

# Airborne pollen in the El-Hadjar town (Algeria NE)

Asma Necib · Larbi Boughediri

Received: 12 July 2014 / Accepted: 16 July 2015 / Published online: 28 July 2015  
© Springer Science+Business Media Dordrecht 2015

**Abstract** The diversity of airborne pollen grains in El-Hadjar town (northeast Algeria) was measured for 1 year, from July 1, 2012 to June 30, 2013, by means of the gravimetric method using Durham apparatus. The total number of pollen grains/cm<sup>2</sup> was calculated from slides that were changed daily. This aerobiological study documented the air concentration of pollen from 50 taxa, where 28 belonged to arboreal and 22 to non-arboreal taxa. The percentage of pollen from arboreal and non-arboreal taxa was 56 and 44 %, respectively. From the list, the major collected taxa causing allergy in humans dominant in the Mediterranean area were Cupressaceae (14.86 %), *Olea* sp. (7.18 %), *Casuarina* sp. (6.44 %), and *Fraxinus* sp. (3.83 %) among arboreal plants, whereas for the non-arboreal plants Poaceae (23.20 %), *Mercurialis* sp. (12.58 %), *Plantago* sp. (1.69 %), Urticaceae (0.95 %), and Chenopodiaceae (0.85 %). The highest pollen counts occurred in the period from February to April. The pollen calendar for the region presented in this paper may be a useful tool for allergologists and botanical awareness.

**Keywords** Pollen calendar · Pollen allergy · Aerobiology · Airborne pollen · Algeria

## 1 Introduction

Many grasses, trees, and weeds produce sufficient quantities of lightweight pollen to sensitize genetically susceptible individuals (Esch et al. 2001). Airborne pollen grains, which are produced in particular by anemogame plant species, are significant organic bioaerosols (Tosunoğlu et al. 2013); they are the most important source of allergens in the atmosphere (Çeter et al. 2012). Thus, pollen allergy is a seasonal disease, and its symptoms are associated with the presence in the abundance of airborne pollen grains (Piotrowska and Kaszewski 2009), where approximately 60–75 % of seasonal rhinitis patients have positive skin test reactions to weed pollens, 40 % to grass pollens, and 10 % to tree pollens (Esch et al. 2001). Airborne pollen and fungal spores are common triggers of type I IgE-mediated allergic reactions in patients with rhinitis and bronchial asthma (Al-Frayh et al. 1989). Subsequently, symptoms that normally affect most people with pollen allergy are sneezing, itching, nasal discharge, and ocular itching. (Sánchez-Mesa et al. 2005).

In each geographic area, there is a succession of different flowering species throughout the year, so it is important to document the timing, floral intensity, and types of airborne pollen in different locations,

---

A. Necib (✉) · L. Boughediri  
Laboratory of Vegetal Biology and Environment (LBVE),  
Department of Biology, Faculty of Sciences, Badji  
Mokhtar University, PB 12, 23000 Annaba, Algeria  
e-mail: sama.nb@hotmail.com

L. Boughediri  
e-mail: lboughediri@yahoo.com

especially in highly populated cities (Boi and Llorens 2013). It is therefore a vital goal; however, these data prove helpful in the treatment for patients suffering from plenty of diseases (Erkan et al. 2011).

For this reason, pollen calendars have been prepared all over the world for several years by various studies to determine and evaluate airborne pollen grain dispersal (Chabert 1971; Korteby et al. 1977; Chen and Huang 1980; Savitsky et al. 1996; Biçakçi et al. 1999; Rojas-Villegas and Roure-Nolla 2001; Giner et al. 2002; Yang et al. 2003; Weryszko-Chmielewska and Piotrowska 2004; Hasnain et al. 2005; Chauhan and Goyal 2006; Stefanic et al. 2007; Vergamini et al. 2007; Al-Qura'n 2008; Chafai-Ketfi et al. 2009; Altunoglu et al. 2010; Pérez-Badia et al. 2011; Ianovici et al. 2013; Tosunoğlu et al. 2013). The allergen calendar compiled for each region of a country can be used in allergy clinics and hospitals for symptom correlations and subsequent selection of allergens for diagnosis and treatment (Ianovici et al. 2013). Allergenic-pollen-producing plants typical of the Mediterranean climate are *Parietaria*, *Olea*, and Cupressaceae. However, during the last 30 years or so, aerobiological and allergological studies have been developed rapidly in most parts of Europe and also in the Mediterranean area (D'Amato et al. 2007).

The aim of the present study therefore was to identify the airborne pollen content during 1 year, to recognize the atmospheric pollen seasons by determining its beginning, duration, end of different types of airborne pollen found, especially allergenic pollen taxa, and to establish a preliminary pollen calendar for El-Hadjar town.

## 2 Materials and methods

### 2.1 Study area

El-Hadjar is a town situated in the province of Annaba (northeast Algeria) [36° 48' 0" North, 7° 44' 0" East] (Fig. 1), on the Mediterranean coast at an altitude of 3 m above sea level, covering approximately an area of 63 km<sup>2</sup>. It is the fourth most populous town in the Wilaya of Annaba after Annaba town, Sidi Amar, and El Bouni, according to the general census of population and housing with 37,364 inhabitants.

The northeast Algerian exhibits a typical Mediterranean climate; the direction of the dominant wind is

north-west with an average of 2.4 m/s, an average annual mean temperature of 17 °C, and an average rainfall of 630 mm/year.

### 2.2 Vegetation

The vegetation of the area of Annaba shows a rich plant diversity and Mediterranean maquis consisting mainly of shrubs and small trees, including: *Arbutus unedo*, *Cistus salvifolius*, *Cistus triflorus*, *Ampelodesma mauritanicum*, *Erica arborea*, *Lavandula stoechas*, *Chamaerops humilis*, *Calycotom spinosa*, *Asphodelus microcarpus*, *Myrtus communis*, *Pistacia lentiscus*, *Genista numidia*, *Phyllirea angustifolia*, *Olea europaea*, *Laurus nobilis*, and *Daphne gnidium*.

In addition, the forestry assets consist of natural forest *Quercus suber* and *Quercus faginea*; hardy species *Ceratonia siliqua*, *Castanea sativa*, and *Fraxinus oxyphylla*; artificial forests *Eucalyptus camaldulensis*, *Eucalyptus globulus*, *Eucalyptus gomphocephala*, *Pinus maritima*, and *Pinus pinea*. Other species reforested are *Acacia cyanophylla*, *Acacia melanoxylon*, and *Cupressus sempervirens* (General Directorate of Forestry 2013).

