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Medicinal plants in Cyrenaica, Libya: existence and extinction

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Abstract

Cyrenaica is a distinguished region located in the south of the Mediterranean region. Eighty-nine plant taxa were collected and identified as having medicinal properties from four main valleys in Cyrenaica in 2001 and 2013. Collections included the same 47 families in both years, dominated by Lamiaceae (9%) followed by Apiacea (8%) and Asteraceae (7%); only two of these species collected were endemic. Species frequency was assessed in both years and showed a dramatic decrease in 25 taxa over all sites. Regression analysis was applied to determine which plant families in Cyrenaica are more likely to contain species with medicinal compounds. Climate change was clearly noticeable in the last few decades; metrological data showed an increase in the mean monthly temperate and a decline in the annual rainfall over the whole area. This study concludes that there is a significant diversity of medicinal plant species on the southern edge of the Mediterranean which is being disturbed and some of wild native plant species could be under threat. Findings of this work suggest that conservation strategies should take place urgently; and suggest a number of important strategies that could be effective to preserve the plant community structure in this area.

Key words: Mediterranean; plant diversity; endangered species, medicinal plants, climate change, Cyrenaica

1. Introduction

The county of Cyrenaica occupies about 500 000 km² which is equal to one third of the total area of Libya, the coastal belt is about 7% of the whole county (Boulos, 1972). The coastal sector of this county receives an adequate amount of rainfall in winter (see below), which exhibits the typical Mediterranean flora, and that includes about 1582 vascular species distributed in 709 genera and 116 families, contains 75 endemic species (Ali and Jafri, 1977; Jafri and El-Gadi, 1986).

Recent vegetation studies showed high plant diversity over the whole sector, and Cyrenaica is a typical Mediterranean spot located on the south coast of the sea in North Africa (Sherif *et al.*, 1991; El-Barasi *et al.*, 2003; El-Barasi *et al.*, 2011; Mukassabi *et al.*, 2012). Moreover, the majority of wild plants in North Africa have a potential value for medicinal and biotechnology use (UNEP, 2002). However, a change in the vegetation in this fragile ecosystem can take place due to factors such as climate change, urbanisation and destruction of natural vegetation, overgrazing, increase in the rate of dryland degradation, and desertification (MEA, 2005; Saad *et al.*, 2011; El-Barasi and Saaed, 2013).

More than 70 000 plant species over the world are considered as medicinal plants or at least involved in folk ethnotherapy (IUCN, 2008). The history of wild plant exploration in Cyrenaica in northeast Libya was first discussed by Durand and Barratte (1910) and Pampanini (1931). Boulos (1972), Ali and Jafri (1977), Jafri and El-Gadi (1986) and El-Gadi (1989) published different volumes on flora including all plants growing in Libya, including plants of Cyrenaica. However, medicinal plants in Libya were first briefly mentioned in a UNESCO report (UNESCO, 1960). Kotb (1985) reviewed 352 wild and cultivated medicinal plant species grown in Libya and described in detail the parts used and particular medicinal effect of those plants. On a similar matter, El-Gadi and Hossain (1986) discussed the morphological description and active substance materials of 93 wild poisonous plant species in Libya. As a sector of the Mediterranean region, medicinal plant species widely grow in various habitats in Cyrenaica; representing a rich component of the biological diversity of the region (Mukassabi *et al.*, 2012). However, due to the continuous use of the

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folk ethnotherapy in the last few decades, many species of these plants appear to be threatened and some are on the brink of extinction (Louhaichi *et al.*, 2011; El-Barasi and Saaed, 2013; El-Mokasabi, 2014).

Nevertheless, despite the frequent use of these plants, there are gaps of knowledge about the medicinal plants in the region including their autecology, distribution, productivity and possibility of cultivation. It is indispensable to undertake studies on these plants and investigate methods of conservation (El-Barasi and Saaed, 2013; El-Mokasabi, 2014).

The aim of this work is to survey medicinal plants in four main valleys in Cyrenaica and to 1) assess the changes in species frequency of those plants over 12 years, and 2) investigate which life-form spectrum is most represented in the medicinal plants in the area studied.

2. Materials and methods

1.1. *Area of study*

Three main valleys were mainly investigated in terms of species frequency and another valley was surveyed and notes were recorded.

Site 1: Wadi Zaza: The valley is located in southwest of the Cyrenaica region (Fig. 1). It lies between 20° 45' and 20° 30' E, 32° 15' and 32° 30' N. The Zaza Valley runs 38 km from north to south, rising from the sea level in the north to 380 m in the south. It is only 55 km east of Benghazi.

