Age structure of *Ficus benghalensis* L.: a Threatened Introduced Population in Ismailia, Egypt

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Abstract: The present study aimed to investigate the age structure of *Ficus benghalensis* trees including the oldest and youngest tree in the main population and proposing certain conservation plan for conserving the landscape of Ismailia which is established by *Ficus* trees. *F. benghalensis* is considered one of the most important trees on our planet due to its medicinal and economic importance and represents the first line of defense against undesirable meteorological conditions such as windy and sandy storms. Four localities for *F. benghalensis* were chosen for this study, the major vegetative parameters were measured in a total of 114 trees in those four main localities; El-Mawany area, Mohamed Ali area, Amon area and Nemra Ceta area. Crown cover, tree height, circumference at base, circumference at breast height, vitality, number of aerial roots and number of annual rings were measured for all trees at the four localities. The assessment of age dating of *F. benghalensis* was through inspecting the cut trees and counting the annual rings. Soil analyses were done including soil texture, organic matter, pH, and EC. Regression equation was used to calculate diameter and annual rings of each branch of main trunk of trees. The results based on the regression revealed that the oldest *F. benghalensis* tree was located at (El-Mawany area) with 394 years, and the second oldest tree was found at Nemra Ceta area with 357 years.
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1. Introduction

The genus *Ficus* belongs to Moraceae (Mulberry family). It is made up of about 1,000 species from pantropica land subtropical origins (Wagner *et al.*, 1999). Plants of the genus are all woody, ranging from trees and shrubs to climbers (Neal, 1965), Most of them are tropical and evergreen considered being one of the most important trees due to its medical and economic importance, as fruit, tuber, latex and prop root. *F. benghalensis*, which has many common names as Indian banyan tree, East Indian fig tree, and vada tree (Neal, 1965; Bailey and Bailey, 1976). Its name has been derived from the Hindu traders, called Banyans, who favored the tree (Neal, 1965).

Banyan tree is considered sacred by Hindus and is largely grown near temples. It is a large and extensive growing tree of the Indian subcontinent. The wood is grey, moderately hard and durable under water. The wood of the 'props' is stronger than that of the main trunk. The timber is used for making well-curbs, furniture, crates, door panels and cart-shafts. The props are used for tent poles and umbrella handles. The leaves are used as fodder for cattle and elephants.

F. benghalensis, often very large, up to 30 m lenght, with many aerial roots which can extend into new trunks so that the tree goes on thinning out laterally indefinitely; a single tree can thus cover a very wide area. The leaves are leathery, entire, ovate or elliptic, 20-40 cm long with prominent lateral veins. The figs are 1 to 2 cm in diameter, without stalks, in pairs in leaf axils, and when ripe are bright red. Banyan is used in the production of shellac, an ingredient of French polish. Shellac is derived from a resinous secretion called lac, produced by various insects living on the tree, the most commercially important of which is the lac insect (*Laccifer lacca*). Shellac has many industrial uses, and is an ingredient of hair lacquer. Lac dye is used in skin cosmetics. Banyan has many uses in traditional medicine, for example, the milky sap is applied externally for treating pains and bruises, and is a remedy for toothache. Despite this, Only now scientists are beginning to investigate the plant, for example leucocyanids, which may have potential for treating diabetes, have been isolated from the tree.

The milky latex is used outwardly for treating pains in rheumatism, skin diseases and in lumbago. The combination of the bark is used for treating diarrhea, dysentery, and diabetes. *F. benghalensis* produces propagating roots which grow downwards as aerial roots. Once these roots reach the ground, they

grow into woody trunks that can become indistinguishable from the main trunk. The figs are eaten by birds and mammals. Fig seeds are dispersed by birds such as the Indian Mynas. Studies had shown that seeds that pass through the digestive system of the bird are more likely to germinate as well as sprout earlier.

In Egypt, various *Ficus* species are establish in streets, gardens, parks and outside the canal banks. Two of the most favorable fruits are eaten by Egyptian peoples (*F. carica* and *F. sycomorus*) and also they use *Ficus* in their traditional uses in folk medicine respiratory disorders and certain skin diseases (Mousa *et al*., 1994). Mousa *et al.* (1994) reported that there are about 20 species of *Ficus* native to Egypt, most of them are cultivated as street trees for providing shade (eg. *F. retusa*) as in Alexandria city, while other species used as ornamental plants (eg. *F. religiosa*). Edlin and Nimmo (1978) proved that the latex (source of rubber) has been found in large quantity in the wood of *Ficus* genus, which is representing one of the largest economical uses of *Ficus* in Egypt.

