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Pollen Diversity of some Woody Plants in New Damietta City, Egypt

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Abstract

The pollen morphology of 36 woody species from the New Damietta City, Egypt. Belonging to 20 families of angiosperms, distributed in eighteen dicots and two monocots were investigated. The pollen grains were acetolysed, measured, described and illustrated under light microscopy (LM). Examination of these families revealed great pollen diversity in their qualitative and quantitative characters. The results revealed 58.3% of species with prolate-spheroidal pollen, 16.7% with oblate-spheroidal pollen, 16.7% with subprolate pollen, 5.6% with prolate pollen and 2.7% with suboblate pollen. Tricolporate apertures accounted for almost half of apertures types; triporate, monocolpate, tricolpate, tetra- to penta-porate, tetraporate, pantoporate, inaperturate, tetracolporate and spiral aperture representing the remainder. Exine ornamentations ranged from psilate (33.3%), reticulate (27.7%) to micro-reticulate, scabrate, granulate, echinate each represents (2%) and clavate, verrucate, rugulate, striate, psilate-perforate, clavate-reticulate made up (1%) for each type. On the basis of pollen units, number and type of apertures, exine patterns were great diagnostic significance among the examined taxa. Six major pollen types and nine subtypes included in two groups (polyads and monads) were recognized. Description of pollen types, LM micrographs and a key for identification of the investigated taxa are provided.

Keywords: Egypt, New Damietta City, Pollen Morphology, Woody Plants.

Introduction

Damietta governorate is located in the downstream part of the Damietta branch of the River Nile at 31º 25□ 10□□ north to 31º 48□ 54□ east N-32° 00□ longitude to the north east of the Nile delta region of egypt (Fig.1). The coast of Damietta governorate extends from El-Deeba village (about 20 km from port-said) to Gamasa at west along the Mediterranean Sea for about 42 km. This province is bounded by Lake Manzala at the east, Mediterranean Sea from the north and El-Dakahlia governorate from the west and the south. The total average area of Damietta Province is about 1029 km2 and the total agricultural area is about 115892 feddans (Mashaly, 2001).

With strong broad research in the field of science, the application of palynological investigations in solving taxonomic difficulties is increasingly gaining footing (Maghni et al., 2020; Khaleghi et al., 2019). Pollen shape, size,

symmetry, polar and equatorial outlines, exine thickness, number of apertures, aperture diameter, and exine ornamentation are principal morphological features of prospective taxonomic significance that are problem-solving at the species level and supply helpful information for the classification of the larger genera (El-Amier, 2015; Doaigey et al., 2017; Edeoga et al., 1998; and Edeoga & Ikem, 2002). Pollen grains occurring in large concentrations in the atmosphere trigger allergy disorders in many people (Wafaa, 2020). To avoid pollen allergies, it is vital to understand the types of allergic pollens prevalent in the region's atmosphere, as well as their concentration throughout different seasons (Tütüncü & Dane, 2012). Aeropalynology is founded on a thorough understanding of pollen morphology. Since there is a limited research available on the pollen morphology of plants in studied area, our goal is to examine the morphology of their pollen in sequential studies.

This study aims to present a comprehensive review of pollen morphology of 36 woody species collected from New Damietta City, Egypt by using light microscopy, in order to expand the knowledge on pollen morphology of genera and species of this area and to construct an artificial key to be applied for the identification of these taxa.

Materials and Methods

Sampling

Fresh polleniferous materials of 36 woody species representing 20 families had been collected from studied area. All materials were taken from mature anthers of flowering buds. The identification of taxa and nomenclature was followed by (Heneidy, 2010 & POWO, 2022). Photographs of studied species were grouped in (Plate 3 & 4). List of specimens investigated is organized by family rank. These families are listed alphabetically, as are the genera and species within each family (Table 1). Voucher specimens and pollen slides were kept in Damietta University Herbarium, Faculty of Science, Botany and Microbiology department.