Site 2: Wadi Al Ager: located eight km south of Al-Marj, on the eastern edge of Al-Jabal Al-Akhdar mountain, it extends 60 km to the south-east and is located between 20º 45' and 21º 15' E, 32 º 00' and 32º 30' N (Fig. 1). The soil is clay (Redsina) in the north of the valley, and drier in the south.

Site 3: Wadi Jarjar Amma: located at 32º 47´ N, 21º 28´ E and elev. 0-380 m (Fig. 1), 25 km south of the Qaser Libya area and 7 km west of Al Haniyah. The valley is about 20 km long and ranges between 1 and 6 km in width. Along this valley, the red upper layer of soil is mixed with calcareous gravels and rocks, and is rich in oxides and silica; the colour of soil is attributed to the high level of iron and low organic matter. Silt is the second most major component of the soil, especially on the floor of the valley, where it consists of loams, clay and gravel (Buru, 1968).

Site 4: Wadi Ras Al-Hilal: is about 14 km long, slops from the main road in Labraq 32º 51´ N, 22º 06´ to the Costal road in Ras Al-Hilal 32º 52´ N, 22º 10´ E. Elevation ranges from the sea level up to 506 m. The soil varies between clay loams to silt loam in some areas, and seems to be rich in calcium carbonate and nitrogen (Sherif *et al.*, 1991).

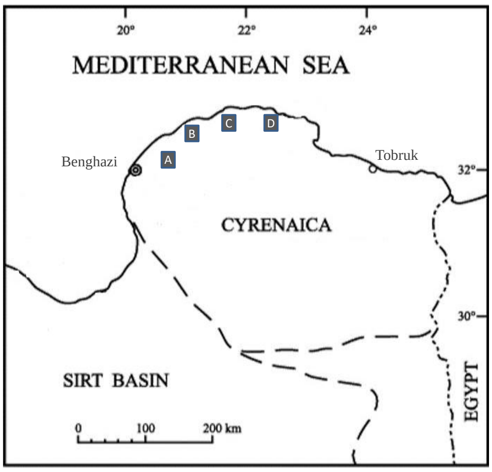

Figure 1. Location of the four valleys studied in northern Cyrenaica. A = Wadi Zaza, B = Wadi Al Ager, C = Wadi Jarjar Amma, D = Wadi Ras Al Hilal

1.2. *Climate of the area*

The climate in the Al-Jabal Al-Akhdar is mainly Mediterranean, characterised by dry summers (June-October) and relatively wet winters (November-May). The highest mean monthly rainfall in December and January is 63 and 62 mm, respectively. The mean annual rainfall is around 300 mm although very spatially erratic. Humidity rises just before spring, reaching 32% in March. The mean maximum monthly temperature reaches 41ºC in June and decreases to 21ºC and 22ºC in January and December, respectively. The lowest mean minimum monthly temperature is recorded in January and December at 6ºC and 7ºC, respectively (Benina Metrological Station, 1977-2000).

1.3. *Collections and species frequency*

Six collection trips were made to the four sites between February and May in 2001 and 2013. At least one additional collection trip to each site in each year was made between August and December. Collections included all plant species grown in the four sites.

Specimens were identified based on the Flora of Libya and checked against the African Plant Database at http://www.ville-ge.ch/musinfo/bd/cjb/africa/recherche.php (last viewed 8/2/2016). Medicinal use of all plants was based on Kotb (1985) and interviews with indigenous people. Twenty-three old local indigenous people were interviewed in order to reach a complete determination of all medicinal aspects of the folk use of plant species collected. Plant-life form was categorised based on Raunkiaer's biological spectrum (Raunkiaer, 1934). Specimens were deposited in the Cyrenaica Herbarium, Botany Department, University of Benghazi (CHUG); all specimens are identified by the tag 'MP Project'. Ten 1 m^2 quadrats were randomly arranged along two transects within the highest altitude and undisturbed areas of gentler slopes along the valley floor. Survey sites covered an area of at least 1 km^2 in each valley. Quadrats were repeated in both years in order to determine the changing frequency of both annuals and herbs.

1.4. *Statistical analysis*

A linear regression model was carried out to assess the relationship between the number of medicinal species and floral species in all plant families that contained any medicinal species. Residuals were calculated according to Kindscher *et al.* (2013). One-way ANOVA was used followed by Tukey's *post hoc* paired comparisons to assess the difference between the two years (2001-2013) in species frequency. Minitab® version 16 was used for the analysis..

3. Results

1.5. *Species collection and life-form*

A total of 569 plant species were found in the four valleys (wadis) studied, contained within 72 plant families. The Wadi Zaza site showed the highest diversity with 332 species across 56 families (Table 1). Across the four valleys, 89 medicinal plant species (in 47 families) were found which formed 16% of the wild flora of the area (Table 1; Appendix 1).

