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Research Paper

CLIMATE CHANGE CAUSE EXTINCTION FOR *Primula boveana* FROM ITS NATURAL HABITATS IN SOUTH SINAI, EGYPT

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Abstract

Primula boveana is the Egyptian only species in this genus and furthermore, the Egyptian rarest endemic plant. The distribution of *Primula boveana* is restricted to high elevations areas in the Sinai (above1700m) near springs in red granitic rocks in the Catherine and Serbal mountains. Most these habitats are subjected to a number of natural and human threats which cause continues deterioration and declining in the populations in both number and size. These threats include climate change, environmental fluctuation, and human impact.In this paper we aimed to focus on ecology, distribution, main threats causing reduction in the number and more attention to the impact of climate change which amplifying the effect and may lead to disappearance of this species in the nature. We focused on the distribution, morphology and usage in folk medicine, reviewing most related studies on using *Primula* and more consideration figuring out an appropriate conservation strategy for *Primula boveana* to reserve existing genetic diversity in the leftover of population and how to save the natural habitats and limiting the anthropogenic factors in the area.

Key words: *Primula boveana***,** natural threats, folk medicine, conservation plan, climate change, South Sinai, Serbal Mountain.

INTRODUCTION

The Sinai Primrose, *Primula boveana* Decne. Ex.Duby (Primulaceae), has been recorded long time ago as one of the rarest and most threatened plant species worldwide (Richards, 2003). Generally, the primroses are a group of plants beloved by the agricultural industry for their floral display. Common Names: Sinai primrose (English), Hepk Elqualah, Khass El-Gabal, Sahseeh (Arabic). The genus name derived from the Latin primus meaning first, refers to its early flowering, whereas the species is named in honor of Bove who collected the type of specimen in 1832. Furthermore, the genus *Primula* provides an ideal system to study the changing distribution of plant species across the global landscape. It shows a great variation in geographic range, with

some species occurring all over the globe and others confined to tiny endemic populations.

Primula species are widely distributed throughout the northern high latitudes of Eurasia, with a center of diversity in the Himalayas and western China (Alpin and Lovell, 2001). Their distribution extends to the high latitudes of North America, with few species growing in South America, Indonesia and Africa (Richards, 2003). Six species of *Primula* endemic to areas of the Middle East (northeastern Africa and western Asia) are related and thought to be derived from a single inherited species that was extensively distributed in Asia and Africa during a cool wet period about 6 million years ago (Wendelbo, 1961).

Its very well known that water-loving *Primula* populations were isolated on cooler, high mountains, as a result of the climate became drier, eventually forming several endemic species in Yemen, Saudi Arabia, Turkey, Iran and Ethiopia (Shemska *et al*., 1994).

Primula boveana occupies north facing walls at high-elevations areas in Saint Catherine Protectorate (above 1700 m) around persistent springs in red granitic rocks (Moustafa *et al*., 1999). Its distribution is associated with high soil moisture content, organic matter, carbonates, electric conductivity, shaded habitats, closed caves and fissured walls of red granite. The typical nature of soil surface where *Primula boveana* occurs in Shaq Mousa, Ain Shinara and closed shaded habitats on Serbal Mountain where lots of shaded and favorable elevated habitats. One can say that *Primula* occurred in natural habitats with a highly slopped outcrop of bare rock (walls) and fine fractions in crevices and pockets (Zaghloul, 1997).

Disturbances and anthropogenic activities have been recorded formerly and freshly all over the St. Catherine Protectorate, including overgrazing, urbanization (construction of new settlements), tourism, quarries and solid wastes. The Bedouins are using the sites of *P. boveana* as resting sites and barbeque for tourists groups during hiking trips due to availability of water, beauty cheers of the sites, and shaded locations. Furthermore, the Bedouins used its flowers and roots in folk medicine for headache, respiratory problems, neuralgia, shaking of the limbs, and cardiac weakness (Wagner *et al*., 1984). Due to these disturbances, *P. boveana* has experienced a significant reduction in size of extant populations and the threating of many populations (Moustafa *et al*., 1998; 1999b). Recently, the species is found only on Gebel Catherine, mainly on north-facing cliffs and in bad shape and the natural habitats became very threatened and subsequently the reduction in number become huge danger due to drought and shortage of precipitation as sign of climate change factor (Moustafa *et al*., 2001).

Another problem has been raised by Mansour (2010), that if the species escapes extinction, individuals within remaining small populations may exhibit low fitness as genetic variation is depleted by random genetic drift (Oostermeijer *et al*., 1994; Fischer and Matthies, 1998; Luijten *et al*., 2000; Hansson and Westerberg, 2002). This loss of

genetic variation can reduce the viability of populations in changing environments (Young *et al*., 1996) and subsequently assessing and monitoring genetic diversity is needed (Shemska*et al*., 1994; Sydes and Peakall, 1998). The main objectives of this study focuses on the ecological status of *Primula boveana* as rare and endemic species and impact climate change, importance of *Primula* in folk medicine, distribution, threats, consume, and figuring out a conservation plan for keeping this species from extension.

Morphology

A perennial herb has thin, sharply incised serrate leaves. The leaves are mealy beneath, the lowermost rosette, the upper ones in distant whorls, both surviving throughout the year. Flowers are whorled, yellow, and tubular with spreading regular limb whorled leaves. Corolla is lemon-colored, about 3 times as long as calyx. The mean number of seeds in one fruit is 423, and one gram of seeds contains about 32,258 seed. Minute seeds like those produce by *Primula* are named as dust seeds (Zaghloul, 1997). Flouring stage usually star appearing February to May while sheds seeds in July and August in the meantime vegetative growth activity continues all over the four seasons with its minimum in July and maximum in September(Photo 1) (Mansour, 2010).

Photo1: A complete form of the whole plant of *Primula boveana* growing on the granite rock units in Saint Catherine Mountains.

