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An Investigation on Plants with Allergic Pollen: The Case of Rize Urban Open Green Areas

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Abstract

With its environmental, social, and economic advantages, urban open and green areas play an essential role in improving the quality of life of city dwellers. Plants, which constitute the foundation of these areas, have both positive and detrimental effects on human health and provide numerous essential advantages to the urban ecosystem. One of these negative effects is that pollen causes allergic responses. The goal of this study was to identify allergenic plant taxa in Rize province's urban open green areas. In the Rize urban open green areas, 110 plant taxa that potentially induce allergic reactions were discovered as part of the study. These plants were evaluated in terms of family, life form, flowering period, allergen rate, protective case and location. As a result of this evaluation, from 110 plants; it was determined that 42 of them had low allergen rate, 26 of them had moderate allergen rate and 42 of them had high allergen rate. In addition, several proposals for using these species in planting design applications have been produced.

Keywords: *Allergic plants, urban open green areas, Rize*

Alerjik Polenlere Sahip Bitkiler Üzerine Bir Araştırma: Rize Kentsel Açık Yeşil Alanlar Örneği

Öz

Kentsel açık ve yeşil alanlar sağladıkları çevresel, sosyal ve ekonomik faydalar ile kentlilerin yaşam kalitesinin iyileştirilmesinde önemli bir rol oynamaktadır. Bu alanların temelini oluşturan bitkiler, insan sağlığı üzerinde hem olumlu hem de olumsuz etkilere sahip olup, kentsel ekosisteme çok önemli katkılar sağlamaktadır. Bitkilerin olumsuz etkilerinden biri de polenlerin alerjik reaksiyonlara neden olmasıdır. Bu çalışmanın amacı, Rize ilinin kentsel açık yeşil alanlarındaki alerjik bitki taksonlarını belirlemektir. Çalışma kapsamında Rize kentsel açık yeşil alanlarında alerjik reaksiyonlara neden olabilecek 110 bitki taksonu tespit edilmiştir. Bu bitkiler familya, yaşam formu, çiçeklenme dönemi, alerjen oranı, evcik durumu ve lokasyon açısından değerlendirilmiştir. Bu değerlendirme sonucunda 110 bitkiden; 42 tanesinin düşük alerjen oranı, 26 tanesinin orta düzeyde alerjen oranı ve 42 tanesinin yüksek alerjen oranına sahip olduğu belirlenmiştir. Ayrıca, bu bitkilerin bitkisel tasarım çalışmalarında kullanımları ile ilgili çeşitli öneriler geliştirilmiştir.

Anahtar Kelimeler: *Alerjik bitkiler, kentsel açık yeşil alanlar, Rize*

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1. Introduction

Urban open green areas are planned for ecological, social, and economic purposes in order to eliminate the negative effects of urbanization, which is one of the biggest problems of today, and to create sustainable cities (Çetinkaya & Uzun, 2014; Gülçin, 2020). In addition to contributing to the re-establishment of the relationship between humans and nature, these areas play an important role in increasing the quality of life of urban people, especially with the environmental, social, and economic contributions they provide (Ahern, 1995; Bayramoğlu & Yurdakul, 2019; Ekren, 2020; Eren, Düzenli & Alpak, 2020). Green areas have positive effects on human health by enabling individuals to get rid of stress, mental fatigue, and diseases faster (Velarde, Fry & Tveit, 2007; Qin, Zhou, Sun, Leng & Lian, 2013; Karaşah, 2017). When the intense population growth in Turkish cities was examined, it was seen that the number of people living in cities constitutes approximately 76% of the total population as of 2020 (Ritchie & Roser, 2021). This demographic trend puts pressure on ecosystems and the quality of life of urban residents, so the importance of open and green area designs in the planning of cities is increasing day by day.

The main component of urban open and green areas is plants. Plants provide many benefits such as reducing air pollution, regulating micro-climate, providing habitat for wild animals, carbon sequestration, energy saving, reducing noise, erosion control, making positive contributions to urban aesthetics, and creating space (Önder & Akbulut, 2011; Sakıcı, Karakaş & Kesimoğlu, 2013; Yılmaz, Düzenli & Dinçer, 2017; Düzenli, Yılmaz & Tarakçı Eren, 2018; Eren, 2019; Gülçin & Van Den Bosch, 2021; Karaşah, 2021). However, despite all these benefits, it was seen that many plant species used in open and green spaces designed today are mostly chosen by keeping their form, color, and aesthetic features in the foreground (Bayramoğlu & Şatıroğlu, 2018; Sarı & Karaşah, 2018). The aim of planting design should be to create aesthetic and functional uses for users. For this reason, the plant taxa selected in the design of urban open and green areas should be evaluated as a whole with both their physiological and morphological characteristics.

