



## POLLEN DISPERSAL AND DEPOSITION IN AN AGROECOSYSTEM AT PROVINCE OF BUENOS AIRES, ARGENTINA

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**Abstract.** Madanes, N & C. A. Fernández. 2018. Pollen dispersal and deposition in an agroecosystem at Province of Buenos Aires, Argentina. *Darwiniana*, nueva serie 6(1): 35-46.

The aim of this study is to analyze factors and mechanisms involved in dispersal and deposition of airborne pollen captured with Tauber type traps in a 20 x 20 m plot of *Helianthus annuus* cultivation and accompanying weeds and to investigate the relation of these processes with the vegetation structure and dynamics from cultivation to its senescence over a 14 week period. Weekly samples obtained with pollen traps showed a significant change in the deposition due to a filter effect and dispersal patterns due to source variations during the time elapsed. A conceptual and interpretative model for both processes and its relation to pollen sources is proposed. Our results showed that in the study site, the leaves development of *Helianthus annuus* produced a pollen filter effect. Furthermore the cultivation and weeds phenology was linked to deposition and dispersal of pollen, whose sources were the study plot, local or extralocal distances. Three periods could be characterized according to the presence of pollen contents coming from different pollen sources. The first period was characterized by deposition of local and extralocal pollen types such as Caryophyllaceae, t. *Physalis*, etc, the second by pollen originate from the study plot (such as *Helianthus annuus*) and the third by a combination of all three sources.

**Keywords.** Airborne pollen; phenology; *Helianthus annuus*; weeds.

**Resumen.** Madanes, N & C. A. Fernández. 2018. Dispersión y deposición de polen en un agrosistema de la Provincia de Buenos Aires, Argentina. *Darwiniana*, nueva serie 6(1): 35-46.

Los objetivos de este estudio fueron analizar los factores y mecanismos implicados en la dispersión y depositación del polen aéreo capturado con trampas tipo Tauber en una parcela de 20x20 m cultivada con *Helianthus annuus* y acompañada por sus malezas e investigar la relación de estos procesos con la estructura y dinámica de la vegetación desde la fecha de siembra hasta la senescencia del cultivo en un periodo de 14 semanas. Se tomaron muestras semanales del polen capturado en las trampas. Se registraron cambios en la depositación debido al efecto de filtro y en los patrones de dispersión debido a la variación de las fuentes durante el lapso de tiempo estudiado. Se propuso un modelo conceptual e interpretativo de ambos procesos y su relación con las fuentes de polen. Nuestros resultados mostraron que en el sitio de estudio, el desarrollo de las hojas de *Helianthus annuus* produce un efecto de filtro. Además la fenología del cultivo y de las malezas fue relacionada con la depositación y dispersión del polen. Las fuentes de polen fueron clasificadas en in situ, local o extralocal. Se caracterizaron tres periodos de acuerdo a la presencia del polen contenido proveniente de diferentes fuentes polínicas. El primer periodo caracterizado por la depositación de tipos polínicos locales o extralocales tales como Caryophyllaceae, t. *Physalis*, etc., el segundo caracterizado por el polen originado a partir de la parcela de estudio (*Helianthus annuus*) y el tercer periodo por la combinación de las tres fuentes de polen.

**Palabras clave.** Fenología; *Helianthus annuus*; malezas; polen aéreo.

## INTRODUCTION

Airborne pollen studies in present agroecosystems, contribute to the knowledge of palaeo-environments due to the fact that pollen records of archaeological sites can contain evidence of environmental modifications by land use (Faegri & Iversen, 1992; Broström et al., 1998; Mazier et al., 2006; Medina et al., 2008; Brun, 2011; Pang et al., 2011; Hjelle et al., 2015). One of the applications of pollen/vegetation relationship is linked to the interpretation of past human activity. For example, natural and agro-ecosystem can be characterized by its pollen assemblages and specific combinations of pollen taxa abundances. Such studies are important to understand changes in the landscape and human impact in a spatial scale of high resolution (Brun et al., 2007; Hjelle, 1999 a, 1999 b; Pang et al., 2011)

The importance of research upon modern analogues by investigating present pollen spectra and its relationship to its vegetation sources, has already been pointed out by Birks and Birks (1980), D'Antoni (1991), Madanes & Fernández (2000), D'Antoni (2008). Furthermore, only few studies have investigated the relationship between pollen and vegetation in cultivated fields (Madanes & Millones, 2004; Mazier et al., 2006; Brun et al., 2007; Brun, 2011; Pang et al., 2011). The concept of anthropogenic indicators relies on the occurrence of particular pollen taxa, which are closely correlated with human activities, e.g., cultivated plants and weeds (Behre, 1981; Brun, 2011). Fossil pollen sequences are interpreted qualitatively with the help of these pollen indicators of different human activities such as cultivation, grazing, trampling, settlement and mowing. This so-called "indicator species" approach is the most widely used method for tracing the history of habitation and its changing intensity over time (Court Picon et al., 2006; Brun, 2011)

