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Phenopalynological Study of Some Ornamental Species in the Giza Region, Egypt

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ABSTRACT

Mature flower buds were collected from twenty species planted on the different roads in the Giza district from May to September 2022 and 2023. The pollen grains were examined carefully and photographed using a 40x10x magnification lens in an OPTICA (B-150D) light microscope fitted with a USB digital video Camera and Computer Software. At least 30 pollen grains/each species were measured and described. Non-catalyzed pollens were sputtered onto Aluminum stubs, coated with 30 nm gold, and examined and photographed using JEOL JSL IT 200 SEM. The morphological characters of the pollen grains were examined. According to the pollen size *Acalypha wilkesiana* and *Tecoma stans* were the smallest pollen grains, from 20.0µm to 26.0µm, which facilitate their introduction to the nose causing asthma and rhinitis. *Clerodendrum inerme* pollen grains have echinate exine surface, which causes allergic symptoms more than the psilate ones. *Plumbago capensis* has intectate exine with echinate columella causing human disorders. This study demonstrates the critical position of air pollution in this area with the change in the phenological aspects of the plants resulting in producing immature pollen grains in huge amounts, which cause human disorders and pollinosis. Our results showed that the studied species can induce allergy in one way or another if we consider the situation of the studied area, weather pattern, and pollen characteristics.

INTRODUCTION

Climate change has led to an increase in people suffering from different types of allergies and respiratory problems. Pollen allergy is one of the severe respiratory disorders resulting from inhaling the pollen grains carried by wind. The exact knowledge of the plants causing allergies is still a matter of investigation. Many studies have been carried out to investigate the exact plants causing pollinosis, i.e. pollen allergy, in different countries and cities. Mansouritorghabeh et al. (2019), besides many other authors, mentioned that trees belonging to certain orders, such as Fabales, Fagales, Lamiales, Proteales, and Pinales, are from the most allergen pollens. Taia (2020) mentioned that allergy is not restricted to certain trees, shrubs, or herbs, but it depends on the quantity of pollen grains carried by air, pollen grain size, beside other environmental factors. Thakur & Sharma (2018) found that symptoms of pollinosis have increased nowadays due to climate change, heat waves, beside various environmental factors. The increase in the planting of the city's ornamental trees, besides air pollution as a result of urbanization, constitutes harmful conducive to allergies (Aerts et al. 2021).

The study of pollen grains as the cause of allergy has been investigated by many authors (Shea et al. 2008, Aboulaich et al. 2013, Pawankar et al. 2013, Bohwmik et al. 2021, Taia 2020, Taia & Bassioni 2022). Mansouritorghabeh et al. (2019) mentioned that there are two categories of risk factors for allergy, first is patient characteristics, and the second is environmental factors. They reported that 40% of allergic people have been affected by pollen grains besides the global climate change, especially in the Middle East area. Oh (2022) found that increases in CO_2 concentration and atmospheric temperature raise pollen concentration. Many studies clarified the significant impact of climate fluctuation on the phenology of the plants in many areas around the world, besides the other aeroallergens and their impact on public health (Beggs 2004, Assarehzadegan et al. 2013). This change in the phenology of the plants resulted in producing pollen grains at unsuitable times for fertilization and kept huge amounts of pollen carried by air. This fact promotes the need for continuous studies of allergenic tree pollens in each region and city.

Although many researchers have investigated the relationship between urban vegetation and air pollution, few studies have focused on the role of pollen grains as air pollutants. El-Shamy et al. (2023) found that six different plants belonging to the Fabaceae family (*Bauhinia variegate*, *Cassia javanica*, *Delonix regia*, *Peltophorum africanum*, *Senna didymobotrya* and *Senna surattensis*) and four different plants belonging to Poaceae family (*Avena sativa*, *Setaria viridis*, *Sorghum bicolour* and *Zea mays*) have hydrophilic proteins antigen in their pollens. They concluded that pollen grains related to the Fabaceae and Poaceae families are responsible for allergic patients in Egypt. García-Mozo (2017) concluded that the family Poaceae is the main family responsible for pollen allergy. Pollen allergens must be water-soluble proteins, glycoproteins, starch, or fats, which make them capable of evoking an IgE antibody-mediated allergic reaction immediately in sensitive people. Stewart et al. (2009) identified 15 distinct groups of proteins with different biochemical properties as allergens in taxa of the subfamily Pooideae, family Poaceae. Pollinosis is an illness induced by glycoprotein derivatives which are in the external part of the pollen cell wall (Exine). These glycoprotein derivatives bond to certain receptors situated in the mucous membranes, stimulating the secretion of histamine and causing inflammation symptoms (Taia & Zayed 2021).

This work aimed to investigate the pollen characteristic of the twenty species of the most common ornamental species planted in the roads of the Giza district within the great Cairo. Giza has its characteristic weather all through the year. It is dry-hot during the summer and exposed to windstorms during the winter. It is affected by the surrounding factories, which make the air polluted by a great number of gases, dust, pollen grains, and fungal spores.

MATERIALS AND METHODS

Study Area

Cairo, the capital of Egypt, is considered one of the most highly polluted cities in the world. The city is highly crowded with people, vehicles, and cars. The dense gas evolved by cars, transportation, and industrialization processes made the air highly polluted. The Giza district lies west of Cairo and is considered an important part of Cairo city. It is visited by tourists for the most important Egyptian monuments and historical places. A narrow strip of Giza Governorate lies on the west bank of the river Nile and has two industrial centers. Giza is surrounded by El-Mokatam plateau and Shobra El-Khema, which is a big industrial area. Giza city has brick industries along the western bank of the river Nile, north and south of Giza. Accordingly, the air quality in Giza is full of industrial emissions besides the dust storms from the El-Mokatam Plateau and CO_2 gas from agricultural waste burning in the delta Nile valley (Hassan & Khoder 2017).