In addition to the positive benefits that plants provide, they can also have some negative effects on their environment throughout their life processes. These negative effects can cause a number of problems on human health. Some exotic and invasive plants used in urban areas can cause public health problems (allergies, toxic effects, etc.) (Lorenzoni-Chiesura, Giorato & Marcer, 2000; Sarı, 2019). One of the most important negative effects of plants on human health is allergic reactions caused by pollen (Cariñanos, Grilo, Pinho, Casares-Porcel, Braquinho, Acil & Calaza-Martinez, 2019; Hsieh, Yu, Tai, Jan, Wen, Lin & Tseng, 2019; Kasprzyk, Ćwik, Kluska, Wójcik & Cariñanos, 2019; Lara, Rojo, Fernández-González &Pérez-Badia, 2019; Aerts, Stas, Vanlessen, Hendrickx, Bruffaerts, Hoebeke & Aerts, 2020). Pollen, which is an important food for many living creatures such as bees, insects, and birds, has a key role in the continuation of the generations of plants (Gunnell, Williams & Murphy, 2019; Stoskopf, Tomes & Christie, 2019; Quinlan, 2020; Sarı, 2021). In addition, pollen is one of the essential substances in nature for human survival (Kieliszek, Piwowarek, Kot, Błażejak, Chlebowska-Śmigiel & Wolska, 2018). They have a key part in the development of numerous objects, from paper to pencils, in addition to being important factors in the formation of many nutrients (fruits, honey, etc.) (Socha, Cayón, Ligarreto & Chaves, 2019; Bortolotti, Pošćić & Bogo, 2020; Melin, Colville, Duckworth, Altwegg, Slabbert, Midgley & Donaldson, 2020; Panettieri, Chatzifotis, Messina, Olivotto, Manuguerra, Randazzo & Piccolo, 2020). Pollens are renowned as the most prevalent allergens in the atmosphere and create detrimental effects on human health in addition to all of these great characteristics (Oduber, Calvo, Blanco-Alegre, Castro, Vega-Maray, Valencia-Barrera & Fraile, 2019; Ortega Rosas, Calderón-Ezquerro & Gutiérrez-Ruacho, 2019; Ouyang, Yin, Li, Fan & Zhang, 2019).

Pollen, which is defined as the structure containing male gametes and formed in the male organs of the flower, which affects the reproduction of seed plants, can cause allergic effects when released into the air in large amounts (Güngüder, 2006; Girişken, 2008). When researchers looked at the times when the plants distributed pollen, they discovered that they did it predominantly during flowering periods and in the morning hours (D'Amato, Cecchi, Bonini, Nunes, Annesi-Maesano, Behrendt, Liccardi, Popov & Van Cauwenberge, 2007). Furthermore, pollen emitted by trees is more visible in

the initial months of spring, while pollen emitted by herbaceous plants is more visible in the summer and autumn (Gözcelioğlu, 2012). Pollen levels in the sky are substantially higher in dry and hot weather than in periods of heavy rainfall, according to research (İnceoğlu, Pınar, Şakıyan and Sorkun, 1994; Pınar, Şakıyan, İnceoğlu & Kaplan, 1999). It was seen that the relations between people and plants should be maintained more carefully since the pollen emitted from plants coincides with the spring and summer months, which are the periods when people use urban open green areas the most.

Pollen accumulated in the nose, bronchus, and eyes through respiration in humans manifests itself as hay fever with symptoms such as nasal discharge and congestion, sneezing, dry cough, itching, and watering in the throat, nose, ears, and eyes. If necessary precautions are not taken, it can turn into diseases such as sinusitis, bronchitis, otitis media and asthma. Plant species that are commonly used in cities due to poor landscaping methods cause a variety of issues, including allergic rhinitis, colds, asthma, and even heart disease (Cariñanos & Casares-Porcel, 2011).

Detection of pollen emitted from plants used in urban open and green areas and which have negative effects on human health is very important in terms of diagnosis and treatment of allergic diseases (Jianan, Zhiyun, Hua, Xiaoke & Hong, 2007). Therefore, it is important to determine the planting designs to be made in these areas and the intensity of use of the plants to be preferred. This study was carried out to determine the existing allergic plant taxa in the urban open green areas of Rize province, which has rich vegetation due to its natural structure. In this context, in addition to the allergen rates of the plants, their protective case and flowering periods were also determined.

2. Material and Method

The main material of the research is the plant taxa that can cause pollen allergy in the urban open and green areas of Rize province. All trees, shrubs and climbers in these areas that were found to spread allergic pollen were included in the study. At the same time, the literature on plants that can cause pollen allergy was also evaluated as research material.

The research consisted of three stages. In the first stage, urban open and green areas examined within the scope of the study were determined. These areas were given in Table 1. In the determination of these areas, the presence of plants emitting allergic pollen in the areas and the high number of taxa were effective.

Table 1. Urban open and green areas included in the study

No	Name of urban open and green area	Number of taxa
1	15 Temmuz Demokrasi Park	35
2	Doğu Park	13
3	28 Ağustos Fetih Park	29
4	Isırlık Natural Park	64
5	Kale Park	10
6	Recep Tayyip Erdoğan University Zihni Derin Campus	116
7	Sahil Camii Park	11
8	Sahil Park/Mesut Yılmaz Park	87
9	Tanyel Park	7
10	Tuzcuoğlu Memiş Ağa Park	19
11	Ziraat Botanic Park	125

The locations of urban open and green areas examined within the scope of the study were given in Figure 1.

