



Comparative Study of Airborne Pollen from the Northern to the Southern of Tunisia

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Authors' contributions

This work was carried out in collaboration among all authors. Author SHH designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors ABD and AL managed the analyses of the study. Author MM managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aerobiology is a multidisciplinary science dealing with biological particles in the atmosphere generated by natural activities during flowering season. Airborne pollen is now the main studied biological structure which is used as a reliable tool to study plant phenology, plant distribution changes and prediction of crop production. The main aims of this work is to determine the distribution of the different spring flowering species from the North to the South of Tunisia and to establish the pollen spectrum of three regions Mornag (North), Menzel M'hiri (Centre) and Chaal (South) in 2017.

Airborne pollen data were collected using three volumetric Hirst-type spore traps placed in Mornag (36°39N; 10°16E), Menzel M'hiri (35°38N; 10°41E) and Chaal (34°34N; 10°19E) during olive flowering season. The highest pollen index was recorded in the north (Mornag, 6487.1) corresponding mainly to 18 different pollen types emitted by anemophilous species with an important presence of *Cupressus* pollen type having the highest contribution. Lower pollen amounts were recorded in Menzel M'hiri (5983.8) and Chaal (925.3). *Olea europoeae* was the most presented

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pollen type in these regions. However comparing the different study sites we can note a large distribution of some taxa from north to the south. The main common taxa were *Olea europaea*, Cupressaceae, Poaceae and Amaranthaceae. Their atmospheric concentrations varied also between the regions. Individual pollen index showed a sharp heterogeneity between the taxa in the same region in one hand and between the study sites in the other hand, thus a statistical analysis was performed to define the main group of taxa according to their individual pollen index. Flowering phenology of the main common taxa was also established.

Keywords: Airborne pollen concentration; pollen types; meteorological parameters; taxa.

1. INTRODUCTION

Atmospheric pollen data is being an important asset in aerobiological studies providing information about in one hand vegetative cover and plant phenology and in the other hand about eventual environmental changes since airborne pollen is deeply affected by environmental conditions [1,2,3,4]. Pollen studies are also used for agronomic purposes in predicting annual plant yield [5,6,7]. In fact, airborne pollen is one of the main reason for bad air quality since it causes respiratory diseases and allergy for human thus monitoring atmospheric pollen content is an important additionally to its initial role as an important issue for human health and respiratory diseases treatment by studying pollen sources and pollen calendars [8]. However aeropalynological studies are now including several disciplines monitoring plant phenology, plant production and climatology [9]. In Aeropalynology, it is known that the relationship between airborne pollen and vegetation depends on a number of factors, such as the pollen production of individual species, pollen dispersal (depending on the pollen aerodynamic features and atmospheric conditions) and the spatial distribution of the vegetation around the sampling site [10]. Therefore, the aerobiological properties of an area depend on multiple factors such as vegetation, environmental conditions, topography and atmospheric dynamics [11].

Otherwise, airborne pollen concentrations fluctuate considerably from year to year and from a region to another. Currently, it has been reported that these fluctuations are generated mainly by exogenous factors such as temperature and water availability [12]. Thus, a dynamic process will be set up reflecting an unstable ecosystem. Understanding how these factors interact with airborne pollen becomes an important asset to forecast airborne pollen concentrations and to evaluate the effects of climate change [13].

Several techniques were developed for aerobiological studies starting with gravimetric methods using Petri dishes providing confused pollen data with very limited information and nowadays we have more exact methods using pollen sensors which can provide reliable data about atmospheric pollen that can be used to study flora distribution, biodiversity, to establish pollen calendars and perform statistical analysis making relationships between biological data and climatic data. Several authors are using pollen data as a bio indicator of climatic changes using long data base series [14]. This work aims to compare airborne pollen content in three regions of Tunisia and to follow flowering phenology of the main plant species in these study areas using pollen data.