Geographic Range

Primula boveana is endemic to Egypt and occurred definitely in Saint Catherine Protectorate; it was recorded in the past in six main very small localities in Saint Catherine area (Sad Abu Hebiq, Kahf Elghola, Elgabal El-Ahmar, Ain Shennarah, Shaq Mousa, and Shaq El-Gragenia) and few populations in north-facing hills of Serbal Mountain. A narrow altitudinal range was recorded for this species ranging between 1745 and 2210 m. It was observed that population size positively affected by elevation. Many studies revealed that *Primula boveana* is highly located in slopes that face northeast (78%) and east aspect (22%) with slope degree ranging from 55°to 90°

(Mansour, 2010). According to IUCN Habitats Classification Scheme, this species belong to rocky habitat (mountain peaks), is restricted to cliffs and fissures' habitats fed by melted snow and distributed in most moist ground in the area of wells and sheltered mountain areas, especially cliffs and caves with steep granite slopes (Plate 1).

Plate 1: The general feature of the *Primula* habitats in Saint Catherine Protectorate in South Sinai, (a) general view shows the mountainous

habitats and cave forms, (b) moisten walls of red granite with very narrow fissured filled with water and organic matter supporting *Primula* growth, (c) solitary growth of *Primula* on carboniferous surface on rocky habitats with lots of coarse sand of soil surface, (d) Many seedlings of *Primula* usually grows first and never continues its normal growth due to environmental conditions, (e) old plant grows on the edges of rocky surface on soil pockets on the surface due to erosion effect with calcium carbonate substrata, and (f) A complete plant of *Primula* grows on cliffs and shallow crevices filled with organic matter and calcium carbonates.

Photo 2. Close view inside Kahf Elghola site showing the growth of *Primula boveana*on the walls indicated by red circles, where very dense growth of *Hypericum sinaicum* and *Mentha longifolia*asa basic substatum and more other growth of labaite species including *Nepeta septemcrenata*, *Ballota undulata*, and *Origanium syriacum* (Photo 2).

Ecology and site description of *Primula*

No whim that *Primula boveana* is one of the most important rarest, endemic, medicinal plant species in Sinai. This is due to its beauty as first flowering plants species and its origin as isolated plants due to environmental conditions. It occurs generally at elevation above 1700m near springs which flow throughout the whole year. In fact, the main occurrence of *Primula* in St. Catherine Protectorate which represents the core of the Sinai Peninsula, and located mainly near its southern end which is characterized by altitudinal gradient starting from 1500 m a.s.l. till the highest peak (St. Catherine Mountain) that is 2641 m a.s.l. The area where *Primula* occurred is located between 33°57' to 34°0' east, and 28°30' to 28° 34' north (Figure 1). It consists of an intricate complex of high and very rugged igneous and metamorphic mountains that range between 1500 and 2641m a.s.l. Saint Catherine area is formed geomorphological of

highly rugged mountains with acid plutonic and volcanic rocks - belonging to the Precambrian basement complex of the southern part of Sinai Peninsula which is dissected by numerous incised wadis that are everywhere showing signs of down cutting (Said, 1990). Furthermore Saint Catherine Protectorate was described by Said (1962) as predominantly smooth-faced granite outcrops forming mountains such as Mountain Serbal, Ras Sefsafa and Mountain El-Rabah. Said (1990) described the common black mountains consisting of old volcanic rocks to be historically uplifted to their present altitude passing through stages starting at the end of the Miocene.

St. Catherine mountains has a diversity of landforms (slopes, gorges, terraces, plains, ridges, and wadis), geologic structures, geomorphologic formations, and altitudinal gradients that lead to a number of microhabitats, each of which has its peculiar environmental conditions and plant cover and results in a relatively rich.

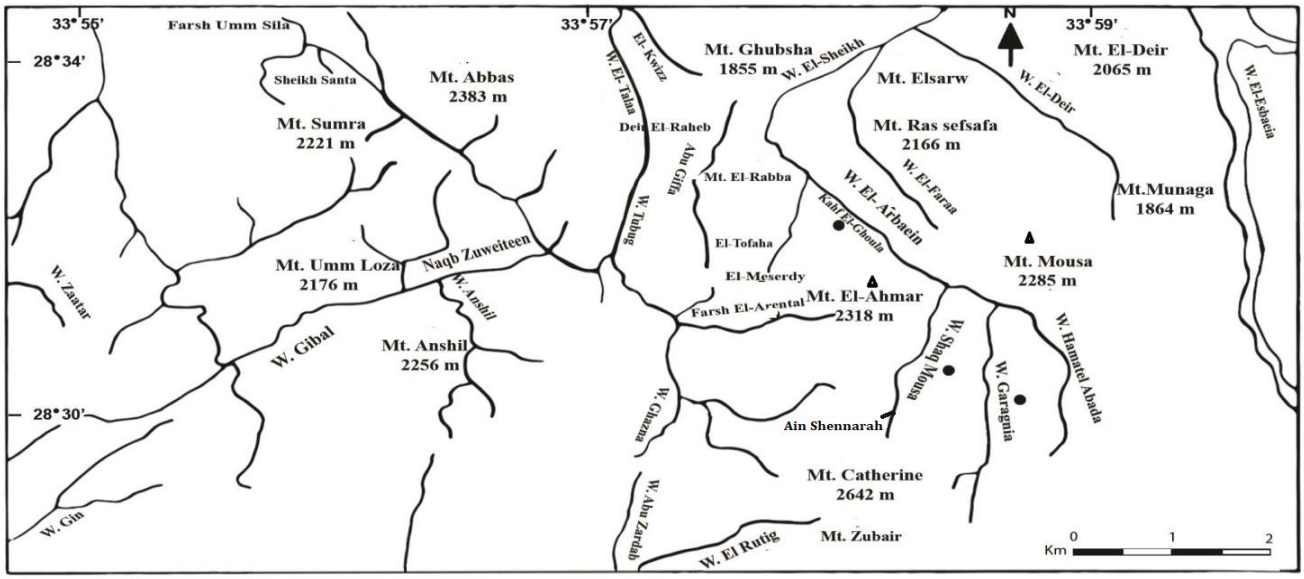

Figure1: Map of the study area (Saint Catherine Protectorate) in the southern part of Sinai. Mountain tops (Mt.) are represented by (▲), Wadis or valleys (W) and locations of the studied areas represented by (•).