Under Egyptian conditions, *Ficus* trees have special importance in parks and in the newly established cities to reduce the impact of the desert environment (Abo Rehab *et al*., 2014). *Ficus benghalensis* is thought to be cultivated 150 years ago in Ismailia during the process of digging the Suez Canal back in 1859-1869. Nowadays, *Ficus* trees are subjected to many threats affecting the presence of main populations. These threats comprised by the following points: (a) human cutting for general purposes, (b) cutting by council city for shifting landscape of the city, and (c) absence of a specific pollinating wasp in order to reproduce and spread (Ramirez, 1970). For these reasons and subsequently results, it's very hard to find a new tree individuals coming up to these areas of *Ficus*. These threats will change the landscape of the whole area in the next few years. In addition, there are no age dating investigations done or estimates worldwide available yet and no publications on this subject.

Subsequently, this study aimed to anticipate a strategic conservation plan for landscape construction primed by *Ficus* tress in Ismailia area. This can be done through the following points: (a) recognizing the most important populations of *Ficus benghalensis* in Ismailia city, and (b) determining the age structure of main populations of *F. benghalensis.*

2. Material and Methods

1-Study Area

Ismailia governorate is located in the eastern part of Egypt at the middle part of Suez Canal. It is bounded from the East by Suez Canal (that penetrates Temsah Lake and Bitter Lakes), from the West by the eastern borders of Delta along Damietta Nile branch, from the South by Suez-Cairo high way, and Port Said and Manzala Lake from the North (Figure 1). It was established as a separate governorate by the declaration law number 24 in 1960. Its area is 5067 km^2 and has seven main cities, Ismailia (the capital), Fayed, El-Tal El-Kber, El-Kantara east, El-Kantara west, El-Ksasen and Abo Souer. Human population of Ismailia governorate reaches 1.4 million individuals.

2-Field Visits and Sampling

Four main localities characterized by large number of *F. benghalensis*, trees were selected in Ismailia city for the present study. These localities are; El-Mawany area comprises of fifty-five trees, Mohamed Ali area comprises of five trees, Amon area comprises of sixteen trees, and Nemra Ceta comprise of thirty-eight trees (Figures 2 and 3). In each locality, number of vegetation parameters was measured to describe the *Ficus* trees including; height, cover, circumference at base (CAB), circumference at breast height (CBH), number of aerial root and vitality. Tree vitality has also been measured using the visual assessment of crown conditions. Tree condition is often used in conjunction with other vitality assessments for verification purposes (Barford *et al*., 2001; Jonard *et al*., 2010). However, vitality was measured according to the following scale: high, excellent healthy plant (vigor); medium, normal or some yellow leaflets and low, not healthy with yellow leaves (Martinez-Trinidad *et al*., 2010).

3- Soil Analysis

In each site, three soil samples (0-20 cm depth) were taken for soil chemical and physical analyses. Particle size analysis was done by dry sieving for the coarse sand and by pipette for fine sand, slit, and clay (Richards, 1954). Soil aggregation was treated by 5 % of sodium hexa-meta-phosphate as a dispersing agent. Soil was classified based on the percentage of clay and sand using USDA limits of the basic soil textural classes (Gee and Bauder, 1986). Soil pH was measured electrometrically using pH meter model 1671 in soil suspension of ratio 1:2.5 soil to water. The soil-water mixture was first shacked for 2 hours, and then pH was measured (Thomas, 1996).

Electrical conductivity (EC) was measured in soil water extract 1:1 using electrical conductivity meter model 4310 ENAWY (Smith and Doran, 1996). Reported the degree of salinity for the course to loamy sand (1:1 soil water extract) as follows: 0.1-1 ds\m for non saline, and 1.2-2.4 ds\m for slightly saline, 2.5-4.4 ds\m for modestly saline and 4.5-8.9 ds/m for strongly saline. Soil organic matter influences many soil properties including (i) the capacity of soil to supply, N, P and S and trace metals to plant's, (ii)

infiltration and retention of water, (iii) degree of aggregation and overall structure that affect air and water relationships, (iv) cation exchange capacity, (v) soil color, which in turn affects temperature relationships (Nelson and Sommers, 1996). Soil organic matter was measured using loss-on ignition (LOI) method carried out at a high temperature. This method gives quantitative oxidation of organic matter (Nelson and Sommers, 1996).

