Journal of Biodiversity & Endangered Species

Hosny et al., J Biodivers Endanger Species 2018, 6:1
DOI: 10.4172/2332-2543.1000210

Research Article Open Access

Size Structure and Floristic Diversity of Acacia trees population in Taif Area, Saudi Arabia

Mosallam Hosny A[1], **Ramadan A. Shawky**[2*] **and Ahmed A. Hashim**[1]

[1]*Botany Department, Faculty of Science, Ain Shams University, Cairo, Egypt*

[2]*Plant Ecology and Ranges Department, Desert Research Center, Cairo, Egypt*

[*]**Corresponding author:** Ramadan A. Shawky, Plant Ecology and Ranges Department, Desert Research Center, Cairo, Egypt, Tel: + 201227207191; E-mail: ramadan_salam@hotmail.com

Received date: February 05, 2018; **Accepted date:** February 16, 2018; **Published date:** February 23, 2018

Abstract

Acacia trees are considered keystone species in many desert ecosystems and suffer from different anthropogenic effects. This study estimated the size structure of Acacia trees population in El-Taif area, which indicated that all the populations of Acacia present in El-Taif Area seems to be young as the proportion of small and medium individuals is greater than that of large individuals except the species *Acacia albida*. Absence of plant species under the canopy of Acacia trees may be due to the severe impact of grazing. In general, distribution of Acacia trees is controlled by physiographic features, and topographical irregularities. Phytosociologically, the area is inhabited by (79) species belonging to (59) genera and related to (26) families. the most characteristic family is Fabaceae (16 species) followed by Asteraceae (15 species). The life-form spectrum in the present study is characteristic of an arid desert region with the dominance of chamaephytes (43% of the recorded species) followed by phanerophytes (31%), therophytes (16%) and hemicryptophytes (10%). The preponderance of annuals and shrubs reflects a typical desert flora, where it is closely related to topography. Phytogeographically, the shrub layer is composed mainly of the Saharo-Arabian with a Sudano-Zambezian focus on distribution. Pure Mediterranean taxa are not represented in the therophyte and chamaephyte layers, whereas they are represented in the bi- and pluriregional taxa. This may be attributed to the fact that plants of the Saharo-Arabian region are good indicators for desert environmental conditions, while Mediterranean species represent more mesic environments.

Keywords: Size classes; Acacia; Floristic diversity; El-Taif; Saudi Arabia

Introduction

In arid lands, the population size class structure and dynamics are related to species density as an evidenced to the correlation between the two characteristics over the population growth history [1]. Following the cessation of grazing, increasing population density is accompanied by a high-rate plant growth, where individuals attain a plant size above the average [2]. The role of individuals in the population can be expressed by their size, height, breadth and biomass; as these characteristics usually express their survival and reproductive possibilities. Due to the presence of various growth modifying agents, tree size differences may occur between even aged individuals in the same growth stage. These differences become much more conspicuous if the population has uneven-aged individuals, where the individual's size and biomass change with age [2,3]. The world's fast pace of urbanization has exerted profound pressure on urban trees [4].

The demography of tree species populations, particularly when dealing with field data including density, spatial distribution, size or age classes, seedling establishment, and mortality rates will support species management and conservation efforts [5-7]. The change in population tree size is characteristic of the species having high growth rates and high fecundity. Usually, these species possess functional properties which may cause the elimination of neighbors, for example, by occupying wider niche space as a factor, plays a significant role in population structure and dynamics [8-10], where some tree species may attain within a short time, an absolute dominance over other phytocoenotic components, by increasing their number and spatial distribution.

Population size may play a significant role in influencing the dynamic of plant populations [11,12]. Size differences may be caused directly or through differences in growth rates due to age differences, genetic variation, heterogeneity of resources, herbivory, and competition [10]. Little studies have been carried out on the size structure of tree populations such as [13-16].

Published demographic studies on subtropical trees don't enable an evaluation of vegetation climax stage [17]. The populations of Acacia trees, one of the most important tree components of the desert wadis in the central region of Saudi Arabia area subjected to tremendous pressure from human impacts. Apart from human caused changes in the unprotected habitats, other biotic and abiotic factors may also play a role in the decline of the plant population. This study aims to analyze the floristic diversity and the population size structure of Acacia sp within El-Taif area, Saudi Arabia.