Table 1. Number of total plant species and number of medicinal plant species in the four sites studies

Site	Flora		Medicinal species	
	Species	Families	Species	Families
Wadi Zaza	332	56	49	30
Wadi Al Ager	190	47	36	24
Wadi Jarjar Amma	238	51	41	30
Wadi Ras Al Hilal	155	46	29	25
All sites studied	569	72	89	47

Only ten plant families were represented by three or more species and considered as high use plant families in folk medicine (Table 2); five more plant families were represented by only 2 species (Anacardaceae, Asparagaceae, Euphorbiaceae, Malvaceae and Zyigophylacae) and 32 families contained only one species.

One Way ANOVA showed a significant relationship between the number of medicinal species found within each plant family as a proportion of the total number of plant species found ($F_{8, 47} = 47.09$; $P < 0.001$); the more species found in the plant family, the more appearance of the plant family over the four sites (Table 2). The family of Lamiaceae showed the highest number of medicinal species (8 species) which were *Phlomis floccosa* D. Don, *Rosmarinus officinalis* L., *Marrubium vulgare* L., *Satureja thymbra* L., *Salvia fruticosa* Mill., *Thymbra capitata* (L.) Cav., *Teucrium polium* L. and *Ocimum basilicum* L. These formed 9% of medicinal plant species found in the area of study. This was followed by the families of Apiaceae (*Ammi majus* L., *Apium graveolens* L., *Conium maculatum* L., *Cuminum cyminum* L., *Deverra tortuosa* (Desf.) DC., *Eryngium campestre* L., *Thapsia garganica* L.), Asteraceae (*Artemisia campestris* L., *Artemisia herba-alba* Asso, *Carthamus lanatus* L., *Launaea nudicaulis* (L.) Hook. f., *Phagnalon rupestre* (L.) DC., *Silybum marianum* (L.) Gaertn. and Brassicaceae (*Capsella bursa-pastoris* (L.) Medik., *Eruca vesicaria* subsp. *sativa* (Mill.) Thell., *Moricandia arvensis* (L.) DC., *Raphanus raphanistrum* L., *Sinapis alba* L.) with 7, 6, 5 medicinal plant species, respectively, which form 8, 7 and 6%, respectively of the plant population (Table 1; Appendix 1).

Table 2. Number of plant species in the highest use families in the 4 sites surveyed. Sites were Wadi Zaza, Wadi Al Ager, Wadi Jarjar Amma and Wadi Ras Al Hilal, respectively. The rest of plant families were classified as low use and represented by only 2 species (5 families) or 1 species (32 families). FL= number of species in the wild flora, ME= number of medicinal species. % ME species = percentage of medicinal species per plant family over the four sites

Plant Family	Site 1		Site 2		Site 3		Site 4		All sites		% ME species	Residual
	FL	ME	FL	ME	FL	ME	FL	ME	FL	ME		
Lamiaceae	18	6	10	4	13	4	11	4	28	8	34	1.7316
Apiaceae	18	3	5	1	12	4	4	1	27	7	23	3.8065
Asteraceae	45	4	31	3	36	2	15	1	80	6	8	-1.1615
Brassicaceae	15	2	12	3	9	2	7	2	27	5	21	1.8065
Chenopodac	1	1	8	2	2	2	0	0	10	4	6	-2.0387
Fabaceae	38	3	24	2	42	1	12	1	65	4	46	2.0795
Geraniaceae	11	3	8	3	3	1	2	1	15	4	33	1.7049
Poaceae	23	1	17	1	2	2	18	0	39	3	7	-1.0918
Polygonacea	6	2	2	0	2	1	3	1	11	3	27	1.0044
Solanaceae	5	3	1	0	0	0	1	1	5	3	57	1.4536

Among the abundant plant families used in ethnobotany across the 4 valleys, the family of Lamiaceae dominated, as shown by One Way ANOVA significant differences between this family and other plant families over the area in the number of medicinal species found ($F_{10,\,40} = 3.90$; $P < 0.01$), but no differences were found with the families of Apiaceae, Asteracea, Brassicaceae and Chenopodaceae. There were no significant differences in species presence between sites.

Over the four sites studied, the number of medicinal species per plant family was regressed against the number of the wild flora species per family. The result showed a significant relationship ($P < 0.001$) with a coefficient of determination (r^2) of 0.490; this can be interpreted as 49% of the variance in the number of species used medicinally per family can be explained by the number of available species per family. Within the high use medicinal plant families, the residuals resulted in the linear regression showing high positive values for families of Lamiaceae, Apiaceae and Chenopodaceae (Table 2).

