Phenological Variations of Three Urban Forest Trees Grown in North and Upper Egypt

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ABSTRACT

Patterns of leaf-flushing, leaf-completion, defoliation, flowering-on, flowering-off, pod (fruiting)-on, pod maturation and pod opening of trees were studied to detect the phenological variations of Albizia lebbeck, Cassia javanica, and Delonix regia trees in both Alexandria, as North of Egypt, and Aswan, as Upper Egypt, for three consecutive annual cycles (from first week of March 2009 to December 2011). At both cities, the trees of three genera began to flush leaves during spring season (April- June), reached a completion phase before the summer season. The results indicate that, high temperature resulted in leaves completion beginning 3-5 weeks earlier and defoliation delayed 13- 25 weeks later, as noticed in Aswan for the three genera. Additionally, max. and min. temperature and day length were well correlated with leaves flushing of both Albizia lebbeck and Delonix regia in Alexandria as well as, for Cassia javanica in Aswan. On the other hand, max. and min. temperature, and day length were also significantly correlated with flowering of both Albizia lebbeck and Cassia javanica in Aswan whereas, correlation between max. temperature and min. temperature were existed only for Cassia javanica with leaves flushing in Alexandria. Generally, relative humidity did not affect the observed phenophases of the three genera in both cities during the three years.

Key words: Phenology- ***Albizia lebbeck- Cassia javanica- Delonix regia-*** **Urban forests**

INTRODUCTION

Although there are several commercial hybrid Urban forests strongly contribute to environment preservation and provide many important benefits including shade and reducing temperature, increased property values, improved urban soil, water, air quality, energy conservation, decreasing storm water run-off, noise abatement, traffic calming and glare reduction, and adding aesthetic sense of roads and streets. Deficient understanding of site variations has restricted such uses. Phenology of tree in any ecosystem is the study of movement pattern or the timing of periodic biological events in the plant kingdom as influenced by the environment variation (Rivera *et al*., 2002; Schwartz, 2003; Hamann, 2004 and Zhang *et al*., 2006). These events include flushing, flowering, fruiting and autumn leaf-fall. The dependence of plants on the climate for the succession of different life phases increases the significance of phenological studies in its connection with climate change and global climate monitoring (Schwartz, 1999; Mezel, 2002 and Schwartz *et al*., 2006). The phenological studies are instrumental in assessing the response of plants and plant community against climatic disturbances. The effect of climatic change may be assessed by correlating seasonal climatic conditions and the different phenophases of the plants (Kushwaha and Singh, 2008).

Forest tree phenology is important not only from botanical perspective, but it also enables scientists to broaden the geographic and temporal scale of their observations. The goals of urban forests phenology are to 1) increase awareness of phenology as an area of scientific study; 2) increase awareness of the impacts of changing climates on plants. In mid-latitudes, bud burst, leaf emergence and flowering of many species are dependent on spring air temperatures (Chmielewski and Rötzer, 2001). Also, Menzel, (2000); Sparks *et al*., (2000) and Defila and Clot, (2001) have shown that the timing of spring events has become earlier, particularly since the 1970s, and the earlier onset of spring growth in plants in temperate climates has been used as an indicator of climate change (Schwartz, 1999). On the other hand, the timing of autumn events, such as leaf discolouring and leaf fall, has shown less change over the same time period (Chmielewski and Rötzer 2001; Menzel, 2000 and Defila and Clot, 2001). This suggests that the length of the growing season (LGS) is increasing mainly due to the earlier onset of spring and those factors such as photoperiod and increasing atmospheric CO_2 concentration may have a stronger influence than temperature on the timing of events at the end of the growing season. In Egypt, climate and phenology interactions are poorly understood. Regional studies of plant phenology even carried out in small area are equally important and at the same time it requires low budget. Once the data is generated, these studies can throw light on regional peculiarities which can be utilized at national and international levels (Menzel and Estella, 2001). Wide range of defoliation duration has been reported in other dry tropical regions: 1–3.5 months in Venezuela (Olivares and Medina, 1992); less than 1–4 months in Thailand (Rivera *et al*., 2002); up to 8 months in West Africa (De Bie *et al*., 1998). Huge variations in defoliation duration occur even in conspecific individuals of many tropical tree species due to differences in site conditions (De Bie *et al.*, 1998; Singh and Kushwaha, 2005).

According to the meteorological data, the South of Egypt is characterized by the continental climate and differs greatly in temperature between day and night. Air temperature reaches a maximum of 42°C in Aswan during the summer and 13°C in winter. On the other hand, in the North at the Mediterranean Coast, it reaches a maximum of 30°C in summer and 18.5°C in winter. The relative humidity is high in the North of Egypt with maximum of 70- 72% on the average in summer. It decreases towards the South with a minimum of 13% in Aswan in summer. Thus, both aridity and gigh evaporation are the critical factors restricting the distribution and growth of natural vegetation (FRA- Country Report, Egypt, 2008).