In the El-Hadjar town, the principal plants species found are: Poaceae (*Phleum pratense*, *Lolium perenne*, *Dactylis glomerata*, *Bromus mollis*, *Hordeum murinum*, *Avena sativa*, *Avena sterilis*), Salicaceae (*Populus alba*, *Populus nigra*, *Salix alba*, *Salix nigra*), Oleaceae (*Olea europaea*, *Fraxinus angustifolia*, *Phyllirea angustifolia*, *Ligustrum vulgare*), Fagaceae (*Quercus suber*, *Quercus faginea*, *Castanea sativa*), Urticaceae (*Parietaria mauritanica*, *Parietaria officinalis*, *Urtica dioica*, *Urtica urens*), Fabaceae (*Acacia dealbata*, *Acacia horrida*, *Acacia floribanda*), Plantaginaceae (*Plantago lanceolata*, *Plantago minor*), Polygonaceae (*Rumex bucephalophorus*, *Rumex obtusifolius*), Chenopodiaceae (*Chenopodium album*, *Salsola kali*), Pinaceae (*Pinus maritima*, *Pinus halepensis*), Cupressaceae (*Cupressus sempervirens*, *Thuja occidentalis*), Asteraceae (*Bellis perennis*, *Inula viscosa*), and Araceae (*Phoenix canariensis*) (Ketfi 1998).

### 2.3 Aerobiological survey

In this study, a continuous aerobiological survey of El-Hadjar city atmosphere was carried out from July 2012 to June 2013. Pollen data were collected using the Durham apparatus (Durham 1946); the apparatus was

**Fig. 1** Localization of the study area



placed in the town center at 4.5 m for gravimetric study.

The slides were covered with glycerin jelly mixed with basic fuchsine (Charpin et al. 1974). They were changed daily after 24 h of exposure, for reading all the surface of the slide (50 mm × 24 mm) under a light microscopy (Carl Zeiss, standard 20) using (×400) magnification. Then, the total number of taxa was divided by the examined surface (12 cm<sup>2</sup>) to obtain the number of pollen grains/cm<sup>2</sup>, and airborne pollen was expressed as monthly averages. The pollen grains were identified and counted, identifying at genus and at family level using pollen Atlas of Reille (1992). The grains that were not identified were considered unidentified types.

### 3 Results and discussion

The 1-year calendar of airborne pollen grains of El-Hadjar town is presented in Tables 1 and 2 and Fig. 2. During this period, a total of 2039 pollen grains/cm<sup>2</sup> belonging to 50 taxa were recorded. Out of these, 28 (49.56 %) belong to the arboreal taxa and 22 (46.87 %) belong to the non-arboreal ones.

The frequency of pollen from both categories shows that arboreal taxa are dominant in April (13.27 %) and February (11.69 %), whereas non-arboreal taxa are dominant in April, March, and May with 16.59, 7.93, and 7.61 %, respectively.

The highest total annual count for arboreal pollen (271 pollen grains/cm<sup>2</sup>) and for non-arboreal pollen (338 pollen grains/cm<sup>2</sup>) was observed in April.

The amount of pollen began to increase in February and reached its peak in April with 624 pollen grains/cm<sup>2</sup>. Pollen grains of Poaceae (23.20 %) were the most abundant type in the atmosphere, and it ranked first which was followed by Cupressaceae (14.86 %), Euphorbiaceae (*Mercurialis* sp.) (12.58 %), *Olea* sp. (7.18 %), and *Casuarina* sp. (6.44 %) (Tables 1, 2). The lowest numbers of pollen grains were recorded in October with 31.58 PG/cm<sup>2</sup>.

Fungal spore was collected during all the study period, with 483 spores/cm<sup>2</sup> (19.15 % of total airborne particles). The ratio of spores on pollen grains cached was 23.68 %. One peak was unregistered in November (4 %). The lowest value was observed in January (0.15 %).

According to the data shown in the pollen calendar, this aerobiological investigation shows the distribution of the major taxa with considerable allergenic capacity as follows:

#### 3.1 Cupressaceae

Presented by *Cupressus* sp. and *Juniperus* sp. It was observed from September to March. The maximum value of pollen grains of these taxa was 207.56 PG/cm<sup>2</sup> in February; it presented 14.86 % of total annual pollen collected. In a similar study at El-Hadjar town, Chafai-Ketfi et al. (2009) observed that the pollination started from March to July. Chabert (1971) noted that Cupressaceae pollen grains were the important density collected in the air of Rabat, it appeared at the end of January, but it was abundant in February–March, and disappeared at the end of April. However, (20.6 %) of

