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Adaptation of *Marrubium vulgare* L Species to The Habitat Alteration in Disturbance Regime

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MARRUBIUM VULGARE L (white horehound) is a perennial flowering species belongs to Labiatae (Lamiaceae). *Marrubium* genus is native to North Africa, Europe, and the Mediterranean basin. Worldwide, it represented by 30 species. In Egypt, there are two species only distributed in the northern coastal belt wherever calcareous or oolitic sand formation, especially in marginal lands and waste ground, the ruins of the old abandoned house and road sides. The main differences between the two species are life span (perennial and annual), number of calyx teeth (10 and 5) and the color of the corolla (white and pale pink) of *M. vulgare* and *M. alysson,* respectively. With the accelerated rate of climate change and urbanization and their destroyed effects on biodiversity loss and fragmentation of habitat. This study examines if some species could adapted to habitat disturbance. For this purposes we choose *M. vulgare* as a model species for habitat disturbance. Phenological aspects, distribution, density, size structure and reproductive efforts of *M. vulgare* were studied in four different locations in the western Mediterranean section. Locations are representing two different habitats: Road sides (wild habitats) and abandoned places (urban habitat). The study claimed that there are a significant difference between reproductive efforts, size index and density, whereas, no differences between the phenological aspects.

Keyword: Disturbed habitats, Size index, Reproductive efforts, *Marrubium vulgare*, Urban escosystem.

Introduction

Nowadays, the threat of climate change has been become one of the most dilemmas facing the human being around the world. Climate change is expected to occur more rapidly than the rate at which ecosystem can adapt and reestablish themselves. The more intense and far-reaching the impacts of the climate change are, the greater the loss of plants and animal species will be, the greater the deterioration of dry lands around the world. With regard to impacts on species, climate change is causing habitats to shift and species to experience changes in life cycles, the development of new physical traits, and in extreme cases, die-off and extinctions (UNFCCC, 2007).

Being an arid country, Egypt is very vulnerable to the climate change impacts. The most stable ecosystem at the Mediterranean coastal belt, Sinai Peninsula and Red Sea are threatened with human impacts such as: overgrazing, uprooting of medicinal plants, and extension of touristic resorts and villages. These unwise impacts may lead to decreasing the wild habitats to urban one and transfer stable, diverse habitat to fragile destroyed one.

Few studies were performed to investigate habitat structures, plant diversity, plant communities and even autoecology of some species. These studies include: Ayyad (1973), Ayyad & El- Ghareeb (1984), Botanouny & Zaki (1974), Kamal (1982), Shaltout (1985) and Fakhry (1994) in the western Mediterreanean section; Zahran et al. (1985, 1990), Mashaly (2002) and Galal & Fawzi (2007) in the Nile delta; Moustafa & Zahghloul (1996) and El-Bana et al. (2003, 2007) in Sinai peninsula; Abd El- Ghani & Abd EL- Khalik

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(2006), Abd El- Ghani et al. (2013), Sheded et al. (2014) in the Red sea. However, little is known on the Urban ecosystem (e.g. Shaltout & El- Sheikh, 2002 and Abd El- Ghani et al., 2015). Moreover, the ecology of the species distributed at the fragile and waste habitats is uncommon. Our species, *M. vulgare*, is an indicator of habitat disturbance. It occurs in overgrazed area, and replaces the native flora. It is hardly found in the natural habitat and also, occasionally appears along the roadside. It tends to invade lands that have been disturbed, overgrazed or previously grazed by sheep. *M. vulgare* is treated as invasive species in some parts of the world, especially America and Australia continents (Weiss & Sagliocco, 2000). The present study aims at comparing the density, phenological aspects, size structure and the reproductive efforts of *M.vulgare* in different habitats.