Pollen Grains Collection

Mature flower buds were collected from twenty species planted on the different roads in the Giza district from May to September 2022 and 2023. The name of the trees is present in Table 1. Each species is represented by ten flower buds from five different trees. The buds were carefully opened to release the stamens. The pollen grains were sputtered onto a clean glass slide with a few drops of glycerol, covered by cover slides, and sealed with wax for light microscope examination. The pollen grains were examined and photographed using a 40x10x magnification lens in an OPTICA (B-150D) light microscope fitted with USB digital video Camera and Computer Software. At least 30 pollen grains/each species were measured and described. Non-acetolyzed pollens were sputtered onto Aluminum stubs, coated with 30 nm gold, and examined and photographed using JEOL JSL IT 200 SEM allocated at the Faculty of Science, Alexandria University at 15 Kev. For pollen description, the terminology used here is that of Walker & Doyle (1976).

RESULTS

Pollen Morphology of the Studied Taxa

Pollen grains of the studied trees are mostly of medium size. Only two species have small pollen grains from 20.0 to 25.0 μm; *Acalypha wilkesiana* and *Tecoma stans*; and another three species have large pollen grains over 50.0 μm, *Plumbago capensis*, *Senna surattensis* and *Jacaranda mimosifolia*. The pollen size categories are not related to the state of the tree, deciduous or evergreen. Pollen

Table 1: Studied trees and their taxonomic position, citation and place of origin.

No.	Species	Family	Date of collection	Citation	Origin
1.	*Plumbago capensis* Thunb.	Plumbaginaceae	22/5/2022	Lam., Encycl. 2: 270 (1786)	S. Africa
2.	*Calliandra haematocephala* Hassk.	Fabaceae	20/6/2023	Retzia 1:216 (1855)	South America.
3.	*Cassia fistula* L.		20/6/2023	Sp. Pl. 377. 1753	India, Malaysia and Southeast Asia
4.	*Cassia javanica* L.		19/5/2022	Sp. Pl.: 379 (1753	South East Asia
5.	*Delonix regia* (Bojer ex Hook.) Raf.		19/7/2022	Sp. Pl.: 379 (1753	Madagascar
6.	*Senna surattensis* (Burm. f.) Irwin & Barenby		20/7/2022	Mem. New York Bot. Gard.35(1): 81 (1982)	Tropical Asia to Australia.
7.	*Lagerstroemia indica* L.	Lythraceae	19/7/2022	Syst. Nat. ed. 10, 2: 1076 (1759)	Himalaya to South Asia
8.	*Punica granatum* L.		24/8/2023	Sp. Pl. : 472 (1753)	Afghanistan and Iran.
9.	*Euphorbia milii* Des Moul.	Euphorbiaceae	20/6/2023	Bull. Hist. Nat. Soc. Linn. Bordeaux 1: 27 (1826)	Madagascar
10.	*Acalypha wilkesiana* Mull. Arg.		24/8/2023	Prodr. 15(2): 817 (1866)	Micronesia
11.	*Cascabela thevetia* (L.) Lippold	Apocynaceae	19/7/2022	Feddes Repert. 91: 52. 1980	Argentina and Bolivia.
12.	*Catharanthus roseus* (L.) G. Don		20/6/2023	Gen. Hist. 4: 95 (1837)	Madagascar
13.	*Nerium oleander* L.		24/8/2023	Sp. Pl.: 209 (1753)	Mediterranean to Japan
14.	*Plumeria rubra* L.		19/7/2022	Sp. Pl. : 209 (1753)	Mexico and Panama
15.	*Withania somnifera* (L.) Dunal	Solanaceae	11/6/2022	Prodr. [A.P. de Candolle] 13(1): 453. 1852	India
16.	*Jacaranda mimosifolia* D. Don	Bignoniaceae	19/7/2022	Bot. Reg. 8: t.631 (1822)	Argentina and Bolivia.
17.	*Tecoma stans* (L.) Juss. ex Kunt*h*		11/6/2022	Nov. Gen. Sp. Pl. 3:144	S. America
18.	*Clerodendrum inerme* Gaertin.	Lamiaceae	24/8/2023	Sp. Pl. : 637 (1753)	China, India and Australia
19.	*Vitex agnus-castus* L.		19/7/2022	Sp. Pl.: 638 (1753)	Mediterranean region
20.	*Lantana camara* L.	Verbenaceae	24/8/2023	Sp. Pl. : 627 (1753)	Central and South America

phenocharacters of the studied trees are summarized in Table 2.

1. *Plumbago capensis* Thunb. Plum, Baginaceae, evergreen tree (Figs. 1-4)

Pollen grains are dispersed as monads, radiosymmetric, and isopolar with large pollen grains. The mean polar axis length is 55.8 µm while the mean equatorial axis diameter is 38.9 µm with P/E equal to 1.4. Their shapes are prolate with three zonocolpate apertures (Figs. 1, 2). The colpi are nearly the same length as the polar axis but still free (Figs. 2, 3). The apocolpi are narrow, and the colpi membranes are smooth. Exine thickness is 2.8 µm, intectate with long bacullae and pointed echinated capitae (Fig. 4).