2. MATERIALS AND METHODS

From March to May in 2017 three volumetric Hirst-type traps model Lanzoni VPPS-2000 (Fig. 1) were placed in different monitoring stations in Northern of Tunisia, Mornag (36°39N; 10°16E), in the center Menzel M'hiri (35°38N; 10°41E) and in the South, Chaal (34°34N; 10°19E) at 20 m above the ground level. The sampler consists of an electronic pump aspirating a known volume of air (10L/min) through an entrance orifice measuring 14*2 mm. All the air particles are projected on an adhesive surface (Melinex tape) fixed on a cylindrical piece (drum). The drum is driven with a clockwork mechanism enabled it to rotate 2 mm/hour thus ensuring continuously a sampling time of 7 days [15]. From weekly tapes daily slides were prepared following the standard methods accepted by the Spanish Aerobiology Network [16]. The Melinex tape is then cutted into 7 portions measuring each one 48 mm corresponding to 24 hours of sampling. Pollen samples are also stained by the fushin-stained glycerin gelatin. Daily pollen concentrations were established using light microscopy (Leica DM/L) and expressed as pg/m³ of air. Pollen grains were identified as species (i.e. *Mercurialis*

annua), genus (i.e. *Cupressus*), family (i.e. Poaceae) or type (i.e. Amarnathaceae).

Statistical analyses were performed using SPSS statistical software (IBM version 20) to determine the dominance of taxa in each site. The pollen

season of the main taxa in the different studied areas is also defined using the 95% method omitting the 5% of the total pollen amount at the beginning and 95% at the end of the pollen season considering cumulative daily pollen concentrations [17].

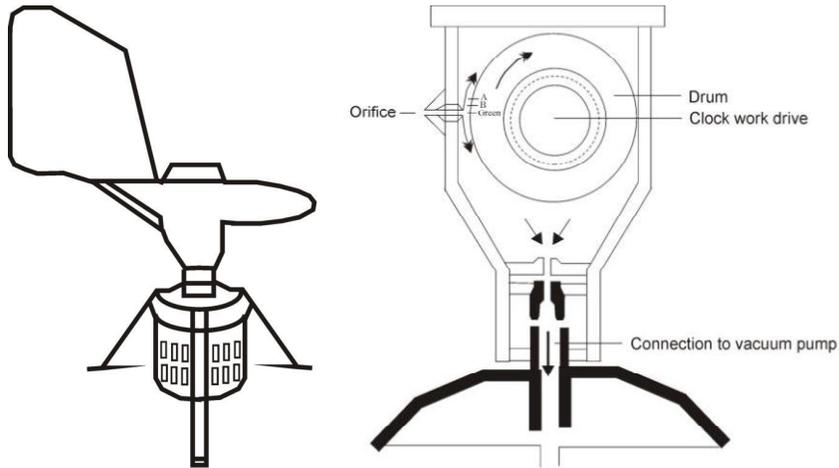


Fig. 1. Volumetric Hirst-type trap model Lanzoni VPPS (2000) (Hirst. 1952)



Fig. 2. Monitoring sites during the studied period in Tunisia

3. RESULTS

3.1 Meteorology

The studied regions are characterized by a Mediterranean climate. Mornag is a semi-arid region with an annual precipitation of 450 mm. The mean temperature is about 18.5°C. In the region of Menzel M'hiri and Chaal the climate is arid and water is less available. Annual precipitation didn't exceed 200 mm and the average of temperature is about 18.5°C. During the studied period we have recorded a general decrease of precipitations with an annual average of 265 mm in the north and the rainy months was December and January when we have recorded respectively 80 and 55 mm. Equally in Menzel M'hiri and Chaal the mean of precipitations decreased sharply to be limited to 250 and 117 mm annually. The highest precipitations were recorded in December. In the other hand an increase of the mean temperature was observed to have an annual average of 22.5°C in Mornag and 23°C in Menzel M'hiri and Chaal.