Figure 1. The locations of study areas (Google Earth, 2022)

In the second stage of the study, plants with allergic pollen were identified in the study areas. In the last stage, these plants were evaluated in terms of family, life form, flowering period, allergen rate, protective case and location. While making these evaluations, the following criteria were taken into account.

Plants were classified according to the life form as follows; natural (N), exotic (E), exotic cultured (EC), exotic hybrid (EH), and naturalized/semi-natural (SN).

The allergen rates of pollen were evaluated in three categories as low, moderate and high by examining the literature (Acar, 2013; Cariñanos, Casares-Porcel & Quesada-Rubio, 2014; Cariñanos, Adinolfi, Guardia, Linares & Casares-Porcel, 2016).

The flowering periods of the plants were determined because the plants emit more pollen throughout these times. The numbering of these times is as follows; 1: January, 2: February, 3: March, 4: April, 5: May, 6: June, 7: July, 8: August, 9: September, 10: October, 11: November, 12: December.

Since pollens are found in male individuals of plants, it is very important to determine the protective case of taxa. In this context, the protective cases of the plants were determined as monoequatic, dioecious or polyequatic. However, the protective cases of some shrubs and climbing plants could not be determined and this situation was expressed with a "-" sign. The location information of the plants was given based on Table 1.

3. Results and Discussion

The plants that were found to spread allergic pollen in the study areas and their family, life form, flowering period, allergen rate, protective case and location were given in Table 2.

Table 2. Plant taxa with allergic pollen detected within the scope of the study and their characteristics (D'Amato et al., 2007; Cariñanos & Casares-Porcel, 2011; Acar, 2013; Cariñanos et al., 2014; Cariñanos et al., 2016; Kasprzyk et al., 2019)

No	Latin Name	Family	Flowering Period	Allergen Rate	Protective Case	Location
CONIFEROUS TREES AND TREELETS						
1	*Abies nordmanniana* (Stev.) Spach. *subsp. nordmanniana*	PINACEAE	7-10	Low	Monoecious	3
2	*Araucaria angustifolia* (Bert.) O. Kuntze)	ARAUCARIACEAE	5-6	High	Dioecious	11
3	*Araucaria heterophylla* (Salisb.)	ARAUCARIACEAE	5-6	High	Dioecious	11

	Franco					
4	*Calocedrus decurrens* (Torr.) Florin (syn. *Libocedrus decurrens* Torr.)	CUPRESSACEAE	10-11	High	Monoecious	11
5	*Cedrus atlantica* (Endl.) Carr.	PINACEAE	10-11	Moderate	Monoecious	11
6	*Cedrus deodara* (Roxb.) G. Don	PINACEAE	10-11	Moderate	Monoecious	3,4,6,7,8, 11
7	*Cedrus libani* A.Rich.	PINACEAE	10-11	Moderate	Monoecious	3,4,7
8	*Chamaecyparis lawsoniana* (A. Murray) Parl.	CUPRESSACEAE	3-4	High	Monoecious	3,4,5,6,8, 10,11
9	*Cryptomeria japonica* (Thunb. ex L.f.) D.Don	CUPRESSACEAE	2-3	High	Monoecious	3,4,6,8,1 1
10	*Cupressocyparis leylandii* (A.B.Jacks. & Dallim.) Dallim.	CUPRESSACEAE	4-5	High	Monoecious	2,5,8,11
11	*Cupressus arizonica* Greene	CUPRESSACEAE	5-6	High	Monoecious	3,4,6,8,1 1
12	*Cupressus sempervirens* L.	CUPRESSACEAE	5-6	High	Monoecious	1,4,7,8,1 1
13	*Ginkgo biloba* L.	GINKGOACEAE	5-6	Moderate	Dioecious	6,11
14	*Juniperus virginiana* L.	CUPRESSACEAE	2-3	High	Dioecious	8
15	*Picea abies* (L.) H.Karst.	PINACEAE	5-6	Low	Monoecious	4,6,8,11
16	*Picea orientalis* L.(Link.)	PINACEAE	5-6	Low	Monoecious	3,5,8,11
17	*Picea pungens* Engel.	PINACEAE	5-6	Low	Monoecious	5
18	*Pinus brutia* Ten.	PINACEAE	5-6	Moderate	Monoecious	11
19	*Pinus nigra* J.F.Arnold	PINACEAE	5-6	Moderate	Monoecious	5, 8
20	*Pinus pinaster* Aiton	PINACEAE	5-6	Moderate	Monoecious	3,6,8
21	*Pinus pinea* L.	PINACEAE	5-6	Moderate	Monoecious	5,8,11
22	*Pinus sylvestris* L.	PINACEAE	5-6	Moderate	Monoecious	4,11
23	*Sequoia sempervirens* (D. Don) Endl.	CUPRESSACEAE	2-4	Moderate	Monoecious	3,4,8,11
24	*Sequoiadendron giganteum* (Lindl.) Buchh.	CUPRESSACEAE	3-4	Moderate	Monoecious	11
25	*Taxus baccata* L.	TAXACEAE	5-6	High	Dioecious	4,6
26	*Thuja occidentalis* L.	CUPRESSACEAE	5-6	High	Monoecious	8,10,11
27	*Thuja orientalis* (L.) Franco	CUPRESSACEAE	5-6	High	Monoecious	6,7,8,11
CONIFEROUS SHRUBS						
1	*Juniperus horizontalis* Moench	CUPRESSACEAE	3-4	High	Dioecious	4,8
2	*Juniperus sabina* L.	CUPRESSACEAE	3-4	High	Dioecious	8
BROADLEAF TREES AND TREELETS						
1	*Acacia dealbata* L.	LEGUMINOSAE	1-3	Low	Monoecious	4,11
2	*Acer negundo* L.	SAPINDACEAE	4-5	High	Monoecious	4,5,8
3	*Acer palmatum* Thunb.	SAPINDACEAE	4-5	High	Monoecious	2,5,7,10
4	*Aesculus hippocastanum* L.	SAPINDACEAE	4-5	Moderate	Monoecious	4,8,9
5	**Ailanthus altissima* (Mill.) Swingle	SIMORIBACEAE	5-6	Moderate	Polygamous	6,8,11
6	*Albizia julibrissin* Durazz.	FABACEAE	7-8	Low	Polygamous	4,6
7	*Alnus glutinosa* (L.) Gaertn.	BETULACEAE	3-4	High	Monoecious	4,6
8	*Betula alba* L.	BETULACEAE	3-4	High	Monoecious	6,8
9	*Carpinus betulus* Mill.	BETULACEAE	4-5	High	Monoecious	8
10	*Castanea sativa* Mill.	FAGACEAE	6-7	Moderate	Monoecious	4,11
11	*Catalpa bignonioides* Walter	BIGNONIACEAE	5-6	Low	Monoecious	4
12	*Cercis siliquastrum L.*	FABACEAE	4-5	Low	Polygamous	4,6,11
13	*Corylus avellana* L.	BETULACEAE	3-4	Low	Monoecious	4,6
14	*Diospyros kaki* Thunb.	EBENACEAE	5-6	Low	Dioecious	3,11
15	*Eriobotrya japonica* (Thunb.) Lindl.	ROSACEAE	11-12	Low	-	3,4,6,7,8, 11
16	*Eucalyptus camaldulensis* Dehn.	MYRTACEAE	1-3	Low	Monoecious	4,8

