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Distribution pattern of trees diversity in Orman Botanical Garden

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ABSTRACT

This study characterized the floristic composition diversity and density of trees in Orman Botanical Garden, Giza- Egypt. The survey showed that total of 576 individual trees in the garden representing 247 species and 58 families. Fabaceae is the most dominant family in the garden followed by Moraceae, Cupressaceae, Malvaceae, Pinaceae, Meliaceae and Bignoniaceae. Out of 247 species recorded in the garden, angiosperms clade contributed 228 tree species belonging to 158 genera of 53 families, which are quite higher than those of gymnosperms. The tallest trees in the garden were *Dalbergia sisso* (1 specimen), *Eucalyptus camaldulensis* (4 specimens) and *Terminalia arjuna* (1 specimen). The suppressed tree was *Tabernaemontana divaricate*. The giant 3 trees were *Ficus benghalensis, F. palmata and F. religiosa* with 250, 222.3 and 213.7 cm at dbh, respectively. On the other hand, *Ficus nitida* and *Taxodium distichum* had the highest relative species density RD_i while, *Taxodium distichum* had the higher relative species dominance RD_o in the garden followed by *Ficus nitida* and *Ficus religiosa. Taxodium distichum* had the highest Importance value index IVI followed by *Ficus nitida*. The species richness, evenness and diversity (Shannon-Weaver, Simpson's indices) and similarity (Jaccard and Sorensen indices) were discussed. The garden condition was evaluated to found that most trees species (97.7%) belong to "good" class with 3 trees belong to "extinct" class. Both of *Podocarpus elongata* and *Ficus pyriformis,* which belong to "endangered" class, are lonely species that were found in the garden therefore, they should be rescued and propagated.

Keywords: Biodiversity; trees; richness; Shannon-Weaver index; Simpson's index

Introduction

The botanical gardens are supporting the Sustainable Development Goals, highlighting the intersections between plant diversity and sustainable development – intersections occur pretty much everywhere in terrestrial ecosystems. As always, when we try to make the case for biological diversity underpinning our life support systems, we quickly come up against the question of 'How much biodiversity do we need? (Smith, 2018). The Orman Garden, which was founded in 1875, is one of the most famous and oldest botanical gardens in Egypt (Diwan *et al*.,2004) and occupies an area of 28 feddans (11.76 ha). Orman Botanical Garden also defined as urban forest. Nowak and Dwyer, (2007) mentioned that urban forests provide vital roles such as tree species diversity conservation, place for relaxation and social activities, filtering the air and add aesthetics to the environment. The botanic gardens that achieved the species conservation could, partly, be assessed by the retention of genetic diversity that would otherwise have been lost. Orman Garden is the most diversified and species rich among six botanical gardens in Egypt studied by Hamdy *et al*., (2007).The information on tree species structure and function can provide basic information for conservation of the diversity of the trees in the study area. Knowing tree composition and structure is a vital tool in assessing the sustainability of the species conservation, and management of forest ecosystems (Kacholi, 2014). Long-term biodiversity conservation depends basically on the knowledge of the structure, species richness, and the ecological characteristics of vegetation. Species richness are the number of species that has been recorded during a specific time in a specific area. Evenness is the abundance distribution of the species of a community. In communities where one species dominates and the others have low number, biomass or cover, the evenness is low, and in polydominant communities, it is high (Vasilevich, 2009).Species richness, the number of unique species in a defined area, is the most commonly used measure of biological diversity (Gaston, 1996 and Moreno *et al*., 2006). Species

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richness can be used to delineate protected areas, monitor biological systems and investigate environmental relationships. Surveys rarely find all of the species in one area; therefore, numerous estimators have been proposed to improve upon the negative bias of raw counts. Biodiversity is commonly considered as a function of the relative distribution of individuals among species. The species diversity is regulated by long-term factors such as community stability and evolutionary time as heterogeneity of both microclimate and macroclimate affects the diversification among the different communities (Verma *et al*. 2004).Thus, the tallest tree species, although not necessarily the most numerous, may have a higher relative dominance and higher IVI because of longer post-planting time. Tree species with a lower relative dominance but a higher relative coverage may similarly have a higher IVI; thus, IVI can reflect the varying preferences of the different regions for nursery stock used in greening (Wang *et al*. 2015).According to Kent and Coker, (1992) a forest community is said to be rich if it has a Shannon Diversity value ≥3.5.

The aims of this study is to identify and quantify the collection diversity of tree forest species in Orman Botanical Garden to predict what actions are required to assure that the trees of the gardens are aligned with their aims for conservation and sustainable development. Also, the dominant tree species in Orman Botanical Garden can be used in afforestation in the same area or another area has the same environmental conditions.