Climate of Sinai

Sinai is characterized by an arid to extremely arid climate with long hot rainless summers and mild winters (Migahid *et al*., 1959; Zohary, 1973; Issar and Gilad, 1982; and Danin, 1983; 1986). St. Catherine area is characterized by a unique climate. It is the coolest area in Sinai and Egypt due to its high elevation. The lowest mean minimum temperature is recorded in January and February (1.4° C), while the highest mean maximum temperature in June and July is 30.8 and 31.8° C, respectively (Abd El-Wahab, 1995). Its climate is influenced by the Mediterranean and by the orographic impact of high elevation. Its precipitation occurs during autumn, winter, and spring and is

characterized by temporal and spatial irregularity. The mean annual rainfall in the St. Catherine area is about 60 mm which is the greatest mean over the southern Sinai. The high mountains receive snow that ranges between 20-30 mm in the rainy years.

Climate of the study area, Saint Catherine area is recorded in (Table 1) from Saint Catherine International Airport Station in the period from 2007 to 2015 by Cedar Lake Ventures (2015).

1. Temperature

Due to the wide range of altitude, South Sinai is characterized by a wide range of variation in air temperature (Moustafa *et al*., 1999; 2001) described Saint Catherine to be the coolest area in Sinai and Egypt as a whole due to its high elevation. During the period from 1979 to 1992, the lowest monthly mean minimum temperature was recorded in January and February (1.4^{o}C), while the highest mean maximum temperature in June and July 30.8 & 31.8^{o}C, respectively (Abd El-Wahab, 2003).

According to Cedar Lake Ventures (2015), the hottest day of 2013 recorded from the International Airport Station of Saint Catherine was June 3rd, with a high temperature of 37°C. On that day the average high temperature was 30°C and the high temperature exceeded 33°C only one day in ten. The hottest month of 2013 was July with an average daily high temperature of 32°C (Figure 2).

Relative to the average temperature (18°C), the hottest day was February 25th when the high temperature was 29°C with a difference of 11°C. In relative terms, the warmest month was February, with an average high temperature of 18°C, compared to a typical value of 17°C. The period from November 22 to December 5 witnessed the longest warm spell constituting fourteen consecutive days with warmer than average high temperatures. The month of March had the largest fraction of warmer than average days with 55% days with higher than average high temperatures.

The coldest day of 2013 was January 11, with a low temperature of -3°C. For reference, on that day the average low temperature is 3°C and the low temperature drops below 0°C only one day in ten. The coldest month of 2013 was December with an average daily low temperature of 4°C.

Relative to the average, the coldest day was October 7. The low temperature of that day was 6°C, compared to the average of 15°C, a difference of 9°C. In relative terms the coldest month was October, with an average low temperature of 11°C, compared to a typical value of 14°C. The period from December 9 to December 26 witnessed the longest cold spell constituting eighteen consecutive days with cooler than average low temperatures. The month of October had the largest fraction of cooler than average days with 84% days with lower than average low temperatures.

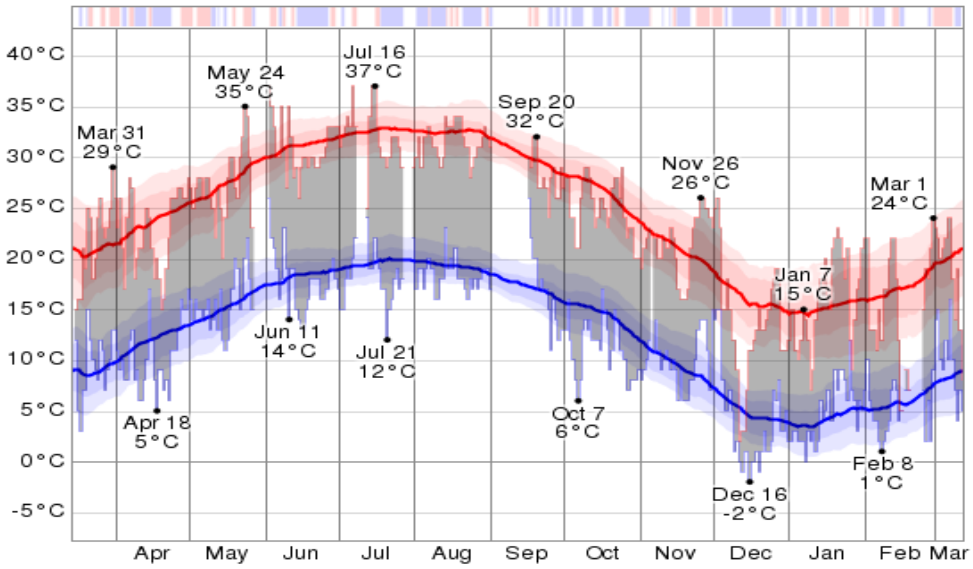

Figure 2: Variation of temperature in the study area during year 2013 where the daily low temperature is blue and the high one is red.

2. Relative humidity

Humidity is an important factor. During the period from 1979 to 1992, the relative humidity in Saint Catherine area ranges between 24.9 % in May and 49.8 % in January. The evaporation is greater during summer than that during winter, with maximum of 17.7 in June and 5.7 in January. A short humid period was observed in Saint Catherine in the middle of October until the end of March during the period from 1934 to 1937 but this humid period disappeared in the period from 1979 to 1992 (Abd El-Wahab, 2003).

