Universal Journal of Environmental Research and Technology
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Available Online at: www.environmentaljournal.org
Volume 2, Issue 6: 525-538

Open Access **Research Article**

Plant Metabolites Responses to Spatial Variation in South Sinai, Egypt

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Abstract:

The study was conducted to investigate the variation in Plant metabolites adaptive responses which is due to the spatial variation (altitude).In this investigation, samples of two plant species, *Fagonia mollis* and *Zilla spinosa* was collected during two seasons, from three locations at different elevation in, south Sinai, Egypt. Evaluation of present methods used for analyzing the major biochemical contents (Soluble Carbohydrate, Water Soluble protein, Proline, Phenol and Photosynthetic Pigments). Results were statistically analyzed by using One-way ANOVA and Post hoc-LSD tests (the least significant difference). Prominent variation was recorded as regards the biochemical constituents of the plants among the different wadis in all stages of growth .It is evident from this study that different biochemical attributes varied significantly during different seasons. It was found that spatial variation play a great role in the variation of these contents resulting from variation in altitudinal and latitudinal variation that lead to variation in climatic conditions and consequently make changes in all ecosystem components.

Keywords: Eco physiology, Plant metabolites, Seasonal variation, South Sinai, Spatial variation.

1.0 Introduction:

Spatial variation is the variation across the landscape that is normally associated with populations. Factors causing geographic variation include geologic differences that affect soil type, and thus habitat, and weather patterns, e.g., differences in rainfall across the landscape **(Ruggiero *et al.* 1994)**. Spatial pattern plays a central role in plant community dynamics, such as succession, adaptation, maintenance of species diversity, and competition **(Legendre and Fortin, 1989; Purves and Law, 2002)**. The study of plant spatial pattern is therefore useful for ecological theory and for restoration management. **Perry *et al.* (2006)** reviewed a range of plant spatial pattern methods, mainly local and global autocorrelation. They concluded that local analyses provide a potentially useful means of taking the 'plant's-eye view' **(Purves and Law, 2002)** and thereby link spatial pattern with ecological theory.

Physiological, biochemical and now also molecular mechanisms putatively favourable for adaptation to these conditions are assessed in the laboratory. Their actual action and effectiveness then must again be tested in the field, since it is not always given that traits intuitively considered favourable for ecological adaptation correlate with actual ecological distribution of plants (**Lambers *et al.*, 1998, Larcher 2003).** Environmental stress can disrupt cellular structures and impair key physiological functions **(Larcher, 2003).** Drought, salinity, and low temperature stress impose an osmotic stress that can lead to turgor loss. Different plant species are highly variable with respect to their optimum environments, and a harsh environmental condition, which is harmful for one plant species, might not be stressful for another **(Larcher, 2003; Munns and Tester, 2008).**

Number of plant quality traits change with elevation including foliar nitrogen **(Erelli et al. 1998, Hengxiao et al. 1999, Richardson 2004)**, defensive chemistry such as alkaloids, Coumadin's, phenolics, and terpenes **(Erelli et al. 1998, Hengxiao et al. 1999, Salmore and Hunter 2001, Alonso et al. 2005)**, structural compounds such as lignin and cellulose **(Richardson 2004)**, and leaf morphology **(Hengxiao et al. 1999). El-Shourbagy (1974)** reported that the decrease in total

carbohydrate concentration as a result of increasing water stress may be due to the decrease in photosynthetic process beside an increase of respiration in different plant species. **Harris *et al.* (2006)** and **Mountousis *et al*. (2011)** found that the change in protein content may result from altitudinal variation and seasonal variation. **Batanouny *et*. *al*. (1991)** reported that there is a relationship between the photosynthetic pathway and the ecological conditions in the habitat of a particular species. Among environmental stresses, water insufficiency is one of the main limitations to photosynthesis in mesophytic plants **(Kicheva *et. al.,* 1994).** Many researchers also detect that altitudinal variation lead to change in pigment content such as **Spitaler et al. (2006), González et al. (2007) and Zhang et al. (2012).** There are a lot of studies which showed use of genetically modified plants to demonstrate that the proline metabolism has effect on stress responses and proline accumulation is important for the preservation of plants from certain adverse environmental conditions such as **(Miller et al. 2009).** Phenolic compounds one of the most groups of phytochemicals are of considerable in physiological and morphological importance in plants. These compounds are very important to the plants; where it plays an important role in pigmentation, growth, reproduction, resistance to pathogens and thereby protecting leaves from photo induced oxidative damage. Therefore, phenolic concentrations might be expected to increase with elevation because the risk of photo damage is higher at high elevations than at low elevations **(Close and McArthur 2002).**

Several environmental factors such as nutrient supply, temperature, light conditions and atmospheric CO2 concentrations can influence the levels of total phenolics and flavonoids in plants **(Fine *et al.,* 2006).**
Sinai Peninsula has the geographical importance and uniqueness of being the meeting place of Asia and Africa. For this reason its flora combines elements from these two continents, including Saharo-Arabian, Irano- Turanian, Mediterranean and sudanian elements. At the same time, the Gulf of Suez and the Gulf of Aqaba separate it from the phytogeographical regions of Africa and Asia and thus the flora of Sinai has involved in isolation **(Hatab, 2009 and Omar *et al.* 2012)**. The unique formation of the south Sinai Mountain, lead to greater variation in the climate and the vegetation than elsewhere. The clearest characteristics of the desert vegetation are scarcity of plant growth and near lack of trees; many plant species have become endangered due to increasing aridity and human activities. The continuous overgrazing, overcutting and uprooting are leading to the disappearance of the pastoral plant communities, a reduction of plant cover and soil erosion **(Hatab, 2003).** This paper therefore try to detect the effect of environmental factors (Climatic factors, Edaphic factors, Human activates) on physiological characters (plant metabolites) of certain ecological important plants in each wadies.
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2.0 Material and Methods:

2.1 Study area:

Three locations were sampled for this study, the selection of these locations was based on the following criteria: (1) the area must be isolated (Altitudinal variation), (2) the plant can be collected from this area, (3) number of plant individuals within each location must be sufficient for collection because our goal to conserve this plant not to consume the gene bank. The selected locations varying in altitude rangeWadi Gebal (1800 m), Wadi Gharaba (1100 m) and Wadi Hodra (600 m). These locations are illustrated on the map ofthe study areas (Fig. 1).
The selection of tested samples (locations) was depending on the presence of target species within all locations.