Table 1: A list of the investigated taxa with their localities

Family	Examined taxa	Locality	Life form
Acanthaceae	Thunbergia grandiflora	31°26□18.36"N, 31°41□05.51"E	evergreen shrub
Apocynaceae	Nerium oleander	31°26□41.60"N, 31°40□55.05"E	evergreen shrub or small tree
	Plumeria rubra	31°26□46.46"N, 31°40□50.55"E	deciduous tree
	Thevetia peruviana	31°26□28.84"N, 31°41□01.14"E	evergreen shrub or small tree
Arecaceae	Washingtonia robusta	31°26□42.89"N, 31°40□3750.23"E	evergreen tree
Asparagaceae	Yucca aloifolia	31°26□28.83"N, 31°41□01.31"E	evergreen shrub
Bignoniaceae	Jacaranda acutifolia	31°26□14.84"N, 31°41□03.74"E	semi-evergreen or deciduous tree
	Tecomaria capensis	31°26□10.03"N, 31°40□45.55"E	evergreen shrub
Casuarinaceae	Casuarina stricta	31°26□34.48"N, 31°40□48.96"E	deciduous tree
Caprifoliaceae	Lonicera japonica	31°26□40.50"N, 31°40□54.34"E	deciduous woody twining vine
Euphorbiaceae	Jatropha curcas	31°26□22.19"N, 31°40□55.18"E	semi-evergreen shrub or small tree
	Jatropha integerrima	31°26□24.66"N, 31°41□43.11"E	evergreen shrub or small tree
Fabaceae	Acacia ehrenbergiana	31°26□22.90"N, 31°40□56.05"E	evergreen small tree
	Acacia saligna	31°26□20.35"N, 31°40□57.87"E	evergreen shrub or small tree
	Cassia alata	31°26□23.71"N, 31°40□59.68"E	evergreen tree
	Calliandra emarginata	31°26□21.89"N, 31°40□59.68"E	evergreen shrub
	Cassia fistula	31°26□21.85"N, 31°41□00.17"E	deciduous tree
	Cassia nodosa	31°26□21.89"N, 31°40□59.68"E	deciduous tree
	Delonix regia	31°26□21"N, 31°40□59"E	evergreen or semi-deciduous tree
	Leucaena leucocephala	31°26□23.53"N, 31°40□59.61"E	evergreen shrub or small tree
Lythraceae	Punica granatum	31°26□33.97"N, 31°40□46.63"E	deciduous tree
Malvaceae	Bombax ceiba	31°26□43.01"N, 31°40□51.68"E	deciduous tree
	Brachychiton discolor	31°26□23.20"N, 31°41□05.80"E	deciduous tree
	Hibiscus rosa- sinensis	31°26□28.69"N, 31°40□55.52"E	evergreen shrub
Myrtaceae	Callistemon citrinus	31°26□29.50"N, 31°41□00.36"E	evergreen shrub or small tree
Moringaceae	Moringa oleifera	31°26□28.37"N, 31°41□09.07"E	deciduous tree
Nyctaginaceae	Bougainvillea glabra	31°26□28.37"N, 31°40□53.57"E	evergreen shrub
Oleaceae	Jasminium officinale	31°26□06.80"N, 31°41□04.13"E	deciduous climbing shrub
	Jasminium sambac	31°26□12.67"N, 31°41□04.31"E	evergreen shrub
	Olea europaea	31°26□09.29"N, 31°41□58.88"E	evergreen tree
Rutaceae	Citrus limon	31°26□22.42"N, 31°40□46.63"E	small evergreen tree
	Citrus medica	31°26□22.84"N, 31°40□59.99"E	small evergreen tree
Rosaceae	Prunus persica	31°26□33.97"N, 31°40□46.63"E	small deciduous tree
Rhamnaceae	Ziziphus spina-christi	31°26□08.54"N, 31°41□08.02"E	evergreen tree
Solanaceae	Cestrum nocturnum	31°26□45.91"N, 31°40□49.43"E	evergreen shrub
Sapindaceae	Dodonaea viscosa	31°26□31.93"N, 31°40□41.75"E	evergreen shrub or small tree

Microscopy

Light microscopy

Pollen grains for light microscope (LM) were prepared according to Erdtman's acetolysis method (Erdtman, 1960). Measurements were based on at least 15-20 pollen grains for every sample. Various pollen characters viz: shape, size, aperture type and exine sculpture were determined (Table 2). Photomicrographs of pollen grains have been taken by using a Motic SFC-200FL microscope supplied with EGY-CAM camera at 100x magnification using 16x eyepieces (Plate 1 & 2). The terminology used follows Moore et al. (1991), Faegri and Iversen (1989), Erdtman (1952), and Punt et al. (2007).

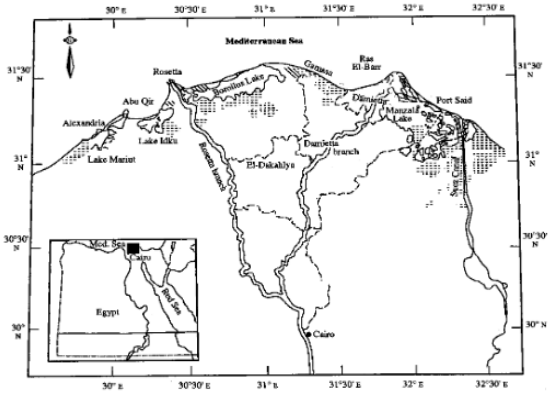

Fig (1): Location map of New Damietta City

Results

The palynological data of the examined taxa are summarized in table (2). The careful examination of the available pollen material of the investigated taxa revealed the presence of six pollen types and nine subtypes included in two groups (complex and single pollen groups).

1. pollen morphological description:

A. Complex pollen grains group.
1. Polyads type: This type can be divided into two subtypes according to the shape of polyads as follow:
1a. Polyads with uniform ends subtype:
Polyads acalymmate circular to semi rounded, biconvex, medium to large sized 44- 58.5 µm x 38-54.6 µm, with uniform ends; composed of 16 pollen grains in a regular arrangement arranged as eight central pollen grains in two planes (4 + 4) surrounded by eight peripheral grains. Pollen grains isopolar, subprolate in equatorial view, P/E ratio (1.25-1.32), inaperturate. Exine sculpture psilate, exine thickness 1.46-1.6 µm. Examined taxa: *Acacia* saligna (Labill.) H.L.Wendl and ***Acacia ehrenbergiana*** Hayne, (Plate 1, photo 13 & 14).