Materials and Methods

The study area

Taif region lies south-east of Jiddah and the Holy City of Makkah and is situated in the central foothills of the western mountains at an altitude of approximately 2500 m above sea level (21°16`N - 40°25`E) (Figure 1). It is an important place for the people due to its scenic views and fertile valleys which support the growth of many fruits and vegetables. The geological units that outcrop in the Taif area from the

Citation: Hosny AM, Shawky RA, Hashim AA (2018) Size Structure and Floristic Diversity of Acacia trees population in Taif Area, Saudi Arabia. J Biodivers Endanger Species 6: 210. doi:10.4172/2332-2543.1000210

oldest to youngest are: Precambrian rocks, Tertiary sediments, Tertiary to Quaternary basalt, flows and Quaternary deposits.

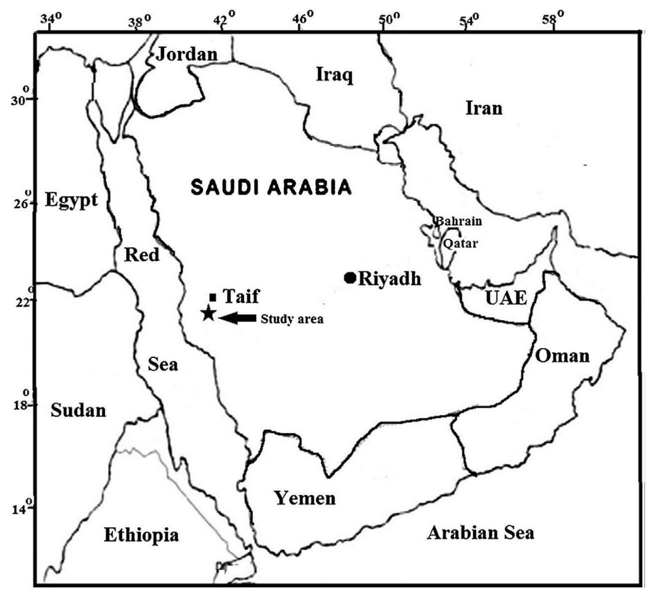


Figure 1: Map showing the location of the study area.

Floristic analysis

The collected plant specimens were identified and named [18-20]. Species life forms were determined depending upon the location of the regenerative buds and the shed parts during the unfavorable season [21]. A chronological analysis of the floristic categories species was made to assign the recorded species to World geographical groups [22,23].

Population size structure

All the individuals of Acacia population were counted in the studied sites. Trunk diameter was measured at breast height (DBH). The size was estimated by measuring the height and mean crown diameter. The tree size was calculated as the canopy volume "V" following [24,25] according to the equation: V=4/3*ab, where "a" is the average canopy radius and "b" represents the canopy height. The size class values were then used to classify Acacia populations into 13 size-classes: the first <0.0050 m^3 and second 0.0051–0.050 m^3 classes were chosen to represent the established seedling and juvenile stages, respectively. The other classes (A1(1-20); A2(20-40); A3(40-60); A4(60-80); A5(80-100); A6 >100) separated the populations into different sizes. The frequency of individuals within each class was determined as relative values. Density was calculated as individuals per hectare. The mean and standard deviation of density, height and diameter of Acacia species were also calculated.

Results

Floristic composition

The recorded plant species (80) in the present study belonging to (59) genera and related to (26) families. Table 1 showed that, the family Fabaceae (15 species), followed by Asteraceae (15 species), Asclepiadaceae and Capparaceae (5 species, each), Lamiaceae (4 species), Chenopodiaceae, Solanaceae and Zygophyllaceae (3 species). 8 families with 2 species, other of them, Aizoaceae, Amaranthaceae, Boraginaceae, Cleomaceae, Cucurbitaceae, Malvaceae, Plantaginaceae and Resedaceae. The remain 10 families with one species only, other of them, Acanthaceae, Amaryllidaceae, Anacardiaceae, Caryophyllaceae, Brassicaceae, Cupressaceae, Poaceae, Rhamnaceae, Polygonaceae and Scrophuariaceae.

Life forms analysis of the study area revealed that 34 species (43%) of the total recorded species are Chamaephytes, followed by 25 species (31%) are Phanerophytes, 13 species (16%) are Therophytes and 8 species (10%) are Hemicryptophytes (Figure 2a).