In the area of study, more than the half the species (57%) in the Solanaceae family are used for medicinal purposes, (Table 2). Moreover, the families of Chenopodaceae, Lamiaceae and Geraniaceae also had a high percentage of medicinal plants (46, 34 and 33%, respectively; Table 2). However, in some of these families very few total species were recorded.

In terms of life-form, Therophytes formed 39% (35 species) of medicinal plants found in the area of study, followed by Phanerophytes and Chamaephytes with 24% each (21 species in each) and lastly Hemicryptophytes and Cryptophytes with 8 and 6% (7 and 5 species), respectively (Fig. 2). The Phanerophytes were mostly restricted to shrubs and subshrubs since there were only nine species of tree observed: *Arbutus pavarii* Pamp., *Ceratonia siliqua* L., *Cupressus sempervirens* L., *Myrtus communis* L., *Olea europaea* L., *Pistacia atlantica* Desf., *Pistacia lentiscus* L., *Ricinus communis* L. and *Tamarix aphylla* (L.) H. Karst. (Appendix 1).

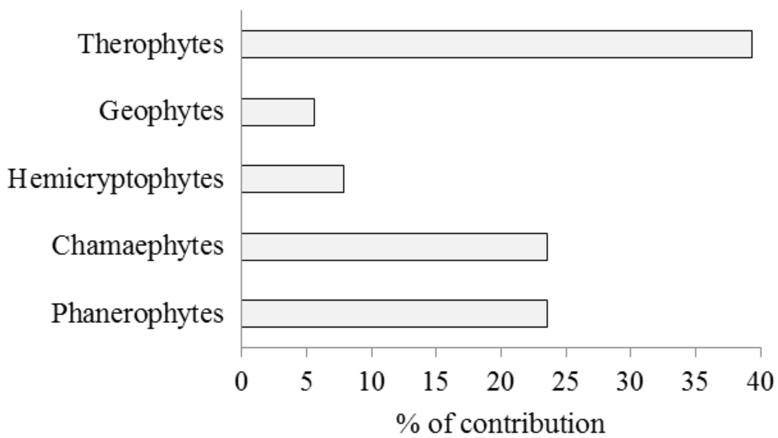

Figure 2. Percentage of contribution of plant life-form found across the four valleys studied. Categorises are based on Raunkiaer's system (Raunkiaer, 1934)

1.6. *Species frequency*

The total number of medicinal species included in our frequency assessment over the first three sites was 31 species, only three of those species were found in the 3 sites (*Erodium glaucophyllum*, *Euphorbia peplus* and *Papaver rhoeas*) and were all Therophytes; more similarity was found in sites 1 and 2, since annuals (Therophytes – 25 species) formed 81% of the plants sampled, where the Hemicryptophytes, Chamaephytes and Geophytes were only 10%, 6% and 3%, respectively (Table 3). One Way ANOVA showed significant differences between plant life-forms and number of species, since Therophytes were significantly different from Geophytes, Chamaephytes and Hemicryptophytes (Table 3). But there were no significant differences in number of frequency between species.

Table 3. Number of plant species found in the frequency trail classified based on the life-form and mean frequency rate of each category in both years. Life-forms; Ch = Chamaephytes, H = Hemicryptophytes, G = Geophytes, Th = Therophytes. sp. = number of plant species. frq = mean number of appearance in one species. Sites studied; 1 = Wadi Zaza, 2 = Wadi Al Ager, 3 = Wadi Jarjar Amma

	2001								2013							
	h	C		H		G	h	T	h	C		H		G	h	T
ite	p.	rq	p.	rq	p.	rq	p.	rq	p.	rq	p.	rq	p.	rq	p.	rq
		.0		.5		.0	2	.1		.0		.5		.0	6	.1
				.3		.0	0	.8				.0		.0	0	.4
		.0					4	.7		.0					4	.9
ll		.5		.4		.5	5	.5		.0		.2		.5	5	.5

Comparing frequency of occurrence of species between 2001 and 2013 showed a significant relationship since the linear regression showed that more than 74% of the species frequency can be explained by the current data of specie frequency (r^2 = 0.749; $P < 0.001$) (Fig. 3). Generally, species that were abundant in 2001 were still the most abundant species in 2013. However, One Way ANOVA showed that while the pattern of abundance was similar, there was a significant decrease in species frequency in 2013 over all the 4 sites ($F_{2,\ 90}$ = 7.51; $P < 0.05$). There was also a significant decrease in the mean frequency of Therophytes compared to the other three life-form groups ($F_{4,\ 90}$ = 3.25; $P < 0.05$).