According to Cedar Lake Ventures (2015), the least humid month of 2013 recorded from the International Airport Station of Saint Catherine was June with an average daily low humidity of 13%, and the most humid month was December with an average daily low humidity of 33% (Figure 3). During 2013, January had 23 dry days, 4 comfortable days of dew point ranging from 10° C to 20° C. There were no humid days in January, whereas April had 30 dry days, no comfortable days, and no humid days as well. On the other hand, July had 2 dry days, 20 comfortable days, and only one humid day. October had witnessed 24 dry days, 7 comfortable days, and no humid days.

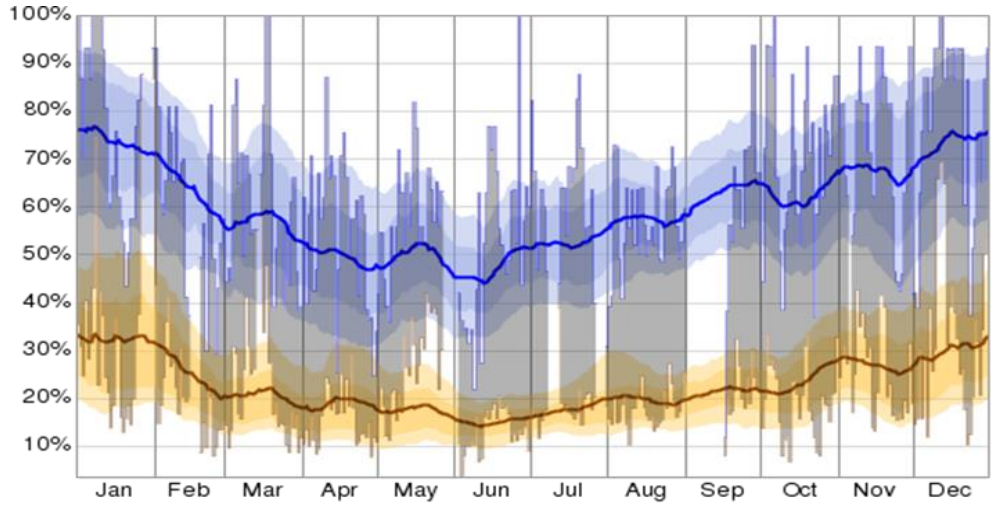

Figure 3: Variation of relative humidity in the study area during year 2013 where the daily low relative humidity is brown and the high one is blue.

3. Wind speed

According to Cedar Lake Ventures (2015), the highest sustained wind speed during 2013 recorded from the International Airport Station of Saint Catherine was 21 m/s, occurring on February 1st, and the highest daily mean wind speed was 13 m/s on the same day of February. The windiest month was April with an average wind speed of 4 mph. On the other hand, November was the least windy month with an average wind speed of only 2 m/s (Figure4).

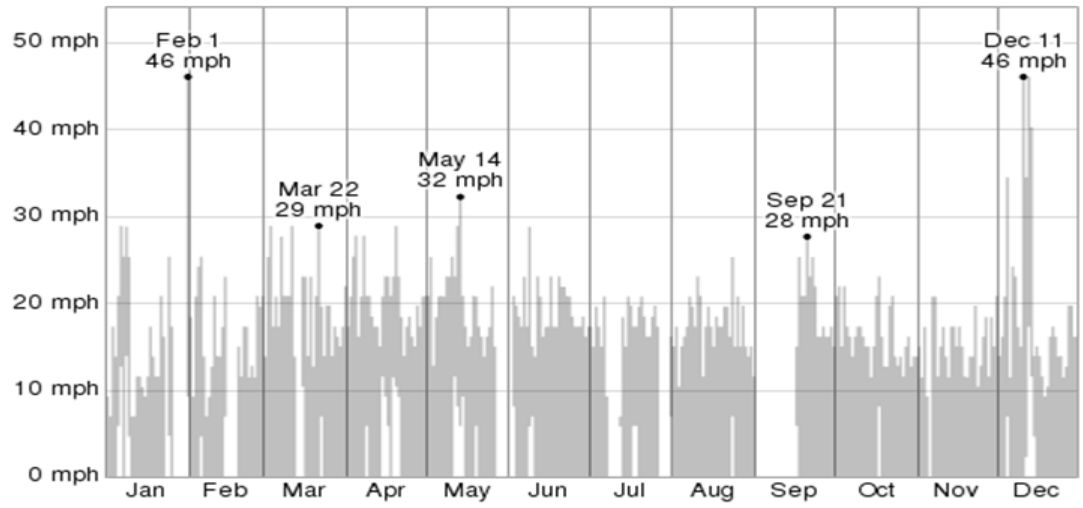

Figure 4: Variation of wind speed in the study area during year 2013 where the daily low and high wind speed is shown by light gray area.

4. Precipitation and Snow

Most of the precipitation in study area (St. Catherine) occurs during autumn, winter, and spring. Considerable precipitation occurs as a result of convective rains which are very local in extent and irregular in occurrence. The number of convective rains per

season is unpredictable (Danin, 1983). Flash floods due to heavy rainfall may occur. The maximum amount of rainfall during one day was 76.2 mm in November, 1937 (Dames & Moore, 1993). Precipitation may occur as snow on the high peaks of southern Sinai Mountains (Plate 2), and winter snow lasting two to four weeks has been observed on the northern slopes of Mountain Catherine. More than one snowfall may occur during some years while during others it may be absent. Precipitation which falls as rain in the valleys of southern Sinai may occur as hail on the high peaks. Water derived from melting snow or hail is more likely to infiltrate the desert soil because of its low rate of percolation (Danin, 1983).