**Table 1** Contribution of arboreal pollen grains (PG/cm<sup>3</sup>) and % of occurrence to annual total

Months	July		August		September		October		November		December	
	PG/cm <sup>3</sup>	%	PG/cm <sup>3</sup>	%	PG/cm <sup>3</sup>	%	PG/cm <sup>3</sup>	%	PG/cm <sup>3</sup>	%	PG/cm <sup>3</sup>	%
<i>Alnus</i> sp.	–	–	–	–	–	–	–	–	–	–	0.29	0.01
<i>Betula</i> sp.	–	–	–	–	–	–	–	–	–	–	–	–
<i>Carya</i> sp.	–	–	–	–	–	–	–	–	–	–	–	–
<i>Casuarina</i> sp.	–	–	0.50	0.02	68	3.33	11.20	0.55	40.36	1.98	4.36	0.21
<i>Corylus avellana</i>	–	–	–	–	–	–	–	–	–	–	–	–
Cupressaceae	0.21	0.01	–	–	0.94	0.06	0.29	0.01	0.29	0.01	3.27	0.16
Ericaceae	0.07	0.003	0.21	0.01	0.29	0.01	0.29	0.01	0.36	0.02	0.29	0.01
<i>Eucalyptus</i> sp.	0.72	0.03	0.07	0.003	–	–	0.07	0.003	0.07	0.003	0.14	0.006
Fabaceae	–	–	–	–	0.87	0.04	–	–	–	–	–	–
Fagaceae	–	–	–	–	–	–	–	–	–	–	–	–
<i>Fraxinus</i> sp.	–	–	–	–	–	–	–	–	1.23	0.06	70.47	0.36
<i>Juglans</i> sp.	–	–	–	–	–	–	–	–	–	–	–	–
<i>Ligustrum</i> sp.	–	–	–	–	–	–	–	–	–	–	–	–
Miliaceae	–	–	–	–	–	–	–	–	–	–	–	–
Mimosaceae	2.10	0.10	1.09	0.0	0.14	0.006	0.14	0.006	–	–	–	–
<i>Olea</i> sp.	0.14	0.006	–	–	–	–	–	–	–	–	–	–
<i>Ostrya</i> sp.	–	–	–	–	–	–	–	–	–	–	–	–
<i>Phoenix</i> sp.	–	–	–	–	–	–	–	–	–	–	0.07	0.003
Pinaceae	3.49	0.17	4.36	0.21	–	–	0.21	0.01	–	–	0.43	0.02
<i>Platanus</i> sp.	–	–	–	–	–	–	–	–	–	–	0.5	0.02
<i>Populus</i> sp.	–	–	–	–	–	–	–	–	–	–	–	–
<i>Quercus</i> sp.	0.14	0.006	–	–	–	–	–	–	–	–	–	–
Rosaceae	–	–	–	–	–	–	–	–	–	–	–	–
Rutaceae	–	–	–	–	–	–	–	–	–	–	–	–
<i>Salix</i> sp.	–	–	–	–	–	–	–	–	–	–	–	–
<i>Tilia</i> sp.	–	–	–	–	–	–	–	–	–	–	–	–
Ulmaceae	–	–	–	–	–	–	–	–	–	–	0.50	0.02
Vitaceae	–	–	–	–	–	–	–	–	–	–	–	–
Total AP	6.87	0.32	6.23	0.24	70.27	3.45	12.20	0.59	42.31	2.07	80.32	0.82

**Table 1** continued

Months	January		February		March		April		May		June		Total	
	PG/cm <sup>2</sup>	%	PG/cm <sup>2</sup>	%	PG/cm <sup>2</sup>	%	PG/cm <sup>2</sup>	%	PG/cm <sup>2</sup>	%	PG/cm <sup>2</sup>	%	PG/cm <sup>2</sup>	%
<i>Alnus</i> sp.	2.69	0.13	0.43	0.02	0.21	0.01	0.14	0.006	0.07	0.003	-	-	3.83	0.18
<i>Betula</i> sp.	-	-	-	-	-	-	0.36	0.017	0.14	0.006	-	-	0.5	0.02
<i>Carya</i> sp.	-	-	-	-	1.30	0.06	8.87	0.43	0.14	0.006	-	-	10.31	0.50
<i>Casuarina</i> sp.	6.18	0.30	0.65	0.03	-	-	-	-	-	-	-	-	131.25	6.44
<i>Corylus avellana</i>	-	-	0.36	0.02	0.50	0.02	0.43	0.02	0.07	0.003	-	-	1.36	0.07
Cupressaceae	4.87	0.24	207.56	10.18	82.54	4.04	1.16	0.06	1.23	0.06	0.58	0.03	302.94	14.86
Ericaceae	0.29	0.01	23.05	1.13	58.54	2.87	5.38	0.26	1.09	0.05	0.14	0.006	90	4.41
<i>Eucalyptus</i> sp.	0.21	0.01	-	-	0.07	0.006	1.38	0.07	2.40	0.12	5.38	0.63	10.51	0.51
Fabaceae	-	-	-	-	-	-	-	-	-	-	0.29	0.01	1.16	0.06
Fagaceae	0.07	0.003	-	-	-	-	-	-	-	-	-	-	0.07	0.003
<i>Fraxinus</i> sp.	4.94	0.24	1.30	0.06	-	-	-	-	-	-	0.14	0.006	78.08	3.83
<i>Juglans</i> sp.	-	-	-	-	-	-	0.29	0.01	-	-	-	-	0.29	0.014
<i>Ligustrum</i> sp.	-	-	-	-	-	-	1.89	0.09	4.50	0.22	2.18	0.11	8.57	0.42
Miliaceae	-	-	-	-	0.14	0.006	0.8	0.04	0.36	0.08	-	-	1.30	0.06
Mimosaceae	-	-	-	-	0.58	0.09	0.65	0.03	0.94	0.05	1.09	0.05	6.73	0.33
<i>Olea</i> sp.	-	-	-	-	1.01	0.05	117.67	5.77	24.72	1.21	2.83	0.38	146.37	7.18
<i>Ostrya</i> sp.	-	-	-	-	-	-	0.87	0.04	-	-	-	-	0.87	0.042
<i>Phoenix</i> sp.	1.16	0.56	-	-	1.60	0.08	-	-	0.58	0.03	33.74	1.65	37.15	1.82
Pinaceae	0.29	0.01	2.47	0.12	7.27	0.36	7.72	0.38	1.89	0.09	1.01	0.05	29.14	1.43
<i>Platanus</i> sp.	-	-	-	-	0.07	0.003	1.60	0.08	0.58	0.03	0.87	0.04	3.62	0.18
<i>Populus</i> sp.	-	-	0.07	0.003	6.03	0.29	1.30	0.06	0.07	0.003	-	-	7.47	0.37
<i>Quercus</i> sp.	-	-	0.14	0.006	0.87	0.04	42.4	2.08	12.07	0.59	-	-	55.62	2.73
Rosaceae	-	-	-	-	0.29	0.01	16.72	0.82	1.23	0.06	-	-	18.24	0.89
Rutaceae	-	-	-	-	-	-	-	-	-	-	0.14	0.006	0.14	0.006
<i>Salix</i> sp.	-	-	-	-	-	-	0.14	0.006	0.14	0.006	-	-	0.28	0.01
<i>Tilia</i> sp.	-	-	-	-	-	-	3.34	0.16	0.94	0.07	-	-	4.28	0.02
Ulmaceae	-	-	2.54	0.12	2.32	0.11	0.29	0.01	-	-	-	-	5.65	0.28
Vitaceae	-	-	-	-	-	-	57.67	2.83	1.38	0.07	-	-	59.05	2.90
Total AP	20.70	1.50	238.57	11.69	163.34	8.04	271.07	13.27	54.54	2.76	48.39	2.97	1014.78	49.56

