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# Impact of Climate Change on Surviving of *Phlomis aurea* as an Endemic Species Growing in Southern Sinai, Egypt

**Marwa M. Serag, Abdel Raouf A. Moustafa* and Sara S. Qiqa**
Botany Department, Faculty of Science, Suez Canal University, 41522 Ismailia, Egypt

## ABSTRACT

The changing climate globally is one of the most important influences that affect distribution patterns and phenology of plants. Global average temperatures have increased by more than 2°C. In the last century while precipitation patterns have plummeted dramatically. *Phlomis aurea* is a perennial species, endemic to South Sinai in Egypt; it grows in basins and gorge habitats which increase its ability to survive the natural arid environment of South Sinai. *Phlomis aurea* has a significant ecological and medicinal feature; it has a role in pollination due to the lipped flower it carries forming an arrival stage for honey bees, while medicinally, it has anti-inflammatory, antimicrobial, cytostatic and immunosuppressant characteristics. Moreover, it's famous for antidiabetic activity in folk medicine. According to the IUCN, *Phlomis aurea* is a threatened species in Egypt that needs firm conservation plans considering the changing climate as a threat to biodiversity loss. The following review aims at investigating the current status of *Phlomis aurea* in Egypt and its vulnerability to climate change incidence taking over the globe. In conclusion, it's expected that, *Phlomis.aurea* would be highly resistant to increased drought; however, on the long run and with harsher climate change scenarios there could be a severe decline in the population unless precautions have been followed.

**Keywords:** Impact of climate change, *Phlomis aurea*, Endemic species, Folk medicine, Seed germination, Phenology, Conservation.

## INTRODUCTION

Climate is one of the basic factors that affect the organism life cycle like plant germination and flowering. It can alter the habitat and food resources of the organism, can lead to migration of organism and thus affect negatively on the biodiversity population size and ecosystem (Hui, 2013). Global climate change is extremely considered as one of the fundamental factors causing biodiversity loss. Over the past 100 years, the global average temperature has expanded by around 0.6°C and is projected keep on rising at a quick rate (Root *et al*., 2003), the continuous increasing temperature will affect negatively on plant biodiversity and on the ecosystem in general.

Unlike climate change, an important factor influencing wildlife in general and plant life and its diversity, in particular, is an event that occupies the world these days because of its future potential to threaten the environment, thus assessing the climate change and its influence on the plant should take in consideration in any conservation program. In order to establish an effective conservation program for a plant species, we should have enough knowledge of its biology and ecology.

The importance of nature preservation methodology is the foundation and up keeping with a framework or system of ensured zones, yet it is not enough to change the world (Huntley, 1999). Providing a database on the target species is the most important step in any conservation program (Shaltout *et al.,* 2015).The process of gathering this information is sometimes referred to as an Eco-geographical survey or study (Maxted *et al*., 1995), which is the driven of all protection issues and a key necessity in the advancement of any preservation methodology (Ouédraogo, 1997). The protection of endemic species is a worldwide need; endemic species are regularly the most defenceless against anthropogenic dangers because of their exceptional transformative history and similarly low population size.

Thus, this review article focuses on the status of *phlomis aurea* as an endemic species amid the dramatic effect of climate change with some suggestions and recommendations to conserve its population.

### Morphology

*Phlomis.aurea* Decne (its Vernacular name is Awarwar) is a wild golden woolly perennial species; It is characterized by its yellow colored petals, shrubby habit and the medium size that vary from 24-36 tall. The shrub grows to 60-90 cm in height and 90-120 cm in width (Photo.1).

**Photo (1):** Flower of *Phlomis aurea* Dence.

### Geographical distribution and Ecology

Genus *Phlomis* (Lamiaceae) comprises about 100 species in the world (Mediterranean region to central Asia and China). In Egypt, two *Phlomis* species occur, *Phlomis aurea* Decne and *Phlomis floccosa* D. Don

* *Corresponding author: raoufmoustafa2@hotmail.com*

(Täckholm, 1974; Boulos, 2002). *Phlomis aurea* Decne is a wild golden-woolly perennial species; it is a rare and endangered endemic species restricted to the high altitudes in the southern Sinai Peninsula (Fig. 1) (Boulos, 2008), especially in Saint Catharine and Mousa mountains (El-Hadidi and Hosni, 2000).


**Figure (1):** Map shows the geographical distribution of *Phlomis aurea* in Egypt.

## Phenology

Vegetative growth starts slowly in October, maximizes in April and declines in June. Flower budding starts slowly in April, then maximizes and declines in May. Flowering starts slowly in May, maximizes and declines in June (Fig. 2). Seed shedding starts and increases progressively through July-August but maximizes in September, then plants keep vegetative from October through March.