Factors and mechanisms that influence deposition and dispersal of pollen grains allow us to make inferences about vegetation characteristics that include both spatial and temporal components. Thus, the surrounding vegetation can be reflected by airborne pollen emitted from sources at different distances (Janssen, 1966; Wright, 1967; Madanes & Fernández, 2000; Madanes & Millones,

2004). The relationship between pollen dispersed and deposited over time in a given site and its surrounding source of vegetation is strengthened by phenological data of species at the site. Both phenological and aerobiological sets of data should be as similar as possible (Estrella et al., 2006; Jato et al., 2007; Tormo et al., 2011)

Several approaches have been made in order to explore qualitative and quantitative relations between vegetation and its pollen representation (Moore et al., 1991; Brun et al., 2007; Hjelle et al., 2015). Many papers concerning these comparisons deal with types of vegetation subjected by different anthropogenic land-uses (Behre, 1981; Gaillard et al., 1992; Hicks & Birks 1996; Hjelle 1997, 1999 a, 1999 b; Hjelle et al., 2015; Broström et al., 1998; Court Picon et al., 2005, 2006;

Mazier et al., 2006). Furthermore, Heim (1970), Vuerela (1973), Hall (1989), Madanes & Millones (2004), Brun et al. (2007) mentioned papers that analyze pollen/vegetation relationship of cultivated fields and in turn they study this relationship upon local scale, using moss samples in land crops and fallows as pollen traps.

The aim of this study is to analyze factors and mechanisms involved in dispersal and deposition of airborne pollen and to investigate the relation of these processes with the vegetation structure and dynamics in different crops of the Pampas. Three pollen emission sources were defined for this study (Madanes & Millones, 2004; Madanes, 1999) according to its distance from the deposition site: 1) plot (site dispersed by *Helianthus annuus* L. environment) 2) local (includes three immediate surrounding environments defined as relictual, landscaped, and agroproductive, this last one containing the plot of *H. annuus* cultivation and 3) regional (vegetation surrounding EEA- INTA Balcarce station).

## STUDY AREA

The study took place at the Agriculture Experimental Station of INTA Balcarce (EEA-INTA), south of Buenos Aires province (37°45'40.2"S 58°17'55.1"W) located in the transition zone between Pampa Deprimida and Pampa Austral (Solbrig & Morello, 1997) (Fig. 1).

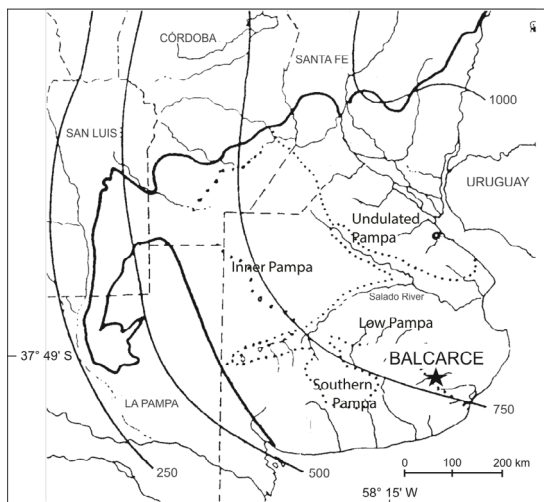


Fig. 1. Map showing the site of the study area in the transition zone between Pampa Deprimida and Pampa Austral. Isohietas from 250 mm to 1000 mm are indicated.

Natural vegetation is composed mainly by grasslands with several species of *Stipa* and *Piptochaetium* genera (Cabrera & Zardini, 1978). However, the present landscape is deeply modified by cattle and agricultural activities developed since the XVIII century. At present, the climate is mesothermal, subhumid with none or scarce water deficiency and a 48% summer concentration of thermic efficiency (Voorst, 1967). Annual mean temperature is 13°-17° C, mean annual precipitation is 960 mm, 63% of precipitations occur during the warm season (October to March) (Voorst, 1967). Figure 2 shows hydric balance for the period studied. The mean period free of frost is 231 days and the extreme is 166 days (Andrade et al., 1996).