4- Age Dating

Age dating of *Ficus* trees was assessed by counting the annual rings and measuring the circumference of the branches. To avoid destruction of *Ficus* trees, the counting procedure was applied to the already cut branches in each site. Annual rings and circumference of the available twenty-one cross sections of *Ficus* trees were measured. Simple regression between annual rings as dependent variable and circumference as independent variable was carried out to have the regression equation that used to figure out the age dating of the main trunk of *F. benghalensis* trees.

To describe the age dating structure of *Ficus* trees at different sites, scale as follows: <150 years- 151-200 years- 201-250 years- 251-300 years- 301-350 years-> 350 years (Table 4).

5-Data Treatment

Data were statistically analyzed (Zar, 1984) using SPSS software (statistical package for social sciences, version 8). One-way ANOVA was carried out to test the variation of different variables between different four sites. Linear correlation coefficient, *r*, was estimated to find out the relationships between age dating, height and tree cover.

3. Results

1-Vegetation Parameters

The maximum tree height was 12.5 m recorded at site four (Nemra Ceta) while the minimum tree height was 1.70 m recorded at site two (Mohamed Ali). The circumference at base (CAB) ranged between 0.56 m and 1.9 m found at Nemra Ceta, while the highest Circumference at breast height (CBH) was 1.8 m and lowest value of 0.65 m, both found at site one (El Mawany). The crown cover of trees ranged between 3.70 m^2 and 268.67 m^2, whereas highest value found at site three (Amon area) and lowest value was at site four (Nemra Ceta) (Table 1). The number of aerial roots that were recognized in the studied sites fluctuated from one to 183 roots. Mean values of four localities are shown in Table (2).

2- Soil Properties

Soils of the study area have two different texture classes, sand and loamy sand. Soil of site one (El Mawany) is loamy sand, whereas soils of the other three sites are sandy soils. Soil pH ranged from 7.43 to 9.14. Soil of site one (El Mawany) has the highest value (pH = 9.14) whereas site three (Amon) shows the lowest value (pH = 7.43) (Table 3).

As shown in table (3) summarizing the soil properties of the four sites studied, site one (El Mawany) has the lowest EC (4.52 ds/m) whereas site two (Mohamed Ali) shows the highest EC (7.84 ds\m) and both EC values of sites three (Amon) and four (Nemra Ceta) were (4.56 ds\m) and (5.47 ds\m) respectively. Site four (Nemra Ceta) shows the highest content of organic matter (7.80%) whereas site one (El Mawany) show the lowest content (4.18%), while results for sites three (Amon) and two (Mohamed Ali) were 7.30 % & 6.60 %, respectively. Site one (El Mawany) shows the lowest content of sand was 89.33% whereas moderate content of clay 5% and highest content of silt 5.67 %. Site three (Amon) shows highest content of sand 92.67 % whereas the lowest silt content and clay 3.67 %. Site four (Nemra Ceta) shows the highest content of clay 5.33 % whereas moderate content of fine sand fraction 91 % and lowest content of silt 3.67 %.

3-Age Dating

Diameter and annual rings of each branch were measured and regression equation was calculated using the data of diameter and number of growth rings in order to figure out the age dating of the main trunk of different *Ficus* trees. The regression equation is:
No. of rings = (-0.933+2.195 circumference (cm))
(Figure 4).

$r = 0.95 \quad r^2 = 0.90 \quad P \leq 0.0001$

Age dating at El Mawany, ranged from 142 years to 394 years. The oldest tree is 394 years, 10.51m height and 106.73 m^2 cover while the youngest tress is 142 years, 3.52 m height and 20.58 m^2 cover. At site two (Mohamad Ali) which has 16 trees age dating of these trees ranges from 175 years to 295 years, the oldest tree is 295 years, 7.50 m height and 59.42 m^2 cover, and whereas the youngest tree is 1.70 m height and 80.32 m^2 cover. Whereas Site three (Amon) includes 5 trees, age of these trees range from 240 years to 344 years, the oldest tree is 344 years, 10.50 m height and 268.67 m^2 cover; whereas the youngest tree which is 240 years old, 10 m height and 224.20 m^2 cover. Site four (Nemra Ceta) which has 38 trees, age of these trees ranges from 96 years to 357 years, the oldest tree which is 357 years, 8 m height and 124.82 m^2 cover, whereas the youngest tree is 126 years, 5 m height and 13.72 m^2 cover.

Based on the regression results, the oldest *Ficus* tree is 394 years found at site one (El Mawany), followed by the second oldest tree about 357 years found at site four (Nemra Ceta).

