British Journal of Medicine & Medical Research
14(7): 1-15, 2016, Article no.BJMMR.24644
ISSN: 2231-0614, NLM ID: 101570965

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Airborne Weed Pollen in Relation to Allergic Rhinitis in Riyadh, Saudi Arabia

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Authors' contributions

This work was carried out in collaboration between all authors. Author SMH contributed in analysis of data, manuscript writing and data presentation. Author AA contributed in reading slides, calculation, data analysis, writing and references. Author ASAM managed the project, obtained fund approval, participate review and discussion. Author MOM contributed in site selection, management of the trap operation, coordinating project purchasing, review and discussion and author AAF contributed in manuscript review, advice, guidance of the project and allergens data. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJMMR/2016/24644
Editor(s):
(1) Syed Faisal Zaidi, Department of Basic Medical Sciences, College of Medicine, King Saud Bin Abdulaziz University-HS, National Guard Health Affairs, King Abdulaziz Medical City, Kingdom of Saudi Arabia.
Reviewers:
(1) Bozena Denisow, University of Life Sciences in Lublin, Poland.
(2) Diego Saporta, USA.
Complete Peer review History: http://sciencedomain.org/review-history/13752

Original Research Article

Received 28th January 2016
Accepted 3rd March 2016
Published 18th March 2016

ABSTRACT

Aims: The study was conducted to investigate the frequently encountered allergenic pollen grains in the environment of Riyadh, Saudi Arabia as well as to determine their seasonal and annual growth pattern in the region.
Study Design: Volumetric air sampling of two City sites with qualitative and quantitative comparison of data on seasonal and diurnal concentrations of weed pollen aeroallergens.
Place and Duration of Study: The work was conducted in the capital City of Riyadh, Saudi Arabia

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and the sampling was conducted for a continuous 12 month period from January to December 2012.

Methodology: Using two Burkard 7-Day Volumetric Air Sampler, airborne pollen grain for two sites in Riyadh City (City Center site in the middle of City) and Riyadh airport site (40 km away from the city) was studied. The data were collected for at least 12 months period in both sites.

Results: The pollen grains from grasses, weeds and trees were identified. However, the weeds pollen dominated the pollen flora by a ratio of 70% followed by trees 20%, and grasses 10%. The major weeds pollen identified were: *Amaranthus viridis, Artemisia monosperma, Atriplex nummularia, Chenopodium murale, Plantago boissieri, Ricinus communis, Rumex vesicarius* and *Salsola imbricata.* Riyadh City Center site constituted higher percentage of total weeds (69%) compared to Riyadh airport site (31%).

Conclusion: Seasonal periodicities of major allergens, reveal a trend that would help allergists and allergic patients for diagnosis and prevention.

Keywords: Aeroallergens; pollen grains; weed pollen; allergy; asthma; allergic rhinitis; airborne allergens.

1. INTRODUCTION

Airborne biological particles include a large number of anemophilous (wind pollinated) pollen grains from grasses, trees and weeds, fungal spores and many other biological fragments which are considered to be responsible for the common respiratory allergies diseases especially Allergic Rhinitis (previously known as pollinosis or hay fever), rhino-conjunctivitis, conjunctivitis, Allergic-Bronco-Pulmonary-Aspergillosis (ABPA), aspergilloma and bronchial asthma. However, Allergic Rhinitis, particularly the seasonal rhinitis is very much linked to the seasonal appearance of various pollen grains in the environment. A massive exposure or with low levels but prolonged exposure may result in sensitization (development of IgE specific antibodies) in susceptible (genetically predisposed) individuals. Individuals sensitized with allergenic weeds pollen, generally manifest type I allergy (immediate manifestations with sneezing, wheezing and running nose etc.). In Saudi Arabia, a two-fold increase in the prevalence of allergic rhinitis as well as bronchial asthma has been recorded within a 9 year period [1]. Pollen grains are considered to be one of the main causes of allergic rhinitis [2] and sensitization can take place by exposure to any group of airborne pollen (grasses, trees and weeds) [3].

The allergenic pollen grains vary according to weather conditions and geography [2]. Globally, grasses are major aeroallergen sources worldwide (e.g. *Cynodon dactylon*; Bermuda grass) [4]. In Europe the major pollen allergens are Grass pollen [5], and Euro-Asia country, Turkey, most common pollen were cereal pollen followed by the grass pollen [6]. In Mexico, the tree pollen dominated the airborne pollen flora of the country [7], while in desert Gulf countries, the weed pollen grains were recorded in abundance [8]. Weed pollen is considered to be a highly allergenic pollen worldwide [9]. Limited publications from Riyadh indicate that grass pollen mainly Poaceae constituted only 10% of the total pollen trapped. In contrast, tree pollen particularly (*Prosopis juliflora, Fraxinus excelsior, Phoenix dactylifera, Morus alba* and *Olea europaea*) constituted up to 20% of total pollen in the area. However, pollen grains from weeds which require little rain and can survive in the desert and dry climate, constituted up to 70% of the total pollen trapped [10].

This paper summarizes environmental data on major weed allergens collected from the two sites in the capital city of Riyadh from January – December 2012.

2. MATERIALS AND METHODS

2.1 Sampling Locations

Sampling was conducted at two different sites, 40 km apart in Riyadh (the Capital city of Saudi Arabia) representing developed (urban) and less-developed sites. Riyadh is situated in the middle of Saudi Arabia on the eastern part of the Arabian Peninsula, at a latitude 38.24 degrees north and a longitude 43.64 degrees east. The city is located at about 600m above the sea level.

- Riyadh city center (Civil Defense): Rooftop of a Civil Defense building in the populated urban center of Olaya district (Developed area). Surrounding area at this side contain commercial buildings as well as housing complexes allowing some

environmental trees growing on roadside verges.

- Riyadh airport: Rooftop of the Meteorology and Environmental building near Riyadh airport (40 km from City Centre) located in the semi-urban region (Less-developed area). The area is surrounding with naturally growing weeds and grasses and some ornamental plant on the roadside.

2.2 Sampling Methods

The Burkard Volumetric Spore Trap (Burkard Manufacturer Company, England) is considered to be efficient instrument for outdoor air sampling and widely used in USA, Europe and Asia. The trap is a compact unit with built in vacuum pump, designed to sample airborne particles continuously for periods of seven days with one change of drum. Particles are impacted on adhesive coated transparent plastic tape supported in a clock-work driven drum. The drum moves 2 mm/hr. Therefore, a deposit/sample of 48 mm represents a day's sampling [11].

Samplers installed on the roof of the two locations, approximately 10 meters above the ground levels. The Samplers were operated at least 18 months in order to get 12 months continuous data. The sites were selected and evaluated (before installation) depending on technical aspects and geographical variations. This included availability of power supply, any horizontal building obstruction around the trap out of reach of common people and children etc. The slides were mounted with a gelvatol-phenol mixture onto a microscopic slide. Identification and counting were undertaken in 5 random fields for each alternate hours (4-mm traverse) a total of (60/24 hrs. fields). Slides were scanned at a magnification of ×400 for counting and, where necessary, ×1000 under oil immersion for identification [11,12].