Chorological analysis of the study area revealed that, 22 species (28%) of the total recorded species are Saharo-Arabian+Sudano-Zambezian. 14 species (18%) are Saharo-Arabian. 8 species (10%) are Sudano-Zambezian. Saharao-Arabia+Sudanian and Saharo-Arabian +Saharo-Arabian, Irano-Turanian-Sudano-Zambezian consists of 7 species (10.81%, each). 6 species (8%) are Irano-Turanian, The Mediteranean one with 3 species (4%). The remained chorological affinities represented by two or one species as in (Figure 2b).

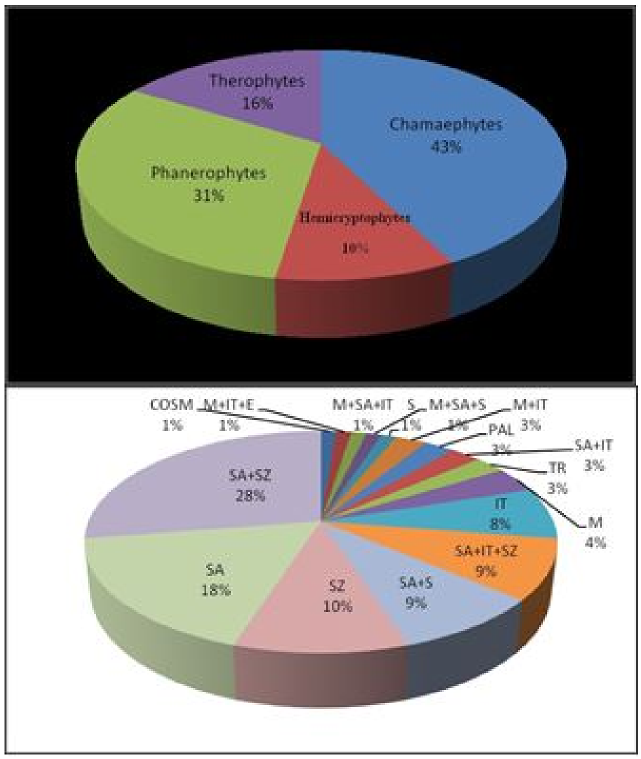


Figure 2: Diagram of life form (a) and chorological analysis (b) of the study area.

Family	Species	Life Form	Chorology
Acanthaceae	*Blepharis ciliaris (L.) B.L.Burtt*	Ch	SA+SZ+IT
Aizoaceae	*Aizoon canariense L.*	Th	SA+SZ
	Zaleya pentandra (L.) C.Jeffrey	He	SZ
Amaranthaceae	*Aerva javanica (Burm. f.) Juss. ex Schul.*	Ch	SA+SZ
	Aerva lanata (L.) Juss. ex Schult.	Ch	TR
Amaryllidaceae	*Pancratium sickenbergeri Ach.*	Th	M+IT+SA
Anacardiaceae	*Rhazya stricta Decne.*	Ch	SA+S
Asclepiadaceae	*Asclipias sinaica (Boiss.) Muschl.*	Ch	SA
	Calotropis procera (Aiton) W.T.Aiton	Ph	SZ
	Caralluma retrospeciens (Ehrenb.) N.E.Br.	Ch	SA+SZ
	Periploca aphylla Decne.	Ph	SA+SZ
	Pergularia tomentosa L.	Ch	SZ
Asteraceae	*Asteriscus graveolens (Forssk.) Less*	Ch	SA
	Asteriscus pygmaeus (DC.) Coss. & Dur.	Th	SA
	Centaurea sinaica DC.	Th	M
	Cirsium vulgare (Savi) Ten.	He	IT
	Crepis rueppellii Sch. Bip.	Th	IT
	Echinops spinosissmus L.	He	M
	Euryops arabicus Steud.	Ch	TR
	Felicia dentata (A.Rich) Dandy.	He	SZ
	Launaea sonchoides (Cass.) N. Kilian	Th	SA
	Launaea capitata (Spreng.) Dandy	Ch	SA+S
	Osteospermum vaillantii (Decne.) Norl.	Ch	SA+SZ
	Phagnalon sinaicum Bornm. & Kneuck.	Ch	IT
	Psiadia punctulata (DC.) Vatke	Ch	SA
	Pulicaria crispa (Forssk.) Oliv.	Ch	SA+S
	Xanthium strumarium L.	Th	M+IT
Boraginaceae	*Arnebia hispidissima (Lehm.) DC.*	Ch	SA+SZ
	Trichodesma ehrenbergii Schweinf.	Ch	SZ
Brassicaceae	*Savignya parviflora (Del.) Webb. in Giorn.*	Th	SA
Capparaceae	*Capparis decidua Veil.*	Ph	SA+SZ
	Capparis spinosa L.	Ph	SA
	Maerua crassifolia Forssk.	Ph	SA+IT+SZ
	Maerua oblongifolia (Forssk). A. Rich.	Ph	SA+IT+SZ
	Morettia parviflora Boiss.	Ch	SZ