3.2 Pollen Data

Microscopic analysis showed a total pollen index (PI) 6487.1 corresponding to 18 different pollen types from anemophilous species in the region of Mornag. Lower atmospheric pollen amounts was recorded in Menzel M'hiri and Chaal. They are respectively 5983.8 and 925.3. In Mornag, *Cupressus* pollen type represented 66% of the total sampled pollen quantity. However *Olea europaea* was the most abundant pollen type in Menzel M'hiri (> 90%) and Chaal (83%). The identified pollen types were classified into different groups according to their relative airborne abundance. The analyze of variance performed with the main pollen type scores showed the groups presented in Table 1. The comparison between the studied sites showed a higher number of taxa identified in Mornag and some of them were also present in Menzel M'hiri and Chaal with different atmospheric pollen concentrations. It is the case mainly of trees (*Cupressus*, *Pinus*, *Cedrus*, *Olea europaea* and *Palmea*) and herbaceous plants (Amaranthaceae, Poaceae, Urticaceae).

Additionally to the variations of their airborne pollen concentrations notable patterns were also observed in the flowering phenology of these taxa between the studied regions. The Table 2 summarizes the different phenological stages the

common identified species during their flowering season. In fact an early start of flowering of the dominant taxa in the center and the south of Tunisia (Menzel M'hiri and Chaal) few days later at Mornag. Airborne pollen of *Cupressus*, *Chenopodiaceae*, *Poaceae* and *Urticaceae* was more abundant in the north with higher pollen indexes. However, their presence in the atmosphere was limited at Menzel M'hiri and Chaal. Contrary to *Olea europaea* pollen type which had the highest pollen production at Menzel M'hiri and less important at Chaal and Mornag.

4. DISCUSSION

Studying airborne pollen content provides important information about the vegetative cover and flore distribution between different regions and may be a reliable tool for monitoring flowering phenology. The collected data from the atmosphere in three regions showed that Mornag had the highest pollen index contributed mainly to *Cupressus* pollen with an important pollen amount. Less total pollen amount was collected in Menzel M'hiri and Chaal and *Olea europaea* was the major pollen type. This limited pollen production is probably caused by the rainfall regime of these regions [18]. Nevertheless historical pollen data found by [19] showed higher pollen amount recorded in Mornag in 2011- 2012 when we had sufficient water availability for pollen production. Thus a decrease of water availability is a major limiting factor of pollen production [20]. Despite the critical conditions some plant species were able to grow and overcome difficult environmental conditions particularly the limited water availability. In our study *Cupressus*, *Olea europaea*, *Poaceae* and *Amaranthaceae* were present in all the studied areas and there airborne pollen concentrations were also different from the North to the South according to in one hand to pollen production and in the other hand to the abundance of each plant species. Garcia-Mozo et al. [21] and Oteros et al. [22] confirm that airborne pollen concentrations strongly correlate with flowering intensity of wind-pollinated species growing at and around monitoring sites and the pollen spectrum is determined by land use and its changes and that airborne pollen concentrations depend on the spatial distribution of vegetation and on the pollen production of individual species. Equally Cariñanos et al. [23] reported that *Amaranthaceae* resist to extreme environmental conditions and grow in different type of soil.

Table 1. Analyse of variance of the main identified taxa in the studied regions to define the different groups

Mornag	Pollen index	Pollen types
Dominant Taxa	>160	<i>Olea europaea-Cupressus</i>
Secondary Taxa	65.64≤PI≤160	<i>Querus-Urticaceae-Amaranthaceae -Poaceae-Morus-Mercurialisannua</i>
Minor Taxa	18.94<PI≤65.74	<i>Pinus-Palmeae-Plantago-Casuarina-Brassicaceae</i>
Rare Taxa	PI≤18.94	<i>Asteraceae-Erica-Euphorbiaceae</i>
MenzelM'hiri	Pollen Index	Pollen Types
Dominant Taxa	>114.5	<i>Olea europaea</i>
Secondary Taxa	114.5<PI<33.82	Poaceae
Minor Taxa	10.8<PI<33.82	<i>Cupressus-Urticaceae-Ricinus-Amaranthaceae</i>
Rare Taxa	≤10.8	<i>Palmeae-Quercus-Fagus-Cedrus</i>
Chaal	Pollen Index	Pollen Types
Dominant Taxa	>50.28	<i>Olea europaea</i>
Secondary Taxa	15.39<PI<50.29	Poaceae-Cupressus
Minor Taxa	6.46≤PI<15.39	Amaranthaceae
Rare Taxa	<6.46	<i>Urticaceae-Palmeae-Cedrus-Pinus</i>