1b. Polyads with one tapered end subtype:
Polyads calymmate, slightly elliptic in polar view, very large in size (100-130 µm x 60 –70 µm), with one end rounded and the opposite end tapered (drop shape), composed of 8 pollen grains, being one central pollen grain surrounded by seven peripheral heteromorphic pollen grains, one of the peripheral has a conical and tapered shape. Pollen grains heteropolar, prolate in equatorial view, P/E ratio (1.676), tetra- to penta-porate, pores found in the regions in contact with the others. Exine sculpture verrucate, exine thickness 2.2 µm. Examined taxa: *Calliandra emarginata* Benth, (Plate 1, photo 16).
B. Single pollen grains group: Five major pollen types can be distinguished based on the presence or absence and the shape of apertures viz: porate, colpate, colporate, spiraperturate and inaperaturate types. Among these major types, eight pollen subtypes were recognized based on the number, exine sculpture and other pollen characters.
1- Porate pollen type: Included three subtypes based on the number of porate apertures.
1a. Triporate pollen subtype:
Pollen grains medium to large with polar axis 27.51±2.3 - 78±4.9 µm and mean equatorial diameter 26.69±2.37 - 73.32±7.5 µm, prolate-spheroidal to suboblate in equatorial view, triangular to circular in polar view, P/E ratio 0.87 - 1.06. Grains triporate, isopolar. Exine sculpture psilate - reticulate - micro-reticulate, exine thickness 1.95 - 3.505 µm. Examined taxa: (*Dodonaea* viscosa Jacq & *Bombax ceiba* L. & *Thevetia* ***peruviana*** (Pers.) K.Schum), (Plate 1, photo 3. Plate 2, 22 & 36).
1b. Tetraporate pollen subtype:
Pollen grains medium in size with polar axis of 31.2 - 48.5 µm and equatorial diameter of 23.4 - 42.9 µm, prolate-spheroidal in equatorial view, circular in polar view, P/E ratio (1.1). Grains tetraporate, isopolar. Exine sculpture psilate, exine thickness 1.47 µm. This type distinguishes (*Nerium oleander* L.), (Plate 1, photo 1).
1c. Pantoporate pollen subtype:
Pollen grains very large in size with dimensions

between 108 - 133.9 µm, oblate- spheroidal in equatorial view, circular in outline view, P/E ratio (0.99). Grains pantoporate, isopolar. Exine sculpture echinate, exine thickness 3.08 µm. This type distinguishes (*Hibiscus rosa-sinensis* L.), (Plate 2, photo 24).

2- Colpate pollen type: Included two subtypes based on the number of colpate apertures.

2a. Monocolpate pollen subtype: This subtype characterized to monocots taxa.

Pollen grains medium in size with polar axis 30.5±1.5 - 39.13±2 µm and mean equatorial diameter 22.7±5.3 - 35.5±2.88 µm, prolate to prolate-spheroidal in equatorial view, circular to elliptic in polar view, P/E ratio (1.1-1.75). Grains monocolpate, isopolar. Exine sculpture micro reticulate - granulate, exine thickness 1.07-1.54 µm. Examined taxa: (*Washingtonia robusta* H. wendl. & Yucca aloifolia L.), (Plate 1, photo 5 & 6).

2b. Tricolpate pollen subtype:

Pollen grains small to medium in size with polar axis 19.7±1.2 – 48.2±5.2 µm or large 56.6±5.9 µm and mean equatorial diameter 19.4±1.4 – 46.3±3.8 or 52.5±6.2 µm, prolate-spheroidal in equatorial view, circular in polar view, P/E ratio (1.015-1.08). Grains tricolpate, isopolar. Exine sculpture echinate to reticulate, exine thickness 1.55-2.8 µm. Examined taxa:**(***Bougainvillea* glabra Choisy & *Jasminium Sambac* (L.)Aiton & Lonicera japonica Thunb), (Plate 1, photo 10. Plate 2, photo 27 & 29).

3- Colporate pollen type: Included two subtypes based on the number of apertures.

3a. Tricolporate pollen subtype: Divided into two subtypes according to pollen shape.

1- Pollen grains small to medium in size with mean polar axis 14.7 – 57.3µm and mean equatorial diameter 15.6 – 54.39µm, prolate-spheroidal in equatorial view, circular- elliptic or triangular in polar view, P/E ratio (0.98-1.1). Grains tricolporate, isopolar. Exine sculpture reticulate, psilate or scabrate, exine thickness 1.54-3.4µm. This subtype characterized to Malvaceae (Brachychiton discolor F. Muell.), Fabaceae (*Cassia* alata L, *Cassia nodosa* L & *Leucaena leucocephala* (Lam.) de wit.), Rutaceae (*Citrus medica* L.), Solanaceae (Cestrum nocturnum L.), Casuarinaceae (*Casuarina stricta* Aiton), Bignoniaceae (*Jacaranda acutifolia* D.Don), Oleaceae (*Jasminium officinale* L & *Olea europaea* L) and Myrtaceae (*Callistemon citrinus* (Curtis) Skeels [es].), (Plate 1, photo 7, 9, 15, 18 & 20. Plate 2, photo 23, 25, 28, 30, 32 & 35).

2- Pollen grains small to medium in size with mean polar axis 17.64 – 56 µm and mean equatorial diameter 14.7 – 44 µm, oblate-spheroidal to subprolate in equatorial view, circular - triangular or quadrangular in polar view, P/E ratio (0.89-1.2). Grains tricolporate, isopolar. Exine sculpture reticulate, psilate, striate, rugulate or granulate. exine thickness 1.41-4.56 µm. This subtype characterized to Moringaceae (Moringa oleifera Lam), Fabaceae (*Cassia fistula* L. & *Delonix regia* (Boj. ex Hook) Raf).), Lythraceae (Punica granatum L.), Rosaceae (*Prunus* persica(L.) Batsch), Apocynaceae (Plumeria rubra L.), Bignoniaceae (*Tecomaria capensis*(Thunb.) Lindi) and Rhamnaceae (Ziziphus spina –christi (L.)Desf), (Plate 1, photo 2, 8, 17 & 19. Plate 2, photo 21, 26, 33 & 34).

