

# **Environmental and Anthropogenic Pressures on Geophytes of Iran and the Possible Protection Strategies: A Review**

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## **Abstract**

Ornamental geophytes (ornamental flower bulbs) are international and national heritage considering their contribution to people's life quality around the world. Iranian habitats support about 8000 species of flowering plants (belonging to 167 families and 100 genera) of which almost 1700 are endemic. Iran is a rich country in terms of distribution of bulbous plants. More than 200 species of bulbous species from different plant families naturally grow in Iran and play an important role in the colorful display of flowers in the plains, mountains, and forests. Unfortunately, some flower bulbs are at the risk of eradication in Iran due to some factors, including inappropriate herbivory and overgrazing, land use change, illegal bulb and flower harvesting, road construction, mining activities, drought, etc. The establishment of protected areas, efficient propagation methods such as micropropagation, gathering the species at the risk of extinction in Botanical Gardens and Research Centers, highlighting the decisive role of Non-governmental organizations (NGOs), and improving tourism are some approaches suggested for better conservation. Meanwhile, under the current situation, national and international protecting rules and regulations should be assigned and fulfilled to save this invaluable natural heritage.

**Keywords:** Bulbous plants, Iran, genetic erosion, habitat destruction.

## **Introduction**

Flowers have long been associated with each civilization and culture in the world. Dating as far back as the Neanderthals, flowers were used to decorate graves and celebrate major life events, expressing emotions in ways that words are deficient. Numerous cultures have incorporated flowers in their everyday lives as expressions of beauty and art (Anderson, 2006). Bulbous plants have a long and

glamorous history as garden plants. Frescoes and vases decorated with lily motifs have been discovered in the relics of ancient Crete, dating from 1800 or 1600 B.C. Records show that the Pharaohs grew anemones in their gardens and these narcissi and lilies were used by the ancient Egyptians in their funeral wreaths (Wentzell, 1973).

Solomon, the ancient king mentioned in the Old Testament, had a garden containing lilies and *Crocus*. As early as 380 B.C., the Greeks were using *Crocus*, lilies, and

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hyacinths in ceremonial crowns, and the philosopher and botanist Theophrastus, in about 340 B.C., wrote about *Allium*, *Anemone*, *Crocus*, *Cyclamen*, *Gladiolus*, *Ranunculus*, and *Scilla* species. Together with hyacinths and narcissi, lilies had an important place in the gardens of the early Romans, who valued these flowers for their use in religious ceremonies (Wentzell, 1973).

A greater number of bulbous species grow in the Middle East and south-eastern Europe in comparison to other parts of the world. If a circle be drawn with Istanbul as the center and taking in Greece and Bulgaria, Syria and the Lebanon, Persia and Afghanistan and neighboring countries, it can be seen that many of the most popular flowering bulbs are grown within these areas (Genders, 1973). This rich vegetation (flora) may reflect the varying climatic conditions in these areas including xeric, mesic and alpine climates. Variation is the law of nature. It occurs everywhere and every moment. The variety and variability of organisms and ecosystems is referred to as biological diversity or biodiversity. Biodiversity is recognized to be of global importance, yet species and habitats continue to be under increasing pressure from human-induced influences, whether in urban, rural or wilderness settings (Hill *et al.*, 2006).

The World Conservation Union's (IUCN's) Red List of Threatened Plants suggests that 34000 plant species are threatened globally, equivalent to some 12.5% of the estimated world flora. The world's biodiversity is declining at an unprecedented rate. During the period 1996-2004, a total of 8321 plant species were added to the International Union for the Conservation of Nature and Natural Resources (IUCN, 2004). The main purpose of IUCN Red List is to catalogue and highlight those taxa that are facing a higher risk of global extinction. During this period, there was an increase of over 60% in the number of plants recorded as critically endangered. This is alarming and

immediate conservation measures are required to safeguard many of these species (Sarasan *et al.*, 2006). Worldwide loss of biodiversity is a great global concern and has increasingly become a research focus since the Rio Summit in 1992 (Lomba *et al.*, 2010).

Conserving biodiversity for its sustainable use by the present and future generations is integral to UNCED's Agenda 21 and the International Convention on Biological Diversity (ICBD) signed by more than 150 of the nations which attended the Earth Summit in 1992. The world is inhabited by myriads of life forms, animals and plants. These life forms are of great diversity, living in diverse habitats and possessing diverse qualities, which in themselves make very interesting studies. In the present day, many species of plants and animals are being destroyed at a rapid rate. Last but not least, it is an undeniable fact that the human race has taken upon itself an arrogant role, as though *Homo sapiens* is the only species and other species do not matter (Kumar and Sharma, 2001).

### **Ornamental geophytes in Iran**

Iran is the sixteenth largest country in the world (FAO, 2005) and after Turkey ranks the richest country of plant diversity in the Middle East (Yavari and Shahgolzar, 2010). Iran is located in the Middle East and surrounded by Armenia, Azerbaijan, the Caspian Sea, and Turkmenistan on the north, Afghanistan and Pakistan on the East, Oman Sea and Persian Gulf on the South and Iraq and Turkey on the west. The population of Iran is about 70 million with a growth rate estimated as 1.7% and has 30 provinces (Heshmati, 2007). Iran's important mountains are the Alborz and Zagros ranges. These mountains play an important role in determining the non-uniform spatial and temporal distribution of precipitation in the whole country. The area within the mentioned mountain ranges is a high plateau with its own secondary ranges and gradually slopes down to

become desert which continues into southern parts of Afghanistan and near the Pakistan border. The Damavand peak in the Alborz reaches 5670 m above the mean sea level while the Caspian coastal area is below sea level (-28 m) (Heshmati, 2007). The country's climate is mainly arid and semi-arid, except the northern coastal and parts of western Iran. The climate is extremely continental with hot and dry summers and very cold winters particularly in inland areas. The average annual rainfall of the country is about 240mm with maximum amounts in the Caspian Sea plains, Alborz and Zagros slopes with more than 1800 and 480mm, respectively (Heshmati, 2007). Minimum precipitation

is less than 100 mm in the central region (Amiraslani and Dragovich, 2013). The rich flora and fauna and the unique landscapes of this land, as well as its ancient civilization, have attracted many biologists and orientalists (Yavari and Shahgolzar, 2010).

