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Research Paper

MONITORING OF POPULATION DYNAMICS OF THE *Acacia* SPECIES POPULATIONS IN SOUTHERN SINAI, EGYPT

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Abstract

The present study aimed to assess the impact of fencing of *Acacia* tress inside enclosures on grow th and productivity against unfenced trees, and selecting an appropriate number of *Acacia* populations in the area that would represent the most important variations in the physiographic structure in order to conserve the current populations. Thirteen enclosures have been built in order to monitor the changes before and after fencing; six in Wadi Mandar and seven in Wadi Lithi. The results revealed that the mean values of growth parameter of the fenced *Acacia* trees were significantly higher than those values of unprotected trees. It is shown also that the average weight of seeds collected from W. Mandar was higher than those collected from W. Lithi and the highest germination percentage was that of sulphuric acid and the physical scarification treatments. In the meantime, fencing led to increase the soil organic matter and seed bank inside the enclosures and this would protect the species and give the chance for threatened species to appear and grow in the near future. The study came out with a highly recommendation for managing the grazing practice by the local Bedouins in the area.

Key words: Population dynamics, South Sinai, *Acacia*, W. Mander, W. Lithi.

INTRODUCTION

The genus Acacia with about 1350 species is considered the second largest in the family Leguminosae. It is distributed throughout warm temperate and tropical areas of the world, with its largest concentration in Australia (ca 957 species), the Americas (ca 185 species), Africa (144 species) and Asia (89 species). *Acacia tortilis* ssp *tortilis* is the most dominant tree species in Sinai desert followed by subspp. *raddiana. Acacia tortilis* and associated vegetation have long been subjected to over-grazing, cutting, uprooting of shrubs and sub-shrubs for fuel. Drought and lethal cutting are the main mortality factors in south Sinai. There is a widespread concern

over the high mortality and low recruitment of *Acacia* trees in arid and hyper arid ecosystems [1] [2]. This mortality is possibly unmanaged anthropogenic activities including aquifer depletion for agriculture, grazing, cutting for different purposes and quarrying have major impacts on *Acacia* tree survival [3]. *Acacia* trees also suffer extraordinarily high levels of infestation by bruchid beetle, which subsequently diminishes the probability of germination of the seeds, increases the mortality of mature trees and reduces natural recruitment [4]. High mortality in desert trees combined with lack of recruitment will endanger tree populations and services provided by this keystone species [5].
Recently some studies have focused on the vegetation of southern Sinai [6] and [7], including two studies on *Acacia tortilis* [8] [9]. The present study is primarily focused on how to conserve the threatened populations of *Acacia* species in most two deteriorated wadis in South Sinai and to evaluate the impact of fencing against the grazing on the *Acacia* trees populations in South Sinai, and selecting an appropriate number of *Acacia* populations in the area that would represent the most important variations in the physiographic structure in order to conserve the current populations.

MATERIALS AND METHODS

Study Area

The present study was carried out in southern part of Sinai, which is one third of the Peninsula in which the basement rocks occupy more than 80% of the area and are mainly of granitic composition. South Sinai is a very cool area due to its high elevation; the general features of the climate of the study area may be approximated from the recorded data in the period January to November 2014 obtained from International Airport (Sharm El Sheikh, Egypt). The lowest minimum temperature was recorded in February (5^{o}C), while the highest maximum temperature was in June (43^{o}C). The present study is carried out in two main localities of South Sinai; W. Mandar and W. Lithi (Figure 1).

1. Wadi Mandar

The width of the main wadi is around 100 m, dominated by fifty-nine trees were fenced in six main enclosures located in this wadi. The area of each enclosure was varied according to the number of *Acacia* trees as target species, where the smallest enclosure was around 656.5 m^2 with only two trees while the largest one was 5735 m^2 dominated by with seven *Acacia* trees. Although, enclosure number 1 is not the largest enclosure, but it is considered as the most densely enclosure with 18 trees (Table 1).

2. Wadi Lithi

The length of the wadi reaches about 35 km, fifty-two trees were fenced in seven main enclosures located in W. Lithi. The smallest enclosure is about 634.0 m^2 in area with only four trees whereas the largest one is 2517.36 m^2 with twenty-one tree of *Acacia* (Table 1).