2.3 Mounting and Staining Method

Gelvatol is a water soluble plastic and makes the mounting a permanent one. The samples were permanently mounted using a gelvatol/glycerol mounted as per following formula (as suggested by manufacturing company):

- 35 g Gelvatol (grade 40-20)
- 100 ml distilled water
- 50 ml glycerol (also known as glycerin) or 40 ml lactic acid
- 2 g phenol crystals

The staining of the mounting made using basic fuchsin which stains the pollen grain in bright pink color but the fungal spores remain unchanged [11].

2.4 Climate

Riyadh has hot and dry climate, warm all year round, and are extremely hot in the summer with maximum temperatures of 40 to 50℃. It has very little rainfall, making the climate extremely dry and hard for plants to survive [10, 13].

2.5 Calculation Method

Slides were scanned at X600 for counting and, where necessary, at X1500 under oil immersion for identification. 1 field of view at X600 was calculated to be 0.04 mm². 5 such fields were examined for each alternate hour of trapping; the numbers of pollen grains recorded were converted to concentration/m³ of air by applying the formula:

$$\text{Concentration} = \frac{N_T \times A_E}{n \times a \times V_a}$$

Where N_T = total number of spores in n fields of view; n = number of fields counted; a = unit area of field, mm²; V_a = air volume sampled; and A_E = total effective area, mm². The maximum concentration refers to a concentration reached by pollen at a particular hour on a particular day during a particular month. Then it was converted to conc. /m³ of air as formula presented above [14].

The mean monthly concentration (each alternate hours of the day counted).

Generally majority of pollen show a diurnal pattern and dry spora and majority of basidiospores and ascospores show nocturnal maxima. These are based on release or discharge pattern of the spores [14,15].

3. RESULTS

3.1 Interpretation of Results

- Results for major pollen type are presented under the following categories:
- Maximum concentrations of major individual types of weed allergens are presented in Figs. 1A to 8A
- Monthly mean concentrations of major individual types of weed allergens are (showing seasonal periodicities, per m^3) presented in Figs. 1B to 8B

- Diel periodicities of airborne pollen (per m^3) are presented in Figs. 1C to 8C
- Total percentage of weed pollen at the two sites is presented in Fig. 9.

Table 1 summarizes the percentages of major individual types of all pollen grains against the total pollen at the two sites. The table shows that some individual pollen types constituted higher percentage at Riyadh city center site compared to Riyadh airport site with one or two exceptions. It appears that *Salsola imbricata* pollen was much higher at Riyadh airport site compared to Riyadh city center site. This maybe because of the growth opportunities of *S. imbricata* exist more in the open area than in the city area.

There appear to be two or more seasons for *A. viridis*, as is evident from Fig. 1B; one in Feb-Mar and second in Sep-Oct. Maximum concentration approaching level 900 pollen m^3 at Riyadh city center site recorded was much higher compared to Riyadh airport ($120/m^3$). Likewise, the monthly mean concentration was higher at developed site and the diel periodicity showed a clear diurnal (day maxima) pattern at both locations.

The *Artemisia monosperma* pollen showed greater concentration in spring months. The Riyadh city center area shows higher number of pollen compared to semi-developed area. *A. monosperma* pollen displayed higher level during daytime, confirming its diurnal nature of release and dissemination.

Atriplex nummularia shows a seasonal pattern with maximum concentration ($800/m^3$) in spring. Concentration of *Atriplex* pollen during the day, lasting 4–8 hours, confirming its diurnal pattern.

Chenopodium murale was recorded with high level in the air during the low temperature months (winter). The pollen level in the air was higher during the day while very low in the night confirming its diurnal pattern.

Plantago pollen was observed in Feb and March. There was no significant difference in maximum concentration between the Riyadh city center and Riyadh airport sites. Diel periodicity confirming its diurnal pattern release. The high occurrence period for *p*ollen was during the morning and in the afternoon.

Ricinus communis pollen reached their highest levels in winter, particularly in November. Riyadh city center site showed higher concentration from October to January while the Riyadh airport site pollen was recorded in November only. Seasonal pattern revealed spring with comparatively higher pollen level while the diel periodicity was recorded to be diurnal.

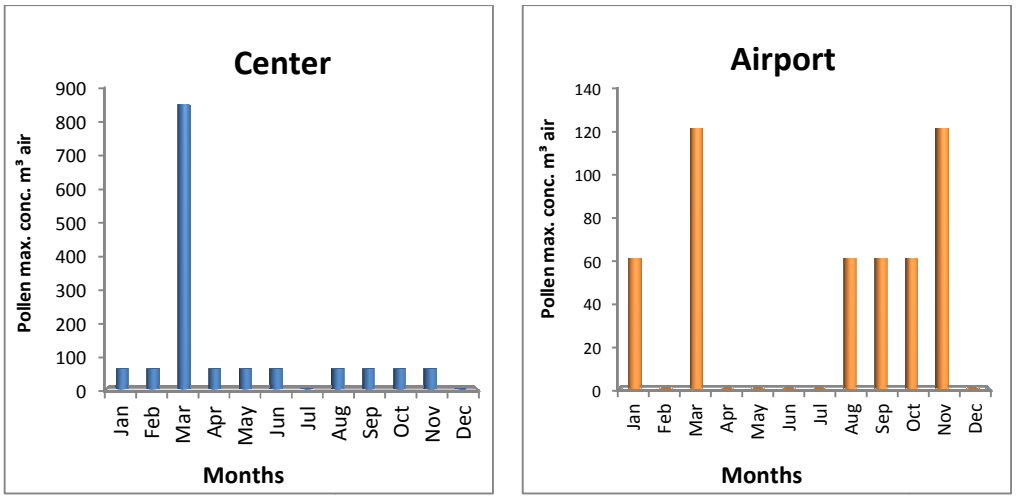
The *R. vesicarius* pollen was recorded more frequently from April to July at both sites but comparatively with higher concentration at developed site. An early morning to early evening pattern confirms the diurnal pattern of release.

Salsola imbricata displayed a similarity at the two sites with one exception of maximum concentration which was recorded higher at less developed site ($200/m^3$) than the developed site ($140/m^3$). However, for monthly mean and diel periodicity continued to be approximately equal at both sites. *S. imbricata* is also a diurnal pollen type.

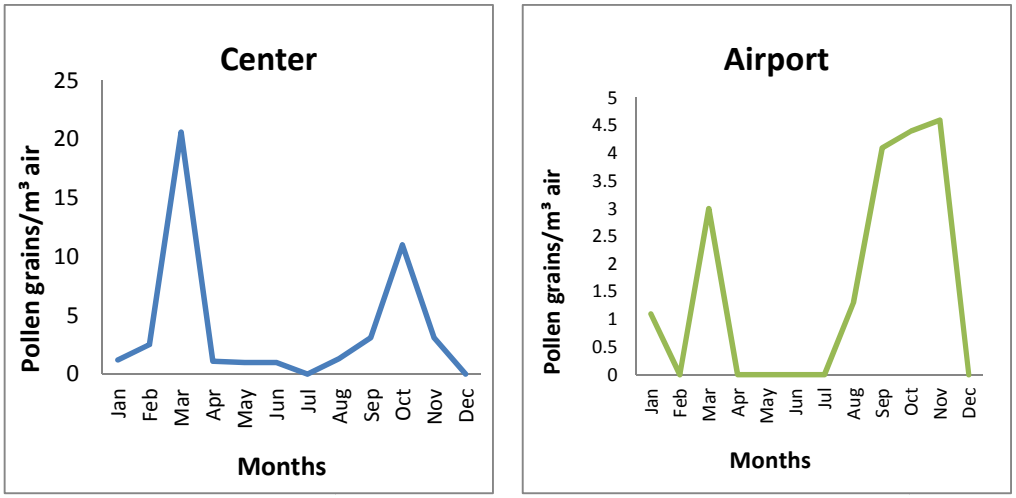
Table 1. Percentage of major individual pollen type amongst the total pollen counted