Zohary (1935) suggested that some of the higher mountains receive an annual precipitation of not less than 300 mm due to snow fall and orographic precipitation. Danin (1978a) mentioned that the range of mean rainfall is 70 to 100 mm. Issar & Gilad (1982) mentioned that the study area receives approximately 50 mm of precipitation, partly as snow. Abd El-Wahab (1995) calculated the mean rainfall of 22 years as about 44.2 mm. Ghodeif (1995) draw an isohyet contour map for the mean annual precipitation on southern Sinai and showed that St. Catherine area receives about 60 mm which is the greatest mean all over southern Sinai. In dry years, the isohyets shift to the north and west, while in wet years they shift to the south and east (Danin, 1983). During the period from 1979 to 1992, the mean annual rainfall in Saint Catherine area was 42.59 mm (Abd El-Wahab, 2003).

According to Cedar Lake Ventures (2015), the day in 2013 with the most precipitation observations was December 13th. There were 12 hourly weather that day (out of a maximum of 24) in which some form of precipitation was observed at or near the study area. The month with the most precipitation observations was December, with 14 hourly present weather involving some form of precipitation. The longest dry spell was from March 16th to May 28th, constituting 74 consecutive days with no observed precipitation. The month with the largest fraction of days with at least some observed precipitation was September, with 47% of days observed precipitation. April, August, and October completely showed no observed precipitation. The years of 2011, 2012, 2013, and 2014 showed the highest record of annual precipitation ever happened in the whole history of Sinai which raise the need for future studies to emphasize this climatic change. The recorded data showed that the winter seasons of 2012-2013 and 2013-2014 were abnormal in rain and snow where Saint Catherine area was subjected to two snow storms in winter of 2013-2014 in December 11th, 12th, and in February 19th (Cedar Lake Ventures, 2015) (Plate 2).

According to available recorded data (Table1) the mean annual precipitation in the study area in the time of 15 years (1991-2005) is 15 mm. The monthly mean temperature varies between 6.8°C in January and 26.1 °C in August (Table1). The relative humidity is higher in winter than in summer; it attains a minimum average of 32% in May and 62% in February. Climatic diagrams of the study area clarify the aridity situation of the study area and give an obvious note about climatic changes in Saint Catherine Protectorate (Figure 5).

Based on the climatic diagrams, temperature at Saint Catherine Protectorate has been shifted to a more warm condition over time (Ali, 2009).

Table 1: Mean temperature (°C), wind speed (km/h), precipitation (mm) and dew Point recorded in Saint Catherine from 2007 to 2014.

Month	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Year	**Mean Temperature (°C)**											
2007	9	10	13	20	20	24	25	24	23	20	13	9
2008	14	9	12	14	18	21	24	24	20	22	13	9
2009	9	9	12	14	19	23	25	25	22	17	14	11
2010	8	10	10	14	17	21	26	24	20	17	13	10
2011	9	9	11	15	19	22	24	24	22	17	14	12
2012	10	7	13	15	17	23	26	25	21	18	15	11
2013	9	8	13	15	17	21	25	25	21	10	14	10
2014	10	11	11	14								
	Wind Speed (km/h)											
2007	7.3	14	11.2	10,4	9.3	9.6	8.1	7.2	7.6	6.8	8.1	6.3
2008	18	12	19	18	10	11	15	13	13	13	11	12
2009	12	13	15	11	10	13	15	12	15	12	13	16
2010	12	16	13	12	12	12	13	14	14	12	14	14
2011	10	11	12	12	14	15	15	12	11	11	7	17
2012	12	14	12	14	11	13	15	12	12	11	10	14
2013	11	13	14	12	15	12	12	13	14	10	16	10
2014	10	13	12	10								
	Precipitation (mm)											
2007	2.4	9	10.6	4	1	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	20.50	90.36
2013	66.89	0	0	0	0	0	0	0	0	0	0	22.87
2014	93.45	78.47	67.27	21.58	-							
	Dew point											
2007	45	44	39	53	57	67	60	44	38	40	52	51
2008	7	3	5	7	11	15	15	15	12	12	9	5
2009	4	1	4	9	12		14	15	18	14	10	9
2010	4	4	4	5	10	14	17	15	12	11	8	3
2011	4	4	5	8	10	13	14	15	15	10	10	5
2012	4	0	5	9	11	14	14	18	15	13	10	5
2013	5	2	7	9	10	13	17	16	14	15	8	6
2014	6	6	6	10								

Plate 2: Showing the area of saint Catherine mountain in the winter season with lots of snow on the top of Catherine mountain, (a) Shaq Mousa route towards of Ain shinarah , and (b) the huge fissure showing Gargina.