Caryophyllaceae	*Polycarpaea repens (Forssk). Asch. & Sehweinf*	Ch	SA+S
Chenopodiaceae	*Bassia muricata (L.). Asch.*	Ph	SA+IT
	Haloxylon salicornicum (Moq.) Bunge	Ch	S
	Salsola spinescens Moq.	Ch	SA
Cleomaceae	*Cleome amblyocarpa L.*	Ch	IT
	Cleome chilensis DC.	Ch	SA
Cucurbitaceae	*Citrullus colocynthis (L) Schrad*	He	SA
	Cucumis prophetarum L.var dissectus (Naudin) C. Jeffrey.	He	SA+SZ
Cupressaceae	*Juniperus procera Hochst.*	Ph	COSM
Fabaceae	*Acacia gerrardii Benth. var. gerrardii*	Ph	SA+SZ
	Acacia gerrardii Benth. Subsp. negevesis		
	Acacia asak (Forssk) willd.		
	Acacia etbaica Schweinf.		
	Acacia hamulosa Benth.		
	Acacia albida (Delile) A.Chev.		
	Acacia origena Hunde. (Hunde) Kyal. & Boatwr.		
	Acacia nubica Benth.		
	Acacia ehrenbergiana Hayne. (Forssk.) Schweinf.		
	Acacia johnwoodii Boulos		
	Acacia tortilis subsp. raddiana Savi		
	Acacia tortilis (Forssk.) Hayne. subsp. tortilis		
	Astragalus sieberi DC.		
	Indigofera spinosa Forssk.		
	Lotus glinoides Delile		
	Senna italic Mill.		
	Lavandula dentata L.		
	Lavandula pubescens Decne.		
	Marrubium vulgare	Ch	
	Otostegia fruticosa (Forssk.) Penz.	Ch	
	Alcea rhyticarpa (Trautv.)	Th	
	Malva parviflora L.	Ph	
Plantaginaceae	*Plantago major L.*	Th	
	Plantago ciliata Desf.	Ch	
Poaceae	*Stipagrostis plumosa (L.) Munro ex T. Anderson*	He	
Polygonaceae	*Rumex vesicarius L.*	Ch	
Resedaceae	*Ochradenus baccatus Delile.*	Ph	

Citation: Hosny AM, Shawky RA, Hashim AA (2018) Size Structure and Floristic Diversity of Acacia trees population in Taif Area, Saudi Arabia. J Biodivers Endanger Species 6: 210. doi:10.4172/2332-2543.1000210

	Reseda alba L.	Ph	
Rhamnaceae	*Ziziphus spina-christi (L.) Desf.*	Ph	
Scrophuariaceae	*Kickxia floribunda (Boiss.) Täckh. & Boulos*	Ch	
Solanaceae	*Lycium depressum Stocks.*	Th	
	Lycium shawii Roem. & Schult.	Ph	
	Solanum incanum L.	Ch	
Zyegophyllaceae	*Fagonia boveana (Hadidi) Hadidi & Garf*	Ch	
	Fagonia indica Burm.f.	Ch	
	Tribulus terrestris L.	Th	

Table 1: List of species associated with the distribution of Acacia sp and in Taif area. Ph.=Phanerophytes; COSM=Cosmopolitan; H.=Hemicryptophytes; Th.=Therophytes; Ch.=Chamaephytes; PAL=Palaeotropical; TR.= Tropical M=Mediterranean; SA=Saharo-Arabian; IT=Irano-Turanian; E=Euro-Siberian; S=Sudanian and SZ=Sudano-Zambezian.