Materials and Methods

Study Area

The study was carried out within the Orman Botanical Garden located in Giza Governorate, Egypt (Figure, 1). The zone of study covers a total surface of 11.09 ha. It lies between 30° 01′ 45.12″ N, and 31° 12′ 47.16″ E. The climate of the study area is a dry weather type. Mean rainfall is of 1.2 mm y^{-1}, with a hot season from April to October and a short wet season from November to March. On average, the warmest month is July and the coolest month is January. The average annual maximum temperature is 27.0°C and the average annual minimum temperature is 15.0°C (Figure, 2) and the soil is clayey texture

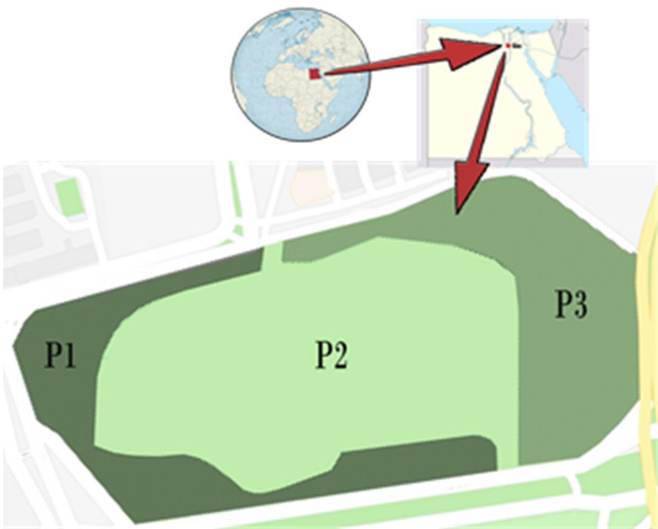

Fig. 1: Location of Orman Botanical Garden in Egypt with its three plots under this study

Numerous visits to the garden for collecting the data of this study were carried out between February 2017 to September 2018. Therefore, plot sampling, data collection and tree identifying were performed by trained crew. All tree species in each plot were identified to family, genus, species and variety at the herbaria of the Orman Garden.

Data collection

The tree sampling for data collection was performed in 3 plots with various areas in the garden as well as, the tree abundance (tree number) was tallied and tree density was detected as No. tree per hectare (Table, 1). All woody plants (trees and shrubs) were assigned then total height (m) was measured using (Suunto PM-5/360PC) Clinometer. Circumferences of all trunks were measured (cm) and converted to diameters at breast height DBH. The total height was distributed in 5 classes (<5, 5-10, 10-15, 15-20 and 20-25m). Likewise, the DBH was distributed in 7 classes ((<5, 5-25, 25-50, 50-100, 100-150, 150-200 and >200 cm).The condition of all trees was visually evaluated and classed in (good, weak and dead).

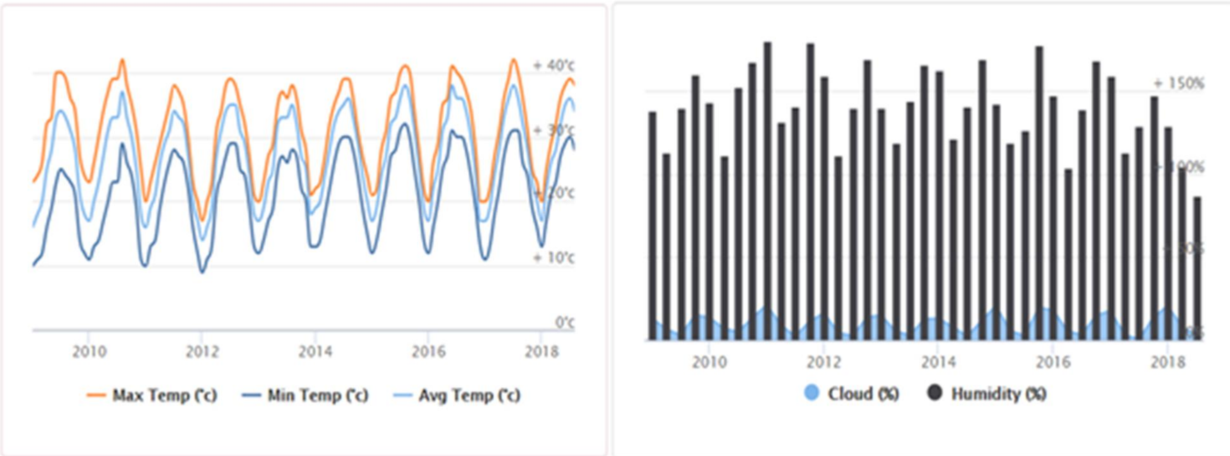

Fig. 2: Ombrothermic diagrams of Giza governorate that Orman botanical garden located in, from January 2009 to September 2018 (source: www.worldweatheronline.com)