3b. Tetracolporate pollen subtype:

Pollen grains medium in size with polar axis ranges between 24 - 33.88 µm and equatorial diameter ranges between 20 - 30.8 µm, prolate-spheroidal in equatorial view, circular in outline view, P/E ratio (1.127). Grains tetracolporate, isopolar. Exine sculpture reticulate, exine thickness 2µm. Examined taxa: (*Citrus* limon (L.) Osbeck), (Plate 2, photo 31).

4- Spiraperturate pollen type.

Pollen grains large in size with polar axis ranges between 72-96 µm and equatorial diameter ranges between 72-100 µm, prolate-spheroidal in equatorial view, circular in outline view, P/E ratio (1.022). Grains have spiral aperture, isopolar. Exine sculpture scabrate, exine thickness 4.8 µm. Examined taxa: (*Thunbergia grandiflora* (Roxb. ex Rottler) Roxb), (Plate 1, photo 4).

5- Inaperturate pollen type:

Pollen grains large in size with mean dimension ranges between 65.1-66.4 µm, prolate-spheroidal in equatorial view, circular in outline view, P/E ratio (1.04-1.11). Grains inaperturate, apolar. Exine sculpture clavate to reticulate, exine thickness 5.2-6 µm. Examined taxa: (Jatropha curcas L. & Jatropha integerrima Jacq).), (Plate 1, photo 11 & 12).

Table (2): The pollen morphological characters of the examined taxa (values in parentheses represent average lengths)

Family	Taxa	Polar axis (P)(µm)	Equatorial diameter (E)(µm)	P/E ratio	Pollen Size	Pollen Unit	Shape in Equatorial view	Shape in Polar view	Polarity	Aperture condition	Exine thickness (µm)	Exine sculpture Pattern
Acanthaceae	*Thunbergia grandiflora*	72-100 (81.8±7.1)	72-96 (79.98±7)	(1.022) 0.88-1.22	Large	Monad	Prolate spheroidal	Circular	Isopolar	Spiral aperture	4.8	Scabrate
Apocynaceae	*Nerium oleander*	31.2-48.5 (39.37±5.5)	23.4-42.9 (35.63±5.3)	(1.1) 1-1.33	Medium	Monad	Prolate spheroidal	Circular	Isopolar	Tetraporate	1.47	Psilate
	Plumeria rubra	23.52-27.9 (25.8±1.6)	24.99-29.4 (28.3± 1.4)	(0.91) 0.84-1	Medium	Monad	Oblate spheroidal	Circular	Isopolar	Tricolporate	1.43	Psilate
	Thevetia peruviana	74.1-89.7 (78±4.9)	62.4-85.8 (73.32±7.5)	(1.06) 1-1.25	Large	Monad	Prolate spheroidal	Triangular-Circular	Isopolar	Triporate	3.505	Micro-reticulate
Arecaceae	*Washingtonia robusta*	28-32.34 (30.5 ±1.5)	15-28 (22.7± 5.3)	(1.07) 1.14-2	Medium	Monad	Prolate	Circular- Elliptic	Isopolar	Monocolpate	1.54	Micro-reticulate
Asparagaceae	*Yucca aloifolia*	35.28-41.2 (39.13 ± 2)	32.34-39.69 (35.5±2.88)	(1.10) 1-1.27	Medium	Monad	Prolate spheroidal	Circular	Isopolar	Monocolpate	1.75	Granulate
Bignoniaceae	*Jacaranda acutifolia*	39.69-57.3 (47.92±6)	38.22-54.39 (46.3±6.09)	(1.03) 0.97-1.1	Medium	Monad	Prolate spheroidal	Circular	Isopolar	Tricolporate	1.58	Scabrate
	Tecomaria capensis	24.9-38.2 (31.2±4)	17.7-29.4 (24.34±3.9)	(1.28) 1.1-1.4	Medium	Monad	Subprolate	Circular-Triangular	Isopolar	Tricolporate	1.8	Reticulate
Casuarinaceae	*Casuarina stricta*	24.99-33.8 (28.4±2.9)	22.05-27.93 (25.62±2.2)	(1.106) 0.94-1.2	Medium	Monad	Prolate spheroidal	Triangular – Circular	Isopolar	Tricolporate	1.66	Psilate
Caprifoliaceae	*Lonicera japonica*	49.98-63.2 (56.6±5.9)	45.57-64.68 (52.5±6.2)	(1.08) 0.98-1.23	Large	Monad	Prolate spheroidal	Circular	Isopolar	Tricolpate	1.55	Echinate
Euphorbiaceae	*Jatropha curcas*	63-69.8 (65.1)		1.04	Large	Monad	Prolate spheroidal	Circular	Apolar	Inaperturate	6	Clavate
	Jatropha integerrima	62- 69 (66.4)		1.11	Large	Monad	Prolate spheroidal	Circular	Apolar	Inaperturate	5.2	Clavate-Reticulate
Fabaceae	*Acacia ehrenbergiana*	50.7-58.5 (55.4±3.3)	27.3-54.6 (44.46±10.5)	(1.25) 1.07-1.27	Large	Polyad	Subprolate	Rounded	Isopolar	Inaperturate	1.6	Psilate
	Acacia saligna	44-52 (48.5±2.9)	38-48 (36.8±5.8)	(1.32) 1-1.85	Medium	Polyad	Subprolate	Circular to Semi rounded	Isopolar	Inaperturate	1.46	Psilate
	Cassia alata	27.9-32.3 (29.9 ±1.7)	27.9-29.4 (29± 0.69)	(1.03) 1-1.09	Medium	Monad	Prolate spheroidal	Circular	Isopolar	Tricolporate	1.59	Psilate
	Calliandra emarginata	100-130 (114±9.8)	60-70 (68±4.1)	(1.676) 1.43-1.86	Very large	Polyad	Prolate	Slightly elliptic	Heteropolar	Tetra- to Penta-porate	2.2	Verrucate
	Cassia fistula	27.9-37 (33.8±2.3)	31.2-39 (35.9± 2.7)	(0.94) 0.8-1.13	Medium	Monad	Oblate spheroidal	Circular to Subtriangular	Isopolar	Tricolporate	2.8	Granulate
	Cassia nodosa	23.4-35.1 (30.5±2.9)	23.4-35.1 (27.7±2.8)	(1.1) 0.86-1.3	Medium	Monad	Prolate spheroidal	Circular-Triangular	Isopolar	Tricolporate	1.84	Psilate