Population size structure

Size distribution analysis of Acacia population using canopy cover, tree height and Diameter (Figure 3) shows presence of juveniles in some of Acacia species such as *Acacia gerrardii var. gerrardii*, *Acacia tortilis*, *Acacia ehernbergiana*, *Acacia nubica*, *Acacia origena*, *Acacia hamulosa*, *Acacia asak* and *Acacia gerrardii subsp. negevensis*, on the other hand it was absent in *Acacia etabica*, *Acacia raddiana* and *Acacia albida*. clear reduction in numbers of small and large categories and increasing in numbers of medium categories in *Acacia johnwoodii* and *Acacia etabica*. This pattern of distribution indicates the absence of recruitment to supplement the smallest size categories. In addition, human disturbance in the study area is responsible for high mortality, which is clear from the decline numbers of small and large trees.

The size structure of Acacia populations showed different size classes distribution. Five distribution models are shown in Figure 3: (1) Populations with continuous regeneration inputs, for example, *Acacia johnwoodii* and *Acacia etabica* where the percentage of individuals of young ages with crown size classes up to 20 m^3 were represented; (2) Populations that lack regeneration where old individuals are sparsely represented with different size classes and young ages are not represented (e.g., Acacia albida; (3) Populations in serial successional stages as in Acacia hamulosa and Acacia ehrenbergiana. where the largest size classes are not represented; (4) Populations with young individuals as in Acacia tortilis, Acacia gerrardii subsp. negevensis and Acacia gerrardii var. gerrardii; and (5) Populations that almost reached extinction as in Acacia albida.

The relationships between the individual heights and diameters of Acacia trees population are simple linear (Figure 4). The result shows that the relation between height and diameter of trees was positive in all Acacia species except Acacia gerrardi (ger) and Acacia tortilis was negative. On the other hand, (Table 2) shows that the mean height to diameter ratio for both Acacia species was the highest in Acacia origena (60.0) and the lowest in Acacia hamulosa (1.6). Regarding the variation in the canopy size was the highest in Acacia *albida* (204.4) and the lowest in *Acacia origena* (13.6). Also, the height has the highest value (17.8 m) in Acacia albida and lowest (3.31 and 3.32 m) *Acacia nubica* and *Acacia hamulosa*, respectively. The diameter has the highest value (2.07 m) in *Acacia hamulosa* and lowest (0.1 m) in *Acacia origena.*