## MATERIAL AND METHODS

### Pollen

Pollen was captured in 4 type Tauber traps placed on the angles and one in the center of the *Helianthus annuus* cultivation and accompanying weeds (*Helianthus annuus*/weeds) plot of 20 × 20 at ground level. Traps were exposed during a 7 to 10 days period after which traps were collected, washed, emptied and replaced. This procedure was repeated all along the time elapsed between the emergence of the cultivation

until its senescence (98 days). Samples were collected fourteen times. Observations were made from late October to early March. Samples' treatment was performed according to the following sequence: 10% KOH at 100 °C during 10 minutes followed by distilled water washings. HCL acid in 10% water solution, cold HF 70% for 24 hours, 30% HCL 60°C, washed with distilled warm water, and 12 minutes acetolysis at 100°C washed with glacial acetic acid and distilled water. Finally, the samples were included in 5 ml glycerine in residue tubes. The minimum volume was 60 µl determined by the Cain method (Mueller-Dombois & Ellenberg 1974) reaching average sums in each date from 111 to 2763.8 pollen grains. Slides were observed with an Olympus BH 2 light photomicroscope in immersion 1000 X. The pollen reference collection of the Palynology Laboratory UNMDP was used for identification control as well as published descriptions given in Erdtman (1969, 1972), Heusser (1971), Huang (1972), Markgraf & D' Antoni (1978), Morbelli (1980) and Madanes (1999). Furthermore, identification of pollen grains was made to the least possible taxonomic hierarchy.

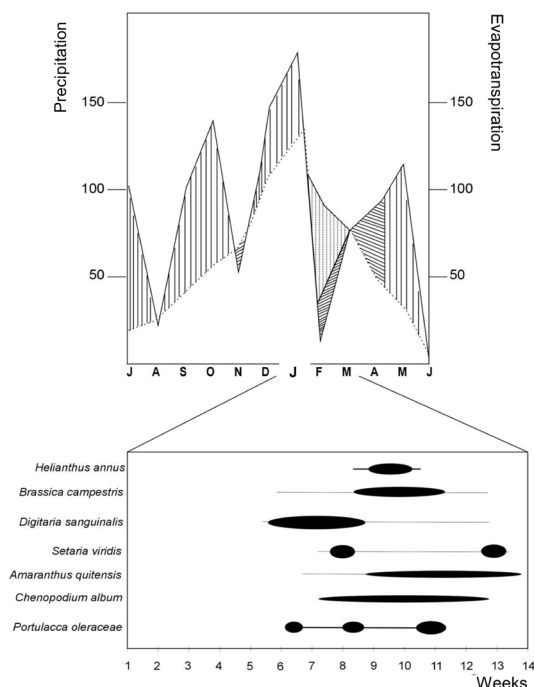
For each date pollen counts corresponding to five Tauber traps were averaged and percentages for each pollen type were calculated in respect to the total pollen sum. Only taxa over 2% or equal were considered for the data calculation. The pollen diagram was constructed by means of TGView version 2.0.2 (Grimm, 1992). Program CONISS was used for restricted cluster analysis including Euclidian distance (Grimm, 1992). Percentage data were transformed using the function arc sen  $\sqrt{x}$  in order to normalize data and stabilize variance (Zar, 1984).

### Pollen sources and environmental units

Pollen sources from EEA-INTA were identified (Madanes, 1999; Madanes & Millones, 2004). Pollen and surrounding vegetation were sampled simultaneously. Zonation of the study area EEA-INTA was done in order to delimit and characterize the environmental units on the basis of vegetation structure. Environments were classified according to their origin (anthropic/natural) and its use (frequency and intensity) (Madanes, 1999; Madanes & Millones, 2004). Environmental units were: *Helianthus annuus* /weeds, agroproductive and relictual. A floristic list for the environments mentioned above was compiled and analogue to its pollen types list (Table 1).

**Table 1.** Total floristic list of vegetation analogued to its pollen types Table shows presence/absence in four pollen sources and pollen captured in Tauber traps.

TAXA	POLLEN SOURCES				POLLEN
	RELICTUAL	LAND SCAPED	AGRO PRODUCTIVE	H-annus /Weeds	
Poaceae 35µ					
Cheno/Ams					
Poaceae 25µ					
Brassicaceae					
<i>Taraxacum</i> type					
Apiaceae					
Caryophyllaceae					
<i>Echium</i> type					
<i>Polygonum</i> sp					
Fabaceae					
Poaceae 50µ					
<i>Senecio</i> sp.					
<i>Carduus</i> sp					
<i>Gnaphalium</i> sp					
<i>Helianthus annuus</i>					
<i>Anthemis</i> type					
<i>Xanthium</i>					
<i>Phyla</i> type					
<i>Centaurea</i> sp					
<i>Conyza</i> sp					
<i>Oxalis</i> sp					
<i>Zea mays</i>					
<i>Lotus</i> sp					
<i>Ambrosia</i> sp					
<i>Cotula</i> sp					
<i>Solanum</i> sp.					
<i>Ranunculus</i> sp.					
Cyperaceae					
Plantaginaceae					
<i>Solidago</i> type					
<i>Euphorbia</i> sp					
<i>Anagallis</i> sp.					
<i>Baccharis articulata</i>					
<i>Juncus</i> sp					
Liliaceae					
<i>Achyrocline satyroides</i>					
<i>Psidium luridum</i>					
<i>Galinsoga parviflora</i>					
<i>Evolvulus cericeus</i>					
<i>Zephyranthes minima</i>					
<i>Triticum durum</i>					
<i>Viola arvensis</i>					
Anacardiaceae					
<i>Bidens</i> sp					
Caesalpinioideae					
Eupatoriae					
<i>Gomphrena</i> sp					
Lamiaceae					
<i>Leuceria</i> sp					
Malvaceae					
<i>Melilotus</i> sp					
Mimosoideae					
Mutisiae					
Polygonaceae					
Rubiaceae					
<i>Rubus</i> sp					
Scrophulariaceae					
<i>Sysimbrium</i> sp					
Solanaceae					
<i>Tessaria</i> sp					
<i>Werneria</i> sp					
<i>Cupressus</i>					
<i>Pinus</i> sp					
<i>Eucalyptus</i> sp					