2. *Calliandra haematocephala* Hassk. Fabaceae, Mimosoideae, evergreen tree (Figs. 5, 6)

Pollen grains dispersed in polyads consist of seven to nine pollen grains (Fig. 6). The polyads are non-appendiculate (Fig. 5). The apical pollen grain is acute.

3. *Cassia fistula* L. Fabaceae, Caesalpinoideae, Deciduous tree (Figs. 7-10)

Pollen grains are dispersed in monads, radiosymmetric, and isopolar with medium pollen grains. The mean polar axis length is 40.7 µm while the mean equatorial axis diameter is 32.6 µm with P/E equal to 1.2. Their shapes are subprolate with three zonocolporate apertures (Figs. 7, 9). The colpi are nearly the same length as the polar axis but still free

(Fig. 8). The apocolpi are narrow, and the colpi membranes are smooth. The pores are lolongate, small, and covered by an exinous bridge. Exine thickness is 2.2 µm, and tectate perforate with rugate ectexine (Fig. 10).

4. *Cassia javanica* L. Fabaceae, Caesalpinoideae, Deciduous tree (Figs. 11-14)

Pollen grains are dispersed in monads, radiosymmetric, and isopolar with medium pollen grains. The mean polar axis length is 38.2 µm while the mean equatorial axis diameter is 28.5 µm with P/E equal to 1.3. Their shapes are prolate with three zonocolporate apertures (Figs. 11, 12). The colpi are nearly the same length as the polar axis but still free (Figs. 12, 13, 14). The apocolpi are narrow, and the colpi membranes are smooth. The pores are lolongate, oval and exposed. Exine thickness is 2.5 µm, and tectate perforate with foveolate ectexine (Fig. 14).

5. *Delonix regia* (Bojer ex Hook.) Raf. Fabaceae, Caesalpinoideae, Deciduous tree (Figs. 15, 16)

Pollen grains are dispersed in monads, radiosymmetric, and isopolar with medium pollen grains. The mean polar axis length is 36.3 µm while the mean equatorial axis diameter is 36.3 µm with P/E equal to 1.0. Their shapes are spheroidal with three zonocolporate apertures (Fig. 15). The colpi are short with rounded ends (Fig. 16). The apocolpi are wide, and the colpi membranes are granulated. The pores are lolongate, small and exposed. Exine thickness is 1.8 µm, tectate perforate with reticulate ectexine (Fig. 16). The luminae are enriched with rounded granules.

6. *Senna surattensis* (Burm. f.) Irwin & Barenby Fabaceae, Caesalpinoideae, evergreen tree (Figs. 17, 18)

Pollen grains are dispersed in monads, radiosymmetric, and isopolar with large pollen grains. The mean polar axis length is 52.8 µm while the mean equatorial axis diameter is 47.2 µm with P/E equal to 1.1. Their shapes are subprolate with three zonocolporate apertures (Figs. 17, 18). The colpi are shorter than the polar axis (Fig. 17). The apocolpi are wide, and the colpi membranes are smooth. The pores are small and plugged. Exine thickness is 2.5 µm, tectate inperforate with punctate ectexine (Fig. 18).

7. *Lagerstroemia indica* L. Lythraceae, deciduous tree (Figs. 19-22)

Pollen grains are dispersed in monads, radiosymmetric, and isopolar with medium pollen grains. The mean polar axis length is 48.5 µm while the mean equatorial axis diameter is 40.5 µm with P/E equal to 1.2. Their shapes are subprolate with three zonocolporate apertures (Figs. 19, 20). The colpi are shorter than the polar axis (Fig. 20). The apocolpi are wide, and the colpi membranes are granulated. The pores are very small and plugged. Exine thickness is 2.5 µm, and tectate perforate with rugate ectexine (Fig. 21, 22).

8. *Punica granatum* L. Lythraceae, deciduous tree (Figs. 23-26)

Pollen grains are dispersed in monads, radiosymmetric, and isopolar with medium pollen grains. The mean polar axis length is 42.8 µm while the mean equatorial axis diameter is 31.5 µm with P/E equal to 1.4. Their shapes are perprolate with three zonocolporate apertures (Figs. 23, 24). The colpi are shorter than the polar axis (Fig. 25). The apocolpi are wide, and the colpi membranes are granulated. The pores are lolongate, small, oval and plugged. Exine thickness is 2.2 µm, and tectate imperforate with scabrate ectexine (Fig. 26).

9. *Euphorbia milii* Des Moul. Euphorbiaceae, evergreen tree (Figs. 27-30)

Pollen grains are dispersed in monads, radiosymmetric, and isopolar, with medium pollen grains. The mean polar axis length is 40.2 µm, and the mean equatorial diameter is 24.8 µm with P/E equal to 1.6. Their shapes are perprolate with three zonocolporate apertures (Figs. 26, 27). Colpus is shorter than the polar axis (Figs. 27, 28, 29). The apocolpi are wide, and the colpi membranes are smooth. The pores are lolongate, small and plugged. Exine thickness is 2.8 µm, and tectate perforate with reticulate ectexine (Fig. 30).

10. *Acalypha wilkesiana* Mull.Arg. Euphorbiaceae, evergreen tree (Figs. 31-34)

Pollen grains are dispersed in monads, radiosymmetric, isopolar, and small pollen grains. The mean polar axis length is 20.2 µm, and the mean equatorial diameter is 20.2 µm with P/E equal to 1.0. Their shapes are spherical with three zonocolporate apertures (Figs. 31, 32). The colpi are shorter than the polar axis (Fig. 33). The apocolpi are wide, and the colpi membranes are granulated. The pores are lolongate, small and plugged. Exine thickness is 1.2 µm, and tectate perforate with rugate ectexine (Fig. 34).