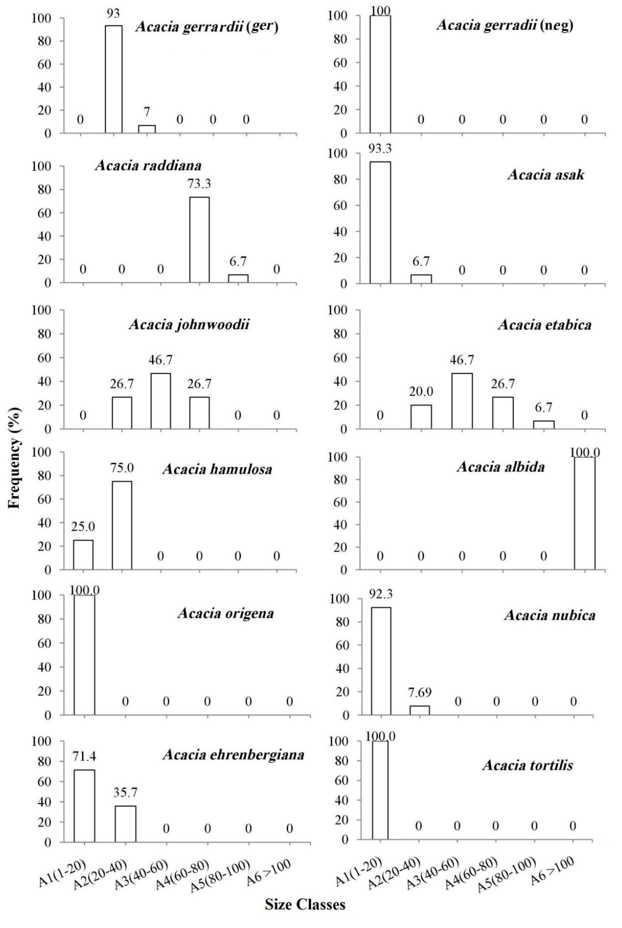
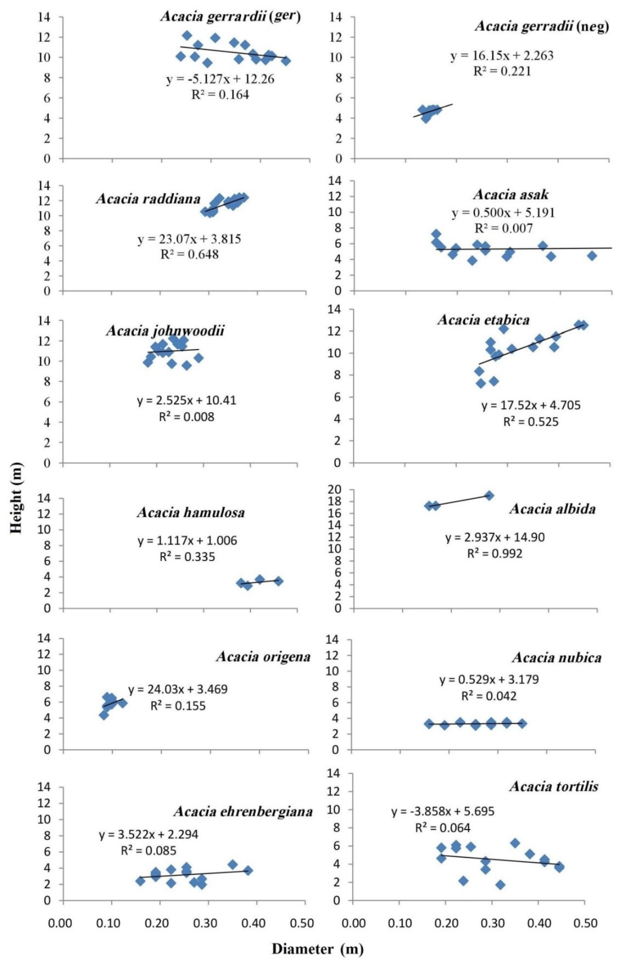


Figure 3: Tree crown size-class distribution of Acacia sp. in El-Taif Area. *Acacia gerrardii* (ger)=*Acacia gerrardii* var. gerrardii and *Acacia gerrardii* (neg)=*Acacia gerrardii* subsp. Negevensis.



-

Figure 4: The relationships between the individual heights and diameters of Acacia sp. in El-Taif Area. *Acacia gerrardii* (ger)=*Acacia gerrardii* var. gerrardii and *Acacia gerrardii* (neg)=*Acacia gerrardii* subsp. Negevensis.

Species	**Circumference DBH**	**Canopy size**	**Diameter (m)**	**Height (m)**	**H/D**
Acacia gerrardii var. gerrardii	1.09	33.3	0.35	10.6	30.4
Acacia gerrardii subsp. negevensis	0.47	14.8	0.15	4.67	31.4
Acacia raddiana	1.04	68.2	0.33	11.5	34.6
Acacia asak	0.93	14.4	0.29	5.34	18.1
Acacia johnwoodii	0.72	48.3	0.23	10.9	47.9
Acacia etabica	1.02	51.5	0.32	10.7	32.1
Acacia hamulosa	2.23	23.1	2.07	3.32	1.6
Acacia albida	3.15	204.4	1	17.8	17.8
Acacia origena	0.3	13.6	0.1	5.79	60
Acacia nubica	0.79	14.9	0.25	3.31	13.1
Acacia ehrenbergiana	0.78	17.9	0.25	3.17	12.8
Acacia tortilis	0.98	8.9	0.31	4.5	14.5
Correlation coefficient (r)	0.082	-0.04	0.069	-0.33	-0.31
P value (p ≤ 0.05)	0.8 ns	0.89 ns	0.83 ns	0.29 ns	0.33 ns

Table 2: Simple correlations between the different variables of Acacia trees population in El-Taif Area. DBH= Diameter at Breath Height

Discussion

The area is inhabited by (79) species belonging to (59) genera and related to (26) families. the most characteristic families are Fabaceae and Asteraceae (15 species, each). The life-form spectrum in the present study is characteristic of an arid desert region with the dominance of chamaephytes (43% of the recorded species) followed by phanerophytes (31%), therophytes (16%) and hemicryptophytes (10%). The preponderance of annuals and shrubs reflects a typical desert flora, where it is closely related to topography [26,27]. On the other hand, they may be a response to the hot, dry climate and human and animal interferences. A comparison of the life-form spectra of the northern part of the Eastern Desert of Egypt [28] and those in the Tihama coastal plains of the Jizan region in south-western Saudi Arabia [29] showed the same results.