Type of pollen	Riyadh city center site %	Riyadh airport site %
Amaranthus viridis	17.4	15.4
Artemisia monosperma	8.3	7
Atriplex nummularia	11.3	9.8
Chenopodium murale	8.5	5.4
Plantago boissieri	6.4	5.1
Ricinus communis	4	2.8
Rumex vesicarius	4.5	3.1
Salsola imbricata *	6.4	13.4
Other minor types	4	3
Grass pollen	10.25	8.9
Phoenix dactylifera	4.3	5.1
Prosopis juliflora	7.3	7.8
Salix sp.	1.4	2
Conocarpus sp.	2.4	3.2
Fraxinus excelsior *	2.6	4
Other minor types	1	4.8

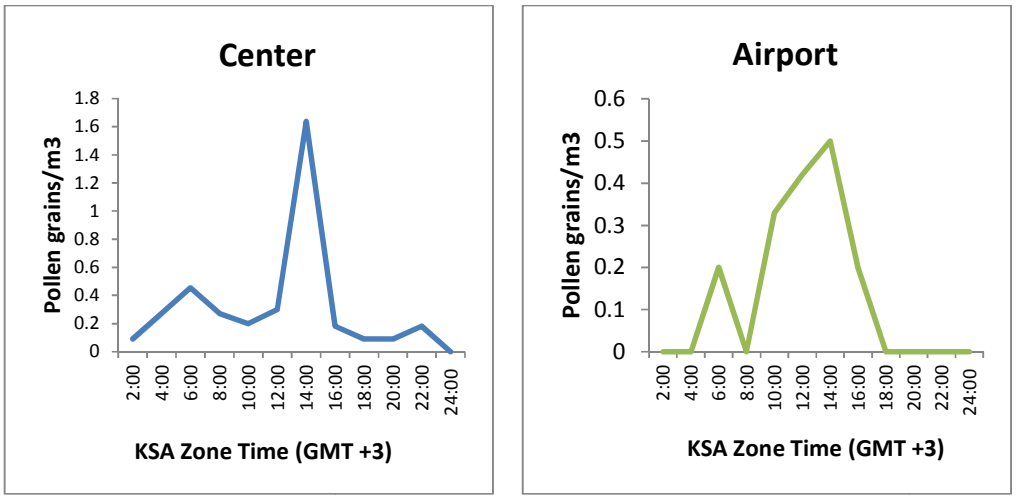
** This weed pollen comparatively higher at Airport than the Center site*



(A) Maximum concentration

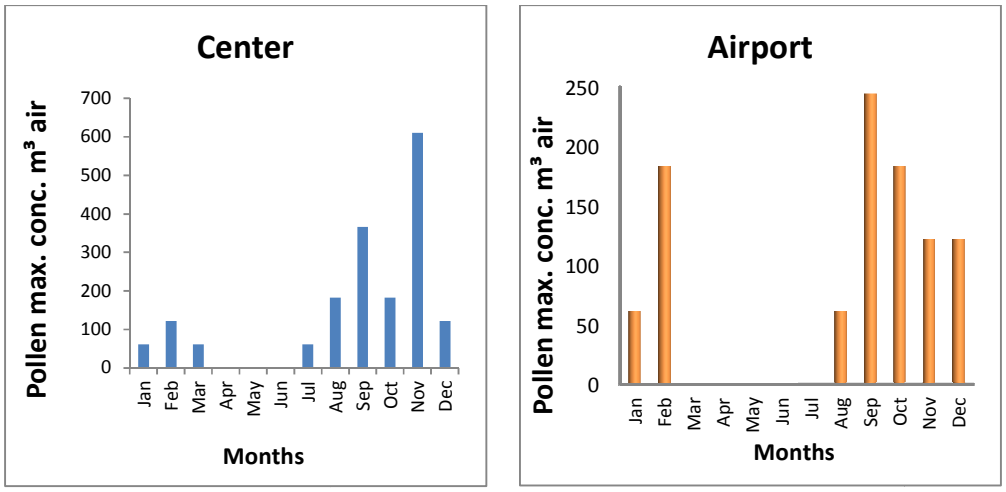


(B) Monthly mean concentration

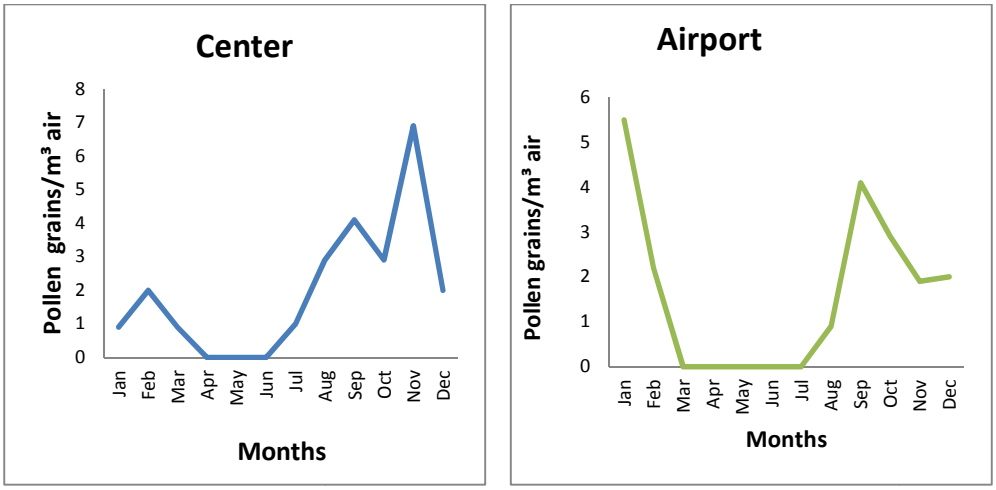


(C) Diel periodicity

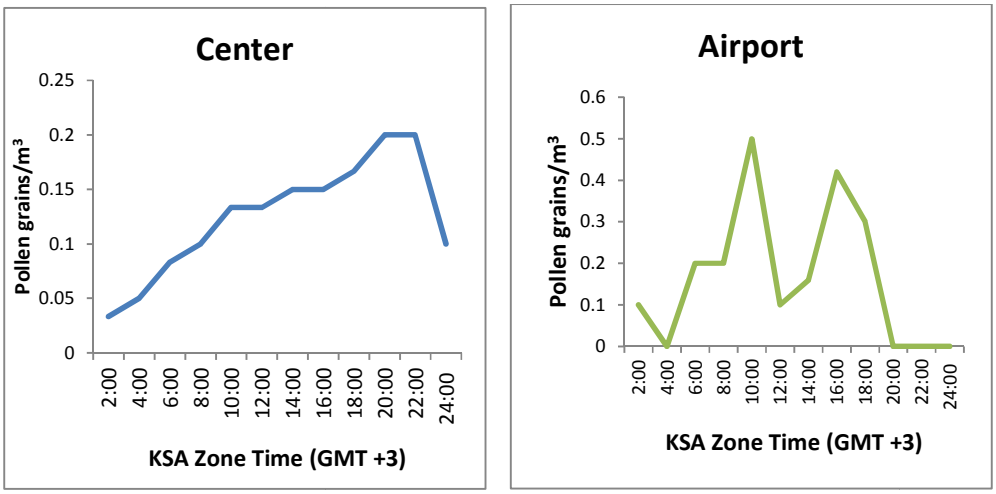
Fig. 1. *Amaranthus viridis* (Slender amaranth, Green amaranth)