Albizia lebbeck is a deciduous tree, grown to 18-30 m tall with a trunk 0.5- 1 m in diameter. The flowers are white and very fragrant and the fruit is a pod 15–30 cm long. It is cultivated as a shade tree as well as it is used to produce timber. It is very drought tolerant, being found in areas with rainfall as low as 300-400 mm/yr. *Albizia lebbeck* has been grown successfully where the 24-hour annual average temperature is 18.7°C ±2.56, but also near sea level where the 24-hour annual average temperature is 25.6 ºC ±1.64. *Albizia lebbeck* has grown well in an area with 24-hour annual average temperature of 20.7 ºC ±4.63. *Cassia javanica* is a deciduous or semi-deciduous tree up to 25 m in height and 35 cm diameter at breast height. The trunk frequently has many shoots. The crown, consisting of descending branches with sparse foliage is wide-open, arched and spread out. It produces a mass of gorgeous flowers, with petals at first pale red, changing to dark red, and then palling again to pink. *Cassia javanica* blooms during the spring and is cultivated as a shade and ornamental tree along streets and in parks and gardens (Wee, 2003). *Delonix regia (*Bojer ex Hook.) Raf. (Fabaceae), commonly known as flamboyant, is a large, fast-growing, deciduous tree of up to 20 m tall, that is grown as an ornamental and shade tree where it has a wide-spreading, umbrella-shaped crown and it is covered with bright red flowers.

The main objective of this study was to assess variation of the different phenological events for selected urban forest species in both Alexandria and Aswan to utilize them to understand the impact of climate changes on the plant species. Since, such type of studies has not been carried out before for the urban forest tree species of the northern and southern Egypt therefore, the data provided here may be used for more climate change assessment.

MATERIALS AND METHODS

A field study was carried out during three consecutive annual cycles (from the first week of March 2009 to the last week of December 2011) in Alexandria, North of Egypt (N 31° 12' E 29° 55') and Aswan, Upper Egypt (N 24° 05' E 32° 53') with distance nearly 1142 km.

Study site: The study was carried out at Antoniadis and Shalalat parks located East and Central of Alexandria city as well as, at Al-Mosta'amara Kom Umbu, Cornish Al- Nile and Ferial Garden located North and South of Aswan city as shown and listed in Fig. (1) and Table (1). The soil of studying locations in Alexandria is loamy sand and averaged sandy loam in Aswan which has a more pronounced dry season than Alexandria (Fig. 2 and 3).

Tree genera: The *Albizia lebbeck, Cassia javanica and Delonix regia* trees grown as urban forest trees have been selected for this phenological study (Table, 2).

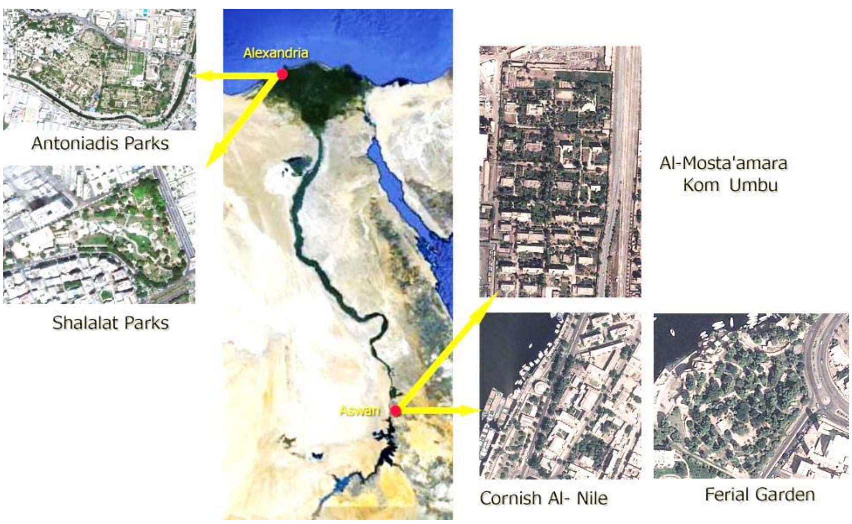

Table 1: Details of both Alexandria and Aswan locations selected for the phenological study

City	Location	Latitude	Longitude	Elevation (m)	District
Alexandria	Antoniadis Parks	N 31° 12.126'	E 29° 56.974'	9.3	East
	Shalalat Park	N 31° 12.214'	E 29° 54.814'	10.3	Central
Aswan	Al-Mosta'amara Kom Umbu	N 24° 28.954'	E 32° 56.753'	109.8	North
	Cornish Al- Nile	N 24° 05.706'	E 32° 53.842'	97.1	South
	Ferial Garden	N 24° 05.024'	E 32° 53.348'	103.5	South

Table 2: Description of three urban tree species observed for the phenological study. (values are mean ±SE).