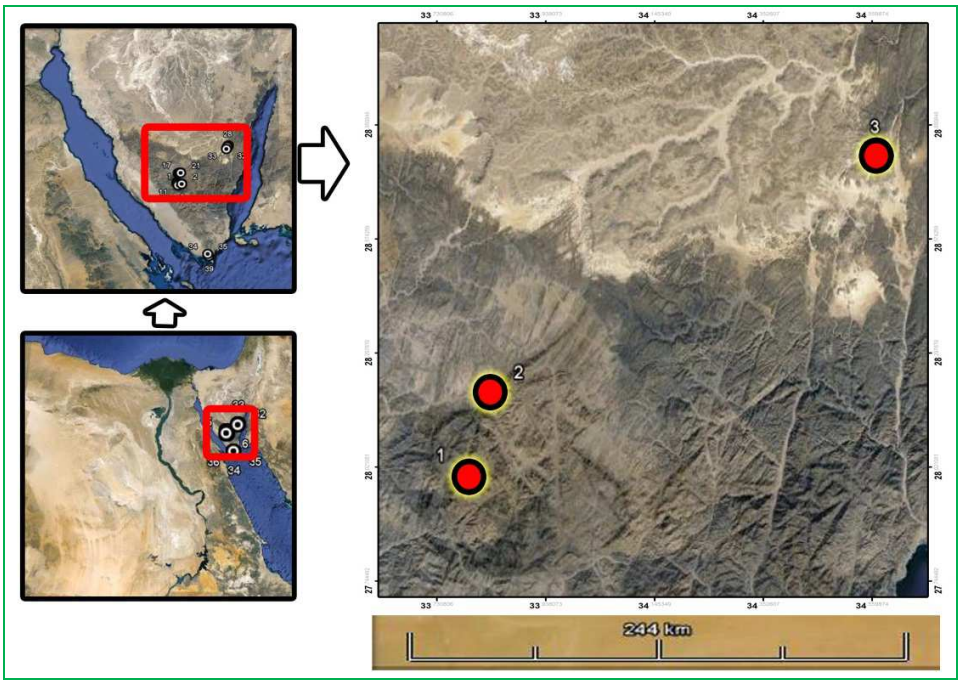
2.2 Plant Materials:

After general survey to the vegetation structure in the three locations we found that *Fagonia mollis* and *Zilla spinosa* are common in the all these locations. We preferred to choose the dominant one in this location to reflect the amount of metabolic contents within this site. Samples (leaves) collected during two seasons. 1stflowersseason at (April, 2011) and 2ndfruits season at (September, 2011) for the determination of plant metabolites. At each location, numbers of different variables (Geographical, Ecological, Climatic and Threats) were recorded such as altitudinal range, aspect, microhabitat, soil characteristics, climatic conditions, grazing pressure and morphological aspects of the plant (leaf length, leaf width, No. of leaf, No. of branches and internode length) which has direct effects on Plant Metabolites Responses.

2.3 Methods:

We used standard methods to showed the plant Biochemical contents as following, Photosynthetic pigments contents were determined according to the method of **Vernon and Seely (1966).**Contents of soluble carbohydrates were determined as glucose equivalents using the sulphuric acid method **(Said *et***

***al*., 1964).**Contents of soluble proteins were estimated according to the methods of **lowery *et al.* (1951).**Contents of free proline were determined according to the method described by **Bates *et al.*, (1973).** Extraction of phenolic compounds was carried out according to that method described by **Daniel and George (1972).**



Map 1: Location map for study area, 1- Wadi Gebal, 2- Wadi Gharaba and 3- Wadi Hudra

2.4Statistical Analysis:

All data were statistically analyzed using One-way ANOVA and Post hoc-LSD tests (the least significant difference) **(PASW® Advanced Statistics 18, 2010)** at 0.05, 0.01 and 0.001 level of probability **(Snedecor and Cochran, 1982)**. The values recorded in the values of the biochemical analysis are means of three replicates. The Pearson linear correlation coefficient was estimated to show the relationship of the physiological parameter to eachother. Discriminant analysis is used to classify several observations, into these known groups **(Härdle and Simar, 2007).**

3.0 Results and Discussion:

Biochemical analysis for *Fagonia mollis* and *Zilla spinosa* were made andsummary of the results was shown in Table 1 and 2.

3.1 Soluble Carbohydrate contents:

Firstly *Fagonia mollis* showed that; at stage A, the maximum value of total soluble carbohydrates content was recorded in W. Gebal (6.30 mg./g.dry wt.), while the minimum value was recorded in *W. Hodra* (2.86 mg./g.dry wt.). On the other hand at stage B, the maximum value of total soluble carbohydrates content was recorded in *W. Gharaba* (5.28 mg./g.dry wt.), while the minimum value was recorded in *W. Gebal* (2.99 mg./g.dry wt.).

From statistical analysis we found a highly significant differences between plants species during stage A (F = 93.259, P = 0.000) and stage B (F = 121.29, P = 0.000) in contents of total soluble carbohydrates (Table 1). Secondly *Zilla spinosa* showed that; at stage A, the maximum value of total soluble carbohydrates content was recorded in W.Gharaba (8.26 mg./g.dry wt.), while the minimum value was recorded in *W.Gebal* (3.92 mg./g.dry wt.). On the other hand at stage B, the maximum value of total soluble carbohydrates content was recorded in W.Gharaba (3.96 mg./g.dry wt.), while the minimum value was recorded in W.Hodra (1.49 mg./g.dry wt.). From statistical analysis we found that there are a highly significant differences between plants species during stage A (F = 1575.974, P = 0.000)

and stage B (F = 703.644, P = 0.000) in contents of total soluble carbohydrates (Table 2).

3.2 Water Soluble Protein Contents:

Firstly *Fagonia mollis* showed that; at stage A, the maximum value of total soluble protein content was recorded in W. Gharaba (0.62 mg./g.dry wt.), while the minimum value was recorded in W. Gebal (0.36 mg./g.dry wt.). At stage B, the maximum value of total soluble protein content was recorded in W. Gebal (0.65 mg./g.dry wt.), while the minimumvalue was recorded in W.Hodra (0.17 mg./g.dry wt.). It is clear from the results in Table 1 that, there are a highly significant differences between plants species during stage A (F = 72.57, P = 0.000) and stage B (F = 189.35, P = 0.000) in contents of total soluble protein. Secondly *Zilla spinosa* showed that; at stage A, the maximum value of total soluble protein content was recorded in W.Gharaba and W.Gebal (0.27 mg./g.dry wt.), while the minimum value was recorded in W.Hodra (0.14 mg./g.dry wt.). At stage B, the maximum value of total soluble protein content was recorded in W.Gebal (0.52 mg./g.dry wt.), while the minimum value was recorded in W.Hodra (0.02 mg./g.dry wt.). It is clear from the results in Table --- that, there are a highly significant differences between plants species during stage A (F = 296.6, P = 0.000) and stage B (F = 468.025, P = 0.000) in contents of total soluble protein.

3.3 Proline Contents:

Firstly *Fagonia mollis* showed that; at stage A, the maximum value of total proline content was recorded in W. Gebal (5.62 mg./g.dry wt.), while the minimum value was recorded in W. Hodra (1.45 mg./g.dry wt.). At stage B, the maximum value of total proline content was recorded in W. Gharaba (9.38 mg./g.dry wt.), while the minimum value was recorded in W. Hodra (2.18 mg. /g. dry wt.). It is clear from the results in Table 1 that, there are a highly significant differences between plants species during stage A (F = 690.694, P = 0.000) and stage B (F = 2696.47, P = 0.000) in contents of total proline. Secondly *Zilla spinosa* showed that; at stage A, the maximum value of total proline content was recorded in W. Gharaba (13.62 mg./g.dry wt.), while the minimum value was recorded in W. Hodra (3.35 mg./g.dry wt.). At stage B, the maximum value of total proline content was recorded in W. Gharaba (3.41 mg./g.dry wt.), while the minimum value was recorded in W. Hodra (0.87 mg. /g. dry wt.). It is clear from the results in Table 2 that, there are a highly significant differences between plants species during stage A (F = 3340.643, P = 0.000) and stage B (F = 494.047, P = 0.000) in contents of total proline.