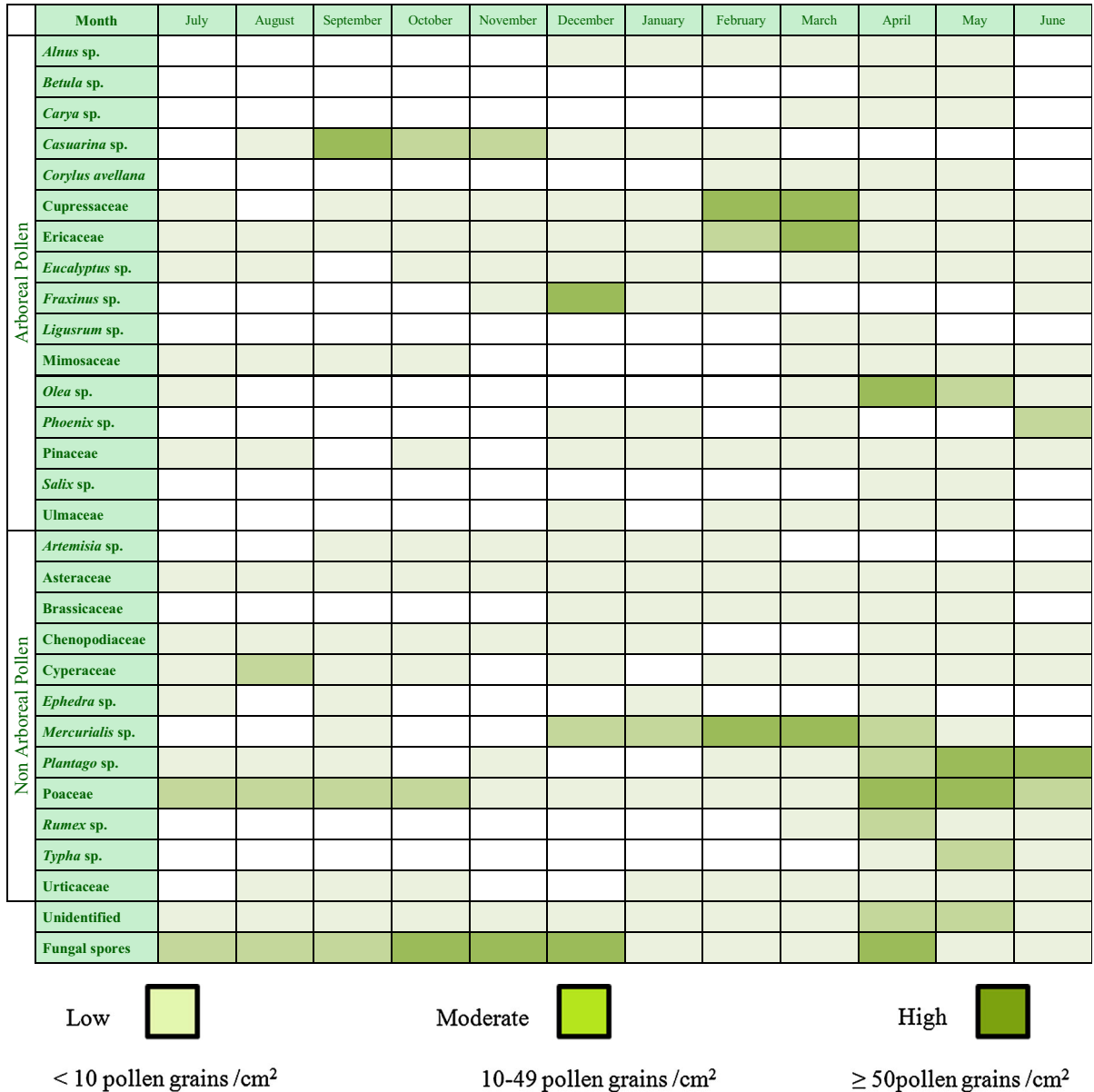
**Table 2** Contribution of non-arboreal pollen grains (PG/cm<sup>2</sup>) and % of occurrence to annual total

Months	July		August		September		October		November		December	
	PG/cm <sup>2</sup>	%	PG/cm <sup>2</sup>	%	PG/cm <sup>2</sup>	%	PG/cm <sup>2</sup>	%	PG/cm <sup>2</sup>	%	PG/cm <sup>2</sup>	%
Apiaceae	0.65	0.03	–	–	0.14	0.007	–	–	–	–	0.14	0.007
<i>Artemisia</i> sp.	–	–	–	–	0.29	0.014	0.72	0.035	0.21	0.01	0.14	0.007
Asteraceae	0.72	0.035	0.43	0.02	0.29	0.014	0.21	0.01	0.07	0.003	0.58	0.03
Boraginaceae	–	–	–	–	–	–	–	–	–	–	–	–
<i>Borago</i> sp.	–	–	–	–	–	–	–	–	–	–	–	–
Brassicaceae	–	–	–	–	–	–	–	–	–	–	3.34	0.16
Caryophyllaceae	–	–	–	–	–	–	–	–	–	–	–	–
Chenopodiaceae	1.30	0.06	3.05	0.15	–	–	1.01	0.05	0.43	0.002	0.07	0.003
Cyperaceae	7.63	0.37	18.90	0.93	6.25	0.31	0.29	0.01	–	–	0.07	0.003
<i>Echium</i> sp.	–	–	–	–	–	–	–	–	–	–	–	–
<i>Ephedra</i> sp.	0.07	0.003	–	–	0.07	0.003	–	–	–	–	–	–
Euphorbiaceae	–	–	–	–	0.36	0.02	–	–	–	–	18.25	0.89
<i>Juncus</i> sp.	–	–	–	–	–	–	–	–	–	–	–	–
Lamiaceae	–	–	–	–	–	–	–	–	–	–	–	–
<i>Plantago</i> sp.	0.21	0.01	0.14	0.007	0.21	0.01	–	–	1.38	0.07	–	–
Poaceae	26.32	1.29	19.56	0.96	10.98	0.54	12.72	0.62	1.81	0.09	1.81	0.09
Polygonaceae	–	–	–	–	–	–	–	–	–	–	–	–
<i>Rumex</i> sp.	–	–	–	–	–	–	–	–	–	–	–	–
Scrophulariaceae	–	–	–	–	–	–	–	–	–	–	–	–
<i>Trifolium</i> sp.	–	–	–	–	–	–	–	–	–	–	–	–
<i>Typha</i> sp.	–	–	–	–	–	–	–	–	–	–	–	–
Urticaceae	–	–	5.30	0.26	3.14	0.15	2.25	0.11	–	–	–	–
Total NAP	36.9	1.80	47.38	2.33	21.73	1.07	17.20	0.83	3.90	0.17	24.40	1.19
Unidentified	1.38	0.07	6.83	0.33	3.49	0.17	2.18	0.11	1.01	0.05	4.21	0.21
Total PG	45.15	2.19	60.44	2.90	95.49	4.69	31.58	1.53	47.22	2.29	108.93	2.22
Fungal spores	18.4	0.73	34.32	1.36	35.56	1.41	51.2	2.03	100.94	4	88.07	3.49