Growth parameters and biodiversity indices

The computations of the following growth parameter and biodiversity indices were undertaken. The basal area of all trees in this study area was calculated using the following formula:

$$BA=\frac{\pi D^2}{4}$$

Where: BA is basal area (m^2), D is diameter at breast height (cm), and π is pie (3.142). The total BA for the garden was obtained by sum all trees BA. Species relative density, which is an index for assessing species relative distribution (Brashears *et al*., 2004) was computed according to the following formula:

$$RD = \left(\frac{n_i}{N}\right) \times 100$$

Where: RD (%) is species relative density; n_i is number of individuals of species and $N$is the total number of all individual trees of all species in the entire community. Species Relative Dominance (RD_o(%)), used in assessing relative space occupancy of a tree, was estimated using (Aidar *et al*., 2001) as follows:

$$RD_o = \frac{(\sum Ba_i \times 100)}{\sum Ba_n}$$

Where: Ba_i is basal area of all trees belonging to a particular species i and Ba_n is basal area of all trees in the garden. The Importance Value Index (IVI) of each species was computed with the relationship in the following equation (Brashears *et al*., 2004):

$$IVI = \frac{(RD + RD_o)}{2}$$

Diversity entails richness (the number of species) and evenness (equality in the number of individuals for every species) was calculated. Shannon diversity index (H') was applied as a measure of species abundance and richness to quantify diversity of the tree species. This index takes both species abundance and species richness into account as follows:

$$H' = \sum_{i=1}^{s} pi \text{ In } pi'$$

Where: s equals number of species and pi equals the ratio of individuals of species i divided by all individuals *N* of all species.

The tree was evaluated visually then, classified as a "good, endangered and extinct" to monitor the condition of the trees in the garden. Descriptive statistics as total number (NO.) means, standard deviation (SD.), maximum (Max.) and minimum (Min.) of all tree species were calculated for the whole area of Orman Botanical Garden. The ComEcolPaC 1.0 program is used to calculate common parameters of community ecology samples and various diversity indices (Drozd, 2010). Also, similarity index between three plots was computed using Jaccard and Renkonen indices.

Results and Discussion

Garden structure

Table (1) shows that a total of 576 individual trees in the garden representing 247 species and 58 families were identified from the three plots. The area of these plots ranged from 3.52 to 3.83 ha with a mean of 3.70 ha plot^{-1}. The abundance ranged from 103 to 330 tree plot^{-1} with a mean of 192 tree plot^{-1}. Moreover, the density ranged from 27.6 to 93.8 trees ha^{-1} with a mean of 52.93 trees ha^{-1}. The three plots were also dominated by uniquely different species without any duplicate species in any plot. Furthermore, Figure (4) illustrates that Fabaceae is the highest dominant family in Orman Botanical Garden with 16% (36 species), followed by Moraceae, Cupressaceae, Malvaceae, Pinaceae, Meliaceae and Bignoniaceae with 15, 9, 7, 6, 4 and 3%represented by 30, 7, 15, 5, 7 and 11 species, respectively. In terms of number of trees per family, Fabaceae was the highest dominant in the whole garden with 96 individuals, followed by Moraceae, Cupressaceae Malvaceae, Pinaceae, Meliaceae and Bignoniaceae with 86, 52, 39, 33, 24 and19 trees, respectively. Out of 247 species recorded in the garden, angiosperms clade (group) contributed 228 tree species belonging to 158 genera of 53 families, which is quite higher than that of gymnosperms.

These results are nearly similar to those of Diwan *et al.* (2004); Abd El Hady (2007); Abd El Migid and Diwan (2014) and Hamdy *et al*., (2007) who concluded that plants (trees, shrubs, perennials and others) of Orman Garden are represented with 250 species belonging to 45 families, Leguminosae, Moraceae, Bignoniaceae, Myrtaceae, Sapotaceae and Anacardiaceae are the families with high number of species. The dominance of family Fabaceae was mainly due to high species richness, abundance, and basal area of the constituent species. The family Fabaceae is known to dominate the tropical lowland forests (Gentry, 1998 and Addo-Fordjour *et al*., 2009).