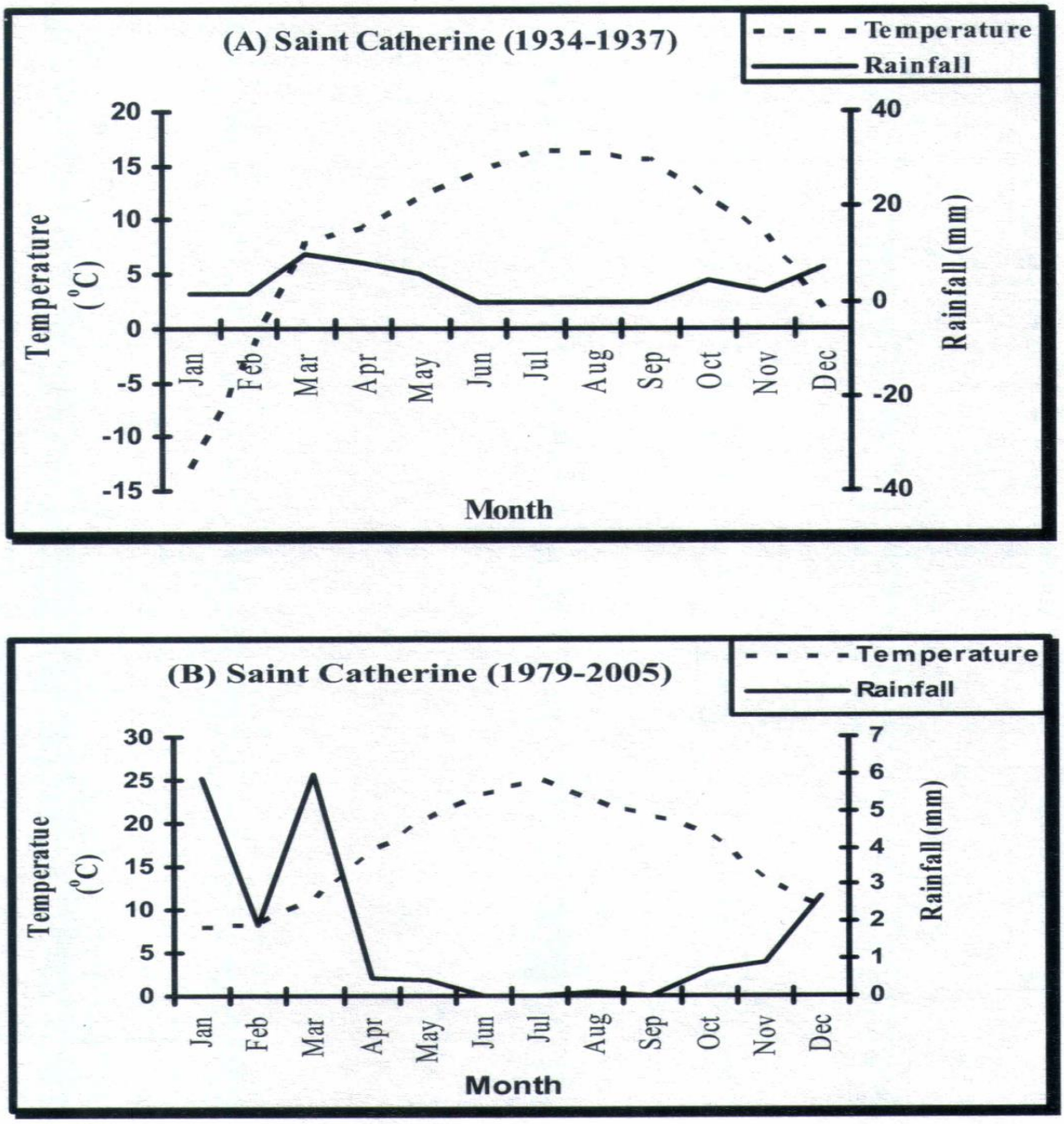

Figure 5:Climatic diagrams of Saint Catherine area showing changes in rainfall and temperature over two different periods; (A) 1934- 1937, and (B) 1991-2005, (Ali, 2009).

Medicinal Uses

Efficiency of primrose extracts which are rich in saponins have been demonstrated in a number of pharmacological studies, which has potent anti-asthmatic, anti-inflammatory and antiviral properties. Phenolic glycosides and saponins are characteristic compounds for the genus *Primula* (Muller *et al.* 2005). Flavonoids may have existed in nature for over one billion years. Methoxyflavones have important effects in plant biochemistry and physiology, acting as antioxidants, enzyme inhibitors, precursors of toxic substances and have long been recognized to possess anti-allergic, anti-inflammatory, antiviral, anti-proliferative and anti-carcinogenic activities as well as

to affect some aspects of mammalian metabolism (Huck *et al*., 2000). Two new flavonol glycosides have been identified and isolated from Italian *Primula* species (Fico *et al*. 2003).The species are collected for pharmacological testing by various scientific research centers. In Sinai, *Primula boveana* used its flowers and roots in folk medicine for headache, respiratory problems, neuralgia, shaking of the limbs, and cardiac weakness. Flower acts as nerviness for headache, neuralgia, shaking of the limbs, as a "heart tonic" in vertigo and cardiac weakness.

Threats and conservation plan

Global warming is considered to be a major potential threat to global biodiversity in the future (Kannan and James, 2009). Increasing atmospheric carbon dioxide certainly affects plant morphology (Ainsworth and Long, 2004) and is acidifying oceans (Doney *et al.,* 2009), and temperature affects species ranges (Loarie *et al.,* 2009, Thomas and Hannah 2005), phenology (Hegland *et al*., 2009), and weather (Min *et al.* 2011), but the major impacts that have been predicted are still just *potential* impacts. We have not documented major extinctions yet, even as climate change drastically alters the biology of many species.

The wild population of this species (*Primula boveana*) could be in extreme danger in the relatively near future as a result of climate change (drought effect). The most important natural threats are the long-lasting droughts, the very scarce irregular precipitation during the year, the fragmentation inherent to its habitat, and the possibility that rare floods may cause harm such as uprooting. The most important human impacts are reductions in water availability caused by collection for human consumption from the nearby areas, insect pests that eat the vegetative parts and may cause reductions in plant vigor, and a species of ant that collects the seeds, perhaps causing reductions in the reproductive rate. It may self-fertilize most of the time, apparently with little or no detrimental effects. Probably deleterious alleles have been purged a long time ago, making inbreeding depression, possibly not a major problem today, although possibly restricting its ability to evolve in response to environmental change.

Eventually, global climate is predictable to continue to change over this era and past. The magnitude of climate change beyond the next few decades depends mainly on the amount of heat-trapping gases released globally, and how sensitive the Earth's climate is to those emissions. Global climate change has already had visible effects on the atmosphere. Glaciers have minimized, ice on rivers and lakes is breaking up earlier, plant and animal ranges have shifted and trees are flowering sooner. The effects of climate which had been had predicted in the past by scientists resulted from global climate change are now happening which appeared in the form of losing of sea ice, speeded sea level rise and stretched, more intense heat waves. Therefore, the Earth's

average temperature has increased about 2 degrees Fahrenheit during the 20th century. Additionally, small changes in temperature relate to enormous changes in the environment. In the meantime, researchers have a very high assurance that global temperatures will continue to rise owing to greenhouse gases produced by human activities. The Intergovernmental Panel on Climate Change (IPCC), which includes more than 1,300 scientists from the United States and other countries, forecasts a temperature rise of 2.5 to 10 degrees Fahrenheit over the next century (NASA report 2020).