Study area

Ecological studies were performed in the western Mediterranean section of Egypt. Geomorophologically, this part was divided into three main units, namely; coastal plain, piedmont plain, and table land (lime stone plateau) (Yousif & Baraka, 2013). Ecologically, this part is divided into main six habitats, namely: Coastal oolitic dunes, Rocky ridges, Inland plateau, Wadis, saline depression and non saline depression (Fakhry, 1994). Soil properties characterizing the study area are more alkaline with high percentage of calcium carbonates (Zahran et al, 2012).

The climate is a typical Mediterranean type which is characterized by short rainy winter season with average rainfall from 140 to 150mm/ year and long hot summer. The mean monthly air temperature ranges from 13.8°C in January to 25.6°C in August (Fig. 1).

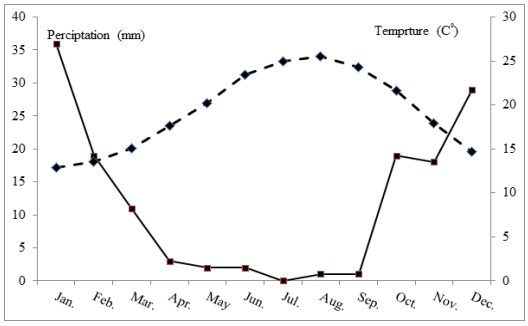

Fig.1. Climate diagram of Marsa Matrouh Area (Egyptian Meteroigical Authority).

Material and methods

The current investigation involved sampling and analyzing of four sites representing *M. vulgare*. The locations of selected sites cover wide area as follow (one site at Ras El- Hekima (site 3), one in Matruh city (site 4), 2 sites west of Sidi- Baranni city (site 1, 2). Sites at Matrouh and Ras El- Hekima comprise urban and waste ground habitats and those of Baranni representing road side habitat. Selection of stands inside each site was depending on the site area (i.e: in big sites, three stands were selected and in small one, we choose one stand). Each stand was randomly subdivided into (10X10) m^2 quadrate. The list of species was recorded and identified according to Boulos (1999, 2000, 2002 and 2005) and updated with Boulos (2009). Phenological feature were recorded in the field through three successive years (2013-2015). Absolute and relative density was measured as the number of species per unit area. Size structure was measured as the average of plant height (H) and diameter (D) based on three diameters of each plant (Shaltout et al., 2002), then the size classes were divided into four classes depending on the size structure as follow: Class I (<30cm), class II (30-60cm), class III (60-90cm), and class IV (90-120cm). Plant shape was assessed as a rectangle area (HxD). Reproductive efforts were measured as the proportion of reproductive biomass to total plant biomass (Kinugasa et al., 2005). Five coherent plant from each site are collected and separated to vegetative parts (leaves and stem) and reproductive organs (Flowers and fruits), then dried to constant mass at 80^0C. One-way analysis of variance (ANOVA) was used to study the differences between sites by using PAST program version 3.14 (Hammer et al., 2001).

Results

Phenological aspects

The phenological sequences of *M. vulgare* at the two different habitats are described in Table 1. In general, there is no differences in the phenological sequences between the two habitats, except, the flowering state of the abandoned places is shorter than that of roadside, however, its seed production state is more longer. The seedling state appears after the first rainfall in October and November. It began in the mid of November to the mid of February. Vegetative stage started in the mid of February to the end of April. Flowering and seed production periods

remain about 100 days from the beginning of May to the mid of August. After seed production and distribution plants enter the dormant state from August to the beginning of November.

Plant density

Plants relative density and richness are considerably different between the two habitats. Roadside sites (16 species) are more diverse than the abandoned sites (9 and 7 species per site). The most common associate species on the road sites are: *Haloxylon scaparium*, *Thymelaea hirsuta*, *Asphodelus aestivus*, *Deverra tortuosa*, *Atriplex halimus*, *Centaurea calcitrapa* and *Plantago ovata.* While, *Nicotiana glauca* and *Peganum harmala*, are the main associates on the abandoned sites (Table 2). Both of the relative and absolute density of *M. vulgare* are significally higher in abandoned places than the road sides habitat.