Iranian habitats support about 8000 species of flowering plants (belonging to 167 families and 100 genera) of which almost 1700 are endemic (Eftekhari and Ramezani, 2004). These plant species grow on four Ecological Zones (Fig. 1) namely, Hyrcanian, Zagros, Iran-o-Touranian and Khalij-o-Omanian which have different ecological and climatic conditions (Heshmati, 2007).



Fig. 1. Distribution of the four ecological zones of Iran (Heshmati, 2007)

More than 200 species of bulbous plants from the major families including Liliaceae, Iridaceae and Amaryllidaceae are grown in Iran and play an important role in the colorful display of flowers to be found in the plains, mountains and forests (Wendelbo, 1977). It should be noted that some species from Araceae including *Arum* spp. L. and *Biarum* spp. Schott (Mozaffarian, 2003) and from Orchidaceae [*Orchis* spp., *Gymnadenia* spp., *Dactylorhiza* spp., *Steveniella* spp. (Mozaffarian, 2003), *Epipactis rechingeri* Renz, *Ophrys kurdistanica* Renz and *Ophrys turcomanica* Renz (Renz, 1978)], *Corydalis* spp. (Fumariaceae), *Leontice*

spp. (Polyphyllaceae) *Geranium tuberosum* (Geraniaceae) have not been included in Wendelbo's (1977) contribution.

The introduction of new species and records of flower bulbous plants from Iran such as *Oxalis articulata* (Ghahremaninejad and Gholamian, 2006), *Tulipa faribae* (Ghahreman *et al.*, 2007), *Muscari kurdicum* Maroofi (Maroofi, 2007), *Eminium jaegeri* (Bogner and Boyce, 2008), *Gagea calcicola* (Zarrei *et al.*, 2010), *Gagea alexii* (Ajani *et al.*, 2010), *Allium* (Razyfard *et al.*, 2011) and *Leopoldia tijtjensis* (Jafari, 2012) indicates the richness of geophytic species in Iran. The flower bulbs of Iran have high potentials for the horticulture and floriculture industry and

could be used as cut flowers, pot flowering plants, and garden and landscape plants (Nazari *et al.*, 2007; Nazari *et al.*, 2011; Farahmand and Nazari, 2014; Nazari *et al.*, 2014).

### **Factors affecting habitat destruction and genetic erosion of flower bulbs in Iran**

#### ***Inappropriate herbivory and overgrazing***

Climatic conditions and grazing history are two important factors affecting species composition and biodiversity in rangeland in semi-arid ecosystems (Hassani *et al.*, 2008). Overgrazing by livestock has been considered as a major degrading factor for plant cover, soil and microclimate in woodlands in southwestern Australia (Yates *et al.*, 2000). Overgrazing changes vegetation structure and composition. Ultimately, some species increase in abundance and others decrease (Hassani *et al.*, 2008). Domestic livestock has grazed Mediterranean rangelands for thousands of years, in particular regions that are found in West Asia and North Africa (WANA) (Louhaichi *et al.*, 2009). Under long-term intensive grazing, the shift in species composition frequently involves the replacement of palatable with unpalatable plant species particularly woody perennials that provide low to no forage value (Louhaichi *et al.*, 2009). Overgrazing has often been perceived as a major factor in the degradation of Mediterranean landscapes (Noy-Meir and Oron, 2001). Sheep and goat production was historically an important occupation for rural populations located within WANA countries (Noor Ahmad, 2006; Louhaichi *et al.*, 2009). Livestock and plants interact constantly within rangeland ecosystems. Overgrazing pressure that accompanies an increase in the human and livestock populations causes a significant reduction in plant growth vigor and reproduction ability and poor establishment of valuable plants, which leads in turn to a changed botanical composition and soil moisture properties (Amiri *et al.*, 2008).

Grazing pressure has a simultaneous effect on both soil and range vegetation cover (Mohseni Saravi *et al.*, 2005). Soil physical properties play an important role in the establishment and growth of rangeland plants. Soil bulk density, mechanical resistance, porosity, and infiltration rate are all affected by soil texture and rangeland management practices (Chaichi *et al.*, 2005). Trampling by livestock results in compaction of the soil surface and this affects soil infiltration. The destructive effects of high intensity grazing on the physical properties of soil have been reported by many researches (Chaichi *et al.*, 2005).

The alpine zone in Iran has been less affected by humans compared to other lowland ecosystems. The harsh conditions and physical barriers limit human settlement and intensive agricultural activities. However, in recent years, the strong impact of grazing is increasingly threatening the fragile subalpine and alpine ecosystems in Iran even in legally protected arenas (Akhani, 1998, 2004). The mountain meadows, steppes and xerophytic plant communities represent sufficient food potential for cattle. Overgrazing leads to the destruction of vegetation, loss of biological diversity, and erosion of soil. The dominance of thorn-cushion formation is obviously one of the consequences of long-term overgrazing and land use in the Iranian plateau. The severe overgrazing in most parts of high altitudes in recent years has resulted in a spread of poisonous species (e.g. *Euphorbia*) observed in Alborz, Binalud and Sahand Mountains (Noroozi *et al.*, 2008).