3.4 Phenol Contents:

Firstly *Fagonia mollis* showed that; at stage A, the maximum value of total phenol content was recorded in W.Gebal (3.37 mg./g.dry wt.), while the minimum value was recorded in W.Hodra (2.60 mg./g.dry wt.). At stage B, the maximum value of total phenol content was recorded in W.Gharaba (5.28 mg./g.dry wt.), while the minimum value was recorded in W.Gebal (2.99 mg. /g. dry wt.). It is clear from the results in Table 1 that, there are a highly significant differences between plants species during stage A (F = 5.131, P = 0.050) and stage B (F = 4.761, P = 0.058) in contents of total phenol. Secondly *Zilla spinosa* showed that; at stage A, the maximum value of total phenol content was recorded in W. Gebal (2.31 mg./g.dry wt.), while the minimum value was recorded in W. Hodra (1.63 mg./g.dry wt.). At stage B, the maximum value of total phenol content was recorded in W. Hodra (2.65 mg./g.dry wt.), while the minimum value was recorded in W. Gebal (1.60 mg. /g. dry wt.). It is clear from the results in Table 2 that, there are a highly significant differences between plants species during stage A (F = 4.515, P = 0.064) and stage B (F = 14.128, P = 0.005) in contents of total phenol.

3.5 Photosynthetic Pigments:

3.5.1 Chlorophyll a

Firstly *Fagonia mollis* showed that; At stage A, the maximum value of total chlorophyll a content was recorded in W. Gebal (6.58 mg. /g. fresh wt.), while the minimum value was recorded in W. Gharaba (4.20 mg./g.dry wt.). At stage B, the maximum value of total chlorophyll a content was recorded in W. Hodra (6.17 mg./g.dry wt.), while the minimum value was recorded in W. Gharaba (3.23 mg. /g. fresh wt.).

It is clear from the results in Table 1 that, there are a highly significant differences between plants species during stage A (F = 34.546, P = 0.001) and stage B (F = 17413.733, P = 0.000) in contents of chlorophyll a. Secondly *Zilla spinosa* showed that; at stage A, the maximum value of total chlorophyll a content was recorded in W.Gharaba (5.68 mg. /g. fresh wt.), while the minimum value was recorded in W.Hodra (3.29 mg./g.dry wt.). At stage B, the maximum value of total chlorophyll a content was recorded in W.Gharaba (4.96 mg./g.dry wt.), while the minimum value was recorded in W.Hodra (3.59 mg. /g. fresh wt.). It is clear from the results in Table 2 that, there are a highly significant

differences between plants species during stage A (F = 18329.04, P = 0.000) and stage B (F = 1442.663, P = 0.000) in contents of chlorophyll a.

3.5.2 Chlorophyll b

Firstly *Fagonia mollis* showed that; at stage A, the maximum value of total chlorophyll b content was recorded in W.Gharaba (3.11 mg./g. fresh wt.), while the minimumvalue was recorded in W.Hodra (2.35 mg./g.dry wt.). At stage B, the maximum value of total chlorophyll b content was recorded in W.Hodra (4.06 mg./g.dry wt.), while the minimumvalue was recorded in W.Gharaba (2.06 mg. /g. fresh wt.). It is clear from the results in Table 1 that, there are a highly significant differences between plants species during stage A (F = 1.004, P = 0.421) and stage B (F = 1349.565, P = 0.000) in contents of chlorophyll b. Secondly *Zilla spinosa* showed that; at stage A, the maximum value of total chlorophyll b content was recorded in W. Gharaba (3.83 mg. /g. fresh wt.), while the minimum value was recorded in W. Hodra (1.99 mg./g.dry wt.). At stage B, the maximum value of total chlorophyll b content was recorded in W. Gebal (5.91 mg./g.dry wt.), while the minimum value was recorded in W. Hodra (2.46 mg. /g. fresh wt.). It is clear from the results in Table --- that, there are a highly significant differences between plants species during stage A (F = 5228.477, P = 0.000) and stage B (F = 7054.317, P = 0.000) in contents of chlorophyll b.

3.5.2 Chlorophyll a+b

Firstly *Fagonia mollis* showed that; at stage A, the maximum value of total chlorophyll a+b content was recorded in W. Gebal (9.01 mg./g. fresh wt.), while the minimum value was recorded in W. Hodra (6.67 mg./g.dry wt.). At stage B, the maximum value of total chlorophyll a+b content was recorded in W. Hodra (10.23 mg./g.dry wt.), while the minimum value was recorded in W. Gharaba (5.30 mg. /g. fresh wt.). It is clear from the results in Table 1 that, there are a highly significant differences between plants species during stage A (F = 11.085, P = 0.010) and stage B (F = 29025.36, P = 0.000) in contents of chlorophyll a+b. Secondly *Zilla spinosa* showed that; At stage A, the maximum value of total chlorophyll a+b content was recorded in W. Gharaba (9.28 mg./g. fresh wt.), while the minimum value was recorded in W. Hodra (5.60 mg./g.dry wt.). At stage B, the maximum value of total chlorophyll a+b content was recorded in W. Gebal (10.30 mg./g.dry wt.), while the minimum value was recorded in W. Hodra (6.06 mg. /g. fresh wt.). It is clear from the results in Table 2 that, there are a highly significant differences between plants species during stage A (F = 58707.7, P = 0.000) and stage B (F = 15235.35, P = 0.000) in contents of chlorophyll a+b.

3.5.3 Carotenoids:

Firstly *Fagonia mollis* showed that; at stage A, the maximum value of total carotenoids content was recorded in W. Gebal (2.28 mg. /g. fresh wt.), while the minimum value was recorded in W. Gharaba (1.08 mg./g.dry wt.). At stage B, the maximum value of total carotenoids content was recorded in W.Hodra (1.50 mg./g.dry wt.), while the minimum value was recorded in W. Gebal and W. Gharaba (1.17 mg./g. fresh wt.). It is clear from the results in Table 1 that, there are a highly significant differences between plants species during stage A (F = 11.266, P = 0.009) and stage B (F = 430.478, P = 0.000) in contents of carotenoids. Secondly *Zilla spinosa* showed that; at stage A, the maximum value of total carotenoids content was recorded in W. Gebal (1.88 mg. /g. fresh wt.), while the minimum value was recorded in W. Hodra (1.08 mg./g.dry wt.). At stage B, the maximum value of total carotenoids content was recorded in W. Gharaba (1.92 mg./g.dry wt.), while the minimum value was recorded in W. Gebal (0.99 mg. /g. fresh wt.). It is clear from the results in Table --- that, there are a highly significant differences between plants species during stage A (F = 1818.375, P = 0.000) and stage B (F 2130.036, P = 0.000) in contents of carotenoids.