**Fig. 2.** Hydric Balance according to Thornthwaite 1948. Source: Meteorologic Station at the Experimental Station of INTA BALCARCE, Buenos Aires Province. Intensity and duration of the flowering season for weeds and cultivation is indicated.

#### *Vegetation sampling of Helianthus annuus cultivation and accompanying weeds community*

The *Helianthus annuus*/weeds cultivation is found within the agroproductive environment. Conventional tillage was carried out in October and sowing took place in December. Plant community samples were taken in six times during the course of crop development, each 7 or 10 days synchronous with pollen sampling. Censuses within the plot *Helianthus annuus*/weeds. Vegetation sampling was carried out according to a design of 25 sq cm subplots at random. Five repetitive samplings were made. In each subplot the floristic composition was determined and the number of individuals for each population was counted and density estimated. As measures were taken from the emergence it was possible to identify the ramets (Harper, 1981) of Poaceae considered in this work as individuals. Agroproductive and

relictual environmental were made according to Braun-Blanquet methodology (Mueller-Dombois & Ellenberg, 1974).

#### *Species phenology of H. annuus cultivation and accompanying weeds community species phenology*

Phenophases of different populations of *Setaria* sp. weeds (*Setaria viridis* + *Setaria verticillata*), *Digitaria sanguinalis*, *Chenopodium album*, *Amaranthus quitensis*, *Portulacca oleracea*, *Brassica campestris*) and *H. annuus* were determined according to the dominant ramet (sensu Harper, 1981) type: vegetative (juvenile, caulinar), pre-flowering, flowering, maturation, dispersal and senescence) and the period when these were registered (dates in which phenophase were recorded). Phenophases were defined as follows: vegetative development I, vegetative development II, pre-flowering period, flowering, maturation dispersal of fruits and seeds and senescence. A data matrix with 140 observations and 42 variables was constructed (Madanes, 1999), where for each observation, the percentage of population in either one phenological phase was considered. For each species, ten individuals per date were phenologically analyzed. Data were analyzed by Detrended Correspondence Analysis DCA using CANOCO version 3.12 (Ter Braak & Smilauer, 1998).

#### *Climate and phenology*

On the basis of climatic data provided by the Experimental Station a water balance for the time of study was calculated according to Thornthwaite (1948) in order to detect periods of deficit and hydric excess, and it was related to the community phenology (Fig. 2).

#### *Airborne pollen and vegetation relationship at the cultivation site*

Pollen grains are described as pollen types, frequently including several plant species, indistinguishable on the basis of pollen morphology. Therefore, the difference in taxonomic resolution may cause bias in the relationship between vegetation and pollen. In order to compare pollen and vegetation data, plant taxa were grouped according to pollen types (Table 1).

In order to analyze the relationship between airborne pollen dispersed and deposited in the cultivation site, a data matrix of 14 observations and 71 cases was constructed. In addition to species of the site's density and intensity values of the flowering species, phenological phases were included in the matrix. Height and foliar area index (FAI) (Saugier, 1976) of the cultivation were also included. All variables were analyzed by means of Principal Component Analysis (PCA) using Statistica program version 6.0. Original data were expressed as percentages with subsequent (arc sen V proportion) angular transformation in order to normalize data and stabilize variance (Zar, 1984).

## RESULTS

### *Pollen sources and environmental units*

In a field of 420 hectares EEA-INTA different environmental units were identified. An agroecosystem that includes *Helianthus annuus*, *Zea mays*, *Triticum durum* crops and weeds, subjected to regular and intensive management for agricultural purposes. The study site (plot) with *Helianthus annuus*/weeds is located in this environment. The second unit (landscaped) comprises the surrounding areas where the Station's facilities are found, and is designed for outdoor recreation practices and installations. This unit is characterized by two strata: an arboreal containing a *Eucalyptus* plantation carried out for ornamental purposes and as barrier against winds, and an herbaceous plantation subjected periodically for mowing. The third unit is a zone containing a relictual community mosaic. In the past, this unit was subjected for grazing, while at present the anthropogenic impact is scarce. The shrub stratum of this unit is dominated by *Baccharis tandilensis* and *B. articulata* and the herbaceous stratum by *Paspalum quadrifarium* (Madanes & Millones, 2004).