Although it has been claimed that geophytes usually respond positively to grazing in the Mediterranean vegetation (Noy-Meir and Stenberg, 2001), the response of geophytes to herbivory varies considering morphological, physiological, geographical and some other influencing conditions. For instance, Noy-Meir *et al.* (1989) categorized geophytes to cattle grazing as positive, negative, or neutral.

Meanwhile, as mentioned by Noy-Meir and Stenberg (2001), the reaction of some geophytes to grazing was not consistent. It seems that some dicot geophytes such as *Anemone coronaria*, *Ranunculus asiaticus* and *Cyclamen persicum* respond to grazing in a negative manner (Noy-Meri and Oron, 2001) and some members of Liliaceae give a positive response to grazing (Noy-Meir and Orong, 2001). It is reported that grazing has positive effects on *Anemone coronaria* L. (Perevolotsky *et al.*, 2011). However, the response to herbivory (grazing) is also dependent on plant species, the time of grazing, and the traffic magnitude of animals.

In the case of some geophytes in Iran trampling by animals is an adverse factor. For instance, although *Fritillaria imperialis* is unpalatable to animals while green, due to chemical compounds such as alkaloids, glycosides, calcium oxalates, etc., it suffers greatly from animal trafficking and trampling during spring. The breakage of the flower stem caused by animals not only prevents fruit and seed formation, but also weakens the underground bulbs because the leaves that should provide the bulbs with carbohydrate reserves for bulblet formation and subsequent growth and flowering are destroyed in this way. Thus, in the case of the genus *Fritillaria* and similar ones, inappropriate grazing and animal trafficking are responsible for habitat

destruction, not overgrazing that is mentioned for some palatable geophytes. Thus, the physical damage to plants from one side and the soil compaction from another side, adversely affect plant growth and development in this case. Animal trafficking directly damages blooming plants (Fig. 2 A) and prevents fruit and seed formation (Fig. 2 B), as well. As this time of the year coincides with spring rainfalls, the soil is wet and the rate of damage is severe. Some people pick the flowering stems just for their fleeting beauty and take them to their homes. Interestingly, because of the bad smell released by this plant particularly after harvest, it cannot be kept at home and should be placed outside. Therefore, this kind of harvesting not only has no benefit for the gatherer, but also adversely affects plant growth cycle, because the photosynthetic leaves which are the main sources of photosynthesis process are harvested. In addition, after harvest, not only are seeds not formed but also carbohydrate supply for bulblet formation and mother bulb growth is disturbed. Therefore, the sexual and asexual reproductive means are impaired. This species is awfully eye-catching during its flowering time in spring and the mountains and plains covered with this fabulous flower bulb attract many nature lovers and enthusiasts particularly in provinces located in the western parts of the country.

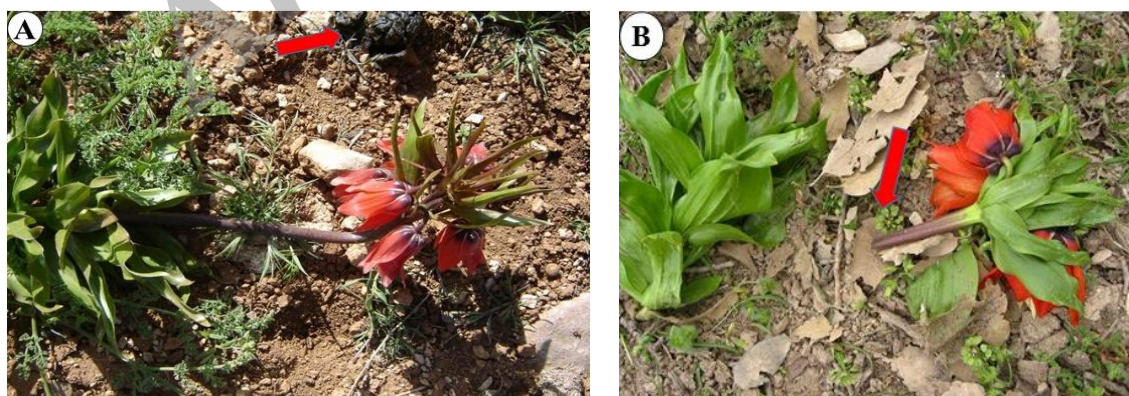


Fig. 2. A and B. *Fritillaria imperialis*: physical damage of animals during growth and flowering season, as shown in the pictures, is a challenge for this species in many parts of the country (A) Derak Mountain in Shiraz province and (B) Manesht Mountain in Ilam province).

Grazing pressure has a simultaneous effect on both soil and range vegetation cover (Mohseni Saravi *et al.*, 2005). Trampling by livestock results in compaction of the soil surface and this affects soil infiltration. The destructive effects of high intensity grazing on the physical properties of soil have been reported by many researches (Chaichi *et al.*, 2005; Azarnivand *et al.*, 2011). Livestock and plants interact constantly within rangeland ecosystems. The overgrazing pressure that accompanies an increase in the human and livestock populations causes a significant reduction in plant growth vigor and reproduction ability and poor establishment of valuable plants, which leads in turn to a changed botanical composition and soil moisture properties (Amiri *et al.*, 2008). The interaction effects of different management and environmental factors on rangeland vegetation are so complicated that it is difficult to distinguish their effects from each other. Many scientists believe that vegetation destruction in rangeland is because of the increment of the grazing pressure and soil deterioration at the same time (Mohseni Saravi *et al.*, 2005). Another endangered species is *Fritillaria gibbosa* Boiss. (Gol-e-Sarnegoun-e-Ghouzi) which is an elegant one particularly for pot plant production and especially for rock garden design. This species is under increasing pressure in the northern parts of Fars province mainly due to inappropriate and heavy grazing during the growth and flowering season. The same conditions described for *Fritillaria* spp. could be mentioned for two *Iris* species in Fars province viz. *Iris lycotis* Woron. (Zanbagh-e-Gol Dorosht) and *Iris lineolata* (Trautv.) Mathew (Zanbagh-e-Parvane'i) (Fig. 3A, B and C). The habitats of some *Iris* species are under pressure in some other parts of the country such as Khorasan-Shomali province as shown in Fig. 3D. Therefore, this phenomenon is not restricted to just one province or one