Table 2. Main pollen season definition of the dominant taxa and their flowering features

Mornag	SD	PI	PP	ED	PSD
<i>Olea europaea</i>	92	815.8	531.24	123	31
<i>Cupressus</i>	75	4228.2	2256.8	103	23
Amaranthaceae	85	111.34	31.9	120	35
Poaceae	96	280.06	142.8	124	28
MenzelM'hiri	SD	PI	PP	ED	PSD
<i>Olea europaea</i>	83	5730.74	2803.6	107	24
<i>Cupressus</i>	83	29.6	16.34	113	30
Amaranthaceae	96	36.2	23.56	120	24
Poaceae	96	123.5	71.06	115	23
Chaal	SD	PI	PP	ED	PSD
<i>Olea europaea</i>	86	768.4	438.2	107	21
<i>Cupressus</i>	92	17.1	11.78	114	22
Amaranthaceae	92	7.98	4.56	117	25
Poaceae	91	68.78	11.7	34	57

SD: Start Date, PI: Pollen Index, PP: Pollen Peak, ED: End Date, PSD: Pollen Season Duration

Flowering phenology of these taxa varied also between the regions. *Olea europaea* flowering season starts early in Menzel M'hiri and Chaal with a short pollen season duration and later in Mornag with a longer period of flowering. In this concern, Fornaciari et al. [24] reported that hot periods at the onset of flowering favour the release of pollen from anthers and may lead to a shorter pollen season. Trigui et al. [25] have established the cultivars distribution of *Olea europaea* from the north to the south thus the difference in the start date of flowering even the intensity of flowering may be attributed to genetic factors in response to their requirements [18]. However *Cupressus* and *Amaranthaceae* pollen season starts early in Mornag where they are more abundant. In Menzel M'hiri and Chaal

their flowering season was less intensive and starts later. These observations may be explained by their limited presence in the studied agrosystems. Poaceae family is presented by different plant species. This group is presented by 620 genera and 10000 species worldwide [26]. In our study grass has the same start date of flowering season in Mornag and Menze IM'hiri with different flowering intensities in the studied sites. Nevertheless in Chaal Poaceae pollen type still for a long time coinciding with an earlier pollen season start date present in the atmosphere corresponding to different species with different flowering phenology. Similar finding were cited by Fernandez Rodriguez et al. [27] and Garcia et al.[14]. This long presence can be also caused by a resuspension of grass pollen.