11. *Cascabela thevetia* (L.) Lippold Apocynaceae, evergreen tree (Figs. 35-38)

Pollen grains are dispersed in monads, radiosymmetric, and isopolar, with medium pollen grains. The mean polar axis length is 35.2 µm, and the mean equatorial diameter is 28.2 µm with P/E equal to 1.3. Their shapes are prolate with three zonocolporate apertures (Figs. 35, 36, 37). The colpi are shorter than the polar axis (Fig. 35). The apocolpi are wide, and the colpi membranes are smooth. The pores are lolongate, wide and covered by an exinous bridge (Fig. 37). Exine thickness is 1.8 µm, and tectate perforate with rugate ectexine (Fig. 38).

12. *Catharanthus roseus* (L.) G. Don Apocynaceae, evergreen tree (Figs. 39- 42)

Pollen grains are dispersed in monads, radiosymmetric, and isopolar, with medium pollen grains. The mean polar axis length is 38.2 µm, and the mean equatorial diameter is 30.4 µm with P/E equal to 1.3. Their shapes are prolate with three zonocolporate apertures (Figs. 39, 40). The colpi are shorter than the polar axis (Fig. 41). The apocolpi are wide, and the colpi membranes are smooth. The pores are lolongate, wide and exposed (Fig. 40). Exine thickness is 1.8 µm, and tectate inperforate with punctate ectexine (Fig. 42).

13. *Nerium oleade* L. Apocynaceae, evergreen tree (Figs. 43-45)

Pollen grains are dispersed in monads, radiosymmetric, and isopolar, with medium pollen grains. The mean polar axis length measures 34.8 µm, and the mean equatorial diameter is 30.2 µm with P/E equal to 1.2. Their shapes are subprolate with three zonocolporate apertures (Figs. 43, 44). The colpi are shorter than the polar axis (Fig. 43). The apocolpi are wide, and the colpi membranes are smooth. The pores are lolongate, small and covered by an exinous bridge (Fig. 44). Exine thickness is 2.8 µm, dictating perforate with foveolate ectexine (Fig. 45).

14. *Plumeria rubra* L. Apocynaceae, deciduous tree (Figs. 46-48)

Pollen grains are dispersed in monads, radiosymmetric, and isopolar, with medium pollen grains. The mean polar axis length is 32.8 µm, and the mean equatorial diameter is 24.6 µm with P/E equal to 1.3. Their shapes are subprolate with three zonocolporate apertures (Fig. 46). The colpi are shorter than the polar axis (Fig. 47). The apocolpi are wide, and the colpi membranes are smooth. The pores are lolongate, oval and plugged (Fig. 47). Exine thickness is 2.4 µm and tectate perforate with scabrate ectexine (Fig. 48).

15. *Withania somnifera* (L.) Dunal *Withania somnifera* (L.) Dunal Solanaceae, evergreen tree (Figs. 49-51)

Pollen grains are dispersed in monads, radiosymmetric, and isopolar, with medium pollen grains. The mean polar axis length is 44.6 µm, and the mean equatorial diameter is 28.8 µm with P/E equal to 1.5. Their shapes are perprolate with three zonocolpate apertures (Fig. 49). The colpi are free and long and extend near the poles (Fig. 50). The apocolpi are narrow, and the colpi membranes are granulated. Exine thickness is 2.0 µm, and tectate perforate with reticulate ectexine (Fig. 51).

16. *Jacaranda mimosifolia* D. Don Bignoniaceae, deciduous tree (Figs. 52-55)

Pollen grains are dispersed in monads, radiosymmetric, and isopolar, with large pollen grains. The mean polar axis length is 52.6 µm, and the mean equatorial diameter is 32.4 µm, with P/E equal to 1.6. Their shapes are perprolate with three zonocolpate apertures (Figs. 52, 53). The colpi are free, long and extend near the poles (Fig. 54). The apocolpi are narrow, and the colpi membranes are granulated. Exine thickness is 2.2 µm, and tectate perforate with foveolate ectexine (Fig. 55).

17. *Tecoma stans* (L.) Juss. ex Kunth Bignoniaceae, evergreen tree (Figs. 56-58)

Pollen grains are dispersed in monads, radiosymmetric, and isopolar, with small pollen grains. The mean polar axis length is 25.0 µm, and the mean equatorial diameter is 16.5 µm with P/E equal to 1.5. Their shapes are perprolate with three zonocolpate apertures (Fig. 56). The colpi are syncolpate, long and unitted at the poles (Figs. 57, 58). The colpi membranes are granulated. Exine thickness is 2.4 µm, and tectate perforate with reticulate ectexine (Fig. 58).

18. *Clerodendrum inerme* Gaertin. Lamiaceae, evergreen tree (Figs. 59-63)

Pollen grains are dispersed in monads, radiosymmetric, and isopolar, with medium pollen grains. The mean polar axis length is 40.2 µm, and the mean equatorial diameter is 29.8 µm with P/E equal to 1.3. Their shapes are subprolate with three zonocolpate apertures (Figs. 59, 60, 61). The colpi are shorter than the polar axis (Fig. 61). The apocolpi are wide, and the colpi membranes are smooth (Figs. 59, 60). Exine thickness is 2.2 µm, and tectate inperforate with echinate ectexine (Fig. 63).