(A) Maximum concentration

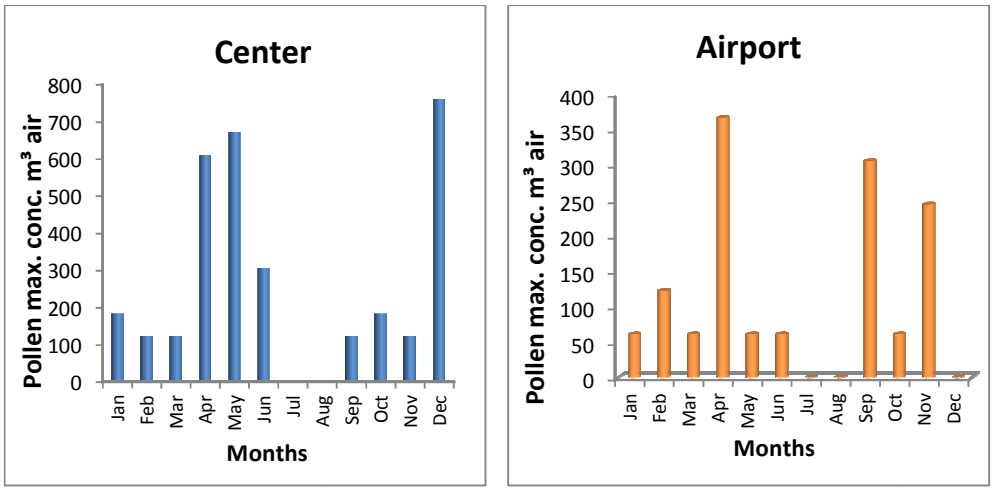


(B) Monthly mean concentration

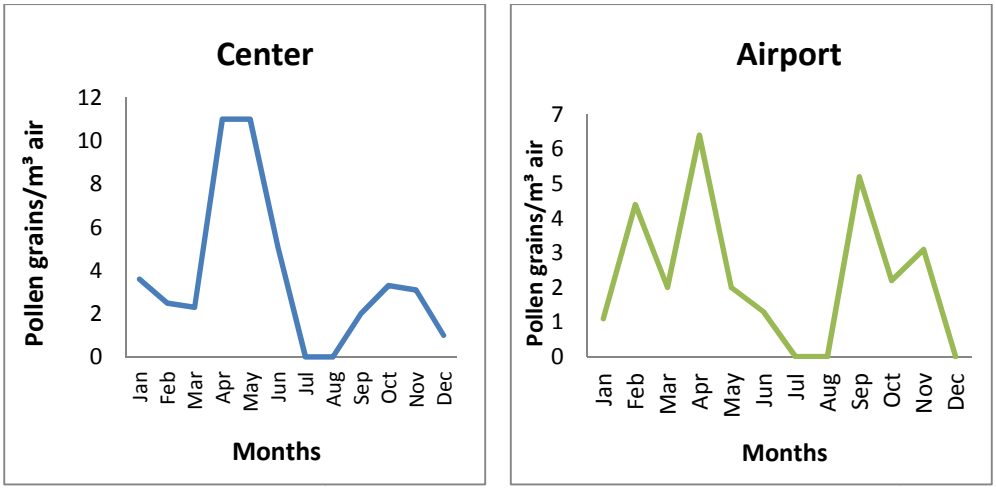


(C) Diel periodicity

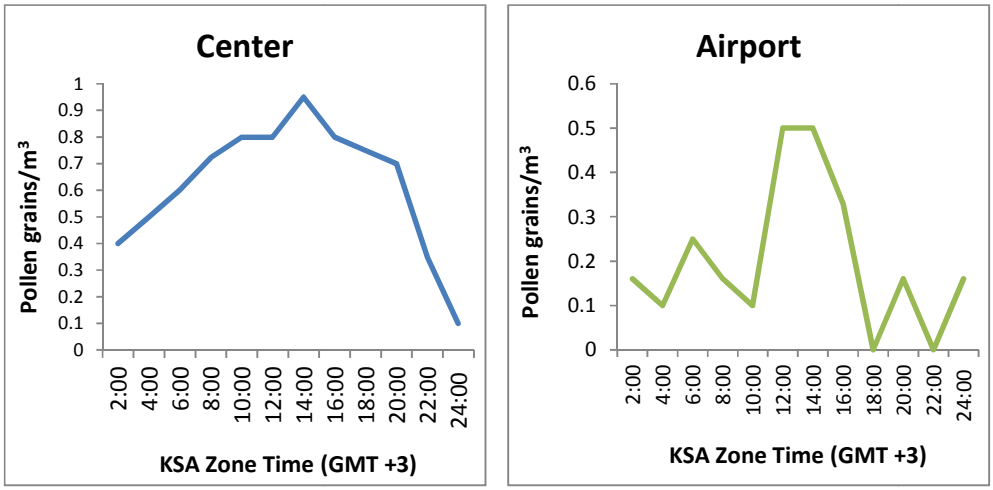
Fig. 2. *Artemisia monosperma* (Sandwormood)