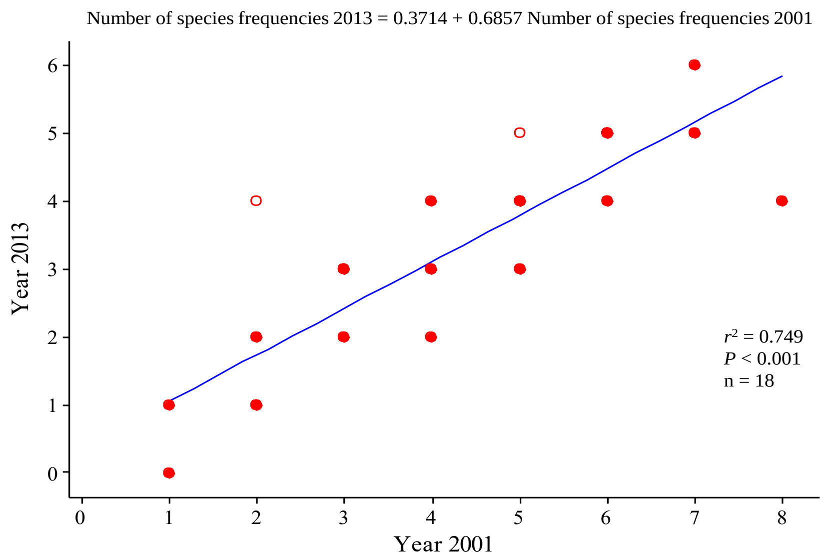

Figure 3. Linear regression showing the relationship between the number of appearance of each species in the 10 quadrats in year 2001 and the appearance of the same species in the same number of quadrats in year 2013 (r^2 = 0.749; $P < 0.001$). *Open circles* indicate frequencies did not show a decrease in year 2013.

4. Conclusions and discussion

In this part of the Mediterranean basin, the total number of species (569 species) was higher than the normal spectrum of Raunkiaer's statistics, and was dominated by Therophytes followed by Chamaephytes and Phanerophytes. The medicinal plants in these typical valleys in Cyrenaica (89 species) were mostly annuals that reflect the climatic conditions of the area; these, with the Hemicryptophytes and Geophytes, form half of vegetation spectrum. It is clear that the Therophytes followed with Phanerophytes are the most represented life-form in our survey. This proportion pattern of life-form was similar at all sites.

The residuals of the regression analysis (Table 2) show that in this African Mediterranean sector that species with medicinal value are concentrated within half of the family taxa found. Of these, Lamiaceae, Apiaceae and Asteraceae, with 21 species, as the most dominant plant families. This is in contrast with many other areas where most medicinal plants are usually concentrated in the Rosaceae and Asteraceae (Moerman, 1979). Unfortunately, the top-ranked plant species of medicinal found in our study were annuals or Chamaephytes which makes finding and collecting those species in the natural habitat very easy, and prone to over collection. The top three ranked plant families in our study which contained 24% of the medicinal plants are, however, among the six biggest families in Libya (Ali and Jafri, 1977; Jafri and El-Gadi, 1986).

In this study, frequency occurrence of many species showed a slight decrease within 12 years, even in Therophytes which were more abundant. Despite the low values of many species, the difference was statistically significant. But, no differences were found between years in the other life-forms apart from the Therophytes. There were also no significant differences between sites in species frequency from which it is concluded that the whole region experienced the same environmental conditions.

If the regression equation in Figure 3 is used to extrapolate into the future (accepting the uncertainty that this carries) then by the year 2040, each of the 12 Therophyte species found in site 1 will be found only in 2 of 10 quadrats, and none of those species will be present in any of the quadrats by the year 2080. This is assuming a linear change in climate, but it is likely that the rate of change of climate will increase and so these predictions may become reality sooner than suggested above.

Moreover, there are some plant species in this region that have become less common because Cyrenaica Herbarium records over the last 20 years show that these species used to be easily found in many places across Al-Jabal Al-Akhder, including Wadi Ras Al Hilal. Now, however, they have not been collected from any of the valleys studied, e.g. *Ruscus aculeatus* which has good medicinal potential (Thomas and Mukassabi, 2014). It is strongly recommend that more quantitative studies are needed to assess the current vegetation, specifically, the medicinal species.