Table 1: Count, mean standard deviations (SD), maximum (max) and minimum (min) values of plot (area, abundance and density) and total number of species and families in Orman Botanical Garden

Plot parameters	Count	Mean(SD)	Max	Min
Area (ha plot^{-1})	3	3.70±0.16	3.83	3.52
Abundance (tree plot^{-1})	3	192±121.14	330	103
Density (tree ha^{-1})	3	52.93±35.73	93.8	27.6
Total No. of species	247			
Total No. of families	58			

In terms of height-class distribution, Fig. (3) illustrates that the trees in the garden were belonged to six classes then, the majority (222 trees) were in height- class 10- 15 m and the minority (14 trees) were in class 25- 30 m. The tallest trees in the garden with 30 m height were *Dalbergia sisso* (1 specimen), *Eucalyptus camaldulensis* (4 specimens) and *Terminalia arjuna* (1 specimen). The suppressed tree was *Tabernaemontana divaricate* with 1 m only. On the other hand, the trees were belonged to seven dbh- classes whereas, the majority 208 trees) belonged to 25- 50 cm class and the minority (3 trees) belonged to class >200 cm. These giant 3 trees were *Ficus benghalensis, F. pseudo-*

sycomorus and F. religiosa with 250, 222.3 and 213.7 cm at dbh, respectively. Contrary, *Agathis robusta* tree had the thinner diameter in the garden as it is planted tree in plot P2 (2 m in height).

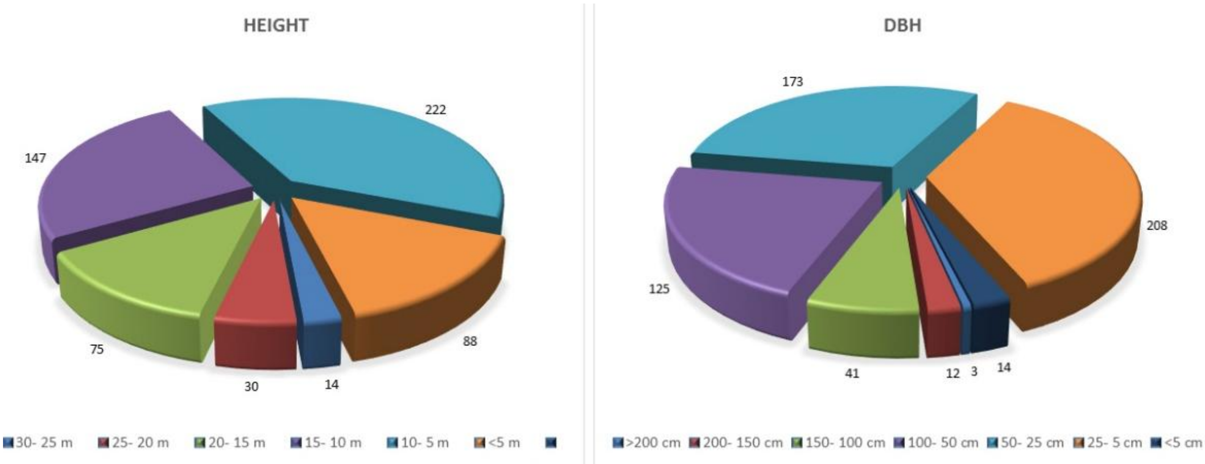

Fig. 3: Distribution of trees in Orman botanical garden by height and diameter at brast height classes