Family	Scientific name	Common name	Average DBH (cm)	
			Alexandria	Aswan
Fabaceae	*Albizia lebbeck* (L.) Benth	Lebbeck	63.0 ±4.2	71.5 ±6.1
	Cassia javanica L. (synonyms: *Cassia nodosa* Buch.-Ham. ex Roxb)	Pink shower	32.3 ±1.3	44.4 ±1.5
	Delonix regia (Bojer ex Hook.) Raf (synonyms: *Poinciana regia* (Boj. ex Hook)	Flamboyant	60.4 ±2.4	62.0± 3.4

Field sampling and data collection: For every genera and site, we selected five adult individuals (the minimum sample size recommended by Fournier and Charpentier, 1975) with well-developed crowns, good shape and healthy stems. These trees were selected on the basis of their diameter (Table, 2) with complete randomized design. Phenological observations were realized every week, taking into account the occurrence and duration of the following events: leaf flushing, defoliation, flowering-on, flowering-off, pod-initiation, pod-ripping and pod opening. Data were acquired, to record the intensity of the foliage, flowering and pods of each tree at one week intervals using a percentage scale (10%= initiation, 25, 50, 75 and 100% = maximum density of leaves, flowers or pods recorded during the observation period). The tree which had 10% new leaves, flowers and fruits was considered in leaf flushing, flowering-on and pod-initiation stages.

Pod maturation was defined as the most pods color turning into yellow for *Albizia lebeck* and brown for *Cassia javanica* and *Delonix regia*. The length of the growing season (LGS) was calculated from the number of weeks between date of leaves flushing and date of defoliation of individuals. In addition, the length of deciduousness (leafless period) for each genera was calculated as the mean leafless duration of individuals.

Statistical analysis:

The phenological records were correlated and cross-correlated by conducting a time-series analysis with meteorological data (e.g., precipitation, temperature, relative humidity and photoperiod) from each site, provided by Central Laboratory for Agricultural Climate, Agric. Res. Center. The Pearson correlation statistic was used to test the impact of the phenological stages by maximum temperature, minimum temperature, relative humidity and day length (photoperiod) across different sites and genera using the mean values of the three consecutive annual cycles. It should be stressed that interactions between meteorological data, tree phenology and other external factors not considered in this study can rather be complex. Hence, the correlation presented hust point to the most likely phenological triggers, bearing in mind that multiple factors could contribute to the observed phenological patterns. The different means of parameters between the two sites were compared using Dunkin's Multiple Range Test (Sendecor and Cochran, 1980).

Meteorological data:

Generally, Figure (2) illustrated that in Alexandria, 2010 was the hottest growing cycle (34.9°C) whereas 2011 was the lowest (20.4°C) and the more humid growing cycle (69%). Furthermore, 2009 was the lowest growing cycle in humidity (63.3%). In Aswan, 2010 was the hottest growing cycle (42.7°C) and lowest in humidity (25.3%) conversely. By contrast, 2009 was the lowest growing cycle in temperature (21.9°C) and the highest in humidity (26.3%). Therefore, 2011 was a moderate growing cycle in both temperature and humidity (Fig., 3).

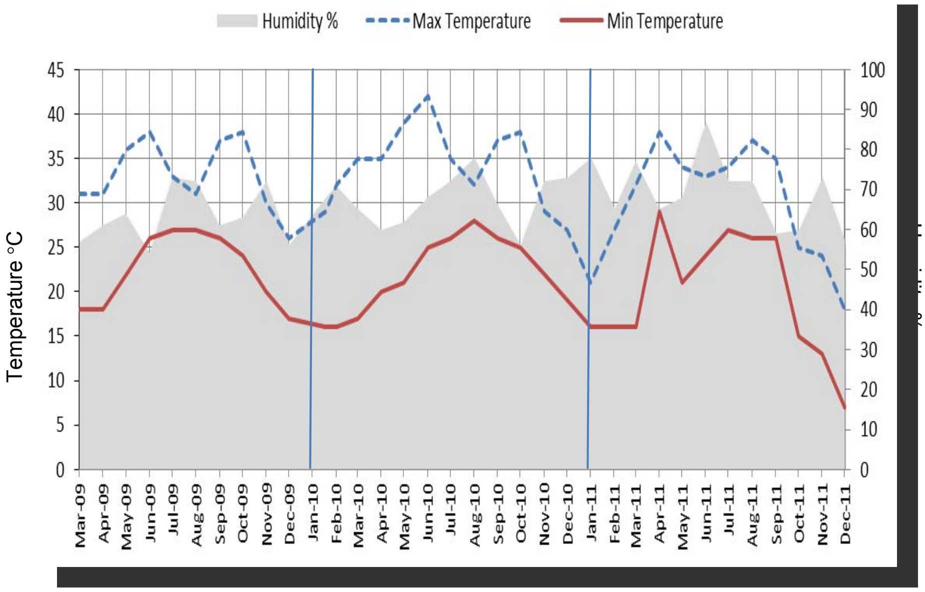

Fig. 2: Monthly meteorological data of Alexandria city from March 2009 to December 2011

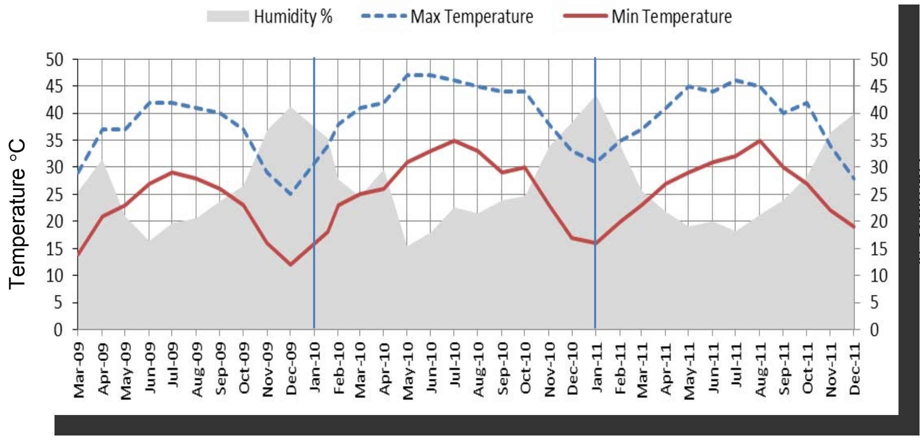

Fig. 3: Monthly meteorological data of Aswan city from March 2009 to December 2011