19. *Vitex agnus-castus* L., Lamiaceae, deciduous tree (Figs. 64-68)

Pollen grains are dispersed in monads, radiosymmetric, and isopolar, with medium pollen grains. The mean polar axis length is 42.8 µm, and the mean equatorial diameter is 32.6 µm with P/E equal to 1.3. Their shapes are subprolate with three zonocolpate apertures (Figs. 64, 65). The colpi are as long as the polar axis (Figs. 66, 67). The apocolpi are narrow, and the colpi membranes are smooth. Exine thickness is 1.8 µm, and tectate perforate with reticulate ectexine (Fig. 68).

20. *Lantana camara* L. Verbenaceae, evergreen tree (Figs. 69-72)

Pollen grains are dispersed in monads, radiosymmetric, and isopolar, with medium pollen grains. The mean polar axis length is 38.0 µm, and the mean equatorial diameter is 37.8 µm, with P/E equal to 1.0. Their shapes are spheroidal with three zonocolporate apertures (Figs. 69, 70). The colpi are as long as the polar axis (Fig. 71). The apocolpi are narrow, and the colpi membranes are smooth. The pores are small lolongate (Fig. 71). Exine thickness is 2.4 µm, and tectate perforates with rugate ectexine (Fig. 72).

Table 2: Pollen phenocharacters of the studied trees.

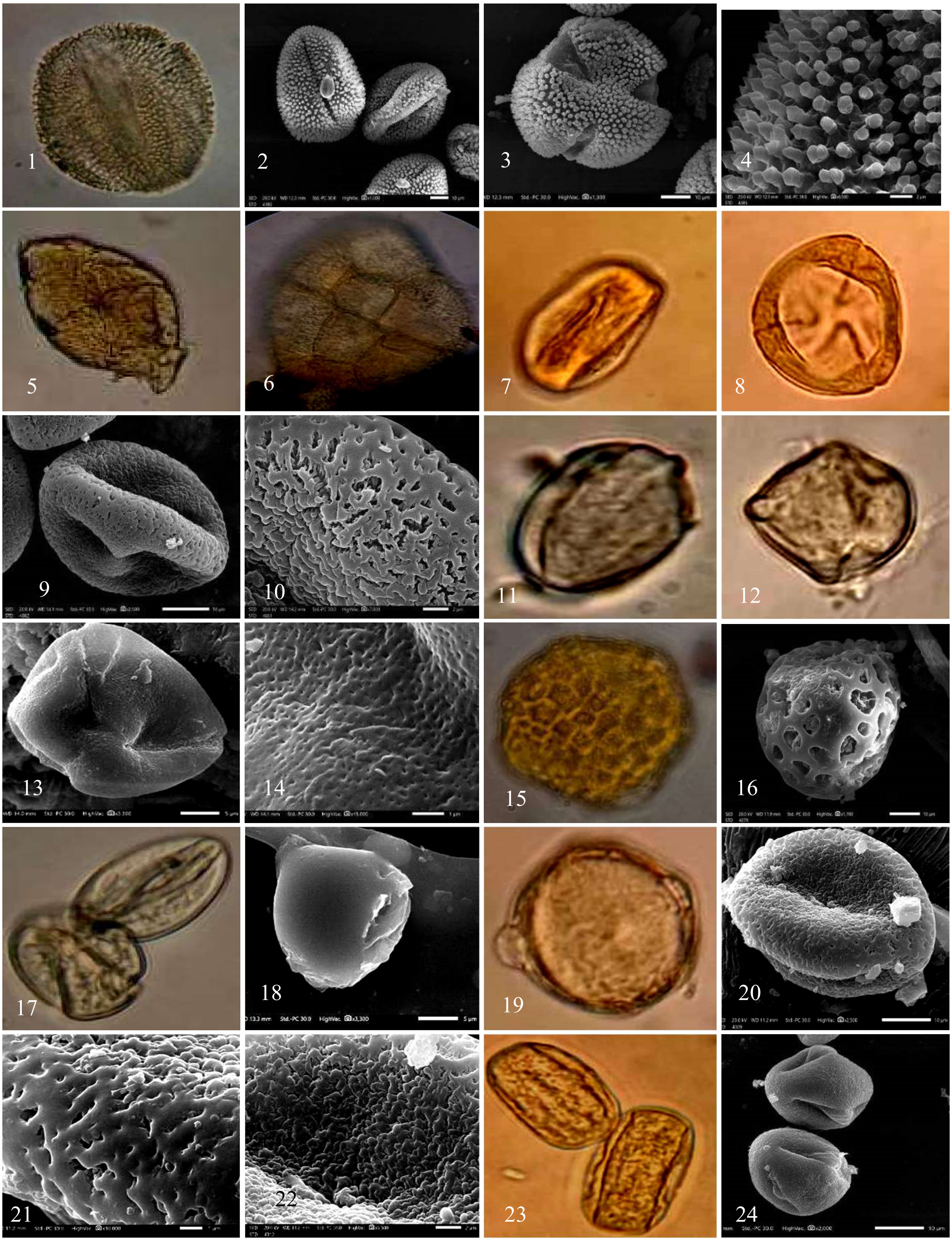
No.	Species	Status	Pollen characters									
			Dis	P.A.L µm M±SD	E.A.D µm M±SD	P/E	Shape	Size	Aperture		Exine	
									No	Type	Th	Or
1.	Plumbago capensis	Eg	M	55.8±1.26	38.9±2.65	1.4	P	L	3	Col	2.8	IT
2.	*Calliandra haematocephala*	Eg	Po	--	--	--		--	--	--	--	--
3.	*Cassia fistula*	D	M	40.7±2.35	32.6±1.89	1.2	SP	Me	3	Colp	2.2	Ru
4.	*Cassia javanica*	D	M	38.2±1.95	28.5±2.25	1.3	P	Me	3	Colp	2.5	Fv
5.	*Delonix regia*	D	M	36.3±2.95	36.3±2.95	1.0	Sph	Me	3	Colp	1.8	R
6.	*Senna surattensis*	Eg	M	52.8±2.98	47.2±2.42	1.1	SP	L	3	Colp	2.5	Pu
7.	*Lagerstroemia indica*	D	M	48.5±2.82	40.5±1.82	1.2	SP	Me	3	Colp	2.5	Ru
8.	*Punica granatum*	D	M	42.8±2.1	31.5±2.85	1.4	PP	Me	3	Colp	2.2	Sc
9.	*Euphorbia milii*	Eg	M	40.2±2.8	24.8±2.6	1.6	PP	Me	3	Colp	2.8	R
10.	*Acalypha wilkesiana*	Eg	M	20.2±1.2	20.2±1.2	1.0	Sph	S	4	Colp	1.2	Ru
11.	*Cascabela thevetia*	Eg	M	35.2±2.6	28.2±2.8	1.3	P	Me	3	Colp	1.8	Ru
12.	*Catharanthus roseus*	Eg	M	38.2±2.4	30.4±1.8	1.3	p	Me	3	Colp	1.8	Pu
13.	*Nerium oleander*	Eg	M	34.8±2.2	30.2±2.4	1.2	SP	Me	3	Colp	2.8	Fv
14.	*Plumeria rubra*	D	M	32.8±2.4	24.6±1.8	1.3	Sp	Me	3	Colp	2.4	Sc
15.	*Withania somnifera*	Eg	M	44.6±2.2	28.8±2.6	1.5	PP	Me	3	Col	2.0	R
16.	*Jacaranda mimosifolia*	D	M	52.6±1.2	32.4±2.2	1.6	PP	L	3	Col	2.2	Fv
17.	*Tecoma stans*	Eg	M	25.0±3.2	16.5±1.8	1.5	PP	S	3	Col	2.4	R
18.	Clerodendrum inerme	Eg	M	40.2±1.8	29.8±2.2	1.3	P	Me	3	Col	2.2	Ec
19.	Vitex agnus-castus	D	M	42.2±0.8	32.6±1.2	1.3	P	Me	3	Col	1.8	R
20.	Lantana camara	Eg	M	38.0±1.2	37.8±1.8	1.0	Sph	Me	3	Colp	2.4	Ru