Primula boveana is dispersed in the St. Catherine Protectorate in different specific closed natural habitats, some had been protected by fenced enclosures, and we watched them through and a regular monitoring program. Recently, although enclosures with *Primula boveana* protected but crashed weathered has been damaged one of the best habitats in Ain Shimara site, therefore, conservation program should takes place with a propagation program in the same sites of the study area, using cultivation inside greenhouses as well as storing its seeds for future use.

For *Primula boveana*, an additional aspect of its biology makes it a compelling study species: a heterostylous floral morphology that is thought to promote outcrossing. *Primula* has long been a model for evolutionary geneticists and botanists interested in the evolution of mating system in that many members of the genus are heterostylous. Of course, in a highly endemic species with many small disjunction populations, this breeding system may impose additional constraints on the population. It is possible; however, that such a breeding system might buffer population genetic and demographic erosion.

The Efforts in different directions to protect this species from extinction: conservation through create genome resource bank and buildup of, seed banks that can act as reservoirs of genetic variation, thus delaying the loss of genetic variation and maintaining the evolutionary potential of populations (Zaghloul, 2008). It is necessary to carry out regular monitoring to keep updated on the population size, distribution and its trends.

In situ conservation through work on rehabilitation and restoration the present population and create more fenced enclosures in the whole area in addition to the enclosure present in Saint Catherine Protectorate. It is important to expand and

encourage sustainable use of plant species, control the unmanaged collection through Bedouin and also botanists and expand protected areas. Concerned experts must adopt public policies and environmental laws that promote protection and conservation of plant species, establish tax system for funding conservation and organize the uncontrolled tourism and tourist industry.

Raising the public awareness and establishment and improvement new educational systems in schools, universities and scientific research centers about the sensitivity of this important threatened species are one of essential points in conservation concept. Also support Bedouin with programs aiming to induce the Bedouin community to accept the idea of protection and conservation and participate in it.

REFERENCES

Abd El-Wahab, R. H. 1995. Reproduction ecology of wild trees and shrubs in Southern Sinai, Egypt. M.Sc. thesis, Botany Department, Faculty of Science, Suez Canal University, Ismailia, Egypt.

Abd El-Wahab, R. H. 2003. Ecological evaluation of soil quality in South Sinai, Egypt. Ph.D. Thesis, Botany Department, Faculty of Science, Suez Canal University, Ismailia.

Ainsworth, E.A. and Long, S.P. 2004. "What have we learned from 15 years of free-air CO_2 enrichment (FACE)? A meta-analytic review of the responses of photosynthesis, canopy properties and plant production to rising CO2". *New Phytologist* 165 (2): 351–372.

Ali, H. E. 2009. Conservation of Plant Diversity of Serbal Mountain, South Sinai, Egypt. M.Sc**.,** thesis**,** Botany Department, Faculty of Science, Suez canal University, Ismailia, Egypt,149 pp.

Alpin, C.G., and C.R. Lovell. 2001. Contact dermatitis due to hardy *Primula* species and their cultivars. Contact Dermatitis 44: 23-29.

Cedar Lake Ventures. 2015. /292512/2015/St-Catherine-Janub-Sinai-Egypt. History.com

Dames and Moore 1993. Sinai Development Study. In association with industrial development programs SA, Vol. IV & VI

Danin, A. 1978a. Species diversity of semishrub xerhalophytic communities in the Judean Desert of Israel. Israel in Journal of Botany, 27: 66-76.

Danin, A.1983. Desert vegetation of Israel and Sinai. Jerusalem: Cana Publishing House.

Danin, A.1986. Flora and vegetation of Sinai. Proceedings of the Royal Society of Edinburgh, 89 (B): 159-168.

Doney, S.C., Fabry, V.J., Feely, R.A., Kleypas, J.A. 2009. "Ocean Acidification: The Other CO Problem". *Annual Review of Marine Science* 1 (1): 169–192.Bibcode:2009ARMS....1..169D.doi:10.1146/annurev.marine.010908. 163834.

Fico, G., Spada, A., Braca, A., Agradi, E., Morelli, I., Tome`, F., 2003. RAPD analysis and flavonoid composition of Aconitum as an aid for Taxonomic discrimination. Bochum. Syst. Ecol. 31, 293–301.

Fischer, M. and D. Matthies. 1998. RAPD variation in relation to population size and plant fitness in the rare Gentianella germainca (Gentianaceae). American Journal of Botany 85: 811-819.

Ghodeif, K. O. 1995. Hydrological studies on east St, Catherine environ, South Central Sinai, Egypt. M. Sc. Thesis Geology Department, Faculty of Science, Suez Canal University, Ismailia, Egypt

Hansson, B., and L. Westerberg. 2002. On the correlation between heterozygosity and fitness in natural populations. Molecular Ecology, 11: 2467- 2474.

Hegland, S. J., A. Nielsen, A. Lazaro. A. Bjerknes and O. Totland 2009. How does climate warming affect plant-pollinator interactions? Ecology Letters.12:184-195.

Huck, C.W., Huber, C.G., Ongania, K.-H., Bonn, G.K., 2000. Isolation and characterization of methoxylated flavones in the flowers of *Primula veris* by liquid chromatography and mass spectrometry. J.Chromatogram. A 870, 453–462.

IPCC 2007, Summary for Policymakers, in *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* Cambridge University Press, Cambridge, UK, p. 17.