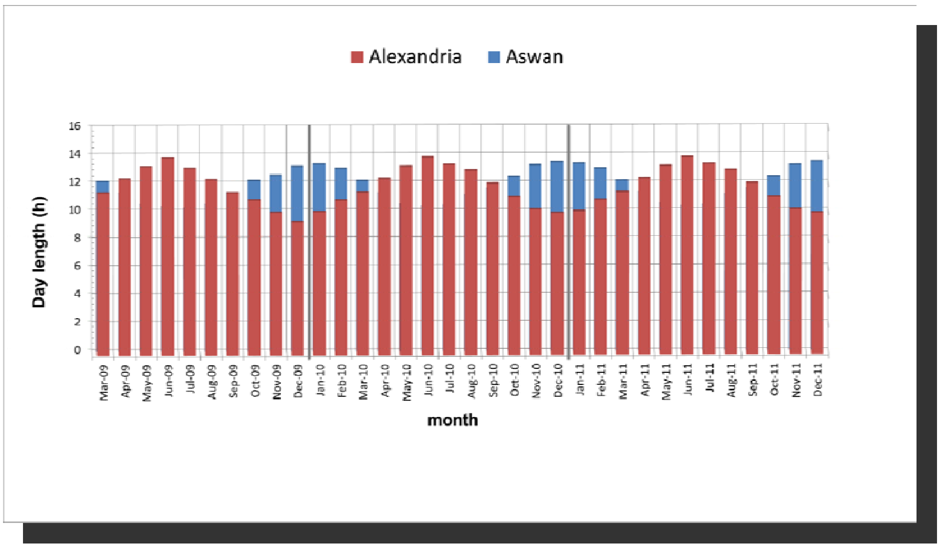

Fig. 4: Monthly day length of Alexandria and Aswan from March 2009 to December 2011

In Alexandria, the mean maximum temperature fluctuated from 18°C in December, 2011 to 42°C in June, 2010 and the mean minimum temperature fluctuated from 7°C in November, 2011 to 29°C in April, 2011 (Fig. 2). June was recorded the highest in humidity level in 2011 (87%) as well as the lowest during 2009 (54%). In Aswan, the mean maximum temperature fluctuated from 25°C in December, 2009 to 47°C in May-June, 2010 and the mean minimum temperature fluctuated from 12°C in December, 2009 to 35°C in July, 2010 and August, 2011. The humidity level varied from 15% during May, 2010 to 43% in January, 2011 (Fig., 3).

RESULTS

Phenological data

Albizia lebbeck

Table (3) indicated that leaves of *Albizia lebbeck* trees grown in Alexandria were significantly more flushed and defoliated earlier by 3 and 13 weeks, respectively than those trees grown in Aswan. The *Albizia lebbeck* trees grown in Aswan had significantly a complete foliage cover at the second week of April which was earlier by 5 weeks than other trees grown in Alexandria.

The time of flower initiation of *Albizia lebbeck* occurred at the third week of May which was not significantly different in both Alexandria and Aswan. Therefore, flowering. completion occurred on the last week of May in Aswan which was significantly earlier by 6 weeks compared with flowering completion in Alexandria which happened on the first week of August. Conversely, flowering off was significantly more retarded by about 15 weeks (third week of October) in Aswan than in Alexandria (first week of July).

The dates of both pod initiation and pod maturation of *Albizia lebbeck* over three years of observing were not significantly different in Alexandria and Aswan since, the pods were initiated through July and maturated in the last week of August and the first week of September in both sites. However, pod opening happened on the third week of October in Alexandria which was highly significant earlier by 17.5 weeks than that happened in Aswan city (last week of February of the next growing cycle).

Generally, the mean of foliage period of *Albizia lebeck* was extended ten weeks in Aswan more than that in Alexandria (49±1 and 39±2 weeks, respectively) then, the length of deciduousness period was 13±2 and 3±1 weeks in Alexandria and Aswan, respectively. Also, data presented in Table (4) and illustrated in Fig. (4) revealed that the mean of flowering period of *Albizia lebeck* was shorter in Alexandria by 15 weeks than that happened in Aswan. Conversely, the mean of pods period (from initiation to maturation) was shorter in Aswan by 4 weeks than in Alexandria.