Abbreviations: Col=Colpate; Colp=Colporate; D=Deciduous; Dis=Dispersal; E.A.D=Equatorial axis diameter; Ec=Echinate; Eg=Evergreen; Fv=Foveolate; IT=Intectate; L=Large; M=Monad; Me=Medium; No=Number; P=Prolate; Po=Polinium; PP=Perprolate; Pu=Punctate; R=Reticulate; Ru=Rugate; S=Small; Sc=Scabrate; SP=Subprolate; Sph=Spheroidal

DISCUSSION

Street planting with roadside trees is essential to make the city livable, improve the environment, enhance public health and support, and advance the infrastructure. Meanwhile, some plants cause health troubles for people, such as allergies. Plants causing allergies are still unidentified. In urban areas with crowded populations, many buildings and factories besides the gases emitted from the traffic and automobiles, can accelerate allergic symptoms. The wind-pollinated trees are considered an important cause of pollen allergy, for being widespread and dense in the human environment, besides their huge production by flowers (Oh 2022). Pollen released by street trees, in combination with air pollutants, has a considerable adverse impact on human health. Pollen allergy; is known as pollinosis hay fever or seasonal allergic rhinitis, increases during spring, summer, and autumn. The pollen grains have specific proteins which are released during their dehydration causing allergic reactions in sensitive people (Elshemy & Abobakr 2013). The most effective pollens are those with small sizes ranging from 10 µm to less than 50 µm, which can penetrate the bronchitis, causing symptoms of allergy (Thakur & Sharma 2018). The small pollen grains are easily carried by air and transferred by wind for long distances. The onset of pollen grains differs annually according to both the species and weather variability (Zhang et al. 2014, Oh 2018). CO_2 concentration in the air is an important factor affecting the quantity of pollen onset by plants (Oh 2018). In an area like Giza is a crowded region with more air pollutants, pollen grains become more harmful, and in combination with the pollutants, symptoms of allergy become severe.