Table 1: Results of one way analysis of variance (ANOVA) of all biochemical contents during growth stages A and B of *Fagonia mollis* leaves in the different locations of south Sinai. Each value is mean of 3 replicates ± standard error of means. Means in a Column with similar letters are not significantly different according to LSD. *** = significant at P < 0.05

Metabolite	Season	W.Gebal	W.Gharaba	W.Hodra	F ratio	P value
Carbohydrate Mg/g.dry.wt	Stage A	6.30±0.282 b	2.95±0.187a	2.86±0.164a	93.259	***
	Stage B	2.99±0.055a	5.28±0.098 b	3.43±0.098a	198.067	***
Protien Mg/g.dry.wt	Stage A	0.36±0.003a	0.62±0.020b	0.48±0.016 b	72.57	***
	Stage B	0.65±0.020a	0.39±0.020 b	0.17±0.008c	189.35	***
Proline Mg/g.dry.wt	Stage A	5.62±0.057a	3.69±0.088 b	1.45±0.088 c	690.694	***
	Stage B	5.60±0.057a	9.38±0.088 b	2.18±0.057c	2696.47	***
Phenol Mg/100g.dry.wt	Stage A	3.37±0.240a	2.72±0.033a	2.60±0.202a	5.131	NS
	Stage B	2.67±0.251a	3.58±0.152a	3.43±0.251a	4.761	NS
Chl A Mg/g.f.wt	Stage A	6.58±0.093a	4.20±0.005b	4.32±0.385b	34.546	***
	Stage B	3.92±0.010a	3.23±0.006a	6.17±0.028 b	17413.733	***
Chl B Mg/g.f.wt	Stage A	2.43±0.695a	3.11±0.010 a	2.35±0.195 a	1.004	NS
	Stage B	2.96±0.023a	2.06±0.008a	4.06±0.040 b	1349.565	***
Chl A+B Mg/g.f.wt	Stage A	9.01±0.601b	7.31±0.005a	6.67±0.190a	11.085	***
	Stage B	6.88±0.020a	5.30±0.010a	10.23±0.012 b	29025.36	***
Carotenoids Mg/g.f.wt	Stage A	2.28±0.300 b	1.08±0.005a	1.60±0.080a	11.266	***
	Stage B	1.17±0.008a	1.17±0.000a	1.50±0.013 b	430.478	***

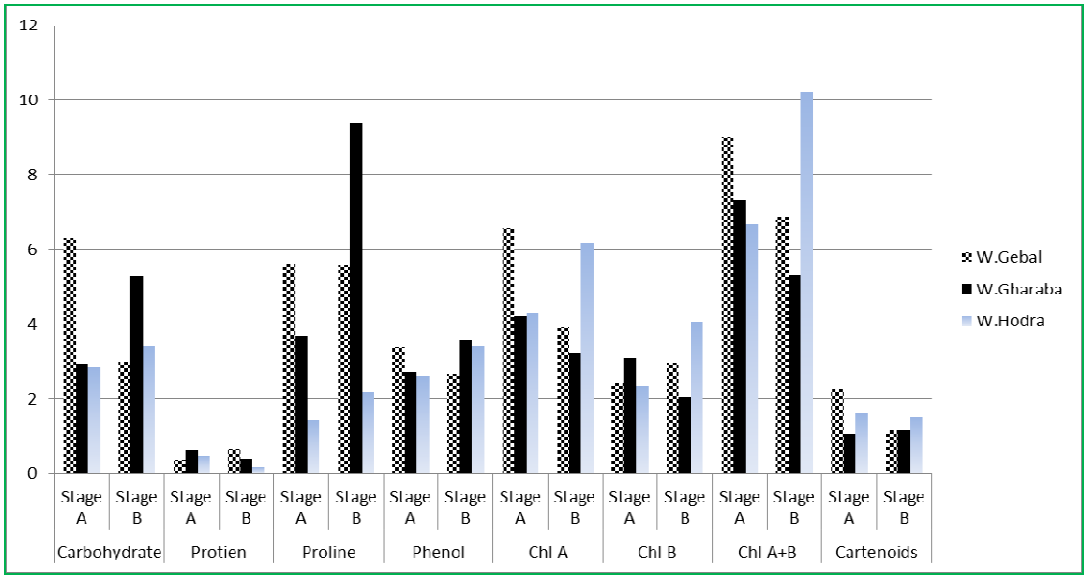


Fig. 1: Plant metabolites during stage A and stage B of *Fagonia mollis* in different locations.

Table 2: Results of one way analysis of variance (ANOVA) of all biochemical contents during growth stages A and B of *Zilla spinosa* leaves in the different locations of south Sinai. Each value is mean of 3 replicates ± standard error of means. Means in a Column with similar letters are not significantly different according to LSD. *** = significant at P < 0.05

Metabolite	Season	W.Gebal	W.Gharaba	W.Hodra	F ratio	P value
Carbohydrate Mg/g.dry.wt	Stage A	3.92±0.052a	8.26±0.023a	6.11±0.075 b	1575.974	***
	Stage B	2.99±0.017a	3.96±0.034b	1.49±0.071 b	703.644	***
Protien Mg/g.dry.wt	Stage A	0.27±0.003a	0.27±0.005a	0.14±0.003 b	296.6	***
	Stage B	0.52±0.020a	0.12±0.000 b	0.02±0.003 c	468.025	***
Proline Mg/g.dry.wt	Stage A	12.66±0.115a	13.62±0.088a	3.35±0.088 b	3340.643	***
	Stage B	1.33±0.066a	3.41±0.057a	0.87±0.057 b	494.047	***
Phenol Mg/100g.dry.wt	Stage A	2.31±0.145b	1.65±0.176a	1.63±0.218a	4.515	***
	Stage B	1.60±0.145b	2.20±0.152a	2.65±0.120a	14.128	***
Chl A Mg/g.f.wt	Stage A	5.58±0.016a	5.68±0.003a	3.29±0.003 b	18329.04	***
	Stage B	4.39±0.020a	4.96±0.008a	3.59±0.021 b	1442.663	***
Chl B Mg/g.f.wt	Stage A	3.07±0.017a	3.83±0.011a	1.99±0.006 b	5228.477	***
	Stage B	5.91±0.008b	3.34±0.014a	2.46±0.032ab	7054.317	***
Chl A+B Mg/g.f.wt	Stage A	8.66±0.005a	9.28±0.012a	5.60±0.008 b	58707.7	***
	Stage B	10.30±0.026a	8.31±0.006 b	6.06±0.011c	15235.35	***
Carotenoids Mg/g.f.wt	Stage A	1.88±0.013a	1.55±0.008a	1.08±0.003a	1818.375	***
	Stage B	0.99±0.005b	1.92±0.006a	1.39±0.015a	2130.036	***