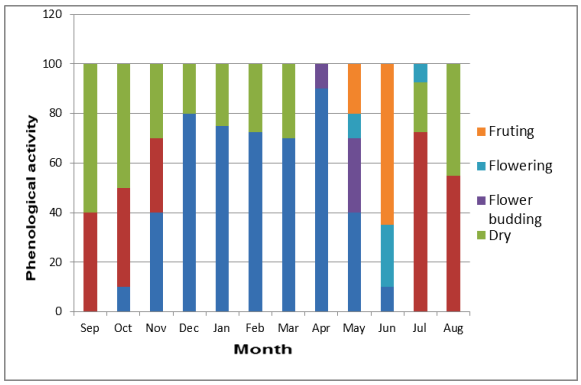


**Figure (2):** Phenological aspects of *Phlomis aurea* (Ramadan *et al.*, 2009).

## Catherine Mountain

Is the highest peak in Egypt (2641 m.s.l.), located in the center of South Sinai and represents a series of mountains at different elevations. The rock sorts are acid plutonic and volcanic rocks. The area of Saint Catherine Mountain has two main deep gorges; Shaq Mousa, and Garagneia, plus five main Wadis: Wadi ElIsbaiya, Wadi ElRutig, Wadi ElArbaeen, Wadi Zawatee, and Wadi Razana (Mosaad, 2017).

## Mousa`s mountain

Mountain Mousa (2285 m.a.s.l.) is one of the holiest, historical, and respectful places in Sinai and the whole world, located on the eastern side of Mountain Catherine. The rock sorts are mainly granite with smooth - faced outcrops. The mountain is characterized by numerous tremendous gorges covered with large boulders.

The geomorphology of the mountain is one of the most fantastic formations which includes; terraces, curved slopes, depressions, and small plains or Farsh such as Farsh Mousa. Mountain mousa has two main Wadis acting as boundaries: Wadi El-Faraa and Wadi El-Deir (Mosaad, 2017). Generally, Bedouins in Saint Catherine are using the dry individuals for fuel, while they cannot use the green individuals directly because it has hairs that attack the skin and eyes and cause itching and allergies (Shaltout *et al.*, 2004).There are increasing threats facing its populations, as it is subjected to severe overcutting and uprooting (for fuel), as well as disturbance through unmanaged human activities and increased drought (Moustafa and Abd El-Wahab, 2013). *Phlomis aurea* is quite resistant to drought; it likes the position in full sunlight. It prefers soils of neutral to alkaline (pH 6.6-8.5), and it is attractive to bees, butterflies, and birds.

In 2015, Shutout recorded the associated taxa with *Phlomis aurea* populations; 63 species related to 56 genera and 30 families. Compositae had the highest contribution (11 species=17.5%), followed by Labiatae (10 species=15.9%), while the perennials were 55 species, while the annuals were 3 species, and biennials were 5 species.

The high percentage of perennials (87.3%) may be related to their ability to resist the drought, salinity and sand accumulation (Barakat *et al.*, 2014). The population of *Phlomis aurea* in the basin had the second highest density (after the gorges) associated with the highest cover and size index (Fig. 3); this might be credited to adequate dampness and nutrients contrasted and alternate living spaces, as it was a catchment region; got an extra measure of water and nutrients from the neighbouring raised regions (Moustafa *et al.*, 1993).

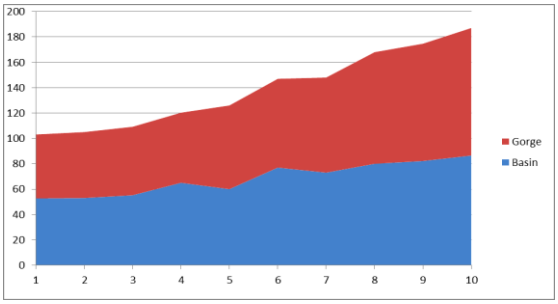


**Figure (3):** The Population density of *Phlomis aurea* in gorge and basin habitat.

## Role in pollination

Lipped flowers typically belong to the Sage Family (Lamiaceae) or the Pea family (Fabaceae). These are specific blooms that by and large have a close association with honey bees or single honey bees. The lip at

the front of the bloom is the arrival stage; the honey bee at that point pushes its head into the flower to get at the nectar which is discharged at the back of the flower. In the meantime, the plant places pollens on to the back of the honey bee's thorax (neck area). It is hard for the honey bee to expel pollen from this spot, and along these lines the honey bee conveys pollen from flower to flower and guarantees fertilization. Lipped blossoms, for example, those in the pea family (Fabaceae) and Sage family (Lamiaceae) take after this example of specialization. These lipped blooms normally have an 'arrival stage' where a honey bee or Anthophora honey bee can arrive before it enters the blossoms. Increasing pollination will provide a food resource for local community and this will make them keen to avoid misusing of *Phlomis aurea* and maintain its population to increase honey production.

