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# Variations and origin of the atmospheric pollen of *Cannabis* detected in the province of Tetouan (NW Morocco): 2008–2010

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## HIGHLIGHTS

- The incidence of Cannabis pollen in the atmosphere of Tetouan (Morocco) is studied.
- The data obtained could serve as an indicator of the cultivation of this species.
- The Cannabis pollen levels could be clinically important for allergic patients.

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## ABSTRACT

*Cannabis*, also called marihuana or hemp, is a wind-pollinated plant that produces hundreds of flowers on large inflorescences. It is also one of the oldest psychoactive plants known to humanity. Morocco has become one of the main producers of *Cannabis* resin (hashish), primarily supplying the European market. The aim of this paper is to ascertain whether the atmospheric monitoring of *Cannabis* pollen can play a role, from a criminological point of view, in the surveillance of *Cannabis* cultivation in the area of Tetouan (NW Morocco) as well as to estimate pollen emission so that the sensitive population can be warned about the allergic diseases that its pollen can cause.

Aerobiological samplings were made with the aid of a Hirst type volumetric trap (Hirst, 1952), which worked uninterruptedly during a 3-year period (2008–2010) according to the methodology proposed by the Spanish Aerobiology Network, the REA.

*Cannabis* pollen was present in the atmosphere of Tetouan mainly from early April to late August, a period in which about 95% of the annual counts were registered. The highest levels were detected in June and July, with concentrations more or less evenly distributed throughout the day with slight increases of 5% between 12:00 and 16:00 h. The strong association between skin test reactivity, respiratory symptoms, and pollination period found by other authors, together with the levels registered, suggests that *Cannabis* pollen could be a clinically important aeroallergen for sensitive patients. On the other hand, the data obtained could serve as an indicator of the cultivation activity of this species and should be taken into account by the state authorities since they provide strong evidence of the existence of *Cannabis* crops in the region of Tetouan.



## 1. Introduction

Marihuana, *Cannabis*, or hemp is one of the older psychoactive plants known to humanity. Some botanists recognize three species belonging to the genus *Cannabis*: *Cannabis sativa* L., *Cannabis indica* Lam. and *Cannabis ruderalis* Janish. (Grinspoon and Bakalar, 1993) while, for others, the last two are subspecies of *C. sativa*. Whatever the case, the first mentioned species is the most abundant in northern Morocco. It is a wind-pollinated plant that produces hundreds of flowers on large inflorescences, a single flower producing about 350,000 pollen grains (Faegri et al., 1989).

Morocco has become one of the main producers of *Cannabis* resin (hashish), supplying primarily the European market. In the past twenty years, *Cannabis* cultivation has spread from the traditional areas in the central Rif, where it had been grown since the fifteenth century, to new areas. This expansion is often at the expense of forested areas, as well as of the best arable and irrigated land, thus contributing to soil erosion and disappearance of licit agriculture. In 2003, the first survey conducted by the Government of Morocco and the United Nations Office on Drugs and Crime (UNODC) attempted to measure the size of the phenomenon. This study estimated *Cannabis* cultivation at about 134,000 ha in a total area of 14,000 km$^2$, covering five provinces, with

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86% of the *Cannabis* cultivated in three of them: Chefchaouen (50%), Taounate (19%) and Al Hoceima (17%), while the provinces of Larache (9%) and Tetouan (5%) only played a secondary role in *Cannabis* cultivation (UNODC, 2003).

In subsequent years, the UNODC surveys revealed a decline in cultivation to 72,500 ha in 2006 (UNODC, 2006) and to 60,000 ha in 2008 (UNODC, 2008), a reduction of 55% compared with 2003, as indicated by the Moroccan Interior Ministry. The most important decreases were in the provinces of Al Hoceima (−54%) and Taounate (−43%) while a smaller fall was noted in the province of Larache (−1%). These decreases are attributed to outreach activities by the local administration. However, *Cannabis* cultivation increased significantly in the provinces of Tetouan (+19%) and Chefchaouen (+13%).

The aim of this paper is to ascertain whether the atmospheric monitoring of *Cannabis* pollen can play a role, from a criminological point of view, in the surveillance of *Cannabis* cultivation, not only in the area of Tetouan but also at a global level, in other areas wherein *Cannabis* is cultivated. In this way, we can either confirm that the drug control policy has put an end to the cultivation of *Cannabis* or, if not, the geographical origin of the crops can be identified. The importance of studying *Cannabis* pollen dispersion in the air of Tetouan is not only to help control the illicit cultivation of *Cannabis*, but also to estimate pollen emission in order to warn the sensitive population about the allergic diseases that its pollen can cause (Sáenz, 1978; Lewis et al., 1983), as occurs in Pakistan (Sadiq et al., 2007), India (Singh and Kumar, 2003) and several regions of North America, where hemp is widely grown (Maloney and Brodkey, 1940; MacQuiddy, 1955; Freeman, 1983; Stokes et al., 2000).

## 2. Material and methods

The city of Tetouan is located in the eastern sector of the Tingitane Peninsula (NW Morocco, 35°34′N; 5°22′W), in the Thermomediterranean belt, at an altitude of 65 m a.s.l. (Fig. 1). Climatic conditions are predominantly Mediterranean warm subhumid (Benabid, 1982), with an average annual rainfall of 728 mm, and annual mean temperature of 18.2 °C. It is situated between two mountain ranges, one located to the northwest (the Haouz-Ghorghiz) and the other one to the southeast (the Rif range), which determines that the prevailing winds are those blowing from the northeast (the coastal zone) and southeast (inland) (Fig. 2).