Height

As seen in Table 3 and Fig. 2, there is high significant variation of the height between sites. The mean height of Sidi Baranni locations is higher than that of Matrouh and Ras El- Hekima. The mean height are 51±6.07, 55.77±11.78, 43.31±7.18 and 33.12±5.19cm, respectively of site 1, 2, 3 and 4.

Diameter

Figure 3 describes the mean plant diameters at the different habitat. There is a significant difference between the four sites (P<0.001) (Table 3). Plants with big diameter, are those of site 2, followed by site 1 and site 3 with mean diameter of 67±16.17, 51.69±15.87 and 49.62±14.84, respectively. On the other hand, plants of site 4 representing the smallest diameter ranged between 21 to 50cm/ individual. The mean value is 31.38±7.88.

Size class

It is obvious that, size structure of *M. vulgare* is highly affected by the habitat and substrate. The most common class is class II (30-60) on all sites with different frequency (i.e: 80% in site 1; 60% in site 2; 84% in site 3, and 61% in site 4) (Fig. 4). However, dwarf plants present in site 3 & 4, the apparently big individual are present in site 1 & 2. Plants with size index more than 60cm are comprising 12% of site 1 and 24% of site 2. Whereas, plant with size class more than 90cm/ individual, present in site 2 only. Dwarf plants are characterizing site 4 (i.e: 39% of site 4 plants are less than 30cm/individual).

Reproductive effort

The different habitat motivates plant species to take different strategy to cope with their habitat structures. As summarized in Table 4, the reproductive organs of species thrive in high disturbances (site 4), which located in Matrouh city is higher than that of other sites (P≤0.01), and reproductive effort is (0.61). While, site 3, which located on the outstkirts of Ras El-Hekima had reproductive effort (0.41). It also, remarkable that the vegetative organs are higher in site 1 & 2 than that of species in site 3 & 4. In addition, the plant area, and the number of fruiting branches are significant between sites, whereas, no significance between the main branches (P=0.06).

TABLE 1. Phenological sequances of *M. vulgare* at the two different selected habitat. ■ Road side, ■ Abandoned places.

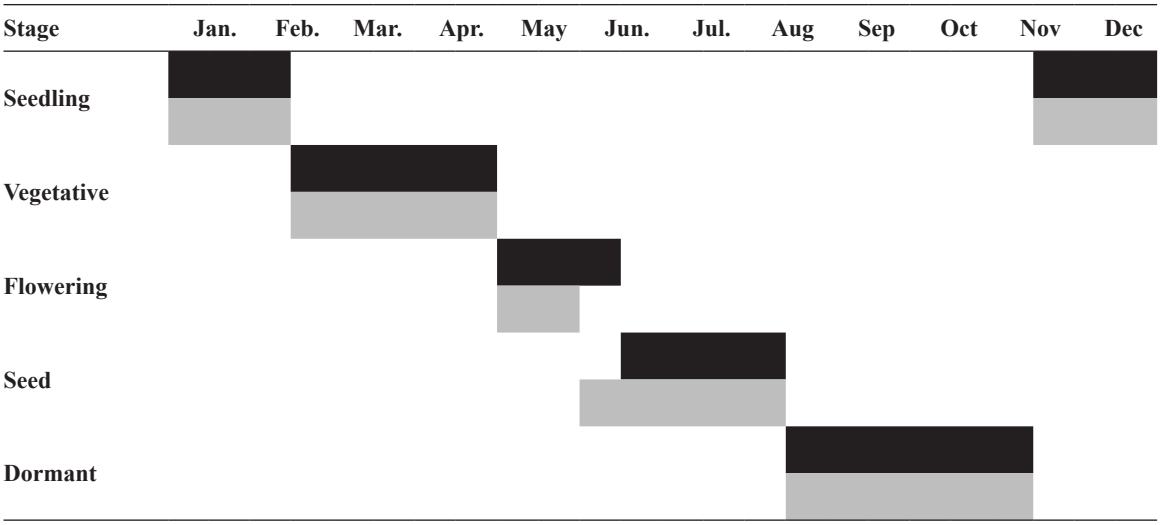

TABLE 2. Relative density of *Marrubium vulgare* L and its associated species in four studied sites representing two different habitats.