Description of Enclosures

Thirteen main populations of *Acacia* were fenced as enclosures to prevent grazing (six enclosures in W. Mandar, and seven in W. Lithi). Choosing of the location and size of each enclosure was based upon several criteria including physiognomy and habitat features as well as density, vitality, morphology, and number of trees. In each enclosure, a number of basic parameters were measured including the number of trees, associated species, GPS readings, and area of each enclosure. For each tree, a number was given and six parameters were measured which are; height, (CAG), (CBH), crown cover, the number of branches, and vitality of tree plant. A modified scale from [10], [11] and [12] for tree vitality was done based on five-degrees as follows: 5= excellent healthy plant or vigour; 4= normal or with yellow lower leaflets, 3= slightly yellow in the lower leaves, 2= moderately yellow, 1= absolutely yellow dry plant, and 0= brown or nearly dead.

Propagation

The pods of *Acacia tortilis* were collected from W. Mandar, located near Sharm El-Sheikh area in South Sinai during summer season in a paper bag and kept in a refrigerator at 10 ^{o}C. Ten seeds were randomly chosen and then tested for viability by using tetrazolium salt solution (0.007

gm/L) [13]. The next step was counting of viable and non-viable seeds. The viable seeds have violet colour embryo, while the non-viable seeds have yellow one.
Due to a waxy and hard or stony testa of *Acacia tortilis,* different treatments were applied in order to break the dormancy. The treatments include: manual soaking for 5, 15, 20, and 25 minutes with gravel and coarse sand, boiling in water for 0, 5, 10, and 15 minutes then leaving till cooling, boiling in water for 0, 5, 10, and 15 minutes then leaving till cooling and soaking (in the same water) for 24, and 72 hours, soaking in hot water for 5 minutes and then in cool water for another 5 minutes for one, two, and three turns and finally, soaking in concentrated sulphuric acid H_2SO_4 for 5, 10, 15, 20, and 25 minutes then washing thoroughly.

Soil Analyses

A number of soil samples per each stand were collected as a mixture of 0-25 cm depth for physical and chemical analysis according to [14]. Moisture content, organic matter, Soil pH, EC, TDS and water holding capacity were measured. Particle size analysis was determined by dry sieving for the coarse sand and by pipette method for fine sand, silt, and clay [15]. Inorganic carbonate in soil was analyzed using a volumetric calcimeter method [16].

Statistical treatment

The mean values of the vegetation parameters at the first reading of monitoring were compared with the mean values of the vegetation parameters of the second reading after fencing to show the differences between the two readings by **t**-test using Minitab 15. The variation in the vegetation parameters throughout the enclosures and between two main readings of *Acacia* trees (before and after protection) were estimated by analysis of variance (ANOVA), following [17].

RESULTS

Imapct of fencing on vegetation parameters

In W. Mander, the height of unprotected trees compared with the trees that present inside enclosures showed that the mean height of these trees increased from 4.9 m to 5.45 m. The same as the height of all protected *Acacia* trees in W. Lithi had been increased.
The mean of the crown cover area of *Acacia* trees in W. Mandar enclosures increased from 58.6 m^2 to 70.9 m^2. The mean difference between the crown cover area of the two records (first reading and second reading) was increased of about 19.2 m^2. Also the mean crown cover of *Acacia* trees in W. Lithi enclosures increased from 62.79 m^2 to 73.5 m^2 (Table 2).
The mean circumference of *Acacia* trees in W. Mandar enclosures had increased from 90.4 cm to 112 cm as CAG (circumference at ground level), and from 76.58 cm to 89.1 cm as CBH (circumference at breast height). The mean circumference of *Acacia* trees in W. Lithi enclosures increased from 98.9 cm to 107 cm as CAG (at ground level), and from 73.94 cm to 83.2 cm as CBH (at breast height) during the study period, (Table 2).
By comparing the observations recorded for the fenced *Acacia* trees in W. Mandar with those kept outside the enclosures, one can say that mean number of branches of *Acacia* trees that fenced inside its six enclosures had increased from 4.45 to 7.88. Also the same result was found at W. Lithi where the mean number of branches of *Acacia* trees inside its seven enclosures had increased from 4.5 to 7.3 (Table 2).
The mean of the vitality of *Acacia* trees in W. Mandar enclosures was increased from 2.7 to 3.8 and that of *Acacia* trees in W. Lithi enclosures also increased from 3.0 to 4.2 (Table 2). By comparing the mean vitality of the trees occurred outside the enclosures with fenced trees, it is found that the vitality value decreased in second records from 3.6 to 3.1.