4-Relationships between Age and Vegetation Parameters

One way ANOVA (Analysis of variance) of height, CAB, CBH, cover, and age have significant variation between the different sites. Multiple comparison of the significant variables using Duncan test showed that site 3 has the highest mean values of different parameters (height = 10.1, CBH = 138.9 m, Cover = 229.8 m^2, and Age = 304 years), followed by site number 1 and 4. On the other hand, site number 2 showed the lowest mean values of these parameters (CBH = 9.8 m and Cover = 51.6 m^2) (Table 2). Analyses of variance of vegetation parameters and age for *F. benghalensis* in the four studies area are shown in table (5).

Correlation analysis of different parameters showed highly significant direct correlation between age dating, cover, height, CAB, and CBH. Age dating data showed the highest correlation coefficient with CBH (r = 1), and CAB (r = 0.909) followed by cover (r = 0.694) and height (r = 0.651).

Table 1: Vegetation parameters for the studied four sites.

	N	Minimum	Maximum	Mean		± SD
Site No. One (El Mawany)						
	statistic	**statistic**	**Statistic**	**Mean**	**±SE**	**Statistic**
HEIGHT	55	3.52	11.52	7.0907	0.2485	1.8428
CAB	33	70	170	121.1818	4.6857	26.9171
CBH	40	65	180.03	110.8703	3.966	25.0832
COVER	55	18.31	223.14	70.1522	5.6871	42.1767
AGE	40	142	394	242.425	8.6843	54.9241
Valid N (listwise)	33					
Site No. Two (Mohamed Ali)						
	N	**Minimum**	**Maximum**	**Mean**		**± SD**
	statistic	**statistic**	**Statistic**	**Mean**	**±SE**	**Statistic**
HEIGHT	16	1.7	12	6.6875	0.5972	2.3888
CAB	7	90	125	121.1818	5.101	13.496
CBH	16	80	135.02	110.8703	4.6881	18.7523
COVER	16	13.68	104.72	70.1522	8.2362	32.9447
AGE	16	175	295	242.425	10.2881	41.1525
Valid N (listwise)	7					
Site No. Three (Amon area)						
	N	**Minimum**	**Maximum**	**Mean**		**± SD**
	statistic	**statistic**	**Statistic**	**Mean**	**±SE**	
HEIGHT	5	8.5	11	10.1	0.4301	0.9618
CAB	0					
CBH	5	109.9	157	138.998	8.2311	18.4053
COVER	5	186.17	268.67	229.786	13.2333	29.5907
AGE	5	240	344	304	18.1466	40.5771
Valid N (listwise)	0					
Site No. Four (Nemra Ceta)						
	N	**Minimum**	**Maximum**	**Mean**		**± SD**
	statistic	**statistic**	**Statistic**	**Mean**	**±SE**	
HEIGHT	38	3	12.5	6.7629	0.3142	1.9368
CAB	28	56	190	111.8929	7.3868	39.0871
CBH	33	44	163.28	105.2173	5.6693	32.5675
COVER	38	3.7	180.89	84.3755	7.9385	48.9363
AGE	33	96	357	229.9697	12.4407	71.4666
Valid N (listwise)	28					

Table 2: Mean values of height, CAB, age and cover for the four studied localities.

	Site one (Elmwany)	Site two (Mohamed Ali)	Site three (Amon)	Site four (Nemra Ceta)
No. of trees	55	16	5	38
Mean height	7	60.68	10.1	6.76
Mean CAB	121.8	98.82	N. R	105.21
Mean age	242.42	216.06	138.99	229.96
Mean cover	70.15	51.65	229.786	84.37

Table 3: Soil physical and chemical characteristics for the studied localities.

Site No.	pH	EC ds\m	OM%	Sand%	Silt %	Clay %	Soil Type
1 (El mawany)	9.14	4.52	4.18	89.33	5.67	5.00	Loamy sand
2 (Mohamed Ali)	7.88	7.84	6.6	91.33	4.00	4.67	Sandy
3 (Amon)	7.43	4.56	7.3	92.67	3.67	3.67	Sandy
4 (Nemra Ceta)	7.93	5.47	7.8	91.00	3.67	5.33	Sandy

Table 4: Age dating scale of *F. benghalensis* for the four studied localities.

Site No.	Age Dating Scale (year)					
	< 150	151-200	201-250	251-300	301-350	>350
1 (El mawany)	1	7	12	14	4	1
2 (Mohamed Ali)	0	9	4	3	0	0
3 (Amon)	0	0	1	1	3	0
4 (Nemra Ceta)	3	10	7	6	6	1

Table 5: ANOVA of vegetation parameters and age of *F. benghalensis* in four main sites.