Species	Roadsides		Abandoned places	
Perennials	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Ajuga iva (L.) Schreb.	3.4	0	0	0
Allium ampeloprasum L.	1.6	0	0	0
Asphodelus aestivus Brot.	13.1	18.8	0	0
Astragalus spinosus (Forssk.) Muschl.	0	2.6	0	0
Atriplex halimus L.	0	11.4	0	2.5
Convolvulus arvensis L.	2.2	0	0	0
Deverra tortuosa (Desf.) DC.	5.8	4.7	0	0
Echinops spinosus L.	0	2.8	0	1.3
Haplophyllum tuberculatum (Forssk.)	0	6.7	5.1	0
Helianthemum vesicarium var. *ciliatum* Boiss	4.4	0	0	0
***Marrubium vulgare* L.**	9.7	15.3	26.4	21.5
Noaea mucronata (Forssk.) Asch.& Schwenif.	2.9	3.9	0	0
Peganum harmala L.	0	0	18.6	13.9
Nicotiana glauca R.C.Graham.	0	0	44.9	51.2
Haloxylon scoparium Pomel.	23.8	19.8	5	4.3
Salvia lanigera Poir.	5.7	0	0	0
Thymelaea hirsuta (L.) Endl.	27.4	14	0	5.3
Annuals				
Anacyclus monanthos (L.) Thell.	0	1	1	0
Asteriscus spinosus (L.)Sch.Bip.	1	1	0	0
Carduus pycnocephalus L.	1	0	0	1
Centaurea calcitrapa L.	1	1	1	0
Heliotropium supinum L.	0	1	0	0
Medicago laciniata (L.)Mill.	1	0	0	0
Papaver rhoeas L.	0	1	0	0
Plantago ovata Forssk.	1	1	0	1
Total number of species	16	16	7	9
Mean number of species per stand	3.2	3.2	1.4	1.8
*Mean absolute density of *M.vulgare*/100m^2	3±0.6	3.83±0.95	19.8±4.1	16.5±1.23

* Absolute density is calculated to *M. vulgare* per quadert area (value± Standard error).

TABLE. 3. ANOVA (Test of equal means) of plant height and diameter of 4 studied sites representing *M. vulgare* species.

	Sum of sqrs	df	Mean square	F	P value
Height (cm)					
Between groups	3784.37	3	1261.46	19.85	1.65E-08
Within groups	3050.15	48	63.5449		
Total	6834.52	51			
Diameter					
Between groups	8334.23	3	2778.08	12.32	4.25E-06
Within groups	10824.8	48	225.516		
Total	19159	51			

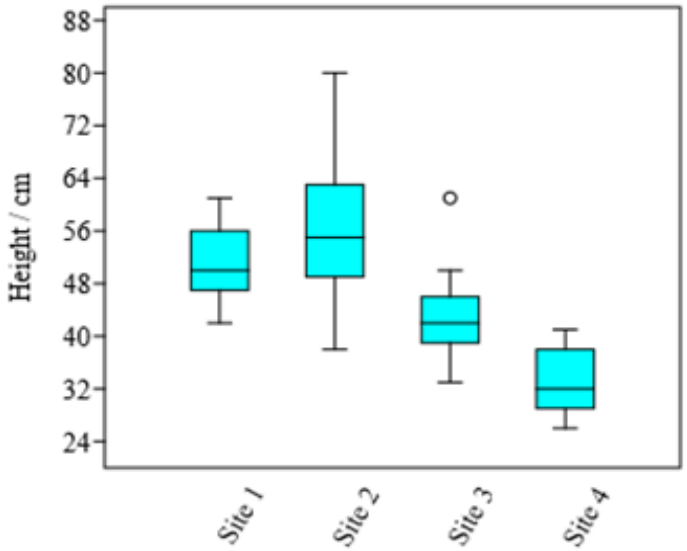

Fig. 2. Box-plot showing the differences between plant height of four sites representing different habitats.