It is concluded that there is a decrease in the percentage of Therophytes in the region, matched by a decline in the monthly rainfall and shortening of the length of precipitation season that could be the underlying reasons. Generally, global models have concluded that there is a strong human influence on regional temperatures and precipitation, and recent studies suggest that a 15% reduction in normal rainfall results in a doubling of drought risk (IPCC, 2013). The local metrological data in Benghazi shows a decline in the annual precipitation by an average of 255 ml in the period between 1996 and 2005, and the highest year did not reach 350 ml (Fig. 4). This spot in the south of the Mediterranean is one of the northern hemispheric areas that are threatened by global climate change moving towards a drier than normal type (IPCC, 2013). Moreover, urbanisation and land use is another factor that could increase the regional temperate (IPCC, 2013), as there is a current wave of unplanned construction that has been invading hundreds of hectares of wild area around the cities and small villages in the Al-Jabal Al-Akhdar since 2001.

Over-collection of the medicinal species for use in folk therapy could be another factor behind the decline, due to the recent public reaction towards using natural treatments rather than pharmaceutical chemicals, which leads to more pressure on local vegetation (IUCN, 2005). Moreover, the number of ethnobotanical shops has recently increased in both capital cities Tripoli and Benghazi, which is another outlet that needs to be addressed in measuring the potential problems of consuming wild plant species in Libya.

However, as the change in the climate over the world has a significant effect on the vegetation and species distribution, it seems that in Cyrenaica this phenomenon reduces the size of plant population, most probably of those range-restricted plant species, which are expected to be extant or extirpated, or in a best case scenario, restricted to a few and small isolated communities. However, many different practical strategies that can help to reduce the anticipated negative effects of climate change have been suggested and recently applied (Mawdsley *et al.*, 2009). In our situation, re-establishing natural reserves and protected areas is very urgent and crucial. At present, no reserves are functional in the whole sector, and even the boundaries that used to be natural and protected areas are now totally destroyed. The strategy of improving management and restoration of existing protected areas to facilitate resilience would be very effective and useful, since establishing small and well-managed parks, nature reserves and natural areas, reduces the cost of management, and those intensive reserves are more tractable and manageable. Also, design of these new natural areas and restoration sites to enhance the resilience of the local vegetation to the lack of annual precipitation and increase in the temperature is another advantageous strategy (Lovejoy, 2005). Ecological restoration projects established along elevational gradients in the Al-Jabal Al-Akhdar will be a practical strategy for certain native taxa, since some particular native species have been missed from sites where they used to be dominant (Mukassabi *et al.*, 2012). Furthermore, focusing conservation resources on species that might become extinct is another strategy that should be considered, giving priority to establishing the new reserves on sites or areas where the species concerned are still found. Establishing captive populations of species that would otherwise face extinction is also another strategy that could help conserve species in Cyrenaica. Seed bank and techniques of propagations of many species have been recently used to assists with re-establishing rare native species in better microhabitats that are likely to be less affected by climate change. If pressure from other sources other than climate change can be controlled, this might allow species to adapt to and survive climate change since human activities play a big role in making the situation worse (Mawdsley *et al.*, 2009).

There is a need to incorporate predicted climate-change impacts into species and land-management plans, programs and activities as a supportive strategy since incorporating information about the potential of local climate-change effects on the vegetation from international sources of data benefits local natural reserve management in helping to refine decision making (IUCN, 2008). However, all the strategies mentioned above would not be effective unless they were protected by law and policy. Thus, reviewing and modifying existing laws, regulations and policies related to biodiversity conservation and natural resources management is very important in order to be certain that their provisions meets the needs of management of wildlife and natural reserves (International Commission on Climate Change, 2007).

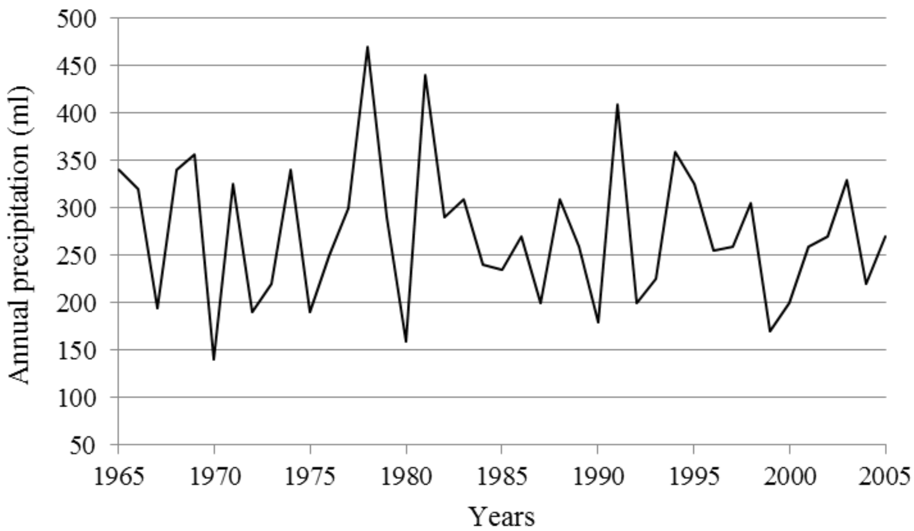

Figure 4. Annual precipitation in Benghazi, Libya between 1965 and 2005 (Benina Metrological Station, Benghazi)