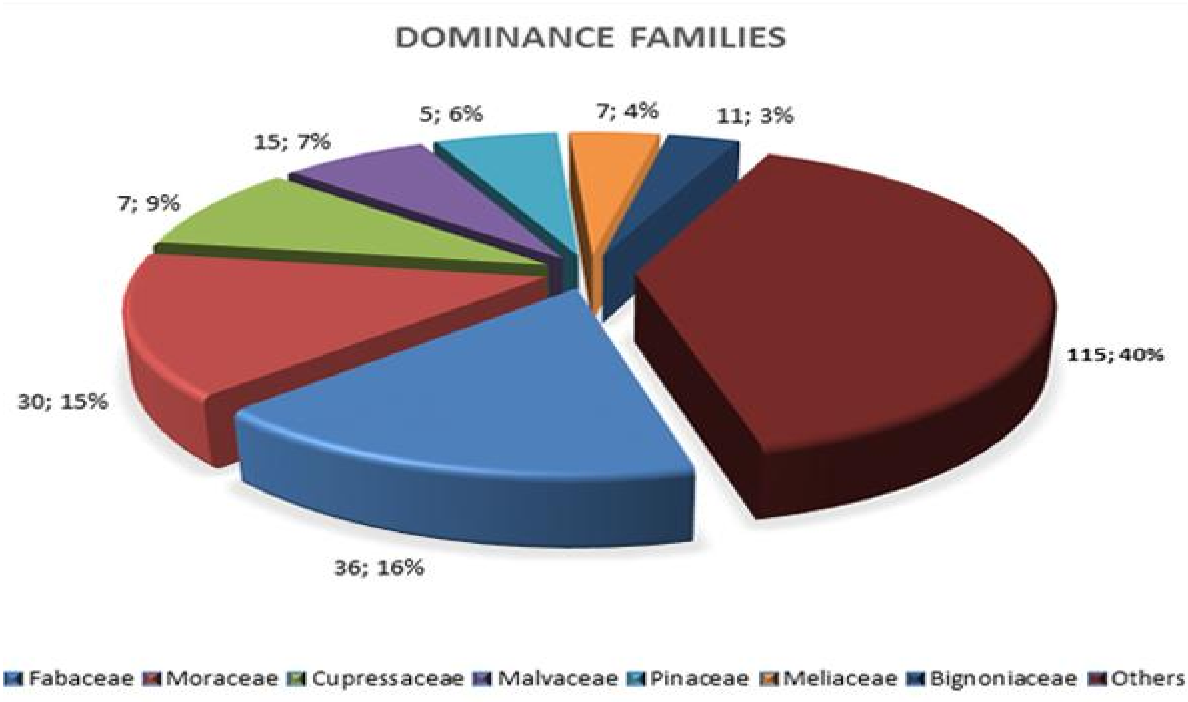

Fig. 4: Distribution Percentage of dominant families and their species number in Orman botanical garden.

Table (2) reveals that, *Ficus nitida* and *Taxodium distichum* had the highest relative species density RD_i (3.99 and 3.30%, respectively) as they had more individual trees (abundance) in the garden (23 and 19 trees, respectively). The relative species dominance (RD_o) depends on basal area hence, *Taxodium distichum* had the supreme relative species dominance in the garden (15.23%) followed by *Ficus nitida* and *Ficus religiosa* (7.00 and 6.26, respectively). Across the tree species in the garden, 226species had IVI less than 1, 19 species exceeding 1 and 2 species had IVI exceeding 3. Consequently, *Taxodium distichum* (9.26) had the highest Importance value index IVI followed by *Ficus nitida* (5.50).

Lower relative species dominance maybe characterized by high abundance of young trees and sometimes lacking individuals in the larger size class (DBH >50 cm) as mentioned by Pardini *et al.*

(2005). The IVI is commonly used in ecological studies as it indicates ecological importance of a tree species in a specified ecosystem. The IVI is also used for prioritizing species conservation whereby species with low IVI value need high conservation priority compared to the ones with high IVI (Kacholi, 2013 and Zegeye *et al*., 2006). The high IVI exhibited by *Taxodium distichum* is largely due to its higher density, and dominance compared to other species.

Table 2: The dominant tree species in Orman Botanical Garden based on importance value index (IVI) exceeding 1.0 and their different diversity parameters: abundance (A), relative abundance (RA), relative species density (RD_i) and relative species dominance(RD_o)

Species	IVI	A	RA (%)	RD_i (%)	RD_o (%)
Taxodium distichum L. Rich.	9.26	19	3.30	3.30	15.23
Ficus retusa L.(*f. nitida*)	5.50	23	3.99	3.99	7.00
Ficus religiosa L.	3.56	5	0.87	0.87	6.26
Toona ciliata M. Roem.	3.26	18	3.13	3.30	3.22
Eucalyptus camaldulensis Dehnh.	2.99	6	1.04	1.04	4.95
Peltophorum africanum Sond.	2.14	9	1.56	1.56	2.73
Ceiba speciosa (A.St.-Hil.) Ravenna	2.12	10	1.74	1.74	2.50
Pinus roxburghii Sarg.	1.86	14	2.43	2.43	1.28
Delonix regia (Boj. ex Hook.) Raf.	1.84	14	2.43	2.43	1.26
Dalbergia sisso Roxb.	1.80	8	1.39	1.39	2.21
Ficus spreguana Mildr.	1.67	4	0.69	0.69	2.64
Mangifera indica L.	1.67	13	2.26	2.26	1.07
Ficus benghalensis L.	1.61	1	0.174	0.17	3.05
Cupressus sempervirens L.	1.60	14	2.43	2.43	0.77
Ficus glomerata L.	1.56	3	0.52	0.52	2.59
Ficus pseudo-sycomorus L.	1.29	1	0.17	0.17	2.41
Thuja orientalis L.	1.27	12	2.08	2.20	0.33
*Cassia javanica*L.	1.25	11	1.91	1.91	0.60
Ficus trigonata L.	1.24	2	0.35	0.35	2.13
Cassia fistula L.	1.08	8	1.39	1.39	0.78
Ficus benjamina L.	1.02	8	1.39	1.39	0.64