The *Helianthus annuus*/weeds community in the study plot was characterized by the *Setaria* species dominance (*Setaria viridis* plus *Setaria verticillata*) and a group of co-dominant species all within the taxonomical group of Poaceae which was the most represented family and contributed up 37% of total species richness (Madanes, 1999).

In the plot, structural changes in the weed's community were given by density variations of *Setaria* species and not by replacement of plant species. Species identified *Portulaca olearacea*, *Amaranthus quitensis* and *Chenopodium album* (pollen type Cheno-Ams), *Digitaria sanguinalis*, *Setaria* sp. (pollen type Poaceae 25 µm) and *Brassica campestris* (pollen type Brassicaceae) are very frequent in summer season agroecosystems at the study area (Madanes & Millones, 2004).

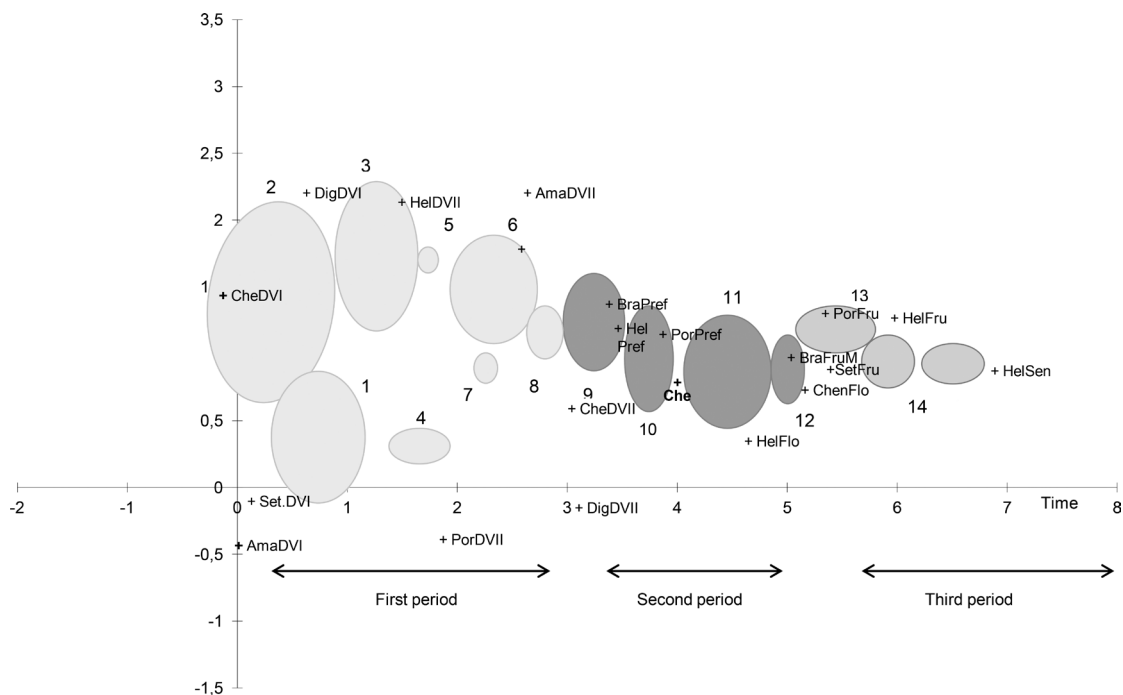
### *Vegetation and climate*

Figure 2 also shows that the emergence of cultivation and weeds occurs, when the soil contains excess of water and water balance is positive. The species reproductive phase develops with higher intensity when precipitation was below the requirements of potential evapotranspiration. Anthesis of *H. annuus* takes place when soils have water capacity. Finally, fructification/maturation and senescence phenophases takes place when water balance is favourable once again.

### *Phenology*

Figure 3 shows the distribution of different phenophases as a function of the first two axes obtained by DCA, which explains 69.54 % of the total variance. The first axis shows a gradient of groups characterized by species abundance in each phenophases. Groups with high values of relative abundance of vegetative phenophases in all species are located towards the lowest values of the positive axis while groups formed by presence and abundance of reproductive, fructification maturation and senescence phenophases are located on the highest values of the positive axis, except for Che DVI (*Chenopodium* development vegetative I ) The second DCA axis explains little of the variance since it was used in the detrend process.