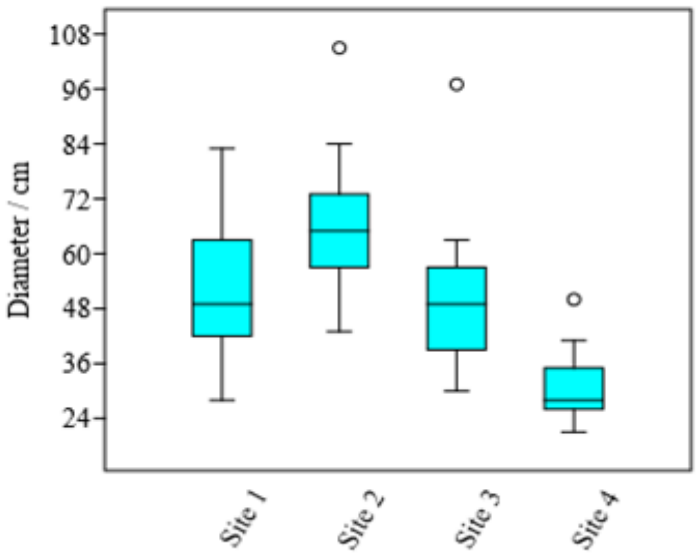

Fig. 3. Box-plot showing the differences between plant diameters of four sites representing different habitat.