**Seed germination**

The shape and size (8x4 mm) of *Phlomis area* seeds (Photo 2). The average seed weight is about 0.00315 g and one gram includes about 317.5 seeds. Each fruit contains four seeds (nutlets), based on naked eye examination and the Tetrazolium viability test, two different types of seeds were recognized, the first type is large, fat and mature, while the second type is thin and immature (just as seed testa). Immature ratio amounts to about 98% of the total seed setting in some populations (Zaghloul, 1997).

**Photo (2):** Seeds of *Phlomis aurea* (Ramadan *et al.*, 2009).

**Soil seed bank**

The germination behaviour of *Phlomis aurea* seeds showed its highest ratio (66%) in dark incubator at a constant temperature (15˚C±2), without seed pretreatment. It was evident also that the germination ratio (32%) under light condition was relatively better than those under shade (19%) and in darkness (12%) (Zaghloul, 1997).

**Conservation status**

The threatened species in Sinai according to the IUCN Red List Categories were 51 species: 13 endangered, 14 vulnerable, 20 rare and 4 indeterminate. IUCN recorded taxa ought to get high need in any protection program (El-Hadidi and Hosni, 2000). *Phlomis aurea* is an uncommon and imperiled endemic species possessing high heights at the southern Sinai Peninsula, Egypt (Boulos, 2002; El-Hadidi and Hosni, 2000), and can adjust numerous natural factors that prompt its distribution in this region (Abd El-Wahab *et al*., 2004). Numerous bushes and trees of the arid regions are of structural and economic importance (Crisp and Lange, 1976). They assumed a paramount part in soil insurance and stabilization against movement by wind or water, provide a source of forage for animals and fuel for local inhabitants (Thalen, 1979). *Phlomis aurea* is threatened by two central points; over cutting and uprooting, the pressure of livestock on *Phlomis aurea* increases as a result of the expansion in Bedouin, population (Shaltout *et al.*, 2004). Distribution and abundance of a plant species within a particular climatic zone are determined.by environmental factors, especially soil conditions, interactions with other species; and dispersal. Survivorship and fertility appear to be primarily determined by the size and the developmental stage, rather than an age of individuals within a plant population (Silver-town, 1981, Werner and Caswell, 1977; Galal, 2011). Along these lines, the status of a plant population will be reflected by its thickness and size structure, in 1985 Weiner suggested that measure contrasts might be caused specifically or through differences in development rates because of age contrasts, hereditary variety, heterogeneity of assets, herbivory, and competition.

**Medicinal uses**

*Folk medicine*

In Egyptian people medication, the plant is utilized as antidiabetic (Watt and Breyer, 1962). Diverse classes of glycosides including diterpenoids (Katagiri *et al*., 1994; Tanaka *et al*., 1983; Tanaka *et al.*, 1985), iridoids (El-Naggar and Beal, 1980; Çalis *et al*., 1991), phenylpropanoids (Saracoglu *et al.*, 1995 and Çalis *et al.*, 1991), phenylethanoids (Saracoglu *et al.*, 1998) and flavonoids (Tomas *et al*., 1986 and El-Negoumy *et al.*, 1986) had been recognized from genus *Phlomis*. Many of the phenylpropanoids isolated from genus *Phlomis* showed significant biological activities, e .g. cytotoxic anti-inflammatory immunosuppressant and anti-microbial effects (Saracoglu *et al.*, 1995). Only flavonoids had been described from *Phlomis aurea* (El-Negoumy *et al.*, 1986). Various *Phlomis* species (Lamiaceae) have been utilized in folk medicine as stimulants, anticough products, and to treat gastric, intestinal as well as abdominal pains, as a tonic, sedative, carminative and astringent. Various activities such as anti-nociceptive, anti-ulcer genic and antioxidant, anti-genotoxic, anticancer and anti-inflammatory.

**Impact of climate change**

Over the last 10,000 years, the climate in Egypt has changed many times. According to temperature data analysis for the last 50 years, the temperature shows an

average increase with decreasing rainfall which is causing severe droughts affected negatively on the population dynamics of many plant and animal species. South Sinai is characterized by an arid to extremely arid climate with long hot rainless summer and mild winter (Migahid *et al.,* 1959; Zohary, 1973; Issar and Gilad, 1982; Danin, 1983; and 1986). Precipitation occurs mostly in winter. The climate is influenced by the Mediterranean and by the orographic impact of the high elevation of the mountains in southern Sinai. The tropical influence is prominent along the Gulf of Suez and the Gulf of Aqaba (Danin, 1986). Due to the wide range of altitude, South Sinai is characterized by a wide range of variation in air temperature (Moustafa *et al.*, 1999).