From the results obtained, both *Acalypha wilkesiana* and *Tecoma stans* have the smallest pollen grains, from 20.0µm to 26.0µm, which facilitate their introduction to the nose causing asthma and rhinitis. Mampage et al. (2022) pointed to the severe impacts of bioaerosols on human health depending on their size and considered the pollen grains range from 10 to 100 µm causatives to allergy. According to Mampage et



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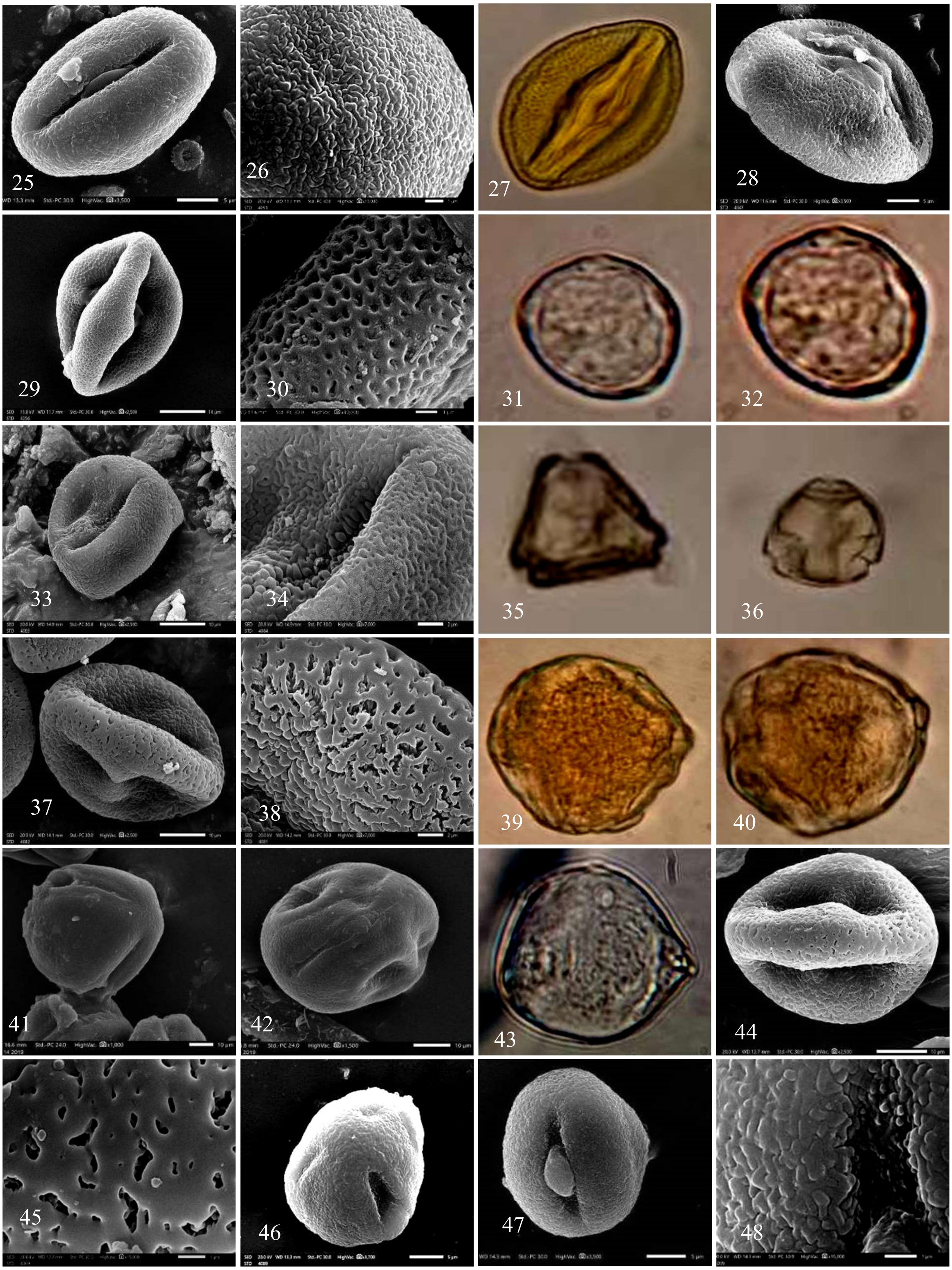