Cyrenaica is a large area on the southern edge of the Mediterranean; it has the richest vegetation diversity of the eastern end of the north coast of the continent (Ali and Jafri, 1977; Jafri and El-Gadi, 1986). This is likely due to the altitudinal variation where this area rises up to more than 800 m above the sea level (Hegazy *et al.*, 2011). Climate plays an important role in the establishment of plant species, but, human encroachment and local community activities are seemingly major hazards faced by the vegetation. The results of this study indicate that this area might be vulnerable to climate change and its impact on biodiversity has to be assessed accurately. These results also agree with most of the recommendations made by Louhaichi *et al.* (2011) to support the conservation of medicinal plants in Libya. Since, establishing a new national strategy, wild conservation areas, increasing the public awareness of the importance of wild plant species, could conserve the vegetation as this region of the world which is located on the brink of critical climate conditions..

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Appendix 1. Medicinal plant species found in the area of study and life-form, Sites were Wadi Zaza, Wadi Al Ager, Wadi Jarjar Amma and Wadi Ras Al Hilal, respectively. Life-form was based on Raunkiaer's system (Smith, 1913). *= endemic species to Cyrenaica.

Plant species	Life-form	Family	Site			
			1	2	3	4
Mesembryanthemum nodiflorum L.	Therophyte	Aizoaceae		2		
Amaranthus hybridus L.	Therophyte	Amaranthaceae	1			
Pistacia lentiscus L.	Phanerophyte	Anacardiaceae	1	2	3	4
Pistacia atlantica Desf.	Phanerophyte	Anacardiaceae			3	
Eryngium campestre L.	Chamaephyte	Apiaceae			3	
Deverra tortuosa (Desf.) DC.	Chamaephyte	Apiaceae	1	2		

Appendix 1. Continued

Apium graveolens L.	Therophyte	Apiaceae	1		3	
Ammi majus L.	Therophyte	Apiaceae			3	
Conium maculatum L.	Therophyte	Apiaceae			3	
Thapsia garganica L.	Therophyte	Apiaceae				4
Cuminum cyminum L.	Therophyte	Apiaceae	1			
Nerium oleander L.	Phanerophyte	Apocynaceae				4
Asparagus aphyllus L.	Cryptophyte	Asparagaceae		2		
Asparagus horridus L.	Cryptophyte	Asparagaceae		2		
Asphodelus ramosus L.	Cryptophyte	Asphodelaceae	1			
Phagnalon rupestre (L.) DC.	Chamaephyte	Asteraceae	1	2	3	4
Artemisia herba-alba Asso	Chamaephyte	Asteraceae		2		
Artemisia campestris L.	Chamaephyte	Asteraceae	1			
Launaea nudicaulis (L.) Hook. f.	Hemicryptophyte	Asteraceae	1	2		
Silybum marianum (L.) Gaertn.	Therophyte	Asteraceae	1			
Carthamus lanatus L.	Therophyte	Asteraceae			3	
Borago officinalis L.	Therophyte	Boraginaceae			3	4
Moricandia arvensis (L.) DC.	Chamaephyte	Brassicaceae		2		
Sinapis alba L.	Phanerophyte	Brassicaceae	1	2	3	4
Raphanus raphanistrum L.	Therophyte	Brassicaceae			3	
Capsella bursa-pastoris (L.) Medik.	Therophyte	Brassicaceae	1			4
Eruca vesicaria subsp. *sativa* (Mill.) Thell.	Therophyte	Brassicaceae		2		
Ceratonia siliqua L.	Phanerophyte	Caesalpiniaceae	1	2	3	4
Capparis orientalis Veill.	Phanerophyte	Capparaceae	1	2		4
Anabasis articulata (Forssk.) Moq.	Chamaephyte	Chenopodiaceae		2		
Chenopodium murale L.	Therophyte	Chenopodiaceae		2	3	
Chenopodium album L.	Therophyte	Chenopodiaceae			3	
Chenopodium ambrosioides L.	Therophyte	Chenopodiaceae	1			
Cressa cretica L.	Chamaephyte	Convolvulaceae			3	
Ecballium elaterium (L.) A. Rich.	Chamaephyte	Cucurbitaceae	1			
Cupressus sempervirens L.	Phanerophyte	Cupressaceae			3*	
Ephedra alata Decne.	Phanerophyte	Ephedraceae	1			
Arbutus pavarii Pamp.	Phanerophyte	Ericaceae	1*		3*	4*
Ricinus communis L.	Phanerophyte	Euphorbiaceae	1			
Euphorbia peplus L.	Therophyte	Euphorbiaceae	1	2	3	4
Anthyllis vulneraria L. subsp. *maura* (Beck) Maire	Chamaephyte	Fabaceae	1			
Lotus corniculatus L.	Hemicryptophyte	Fabaceae	1	2		
Medicago sativa L.	Hemicryptophyte	Fabaceae		2		
Spartium junceum L.	Phanerophyte	Fabaceae	1		3	4
Fumaria capreolata L.	Therophyte	Fumariaceaa			3	
Erodium glaucophyllum (L.) L'Hér.	Therophyte	Geraniaceae	1	2	3	
Geranium robertianum L.	Therophyte	Geraniaceae	1	2		4
Erodium cicutarium (L.) L'Hér.	Therophyte	Geraniaceae		2		
Erodium moschatum (L.) L'Hér.	Therophyte	Geraniaceae	1			
Globularia alypum L.	Chamaephyte	Globulariaceae	1		3	
Drimia maritima (L.) Stearn	Cryptophyte	Hyacinthaceae	1	2		4
Phlomis floccosa D. Don	Chamaephyte	Lamiaceae	1	2	3	4
Rosmarinus officinalis L.	Chamaephyte	Lamiaceae	1	2	3	4
Marrubium vulgare L.	Chamaephyte	Lamiaceae	1	2	3	
Satureja thymbra L.	Chamaephyte	Lamiaceae			3	
Salvia fruticosa Mill.	Chamaephyte	Lamiaceae	1			4
Thymbra capitata (L.) Cav.	Chamaephyte	Lamiaceae	1	2		
Teucrium polium L.	Chamaephyte	Lamiaceae	1			
Ocimum basilicum L.	Therophyte	Lamiaceae				4
Laurus nobilis L.	Phanerophyte	Lauraceae				4