Aerobiological samplings were made with the aid of a Hirst type volumetric trap (Hirst, 1952), a seven-day recorder model by Burkard™, situated on the flat roof of the Department of Biology of the Faculty of Science (University Abdelmalek Essaâdi), 15 m above ground level, in an open area with no nearby buildings that could obstruct the free air circulation. The pollen trap was uninterruptedly kept operational from 1 January 2008 to 31 December 2010, aspirating a flow of 10 l/min. Pollen counts were made by means of a light microscope, 4 longitudinal sweeps per slide being made, using a ×40 objective (0.45 mm microscopic field), according to the methodology proposed by the Spanish Aerobiology Network, the REA (Galán et al., 2007). Samples were always counted by the same operator, the pollen concentrations being expressed as the number of pollen grains/m$^3$ of air. The mean daily values were used for elaborating tables and figures.

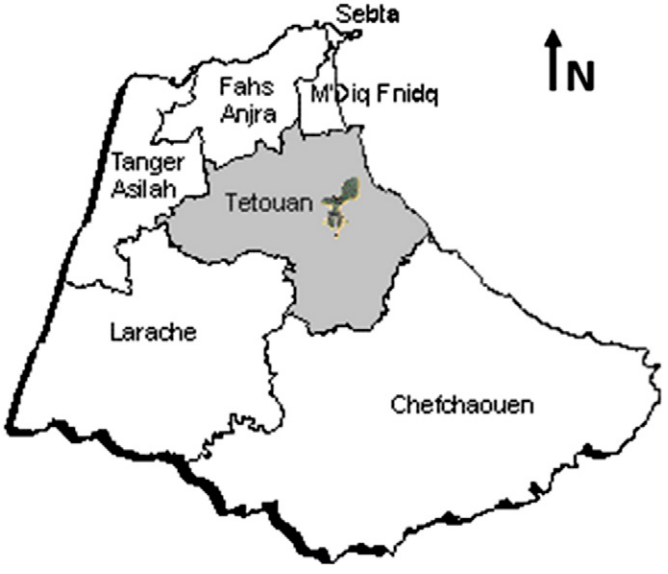


**Fig. 1.** Location of the sampling site, in Tetouan, Morocco.

The main pollen season (MPS) was calculated as described by Andersen (1991). This season represented 95% of the annual total, beginning on the first day in which the cumulative daily count reached 2.5% of the annual figure (calculated from the 1st of January), and finishing on the day in which 97.5% of the annual total had been reached. In order to establish the intradiurnal variations, only rain-free days when the mean daily pollen concentration equalled or exceeded the mean for the MPS were taken. For calculating the Intradiurnal Distribution Index (IDI), the methodology proposed by Trigo et al. (1997) was followed. This index ranges from 0 to 1, depending on the difference between the minimum and the maximum daily concentration values. The graph shows the 2-hour cumulative percentages.

Finally, in order to identify the influence of the main meteorological parameters on pollen concentrations, a statistical analysis was performed using Spearman's correlation test. The meteorological data were provided by an automatic meteorological station located in the Physics Department of the Faculty of Sciences, where the pollen trap was installed. To better study the influence of these meteorological parameters on pollen concentrations, the MPS was divided into pre-peak and post-peak periods in the case of temperatures, since temperatures tend to increase as the MPS progresses, as do pollen concentrations during the pre-peak period. However, during the post-peak period, the pollen counts tend to decrease, while temperatures continue to rise. The pre-peak was defined as the period running from the beginning of the pollen season to the peak day. On the contrary the post-peak is the period that goes from the peak-day to the end of the pollen season.

The meteorological parameters included in the analysis were: air temperature (medium, maximum and minimum daily values), relative humidity (mean, maximum and minimum daily values), daily rainfall, wind speed (mean and maximum daily values), daily wind percentage from the four quadrants (NE, SE, SW and NW) and percentage of calms.

Finally, in order to statistically compare the results obtained for pollen in the different years of study, a Kruskal–Wallis rank classification was made. This is a useful tool when there are more than two independent samples, to know if they come from the same population or from populations with the same average values. As the test result was significant for $p \leq 0.05$, we made an a posteriori test to look for the reasons for the significance found. For this, we used the Mann–Whitney U-test. These tests are a good alternative to parametric test such as ANOVA or *t*-test, when the data (as in our case) do not present normal distribution (Martín Andrés and Luna Castillo, 1995; Sokal and Rohlf, 1995; Siegel and Castellán, 1995; Toro et al., 1998). The same statistical analysis was carried out in the case of mean temperature and rainfall, the two main meteorological parameters that affect pollen concentrations. The normality was checked by means of the test of Kolmogorov–Smirnov.

## 3. Results

### 3.1. Seasonal distribution

*Cannabis* pollen presented an annual pollen index (annual sum of the daily means) of 1862, on average, during the studied period. It is the 5th pollen type in the order of abundance in the atmosphere of Tetouan, representing 4% of the annual total. The highest value (2841) was registered in 2008, while in 2009 and 2010 this annual index showed values of 1436 and 1237, respectively, with a decrease