Family	Taxa	Polar axis (P)(µm)	Equatorial diameter (E)(µm)	P/E ratio	Pollen Size	Pollen Unit	Shape in Equatorial view	Shape in Polar view	Polarity	Aperture condition	Exine thickness (µm)	Exine sculpture Pattern
	Delonix regia	32.5-42.5 (36.3±4.5)	30-42.5 (33.3±4.4)	(1.09) 1-1.3	Medium	Monad	Subprolate	Circular	Isopolar	Tricolporate	4.56	Reticulate
	Leucaena leucocephala	29.4-38.2 (34.4±3.03)	26.46-38.2 (31.31±3.7)	(1.098) 1-1.19	Medium	Monad	Prolate spheroidal	Circular	Isopolar	Tricolporate	2.97	Psilate-Perforate
Lythraceae	Punica granatum	17.64-22 (19.9±1.5)	14.7-19.8 (16.54±1.52)	(1.2) 1-1.5	Small	Monad	Subprolate	Circular	Isopolar	Tricolporate	1.5	Rugulate
Malvaceae	*Bombax ceiba*	39-50.7 (46.8±3.6)	50.7-58.5 (53.82±2.4)	(0.87) 0.77-0.92	Medium	Monad	Suboblate	Triangular	Isopolar	Triporate	1.95	Reticulate
	Brachychiton discolor	33.81-42.6 (38.2 ±2.4)	32.34-39.69 (36.5±1.9)	(1.05) 1-1.08	Medium	Monad	Prolate spheroidal	Circular	Isopolar	Tricolporate	2.8	Reticulate
	Hibiscus rosa-sinensis	108-133.9 (117.5±9.7)		(99.9) 0.93-1.14	Very large	Monad	Oblate spheroidal	Circular	Isopolar	Pantoporate	3.08	Echinate
Myrtaceae	*Callistemon citrinus*	14.7-23.4 (19.8±2.5)	15.6-20.58 (17.8±1.6)	(1.116) 1-1.46	Small	Monad	Prolate spheroidal	Triangular-quadrangular	Isopolar	Tricolporate	1.71	Psilate
Moringaceae	*Moringa oleifera*	26.46-36.7 (30.4±3.3)	30.87-38.22 (34.2± 2.4)	(0.89) 0.7-1.04	Medium	Monad	Oblate spheroidal	Circular	Isopolar	Tricolporate	2.08	Psilate
Nyctaginaceae	*Bougainvillea glabra*	15-20 (19.7±1.2)	15-20 (19.4±1.4)	(1.015) 1-1.11	Small	Monad	Prolate spheroidal	Circular	Isopolar	Tricolpate	2.8	Reticulate
Oleaceae	*Jasminium officinale*	30– 40 (34±5.07)	30-35 (30.6±1.8)	(1.11) 1-1.3	Medium	Monad	Prolate spheroidal	Circular	Isopolar	Tricolporate	3.4	Reticulate
	Jasminium sambac	39.75-54.4 (48.2±5.2)	41.2-51.52 (46.3±3.8)	(1.04) 0.96-1.09	Medium	Monad	Prolate spheroidal	Circular	Isopolar	Tricolpate	2.7	Reticulate
	Olea europaea	23.4-27.3 (24.4±1.7)	23.4-25.35 (23.8±0,8)	(1.03) 0.92-1.17	Medium	Monad	Prolate spheroidal	Circular	Isopolar	Tricolporate	2.44	Reticulate
Rutaceae	*Citrus limon*	24-33.88 (26.5±2.7)	20-30.8 (23.52±3.5)	(1.127) 1-1.4	Medium	Monad	Prolate spheroidal	Circular	Isopolar	Tetracolporate	2	Reticulate
	Citrus medica	35.1-50.7 (46.9±4.5)	39-46.8 (42.5±2.2)	(1.1) 1-1.3	Medium	Monad	Prolate spheroidal	Circular- Elliptic	Isopolar	Tricolporate	2.396	Reticulate
Rosaceae	*Prunus persica*	34-56 (44.27±6.3)	32-44 (37.47±3.7)	(1.18) 1-1.33	Medium	Monad	Subprolate	Triangular-quadrangular	Isopolar	Tricolporate	1.41	Psilate-striate
Rhamnaceae	*Ziziphus spina-christi*	22.05-29.4 (24.5±2.6)	23.52-29.4 (26.754±1.8)	(0.92) 0.8-1.1	Small	Monad	Oblate spheroidal	Triangular	Isopolar	Tricolporate	1.5	Psilate
Solanaceae	*Cestrum nocturnum*	27.3-35.1 (31.2 ±2.5)	27.3-39 (31.85±3.7)	(0.98) 0.87-1.14	Medium	Monad	Oblate spheroidal	Circular	Isopolar	Tricolporate	1.54	Psilate
Sapindaceae	*Dodonaea viscosa*	21.56-30.8 (27.51±2.3)	21.56-29.26 (26.69±2.37)	(1.03) 0.94-1.18	Medium	Monad	Prolate spheroidal	Circular to triangular	Isopolar	Triporate	2.5	Psilate