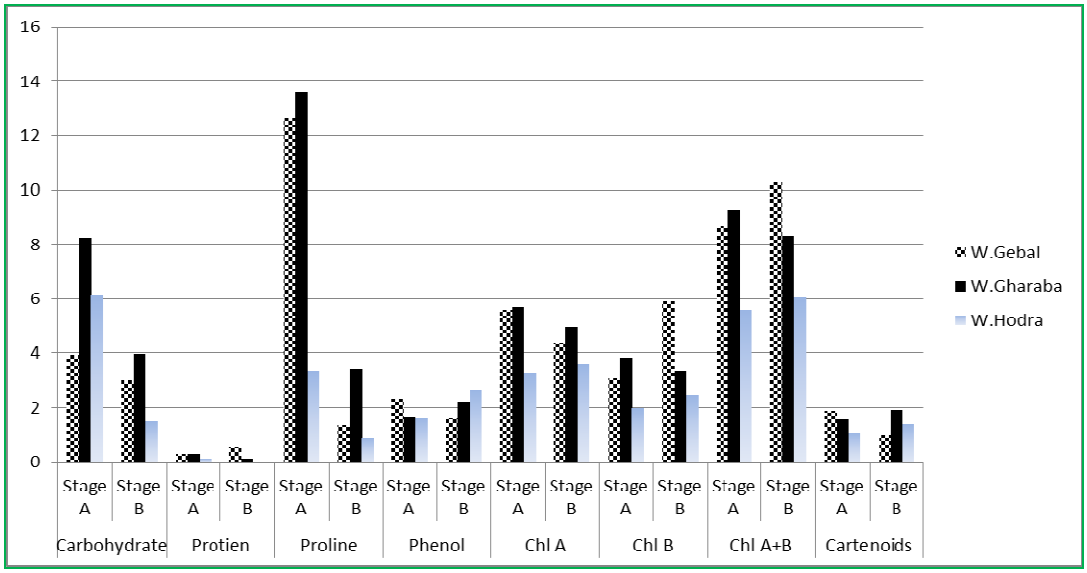


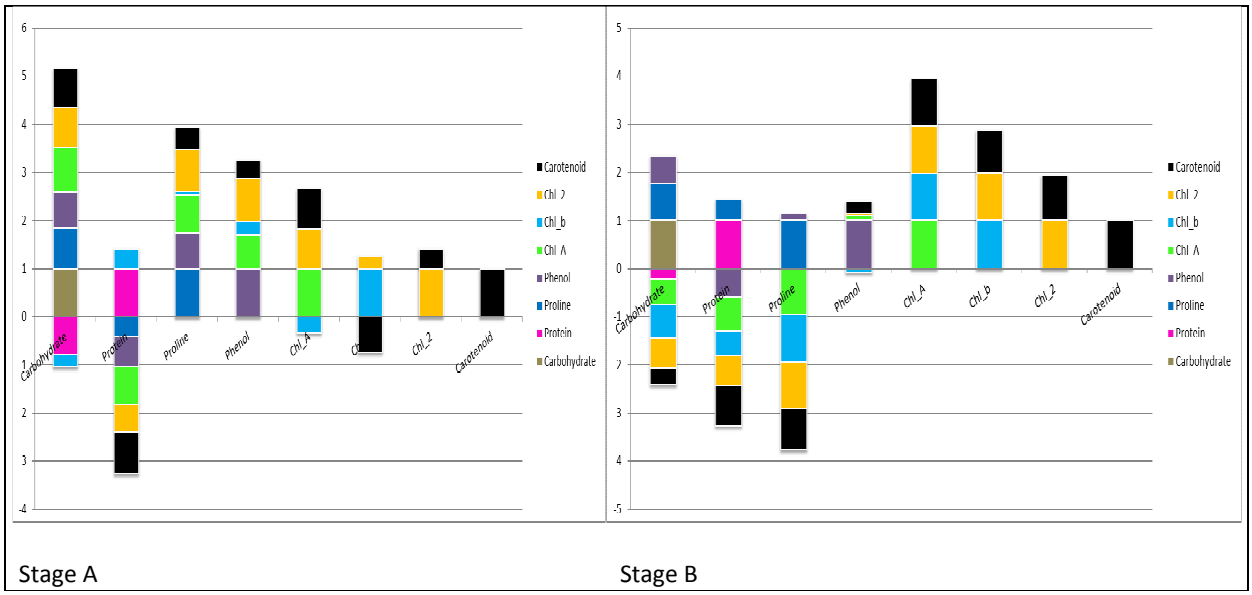
Fig. 2: Plant metabolites during stage A and stage B of *Zilla spinosa* in different locations.

3.6 Bivariate Pearson Correlations:

Correlations detection between different metabolic contents for *Fagoniamollis:*

From Table 3 and Fig. 3 we extract that during stage **(A);** carotenoid and total soluble carbohydrate showed positively correlated with all metabolic contentsand

negatively correlated with protein and chlorophyll b. It is also found that, Phenol positively correlated with all except protein. While protein showed negative correlation with all parameter except chlorophyll b. On the other hand, we notice that during stage B, total soluble carbohydrate show a negative correlation with all parameter except protein and chlorophyll b while proline showed the reverse. It is also found that, protein positively correlated with all parameter except proline. It's showed that there are great variations in metabolic correlation that may reach to be in the reverse way and this may be results from seasonal variation



Stage A Stage B

Fig. 3: Correlation relationship between different metabolites for *Fagonia mollis*

Correlations detection between different metabolic contents for *Zilla spinosa:*

From Table 4 and Fig. 4, we extract that during stage (**A);** water soluble protein, proline, phenol, and pigment and total soluble carbohydrate showed positively correlated with all metabolic except phenol and Carotenoid. On the other hand, we notice that during stage B, total soluble carbohydrate show a positive correlation with all parameter except phenol. It is also found that, protein positively correlated with all parameter except proline, phenol and carotenoid. Total proline shows a positive correlation with all parameter except phenol. While phenol a negative with all parameter except carotenoid, Chl_A and Chl_2 positively correlation with all parameter. It's showed that there are great variations in metabolic correlation that may reach to be in the reverse way and this may be results from seasonal variation.

Table 3: Bivariate Pearson correlations between the total soluble carbohydrate, water soluble protein, phenol, proline and pigment parameters for *Fagonia mollis*

Stage (1)	Carbohydrate	Protein	Proline	Phenol	Chl_A	Chl_b	Chl_2
Protein	-.797-*						
Proline	.837**	-0.417					
Phenol	.748*	-0.619	.737*				
Chl_A	.943**	-.798-**	.792*	.708*			
Chl_b	-0.242	0.419	0.08	0.271	-0.338		
Chl_2	.818**	-0.563	.861**	.891**	.819**	0.263	
Carotenoid	.806**	-.868-**	0.462	0.381	.846**	-.738-*	0.417

Stage (2)	Carbohydrate	Protein	Proline	Phenol	Chl_A	Chl_b	Chl_2
Protein	-0.212						
Proline	.777*	0.437					
Phenol	0.566	-0.603	0.138				
Chl_A	-0.532	-.699-*	-.946-**	0.106			
Chl_b	-.717-*	-0.509	-.995-**	-0.073	.968**		
Chl_2	-0.61	-0.629	-.973-**	0.036	.995**	.988**	
Carotenoid	-0.342	-.828-**	-.852-**	0.264	.975**	.888**	.948**

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4: Bivariate Pearson correlations between the total soluble carbohydrate, water soluble protein, phenol, proline and pigment parameters for *Zilla spinosa*

Stage (1)	Carbohydrate	Protein	Proline	Phenol	Chl_A	Chl_b	Chl_2
Protein	-.029						
Proline	.081	.989**					
Phenol	.664	.425	.341				
Chl_A	.032	.994**	.998**	.387			
Chl_b	.405	.896**	.943**	.097	.926**		
Chl_2	.187	.971**	.994**	.274	.988**	.974**	
Carotenoid	-.415	.919**	.873**	.648	.896**	.662	.816**
Stage (2)	Carbohydrate	Protein	Proline	Phenol	Chl_A	Chl_b	Chl_2
Protein	.302						
Proline	.882**	-.161					
Phenol	-.488	-.862-**	-.094				
Chl_A	.997**	.272	.900**	-.461			
Chl_b	.364	.995**	-.103	-.887-**	.333		
Chl_2	.631	.928**	.205	-.898-**	.606	.952**	
Carotenoid	.463	-.700-*	.816**	.442	.493	-.656	-.393