Relationships among the different phenophases of *Albizia lebbeck* were examined across max. and min. temperature, humidity and day length for the two sites (Table 5). Leaves' flushing was significantly positively correlated with day length, max. and min. temperature in Alexandria ($r = 0.842$, $p < 0.01$, $n = 43$, $r = 0.809$, $p < 0.01$, $n = 43$ and $r = 0.818$, $p<0.01$, $n = 43$, respectively). In Aswan, flowering was significantly positively correlated with max. and min. temperature ($r = 0.836$, $p< 0.01$, $n = 43$ and $r = 0.862$, $p< 0.01$, $n = 43$ and $r = 0.694$, $p<0.01$, $n = 43$ and, respectively). Conversely in Aswan, flowering was significantly negatively correlated with humidity (($r = - 0.694$, $p < 0.01$, $n = 43$). In Alexandria, pod formation was significantly negatively correlated with day length ($r = 0.519$, $p < 0.01$, $n = 43$ and ($r = -0.647$, $p < 0.01$, $n = 43$).

Cassia javanica

Observation of *Cassia javanica* over three years verified that leaves flushing and defoliation were significantly earlier by 6 and 26 weeks, respectively for the trees grown in Alexandria compared with those grown in Aswan although, leaves completion occurred on the fourth week of May with non-significant differences between the two cities.

Table 3: Mean date (week of the year) of the phenophases of *Albizia lebbeck*, *Cassia javanica* and *Delonix regia* for both Alexandria and Aswan throughout three consecutive years.

Phenophase	*Albizia lebbeck*		*Cassia javanica*		*Delonix regia*	
	Alex.	Aswan	Alex.	Aswan	Alex.	Aswan
Leaves flushing	11.1a	14.0b	11.1a	16.8b	12.1a	14.0a
Leaves completion	20.4b	15.3a	20.5a	20.0a	18.2a	15.3a
Defoliation	49.8a	63.1b	42.0a	67.7b	47.1a	63.2b
Flowering-on	16.1a	16.1a	23.8b	17.1a	15.7a	16.1a
Flowering completion	23.1b	17.3a	27.3b	18.5a	21.6b	17.3a
Flowering-off	27.0a	42.1b	31.3a	44.3b	29.5a	42.2b
Pod-initiation	28.0a	31.4a	32.2	-	28.9a	31.4a
Pod maturation	36.3a	35a	36.1	-	37.7a	34.2a
Pod opening	43.3a	60.8b	43.6	-	55.2a	60.8a

- Each number in the table represent the mean of three consecutive years
- Means followed by a similar letter within Alex and Aswan for each phenophase is not significantly different at the 0.05 level of probability by Duncan's Multiple Range Test