17	*Fagus sylvatica L.* 'Atropurpurea'	FAGACEAE	4-5	Moderate	Monoecious	8
18	*Fraxinus excelsior* L.	OLEACEAE	3-4	High	Polygamous	2,3,4,8,9,11
19	*Juglans regia* L.	JUGLANDACEAE	4-5	High	Monoecious	3,4
20	*Koelreuteria paniculata* Laxm.	SAPINDACEAE	6-7	Low	Dioecious	4
21	*Lagerstroemia indica* L.	LYTHRACEAE	6-8	Low	-	1,2,4,6,8,9,11
22	*Laurus nobilis* L.	LAURACEAE	3-5	High	Dioecious	1,2,4,6,9,11
23	*Ligustrum japonicum* Thunb.	OLEACEAE	4-5	High	Monoecious	3,4,6,7,10,11
24	*Liquidambar styraciflua* L.	HAMAMELIDACEAE	5-6	High	Monoecious	6,10,11
25	*Liriodendron tulipifera* L.	MAGNOLIACEAE	5-6	Low	Monoecious	6
26	*Magnolia grandiflora* L.	MAGNOLIACEAE	5-6	Low	Monoecious	1,2,3,4,5,6,8, 10,11
27	*Malus floribunda* Siebold ex Van Houtte	ROSACEAE	4-5	Low	-	8
28	*Melia azedarach* L.	MELIACEAE	4-5	Low	Monoecious	4
29	*Mespilus germanica* L.	ROSACEAE	5-6	Low	Monoecious	6
30	*Morus alba* L.	MORACEAE	4-5	High	Dioecious	4,8,11
31	*Olea europaea* L.	OLEACEAE	6-7	High	Monoecious	1,2,3,9,11
32	*Paulownia tomentosa* Steud.	PAULOWNIACEAE	4-5	Low	-	4,8
33	*Platanus orientalis* L.	PLATANACEAE	4-5	High	Monoecious	2,4,5,8,10
34	*Populus alba* L.	SALICACEAE	4-5	High	Dioecious	8
35	*Populus nigra* L.	SALICACEAE	4-5	High	Dioecious	8,11
36	*Prunus cerasifera* Ehrh.	ROSACEAE	4-5	Low	Monoecious	8
37	*Prunus laurocerasus* L.	ROSACEAE	4-5	Low	Monoecious	1,2,3,4,5,6,7,8,9,10,11
38	*Pyrus communis* L.	ROSACEAE	4-5	Low	Monoecious	4,6,8
39	*Quercus robur* L.	FAGACEAE	4-5	High	Monoecious	4
40	*Quercus rubra* L.	FAGACEAE	4-5	High	Monoecious	6
41	**Robinia pseudoacacia* L.	FABACEAE	5-6	Moderate	Monoecious	4,6,8,11
42	*Salix babylonica* L.	SALICACEAE	3-4	High	Dioecious	2,3,4,5,6,8
43	*Salix caprea* L.	SALICACEAE	3-4	High	Dioecious	4,6
44	*Salix nigra* Marshall	SALICACEAE	3-4	High	Dioecious	8
45	*Sophora japonica* L.	FABACEAE	7-8	Low	Monoecious	4, 11
46	*Sorbus aucuparia* L.	ROSACEAE	5-6	Low	Monoecious	6
47	*Syringa vulgaris* L.	OLEACEAE	4-5	Moderate	Monoecious	8,11
48	*Tamarix tetrandra* Pallas	TAMARICACEAE	4-5	Moderate	Monoecious	4,11
49	*Tilia rubra* DC.	TILIACEAE	6-7	Moderate	-	3,8
50	*Tilia tomentosa* Moench	TILIACEAE	6-7	Moderate	Monoecious	1,4,8
BROADLEAF SHRUBS						
1	*Arbutus unedo* L.	ERICACEAE	10-12	Low	Monoecious	1,4
2	*Berberis thunbergii* DC.	BERBERIDACEAE	3-4	High	-	4,5
3	*Berberis vulgaris* L.	BERBERIDACEAE	3-4	High	-	4,8
4	*Callistemon citrinus* (Curtis) Sheels (syn. *C. lanceolatus* DC)	MYRTACEAE	5-7	Low	Monoecious	8,11
5	*Cotoneaster horizontalis* Decne.	ROSACEAE	5-6	Low	-	8
6	*Forsythia × intermedia* Zabel	OLEACEAE	2-3	High	-	3,5,8
7	*Hibiscus syriacus* L.	MALVACEAE	6-7	Low	Monoecious	3,4,6,8,11
8	*Jasminum fruticans* L.	OLEACEAE	6-7	High	-	4,6,11