locality. *Tulipa* spp. (Fig.3 E and F) suffers greatly from inappropriate and heavy grazing in many parts of Iran. The genus *Tulipa* has 12-18 species in Iran, amongst which four species, namely, *T. ulophylla*, *T. harazensis*, *T. montana* and *T. urumiensis* are endemic (Farahmand and Nazari, 2014). Unlike *Fritillaria* spp. and some other bulbous plants which are unpalatable, tulips are highly palatable. Consequently, inappropriate grazing and overgrazing directly and indirectly threaten them. As tulips are palatable, the leaves are eaten by animals and this defoliation gradually weakens the bulbs. Animals that feed on seeds, bulbs, or other reproductive parts directly reduce the plant's reproduction and may kill the plant (Crawley, 1983; Lubbers and Lechowicz, 1989; Anderson, 1994).

Unfortunately, the flowering season of some bulbous plants coincides with late winter and early spring throughout the country and this time of the year is suitable for the regular migration of Nomads (the so called Ashayer in Persian) from subtropical and tropical regions to temperate ones. This phenomenon is obviously a challenge for palatable species such as tulips and even unpalatable plant species (*Fritillaria* spp.). Due to favorable conditions, this time of the year is suitable for the growth and development (fruit and seed formation) of most spring flowering bulbs, but the plants are eaten by animals or trampled as a consequence of heavy animal trafficking. Animal trafficking damage and particularly overgrazing gradually weaken the plants and may eradicate them if practiced for successive years. Some bulbous species such as *Eremurus* spp. are not palatable when green in the spring, but heavy and inappropriate grazing trample them, and consequently, flower stems are damaged and seeds are not formed in heavily grazed areas. Grazing may have different impacts on plant species due to herbivore preference or plant resistance (Perevolotsky *et al.*, 2011).