Propagation

Viability, infection and dormancy of seeds

The results showed that 40 % of *Acacia* seeds in W. Mandar, and 50 % of those in W. Lithi are viable, especially when seeds are soaked in water for 24 hours (before soaking in tetrazolium salt solution). This viability percentage increased to attain 90 % in W. Mandar, and 80 % in W. Lithi through soaking seed in water for 12 hours only. In addition, the highest percentages of

viable seeds were 100 % and 96.7% when seeds of *Acacia* were scratched by sand paper or by scratching and boiling water for 5 minutes together respectively.
The results of estimating the infected seeds indicated that 15.96 % of the collected seeds from W. Lithi were infected, while only 8.4 % of collected *Acacia* seeds from W. Mandar were infected. It is shown also that the average weight of seeds collected from W. Mandar 92.32 kg. was higher than those collected from W. Lithi 78.87 kg.
The results of dormancy indicated that the highest germination percentage was at sulphuric acid treatment soaking for 20 and 25 minutes, 93% and 83% respectively On the other hand, the physical scarification treatments showed that manual shacking for 10 minutes or boiling in water for 5 minutes and soaking for 24 hours were the best and easiest method to be applied by Bedouins in their gardens (Figure 2)

Soil Analysis

The mean values of soil parameters for the soil samples collected at zero time and after fencing are presented in. It was found that there is no difference between soils collected from both wadis. The saturation percentage of soil varied between 9.50 to 12.5% in soil of W. Mandar and between 10 –15.5 % in W. Lithi. The soil pH values ranged between7.03 – 7.79 in soil of W. Mandar and 7.28 – 7.79 in Wadi Lithi. The mean of electric conductivity ranged between 109 – 953 µs in soil of W. Mandar and 0.064 - 2.947 µs in W. Lithi. In the mean time, carbonate percentage ranged between 4.50 – 8.2 % in soil of W. Mandar and between 7.40 – 12.30 % in W. Lithi (Table 3).
After three years of fencing, and based on the comparison results output by **t**-test between soil parameters before and after protection, it is found that protection increased the soil content of gravel, soil organic matter, matter and carbonates percentage significantly in both wadis (Table 4).

Table 1. Summary table includes the dimension, area, number of tress and GPS reading of each enclosure in the two main Wadis (Mandar and Lithi).

Location	Encl. No.	Area (m^2)	No. of trees	GPS reading	
				N	E
W. Mandar	1	4884	18	28° 6' 44.4"	34° 15' 10.4"
	2	656.6	2	28° 6' 34.4"	34° 15' 5.8"
	3	1986.9	8	28° 6' 49.9"	34° 13' 55.4"
	4	5735.2	7	28° 6' 40.4"	34° 13' 43"
	5	2127.5	10	28° 6' 22.9"	34° 11' 36.3"
	6	5310	9	28° 6' 47"	34° 10' 34.7"
W. Lithi	1	1329.9	4	28° 4' 13"	34° 15' 70"
	2	2517.36	21	28° 4' 20"	34° 12' 53"
	3	634	4	28° 3' 23"	34° 13' 20"
	4	1443.56	4	28° 3' 1.6"	34° 11' 45.2"
	5	2045.4	5	28° 3' 4"	34° 11' 41.1"
	6	1448.4	4	28° 3' 22.6"	34° 11' 25.1"
	7	1097.6	6	28° 3' 23.6"	34° 11' 19.7"
Total	**13**	**3126.42**	**102**		

Table 2. Paired t-Test and the analysis of variance (one way ANOVA) for the growth parameters before and after *Acacia* fencing.