9	*Ligustrum vulgare* L.	OLEACEAE	6-7	High	-	3,5,8,11
10	*Mahonia aquifolium* (Pursh) Nutt.	BERBERIDACEAE	3-4	High	Monoecious	3
11	*Nerium oleander* L.	APOCYNACEAE	6-8	Moderate	Monoecious	1,3,4,6,8,11
12	*Pyracantha coccinea* M.Roem.	ROSACEAE	5-6	Low	-	3,4,8
13	*Spiraea x bumalda* Burv.	ROSACEAE	4-5	Low	-	8
14	*Symphoricarpos orbiculatus* Moench	CAPRIFOLIACEAE	6-7	Moderate	Monoecious	4
15	*Viburnum opulus* L.	ADOXACEAE	4-5	Moderate	-	4,8
16	*Viburnum tinus* L.	ADOXACEAE	4-5	Moderate	Monoecious	5,8,10,11
CITRUS						
1	*Citrus aurantium* L.	RUTACEAE	4-6	Low	-	11
2	*Citrus bergamia* Risso	RUTACEAE	4-6	Low	-	11
3	*Citrus limon* L. Bum.	RUTACEAE	4-6	Low	-	1,2,6,8,11
4	*Citrus reticulata* L.	RUTACEAE	4-6	Low	-	1,2,6,11
5	*Citrus sinensis* L.	RUTACEAE	4-6	Low	-	1,2,6,11
PALM TREES						
1	*Chamaerops excelsa* Thunb. (syn. *Trachycarpus fortunei* (Hook.) H.Wendl.)	ARECACEAE	6-7	High	Dioecious	10,11
2	*Phoenix canariensis* Hort.	ARECACEAE	6-7	High	Dioecious	8,11
3	*Washingtonia filifera* (Linden ex André) H.Wendl. ex de Bary	ARECACEAE	7-8	Low	-	3,8,10
4	*Washingtonia robusta* H. Wendl.	ARECACEAE	7-8	Low	-	8
SUCCULENTS						
1	*Yucca filamentosa* L.	AGAVACEAE	5-6	Low	Monoecious	4,8,11
WRAPPER AND CLIMBERS						
1	*Hedera helix* L.	HEDERACEAE	9-10	Low	-	6,11
2	*Lonicera caprifolium* L.	CAPRIFOLIACEAE	5-6	Moderate	-	6,8,11
3	*Parthenocissus quinquefolia* L.	VITACEAE	6-7	Low	-	6,11
4	*Vitis vinifera* L.	VITACEAE	5-6	Low	-	3,6,7,8,10,11
5	*Wisteria sinensis* (Sims) Sweet.	FABACEAE	4-5	Moderate	-	2,3,4,6,8,11

* Although these taxa are exotic, they are considered as naturalized/semi-natural taxa due to their widespread use in Turkey and their invasive properties.

A total of 110 different plant taxa with allergic properties were identified in the study areas. Of these plants, 27 are coniferous trees, 2 are coniferous shrubs, 50 are broad-leaved trees, 16 are broad-leaved shrubs, 5 are citrus, 4 are palm trees, 1 is succulent, and 5 are climbers. In addition, it was determined that 46 of 110 plants were natural (Natural: 44, Semi-Natural: 2) and 64 of them were exotic (Exotic: 61, Exotic-Hybrid: 2, Exotic-Cultured: 1) (Figure 2).