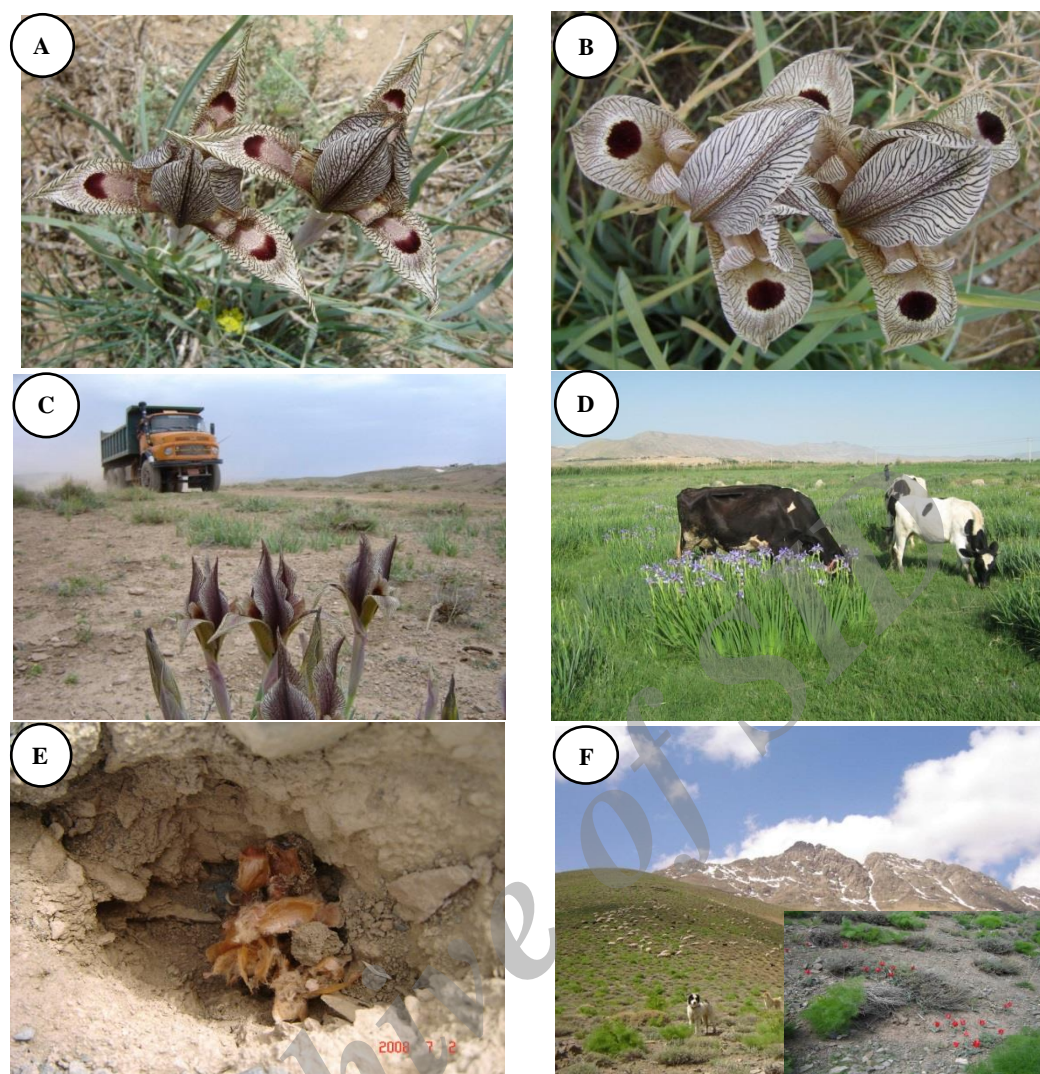


Fig. 3. A) *Iris lycotis* Woron. (Zanbagh-e-Gol Dorosht), B) *Iris lineolata* (Trautv.) Mathew (Zanbagh-e-Parvane'i), C) Land use change and road construction are threatening factors for their habitat destruction in the northern parts of Fars province (Dehbid), and D) Animal grazing in a meadow in Khorasan-Shomali province. *Iris* species are not palatable while green but the physical damage is considered a threat in these cases. E and F) *Tulipa* spp. are palatable and overgrazing by animals or rodents is the real threat for them particularly during blooming from late winter to early spring (Fars province, Dehbid).

*Sternbergia* spp. is another exquisite ornamental bulb in some regions of Iran. In some parts of Fars, Ilam and Kohgiluyeh and Boyer-Ahmad provinces, these spectacular flower bulbs are locally called "Gole Bi Mennate Baroon" meaning the plants that do not need rainfall to flower in autumn [this bulbous plant produces flowers before leaf production in autumn, the state called hysteranthous by De Hertogh and Le Nard (1993)]. This species is slow-to-propagate because a few bulblets are annually formed on the mother bulb; unfortunately, this

species is now scarcely found in Fars province, where it was once seen abundantly in mountains and plains. The most important factor responsible for this depletion is assumed to be inappropriate herbivory and overgrazing in the habitats during its growth and development. This species is also sporadically grown in Kohgiluyeh and Boyer-Ahmad, Ilam and Kurdistan provinces where the mountainous and inaccessible nature of the habitats and less animal traffic help to preserve it singly or in scattered populations (Fig. 4 A and B). Illegal

collection for cut flower industry, fast development of the tourist industry, urban expansion, and building of roads have been mentioned as the factors which threaten *Sternbergia lutea* in Turkey (Gurbuz *et al.*, 2009). Even in the case of grape hyacinth (*Muscari* spp.), which is easily propagated by seed and bulb formation and so considered weed in some cases, trampling and land use change is a critical problem.

It might be claimed that all geophyte species have developed underground specialized organs such as bulb, tuber, corm, rhizome, etc. to cope with abiotic and biotic stresses. Although these evolutionary developed organs play an important role in bypassing environmental stresses, they greatly suffer from stressful factors during their active growth and development which, unfortunately, occur predominantly in developing countries.

*Lilium ledebourii* (Baker) Boiss. with the

Persian name Susan-e-Chelcheragh or Susan-e-Chehelchergh (Fig. 4 C and D), is a perennial endangered rare species endemic to Iran mostly found in Gilan province. This plant grows at altitudes between 1750-2100 m in Euxino-Hyrcanian province and it is under the surveillance of Iranian Regional Environmental Protection Agency (Jalili and Jamzad, 1999). This statement of Wendelbo (1977) is surprising about this rare species: "Indeed, if the Department of the Environment had not placed guards in Rudbar locality (Gilan province) and declared it a National Nature Monument, this beautiful species might well have been on its way to extinction by now." Fortunately, governmental protection of habitats of this native, endangered, and spectacular bulbous species in Gilan province (Damash village), which was put into effect about five decades ago, is continuing.