The first axis indicates a phenophase replacement gradient with three different phenological periods: 1) vegetative, 2) reproductive, and 3) reproductive-senescent. The first one comprises samples from weeks 1 to 7 and is characterized by phenophases in vegetative activity I and II. The second is composed by weeks 8 to 12 and showed preflowering and flowering phenophases in every species with less proportion of fructification matu-



**Fig. 3.** Biplot of the phenologic development process of cultivation and weeds community. Arrows indicate the direction of phenophases replacement. VDI: Vegetative Development I, VDII: Vegetative Development II, PF Pre- flowering, Flo: Flowering, Fru-M: Fructification- Maturation, Sen: senescence, Ama: *Amaranthus quitensis*, Bra: *Brassica campestris*, Che: *Chenopodium album*, Hel: *Helianthus annus*, Por: *Portulaca oleraceae*, Set: *Setaria* spp., Dig: *Digitaria sanguinalis*.

ration. The upper limit of the period is marked by the flowering of *H. annus* and fructification of *B. campestris*. A partial overlapping of vegetative and vegetative/reproductive phenophases between species can be observed. The third period corresponding to weeks 13 to 14 is characterized by reproductive and senescent phenophases.

#### Pollen analysis

A total of 54 pollen types were identified from samples taken through the period of 14 weeks (Table 1). Only 19 pollen types were included in the data matrix and displayed in the pollen diagram, which were represented by values higher than 2% or more.

The pollen diagram (Fig. 4) shows that deposition of airborne pollen took place throughout the entire period of 14 weeks, while dispersal and deposition within the *Helianthus annus* / weeds plot began on the fifth week and extended towards fourteenth week.

The dendrogram at the end of the pollen diagram in figure 4 shows the groups obtained by cluster analysis. Two main groups A and B were differentiated. Abundant taxa in group A, showed a continuous pattern throughout the entire period or from the first to sixth week of observation (early). In contrast, taxa of group B, represented by *H. annus*, showed a marked seasonality between seventh and fourteenth week. Within these groups different periods were differentiated by subgroups (late). Subgroup AI includes abundant taxa in the first observations: Brassicaceae, Poaceae 35  $\mu$ m and Cheno-Ams were recorded throughout the entire period, with high values throughout the study. Anthemidae, *Lotus* and *Solanum* were present in the first period. In the study, size classes of family Poaceae allows to separate *Setaria* sp. and *Digitaria* sp. (analogous to Poaceae 25  $\mu$ m) taxa from the rest of Poaceae pollen grains. In particular, *Lotus* reaches high values during the fourth week. Subgroup AII



as high values of Poaceae 25  $\mu$ m in the fifth and sixth weeks. *Helianthus annuus* dominates in subgroup BI which comprises weeks 7 to 11 together with Poaceae de 35  $\mu$ m and Poaceae de 25  $\mu$ m. Subgroup BII comprises weeks 12 and 13 and is characterized by taxa, which showed high values at the beginning and the end of the study, such as Poaceae 35 $\mu$ m and Cheno-Ams and those present only in those weeks, like *Centaurea* and *Gnaphalium*. Subgroup BIII only consists of week 14 and is characterized by Poaceae 35  $\mu$ m, Cheno/Ams, Brassicaceae and *Ambrosia*.

#### Pollen - Vegetation relationship

In the *Helianthus annuus*/weeds environment, 8 species were identified and linked to 5 taxa at the pollen hierarchical level. The species identified were *Setaria* spp, *Digitaria sanguinalis* (polynically analogue as Poaceae 35 $\mu$ m), *Portulaca oleracea*, *Chenopodium album*, and *Amaranthus quitensis* (polynically analogated as Cheno/Ams), *Agropyron repens* (polynically analogated as Poaceae 25 $\mu$ m), *Brassica campestris* (polynically analogated as Brassicaceae) and *Polygonum convolvulus* (polynically analogated as Polygonaceae). From this plot, *Portulaca oleracea* was not recorded in

the pollen set, instead, pollen of *Polygonum convolvulus* appeared in pollen samples although it had not bloomed.

Figure 5 shows the distribution of weeks over the first two PCA axes which explains 51.36 % of the total variance. Samples 1,2,3,4, 5, 6 and 14 were placed on the third quadrant while samples 7, 12, 13 were located in first one. Samples 9, 10 and 11 were placed on the second one. Sample 8 was located on the bottom of first quadrant. In this way, towards the negative values of the axis 1, the samples that are only deposited in the site are distributed, while the dispersed and deposited in the site samples are distributed to the positive values. Although it was not possible to observe a gradient in the distribution of samples along the axes, discontinuities seem to be related to the second axis regarding intensity and duration of *Helianthus annuus*/weeds and Poaceae 35  $\mu$ m flowering phenophases. For example on the seventh week, even though every weed started its flowering did not account for *H. annuus* which started its flowering from week 8 to week 11 (Fig. 2). In weeks 12 and 13, once again Poaceae and Cheno-Ams reached high values of intensity regarding flowering.