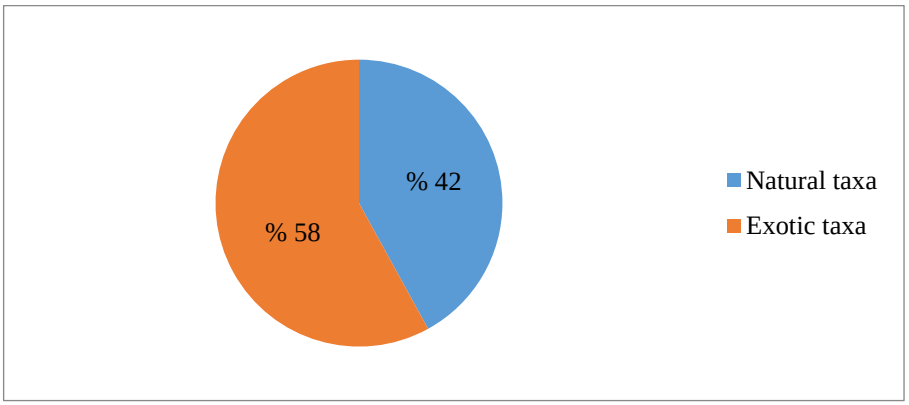

Figure 2. Life forms of the plants

As seen in Figure 3, when the plants in the study area were evaluated according to their families, the families with the most taxa were Cupressaceae (13 taxa), Pinaceae (12 taxa), Rosaceae (10 taxa) and Oleaceae (7 taxa). In the study areas, the Cupressaceae family stands out as the family with the most allergic properties. This situation shows similarity when compared to the studies on the subject in other cities in Turkey. In fact, in the study conducted in Ankara province, the pollens of the Cupressaceae family were dominant, whereas in the province of Kayseri, Pinaceae pollens were determined to be the most dominant family (Acar, 2013).

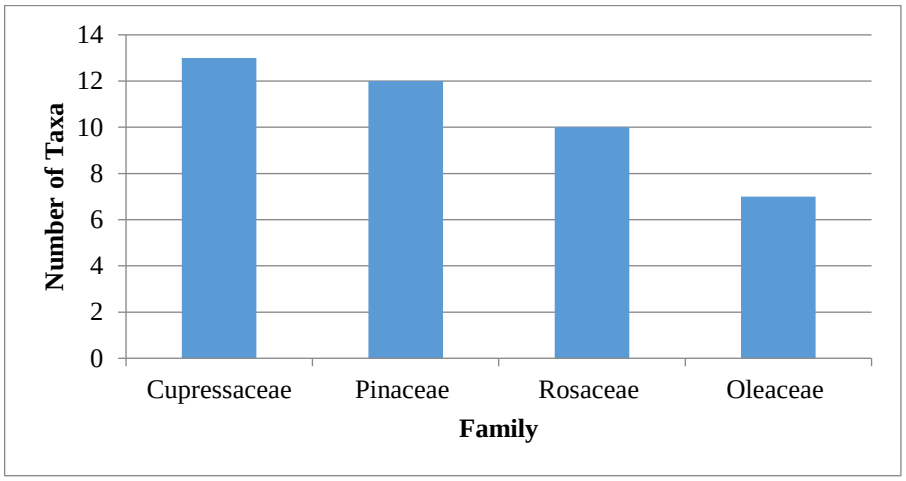

Figure 3. Families with the highest number of taxa with allergic properties in the study areas

As seen in Figure 4, when the plants in the study area were evaluated according to their allergen rates, it was determined that 42 of 110 plants had low allergen rate, 26 had moderate allergen rate and 42 had high allergen rate.

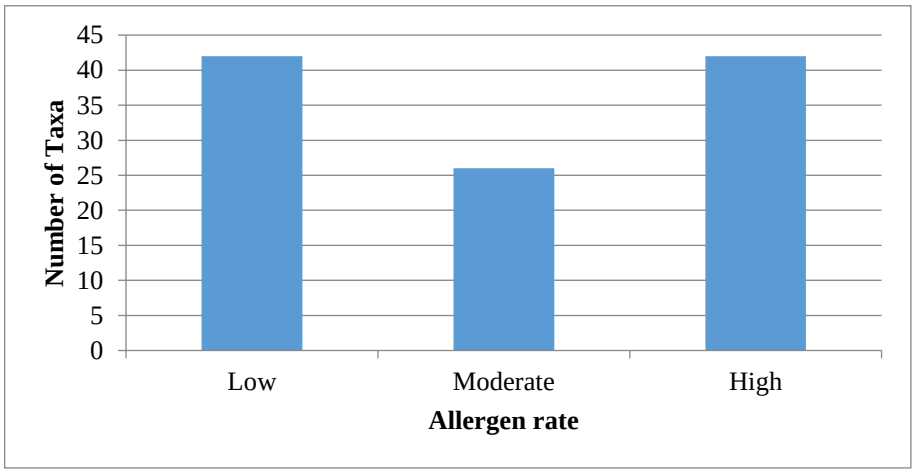

Figure 4. Allergen rates of plants in the study areas

The individual allergen rates of natural and exotic taxa detected in the study area were examined in Table 3. Accordingly, it was determined that 12 (26%) of the detected 46 natural plant species had low, 16 (35%) moderate and 18 (39%) high allergen rates. When the allergen rate of exotic plant taxa was examined, it was seen that 30 (47%) of 64 plants had low, 10 (16%) moderate, and 24 (37%) high allergen rates.