Table 2 continued

Months	January		February		March		April		May		June		Total	
	PG/cm <sup>2</sup>	%	PG/cm <sup>2</sup>	%	PG/cm <sup>2</sup>	%	PG/cm <sup>2</sup>	%	PG/cm <sup>2</sup>	%	PG/cm <sup>2</sup>	%	PG/cm <sup>2</sup>	%
Apiaceae	–	–	–	–	–	–	0.58	0.03	7.92	0.39	2.98	0.15	12.41	0.61
<i>Artemisia</i> sp.	0.14	0.007	0.07	0.003	–	–	–	–	–	–	–	–	1.57	0.08
Asteraceae	0.72	0.03	4.14	0.20	0.65	0.03	2.61	0.13	4.72	0.23	3.34	0.16	18.48	0.91
Boraginaceae	–	–	–	–	7.70	0.38	0.36	0.02	–	–	–	–	8.06	0.39
<i>Borago</i> sp.	–	–	–	–	1.38	0.07	0.43	0.002	–	–	–	–	1.81	0.09
Brassicaceae	2.32	0.11	3.49	0.17	2.32	0.11	2.61	0.13	0.29	0.01	–	–	14.37	0.70
Caryophyllaceae	–	–	–	–	–	–	–	–	0.07	0.003	–	–	0.07	0.003
Chenopodiaceae	0.07	0.003	–	–	–	–	4.94	0.24	2.25	0.11	4.29	0.21	17.41	0.85
Cyperaceae	–	–	0.21	0.01	1.30	0.06	5.38	0.26	2.10	0.10	1.60	0.09	43.73	2.14
<i>Echium</i> sp.	–	–	–	–	–	–	1.67	0.08	1.16	0.06	4.36	0.21	7.19	0.03
<i>Ephedra</i> sp.	0.14	0.007	–	–	–	–	0.07	0.003	–	–	–	–	0.35	0.02
Euphorbiaceae	26.54	1.30	69.52	3.41	127.78	6.27	12.94	0.63	1.23	0.06	–	–	256.62	12.58
<i>Juncus</i> sp.	–	–	–	–	0.07	0.003	0.94	0.05	0.21	0.01	–	–	1.22	0.05
Lamiaceae	–	–	–	–	–	–	–	–	–	–	0.07	0.003	0.07	0.003
<i>Plantago</i> sp.	–	–	0.14	0.007	8.36	0.41	18.54	0.91	4.87	0.24	0.65	0.03	34.5	1.69
Poaceae	1.30	0.06	3.34	0.16	7.27	0.36	272.50	13.36	100.8	4.94	14.69	0.72	473.1	23.20
Polygonaceae	–	–	–	–	–	–	–	–	–	–	0.14	0.007	0.14	0.007
<i>Rumex</i> sp.	–	–	–	–	1.09	0.05	12.58	0.62	0.65	0.03	0.14	0.007	14.46	0.71
Scrophulariaceae	–	–	–	–	–	–	0.07	0.003	–	–	–	–	0.07	0.003
<i>Trifolium</i> sp.	–	–	–	–	–	–	0.14	0.007	0.43	0.02	0.29	0.01	0.86	0.04
<i>Typha</i> sp.	–	–	–	–	–	–	2.18	0.11	28.65	1.40	1.23	0.06	32.06	1.57
Urticaceae	0.58	0.03	2.10	0.10	5.01	0.24	0.21	0.01	0.14	0.007	0.72	0.03	19.45	0.95
Total NAP	31.81	1.55	83.01	4.06	162.93	7.93	338.75	16.59	155.49	7.61	34.50	1.68	958	46.87
Unidentified	2.61	0.13	1.23	0.06	3.05	0.15	13.89	0.68	20.29	0.99	5.67	0.28	65.84	3.23
Total PG	55.12	3.18	322.81	15.81	329	16.12	623.71	30.54	230.32	11.36	88.56	4.93	2038.62	99.66
Fungal spores	3.78	0.15	7.70	0.30	19.49	0.77	62.83	2.49	34.90	1.38	26.32	1.04	483.51	19.15

**Pollen calendar:**



**Fig. 2** Pollen calendar of the atmosphere of El-Hadjar during 1 year of surveillance

pollen cached was presented by Cupressaceae/Taxaceae at Kastamonu (Turkey) (Çeter et al. 2012).

The genus *Cupressus* is widely spread in Mediterranean area, where the most common species are *C. sempervirens*, *C. arizonica*, *C. macrocarpa*, and *C. lusitanica*. Cypress releases an enormous amount of anemophilous pollen, and it has been recognized to be responsible for a large part of total annual amount

of airborne pollen in several Mediterranean areas (D’Amato et al. 2007).

Cypress cedar pollen allergy has been reported in numerous countries located in various geographical areas such as South Africa, Australia, France, Italy, Spain, Morocco, Albania, Greece, Turkey, Iran, and Japan and is currently known as an increasing cause of pollinosis worldwide (Shahali et al. 2010). It has been



recognized as a pollinosis in Mediterranean and extra-Mediterranean (Subiza et al. 1995).