(A) Maximum concentration

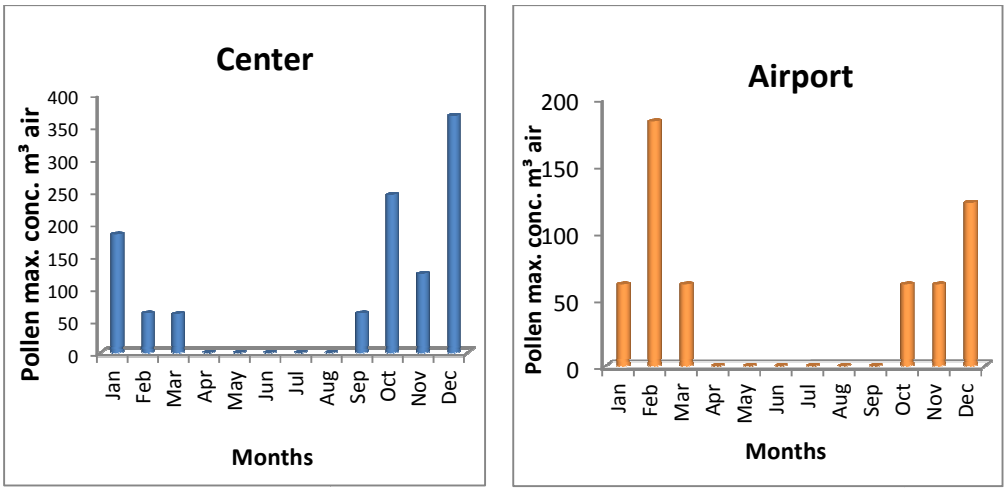


(B) Monthly mean concentration

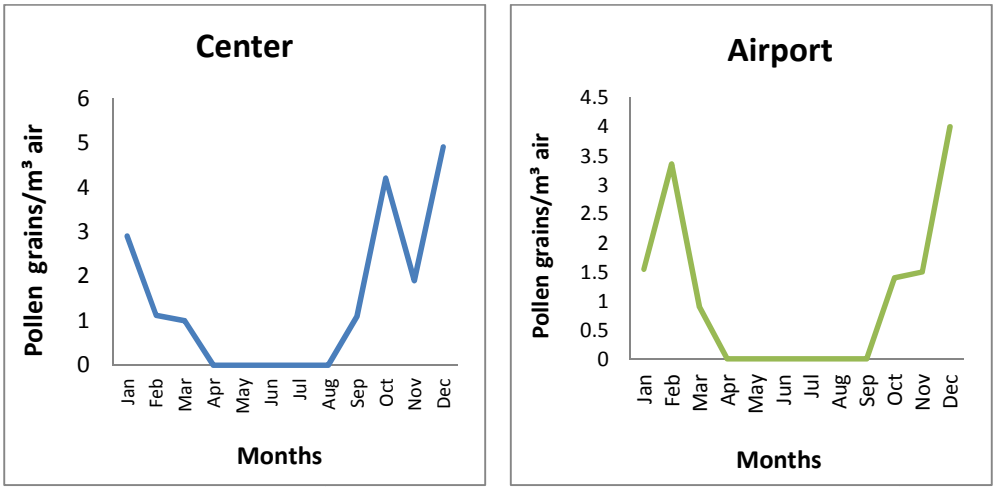


(C) Diel periodicity

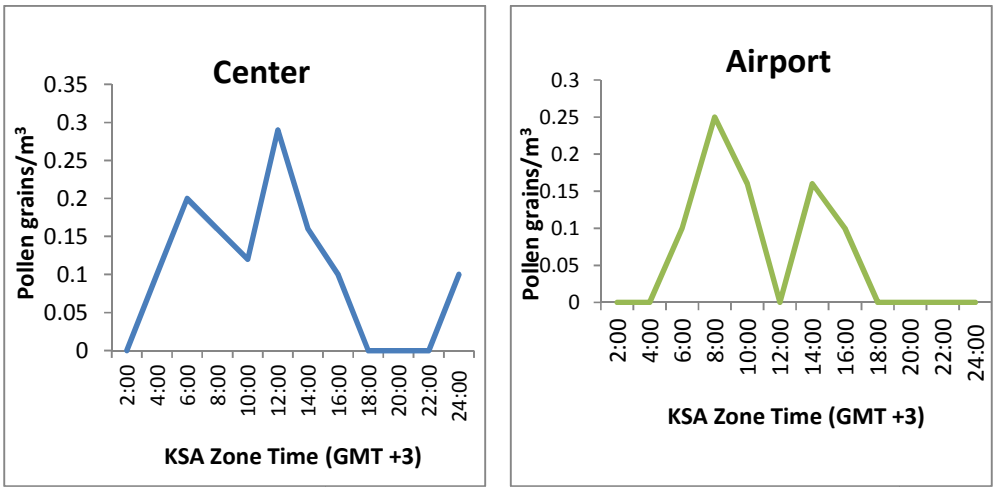
Fig. 3. *Atriplex nummularia* (Giant saltbush)