	Tree Height				Crown Cover area (m^2)				Circumference CAG (cm)				Circumference CBH (cm)				No. of Branches				Vitality			
	Wadi Mandar		Wadi Lithi		W. Mandar		Wadi Lithi		W. Mandar		Wadi Lithi		W. Mandar		Wadi Lithi		W. Mandar		Wadi Lithi		W. Mandar		Wadi Lithi	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Mean	4.9	5.45	5.9	6.4	58.6	70.9	62.8	73.5	90.4	112	98.9	107	76.6	89.1	73.9	83.2	4.45	7.88	5.44	8.02	2.7	3.8	3	4.2
M. Diff.	0.55		0.5		12.3		10.7		21.6		8.1		12.5		9.3		3.43		2.58		1.1		1.2	
St.Dev.	2.551	2.633			4.906	5.42			5.67	5.70														
SE Mean	0.332	0.343			0.687	0.75			0.73	0.74														
T-Test																								
T-value	3.72				10.76				11.23				11.43				7.07				10.41			
P-value	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
One-way ANOVA																								
F-value	74.77				54.02				1333.32				1019.94				16.56				8.76			
P-value	0.000		0.000		0.0003		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	

(1st: The reading before fencing, 2nd: The reading after fencing).

Table 3. Summary table shows the mean values of soil parameters after 3 years of fencing at two main wadis; Mandar and Wadi Lithi.

Location	Enc. No.	Nature of soil surface				Saturation %	Organic matter (%)	pH	EC (S/m)	Carbonate %	Salinity (ppm)
		Sand	Gravel	Cobbles	Boulders						
Wadi Mandar	1	14.2	36.5	17.2	0.0	09.50	1.71	7.55	0.195	08.20	0.60
	2	16.3	33.1	18.1	0.2	11.15	3.95	7.79	0.211	06.30	0.30
	3	19.2	32.5	15.6	0.1	11.75	2.36	7.42	0.139	04.50	0.20
	4	19.3	30.6	13.5	0.5	10.75	1.31	7.79	0.213	07.30	0.40
	5	21.2	34.2	18.5	0.3	12.50	2.22	7.03	0.109	06.70	0.20
	6	13.1	29.3	14.3	0.0	09.75	3.12	7..51	0.953	06.20	0.30
Wadi Lithi	1	12.3	36.2	18.2	0.0	11.00	2.22	7.79	0.159	09.31	0.61
	2	14.4	31.9	20.2	0.2	10.95	1.95	7.78	0.148	08.30	0.32
	3	16.7	32.2	23.5	0.3	11.25	2.89	7.77	0.064	07.40	0.35
	4	19.3	29.2	18.9	0.4	11.50	2.76	7.69	2.947	10.31	0.42
	5	16.6	36.5	17.5	0.0	10.00	2.57	7.74	0.210	12.30	0.45
	6	17.2	33.1	21.6	0.0	10.50	5.03	7.51	0.500	10.41	0.61
	7	13.1	30.2	21.5	0.0	15.50	5.43	7.28	0.351	09.21	0.42

Table 4. The output results of t test between the first and second readings of the soil parameters recorded at Wadi Mandar. And W. Lithi

Wadi Mandar										
Parameter		**Pairs**	**Paired Differences**					**t**	**df**	**Sig. (2-tailed)**
			Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference**				
						Lower	**Upper**			
Soil Surface	Sand	Second - First Reading	-1.67	2.97	1.21	-4.78	1.45	-1.38	5	0.2271
	Gravel	Second - First Reading	6.18	2.98	1.22	3.05	9.32	5.07	5	0.0039
	Cobbles	Second - First Reading	0.12	0.60	0.25	-0.52	0.75	0.47	5	0.6564
	Boulders	Second - First Reading	-0.02	0.04	0.02	-0.06	0.03	-1.00	5	0.3632
Saturation %		Second - First Reading	0.29	0.55	0.22	-0.29	0.86	1.28	5	0.2568
Organic matter %		Second - First Reading	1.64	0.73	0.30	0.88	2.41	5.52	5	0.0027
pH		Second - First Reading	-0.16	0.30	0.12	-0.48	0.16	-1.28	5	0.2558
EC (µS)		Second - First Reading	-0.03	0.17	0.07	-0.20	0.15	-0.41	5	0.6960
Carbonate %		Second - First Reading	3.15	2.96	1.21	0.05	6.26	2.61	5	0.0477
Salinity (ppm)		Second - First Reading	-0.04	0.11	0.04	-0.15	0.08	-0.80	5	0.4575
Wadi Lithi.										
			Paired Differences							