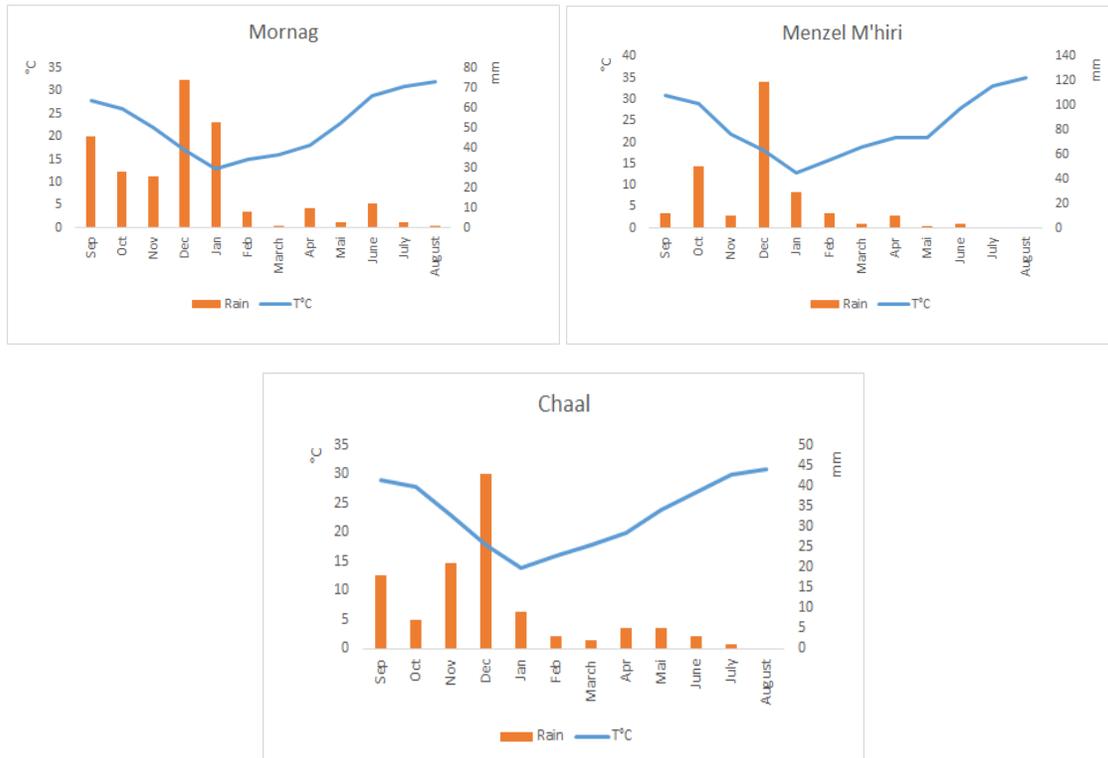


Fig. 3. Main meteorological parameters (mean temperature and rainfall) in the studied regions

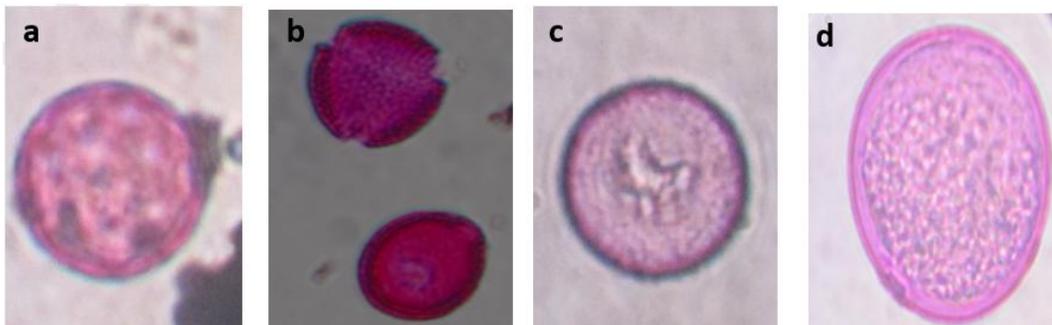


Fig. 4. Main common pollen types identified in the three regions (a) *Amaranthaceae*, (b) *Olea europaea*, (c) *Cupressus* and (d) *Poaceae*

5. CONCLUSION

Airborne pollen was studied in three regions of Tunisia presenting the North, the Center and South. Higher biodiversity was recorded at Mornag and mainly 18 different pollen types were identified with a sharp dominance of *Cupressus* pollen type presenting 66% of the total collected pollen quantity. *Olea europaea* is the second dominant pollen type. *Poaceae*, *Amaranthaceae*, *Urticaceae* and *Mercurialis annua* had also an important contribution in the

Northern region. Nevertheless the atmospheric pollen concentration of these taxa decreased at Menzel M'hiri and Chaal. Higher pollen quantity of *Olea europaea* was recorded in the Center and in the South comparing to *Cupressus* pollen amount in the North. Flowering features of the *Cupressus* and *Olea europaea* showed a clear variability between the study regions in relations with the regional climatic conditions particularly water availability affecting mainly pollen production and mean temperature that determine the temporal limits of the main pollen season.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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