Phytogeographically, the shrub layer is composed mainly of the Saharo-Arabian with a Sudano-Zambezian focus on distribution. Pure Mediterranean taxa are not represented in the therophyte and chamaephyte layers, whereas they are represented in the bi- and pluriregional taxa. This may be attributed to the fact that plants of the Saharo-Arabian region are good indicators for desert environmental conditions, while Mediterranean species represent more mesic environments.

The results of the size distribution study indicated that all population of Acacia present in El-Taif Area seems to be young as the proportion of small and medium individuals is greater than that of large individuals except the species *Acacia albida*.

Acacia trees are considered keystone species in many desert ecosystems [30,31], due to the many provided services and goods, Thus, the conservation of Acacia trees is important particularly in arid and hyper arid deserts for regulating microclimate, improving conditions for survival of associated plant and animal species [32], providing direct benefits for local inhabitants, and for starting sustainable development [33]. Due to aridity and anthropogenic disturbances, floristic diversity of the study area is characterized by a paucity of trees and annuals. The canopy of Acacia shows negative influence on the understory vegetation. Most of the associated species were recorded between canopies.

The absence of plant species under the canopy of Acacia trees may be due to the severe impact of grazing. In no disturbed areas, [13] reported that *A. tortilis* has a positive influence on the understory herbaceous vegetation. In general, distribution of Acacia trees is controlled by physiographic features, and topographical irregularities, which all act through modifying the amount of soil water availability [34].

The height/diameter ratio gives an idea about the growth habit of the plant. In the present study, this ratio is less than unity for Acacia species which means that the individual diameter exceeds, the relation between height and diameter of trees was positive in all Acacia species except *Acacia gerrardi* and *Acacia tortilis* was negative tend to the two-species adapted to escarp from drought seasons. This may be a strategy of the desert plants to provide safe sites for their self-regeneration, as the horizontal expansion usually provides shade, which leads to decrease the severe heating effect and increase the soil moisture [35,36].

In conclusion, the total size structure of Acacia populations in El-Taif area is characterized by the preponderance of the young individuals comparing with the old ones, that we found continuously regeneration of most of Acacia population except one species named: *Acacia albida* which suffer from unregeneration due to some anthropogenic effects in the region.