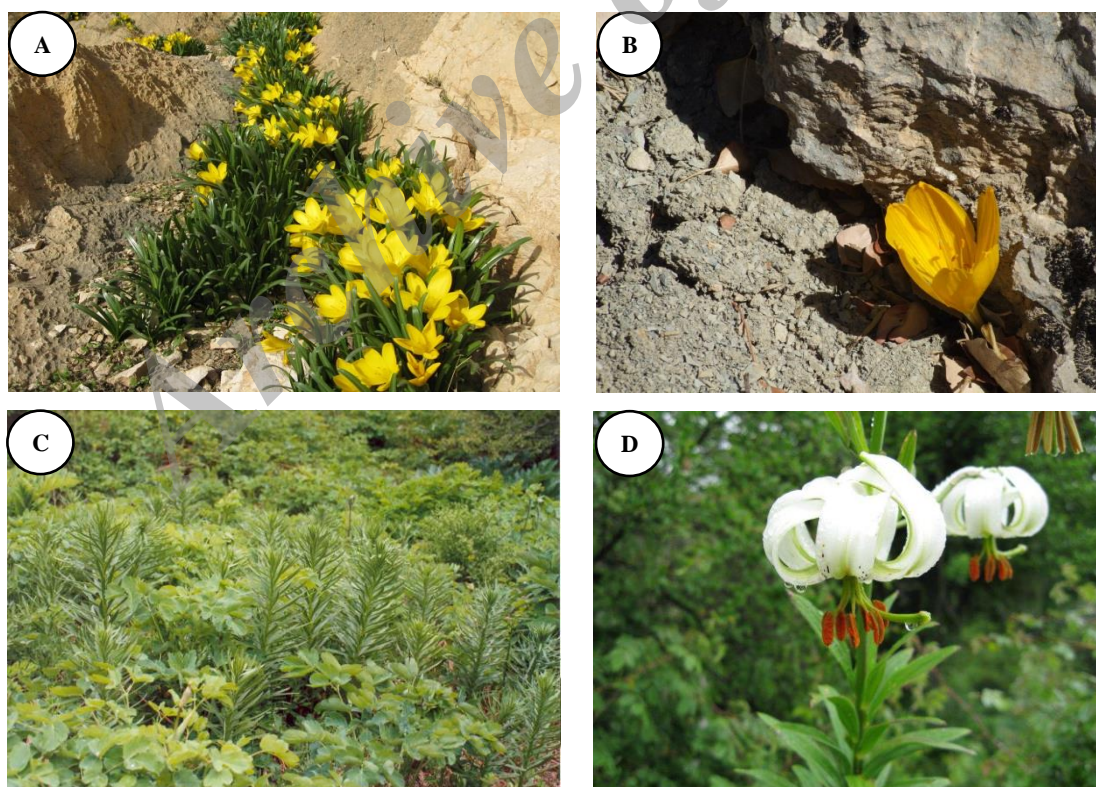


Fig. 4. *Sternbergia* sp. grows singly or in scattered populations in mountainous areas in some provinces such as Ilam (A) and Kohgiluyeh and Boyer-Ahmad (B). C and D) *Lilium ledebourii* (Baker) Boiss. a critically endangered species endemic to the north of Iran.



***Climatic change (Drought and temperature)***

Recent climatic models predict that the 21<sup>st</sup> century will be characterized by increasing temperature, changing precipitation patterns and more frequent severe events such as heat waves and droughts (Pourbabaei *et al.*, 2014). Climate change is one of the most important ecological problems of our times (Eppich *et al.*, 2009). There are many literature references from recent years indicating that increasing temperature could force alpine plants to migrate upwards until they reach the highest elevations. Therefore, many mountain ranges which host a large number of endemic plants are very likely to suffer critical losses (Grabherr *et al.*, 1994; Korner, 1999; Theurillat and Guisan, 2001; Pauli *et al.*, 2007).

West Asia and North Africa (WANA) are characterized by low rainfall and high fluctuation of the precipitation. During the last century, this region experienced many episodes of drought whose frequency has increased during the last decades (McNeely, 2003). This climatic phenomenon has negatively affected agricultural and livestock production and led to natural resource degradation. These problems have been associated with high population growth, and hence they have been aggravated by the use of non-adapted management of natural resources (McNeely, 2003).

Iran's climate is mainly arid and semi-arid, except the northern coastal and parts of western Iran. The climate is extremely continental with hot and dry summers and very cold winters, particularly in inland areas. The average annual rainfall of Iran is about 240 mm with maximum amounts in the Caspian Sea plains, Alborz and Zagros slopes with more than 1800 mm and 480 mm, respectively (Heshmati, 2007). According to Dore (2005), variance is found in the case of precipitation everywhere and dry areas may become drier in the future. Thus, global warming will adversely affect the vegetation of Iran and in particular, the

bulbous species which are in part difficult to propagate. Iran is now experiencing a decade of severe drought and this phenomenon has resulted in drastic damage to the country's vegetation particularly in drought-prone regions. Although geophytes have developed specialized organs to bear adverse environmental conditions, under severe periods of drought they may be damaged, because optimal climatic conditions and, most importantly, rainfall is required for them to make reserves via the photosynthesis process for the dormant (rest) period. Therefore, the lesser the rainfall, the shorter the growth and development period and the lower the carbohydrate reserves, consequently. The amount of snow has dramatically decreased during the past decades in the country and this phenomenon is alarming for those flower bulbs native to mountainous and alpine zones.

***Land use change (farming and mechanization, agricultural and horticultural activities, road construction, mining activities, etc.)***

Semi-arid and arid rangelands form nearly 30% of the world's land surface (Stafford Smith, 1996; Sivakumar *et al.*, 2005). Land degradation is a serious matter in the upper catchment of the semi-arid regions of Iran. In these areas the main causes of land degradation are conversion of rangelands to agricultural areas, improper plowing and irrigation, overgrazing, poor vegetation cover and extensive livestock, which all lead to sudden changes in biological diversity (Heshmati *et al.*, 2013). Ecological problems and the increasing deterioration of natural resources are due to unsustainable and improper land use (Heshmati *et al.*, 2013). Environmental degradation caused by inappropriate land use is a worldwide problem that has attracted the attention of sustainable agriculture production systems (Ayoubi *et al.*, 2011).

Agriculture land conversion (ALC) has been introduced as one of the most important factors affecting ecosystems (Barati *et al.*,

2015). Transformation or destruction of habitats due to unsustainable land use is one of the major threats to biodiversity. Land-use change is perceived as a key driver of future biodiversity loss (Bosing *et al.*, 2014). Transportation infrastructure that enhances connectivity among human settlements often results in decreased connectivity among remaining natural habitats and wildlife populations (Makki *et al.*, 2013). Habitat fragmentation and the creation of barriers by transportation infrastructures reduce landscape connectivity, and this is suspected to be one of the most important factors causing wildlife population decline (Makki *et al.*, 2013). An important type of land use is the production of livestock. Livestock management also strongly influences vegetation dynamics. World-wide plant species composition has changed because of land utilization by domestic livestock as an increase in grazing pressure can lead to a reduction of palatable grasses and herbs and woody plants. This shift in plant species composition has been shown to be accompanied by reduction in primary productivity. Because of these probable

challenges, sustainable management of semi-arid systems requires profound knowledge of the system dynamics (Tietjen and Jeltsch, 2007). The rate of legal and illegal land use change in Iran has been alarming during the past decades and should be managed so that it will not impair vegetation cover and biodiversity any further. The establishment of protected areas is a primary strategy to conserve biodiversity, although reserves alone cannot guarantee that biodiversity will be maintained (Noor Ahmed, 2006).