### 3.2 *Casuarina* sp.

It is the main pollen season generally occurred during late summer and autumn, between September and December (Trigo et al. 1999). In our study, this pollen was recorded at the end of August to February; the higher value was collected in September with 68 PG/cm<sup>2</sup> (3.33 %). In Málaga (Spain), García et al. (1997) observed the presence of pollen *Casuarina* during the months of October and November, particularly during the second week until the fourth week of October. Güvensen and Öztürk (2003) found in the region of Izmir (Turkey) that Casuarinaceae dominates the other species during the third week of September and the first week of October. The prevalence of sensitization to *Casuarina* pollen was proved, and it has been reported that it must be considered as an aeroallergen and a probable cause of autumn pollinosis (García et al. 1997).

### 3.3 *Fraxinus* sp.

Pollen season started in November and finished in February. The important value was observed in December with 70 PG/cm<sup>2</sup> (0.36 %).

In the Mediterranean region, *Fraxinus excelsior* is replaced by *Fraxinus angustifolia*. It pollinates during December and January. Today, the reality of ash pollinosis is clearly established. The diagnosis of this pollinosis has greatly benefited from the knowledge of allergens on a molecular level (Metz-Favre et al. 2010).

### 3.4 *Olea* sp.

*Olea* is considered one of the most important causes of respiratory allergic disease in the Mediterranean region (Florido et al. 1999). This family was present in a large quantity during April, with a total abundance of 7.18 % (Table 1). Pollen grains of these taxa reached a maximum of 117 PG/cm<sup>2</sup> (5.77 %).

Thus, Oleaceae pollen grains constituted 1.07 % of total pollen in the atmosphere of Kırklareli. Pollen season started in the second week of April and ended in the last week of August. The highest count was recorded in the first and second weeks of June and in

the first week of July (Erkan et al. 2011). In the atmosphere of Denizli (Turkey), *Olea* pollen dominated from the second week of April until the second week of July with the highest values in the first week of June (Güvensen et al. 2013).

### 3.5 Poaceae

The results of this study indicate that Poaceae pollen was collected during all the months. It is the most abundant type with 23.20 %. The highest value was recorded in April with 272 pollen grains/cm<sup>2</sup>. According to the data of a similar work realized in the same area, Poaceae was ranked in the first position with 1520 PG/cm<sup>2</sup> (23.77 %), and the maximum value was observed in April and mid-May (Chafai-Ketfi et al. 2009). This could be related to the large area of grassland located in El-Hadjar region.

Considering allergenic pollen as a whole in Spain, grasses are the most important cause of pollinosis. The highest atmospheric grass pollen concentration varies from 40 to 75 grains/m<sup>3</sup> of air, which is the most frequent level in the Spanish Mediterranean coastal area, and from 200 to 400 grains/m<sup>3</sup> in some areas such as Badajoz or Salamanca (central Spain) (Subiza et al. 1995). Pollen grains of this family constituted 13.62 % of total pollen in the atmosphere of Kırklareli. Pollen production continued from the third week of March to the last week of November (Erkan et al. 2011). It was the only major non-arboreal type observed in the atmosphere of Kuşadası. These plants comprised 3.70 % of the total pollen in the study area, in which 480 pollen grains/cm<sup>2</sup> were counted (Tosunoğlu et al. 2013).

Grass pollen allergens are a major cause of allergic respiratory disease (Davies et al. 2012). In the Mediterranean region, respiratory allergies due to Poaceae pollen have increased during the last few decades despite the fall in atmospheric grass pollen levels recorded in some cities (Recio et al. 2010).

### 3.6 Euphorbiaceae

With *Mercurialis* genus, this family is ranked in the second position after Poaceae, its highest value was collected in March with 127 PG/cm<sup>2</sup>. This was observed on slides in the period from December to May, with maximum concentration in March (127.78 PG/cm<sup>2</sup>), due essentially to the existence of

this plant in the vegetation with big quantities in this period. *Mercurialis annua* is reported to be an important allergen source in the Mediterranean areas of Spain and Italy. (Mer a 1) has been described as an allergenic molecule. High levels of sensitization to *Mercurialis* pollen ranging from 28 to 56 % were described in several areas of Spain (Gadermaier et al. 2014).

### 3.7 *Plantago* sp.

The highest quantity of pollen production was 18.45 PG/cm<sup>2</sup> in April (0.91 %). In the atmosphere of Kırklareli, pollen season started in the first week of May and ended in the third week of September. The highest values were noted between 21 and 22 weeks. Pollen grains of this genus constituted 2.60 % of total pollen (Erkan et al. 2011).

### 3.8 Chenopodiaceae

Pollen grains were cached in July and August, from October to January, then from March to June. The highest value was in April (4.94 PG/cm<sup>2</sup>).

It has been reported that in Timisoara (Romania), Chenopodiaceae/Amaranthaceae seasons occurred at regular intervals between June and October each year. Smaller airborne concentrations of Chenopodiaceae/Amaranthaceae were recorded out of each season (Ianovici 2008).

In Salamanca (Spain), this pollen type appears already in late April, increasing its daily levels from early June until the first week of August, where it reaches the highest mean daily value. The highest daily counts usually occurred between late July and mid-August, with the highest value being on August and the lowest on June and July (Rodríguez de la Cruz et al. 2012).

### 3.9 Urticaceae

Represented with 0.95 %, this family was in the maximum value in August (5.30 PG/cm<sup>2</sup>) and in March (5.01 PG/cm<sup>2</sup>). *Parietaria* is the main allergenic genus of the Urticaceae family. The most important species are *Parietaria judaica* and *Parietaria officinalis*. This weed has a very long flowering season, starting early in spring persisting throughout the summer and a shorter pollination period taking

place from end of August to October. The extraordinarily long persistence in the atmosphere of *Parietaria* pollen in the Mediterranean area is responsible for a multi-seasonal symptomatology (D'Amato et al. 2007; Gadermaier et al. 2014). *Parietaria* (Pj) is considered one of the major sources of allergens whose allergenic composition has been studied in detail identifying three independent families of proteins with allergenic activity (Bonura et al. 2013).

### 3.10 Airborne fungal spores

According to the data of the actual study, fungi were present in the air of El-Hadjar town during the study period, with important values. It presented 19.15 % of annual airborne particles collected.

It has been observed that in Turkey, a total of 6.198 spores/cm<sup>2</sup> were recorded from the atmosphere of the Sivrihisar. The highest concentration for the spores was recorded in the second week of June. On the other hand, the highest concentrations of airborne *Cladosporium* and *Alternaria* were recorded during summer. Both spore types are present in lower levels in winter (Potoglu-Erkara et al. 2009). On the other hand, the role of fungi in the sensitization and elicitation of allergic symptoms in atopic subjects is well established (Hasnain et al. 2004).