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

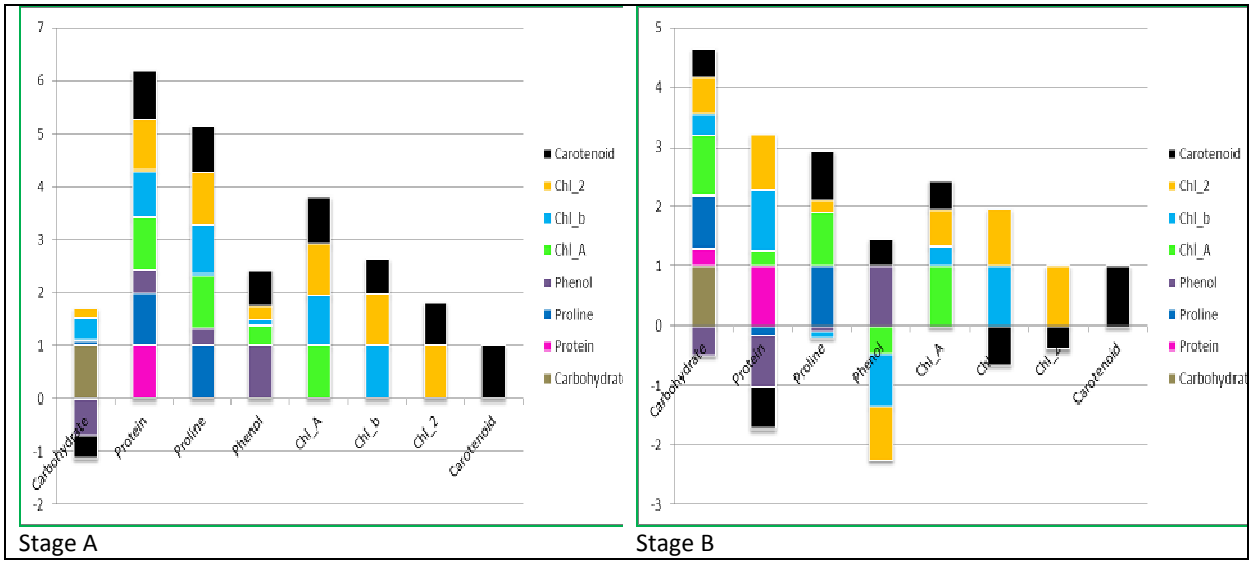


Fig. 4: Correlation relationship between different metabolites for *Zilla spinosa.*

During our study we record great variation in *Fagonia mollis* population structure, population distribution dynamics and morphology (Table 5). The highest records come with location Wadi Gharaba, we record the highest density, cover, No. of leaves, No. of branches for *Fagonia* in this location. We also record it as dominant species in four stands and co-dominate in one others from 7 stands witch studied in this location. However it's recorded in wadi Gebal only once as dominant and co-dominates species from 16 stands. These variations may come from the variation in topographic factors specially Altitude which lead to change in climatic factors and effect the edaphic factors especially w. contents and organic matters and this results totally agrees with those obtained by **Jin *et al.,* (2008**).

Table 5: Spatial variation in *Fagonia mollis* population characteristics

W.Name	Average of Sp. Ind.	Cover %	I.V.I	Presence	Dominant	Co-dominant	N0. leaves	No. of branches	internode
W.Gebal	15	0.8	9	7	1	1	480	15	2
W.Gharaba	26	2.2	69	6	4	1	800	50	1.2
W.Hodra	6	0.4	42	6	2	3	590	35	1

*Zilla spinosa*showed some variation inpopulation structure, population distribution dynamics and morphology (Table 6). The highest records come with location Wadi Gharaba, we record the highest density, cover, No. of leaves, No. of branches for *Zilla spinosa*in this location. We also record it as co-dominate in four stands from 7 stands witch studied in this location. However it's recorded 16 times in Wadi Gebal but not recorded as dominant, only once time recorded as co dominant species.

Table 5: Spatial variation in *Zilla spinosa*population characteristics

W.Name	Average of Sp. Ind.	Cover %	I.V.I	Presence	Dominant	Co-dominant	N0. leaves	No. of branches	internode
W.Gebal	9	0.7	10	16	0	1	7	21	2.5
W.Gharaba	12	4.3	42	7	0	4	45	30	4
W.Hodra	2	0.6	11	3	0	2	5	12	2.5

From the results we found that environment inadequate conditions promoted by abiotic factors such as water, temperature, salt, and mineral elements can provoke reductions in growth and development in plants, disorders in physiological, biochemical, and molecular behaviors and this totally agrees with **Tan *et al*., 1999; Leport *et al.,* 1999; Oliveira Neto *et al*., 2009.** Plants are continually exposed to changes in the ambient temperature. We know little about how metabolism and growth adjust to a fluctuating temperature regime, which features of the regime they respond to, and whether they always respond to temperature in the same way. Temperature affects almost all cellular and physiological processes, with the effect depending on the process and this repeat what obtained by **Larcher, 1995; Atkin and Tjoelker, 2003; Atkin *et al*., 2006.**

We found that the different plant species we selected during the study (*Fagonia mollis*and *Zilla spinosa*) are highly variable with respect to their optimum environments, and a harsh environmental condition, which is harmful for one plant species, might not be stressful for another and this totally agrees with **Larcher, 2003; Munns and Tester, 2008.** This is also reflected in the multitude of different stress-response mechanisms. It was observed that geographic gradients act as natural experiments by providing variation in abiotic factors under which biotic interactions can be evaluated. Elevation gradients provide an excellent example because temperature, soil fertility, risk of photodamge from UVB radiation, and precipitation all vary with changes in altitude and this agrees with **Darrow and Bowers 1997 and Yarnes and Boecklen 2005 (Table 6).**

Table 6: Spatial variation in topographic, edaphic and climatic factors

Location	Alt.	T. min.	T. max.	Rain	pH	EC µs/ cm	T.D.S PPm	water content	Org. matter
W.Gebal	1790	8.4	19.8	105	7.99	106.07	220.63	1.09	7.67
W.Gharaba	1170	9.9	21.2	68	8.47	50.14	104.29	0.73	6.65
W.Hodra	600	14.8	25.7	20	8.84	173.64	356.4	1.05	7.62

Likewise, a number of plant quality traits showed change with elevation including defensive chemistry such as phenolics and this agrees with **Erelli *et al.* 1998, Hengxiao *et al*. 1999, Salmore and Hunter 2001, Alonso *et al.,* 2005.** Temporal variation in leaf quality was more substantial than was spatial variation. None of the foliar characteristics measured exhibited any consistent pattern with elevation, although there were differences among sites. The lack of change along the elevation gradient is surprising. Statistical analysis of the obtained results showed close relationship between the growth stage and the different habitats as regards the contents of chlorophyll a, chlorophyll b, chlorophyll a+b, as well as carotenoid contents. So there is a relationship between the photosynthetic pathway and the ecological conditions in the habitat of a particular species.