Discussion

The light microscopic investigations of the 36 taxa representing 20 taxonomic families in New Damietta province offered additional information on the pollen morphological traits. Pollen shape, size, polarity, polar and equatorial outlines, exine thickness, number of apertures, and exine ornamentation are principal morphological features of prospective taxonomic significance among the examined taxa. The most contributions family is Fabaceae among the investigated taxa, represented by eight species, Apocynaceae, Malvaceae and Oleaceae represented by three species each, Bignoniaceae, Euphorbiaceae, and Rutaceae represented by two species each. Meanwhile, 13 families (11 Dicots and two Monocots) are represented by one species each, Table (3).

Table (3): Pollen representation of different plant families.

	Family	No. of representative Species
1	Fabaceae	8
2	Apocynaceae	3
3	Malvaceae	3
4	Oleaceae	3
5	Bignoniaceae	2
6	Euphorbiaceae	2
7	Rutaceae	2
8	Sapindaceae	1
9	Solanaceae	1
10	Rosaceae	1
11	Rhamnaceae	1
12	Nyctaginaceae	1
13	Lythraceae	1
14	Moringaceae	1
15	Myrtaceae	1
16	Casuarinaceae	1
17	Caprifoliaceae	1
18	Asparagaceae	1
19	Acanthaceae	1
20	Arecaceae	1

As recorded by (Moore et al., 1991) the pollen grain shape is on the basis of the values of P/E ratio. The results revealed 58.3% of species with prolate-spheroidal pollen, 16.7% with oblate-spheroidal pollen, 16.7% with subprolate pollen, 5.6% with prolate pollen and 2.7% with suboblate pollen. There are variances and resemblances in morphology of pollen at the family level (Perveen & Qaiser, 2012). For example, Rutaceae and Oleaceae families in the current study recorded prolate-spheroidal shape, this result agrees with (Noor & Ahmad, 2021). Fabaceae family recorded subprolate, prolate-spheroidal, prolate and oblate-spheroidal pollen shapes, this result agrees with that mentioned by (Jose et al., 2014) which affirms that Fabaceae is eurypalynous. Apocynaceae family recorded both prolate-spheroidal pollen with tetraporate aperture and oblate-spheroidal pollen with tricolporate aperture type. This supports that Apocynaceae has eurypalynous nature and this result agrees with (Chatterjee et al., 2014), Figure (2).

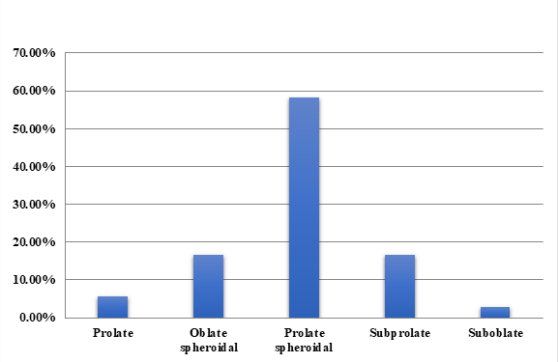

Fig.(2): Frequencies of pollen shape of examined species.

According to pollen units, there are two major groups are recognized viz. complex (Polyads) and single (Monads) pollen groups. According to (Banks et al., 2010) monads are the most primitive in the evolutionary line, whereas Polyads are the most advanced. Lora et al., (2014) stated that plant species with monad grains developed first, followed by species with polyad grains. Al-Watban et al., (2013) reported polyad grains in some members of Mimosoideae which correspond with that recorded for *Acacia* ***ehrenbergiana***, *A. saligna* and *Calliandra emarginata* in this study.

On the basis of (Erdtman, 1952) the majority of pollen grains of examined species were medium, large and small respectively. Pollen grains of Malvaceae and Mimosoideae exhibits the largest pollen diameter and its dimension ranges between (108-133.9) µm and (50.7-58.5) µm respectively. This result agrees with the report of (Khola & Hanif, 2012; Abreu et al., 2014), Figure (3).

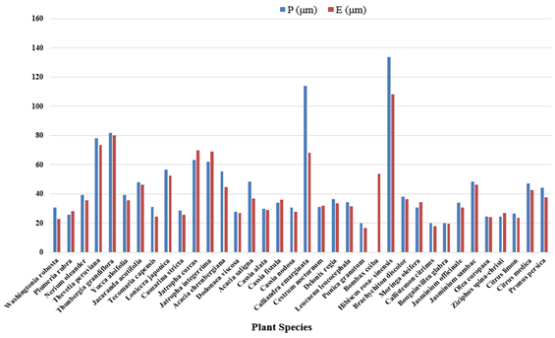

Fig.(3): Representation of polar axis and equatorial diameter of examined pollen grains

At the tribal level, aperture type has been discovered to be a useful taxonomic trait (El Naggar & Sawady 2008). The study revealed ten aperture types, (Fig.4). In all, about 52.8% of the studied species were of the tricolporate aperture type, 8.3% of triporate and tricolpate, 5.55% of monocolpate, 11.2% of inaperturate, 2.77% of the tetraporate, tetracolporate, tetra- to penta-porate, pantoporate and spiral-aperture type. According to (Cappellari et al., 2013) pollen grains with tricolporate type shows evolutionary advanced status while pollen with other aperture types reveals primitive status.