		Sum of squares	Df	Mean Square	F	Sig.
Height	Between groups	51.833	3	17.278	4.619	0.004
	Within groups	411.47	110	3.741		
	Total	463.304	113			
CAB	Between groups	2677.835	3	892.612	0.872	0.46
	Within groups	65528.45	64	1023.882		
	Total	68206.28	67			
CBH	Between groups	6725.245	3	2241.748	3.099	0.031
	Within groups	65107.9	90	723.421		
	Total	71833.15	93			
Cover	Between groups	131041.8	3	43680.6	23.502	0
	Within groups	204448.2	110	1858.62		
	Total	335490	113			
Age	Between groups	32264.92	3	10754.98	3.092	0.031
	Within groups	313077.7	90	3478.641		
	Total	345342.6	93			

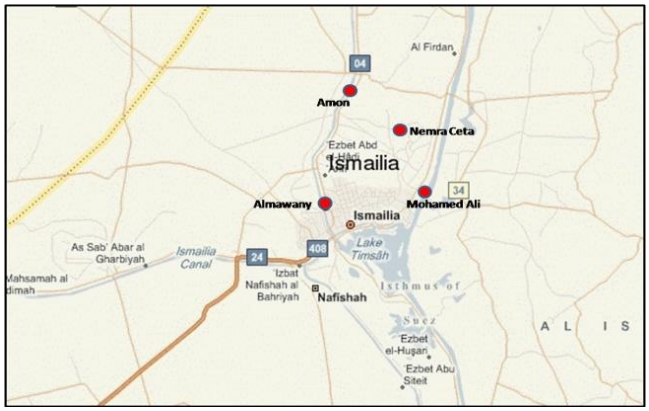

Figure 1: Map showing the four studied localities of *F. benghalensis* chosen for study in Ismailia.

Figure 2: *F. benghalensis* trees in Ismailia roads.

Figure 3: *F. benghalensis* aerial roots in one of the four studied area in Ismailia.

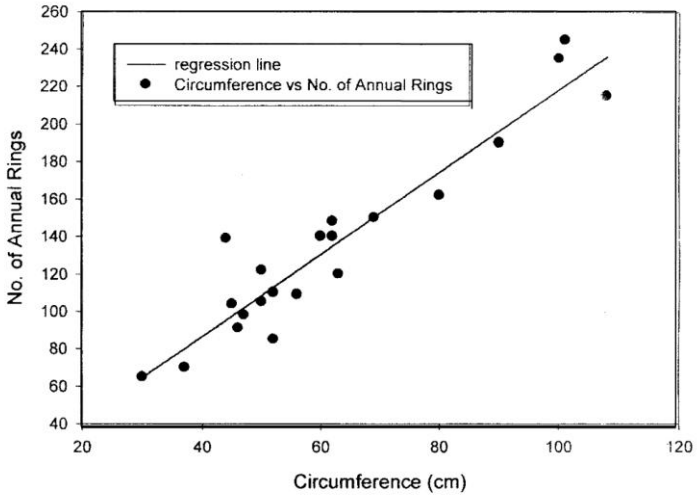

Figure 4: Relation between number of annual rings and circumference (cm).

4. Discussion

F. benghalensis is the world's largest tree in terms of its spread (Riffle, 1998). The tree is native to India and Pakistan (it is named for Benghal). It is a popular shade-tree, cultivated in many tropical countries (El-Hadidi and Boulos, 1988). The plant begins life growing on other trees and eventually envelopes them completely. Aerial roots hang down from the branches and these eventually become trunks. This circle of trunks deriving from one original tree can reach an enormous size – 200 meters in diameter and 30 meters in height. Their shade has made them important gathering places. Known in Hindu mythology as 'the wish-fulfilling tree', banyans represent eternal life. The tree is sacred to Hindus and Buddhists in India and is frequently planted around temples. Being a majestic ornamental tree it is also planted in parks and along streets in the tropics. In temperate climates it is grown as an indoor plant. In general, the banyan is a source of dye and shellac – an important component in French polish – produced by lac insects which inhabit the tree as pests.