Variation among location in pigment content was detected and this reduction of the pigment content may come from the presence of plant under water deficit conditions. Drought resistance has been equated with the ability of a plant to maintain a positive carbon balance under desiccating conditions. Many researchers also detect that altitudinal variation lead to change in pigment content such as **Spitaler et al. (2006), and Zhang *et al*., (2012).**

As South Sinai lies in the arid zone which characterized by low amount of rain which lead to drought and water efficiency, we record variation in total carbohydrate contents among different wadies and this may come from variation in water stress which may be due to the decrease in photosynthetic process beside an increase of respiration in different plant species.

Variation in protein content also comes from the change on soil water contents between deferent wadies and this may come from attitudinal variation, also **Harris *et al*., (2006)** and **Mountousis *et al*., (2011)** found that the change in protein content may result from altitudinal variation and seasonal variation. It was showed that several environmental factors such as nutrient supply, temperature, light conditions and atmospheric CO2 concentrations can influence the levels of total phenolics in plants and this agrees with **Fine *et al.,* 2006.**Phenols content was in the highest levels in Wadi Gebal and Wadi Gharaba, their presence and concentration in plant tissue have been related, with some controversy, to reduced herbivore preferences. But phenolic contents also rise along elevational clines or high energy light gradients as in the tow wadis the highest elevated ones as recorded by **Lovelock *et al*., 1992; Tegelberg and Julkunen-Tiitto, 2001.** As elevation increases, however, biotic factors become less important, this make us detect the reason for metabolic variation across elevation gradient (variation between different wadis) this also recorded by **Fleishman et al., 1998; Gottfried *et al*., 1998.** It was recorded variation in prolein contents among deferent wadi systems, this may come from the spatial and altitudinal variation which may led to change in climatic conditions and put the plants in different environmental stress and this agrees with numerous studies that have shown that the proline content in higher plants increases under different environmental stresses such as **Choudhary *et al.,* 2005, Fabro *et al*., 2004 and Haudecoeur *et al*., 2009)**.

4.0 Conclusions:

The main conclusion of this work as follows:

- It was found that spatial variation plays a great role in the variation of the biochemical contents.
- Variation in altitudinal and latitudinal variation which leading to the variation in climatic conditions and consequently make changes in all ecosystem components.
- South Sinai lies in the arid zone which characterized by low amount of rain which lead to drought and water efficiency, we record variation in total carbohydrate contents among different wadies and this may come from variation in water stress which may be due tothe decrease in photosynthetic process beside an increase of respiration in different plant species.
- This seasonal and spatial variation can be used in economic issue, that we can help local communities to detect the time and place where they can collect their plants for commercial use or for grazing.

5.0 Acknowledgement:

We really appreciate the great effort by Mr. Karim Omar, botanical team leader of Saint Katherine Protectorate for his continuous support step by step during this research. Also we thank Mr. Mohamed Kotb the Head of Saint Katherine Protectorate and also Dr. Mohamed Salem the General Manager of South Sinai Protectorates for their work facilitation.

6.0 References:

1) Alonso, C., Perez, R., Nieto, P. M. and Delgado, J. (2005): Gender dimorphism and altitudinal variation of secondary compounds in leaves of

the gynodioecious shrub Daphne laureola. J. Chem. Ecol. 31: 139Ð150.
2) Ashraf, M. Y., Azmi, A.R., Khan, A. H. and Ala, S. A. (1994): Effect of water stress on total phenols, Peroxidase activity and chlorophyll content in wheat. Acta physiologiae plant arum. 16(3):185-191.
3) Atkin, O. K. and Tjoelker, M. G. (2003): Thermal acclimation and the dynamic response of plant respiration to temperature. Trends in Plant Science, 8, 343–351.
4) Atkin, O. K., Loveys, B. R. and Atkinson, L. J et al. (2006): Phenotypic plasticity and growth-temperature: understanding inter-specific variability. Journal of Experimental Botany, 57, 267–281.
5) Baena-González, E., Rolland, F., Thevelein, J. M. and Sheen, J. (2007): A central integrator of transcription networks in plant stress and energy signalling. Nature 448: 938-943.
6) Batanouny, K. H., Stichler, W. and Ziegler, H. (1991): Photosynthetic pathways and ecological distribution of Euphorbia species in Egypt. Oecologia 87, 565-569.
7) Bates, I. S., Waldern, R. P. and Teare, I. D. (1973): Rapid determination of free proline for water stress studies. Plant and Soil, 39: 205-207.
8) Choudhary, N. L., Sairam, R. K. and Tayagi, A. (2005): Expression of delta1-pyrroline-5-carboxylate synthetase gene during drought in rice (*Oryza sativa* L.). Ind. J. Biochem. Biophys. 42: 366–370.
9) Daniel, H. D. and George, C. M. (1972): Peach seed dormancy in relation to indogenous inhibition and applied growth substances J. of American society of Horticulture Science, 97:651-654.
10) Darrow, K. and Bowers, M. D. (1997): Phenological and population variation in iridoid glycosides of Plantago lanceolata (Plantaginaceae). Biochem. Syst. Ecol. 25: 1Ð11.
11) El-Kheir, M. S., Kandil, S. A. and Mekki, B. B. (1994): Physiological response of two soybean cultivars grown under water stress conditions as affected by CCC treatment. Egypt. J. Physiol. Sci., 18: 179-200.
12) Erelli, M. C., Ayres, M. P. and Eaton, G. K. (1998): Altitudinal patterns in host suitability for forest insects. Oecologia (Berl.) 117: 133Ð142.
13) Fabro, G., Kovacs, I., Pavet, V., Szabados, L. and Alvarez, M.E. (2004): Proline accumulation and AtP5CS2 gene activation are induced by plant–pathogen incompatible interactions in Arabidopsis. Mol. Plant Microbe Interact. 17, 343–350.
14) Fine, P. V. A., Miller, Z. J., Mesones, I., Irazuzta, S., Appel, H. M. and Stevens, M. H. H. (2006): The growth defense tradeoff and habitat specialization by plants in Amazonian forest. Ecology, 87:150–162.
15) Fleischmann, K., Porembski, S., Biedinger, N. and Barthlott. W. (1996): Inselbergs in the sea: Vegetation of granite outcrops on the islands of Mahe, Praslin and Silhouette (Seychelles). Bull. Geobot. Inst. ETH. 62: 61-74.
16) Gonzalez, V., Ospina, M., Palacios, E. and Trujillo, D. (2007): Nesting habitats and rates of cell parasitism in some bee species of the genera Ancylosceleis, Centris and Bugloss (Hymenoptera: Apidae), From Colombia.Boletin del Museo de Entomologa de la Universidad del Valle 8(2):23-29.
17) Gottfried, M., Pauli, H. and Grabherr, G. (1998): Prediction of vegetation patterns at the limit of plant life: a new view of the alpine-nival ecotone. Arctic and Alpine Research 30, 207–221.
18) Härdle, W & Simar, L (2007):"Applied Multivariate Statistical Analysis", 2-edition, Berlin, Germany.
19) Harris, J. A., Hobbs, R. J., Higgs, Eric. and Aronson, J. (2006): Ecological Restoration and Global Climate Change. Restoration Ecology Vol. 14, No. 2, pp. 170–176.
20) Hatab, E. E. (2003): Establishing and Monitoring the Dynamic Population Of Acacia in Saint Katharine Protectorate, South Sinai, Egypt. M.Sc. Thesis, Botany Dep., Facu. Of Sci. Al-Azhar Univ., Egypt.205 pp.
21) Hatab, E.E. (2009): Ecological studies on the Acacia Species and Ecosystem Restoration in the Saint Katherine Protectorate, South Sinai, Egypt. Ph.D., Thesis, Fac. Sci., Al-Azhar Univ 227pp.
22) Haudecoeur, E., Planamente, S., Cirou, A., Tannières, M., Shelp, B. J., Moréra, S. and Faure, D. (2009a): Proline antagonizes GABA-induced quenching of quorum-sensing in Agrobacterium tumefaciens. Proc Natl Acad Sci USA 106: 14587-14593.
23) Hengxiao, G., McMillin, J, D., Wagner, M, R., Zhou, J., Zhou, and. Xu, X. (1999): Altitudinal variation in foliar chemistry and anatomy of Yunnan pine, Pinus yunnanensis, and pine sawßy