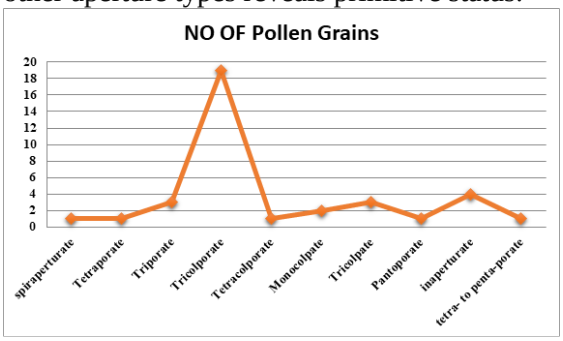

Fig. (4): Diversity in aperture of studied species

According to Furness & Richard, (2004) and Perveen & Qaiser, (2010) within most families, pollen grain features do not differ significantly, and as a result, they can be quite useful in determining affinity. The results revealed twelve exine types were found among the 36 species. Exine ornamentations ranged from psilate (33.3%), reticulate (27.7%) to micro-reticulate, scabrate, granulate, echinate each represents (2%) and clavate, verrucate, rugulate, striate, psilate - perforate, clavate-reticulate made up (1%) for each type, (Fig.5). Verrucate pattern was found in family Fabaceae (*Calliandra emarginata*) only. Psilate type was observed in Myrtaceae, Moringaceae, Fabaceae, Casuarinaceae, Apocynaceae, Rhamnaceae, Solanaceae and Sapindaceae. This is in agreement with (Antonio-Domingues et al, 2018; Noor & Ahmad, 2021). Reticulate type was observed in two members of Malvaceae, Nyctaginaceae, Oleaceae, Rutaceae, Fabaceae and Bignoniaceae.

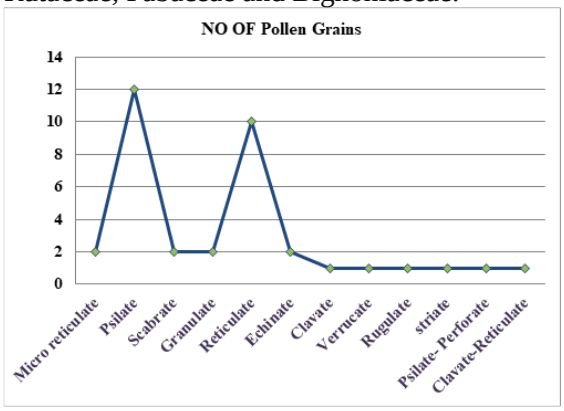

Fig. (5): Diversity in sculpture among examined plant species

PLATE (1)

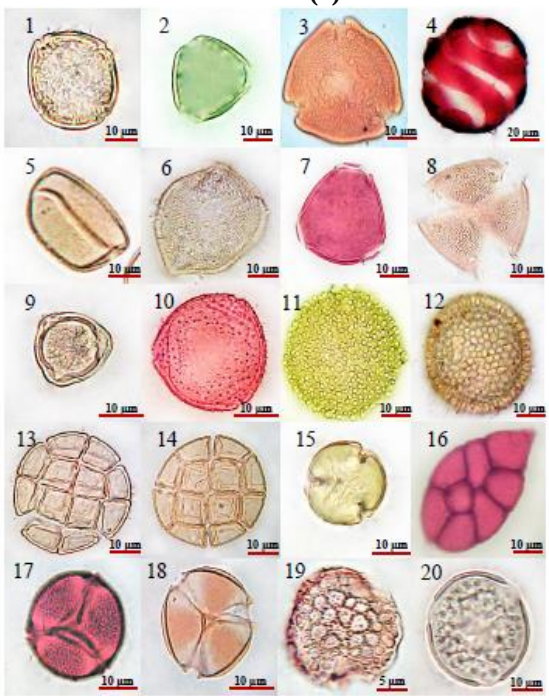

PLATE (1): *Light micrographs of pollen grains of* Nerium oleander (1), Plumeria rubra (2), Thevetia peruviana (3), Thunbergia grandiflora (4), Washingtonia robusta (5), Yucca aloifolia (6), Jacaranda acutifolia (7), Tecomaria capensis (8), Casuarina stricta (9), Lonicera japonica (10), Jatropha curcas (11), Jatropha integerrima (12), Acacia ***ehrenbergiana*** (13), Acacia saligna (14), Cassia alata (15),Calliandra emarginata (16), Cassia fistula (17), Cassia nodosa (18), Delonix regia (19), Leucaena leucocephala (20).

PLATE (2)

PLATE (2): *Light micrographs of pollen grains of* Punica granatum (21), Bombax ceiba (22), Brachychiton discolor (23), Hibiscus rosa- sinensis (24), Callistemon citrinus (25), Moringa oleifera (26), Bougainvillea glabra (27), Jasminium officinale (28), Jasminium sambac (29), Olea europaea (30), Citrus limon (31), Citrus medica (32), Prunus persica (33), Ziziphus spina-christi (34), Cestrum nocturnum (35), Dodonaea viscosa (36).

PLATE (3)

PLATE (3): The photograph of trees. Nerium oleander (1), Plumeria rubra (2), Thevetia peruviana (3), Thunbergia grandiflora (4), Washingtonia robusta (5), Yucca aloifolia (6), Jacaranda acutifolia (7), Tecomaria capensis (8), Casuarina stricta (9), Lonicera japonica (10), Jatropha curcas (11), Jatropha integerrima (12), Acacia ***ehrenbergiana*** (13), Acacia saligna (14), Cassia alata (15),Calliandra emarginata (16), Cassia fistula (17), Cassia nodosa (18), Delonix regia(19), Leucaena leucocephala (20).