Some populations of the genus *Narcissus tazetta* L. grow naturally in the southern and northern parts of Iran particularly in southern provinces, including Fars and Khuzestan. From the perspective of ecotourism, the current natural habitats of *Narcissus* L. in Iran particularly the southern ones, are considered a potential. Many natural habitats of *Narcissus* have been destroyed mainly due to mechanization through the use of heavy field machines including tractors and also illegal and uncontrollable harvest, changing the habitats and pastures for agricultural purposes (Fig. 5. A and B). (Farahmand, 2007; Farahmand *et al.*, 2007).

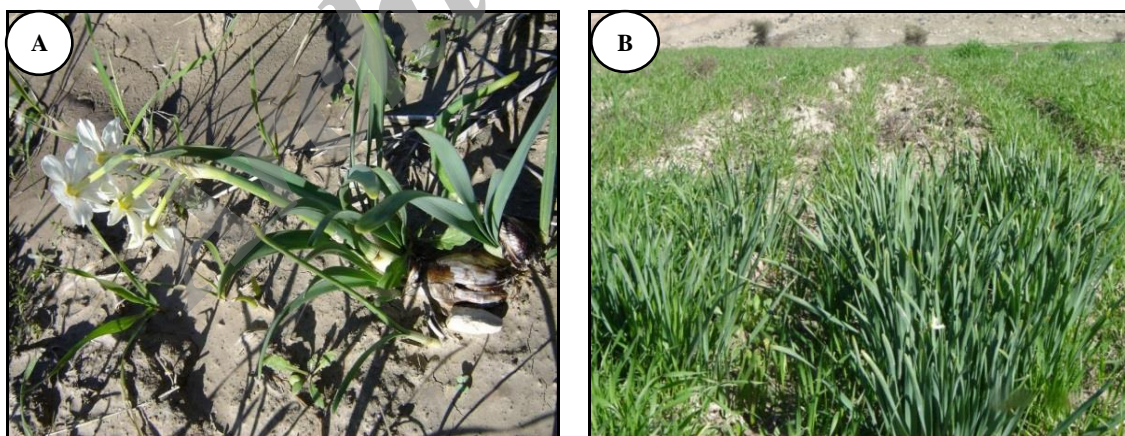


Fig. 5. A and B) *Narcissus tazetta* cv. Meskin at the risk of extinction due to mechanization and changing its habitat to wheat farms in the southern regions of Iran.

Fortunately, some protected areas have been established in southern provinces particularly in Fars province, to conserve the remnant populations of *Narcissus tazetta* L. in the southern parts of the

country (Farahmand, 2007). Dating back just to some decades ago and before the emergence of mechanization, narcissus plants were naturally found as narrow bands between fields especially in the

southern provinces of Iran such as Fars, Khuzestan and Bushehr. But nowadays only sporadic populations of this plant species are found in remote mountainous sites, plains at high elevations (in Fars province), or as protected areas just mentioned above. Factors threatening *Narcissus tazetta* populations are similar to the other bulbous species grown in hillsides and plains suitable for agricultural and horticultural purposes. Many hectares of these types of lands have recently been allocated to farming purposes and this habitat destruction and fragmentation has resulted in the genetic erosion of plant species particularly bulbous plants in many parts of Iran. It is noteworthy to seriously contemplate the statement presented by Wendelbo about 40 years ago: "Although Iran boasts a rich and diverse flower species, there is no simple illustrated guide to the flowering plants. Sheep, goats, and tractors in particular, have combined to despoil and eradicate the natural plant cover over vast stretches of Iran (Wendelbo, 1977)". Changes in land use, abandonment of grazing and some traditional land management practices have been mentioned as the important factors for reducing biodiversity in *Narcissus* species in Central Spain (Rios *et al.*, 2010).

Road construction (Fig.3 C) for many purposes and also mining activities are two other factors with drastic effects on plant species habitats and niches. An important threat to the alpine ecosystems of Iran in recent years is road construction in many mountainous areas (Heshmati, 2007). Not only do such roads destroy large parts of the area, but they also ease access to the high altitudes both for mass climbers and grazing animals. Mining operations have an important role in environmental changes (Alavi *et al.*, 2011). The damage to soil and vegetation caused by mining is usually extreme, because the original ecosystems are drastically disturbed or buried by the mining process (Martinez-Ruiz *et al.*, 2007). Mining practices can result in the

loss of vegetation and fauna, soil degradation, altered hydrology, and landform (Drake *et al.*, 2010). As mining exploitations greatly affect ecosystems and particularly disturb vegetation cover, in the modern world, sustainable mining is being practiced in developed countries to restore natural landscapes during mining operations or as a post-mining strategy (Farahmand *et al.*, 2014).

### ***Medicinal use, illegal and uncontrollable harvesting***

The growing popularity of traditional medicine and the unrestricted collection of medicinal plants from the wild have put many of the slow growing bulbous plant species at the risk of over-exploitation and extinction in South Africa. Medicinal plants are used by billions of people in most developing countries because of the frequently inadequate provision of modern medicine, their low cost, effectiveness, as well as cultural beliefs and preferences (Sheldon *et al.*, 1997; Shanley and Luz, 2003). In South Africa, bulbs are one group of plants that are highly valued and extensively used in the traditional medicine systems. Bulbs are used in the treatment of various ailments (Katerere and Eloff, 2008) and considerable research resources have been directed towards screening for biologically active compounds. Bulbs are ranked as one of the most popular plant groups sold at most of the traditional medicinal markets in South Africa (Mander, 1997). Their use in herbal medicine involves destructive uprooting of the whole plant. Harvesting of the whole plant, roots and bulbs account for approximately 50% of the more than 500 species and 48% of the volume of plants sold in the traditional modern market in Johannesburg (Williams, 2003). The non-suitable harvesting threatens the survival of valuable medicinal plant species; sadly, however, people's livelihood depends on them (Ncube *et al.*, 2011).