(Hym. Diprionidae) performance. J. Appl. Entomol. 123: 465-471.
24) Jin, Y., Pretorius, Z. A., Singh, R. P. and Fetch, T., Jr (2008): Detection of virulence to resistance gene Sr24 within race TTKS of Puccinia graminis f. sp. tritici. Plant Dis. 92: In press.
25) Kicheva, M. I., Tsonev, T. D. and Popova, L.P. (1994): Stomatal and nonstomatallimitations to photosynthesis in two wheat cultivars subjected to water stress. Photosynthetica 30:107-116.
26) Lambers, H., CHAPIN, F.S. and PONS, T.L. (1998): Plant physiological ecology. Springer-Verlag, New York.
27) LARCHER, W. (1995): Physiological Plant Ecology. Springer-Verlag, New York.
28) Larcher, W. (2003): Physiological plant ecology. Springer-Verlag, Berlin.
29) Lavers, C.P., Haines-Young, R.H. (1996): Using models of bird abundance to predict the impact of current land-use and conservation policies in the Flow Country of Caithness and Sutherland northern Scotland. Biol. Conservation 75:71–77.
30) Legendre, P. and Fortin, M. J. (1989): Spatial pattern and ecological analysis. – Vegetation 80: 107–138.
31) Leport, L., Turner, N., French, R., Barr, M., Duda, R., Davies, S., Tennant, D. and Siddique, K. (1999): Physiological responses of chickpea genotypes to terminal drought in a Mediterranean-type environment. European Journal of Agronomy 11: 279-291.
32) Lovelock, C. E., Clough, B. F. and Woodrow, I. E. (1992): Distribution and accumulation of ultraviolet radiation- absorbing compounds in leaves of tropical mangroves. Planta 188:143–154.
33) Lowery, O. H., Rosebrough, N. J., Farr, A. L. and Randall, R. J. (1951): Protein measurement with the fooling reagent. J. Biol.Chem.193:265-275.
34) Miller, G. Honig, A., Stein, H., Suzuki, N., Mittler, R. and Zilberstein, A. (2009): Unraveling delta1-pyrroline-5-carboxylateproline cycle in plants by uncoupled expression of proline of proline oxidation enzymes. J. Biol. Chem. 284, 26482-26492.
35) Mountousis, I., Dotas, V., Stanogias, G., Papanikolaou, K., Roukos, C. and Liamadis, D. (2011): Altitudinal and seasonal variation in herbage composition and energy and protein content of grasslands on Mt Varnoudas, NW Greece. Animal Feed Science and Technology, 164, 174-183.
36) Munns, R., and Tester, M. (2008). Mechanisms of salinity tolerance. Annul. Rev. Plant Biol. 59: 651–681.
37) Oliveira, N., Lobato, A., Costa, R., Maia, W., Santos, F., Alves, G., Brinez, B., Neves, H., Lopes, M. and Cruz, F. (2009): Nitrogen compounds and enzyme activities in sorghum induced to water deficit during three stages. Plant, Soil and Environment 55: 238-244.
38) Omar, K., Khafagi, O. and Elkholy, M. A. (2012): Eco-geographical analysis on mountain plants: A case study of Nepeta septemcrenata in South Sinai, Egypt. Lambert Academic Publishing, 236 pp.
39) Perry, G. L. W. et al. (2006): A comparison of methods for the statistical analysis of spatial point patterns in plant ecology. – Plant Ecol. 187: 59-82.
40) Purves, D. W. and Law, R. (2002): Fine-scale spatial structure in a grassland community: quantifying the plant's-eye view. Journal of Ecology 90: 121-129.
41) Richardson, A. D. (2004): Foliar chemistry of balsam Þr and red spruce in relation to elevation and the canopy light gradient in the mountains of the northeastern United States. Plant Soil 260: 291Ð299.
42) Ruggiero, L. F., Hayward, G. D. and Squires, J. R. (1994): Viability analysis in biological evaluations: Concepts of population viability analysis, biological population, and ecological scale. Conservation Biology 8: 364–372.
43) Said, M. I. and "in part" Ramzy, M. A. (1964): Sucrose determination as a mean of estimations of the "Drown Back Tax" on exported Halawa Tehinia., Bull. fac. sci., Cairo Univ., 39: 209.
44) Salmore, A. K., and Hunter, M. D. (2001): Elevation trends in defense chemistry, vegetation, and reproduction in Sanguinaria canadensis. J. Chem. Ecol. 27: 1713Ð1727.
45) Snedecor, G. M. & Cochran, W. G. (1982): Statistical methods-7th edition, low a state Univ., Press, Ames. loww3a, USA. pp. 325-330.
46) Spitaler, R., Schlorhaufer, P, D., Ellmerer, E, P., Merfort, I., Bortenschlager, S., Stuppner, H. and Zidorn, C. (2006): Altitudinal variation of secondary metabolite profiles in flowering heads of Arnica Montana cv. ARBO. Photochemistry 67:409–417.
47) Tan, D., Wearing, A., Rickert, K. and Birch, C. (1999): Broccoli yield and quality can be determined by cultivar and temperature but not

photoperiod in south-east Queensland. Australian Journal of Experimental Agriculture 39: 901-909.

48) Tegelberg, R. and Julkunen-Tiitto, R. (2001): Quantitative changes in secondary metabolites of dark-leaved willow (Salix myrsinifolia) exposed to enhanced ultraviolet-B radiation. Physiologia Plantarum 113:541–547.
49) Vernon, L. P. and Selly, G. R. (1966): The chlorophylls. Academic press. New York and London.
50) Yarnes, C. T. and Boecklen, W. J. (2005): Abiotic factors promote plant heterogeneity and influence herbivore performance and mortality on Gambel's oak (Quercus gambelli). Entomologia Experimentalis et Applicata. 114: 87-95.
51) Zhang, W., Gerger, A., Labonte, M.J., Yang, D., Bohanes, P.O., Ning, Y., Winder, T., Wilson, P.M.D., Benhaim, L., El-Khoueiry, R., El-Khoueiry, A.B., Iqbal, S., Giamas, G., Stebbing, J. and Lenz, H.J. (2012): Association of gender-related tumor recurrence with a polymorphic variant of LMTK3 in stage II and III colon cancer. J Clin Oncol 30, (suppl 4; abstr 454): 2012; -2012 Gastrointestinal Cancers Symposium. San Francisco, USA.