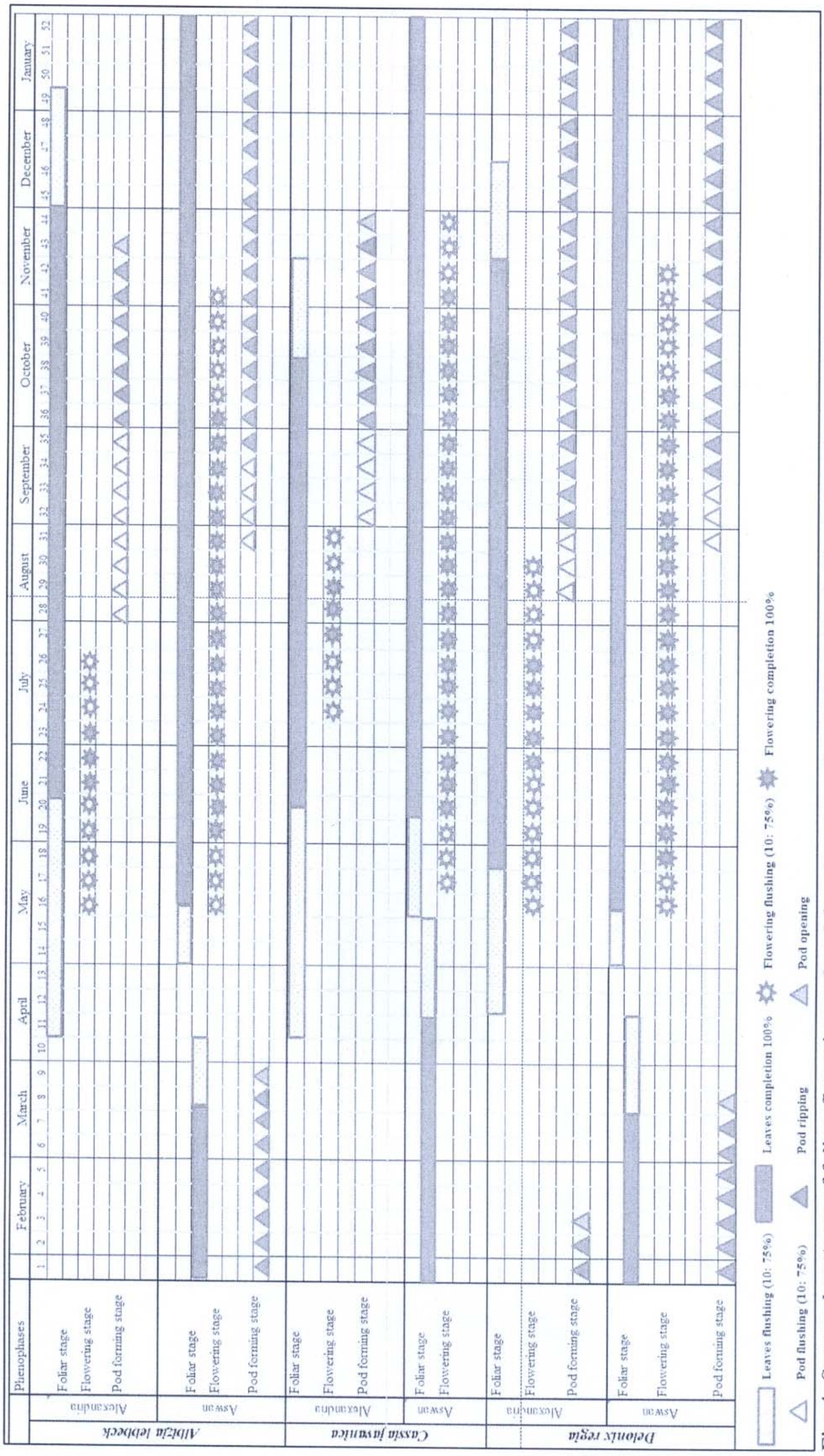

Fig. 4: Seasonal patterns of foliar, flowering and pod forming stages for *Albizia lebbeck*, *Cassia javanica and Delonix regia* tree species as observed during three consecutive annual cycles in both Alexandria and Aswan

Table 4: Mean period of different phenophases of *Albizia lebbeck*, *Cassia javanica* and *Delonix regia* at the observed locations in Alexandria and Aswan throughout three consecutive years. (values are mean ±SE).

Phenophases	*Albizia lebbeck*		*Cassia javanica*		*Delonix regia*	
	Alex	Aswan	Alex	Aswan	Alex	Aswan
	weeks					
Mean of foliage period	39±2	49±1	31±3	51±2	35±3	49±1
Mean of flowering period	11±4	26±1	8±2	27±3	14±3	26±1
Mean of pods period	8±3	4±2	4±4	-	9±2	3±2
Length of deciduousness	13±2	3±1	21±3	1±2	17±3	3±1

Leave flushing was initiated in the second week of April with the increment of day light duration and average minimum and maximum temperature. These newly flushed leaves took about 9 weeks to have been completed. Conversely, flowering-on and flowering completion occurred significantly earlier in Aswan than in Alexandria by 7and 9 weeks, respectively. Flowering off started in Alexandria on the fourth week of July which was earlier than Aswan by 13 weeks where flowering off happened at the last week of October (Table, 3).

The pod phenophases were observed only in Alexandria rather than in Aswan where pod initiation, pod maturation and pod opening occurred at the beginning of August, at the beginning of September and on the last week of October, respectively.

Data presented in Table (4) and illustrated in Fig. (4) showed that, the mean of foliage period of *Cassia javanica* was elongated by 20 weeks in Aswan more than in Alexandria (51±2 and 31±3 weeks, respectively) then, the length of deciduousness period was neglected in Aswan (1±2 weeks) whereas it sustained for 21±3 weeks in Alexandria. Moreover, *Cassia javanica* grown in Aswan had a long flowering period (27±3 weeks) than the flowering period in Alexandria (8±2 weeks). Only, *Cassia javanica* trees that were grown in Alexandria had pods rather than in Aswan therefore, the mean of pods period lasted to 4±4 weeks.

Data presented in Table (5) showed the relationships between phenophases of *Cassia javanica* and different meteorological data in both Alexandria and Aswan. Only leave's flushing in Alexandria was positively correlated with max. and min. temperature and day length (r = 0.631, p < 0.01, n = 43, r = 0.724, p < 0.01, n = 43 and r = 0.923, p < 0.01, n = 43 respectively). Similarly in Aswan, leave's flushing was significantly positively correlated with max. and min. temperature (r = 0.806, p < 0.01, n = 43 and r = 0.853, p < 0.01, n = 43). Also, flowering was significantly positively correlated with max. and min. temperature (r = 0.807, p < 0.01, n = 43 and r = 0.854, p < 0.01, n = 43). In contrast, leave's flushing was significantly negatively correlated with relative humidity and day length (r = -0.633, p < 0.01, n = 43 and r = -0.822, p < 0.01, n = 43) and flowering was significantly negatively correlated with day length (r = -0.833, p < 0.01, n = 43).

Delonix regia

Observations of *Delonix regia* revealed that leaves flushing and compilation were not significantly different since they happened within 2 and 3 weeks interval for the trees grown in Alexandria and Aswan. However, defoliation was significantly different since it started on the fourth week of November which was earlier by 16 weeks for the trees in Alexandria. Moreover, the trees grown in Aswan retained most of their foliage up to the next season (second week of March). Thus, it looked to be semi-deciduous tree in Aswan and deciduous tree in Alexandria. Table (3) showed that flowering–on significantly happened at the same time in both Alexandria and Aswan (week 16th) but flowering completion happened on the fourth week of April and fourth week of May, that was significantly faster by 4 weeks in Aswan than in Alexandria. Conversely, flowering-off happened significantly earlier in Alexandria than in Aswan by about 13 weeks.