Saint Catherine is 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°C), while the highest mean maximum temperature in June and July 30.8 and 31.8°C, respectively (Abd El-Wahab, 2003). According to Cedar Lake Ventures (2017). In Saint Catherine, the summers are long, warm, arid, and clear and the winters are chilly, dry, and mostly clear. Over the course of the year, the temperature typically varies from -2°C to 27°C and is rarely below -5°C or above 29°C. The warm season lasts for 4 months, from May 25 to September 24, with an average daily high temperature above 23°C. The hottest day of the year is August 6, with an average high of 27°C and low of 16°C.

The cold season lasts for 3 months, from December 1 to March 8, with an average daily high temperature below 13°C. The coldest day of the year is January 17, with an average low of -2°C and high of 10°C.Warming straight forwardly influences the rate of plant breath, photosynthesis, and other biogeochemical forms. For example, improved $CO_2$ concentration can increase photosynthetic rate, particularly for plants becoming under a warm and dry condition, for example, C3 plants. Normally, plants have their own specific mechanism to endure a specific level of expanded temperature. As soil temperature increase, the deterioration rate of will increase, and accordingly supplement mineralization and accessibility for plants. In this manner, the communication and diverse blend impact of rising $CO_2$ focus and temperature are dictated by soil properties, water, mineral and nutrients accessibility and so forth, thus the normal reaction of plants in various conditions and atmosphere fluctuation can be either positively or negatively influenced (Amedie, 2013).

All cultures from ancient times to the present day have used plants as a source of medicines. Today, according to the World Health Organization (WHO), as many as 80% of the world's people depends on tradetional medicine for their primary health care needs. The greater part of traditional therapy involves the use of plant extracts or their active principles. The medicinal species that reside in natural areas have received increasing scientific and commercial attention in the recent years; *Phlomis* plants have been mentioned since the times of Dioscorides as natural cures and utilized as a part of customary prescription for the treatment of different conditions, for example, diabetes, hemorrhoids, gastric ulcer, aggravation, and the mending of wound (Amor *et al.,* 2009). These days, some *Phlomis* species are consumed as a tea in some Mediterranean cultures (Couladis *et al*., 2003; Karali *et al.,* 2016 and López *et al*., 2010).

The effects of climate change have become obvious in the natural environment over the last 30 years, together with other threats like habitat destruction, fragmentation, disturbance and loss in biodiversity (Lepetz *et al*, 2009). Surveying the effects of climate change will be a key assignment in developed and in developing countries due to numerous reliant physical, biological and chemical processes are progressing in the earth and human frame works (Amedie, 2013). In regions where climatic change may lead to warmer and drier conditions, mountain vegetation could suffer more as a result of increased evapotranspiration (Elkeblawy, 2014). Another point of view accepting the idea of; the higher the temperature the higher the biodiversity, recently by a team of ecologist from German Centre for integrative biodiversity(iDiv), they discover that number of Nematodes increasing with high temperature in polyculture plot with different plant species while their number declined in monoculture plot (Thakur *et al*., 2017).

## DISCUSSION

The protection of endemic species is a worldwide need; especially under the recent climate change circumstances, endemic species are the most defenceless against anthropogenic threats because of their unique evolutionary history and generally low population estimate. According to the (EEAA), total (GHC) emissions in Egypt has increased from 1933 million tons of eq. $CO_2$ in the year 2000 to 318.2 million tons of eq. $CO_2$ in 2010 with the most contribution of the energy, industry, agriculture and waste sectors (Nakhla *et al.,* 2013). However, Egypt's contribution to the global greenhouse gas (GHG) emissions is only 0.57% and it is considered a non-annex I country which means that there is no urgently needed plan for $CO_2$ emission reduction under the Kyoto protocol (Selim, 2009; United Nations Framework Convention on Climate Change, 2010). Thus, the climate change danger specially in remote destinations such as Saint Cathrine would be rather minimal, not that we under estimate the danger but hopefully there are no signs of further deterioration in the environmental conditions, on the other hand, *Phlomis aurea* is adaptive to arid environment naturally, on morphological, physiological and ecological levels. As it was noticed that leaves sprouting in winter were larger in size, thinner and carrying stellate hairs on both sides, while, those sprouting in spring were smaller in size and covered on both sides with a thick layer of

stellate hairs which is a typical drought resistant strategy to hold in more moisture (Ramadan *et al*., 2009).