(A) Maximum concentration

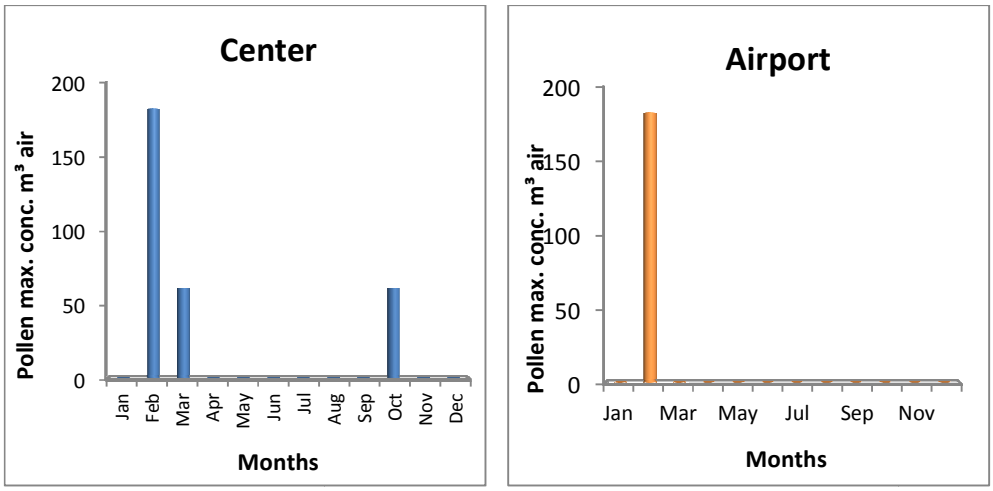


(B) Monthly mean concentration

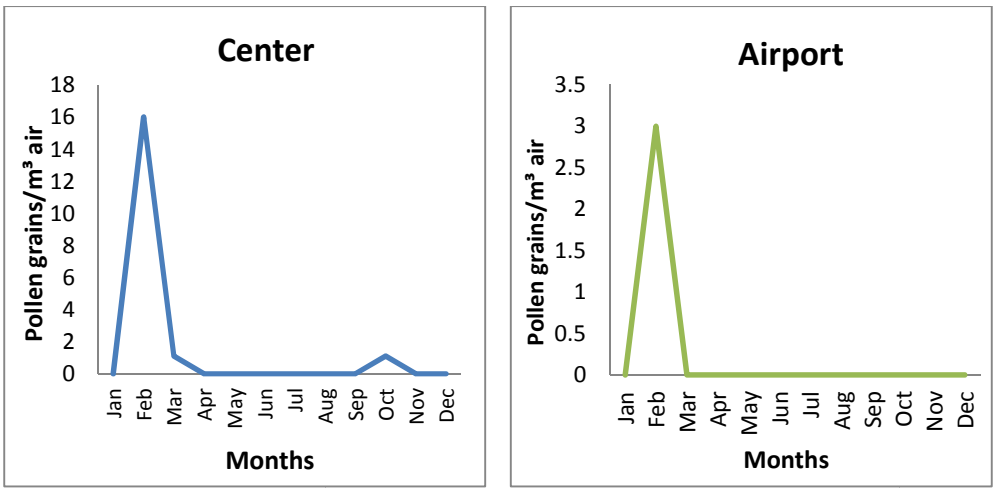


(C) Diel periodicity

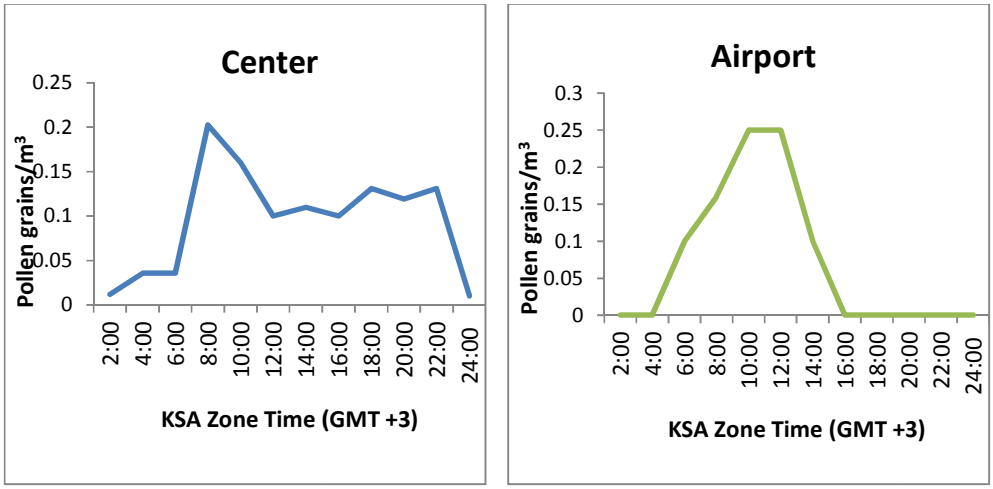
Fig. 4. *Chenopodium murale* (Nettle-leaved Goosefoot)



(A) Maximum concentration

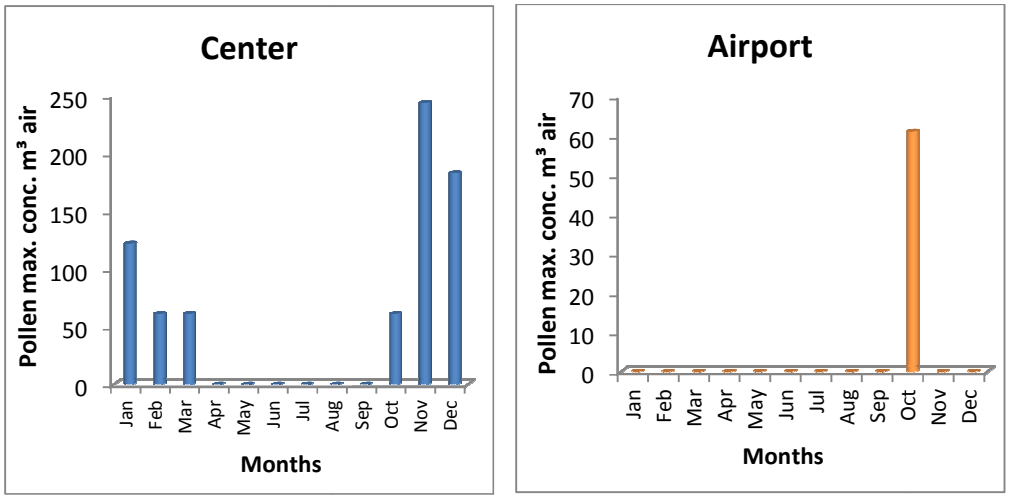


(B) Monthly mean concentration

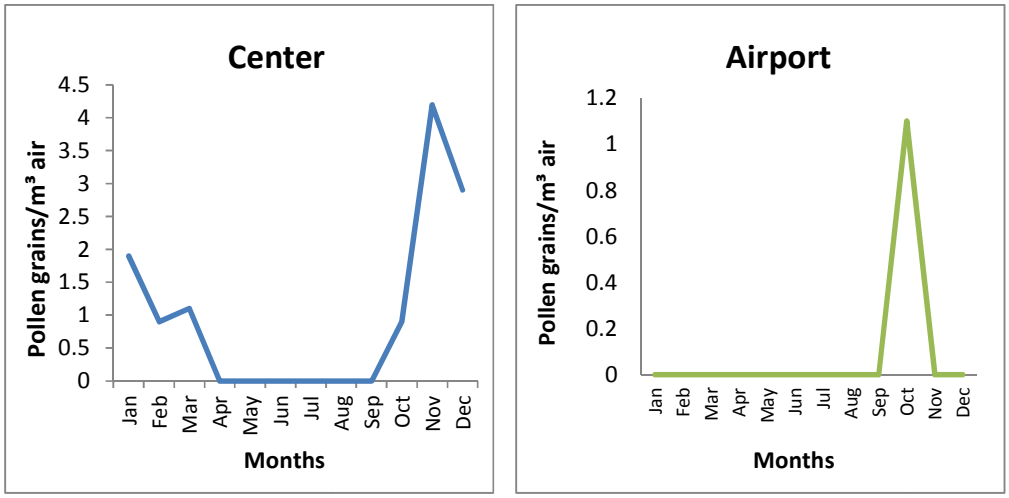


(C) Diel periodicity

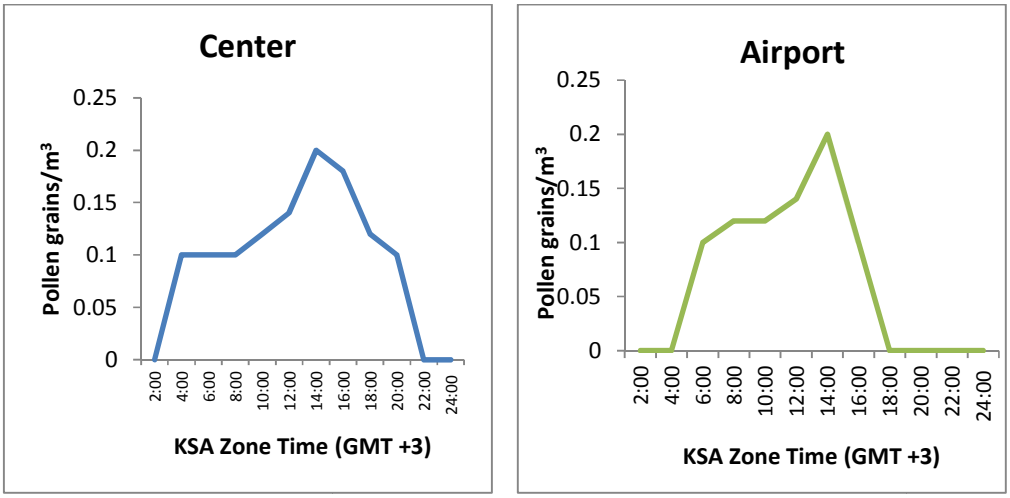
Fig. 5. *Plantago boissieri* (Ribwort)