Furthermore, all pod phenophases (pod-initiation, pod maturation and pod opening) observed in both Alexandria and Aswan were not significantly different. Pod initiation occurred on the second and fourth weeks of August in Alexandria and Aswan, respectively. Next, the pods maturated toward the third week of September in Aswan which happened earlier than in Alexandria by 4 weeks (Table 3). On the other hand, the pods started to open in the next growing cycle (first week of February and fourth week of March in Alexandria and Aswan). Moreover, the *Delonix regia* trees in Aswan retained most of their pods up to the next season probably due to the wind strength.

Data presented in Table (4), showed the mean of foliage period of *Delonix regia* was elongated by 35±3 and 49±1 weeks in Alexandria and Aswan, respectively. Therefore, the length of deciduousness was 17±3 weeks in Alexandria which was neglected in Aswan (3±1) since the foliage activity continues to the next growing cycle (Fig. 4). Furthermore, the mean of flowering period was 14±3 weeks in Alexandria and extended to 26±1 weeks in Aswan.

Table 5: Correlation relationships among max. and min temperatures, humidity, leaves flushing, flowering and pod formation of *Albizia lebbeck* , *Cassia javanica* and *Delonix regia* in Alexandria and Aswan

Variables	*Albizia lebbeck*		*Cassia javanica*		*Delonix regia*	
	Alex.	Aswan	Alex.	Aswan	Alex.	Aswan
Max temp. X leaves flushing	0.809	0.416	0.631	0.806	0.809	0.416
Max temp . X flowering	0.132	0.836	0.452	0.807	0.132	0.836
Max temp . X pod	0.024	0.265	0.411	——	0.024	0.265
Min temp . X leaves flushing	0.818	0.493	0.724	0.853	0.818	0.493
Min temp . X flowering	0.152	0.862	0.430	0.854	0.152	0.862
Min temp . X pod	-0.025	0.283	0.387	——	-0.025	0.283
Humidity X leaves flushing	0.285	-0.007	0.128	-0.633	0.285	-0.007
Humidity X flowering	-0.116	-0.694	-0.021	-0.652	-0.116	-0.694
Humidity X pod	0.445	0.030	0.218	——	0.445	0.030
Day length X leaves flushing	0.842	-0.210	0.923	-0.822	0.842	-0.210
Day length X flowering	0.492	-0.849	0.521	-0.833	0.492	-0.849
Day length X pod	-0.647	0.156	0.045	——	-0.647	0.156

The mean of pods period of *Delonix regia* trees grown in Aswan was three times longer than that grown in Alexandria (9±2 and 3±2, respectively).

Relationships among different phenophases of *Delonix regia* and meteorological data for the two sites are illustrated in Table (5). Leaves' flushing was significantly positively correlated with max. and min. temperature and day length in Alexandria (r =0.809, p < 0.01, n =43, r =0.818, p < 0.01, n =43 and r =0.842, p < 0.01, n =43 respectively) and pod formation was significantly negatively correlated with day length (Alexandria (r = -0.647, p < 0.01, n =43). On the other hand in Aswan, flowering was significantly positively correlated with max. and min. temperature (r =0.836, p < 0.01, n =43 and r =0.862, p < 0.01, n =43) and conversely, flowering was significantly negatively correlated with humidity and day length (r = -0.694, p < 0.01, n =43 and r = -0.849, p < 0.01, n =43)

DISCUSSION

Generally, the three observed genera had the same pattern of phenological behaviour through the three growth cycles except for pod formation phenophase which was not happened in Aswan. The observation of the three tree species clarified that the growing season started and get cessation earlier in Alexandria than Aswan which were matched with Viherä-Aarnio *et al.* (2005) who observed an accelerated growth onset in many boreal tree species, which followed by an accelerated growth cessation, suggesting that the accelerating impact of temperature accumulated in spring is carried over to the autumn. Although the mean of temperature up to the second week of April was higher by about 2°C in Aswan than Alexandria, the leaves of *Albizia lebbeck*, *Cassia javanica* and *Delonix regia* were flushed earlier in Alexandria by 3, 5 and 2 weeks, respectively. This can be ascribed to the fact that Alexandria is a higher urban city than Aswan which has a heat island effect. Results obtained from this study were compatible with that of Dhami (2008) who indicated that the date of budburst in the highly urban area was significantly different from that in the less urban area. Thus, the date of budburst seemed to be verifiable by using temperature as a parameter. This provides useful means for understanding the effect of climate warming on tree phenology. Another point of view stated that, delay of leaves flushing in Aswan and rise early in Alexandria, is possibly a result of warm winter which was attributed to insufficient chilling (Yu, 2010). On the other hand, Dormling (1989); Kalcsits *et al*., (2009) and Tanino *et al*., (2010) suggested that the delay of growth onset caused by climatic warming in winter is not restricted to woody plants. There is increasing experimental evidence that elevated air temperatures during dormancy induction in late summer and early autumn increase the depth of dormancy, so that more chilling is required for rest break and/or more accumulation of temperature sum for bud. The reason of preceding leaves completion in Aswan although it flushed earlier in Alexandria could be the rise of temperature and change in photoperiod which favour to maximize the photosynthesis and vegetative growth (Rivera *et al.,* 2002; Hamann, 2004; Kushwaha and Singh, 2008). Cell division and growth in the buds are temperature dependent, so that the rate of development towards bud burst and growth onset increases with rising air temperatures (Sarvas, 1974). According to Borchert, (1994) the increased photoperiod with rising temperature may cause conversion of starch into sugars in the roots and stem and osmotic adjustment in bud tissues which may induced bud busting by increasing water absorption and availability of sugars in summer flushing trees.