#### POLLEN DISPERSAL AND DEPOSITION IN AN AGROSYSTEM BALGARGE - BUENOS AIRES PROVINCE - ARGENTINA

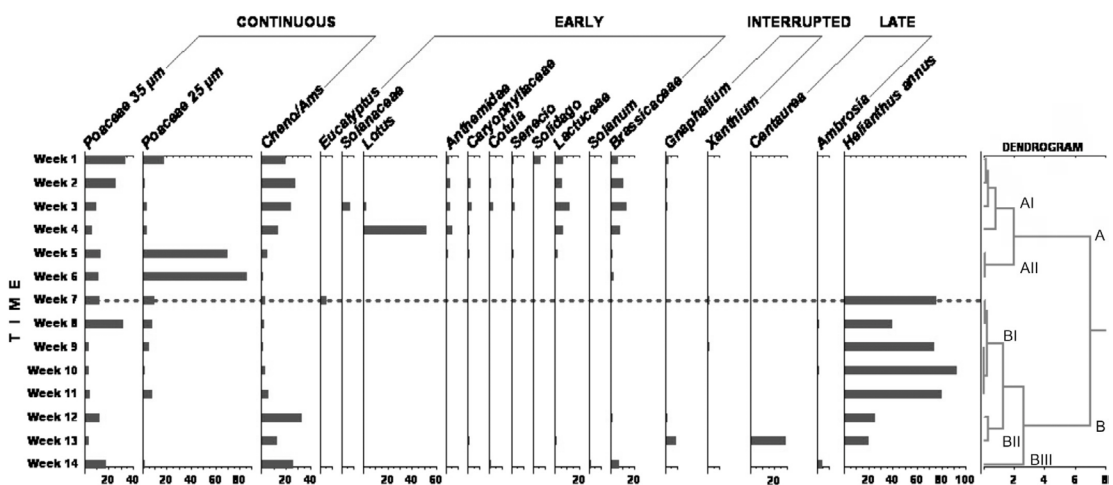


Fig. 4. Pollen diagram of taxa with relative values equal or higher than 2 % of total pollen sum. Dendrogram on the right side of the diagram shows the results of cluster analysis.



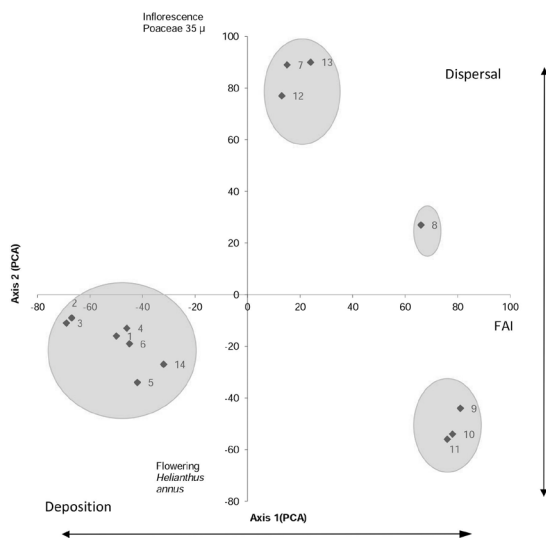


Fig. 5. Biplot of the environmental variables determined in the association of pollen - vegetation samples.

## DISCUSSION

The presence of pollen grains of dominant taxa such as Poaceae, Asteraceae and Brassicaceae in the pollen spectra generally characterizes crop vegetation in France (Brun et al., 2007). Moreover, relevés made by Alonso (1984) at southeast of Buenos Aires province and those made by Requesens et al. (1989) points out that Poaceae and Asteraceae constitute 56% of botanic families in cultivated areas. Hodgson (1986) found the same relationship for an agricultural region in Sheffield, England. From the pollen calendar we can tell that the 3 taxa are important. But Poaceae as well as Asteraceae and Brassicaceae are characteristic families of Pampean plains. This means that in these taxa we are including not also native species but also exotic ones. So, the fact of inferring an anthropogenic environment is difficult to achieve. Nevertheless, the presence of species found in the pollen record such as *Cotula*, *Xanthium* and *Centaurea*, which are exotic in Southamerica may be considered indicators of anthropic environments.

Except for *Eucalyptus* and *Helianthus annuus*, pollen types, the pollen diagram correspond to r-strategy species (generalists) of ruderals (Grime,

1979; Brun, 2011) and presented a spring- summer life cycle. For the phenological community analyses it was considered that plants comprise metapopulations (Harper, 1981). In this way individuals were represented by a set of ramets each one corresponding to a specific phenophase (Arana et al., 1985). The spatial distribution of phenophases shown in figure 3, allows us to interpret the first axis as a temporal variable through which the distribution of phenophases is determined by the life cycle of metapopulations that define the system's temporal function. In this model the cultivation does not deviate of the weed's temporal behavior, where both phenophases are synchronized indicating complementation in the use of time resources.

