day delay in the start of flowering was recorded, on average. The earliest floral phenophase was recorded in TS1 in 1994, when *Corylus* showed both start and full bloom within the first week of January, since the chilling requirement necessary to break dormancy had already been achieved and the following heat accumulation was quickly reached. In each population, differences among plants were also found; these differences depend on the age and the size of the plants, and on microclimatic and edaphic factors, since the flowering patterns are different in each individual due to different micro-environmental features. As a matter of fact, young plants started blooming earlier than old plants, in the same way that plants growing in protected and sunny sites bloomed earlier than plants growing in more windy or shady sites.

Taking into consideration the occurrence of airborne pollen in the studied years, the main pollen season of *Corylus* lasted on average from early February to early April, with the daily peak usually occurring in late February or early March. The main pollen shedding of *Castanea* usually occurred between early June and late July, and the daily peak was recorded around late June or at the beginning of July. The course of the weekly pollen concentrations varied greatly over the years, especially for *Corylus*, since the timing and the behaviour of the pollen release were strongly influenced by the weather. On average, the pollen curves showed a symmetrical pattern in the case of *Castanea*, with the ascendant and descendant phases similar in length, and a partly symmetrical pattern for *Corylus*, with a descendant phase longer than the ascendant one. Refloated grains were frequently found after the end of the pollen season.

The flowering patterns of *Corylus* and *Castanea* were compared with the respective curves of the airborne pollen. The pollen seasons of *Corylus* and *Castanea* grains were usually found, sometimes even in great amounts, outside the flowering period and the pattern outlined by the pollen curves is hardly ever in accordance with that of the flowering phenophases. As already noticed by LATORRE (1999), airborne pollen is not suitable for indicating the exact length of the flowering season, above all when we consider the final stage of the flowering, when a clear discrepancy emerges between the flowering and the end of the presence of airborne pollen. A lack of correlation between the maximum flowering and the maximum pollen concentration was observed, the highest airborne pollen counts occurring two or more weeks after the maximum flowering. Because of the geographical complexity of the area around Trieste, the flowering of *Corylus* and *Castanea* do not occur at the same time everywhere, and grains coming from plants growing at different altitudes and at various distances from the pollen trap were also found. These pollen grains may come from extra-local sources when specific weather conditions allow a medium/long range transport from Slovenia or from the Julian Pre-Alps (RIZZI LONGO et al. 2005). The discontinuous occurrence of pollen observed every year seems, in its turn, to be related to the late flowering of both local and extra-local trees. The phenological data collected in the survey stations do not permit a correct comparison of flowering behaviour with airborne pollen occurrence in this area. The peculiar geographical conformation of the area around Trieste, together with the direction of the two dominant winds (ENE, SE) in relation to the position of the trap and to the location of the survey stations, might represent the main cause of this lack of correlation. To remedy this, other pollen sources could be considered, such as plants growing on the north-eastern outskirts of the town or on the Karst plateau and in farther sites. According to JATO et al. (2002), transport and reflotation should also be considered in order to explain aerobiological data correctly.

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