Floristic composition and species diversity

In terms of species richness, Table (4) reveals that plot P3 had the highest number of species (185) followed by plot P1 (69) whereas, plot P2 had the lowest number (28 species). The evenness index *E* was calculated for each plot in the garden consequently, the values of this index varied from 0.88 to 0.94 in plots P2 and P3, respectively. Of the total recorded trees in the garden, 73.3 and 16.6% were comprised by singletons and doubletons species, respectively whereas, 10.1% had more than two species. Most singletons, doubletons and tripletons (132, 21 and 14 species, respectively) were then in plot P3. Evenness index *E* value is varied from 0 to 1. It is equivalent to 1 when all species have the same abundance (tree numbers) and tend towards zero when the total of flora is concentrated on only one species.

Although P3 and P1 nearly had the same evenness (0.94 and 0.93, respectively) but P3 had higher species richness. This is because P3 had higher number of singleton (species with 1 ndividual), doubleton and tripleton (species with 2 individuals) by 132, 21 and 14 species, respectively. Using the scale of species dominance, 216 species were subrecedent, 32 species recedent, and 27 species subdominant. *Pinus halepensis, Pinus canariensis* and *Markhamia lutea* were recorded as dominant species in plot P2 with 22 individuals. As well, *Ficus nitida* was recorded as dominant in plot P1 with 23 individuals. Only 3 species (*Cupressus sempervirens, Pinus roxburghii* and *Thuja orientalis*) were recorded as eudominant (39 individuals) in plot P2 in the garden.

The biodiversity vary from plot to another on the whole of the garden. Therefore, the plots had Shannon-Weaver diversity index values 5.70, 4.22 and 7.06 for P1, P2 and P3, respectively. These values are higher than 3.5 making it relatively rich in diversity according to Kent and Coker, (1992). Plot P3 had the highest index of species diversity H' as it had the highest species richness and species evenness (185 and 0.94, respectively).The plot P2 was less in diversity than other plots and this may be as it occupied by the gymnosperm families (conifers) while, P3 and P1 plots occupied by tropical families according to Gentry (1998) who mentioned that high species richness is a hall mark of many tropical forests. The value of Simpson's index (D) ranges from 0 to 1 where, the value index (0) represents countless diversity and the value (1) means no diversity. That is, the bigger the value the lower the diversity. Upon this, the three plots of the garden were high diverse however, the plot P3 was the more diverse with of 0.01 value (Table, 4). Magnussen and Boyle, (1995) stated that forward to compute and they have been criticized for a variety of reasons whereas, the Chao1 index (taking in regard number of species with one and two sequences) gives a higher estimate for number of species in the community. Consequently, the analysis of Chao1 index revealed a high dependence of this parameter on the plot diversity.

Table 3: Count, mean standard deviations (SD), maximum (max) and minimum (min) values of tree height and diameter at breast height (DBH) for most abundant species in Orman Botanical Garden

Species	Count	Mean±SD Height (m)	Max	Min	Mean±SD DBH (cm)	Max	Min
Ficus retusa L.(*f.nitida*)	23	15.0±5.6	25	2.5	71.9±33.4	138.5	15.3
Taxodium distichum L. Rich.	19	16.1±1.5	19	13.3	121.0±43.3	179	43.9
Toona ciliata M. Roem.	18	7.9±4.1	22	3.5	7.9±4.1	22	3.5
Cupressus sempervirens L.	15	10.7±4.76	18.9	2	30.2±15.6	50	3.2
Pinus roxburghii Sarg.	14	10.6±9.4	28.7	1.5	32.9±29.2	89.2	4.8
Delonix regia (Boj. ex Hook.) Raf.	14	7.0±2.5	12	4.2	38.7±19.2	85	14.6
Mangifera indica L.	13	10.5±4.2	20	5	37.0±18.8	63.4	11.2
Thuja orientalis L.	12	7.8±2.4	11.3	4.3	22.6±6.4	34.1	13.1
Cassia javanica L.	11	6.3±0.9	7	4.5	32.4±8.0	47.5	20.4
Ceiba speciosa (A.St.-Hil.) Ravenna	10	8.5±4.8	22	6	63.9±33.9	115.6	19.1
Peltophorum africanum Sond.	9	12.8±2.5	17.5	10	65.6±46.2	172	21.3
Dalbergia sisso Roxb.	8	21.3±6.3	30	12	72.6±21.0	108.3	54.1
Cassia fistula L.	8	11.0±3.6	18	7	42.8±13.5	65	25.8
Ficus benjamina L.	8	11.4±5.8	22.7	5	32.1±26.5	91.4	11.1
Eucalyptus camaldulensis Dehnh.	6	28.0±4.0	30	20	128.2±23.3	160.8	97.1
Ficus religiosa L.	5	18.5±3.4	22	14	155.6±42.3	213.7	96.2
Ficus spreguana Mildr.	4	16.2±4.6	20	10.2	114.7±22.3	143.3	95.5