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Parameter		Pairs	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
						Lower	Upper			
Soil Surface	Sand	Second - First Reading	0.21	1.57	0.59	-1.24	1.67	0.36	6	0.7302
	Gravel	Second - First Reading	4.56	6.39	2.42	-1.36	10.47	1.89	6	0.1083
	Cobbles	Second - First Reading	-6.81	2.31	0.87	-8.95	-4.68	-7.82	6	0.0000
	Boulders	Second - First Reading	-0.04	0.13	0.05	-0.16	0.07	-0.89	6	0.4072
Saturation %		Second - First Reading	1.88	1.39	0.52	0.59	3.16	3.58	6	0.0116
Organic matter %		Second - First Reading	1.48	1.00	0.38	0.56	2.41	3.91	6	0.0079
pH		Second - First Reading	-0.22	0.37	0.14	-0.56	0.12	-1.59	6	0.1624
EC (µS)		Second - First Reading	-0.48	1.03	0.39	-1.43	0.47	-1.24	6	0.2620
Carbonate %		Second - First Reading	0.48	1.71	0.65	-1.10	2.07	0.74	6	0.4844
Salinity (ppm)		Second - First Reading	-0.12	0.21	0.08	-0.32	0.08	-1.50	6	0.1840

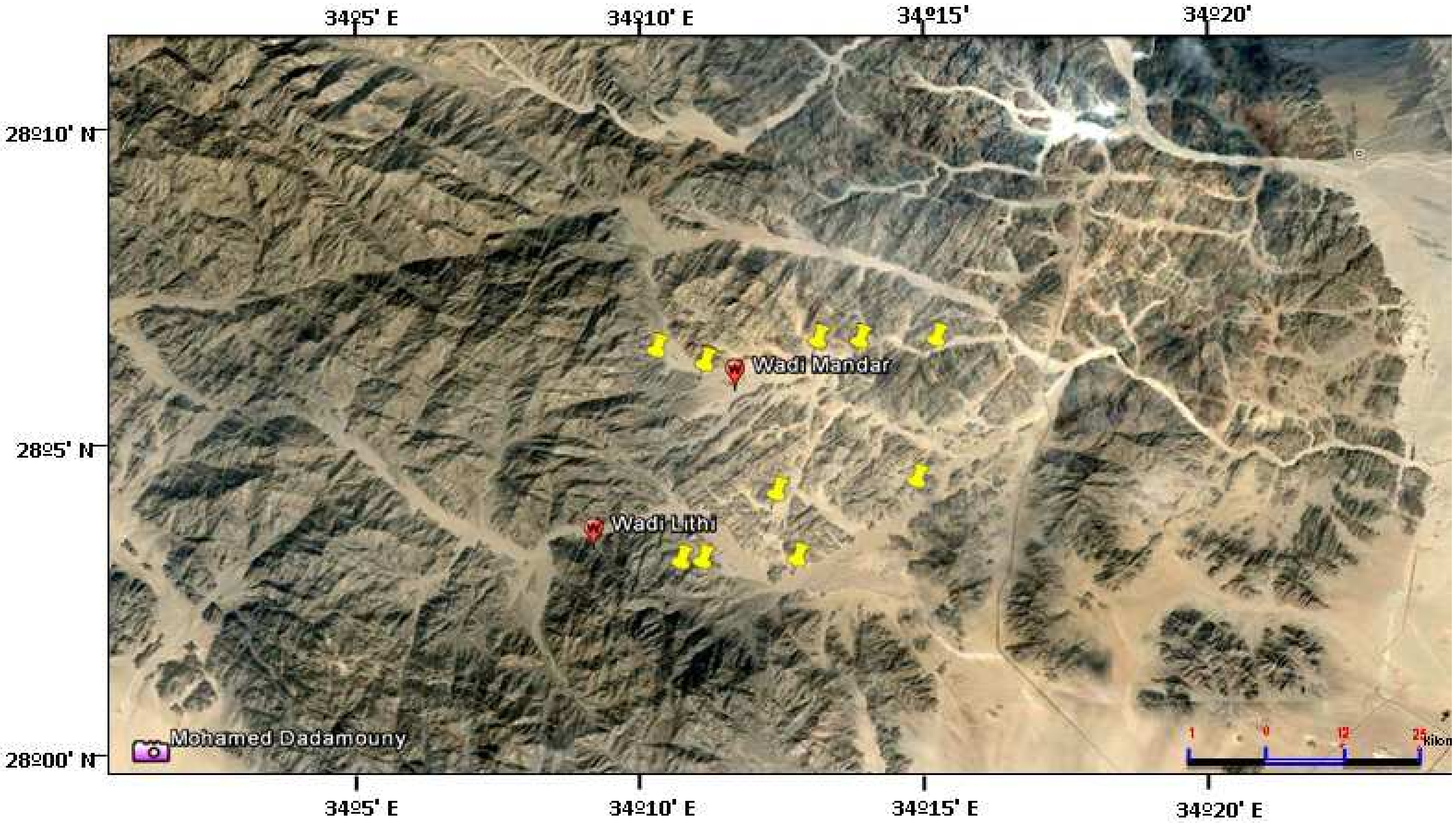

Figure 1. Location map showing the two studied wadis in which *Acacia* trees were fenced, W. Mandar and W. Lithi.

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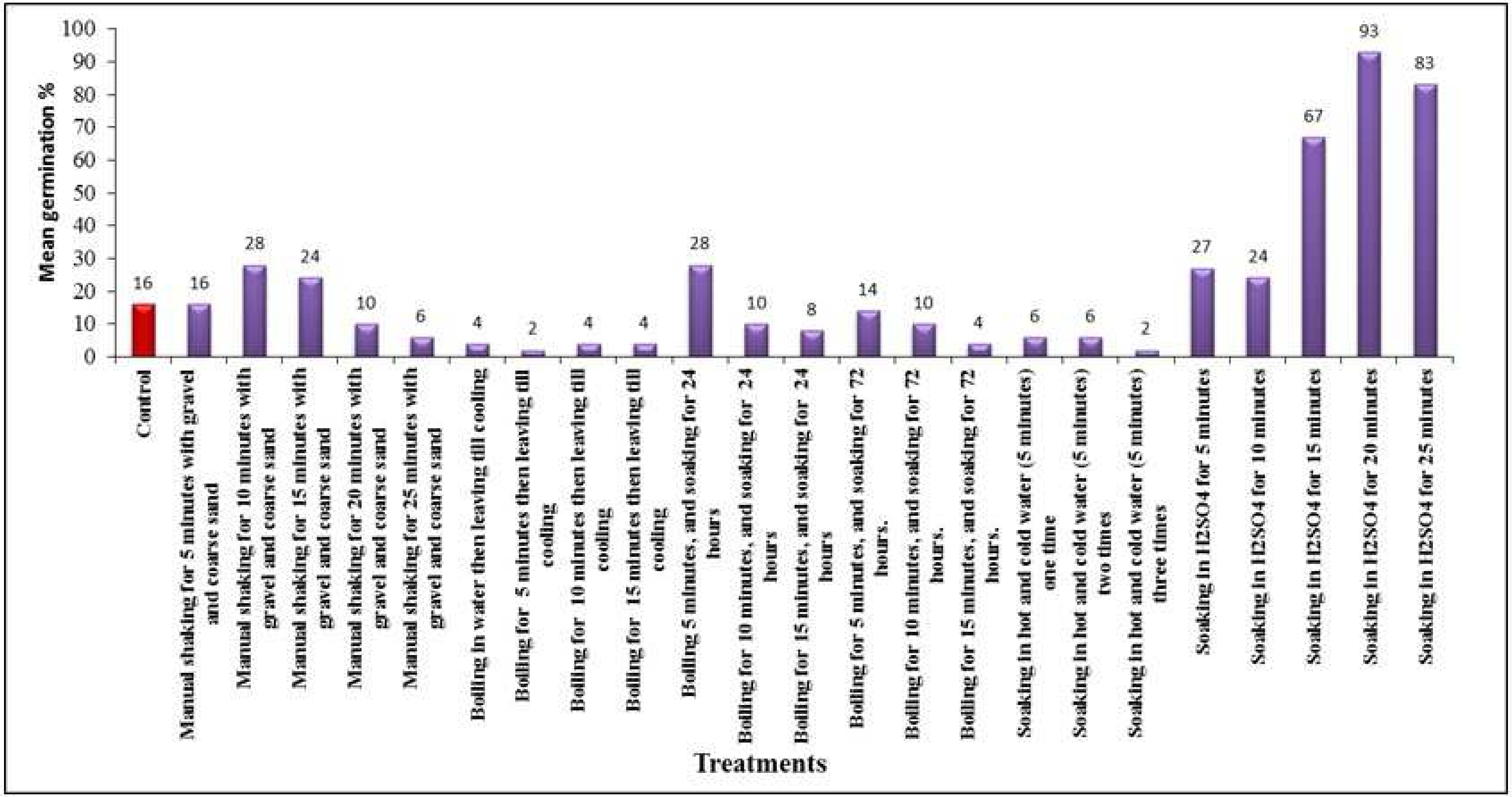