IPCC, 2013: Summary for Policymakers. In: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Issar, A. and Gilad, D. 1982. Ground water flow systems in the arid crystalline province of Southern Sinai. J. Hydrogel. Sci., 27 (3): 309-325.

Jiménez, A., Mansour, H., Keller, B. et al. Low genetic diversity and high levels of inbreeding in the Sinai primrose (*Primula boveana*), a species on the brink of extinction. Plant Syst Evol 300, 1199–1208 (2014) doi: 10.1007/s00606-013-0955-y

Kannan, R. and James, D. A. 2009. "Effects of climate change on global biodiversity: a review of key literature". *Tropical Ecology* 50 (1): 31–39.

Loarie, S.R., Duffy, P.B., Hamilton, H., Asner, G.P., Field, C.B., Ackerly, David D. 2009. "The velocity of climate change". *Nature* 462 (7276): 1052– 1055.

Luijten S. H., A. Dierick, J. Gerard, B. Oostermeijer, L. E. J. Raijmann, and H. C. M. Den Nijs. 2000. Population size, genetic variation, and reproductive success in a rapidly declining, self-incompatible perennial (*Arnicamontana*) in the Netherlands. Conservation Biology 14: 1776-1787.

Migahid, A.M., El-Shafei A., Abel-Rahman A.A., and Hammouda M.A. 1959. Ecological observations in Western and Southern Sinai. Bull. Sco. Georg. d'Egypte 32: 166-206.

Mansour, H. M. 2010. Genetics Basis for Polymorphic Floral Morphology of Sinai Primrose (*Primula boveana*), Ph.D. thesis, botany department, faculty of science, Suez Canal University, Ismailia, 171pp.

Min, S., Xuebin Z., Francis, W. Z., Gabriele C.H. 2011. "Human contribution to more-intense precipitation extremes". *Nature* 470(7334): 378–381.

Moustafa, A. A., A. A. Ramadan, M. S. Zaghloul, and M. A. H. Mansour, 2001. Characteristics of two endemic and endangered species (*Primula boveana* and *Kickxia macilenta*) growing in South Sinai. Egyptian Journal of Botany 41: 17-39.

Moustafa, A. A., R. H. Abd El-Wahab, and M. S. Zaghloul. 1999b. Conservation and Sustainable Use of Medicinal Plants in Arid and Semi-arid Ecosystems of Egypt (St. Katherine - Sinai). Final report. Egyptian Environmental Affairs Agency (EEAA), United Nations Development Program (UNDP), and Global Environmental Facility (GEF).

Moustafa, A. A., R.H. Abd El-Wahab, M. S. Zaghloul, and A. A. El-Rayes. 1998. Botanical Survey of Saint Catherine Protectorate. Final report. St. Catherine Protectorate Development Project, Egyptian Environmental Affairs Agency (EEAA). DESIGN & Tebodin BV. Members ofUERONET Consulting.

Moustafa, A.A., A. A. Ramadan, M.S. Zaghloul, and M.A.H. Mansour. 1999a. Environmental factors affecting endemic species, species richness and diversity

in Saint Catherine Protectorate, South Sinai, Egypt. J. Union Arab Biol. 9(B): 419-446.

Muller, R., S. Tilmes, P. Konopka, J.-U. Grooß and H.-J. Jost 2005. Impact of mixing and chemical change on ozone-tracer relations in the polar vortex, Atmos. Chem. Phys., 5, 3139–3151.

NASA report 2020via https://climate.nasa.gov/effects/.

Oostermeijer,J. G. B., M. W. Van Eijck, andJ.C. M. Den Nijs. 1994. Offspring fitness in relation to population size and genetic variation in the rare perennial plant species *Gentiana pneumonanthe* (Gentianaceae). Oecologia 97: 289-296.

Richards, A. J. 2003. *Primula*, 2nd ed. Portland, Oregon: Timber Press.

Said, R. 1962. The geology of Egypt, Elsevier Publishing, Amsterdam

Said, R. 1990. The Geology of Egypt. Elsevier Publishing Company. Amsterdam.

Shemska D.W., B. C. Husband, M. H. Ruckelshaus, C. Good Willie, I. M. Parker, and J. Bishop 1994. Evaluating approaches to the conservation of rare and endangered plants. Ecology 75: 584-606.

Sydes M.A., and R. Peakall. 1998. Extensive clonality in the endangered shrub Haloragodendron lucasii (Haloragaceae) revealed by allozymes and RAPDs. Molecular Ecology 7: 87-93.

Thomas E.; and Hannah, Lee 2005. *Climate change and biodiversity*. New Haven: Yale University Press. pp. 41–55. ISBN 0-300-10425-1.

Wagner, H.; Bladt, S. and Zginski, E.M. 1984. Plant Drug Analysis, Springer Verlag, Berlin, Heidelberg, New York, Tokyo.

Wendelbo, P. 1961. Studies in Primulaceae. II. An account of *Primula* subgenus Sphenodylia with review of the sections of the genus. Aarbok Universitet Bergen, Matematisk- Natur videnskapelig 11: 1-49.

Young A., T. Boyle, and A. Brown. 1996. The Population genetic consequences of habitat fragmentation for plants. Trends in Ecology and Evolution 11:413-419.

Zaghloul, M. S. 1997. Ecological studies on some endemic plant species in South Sinai, Egypt. M. Sc. Thesis. Department of Botany, Faculty of Science, Suez Canal University.

Zaghloul, M. S. 2008. Diversity in soil seed bank of Sinai and implications for conservation and restoration. African Journal of Environmental Science and Technology, 2 (7): 172-184.

Zohary, M. 1935. Die phtrogeographische Gliederung der Flora der Halbinsel Sinai. Beihe Botanisches Zentralblatt, 52:549-621

Zohary, M. 1973. Geobotanical foundations of the Middle East. Gustav Fischer Verlag. 739 pp. Stuttgart.