## 4 Conclusion

It is concluded that the present gravimetric survey of airborne pollen has contributed significantly to our existing knowledge concerning pollen grains of El-Hadjar town during 1-year aerobiological study.

Pollen grains of 50 taxa were collected in deposited samples in the atmosphere of El-Hadjar. Of these, 28 taxa were from arboreal plants and 22 taxa from non-arboreal ones. Maximum catch of pollen types was observed during April with 624 PG/cm<sup>2</sup> (30.54 %). The major collected taxa were: Cupressaceae, *Casurina* sp., *Olea* sp., *Fraxinus* sp., Poaceae, *Mercurialis* sp., Chenopodiaceae, *Plantago* sp., and Urticaceae, those responsible of the pollinosis in the Mediterranean area.

The pollen calendar for this region presented here may be a useful data for allergologists as an aid in establishing the exact diagnostics. It also provides important evidence for continuous data collection in

order to study the relationships between airborne pollen concentrations and meteorological factors.

## References

- Al-Frayh, A. R., Reilly, H., Harfi, H. A., Hasnain, S. M., Thorogood, R., & Wilson, D. (1989). A 12-month aerobiological survey of pollen in Riyadh. *Annals of Saudi Mediane*, 9(5), 443–447.
- Al-Qura'n, S. (2008). Analysis of airborne pollen fall in Tafleeh, Jordan, 2002–2003. *World Applied Sciences Journal*, 4(5), 730–735.
- Altunoglu, M. K., Toraman, E., Temel, M., Biçakçı, A., & Kargioglu, M. (2010). Analysis of airborne pollen grains in Konya, Turkey, 2005. *Pakistan Journal of Botany*, 42(2), 765–774.
- Biçakçı, A., Benlioglu, O. N., & Erdogan, D. (1999). Airborne pollen concentration in Kütahya. *Turkish Journal of Botany*, 23, 75–81.
- Boi, M., & Llorens, L. (2013). Annual pollen spectrum in the air of Palma de Mallorca (Balearic Islands, Spain). *Aerobiologia*, 29, 385–397.
- Bonura, A., Corinti, S., Schiavi, E., Giacomazza, D., Gianguzza, F., Di Felice, G., & Colombo, P. (2013). The major allergen of the Parietaria pollen contains an LPS-binding region with immuno-modulatory activity. *Allergy*, 68, 297–303.
- Çeter, T., Pinar, N. M., Güney, K., Yildiz, A., Aşçı, B., & Smith, M. (2012). A 2-year aeropalinological survey of allergenic pollen in the atmosphere of Kastamonu, Turkey. *Aerobiologia*, 28, 355–366.
- Chabert, J. (1971). Notes de Sur le l'air composant pollinique de Rabat (Maroc) juillet 1964–juillet 1965. *Société des sciences naturelles et physiques du Maroc, Tome 51*, 166–181.
- Chafai-Ketfi, L., Azzouz, F., Salemour, N., & Boughediri, L. (2009). Contenu pollinique de l'atmosphère de deux régions de Nord-Est Algérien : El-Hadjar (W. Annaba) et Dréan (W. El-Tarf). *Revue Synthèse*, 20, 31–39.
- Charpin, J., Surinyach, R., & Frankland, A. W. (1974). *Atlas of European allergenic pollens*. Paris: Ed. Sandoz.
- Chauhan, S. V. S., & Goyal, R. (2006). Pollen calendar of Agra city with special reference to allergenic significance. *Journal of Environmental Biology*, 27(2), 275–281.
- Chen, S. H., & Huang, T. C. (1980). Aeropalinological study of Taipei Basin, Taiwan. *Grana*, 19(2), 147–155.
- D'Amato, G., Cecchi, L., Bonini, S., Nunes, C., Annesi-Maesano, I., Behrendt, H., et al. (2007). Allergenic pollen and pollen allergy in Europe. *Allergy*, 62, 976–990.
- Davies, J. M., Li, H. Z., Green, M., Towers, M., & Upham, J. W. (2012). Subtropical grass pollen allergens are important for allergic respiratory diseases in subtropical regions. *Clinical and Translational Allergy*, 2(4), 1–10.
- Durham, O. C. (1946). The volumetric incidence of atmospheric allergens. IV. A proposed standard method of gravity sampling, counting and volumetric interpolation of results. *Journal of Allergy*, 17(2), 79–86.
- Erkan, P., Biçakçı, A., Aybeke, M., & Malyer, H. (2011). Analysis of airborne pollen grains in Kirklareli. *Turkish Journal of Botany*, 35, 57–65.
- Esch, R. E., Hartsell, C. J., Crenshaw, R., & Jacobson, R. S. (2001). Common allergenic pollens, fungi, animals, and arthropods. *Clinical Reviews in Allergy and Immunology*, 21, 261–292.
- Florido, J. F., Delgado, P. G., de San Pedro, B. S., Quirarte, J., de Saavedra, J. M. A., Peralta, V., & Valenzuela, L. R. (1999). High Levels of *Olea europaea* pollen and relation with clinical findings. *International Archives of Allergy and Immunology*, 119, 133–137.
- Gadermaier, G., Hauser, M., & Ferreira, F. (2014). Allergens of weed pollen: An overview on recombinant and natural Molecules. *Methods*, 66, 55–66.
- García, J. J., Trigo, M. M., Cabezedo, B., Redo, M., Vega, J. M., Barber, D., et al. (1997). Pollinosis due to Australian pine (*Casuarina*): An aerobiologic and clinical study in southern Spain. *Allergy*, 52, 11–17.
- General Directorate of Forestry. (2013). *La Direction Générale des Forêts de la Wilaya d'Annaba*. Annaba: General Directorate of Forestry.
- Giner, M. M., Carrión-García, J. S., & Camacho, C. N. (2002). Seasonal fluctuations of the airborne pollen spectrum in Murcia (SE Spain) Some peculiarities in the pollen calendar. *Aerobiologia*, 18, 141–151.
- Güvensen, A., Çelik, A., Topuz, B., & Öztürk, M. (2013). Analysis of airborne pollen grains in Denizli. *Turkish Journal of Botany*, 37, 74–84.
- Güvensen, A., & Öztürk, M. (2003). Airborne pollen calendar of Izmir–Turkey. *Annals of Agricultural and Environmental Medicine*, 10, 37–44.
- Hasnain, S. M., Al-Frayh, A. R., Al-Suwaine, A. R., Gad-El-Rab, M. O., Fatima, K., & Al-Sedairy, S. (2004). *Cladosporium* and respiratory allergy: Diagnostic implication in Saudi Arabia. *Mycopathologia*, 157, 171–179.
- Hasnain, S. M., Fatima, K., Al-Frayh, A. R., & Al-Sedairy, S. T. (2005). One-Year pollen and spore calendars of Saudi Arabia: Al-Khobar, Abha and Hofuf. *Aerobiologia*, 21, 241–247.
- Ianovici, N. (2008). Seasonal variations in the atmospheric Chenopodiaceae/Amaranthaceae pollen count in Timișoara, Romania. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 36(2), 17–22.
- Ianovici, N., Bunu-Panaitescu, C., & Brudiu, I. (2013). Analysis of airborne allergenic pollen spectrum for 2009 in Timișoara, Romania. *Aerobiologia*, 29(1), 95–111.
- Ketfi, L. (1998). *Etude aéropalinologique de la region d'El-Hadjar*. Mémoire de Magister: Université Badji Mokhtar, Annaba. 123 p.
- Korteby, H., Hammache, V., Lamrani, Z., Abed, L., & et Larbaoui, D. (1977). L'atmosphère pollinique d'Alger Note sur sa composition durant le deuxième trimestre 1977. *Bulletin of the Society of Natural History of Africa Northern Algeria*, 68(3–4), 75–79.
- Metz-Favre, C., Papanikolaou, I., Purohit, A., Pauli, G., & de Blay, F. (2010). Actualité dans l'allergie au pollen de frêne. *Revue française d'allergologie*, 50, 568–573.
- Pérez-Badia, R., Rapp, A., Vaquero, C., & Fernández-González, F. (2011). Aerobiological study in East-Central Iberian Peninsula: Pollen diversity and dynamics for major taxa. *Annals of Agricultural and Environmental Medicine*, 18, 99–111.