Olmsted, (1954) revealed complicated interactions and delayed effects in the annual cycle of native sugar maple (*Acer saccharum*) and concluded that the differential depth of dormancy was associated with the previous growing season and, in particular, the photoperiod prevailing after bud burst. When plants were grown in a 20h photoperiod, a second flush of growth was produced, as opposed to only one flush in a 9h photoperiod. The plants grown in the 20h photoperiod with two flushes of growth over spring and summer subsequently evinced a greater depth of dormancy in the following autumn and winter than did those grown in the 9h photoperiod. Although 20h and 9h photoperiods are extreme treatments, these results suggest a potentially complicated case of delayed interactive effects of temperature and photoperiod, which can affect the seasonality of the trees under climate warming. Accordingly, if springtime bud burst is advanced or delayed for some reason, photoperiod can interact to induce differential spring and summer growth patterns, which will then influence the subsequent rest during the autumn and winter and finally affect the timing of bud burst the next spring.

According to retain of the foliage of the three observed genera in Aswan to the next growing cycle, Håbørg, (1972) and Junttila, (1980) revealed that species whose dormancy induction is insensitive to the photoperiod, the climate warming is projected to cause an extension of the growing season in the autumn through delayed growth cessation. Climate warming is likely to accelerate bud burst and growth onset in most, but not all, boreal and temperate trees. Growth cessation might be either accelerated or delayed by warming, depending on the species and even on the ecotype. The differences among tree species, ecotypes and cultivars in their phenological responses to warming can have crucial impacts on the structure and functioning of boreal and temperate forest ecosystems, thus contributing to an overall multitude of ecological responses to climate change (Hänninen and Tanino 2011). The differences will also have important implications for practical forestry and horticulture, such as the need to reassess the suitability of a given tree provenance or cultivar used earlier in forest regeneration or flower production.

Günter *et al.*, (2008) revealed that there is strong evidence that flowering is induced not by one factor alone; they identified photoperiodic control, radiation and precipitation as possible proximate causes. Regional differences in the photoperiod response were observed by David and Körner (2012) in *Quercus petraea* and *Abies alba*. They confirmed that for late successional species, photoperiod is thus an important environmental signal that will constrain responses to climatic warming because rising temperatures will drive phenology toward the species specific photoperiod threshold.

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الملخص العربى

الاختلافات الفينولوجية فى ثلاث من أشجار المدن المنزرعة بشمال وجنوب مصر

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قسم بحوث الأشجار الخشبية – معهد بحوث البساتين- مركز البحوث الزراعية- مصر

تم رصد أنماط (تفتح الأوراق، اكتمال الأوراق، تساقط الأوراق، بدء ظهور الأزهار، تساقط الأزهار، بدء ظهور الثمار، نضج الثمار، تفتح الثمار) بغرض تحديد الاختلافات الفينولوجية لأشجاراللبخ والكاسيا نودوزا والبونسيانا في كل من الإسكندرية(شمال مصر)، وأسوان(صعيد مصر) لمدة ثلاث دورات نمو سنوية متتالية بدءاً من الأسبوع الأول من مارس ٢٠٠٩ إلى الأسبوع الأخير من ديسمبر الأول ٢٠١١. وقد بينت النتائج ما يلى:-

- في كلتا المدينتين، بدأت أشجار الأنواع الثلاث فى إنبثاق الأوراق خلال فصل الربيع (أبريل إلى يونيو)، ووصلت إلى مرحلة الاكتمال قبل حلول موسم الصيف.
- وتشير النتائج إلى أن ارتفاع درجة الحرارة فى أسوان أدى إلى تبكير اكتمال الأوراق بحوالى ٣-٥ أسابيع، وتأخير تساقط الأوراق بحوالى ١٣-٢٥ أسابيع مقارنة بالاسكندرية، وذلك للأنواع الثلاث من الأشجار.
- بالإضافة إلى ذلك، فإن درجة الحرارة العظمى والصغرى وطول النهار كانت مرتبطة بشكل جيد مع بدء إنبثاق الأوراق لكل من اللبخ والبونسيانا في الإسكندرية، وكذلك، الكاسيا نودوزا في أسوان.
- من ناحية أخرى فإن درجة الحرارة العظمى والصغرى وطول النهار ارتبطت بشكل كبير مع صفات الإزهار (بدء إنبثاق الأزهار، تساقط الأزهار) لكل من اللبخ والكاسيا نودوزا في أسوان بينما وجد ارتباط بين درجة الحرارة العظمى والصغرى مع بدء إنبثاق الأوراق لأشجار الكاسيا نودوزا فى الاسكندرية.
- بصفة عامة فإن الرطوبة النسبية لم تؤثر على الصفات الفينولوجية التى تم رصدها على الأنواع الثلاثة من الأشجار بكل من الاسكندرية وأسوان خلال فترة الثلاث سنوات.