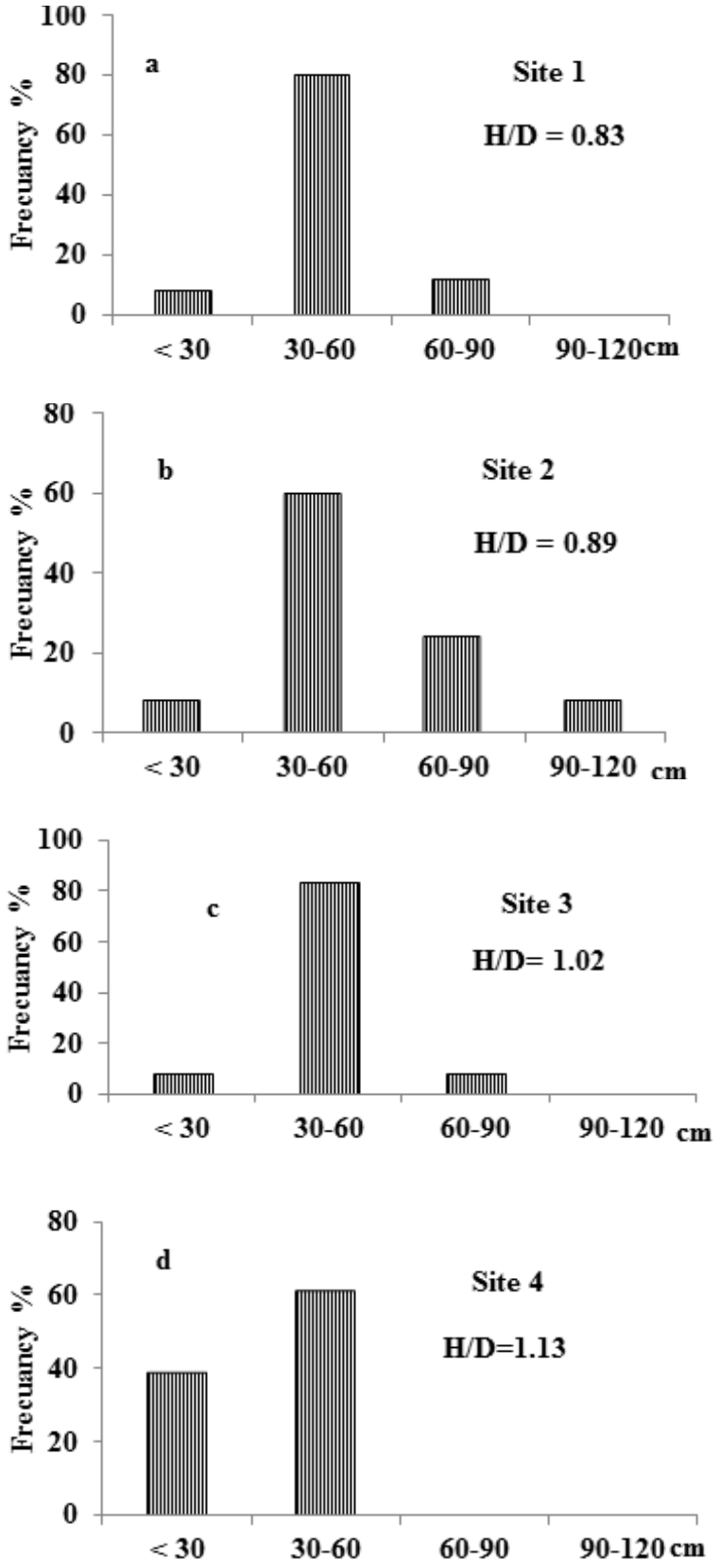

Fig. 4. Histogram showing size classes distribution and frequencies among four sites: a: Site 1, b: Site 2, c: Site 3 and d: Site 4.

TABLE 4. Analysis of variance (ANOVA) of some growth parameters and reproductive effort in the different habitats of *M.vulgare* .

Variables	Road sides		Abandoned places		F ratio	P value
	Site 1	Site 2	Site 3	Site 4		
No. of main branchces/plant	19±3.6	21±4	16.7±2.5	11.33±2.5	3.6	0.06^{ns}
No. of Furiting branchces/ plant	8±3	11±1	14±2.6	6.6±2.08	6.02	0.02*
Plant area /cm^2	2183±804	3790±577	1859±489	864±164	6.03	0.0014***
Vegetative (gm/dry wt.)	1.34±.28	1.72±.36	1.2±.19	0.87±0.17	5.36	0.025*
Reproductive (gm/dry wt.)	0.554±0.15	0.806±.28	0.785±.07	1.35±1.56	10.7	0.003**
Reproductive effort	0.3	0.32	0.41	0.61		

Significance: ns=non-significant, * P≤0.05, **P≤0.01, ***P≤0.001.

Discussion

By the time, the majority of the human population will live in cities. Based on, some estimation, the suburban land in some urban fringe areas increased by 756% from 1974 to 1998 while, rural and wild land area has decreased by 23% over the same time period (Robinson et al., 2005). Further studies have documented that urbaziation fragments, isolates, and degrades wild habitat; simplifies and homogenizes species composition; disrupts hydrological systems; and modifies energy flow and nutrient cycling, (Alberti, 2005). Moreover, Cities characterized by high energy consumption, large amount of waste product, lack of habitat patch integration, invasion of non native species, high metal and organic matter concentration in soils, and modification of natural disturbance regimes. Urban ecosystem includes many habitats (e.g. street tree, house garden, ponds, building infrastructure, abandoned public and industrial places and cemeteries). Understanding the fragile urban habitat structure have an implementation of ecosystem preservation and consequently, mitigation of climate change and anthropogenic impacts.

M. vulgare, is a perennial wild species, has medicinal importance (Said-Al Ahl1 et al., 2015) do best in the fragile ecosystem. The present study examined plant performance in semi natural habitat (road side) in desert areas and the most disturbed habitat (abandoned places) where, there is intensive human and animal impacts. Results indicates, high density of our species in abandoned places comparing with roadside habitat and vice versa in case of plant association richness.