PLATE (4)

PLATE (4): The photograph of trees. Punica granatum (21), Bombax ceiba (22), Brachychiton discolor (23), Hibiscus rosa- sinensis (24), Callistemon citrinus (25), Moringa oleifera (26), Bougainvillea glabra (27), Jasminium officinale (28), Jasminium sambac (29), Olea europaea (30), Citrus limon (31), Citrus medica (32), Prunus persica (33), Ziziphus spina-christi (34), Cestrum nocturnum (35), Dodonaea viscosa (36).

Artificial Key based on the morphological characters of pollen grains of investigated taxa:

1- Pollen in polyads 2
-Pollen in Monads..... 4
2- Polyads with one tapered end, composed of 8 grains ..... Calliandra emarginata
-Polyads with uniform ends, composed of 16 grains 3
3-Polyads medium sized (44-52µm x 38–48µm) ..... Acacia saligna
-Polyads large in size (50.7-58.5µm x 27.3-54.6µm), ... Acacia **ehrenbergiana**
4- Pollen grains aperturate 5
- Pollen grains non-aperturate 22
5- Pollen aperture is porate, colpate or colporate 6

- Pollen grains have spiral aperture ....Thunbergia grandiflora
6- Pollen aperture is porate 7
- Pollen aperture is colpate or colporate 10
7- Exine sculpture ornamented.....8
- Exine sculpture psilate (smooth).....9
8- Exine sculpture micro-reticulate or reticulate .....Thevetia peruviana & Bombax ceiba
- Exine sculpture Echinate .... Hibiscus rosa sinensis
9- Pollen aperture Tetraporate..... ..... Nerium oleander
- Pollen aperture Triporate ....Dodonaea viscosa
10- Pollen aperture colpate.....11
- Pollen aperture colporate 14
11- Pollen aperture monocolpate.....12
- Pollen aperture tricolpate 13
12- Exine sculpture micro-reticulate .....Washingtonia robusta
-Exine sculpture granulate ..... Yucca aloifolia
13- Exine sculpture echinate Lonicera japonica
- Exine sculpture reticulate .... Bougainvillea glabra & Jasminium sambac
14- Pollen aperture tricolporate.....15
- Pollen aperture tetracolporate ...Citrus limon
15- pollen grains small sized .... Lythraceae, Myrtaceae & Rhamnaceae
- pollen grains medium sized 16
16- pollen grains oblate spheroidal ... Plumeria rubra, Cassia fistula, Moringaceae & Solanaceae
- pollen grains prolate spheroidal or subprolate 17
17- pollen grains subprolate 18
- pollen grains prolate spheroidal 19
18- Exine sculpture reticulate .... Tecomaria capensis & Delonix regia
- pollen grains psilate- striate .. Prunus persica
19- Exine sculpture reticulate or psilate 20
- Exine sculpture scabrate..... ..... Jacaranda acutifolia
20- Exine sculpture reticulate ..... Citrus medica, Brachychiton discolor & Oleaceae
- Exine sculpture psilate 21
21- Exine sculpture psilate ..... Casuarina stricta, Cassia alata & Cassia nodosa
- Exine sculpture psilate- perforate ....Leucaena leucocephala
22-Exine sculpture clavate ..... Jatropha curcas
-Exine sculpture clavate, reticulate ....Jatropha integerrima

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الملخص العربي

عنوان البحث: تنوع حبوب اللقاح لبعض النباتات الخشبية في مدينة دمياط الجديدة، مصر

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تهدف الدراسة الحالية إلى دراسة مورفولوجيا حبوب اللقاح في ٣٦ نوعا من النباتات الخشبية تنتمي إلى ٢٠ عائلة من كاسيات البذور ، موزعة في ثمانية عشر من ذوات الفلقتين واثنين من ذوات الفلقة الواحدة في مدينة دمياط الجديدة ، مصر. تم تحليل حبوب اللقاح وقياسها ووصفها وتصويرها تحت المجهر الضوئي. وكشفت النتائج عن تنوع كبير في حبوب اللقاح في خصائصها النوعية والكمية بين هذه النباتات ، حيث أظهرت النتائج ٥٨,٣٪ من الأنواع التي تحتوي على حبوب اللقاح الكروية prolate-spheroidal ، و ١٦,٧٪ مع حبوب اللقاح الكروية المفلطحة oblate-spheroidal ، و ١٦,٧٪ مع حبوب اللقاح subprolate ، و ٥,٦٪ مع حبوب اللقاح prolate و ٢,٧٪ مع حبوب اللقاح suboblate. كما وجد عشرة أنواع من فتحات الانبات ويمثل النوع Tricolporate ما يقرب من نصف أنواع الفتحات. وتراوحت زخارف الطبقة الخارجية لجدار حبوب اللقاح بين اثنا عشر نوعا وكانت النسبة الاكبر للسطح الأملس والشبكي. وعلى أساس وحدات حبوب اللقاح وعدد ونوع الفتحات بين الأصناف التي تم فحصها تم التعرف على ستة أنواع رئيسية من حبوب اللقاح وتسعة أنواع فرعية مدرجة في مجموعتين (monads and polyads). ومن خلال هذه الدراسة أمكن وضع مفتاحا يمكن بواسطته التعرف والتفرقة بين هذه النباتات التي تم دراستها.