Table 3. Allergen rates of natural and exotic taxa in the study areas

Feature	Natural Taxa	Exotic Taxa
Allergen Rate		
Low	12 (%26)	30 (%47)
Moderate	16 (%35)	10 (%16)
High	18 (%39)	24 (%37)
Total	**46**	**64**

The protective cases of 84 of 110 plants in the study areas were determined. As seen in Figure 5, it was determined that 62 of 84 plants were monoecious, 18 were dioecious, and 4 were polygamous.

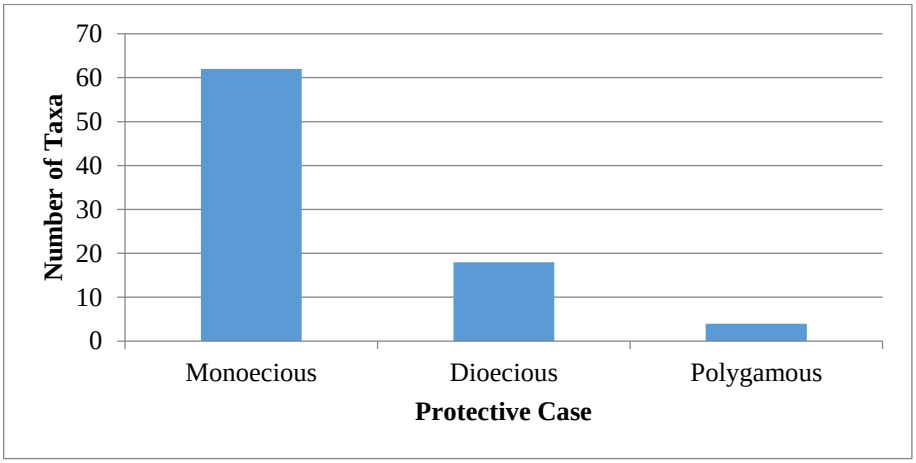

Figure 5. The protective cases of the plants in the study areas

In Figure 6, the flowering periods of the plants in the study areas were examined. Accordingly, the most flowering months of the plants were determined as May (64 taxa), June (50 taxa), April (48 taxa), March (21 taxa) and July (20 taxa). The month of may draws attention as the most flowering month of the plants found to spread pollen that may cause allergic reactions in the study areas. This situation shows similarity when compared to the studies on the subject in other cities in Turkey. In fact, it was stated in the studies conducted in Ankara and Kayseri provinces that the highest pollen concentration was seen in May (Sin, Pınar, Mısırlıgil, Çeter, Yıldız & Alan, 2007; Silici, Çeter, Pınar & Acar, 2012).

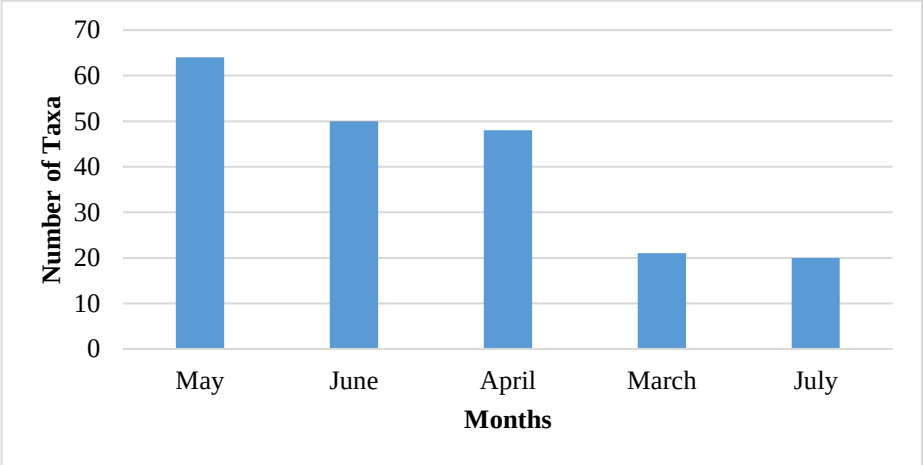

Figure 6. The months when plants with allergic properties can be observed most flowering

As seen in Figure 7, when the urban open green areas with the highest number of plants detected to spread pollen that may cause allergic reactions were examined, 62 of these plants are in Sahil Park/Mesut Yılmaz Park, 59 in Ziraat Botanic Park, 53 in Isırlık Natural Park and 41 of them are in Recep Tayyip Erdoğan University Zihni Derin Campus. Sahil Park/Mesut Yılmaz Park is an urban open green area with the highest number of plants with allergic properties. In addition, there are 24 plants with high allergen rate in this park.