Disturbances play a major role in shaping plant communities in urban environments. Trampling, vehicular movement and building activities recurrently affect vegetation and, hence, only those species capable of regenerating after repeated disturbance become residents of urban habitats (Latzel et al., 2008). Habitat fragmentation may (i) Reduce population genetic diversity through genetic drift, (ii) Drive adaptive changes in plant traits and increase individual plant fitness in a fragmented landscape (Jacquemyn et al., 2012). Lack of plant diversity in abandoned places is related to the most of disturbed places species have an invasive properties, e.g: *Nicotiana glauca* (Boulos, 2002) or allopathic behavior, e.g: *Peganum harmala* (Sodaeizadeh, 2009). Higher density may also related to the lack of competition between species. Species distribution in abandoned habitat takes complete pure patches of the same species. In addition, *M. vulgare*, prefer poor soil with high calcium carbonate percentages (Weiss & Sagliocco, 2000). Besides, high amount of seed production.

Plant shape (height and diameter) is highly affected by soil resources, competition, facilitation and anthropogenic activities. In the stable, less disturbance, habitat, vegetation is much stable. Selection favor large sized plants that devote more vegetative resources rather than reproductive resources to compete the neighbor species (Silvertown & Lovett, 1993).

Size index measurements indicate different behavior of both habitats. In road side habitat, plants tend to mature stage rather than young stage (positive skewed to mature stage), whereas,

plants in abandoned places have positive skewed to young stage. Similar results by Gray (1975) concluded that positive skewed to juvenile stage indicates a self-perpetuating of species. On the other hand, prevailing of the mature stage indicates population declining (Shaltout & Mady, 1993 and Mosallam, 2007). The ratio of height to diameter explain the plant behavior. In the road side habitat, H/D is less than unity, this means that plant diameter is bigger than its height (plant extends horizontally). Shaltout & Mady (1993) concluded that this mechanism is common between desert shrubs in order to provide safe sites for their self- regeneration where, there are availability of moisture and shade places preventing high temperatures. On the other hand, plants at the abandoned places are taller than their diameter (H/D=1.02, 1.13), this means that plants expand vertically. Additionally, The prevailing of juvenile stages may be related to the habit of the new man–made habitat which require new colonization of species.

The relationship between the reproductive capacity and habitat disturbance are frequently studied by many authors as Jacquemyn et al. (2003) and Martı´nkova´ et al. (2011). Both of them concluded that there are a positive correlation between disturbance and plant fitness and fecundity rates, they added also, plants under disturbances producing more seeds than equivalent- sized plants from less disturbed habitat. Other studies, reported that reproductive success of plant species increased with population density (Klinkhamer & Van derlugt, 2004), notably, in insect- pollinated species like our species. Therefore, patches with a high density of flowers would be more frequently visited by pollinators, and hence achieving a higher reproductive success (Klinkhamer & Van der derlugt, 2004).

Conclusion

Climate change is expected to occur more rapidly than the rate at which ecosystem can adapt and reestablish themselves. Ecologists and conservationists should find solutions to mitigate the fluctuation of climate change, habitat fragmentation, and urbanization. Understanding habitats structure and life history of plant species dominated such habitat is the first step in this context. Our model species is escaping from wild habitat and established in the fragile abandoned places, with high density, frequency, and reproduction rate. This species is very important as medicinal, bee plant and give a beautiful view to of the landscape. So, best management of this species in disturbed habitat is considered a way to mitigate habitat disturbance.

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تكيف نبات الروبية لتغير الموائل تحت نظام متدهور

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ينتمى نبات الروبية للعائله الشفوية وينتشر فى البيئات المهمشه فى الساحل الشمالي الغربى لمصر كما أنه ينتشر ايضا فى المناطق المهملة فى البيئات الحضرية. وقد تمت دراسة تطور مراحل نمو النبات وكثافتة والأنواع المرافقة فى كلا من البيئات الطبيعية والحضرية فى أربعة مواقع مختلفة. وقد تم أيضا أخذ قرءات الطول والعرض ومجموعات النمو وكذلك القدرة التكاثرية. وقد أثبتت الدراسة أن ثمة فروق ذات دلالات احصائية بين تلك القراءات فى المواقع المختلفة بينما لاتوجد اختلافات فى مظاهر النمو.