References

1. Hegazy AK, Kabiel HF, Boulos L, Sharashy OS (2010) Conservation approach on the demography and dynamics of protected and unprotected populations of the endemic Ebenus armitagei in the western Mediterranean coast of Egypt. J Nat Conserv 18: 151-158.
2. El-Sheikh MA (2013) Population structure of woody plants in the arid cloud forests of Dhofar, southern Oman. Acta Bot Croat 72: 97-111.
3. Onatibia GR, Martin RA, Pablo AC, Fernardo T (2010) Individual plant and population biomass of dominant shrubs in Patagonian grazed fields. Ecologi´a Austral 20: 269-279.
4. Zhang H, Ying Lai P, Jim CY (2017) Species diversity and spatial pattern of old and precious trees in Macau. Landsc Urban Plan 162: 56-67.
5. Ogden J (1985) An introduction to plant demography with special reference to New Zealand trees. N Z J Bot 23: 751-772.
6. Rockwood LL (2006) Introduction to population ecology. Blackwell Publishing Ltd., Oxford.
7. Roff D (1992) The evolution of life histories theory and analysis. Chapman & Hall, New York.
8. El-Sheikh MA (2013) Weed vegetation ecology of arable land in Salalah, Southern Oman. Saudi J Biol Sci 20: 291-304.
9. Gross MR, Charnov EL (1980) Alternative male life histories in blue gill sunfish. Proceedings of the National Academy of Science USA of Population Biology 77: 6937-6940.
10. Werner P (1977) Ecology of plant populations in successional environments. Syst Bot 1: 246-268.
11. Pullin AS (2002) Conservation Biology. Cambridge University Press, Cambridge.
12. Van Dyke F (2003) Conservation Biology: Foundations, Concepts, Applications. McGraw-Hill, Boston. Saudi J Biol Sci 19: 357-368.
13. Hegazy AK, Lovett-Doust J, Hammouda O, Gomaa NH (2008) Vegetation distribution along the altitudinal gradient in the north western Red Sea region. Community Ecol 8: 151-162.
14. Mosalla H (2005) Size Structure of Zygophyllum album and Cornulaca monacantha Populations in Salhyia Area, East of Egypt. Int J Agric Biol 7: 345-351.
15. Shawky RA (2010) Ecological Studies on Xerophytes and Halophytes in Sinai Peninsula. M.Sc. Thesis, Faculty of Science, Minia University, Minia, Egypt.
16. Wang DP, Ji SY, Chen FP, Xing FW Peng SL (2006) Diversity and relationship with succession of naturally regenerated southern subtropical forests in Shenzhen, China and its comparison with the zonal climax of Hong Kong. For Ecol Manage 222: 384-390.
17. Chaudhary S (1999–2001) Flora of the Kingdom of Saudi Arabia, Ministry of Agriculture and Water, Riyadh.
18. Collenette S (1999) Wildflowers of Saudi Arabia. National Commission for Wild Life Conservation and Development, Riyadh.
19. Migahid AM (1996) Flora of Saudi Arabia, Edition-3, King Saud University Press, Riyadh.
20. Raunkiaer C (1934) The life forms of plants and statistical plant geography. Translated by Carter Fausboll and Tansley; Oxford Univ. Press, London.
21. Wickens GF (1978) The flora of Jebel Marra (Sudan Republic) and its geographical affinities. Kew Bulletin Add. Ser 5-385.
22. Zohary M (1983) Geobotanical Foundation of the Middle East. Gus. Fischer-Verlag, Stuttgart.
23. Hegazy AK, Elhag M (2006) Considerations of demography and life table analysis for conservation of Acacia tortilis in South Sinai. World Appl Sci J 1: 97-106.
24. Solbrig OT (1980) Demography and evolution in plant populations. Botany Monograph 15: 45-48.
25. Zohary M (1973) Geobotanical Foundations of the Middle East. Vols. 1–2. Stuttgart: Gustav Fischer Verlag.
26. Orshan G (1986) The Desert of the Middle East. In: Evenari M, Noy-Meir I & Goodall DW (eds.) Ecosystems of the World, Amsterdam: Elsevier 12B: 1–28.
27. Abd El-Ghani MM (1998) Environmental correlates of species distribution in arid desert ecosystems of eastern Egypt. J Arid Environ 38: 297-313.
28. El-Demerdash MA, Hegazy AK, Zilay AM (1994) Distribution of the plant communities in Tihamah coastal plains of Jazan region, Saudi Arabia. Vegetatio 112: 141-151.
29. Milton SJ, Dean WRJ (1995) South Africa's arid and semiarid rangelands: why are they changing, and can they be restored? Environ Monit Assess 37: 245-264.
30. Moustafa AA, Zaghloul MS, Hatab EE (2000) Acacia Conservation and Rehabilitation Program (SEM 04/220/016A – Egypt). Final Report. Saint Catherine Protectorate Development Project, EEAA.
31. Attum O, Mahmoud T (2012) Docas gazelle and livestock use of trees according to size in a hyper-arid landscape. J Arid Environ 76: 49-53.
32. Chapman GL, Reiss MJ (1995) Ecology, Principles and Applications. Press Syndicate of the University of Cambridge, Cambridge, UK.
33. El-Ghareeb R, Shabana MA (1990) Vegetation-environmental relationships in the bed of Wadi El-Sheikh of southern Sinai. Vegetatio 90: 145-157.
34. Rajalakshmi R, Rajalakshmi S, Parida A (2017) Evaluation of the genetic diversity and population structure in drumstick (Moringa oleifera L.) using SSR markers. Curr Sci Int 112: 1250-1256.
35. Shaltout KH, Mady MA (1993) Current situation of the raudha's woody plant populations in the central Saudi Arabia. Feddes Repertorium 104: 503-509.
36. El-Sheikh MA, Thomas J, Alatar AA, Hegazy AK, Abbady GA, et al. (2013) Vegetation of Thumamah Nature Park: a managed arid land in Saudi Arabia. Rendiconti Lincei. Rend Lincei Sci Fis Nat 24: 349-367.