Appendix 1. Continued

Linum usitatissimum L.	Therophyte	Linaceae			3	
Malva sylvestris L.	Hemicryptophyte	Malvaceae	1	2		
Malva parviflora L.	Therophyte	Malvaceae	1		3	
Myrtus communis L.	Phanerophyte	Myrtaceae	1			4
Neurada procumbens L.	Therophyte	Neuradaceae			3	
Olea europaea L.	Phanerophyte	Oleaceae	1	2	3	4
Papaver rhoeas L.	Therophyte	Papaveraceae	1	2	3	
Plantago ovata Forssk.	Phanerophyte	Plantaginaceae		2		
Panicum turgidum Forssk.	Chamaephyte	Poaceae			3	
Hordeum vulgare L.	Therophyte	Poaceae		2	3	
Cynodon dactylon (L.) Pers.	Therophyte	Poaceae	1			
Polygonum equisetiforme Sibth. & Sm.	Hemicryptophyte	Polygonaceae	1			
Calligonum polygonoides L. subsp. *comosum* (L'Hér.) Soskov	Phanerophyte	Polygonaceae				4
Polygonum aviculare L.	Therophyte	Polygonaceae	1		3	
Adonis aestivalis L.	Therophyte	Ranunculaceae		2		
Reseda lutea L.	Therophyte	Resedaceae				4
Ziziphus lotus (L.) Lam.	Phanerophyte	Rhamnaceae	1	2	3	
Sarcopoterium spinosum (L.) Spach	Chamaephyte	Rosaceae	1	2	3	4
Galium aparine L.	Therophyte	Rubiaceae				4
Scrophularia canina L.	Chamaephyte	Scrophulariaceae	1		3	4
Solanum nigrum L.	Hemicryptophyte	Solanaceae	1			4
Nicotiana glauca Graham	Phanerophyte	Solanaceae	1			
Datura inoxia Mill.	Therophyte	Solanaceae	1			
Tamarix aphylla (L.) H. Karst.	Phanerophyte	Tamaricaceae			3	
Thymelaea hirsuta (L.) EndI.	Phanerophyte	Thymelaeaceae	1		3	4
Typha domingensis Pers.	Cryptophyte	Typhaceae				4
Urtica urens L.	Therophyte	Urticaceae		2	3	
Peganum harmala L.	Hemicryptophyte	Zygophyllaceae		2		
Nitraria retusa (Forssk.) Asch.	Phanerophyte	Zygophyllaceae			3	

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