Figure 1. Location map showing the two studied wadis in which *Acacia* trees were fenced, W. Mandar and W. Lithi.

DISCUSSION

Generally, *Acacia* species all over the world were subject to various important economic studies such as the growth, seed perdition, production and germination of *Acacia* [18], [19], [20], [21], [22] and [23]. On the other hand, many studies have been carried out to investigate the regeneration, distribution and succession in the shrub *Acacia* in different parts of the world [24], [25] and [26]. It is well known that *Acacia* spp. are widely distributed in the Middle East and can survive under harsh environments [27], [28], [29] and [30].

In the last thirty years, the wild vegetation of South Sinai has been endangered in many forms, such as disappearance of palatable species, rarity of trees, and change in vegetation composition as well. The main threats that are affecting the vegetation include the cutting trees for fuel, collecting plants for medical uses, developing projects on a large scale, and over-grazing. *Acacia* is one of the most important trees in the Egyptian desert due to its multipurpose in the Bedouin's life. In the meantime, this tree is under large stress such as cutting, grazing, failure in establishment, and infection of seeds by different insects and fungi and developmental projects that are including constructions of houses and hotels on large scales.

However, sustainable development and conservation policies should be in action to protect our main components of biodiversity. In fact, conservation is primarily a precondition stage for starting saving policy for our plants. Due to the huge stresses on *Acacia*, it was necessary to focus on the following: (1) conserving the most threatened populations of *Acacia*, (2) Investigating the seed germination of *Acacia* (the best treatment to attain the highest germination percent), and (3) studying and monitoring the impact of fencing against the grazing on the *Acacia* trees in Wadi Mander and Wadi Lithi.

Based on the results of this study, one can conclude that the conservation of *Acacia* trees have been succeed in increasing significantly their vegetation due to protection against over-grazing and cutting threats [31], [32]. Virtually all vegetation parameters; (tree height, circumference at ground level (CAG), circumference at breast height (CBH), crown cover area, number of branches, and vitality) were showed a highly significant differences by **t**-test between the two records (before and after fencing).

Actually, the statistical analysis of the differences between the first readings (at starting time) and the second readings after fencing by using ANOVA (one way) revealed that all vegetation parameters of *Acacia* trees located at Wadi Mandar showed non- significant variation except vitality and number of branches, whereas the analysis of starting time data recorded at Wadi Lithi showed that the whole vegetation parameters offered highly significant variations except the number of branches; did not show any variation. On the other hand, the whole vegetation parameters showed significant variations at wadi Lithi except vitality. In Wadi Mandar, only three vegetation parameters (tree height, crown cover area, and number of branches) showed significant variations after protection. In the meantime, the statistical output of data recorded after three years protection showed that tree height, crown cover area and number of branches are significantly varied at wadi Mandar, while all vegetation parameters at Wadi Lithi showed highly significant variations except the vitality.