Table 4: Species richness, diversity, evenness, abundance and other floristic parameters of the trees of the three plots in Orman Botanical Garden. Values of standard deviation (St. Dev.)with (*) were significant at α= 0.05

Parameters	P1	P2	P3
Species abundance	143	103	330
Species richness	69	28	185
E (Evenness)	0.93	0.88	0.94
*Eudominant species 10 % ≤ Di ≤ 100 %	0	3	0
Dominant species 5 % ≤ Di < 10 %	1	3	0
Subdominant species 2 % ≤ Di < 5 %	15	6	6
Recedent species, 1 % ≤ Di < 2 %	13	7	12
Subrecedent species 0 % < Di < 1 %	40	9	167
Singletons (species with 1 individual)	40	9	132
Doubletons (species with 2 individuals)	13	7	21
Tripletons (species with 3 individuals)	6	5	14
H' (Shannon-Wiener diversity index)	5.70	4.22	7.06
D (Simpson's index)	0.03	0.07	0.01
S_{Chao1}	38.95	13.69	86.98

*Tischler's scale for species dominance

Similarity: Jaccard and Sorensen Indices

Jaccard and Sorensen indices give a very good idea of the presence or absence of species in the different transects of the inventory. Species similarities that exist in the garden plots were calculated between P1, P2 and P3. Therefore, Fig. (5), demonstrated that the lowest Jaccard index value was obtained between P2-P3 (0.05). The highest value was noted between P1-P3. The values of coefficient of similarity vary from 0.05 to 0.14 for the index of Jaccard and 0.10 to 0.24% for the index of Renkonen.

Garden condition

In term of conditions, the trees in the garden are in equilibrium state where extinct is matched by the healthy trees. Fig. (6) illustrates that the percentage of species belong to “good” class was 97.7%(566individuals) whereas, 10 and 3 individuals belong to “endangered” and “extinct” classes, respectively. Table (5) exhibits the endangered and extinct number of trees and their locations in the garden. It is also interesting to note that in plot P1, both *Podocarpus elongata, Ficus pyriformis* and *Sequoia sempervirens,* which belong to “endangered” class, are lonely species that were found in the garden therefore, they should be rescued and propagated. One of eight *Celtis occidentalis* individuals in plot P3 was found dead with 5.3 m and 25.5 cm in height and DBH, respectively. Similarly, one of four *Brachychiton rupestris* individuals found dead in plot P3. It was a huge tree (14 m in height and 49.36 cm in DBH). Plot P1 occupied by two trees of *Laurus nobilis* thus, one of them (9 m in height and 22.6 cm in DBH) was found dead.

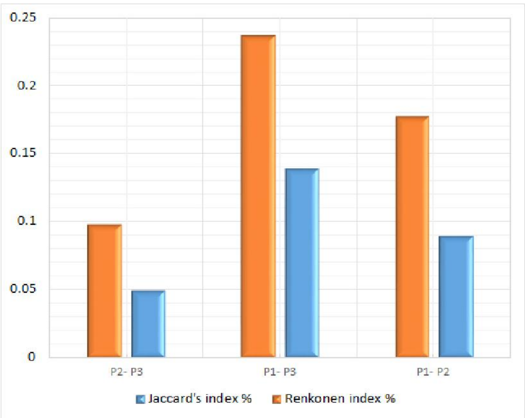

Fig. 5: Similarity indices between three plots in Orman botanical garden.

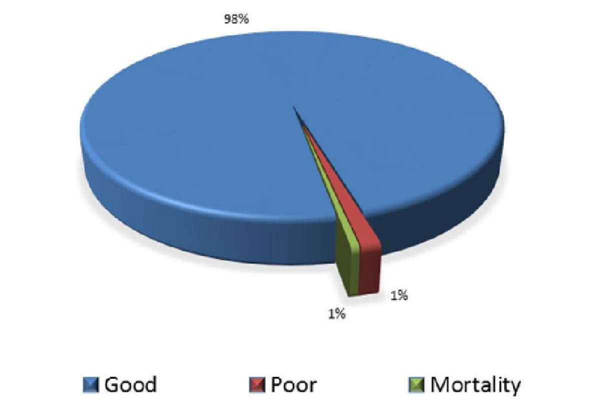

Fig. 6: Condition percentage % of trees in Orman botanical garden.