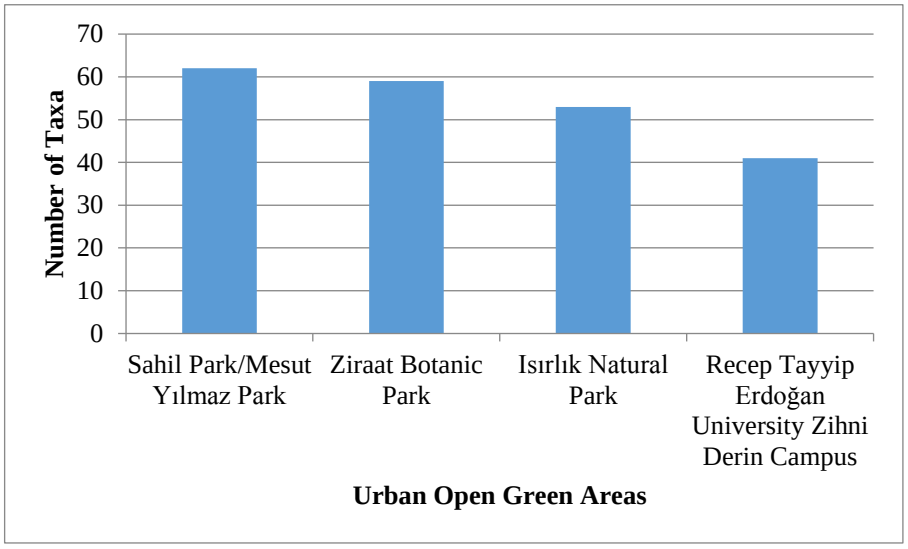

Figure 7. Urban open green areas with the highest number of plants with allergic properties

4. Conclusion

The decrease in open and green areas in today's cities causes many environmental problems. Urban open and green areas play an important role in increasing the quality of life of urban people with the environmental, social and economic contributions they provide. Plants, which are the basic components of these areas, have many important benefits to the urban ecosystem, as well as some negative effects on their environment in their life processes. One of these negative effects is that they cause allergic reactions because of pollen on human health. Pollen, which is of great importance for the survival of many living things, is also known as the most common allergens in the atmosphere and can adversely affect human health. For this reason, the allergen feature of the pollen of plants should be taken into consideration in planting design applications. In this context, the plant taxa to be used in the planting design area should be carefully selected and their location should be determined correctly. Thus, the use of plant taxa with high allergen rates will be avoided and the amount of allergens in the atmosphere will be greatly reduced.

A total of 110 different plant taxa with allergic properties were identified in the study area. Since these plants, especially those belonging to the Cupressaceae family, contain a large amount of pollen, it is recommended not to use them in planting designs that are sensitive to pollen allergy. Plant species belonging to this family are generally preferred in planting design works with fence or image/noise shielding tasks. Species belonging to the genus *Buxus* and *Ligustrum*, which will undertake the same task and have much less pollen content, can be used as an alternative to plant taxa belonging to the Cupressaceae family. In addition, it is recommended not to use exotic allergenic plant taxa unless they contain functional purposes or too many aesthetic properties.

The most important factors in pollen spread are wind, animals and insects. For this reason, plant taxa that can attract creatures such as birds, bees and butterflies less should be chosen in planting designs, and plants with allergic effects should not be used in windy areas. Taxa used as road trees and fences should not have allergenic properties, especially on the roadsides and in areas where pedestrian use is intense.

The months of may and june, which draw attention as the months when the plants that are detected to spread pollen that can cause allergic reactions in the study areas can be observed most as flowering, are also the periods when people use urban open green areas intensively. For this reason, it is necessary to maintain the relations between humans and plants more carefully during these periods. However, it should be taken into account that pollen does not appear only at the period of flowering, but can be seen at different times of the year, and can even be found in areas where there are no plants because they move to very long distances by the wind.

Since the number of pollen in the atmosphere is higher in dry and hot weather than in periods with heavy rainfall, the amount of pollen in the atmosphere can be significantly reduced by installing a

sprinkler system on structural elements such as pergolas and gazebos used in urban open green areas. In addition, indoor spaces such as winter gardens can be designed in urban open and green areas, allowing users to use these areas during periods of high allergen pollen. Allergen plant taxa should not be preferred in heavily used areas such as sports fields, children's playgrounds, picnic areas and amphitheater.

In order for users to access daily data, units that will count pollen in urban open and green areas should be established. It is necessary to prepare pollen calendars with the data to be obtained from pollen monitoring stations. Thanks to these calendars, users will be informed about the periods in which the plants that cause allergic reactions spread their pollen to the atmosphere more intensely, and they will act more carefully in this regard.

It should not be forgotten that the plants used as the main material in planting design applications are living beings and they constantly develop, so they need various maintenance works. Maintenance works should be done by professionals. Particular attention should be paid to the pruning of plants with allergenic effects and they should be pruned at the right time. Pruning the taxa that are suitable for pruning before flowering will also be a correct approach in terms of preventing pollen formation and spread.

Acknowledgment and Information Note

The article complies with national and international research and publication ethics. Ethics committee permission was not required for the study.

Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article. There is no conflict of interest.

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