- Piotrowska, K., & Kaszewski, B. M. (2009). The influence of meteorological conditions on the start of the hazel (*Corylus L.*) pollen season in Lublin, 2001–2009. *Acta Agrobotanica*, 62(2), 59–66.
- Potoglu-Erkara, I., Ilhan, S., & Oner, S. (2009). Monitoring and assessment of airborne *Cladosporium* Link and *Alternaria* Nées spores in Sivrihisar (Eskisehir), Turkey. *Environmental Monitoring Assessment*, 148, 477–484.
- Recio, M., Docampo, S., García-Sánchez, J., Trigo, M. M., Melgar, M., & Cabezudo, B. (2010). Influence of temperature, rainfall and wind trends on grass pollination in Malaga (western Mediterranean coast). *Agricultural and Forest Meteorology*, 150, 931–940.
- Reille, M. (1992). *Pollen et spores d'Europe et d'Afrique du Nord* (ed.). France: Laboratoire de Botanique Historique et Palynologie. Univ. d'Aix-Marseille III.
- Rodríguez de la Cruz, D., Sánchez-Reyes, E., & Sánchez-Sánchez, J. (2012). Analysis of Chenopodiaceae-Amaranthaceae airborne pollen in Salamanca, Spain. *Turkish Journal of Botany*, 36, 336–343.
- Rojas-Villegas, G., & Roure-Nolla, J. M. (2001). Atmospheric pollen in Santiago, Chile. *Grana*, 40, 126–132.
- Sánchez-Mesa, J. A., Serrano, P., Cariñanos, P., Prieto-Baena, J. C., Moreno, C., Guerra, F., & Galán, C. (2005). Pollen allergy in Cordoba city: Frequency of sensitization and relation with antihistamine sales. *Journal of Investigational Allergology and Clinical Immunology*, 15(1), 50–56.
- Savitsky, V. D., Bezus'ko, L. G., Butich, N. G., Tsymbaliuk, Z. M., Savitska, O. V., & Bezus'ko, T. V. (1996). Airborne pollen in Kiev (Ukraine): Gravimetric sampling. *Aerobiologia*, 12, 209–211.
- Shahali, Y., Sutra, J. P., Peltre, G., Charpin, D., Sénéchal, H., & Poncet, P. (2010). Ig-E reactivity to common cypress (*C. sempervirens*) pollen extracts: Evidence for novel allergens. *WAO Journal*, 3, 229–234.
- Stefanic, E., Rasic, S., Merdic, S., & Colakovic, K. (2007). Annual variation of airborne pollen in the city of Vinkovci, Northeastern Croatia. *Annals of Agricultural and Environmental Medicine*, 14, 97–101.
- Subiza, J., Jerez, M., Jimenez, J. A., José-Narganes, M., Cabrera, M., Varela, S., & Subiza, E. (1995). Clinical aspects of allergic disease: Allergenic pollen and pollinosis in Madrid. *Journal of Allergy Clin Immunology*, 96(1), 15–23.
- Tosunoğlu, A., Yenigun, A., Biçakçi, A., & Eliaçık, K. (2013). Airborne pollen content of Kuşadası. *Turkish Journal of Botany*, 37, 297–305.
- Trigo, M. M., Recio, M., Toro, F. J., Cano, M., Dopazo, M., & García, H. (1999). Annual variations of airborne *Casuarina* pollen in the Iberian Peninsula. *Polen*, 10, 71–77.
- Vergamini, S. M., Duso, L., De Antoni Zoppas, B. C., Fernández-González, D., & Valencia Barrera, R. M. (2007). Airborne pollen calendar of Caxias Do Sul (Rio Grande Do Sul, Brazil), 2001–2002. *Polen*, 17, 51–65.
- Weryszko-Chmielewska, E., & Piotrowska, K. (2004). Airborne pollen calendar of Lublin, Poland. *Annals of Agricultural and Environmental Medicine*, 11, 91–97.
- Yang, Y. L., Huang, T. C., & Chen, S. H. (2003). Diurnal Variations of Airborne Pollen and Spores in Taipei City, Taiwan. *Taiwania*, 48(3), 168–179.