The pollen diagram (Fig. 4) showed that the *Helianthus annuus* /weeds system was exposed to deposition of pollen combination of different origin (Table 1). Weeds abundant in the environment were well represented in the pollen record all along the cultivation period. Moreover, *Portulaca oleracea* was not recorded because its flowers are cleistogamous under reduced light intensity (Miyanishi & Cavers, 1984). It should be noted that the high values reached by *Lotus* sp. is due to the fact that this is abundant species in *Paspalum quadrifarium* grasslands, frequent in the region (Ortega et al., 2000).

The sample's spatial distribution shown on figure 5 could be interpreted towards the origin of the pollen type (Table 1). Thus, in the third quadrant, samples formed by local and regional pollen types with low foliar area index (FAI) and pollen dispersed during dominant vegetative phenophases were placed (samples 1,2,3,4,5 and 6) or senescent (sample 14). First quadrant (samples 7, 12, 13) were located in groups whose pollen contribution was mainly from the study parcel due to Cheno-Ams and Brassicaceae and in less proportion local and regional pollen grains. Samples 9, 10 and 11 are placed on the second quadrant of the figure. In this case airborne pollen was originated entirely by the parcel plants, coinciding with the cultivation flowering phenophase and maximum FAI. Sample 8 was located on the 1<sup>st</sup> quadrant of the figure. At this time the whole system was in flowering process, showing a maximum for weeds with high FAI. These results coincide with those of Brun et

al. (2007) who found that pollen samples collected in arable fields contain part of extra-local pollen which belong to the surrounding vegetation.

The probable origin of pollen is reflected in the spatial distribution of samples through principal component analysis (Fig. 5), where the filter effect, caused by leaves size, that affects dispersal and deposition generates, variations in the first axis. While the cultivation was developing, the leaves size, vegetation height increased as well as the FAI. This situation decreased the wind speed within the cultivation and caused particles to be transported, so sunflower plants and weeds acted as filters, slowing down pollen deposition.

Thus, variations in height and foliar area of the cultivation can explain the distortion between composition of the captured pollen set and that of airborne pollen. The second axis is associated with intensity and duration of the community flowering phenophases and would explain dispersal in the study parcel.

Considering dispersal along the three periods already described, the pollen set recorded in the second period (weeks 7 to 13) shows when sunflower reached senescence and therefore with loosing filter efficiency so that the system recovered its local dimensions.

Pollen records shown in the pollen diagram belong to species abundant in the area, with asynchronic development, thus causing overlapping of its flowering periods. Pollen belonging to those species was deposited before and after their flowering in the study site. The greatest deposition of these pollen types occur when there is no deposition in the study site. At the same time the greatest proportion of regional pollen took place at the beginning and end of the study.

The pollen diagram reflects the cyclic and microsuccessional character of the *Helianthus annuus* weeds system owing to pollen contribution of local and regional vegetation even when there was no flowering in the study site.

## CONCLUSIONS

The relationship between modern pollen and vegetation in the Ha/ w plot took into account attributes of the community's dynamic aspects

(development of the *Helianthus annuus*/crop and weeds as wells as phenology analysis). Through a cultivated parcel of 20x20 m during 14 weeks, life cycle, it was possible to evaluate structural and dynamics variables such as phenology.

It's also useful as a basis for interpretation of fossil pollen spectra in quaternary palaeoecological and archaeological studies since the pollen diagram can be compared (given the analysis scale) with deposit pollen spectra which represent many annual and seasonal cycles.

In spite of the cultivation-weed development during 14 weeks and the filter effect in pollen dispersion and deposition, it was possible to identify an anthropic landscape. Therefore, the presence of indicators such T. Lactucaceae, *Carduus*, *Lotus* in quaternary sediments would evidence land use.

The study of vegetation, phenology and airborne pollen in an agroecosystem of Buenos Aires province provided important information to interpret past pollen assemblages and leads to the following conclusions:

1. The pollen diagram showed distinctively three periods that reflected the dynamics of *Helianthus annuus*/weeds community.

2. Lactucaceae, *Carduus*, *Centaurea*, *Cotula*, *Lotus* are pollen indicators, of cultivated areas in SE of Buenos Aires Province could be identified.

This study had important implications for defining modern vegetation of arable fields according to their qualitative pollen representation and displayed analogues for comparison with fossil pollen.

This analysis is a first approach to the problem. However, future results would be expected with the addition of meteorological variables such as wind, precipitation, measurement of FAI, capture devices at cultivation height.

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