In addition, the plant can choose to grow in the form of bushes in gorge habitats and basins that act as reservoirs for nutrients and water collected from precipitations and other sources of irrigation (Moustafa and Zaghloul, 1993). *Phlomis aurea* are stable, uniform, reliable, reprodu-cible and largely independent of age and environmental fluctuations (Sammour, 2014). *Phlomis aurea* is a high polymorphic species, it was suggested that the micro-habitat distribution of *Phlomis. aurea* have caused either epigenetic changes or mutations which were in favour to its high adaptability and stress resistance (El-Sadek *et al*., 2017). From the past literature, *Phlomis aurea* is an endangered plant that is highly resistant to drought and harsh environmental conditions; it's endangered mainly due to over grazing and frequent uprooting by the local community in Saint Cathrine (Abd El-wahab *et al*., 2004). Climate change in a stressing issue globally and regionally however the microhabitat distri-bution of *Phlomis aurea* have provided enough protect-tion for the species to tolerate and withstand slowly changing environment, however, further monitoring will be needed on the long run as the problem of climate change is persistent.

## CONCLUSION AND RECOMMENDATIONS

*Phlomis aurea* is an important plant ecologically, medicinally and economically, it is characteristic to arid and dry lands and contains several bioactive substances that are widely used in the pharmaceutical industries and folk medicine and thus, it is an endangered plant that needs urgent restoration. It's strongly recommended to work on a strict conservation plan for *Phlomis aurea* to rather protect it from the anthropogenic stressors as well as environmental stressors. The Seed bank is one of the known strategies along with increasing public awareness and involving the local communities of south Sinai in the environmental work (Ramadan *et al*., 2009). In addition, increasing the area of the protected areas at mid- to high altitude in the Southern Sinai to grant further protection in zones with the highest density of endemism is recommended (Shaltout *et al*., 2015).

Investigating any potential threat that might cause habitat loss or degradation. Laws and legislation that regulates the conservation process with the help of the administrative authorities of the country are urgently in need. Using plant parts for research purposes should be limited or controlled not to reach the exploitation levels, constructing gene banks of the species from different habitats and destinations. Further testing of the drought tolerance pathways and drought avoidance strategies of the plant should be done in the laboratory for more understanding of its physiological characteristics under different scena-rios of climate change and thus more appropriate future protection plans.

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## تأثير التغير المناخي على بقاء نبات ال phlomis aurea كنوع مستوطن في جنوب سيناء ، مصر

**مروة محمد سراج، عبد الرؤوف مصطفى، سارة صبحي**

قسم النبات، كلية العلوم، جامعة قناة السويس، الإسماعيلية، مصر

### الملخص العربي

المناخ المتغير عالمياً هو واحد من أهم المؤثرات التي تؤثر على أنماط توزيع و phenology للنباتات. زاد متوسط درجات الحرارة العالمية بأكثر من درجتين مئويتين.في القرن الماضي، في حين انخفضت أنماط هطول الأمطار بشكل كبير. يعد Phlomis aurea من الأنواع المستوطنة في جنوب سيناء في مصر. ينمو في الأحواض والموائل الخانقة التي تزيد قدرتها على البقاء على قيد الحياة في البيئة الطبيعية القاحلة في جنوب سيناء. *Phlomis aurea* له ميزة بيئية وطبية كبيرة؛ حيث له دور في التلقيح بسبب الزهرة المليئة بالشحوم، وهو يحمل في طياته مرحلة وصول لنحل العسل، في حين أنه له دواء مضاد للالتهابات ومضاد للميكروبات ومقوي للمناعة. علاوة على ذلك، تشتهر بالنشاط المضاد لمرض السكر في الطب الشعبي.وفقا لـ IUCN، يعتبر Phlomis aurea نوعًا مهددًا في مصربالانقراض يحتاج إلى خطط حفاظ صارمة نظرًا لتغير المناخ باعتباره تهديدًا لفقدان التنوع البيولوجي. وفي هذا المقال نسلط الضوء علي الوضع الحالي لل*Phlomis aurea* في مصر وتأثره بتغير المناخ. ومن المتوقع أن يكون *Phlomis aurea* مقاومًا جيد للجفاف المتزايد؛ ومع سيناريوهات تغير المناخ الأكثر قسوة يمكن ان يحدث له اندثار حاد في ويهدد بالانقراض وهذا في عدم اتباع الاحتياطات اللازمة لبقاء و الحفاظ علي النبات.