The dead *Brachychiton rupestris* tree possibly exceeded the mature stage then declined. Fig. (2) illustrates that average temperature progressively exceeded from 2009 up to 2018 as well as, the humidity percent declined consequently, drought became longer and more intense. As a result, this climate changes may be caused the death or the weak growth of other affected trees in the garden (Birdsey and Pan, 2011).

Historically, Orman Garden included some trees and shrubs according to the Herbarium records (Delchevalerie, 1899) then, they recently are extinct. Table (6) exhibits the extinct trees and shrubs and the causes of their disappearance. The climate conditions of Giza Governorate (high temperature, low humidity and drought) may not was a suitable habitat and ecology for the extinct conifer species as *Calocedrus decurrens, Cephalotaxus fortune, Cercis chinensis, Crataegus Mexicana, Quercus spp*. Also, *Ilex aquifolium* and *Salix pentandra* requires moist environments. The unfavorable conditions led to decline the tree growth. Declining trees may possibly infested by "secondary invaders" such as borers and canker and root disease pathogens afterwards, they die as *Cinnamomum glandulifera, Cryptomeria japonica* and *Juglans nigra*. The other species in Table (6) were under stress of chronic conditions as soil compaction, neglect, air pollution, and low fertility. Unfortunately, the rare African black wood (*Dalbergia melanoxylon*) became extinct by neglection. This species is reported by the IUCN as being near threatened (Washa *et al*., 2012).

Table 5: The endangered and extinct trees number and their location in the garden

Plot	Endangered	Extinct
P1	*Celtis occidentalis* L. *Cupressus lusitanica* Mill. *Ficus pyriformis* Hook. & Arn. *Podocarpus elongata* E.Mey. ex Endl. *Sequoia sempervirens* (D.Don) Endl.	*Celtis occidentalis* L.
P2	*Chamaecyparis lawsoniana* (A. Murray) Parl. *Cupressus lusitanica* Mill.	
P3	*Mangifera indica* L. *Sophora japonica* (L.) Schott *Toona ciliata* M. Roem.	*Brachychiton rupestris* (T.Mitch. ex Lindl.) K.Schum. *Laurus nobilis* L.

Table 6: The extinct trees and shrubs over the garden history and the causes of their disappearance

Unfavorable climate	Chronic conditions	Invaders pests
Calocedrus decurrens(Torr.) Florin	*Acacia neriifolia*A.Cunn. ex Benth.	*Cinnamomum glandulifera* (Wall.) Meisn.
Crataegus Mexicana Moc. & Sessé	*Cercis chinensis*Bunge	*Cryptomeria japonica*(L.f.) D.Don
Crataegus orientalis M.Bieb.	*Allocasuarina verticillata* (Lam.) L.A.S.Johnson	*Juglans nigra* L.
Cupressus corneyana Hort., ex Carriere	*Allocasuarina littoralis* (Salisb.) L.A.S.Johnson	
Cupressus torulosa D. Don ex Lamb.	*Biancaea decapetala* (Roth) O. Deg.	
Quercus incana Bartram	*Casuarina torulosa* Aiton.	
Quercus infectoria	*Dalbergia melanoxylon* Guill. & Perr.	
Cephalotaxus fortune Hook.	*Mimusops caffra*E.Mey. ex A.DC.	
Cercis chinensis	*Cestrum aurantiacum* Lindl.	
*Ilex aquifolium*L.		
Salix pentandra L.		
*Cistus albidus*L.		

When trees aged, they become slower in growth as they approach maximum age, then become more vulnerable to disease, wind and other causes of death (Goff and West, 1975). Site disturbance and unfavourable growing condition create constraints on resource availability and induce stress on mature trees. These will weaken tree health and make them more susceptible to disease invasion problems. The disease problems will draw mature trees' scarce resource for defense and the result can lead to irreversible tree deterioration and death. Tree management programs should be proactive rather than reactive. Treatments should be applied preventively to maintain plant health rather than remedial once decline begins (Clark and Matheny, 1991).

Conclusion

The study detected that Orman Botanical Garden is rich and high in tree diversy. The trees in the garden are in mature stage whereas, the majority were in height- class (10- 15 m) and in dbh- class (25- 5 cm). Therefore, the trees of the garden are aligned with their aims for conservation and sustainable development. The study recommends that scientific management of regeneration, as tissue culture, may increase the tree diversity in the garden especially, those are singletons and doubletons. Finally reforested, as a conservation method, needs to be used for preserving the threaten trees, particularly those having low importance value index (IVI) as well as restoring the extinct species.

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