(A) Maximum concentration

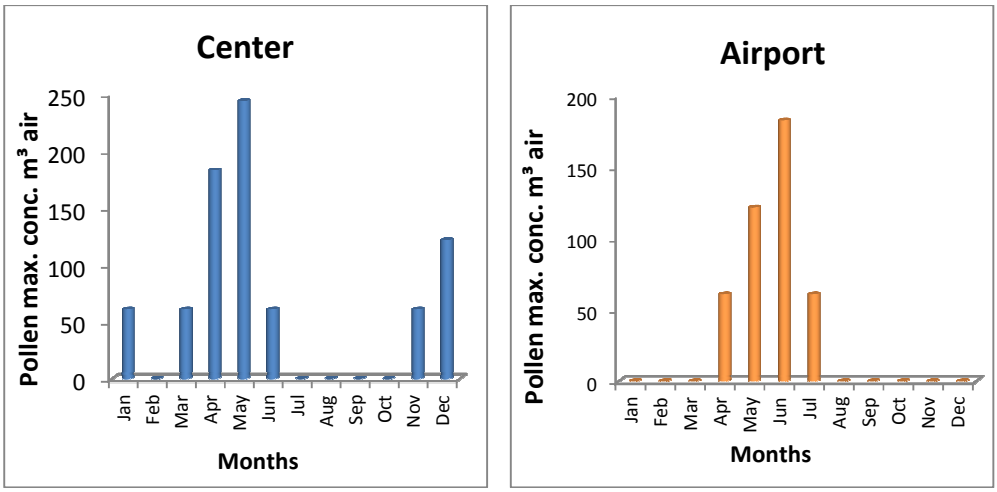


(B) Monthly mean concentration

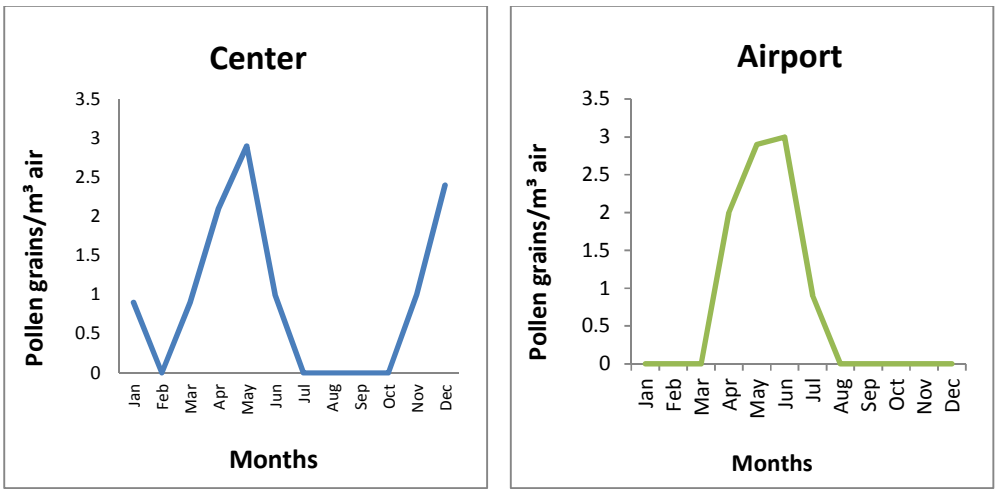


(C) Diel periodicity

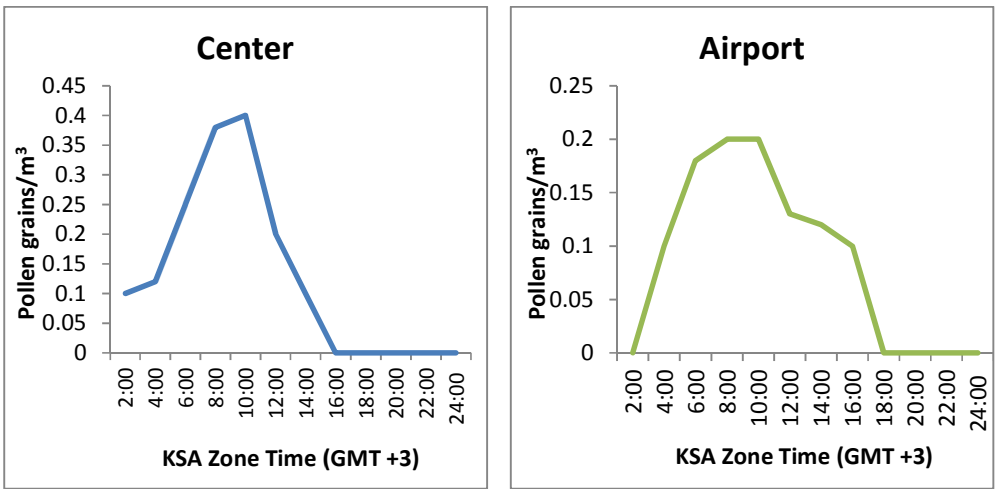
Fig. 6. *Ricinus communis* (Castor bean)