In fact, fencing and using enclosures' technique was very helpful and powerful to let the perennial species as associated species to *Acacia* appear again in the area. One can say that the number of recorded species before fencing changed from six to thirty-six species after three years only. The list of species appeared after protection are: *Achillea fragrantissima, Aerva javanica,Artemisia herba-alba*, *Asclepias sinaica*, *Astragalus asterias, Atraphaxis spinosa*, *Ballota kaiseri, Ballota undulata, Bituminaria bituminosa, Blepharis ciliaris, Capparis sinaica*, *Caylusea hexagyna, Chrozophora tinctori, Citrullus colocynthis, Cleome amylocarpa, Cleome dorserifolia, Crassula alata, Crotalaria aegyptiaca, Crucianella ciliata, Cynodon dactylon, Deverra triradiata, Diplotaxis harra*, *Echinops glaberrimus, Echinops spinosissimus, Fagonia arabica, Fagonia mollis, Forsskaolea tenacissima*, *Galium sinaicum*, *Glaucium arabicum* and *Globularia arabica*.

General speaking, these species are very difficult to be found outside enclosures due to their high palatability to animals and medicinal uses by Bedouins. However, the appearance of such list of associated species will reduce the high intensity of infection by insects to *Acacia* populations. In agreement with [33] that we are destroying species, habitats and perhaps even the life-support system of the planet by our irresponsible behaviour is a depressing thought.

The second main target in the present study was how to get the maximum or the highest possible percentage of germination? The hard seed coat of many leguminous species (including *Acacia*) has evolved to with stand such unfavourable conditions as heat caused by fire, drought, strong teeth of dispersing animals, severe drought and mechanical damage [34]. Therefore, severe treatments are required to make the seed coat permeable to water.

Several pre-sowing treatments have been used to overcome hard seed coat imposed dormancy and these are studied in details by different researchers [34], [35], [36], [37] and [38]. The main purpose of all these treatments is to make the coat permeable to water by acting on specific weak spots of the hard seed coat. The most common pre-sowing treatments, mechanical, acid and hot water scarification treatments are widely used since it provide good results within a relatively short period of time [34].

The present results of seed viability can summarized as follow; the highest viability was 100 % the pre-treatment's of scratching and scratching then soaking in boiling water for 5 minutes increased the viability percentage to in both pre-treatment at Wadi Mandar, and (100 %) with scratching, (96.7 %) with scratching then boiling for 5 minutes at Wadi Lithi. For seed germination, [39] and [40] found that abrasion by sand and chemical scarification by concentrated sulphuric acid for short periods induced a rapid germination to a high percent. [41] found that germination of *Acacia* seeds by disturbing the aril by prolonged heating at 60 ºC or by a scalpel is the most satisfactory method. Seeds of *Acacia farnesiana* treated with sulphuric acid showed the highest germination percent (89 %) while that treated with boiled water showed 76%[42]. Our present results in agreement with [42], but with more success in breaking dormancy of *Acacia* seeds were soaking in H_2SO_4 for 20 minutes which reach (93 %).

All over this study, the soil analysis revealed expected results that there are no differences between the soil samples collected from the Wadi Mandar and Wadi Lithi because they are closely related to each other in the distance. Finally, one can conclude that fencing the threatened *Acacia* populations was very productive technique to protect *Acacia* in the area and to help the new seedlings of *Acacia* and other perennial species to grow. In the meantime, fencing will increase the soil organic matter and seed bank inside enclosure and this would protect the species and give the chance for threatened species to appear and grow in the near future. Our main recommendations include: (1) more ecological studies on the threatened species should be done beside any proposed conservation plan or action, (2) wise management plan for grazing practise should be in action in the studied area, and (3) more attention should be focused on the social problems of local Bedouins in the area.

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