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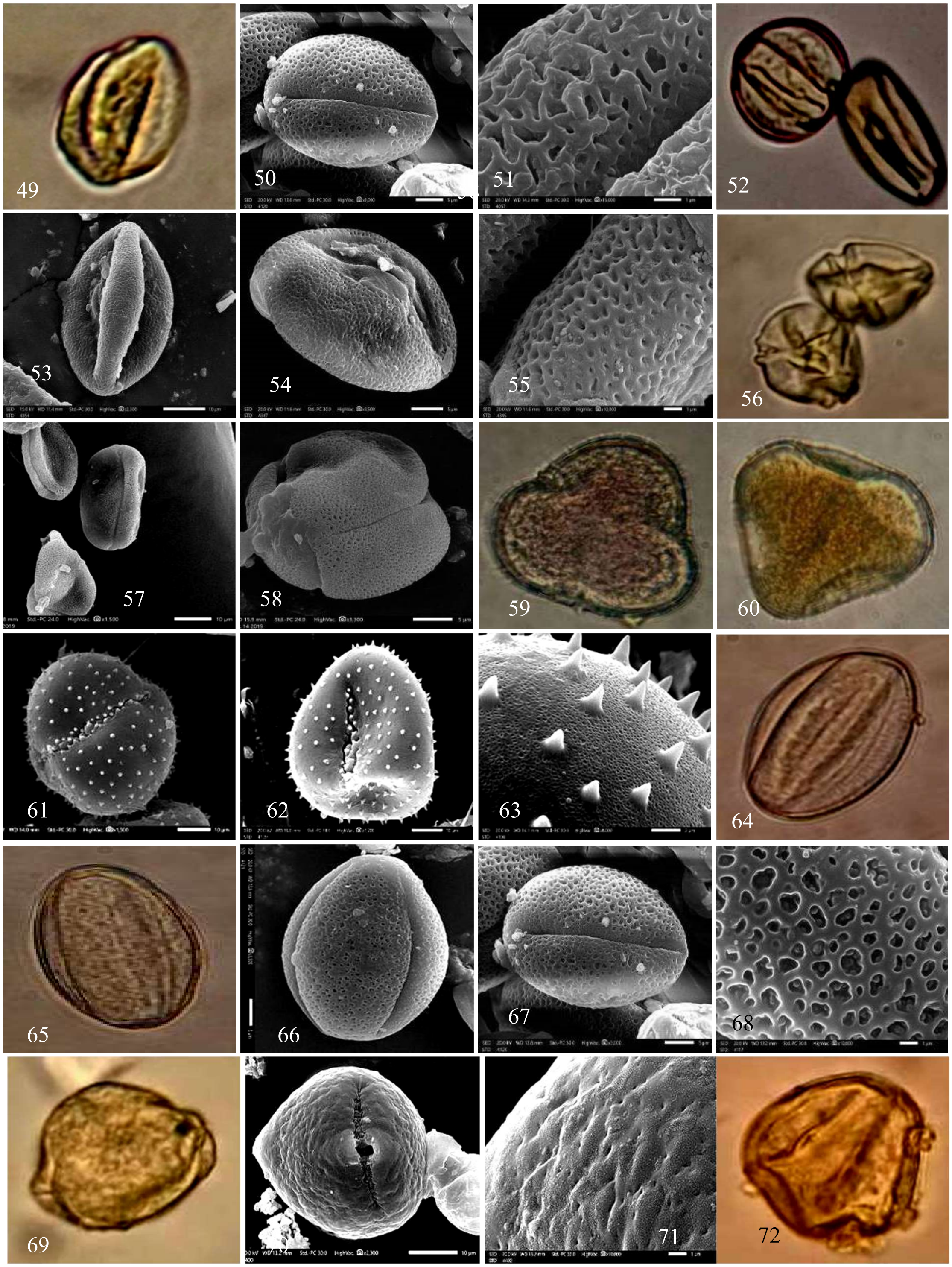

Figs. 1-72: LM and SEM photographs of the pollen grains of the studied species. 1-4 Plumbago capensis, 5-6 polyads of *Calliandra haematocephala*, 7- 10 *Cassia fistula* 11-14 *Casia javanica*, 15-16 *Delonix regia*, 17-18 *Senna surathensis*, 19-22 *Lagerstroemia indica*, 23-26 *Punica granatum*, 27- 30 *Euphorbia milii*, 31-34 *Acalypha wilkesiana*, 34- 38 *Cascabela thevetia*, 39-42 *Catharanthus roseus*, 43-45 *Nerium oleander*, 46-48 *Plumeria rubra*, 49-51 *Withania somnifera*, 52- 55 *Jacaranda mimosifolia*, 56-58 *Tecoma stans*, 59-63 *Clerodendrum inerme*, 64-68- *Vitex agnus-castus*, 69-72 *Lantana camara*.

al. (2022), all the studied pollen trees are allergic and can induce trouble for human health. Oh (2022) pointed to the huge effect of pollen grains as causative and triggering agents of respiratory allergy, and people suffering from pollinosis increased as a result of environmental changes. He pointed to the most allergens pollen grains sizes range from 20 to 60 µm. According to both opinions, all the pollen grains of the studied species are causatives of allergy. The sizes of the studied trees' pollen grains range from 20 to 55 µm, which means that all of them can trigger allergic symptoms. If we add the exine ornamentation, as it can cause itching in their intact eyes and skin, we can say that the echinate surfaces recorded in *Clerodendrum inerme* cause allergic symptoms more than the psilate ones. Dbouk et al. (2022) mentioned that the WHO announced that by 2050, one out of two people will suffer from allergy disorders due to the combination of air pollution beside pollen grains. This warning stimulated scientists to find protection from this harmful combination. Sedghy et al. (2018) considered pollen grains not only as allergen carriers but they can elicit allergic responses in sensitized people. They mentioned that interaction between air pollutants and pollen grains damages the pollen cell wall and increases the number of allergens released into the environment. They considered the big-sized pollen grains that cannot penetrate the bronchitis to have pollen-derived particles, smaller than the pollens themselves, which can induce asthma-related symptoms. Our results showed that the studied trees can induce allergy in one way or another if we consider the situation of the studied area and the weather pattern.

Aperture type and number don't have a considerable role in allergy. They can affect the hydration state of the pollen grains and the secretion of lipids and glycoproteins, stimulating allergy. All the studied trees have tricolpate or tricolporate apertures. This means that all the pollens have the same chance to release the chemical stimulants. Božič & Šiber (2022) made a model illustrating the bursting of the porate pollen grains to release their contents. They mentioned that the air humidity and the environment can desiccate the pollen and make in fold on the surface or swell the pollen and burst it. In the latter case, the release of lipids, proteins, and pollen derivative particles becomes easier and causes many disorders in humans. Thus, if we consider the studied area beside the weather patterns and air pollutants and specks of dust, all together can combine, resulting in delaying the anther opening and releasing the pollens. In this case, the pollen grains become more mature with more allergens (Oh 2022).

CONCLUSIONS

This study clarified the different morphological characteristics of the ornamental species in the Giza district, Egypt. It demonstrates the critical position of air pollution in this area with the change in the phenological aspects of the plants, resulting in the production of immature pollen grains in huge amounts, which cause human disorders and pollinosis. Our results showed that the studied species can induce allergy in one way or another if we consider the situation of the studied area, weather pattern, and pollen characteristics.

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