The present study showed that populations of *Ficus benghalensis* have limited distribution in Ismailia city (target study area). Four sites were only recognized in the study area. The limitation may return to the requirements of the pollinating wasp (*Eupristina masoni*). However, Ismailia city is located near the midpoint of the Suez Canal, on the northwestern shore of Lake Temsaḥ. The lake, is a natural depression, was connected to the Gulf of Suez of the Red Sea in pharaonic times. The city was founded in 1863 by the French engineer Ferdinand de Lesseps, constructor of the Suez Canal, as a base

camp. It was named for the ruling Egyptian khedive (viceroy) Ismail Pasha, whose elaborate palace built for the gala opening of the canal in 1869 has fallen into ruin. Laid out in the 19th century style, with broad avenues, tree-lined squares, parks, and gardens, it has a gridiron street plan. Ismailia was cultivated with huge number of *F. benghalensis* and now is subjected to huge human threats affecting the presence of these trees.

Nadel *et al*. (1992) described the pollination process which is the main reason of not producing off spring of *F. benghalensis*. In general, the genus *Ficus* (Moraceae) is distributed in the tropics and subtropics worldwide. About one-half of the species are monocious, the rest being gynodioecious but functionally dioecious Nadel *et al*. (1992). Most species grow as trees, while others are shrubs or climber. Frequently, germination in many species occurs on other trees, with the seedlings growing epiphytically while sending a set of connections of roots down to the soil, eventually "strangling" their nurse trees (Nadel *et al*., 1992). However, other species begin their lives on rocks or straight in soil. Pantropical in distribution, only a few fig species extend into warm temperate regions.

As stated by Nadel *et al*. (1992), with few exceptions, each fig species is pollinated by a different species of wasp in the family Agaonidae (Hymenoptera: Chacidoidea) (hill, 1967; Ramirez, 1970; Janzen, 1979; Wiebes 1979). The pollination biology of monoecious species has been described by Galil and Eisikowitch (1968, 1969). A pollen-laden female wasp enters the syconium or "fig", an urn-shaped inflorescence which, when in the receptive stage, is lined internally with dozens or hundreds of receptive female flowers and a few immature male flowers. The wasp lays her eggs through the styles into some of the ovaries, pollinating most of the flowers in the process. In dioecious fig species, pollination is more complex. The "male" tree is monoecious, having both male and female flowers in each syconium, but it has only short-styled female flowers. Nearly all of these female flowers are used by the ovipositing wasps, with the result that the tree peoduces no seeds, only pollen and agaonids. The female tree, on the other hand, is truly female; the syconia contain only female flowers. These flowers are all long-styled, which effectively eliminates the ability of the agaonid to oviposit in them. The absences of this process of pollination cause failure in germination of *F. benghalensis.*

Age dating results of *Ficus benghalensis* reflect the history of Ismailia area, which return to the age of Suez Canal. Digging of Suez Canal started in 1862 another canal, Ismailia canal, was constructed in the same time to sustain thousands of workers with water, food and other requirements. El-Mawany area and Nemra Ceta area showing the oldest *Ficus* trees are located near the construction of those canals. Importance of cultivating *F. benghalensis* at that time not only returns to their huge shade but also to their medicinal importance that could help in treatments of different diseases.

Based on age dating results, the oldest *F. benghalensis* is 394 years old cultivated in site number one (El Mawany), whereas the youngest tree is 96 years old cultivated in site number four (Nemra Ceta). The highest mean of age dating was recorded for the trees cultivated in site number three (304 years) located at Mohamed Ali, followed by *Ficus* trees cultivated in site number one (242 years) located at El-Mawany area. The lowest mean of age dating was recorded for *Ficus* trees cultivate in site number four and two (229, 216 years respectively). Correlation analysis indicates the direct correlation between age dating, cover, height, CAB, and CBH. CBH was the most important parameter could be used to predict the age dating of *F. benghalensis.* The results showed very important notes about growth mode of *Ficus benghalensi:* (a) average number of annual rings per centimeter ranges from 13 and 14 annual rings and (b) *Ficus* tree with age of 96 years has height 3 meters and diameter at breast height equals 14 cm and the oldest tree has height and diameter equal 11m and 57 cm respectively.

Age dating of *Ficus benghalensis* data may be interpreted with one of the following two hypotheses. First, these trees may be introduced with age ranges from 150-200 years (about 20-30 cm diameter, and 5-7 m height) and connected with the Suez Canal construction for shade and medicinal importance. The second hypothesis returns the cultivation of these trees to the age before the construction of Suez Canal, and the populations of *F. benghalensis* were selected to be near to the route of Suez Canal and Ismailia canal to get benefit from their shade and medicinal importance.

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