(A) Maximum concentration

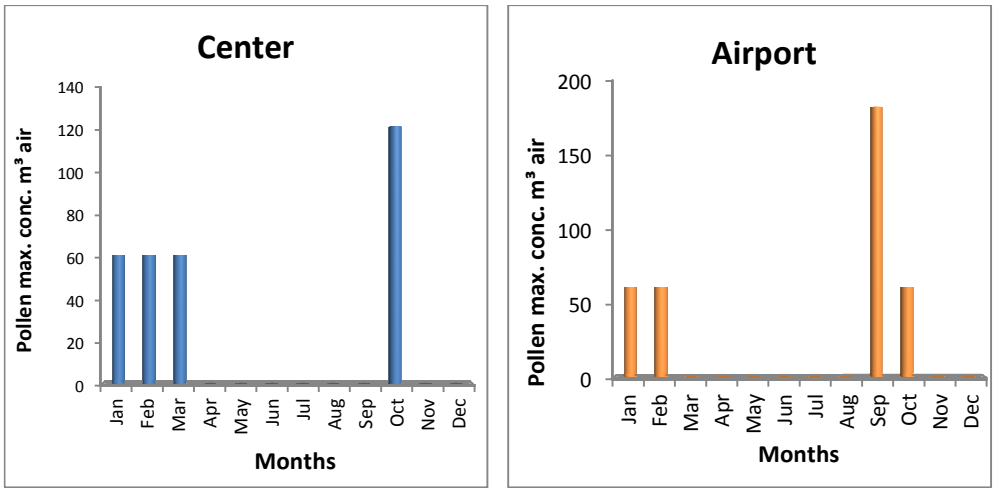


(B) Monthly mean concentration

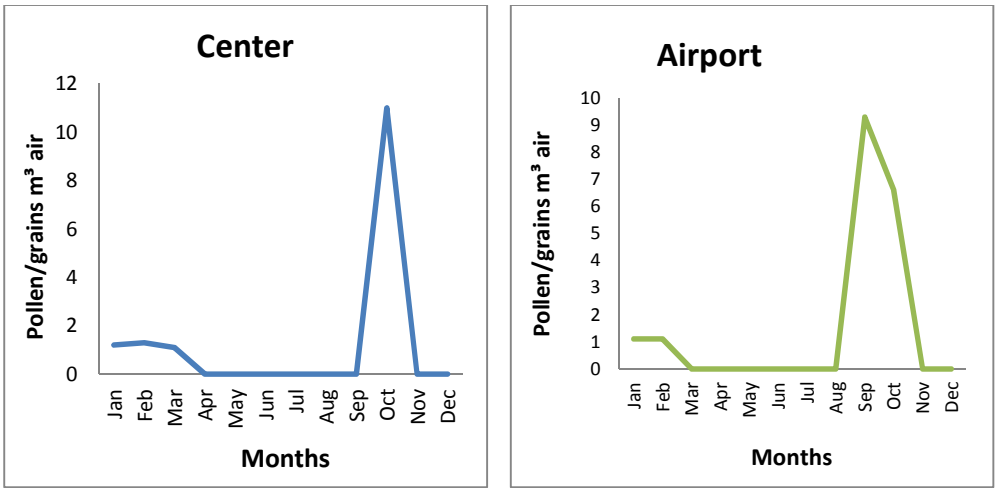


(C) Diel periodicity

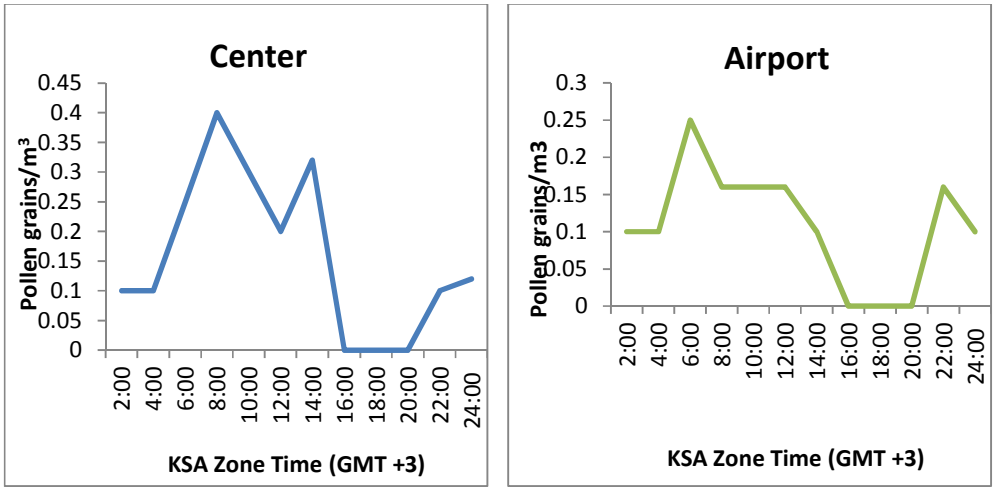
Fig. 7. *Rumex vesicarius* (Bladder dock)



(A) Maximum concentration



(B) Monthly mean concentration



(C) Diel periodicity

Fig. 8. *Salsola imbricate* (Fetid saltwort)

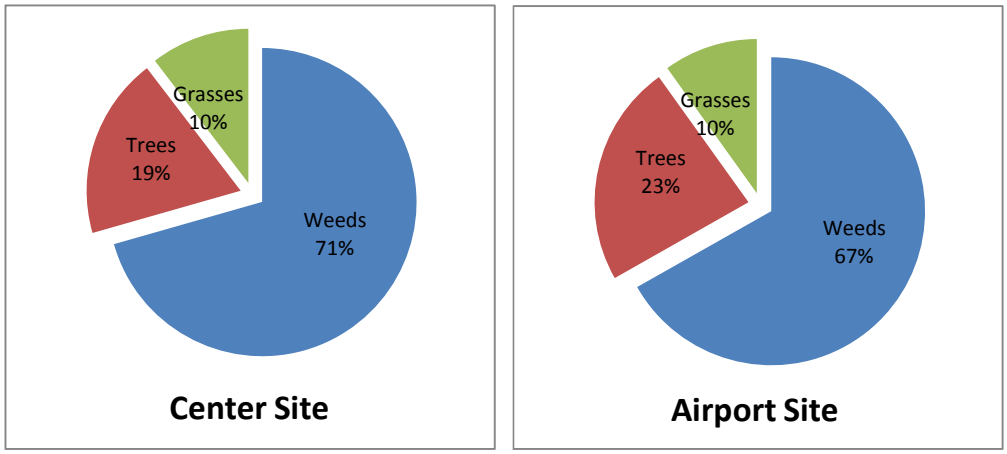


Fig. 9. The total percentage of pollen grains at the two sites

4. DISCUSSION

We have chosen to present data for "weed pollen" allergens because of their abundance in the region constituting between 70-90% of the airborne pollen grains [12]. Therefore, as per Thommen's Postulates, weed pollen grains qualified to be considered as the main source of allergen in the region. For some countries and specific regions, this maybe tree pollen e.g. Alder and Birch [16]. In a study in Kuwait using *in vitro* CAP-RAST method, 77.3% sensitization to pollen allergens was detected [8], while in Skin Prick Test, Salsola (a weed) pollen was predominant cause of sensitization [17]. In a similar study on allergic rhinitis patients in Iran, weed pollen were the most prevalent allergens (77%) followed by grasses (62%). Salsola kali was the most prevalent individual weed pollen allergens showing 72.5% IgE Mediated reactivities [18].

The data presented as the maximum concentration can be interpreted in different ways. Since there is a threshold levels (clinically significant levels) for various allergens and the exposure to that level is required for allergic sensitization (production of specific IgE antibodies), therefore, maximum concentration, even for a shorter duration may act to sensitize susceptible individuals [14]. The maximum concentration levels (Figs. 1A to 8A) for most of the weed pollen allergens are above 100 grains (m^3 air), reaching up to 900 grains (m^3 air).

The levels of pollen grains presented as mean monthly concentration (Fig. 1B to 8B) have been taken as mean data absorbing the peaks in order to provide a seasonal trend of the pollen types. These concentrations are not important in terms of exposure and onset of symptoms. The data indicates that there are two pollen seasons, one in autumn and second in spring. These seasons may be disturbing to most pollen sensitive patient.

In another study on allergic rhinitis in the Middle East covering Kuwait and U.A.E., two pollen seasons were recorded and chenopodiaceae spp., amaranthaceae spp. (weed family) were reported to be predominant allergens [19].

The data presented in the Diel periodicity (Fig. 1C to 8C) is to show the pollen maxima during a 24 hours period; so that avoidance or precautionary measured can be adopted by pollen sensitive individual.

The comparison of the two sites (Fig. 9) revealed that Riyadh city center site (more populated), provided more exposure probability than the Riyadh airport site. A similar pattern was also recorded in northern China [20].

In general, the data presented above indicate that unlike grasses and trees pollen in Europe and North America, grass and tree pollen grains are less abundant in Riyadh, Saudi Arabia (and the Middle East). The study also confirms that some species particularly belonging to chenopodiaceae and amaranthaceae may play a major role in the IgE Mediated sensitization and elicitation of allergic rhinitis.

5. CONCLUSION

Weed is the most prevalent pollen grains in our study. There are two seasons for weed pollen for the majority of weeds in our area.

Amaranthus viridis, Artemisia monsperma, Atriplex nummularia, Chenopodium murale, Platago boissieri, Ricinus communi and *Rumex vesicarius,* are more prevalent weeds in the city, while *Salsola imbricata* is more prevalent in the airport area. The pollen levels in the city area are comparatively much higher than in the airport.

It is expected that the regional Ministry of Health clinics and hospitals as well as private hospitals and clinics dealing in allergy diagnosis and treatment would include major weed pollen extracts in their diagnostic panels and subsequently advice allergic patient to adopt preventive measures during the weed pollen seasons.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

ACKNOWLEDGEMENTS

The authors acknowledge KACST Grant (Project No.: ARP 27-11, RAC#2050029), KFSHRC, Riyadh, KSA, NSTIP Grant (Project No.: 08ENV319-02) to Department of Soil Science, College of Food Sciences and Agriculture, KSU, for their support of the two projects and College of Medicine, RC, Deanship of Scientific Research, KSU, Riyadh, KSA.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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