Tanzania is a wild orchid biodiversity hotspot and has a high prevalence of HIV/AIDS. Every year, between 2.2 to 4.1 million orchid plants consumed in Zambia originate from Tanzania. In addition, more than two million orchid tubers find their way illegally to the markets of Zambia annually. The harvesting of some orchid species by HIV/AIDS gatherers and non-HIV/AIDS gatherers was studied by Challe and Price (2009). The results of this study indicated the decline of some orchid species in Tanzania. Unfortunately, the income of some people depends on this type of business and the harvesting and in some cases smuggling of orchids, which inevitably have negative effects on the survival and diversity of orchid species in this country.

Some medicinal bulbous plants in Iran face challenges similar to those reported for South Africa. For instance, a kind of jam is made of the rhizome of *Polygonatum orientale* (Liliaceae) rhizomatous plants mostly grown in the northern parts of Iran. This jam is called "Morabbay-e-Shaghaghoh" in Persian, and sold in local markets. As the rhizomes are used for making this jam, the plants are destroyed to get the rhizome and this way of unsustainable (destructive) harvesting is a risky method threatening this valuable bulbous plant species restricted to the northern parts of Iran. A kind of powder is produced from the bulbs of *F. imperialis* (Liliaceae) in Iran. This slow-to-propagate popular bulbous plant is also under some other pressures previously discussed. Unfortunately, for making this special powder, the bulbs should be harvested and the species is at the risk of extinction in some regions of Iran.

*Urginea maritima* (Liliaceae) is another bulbous plant which is illegally and mistakenly sold as *Iris hollandica* (Fig.

6A) in some parts of Iran (case study, personal observation in Kerman province), and may be in some other parts of the country, due to people's lack of expertise and absence of protective rules. Surprisingly, the bulbs of this species are sold in winter (the newly-emerged plants are picked and sold) and due to lack of branching root system; the plants are withered and finally die after some time. *Ornithogalum spectabilis* is also used as a medicinal and nutritive plant in some parts of Iran including Kurdistan province (Fig. 6 B). *Orchis* spp. is also used for making ice cream and in confectionary, as well. The dried flowers of genus *Orchis* is also used for making a kind of tea. The rhizomes are also used for medicinal purposes. The leaves of *Biarum* spp. (Fig. 6 C) with an endemic species in Iran (*B. straussii*) are used for making a kind of meal called "Ashe Cardeh" (in Persian) in some parts of Iran, particularly the northern parts of Fars province (e.g., Eghlid). Since the underground specialized structure of this plant is a tuberous-like organ, this unsustainable harvesting of the leaves is a threat for this species because the photosynthetic leaves provide the tubers with carbohydrates ensuring growth and development. *Eremurus* spp. (Fig. 6 D) tuberous roots are also used for preparing a kind of glue called "Serish". The flowers are also used with egg in Kerman province as a meal. Since this species also suffers from inappropriate herbivory and overgrazing as it was mentioned earlier, some protection must come into effect for this multipurpose bulbous plant. In general, in the case of almost all bulbous plants, either bulbs or leaves are used for medicinal purposes, and both types of harvesting are threatening if not handled sustainably.





Fig. 6. *Urginea maritima* which is mistakenly sold as *Iris hollandica* in the city of Kerman, B) *Ornithogalum* sp. Leaves ready for sale at a local market of the city of Sanandaj called “Gilakhe” in the Kurdish language, C and D) *Biarum* and *Eremurus spectabilis* sold as spring vegetables in an Iranian local market, respectively.

### **Population growth rate and development**

The increase in human population has increased the expectations of life standards and exacerbated the scarcity of natural resources (Gholami *et al.*, 2013). Sheep and goat production was historically an important occupation for rural populations located within WANA countries (Louhaichi *et al.*, 2009). Currently WANA rangelands support high human population densities that apply significant pressures on these resources through elevated livestock grazing practices. These impacts have led to increased rates of desertification, a problem that will continue to worsen, unless proper management measures are developed and implemented that reduce these grazing impacts. Over time, impacts associated with livestock grazing have

been heightened due to poor management practices and the arid or semi-arid climate regime characteristics of this area (Louhaichi *et al.*, 2009).

The vast region covering the arid and semi-arid lands of North Africa, the Middle East, and East and Central Asia -the Palearctic Desert- is the cradle of the Old World civilization. While they have given us most of our domestic animals and some of our most important crops, those arid lands have been devastated by wars, overgrazing, and the vagaries of climate for thousands of years. Today, as population increase and modern technology become more pervasive, many of the rural people living in this region face the ancient scourges of hunger, pestilence, and conflict (McNeely, 2003). One of the tragedies of this situation is that the biological

resources which could help make these lands productive are often abused rather than nurtured. Thus, the major challenge in the implementation of the Convention of Biological Diversity (CBD) in arid lands lies not so much in the biology of the species but rather in the social, economic, and political reasons within which people operate (McNeely, 2003).

The population of Iran is about 70 million and the growth rate estimated as 1.7% (FAO, 2005). Iran has the sixteenth largest population in the world (Malekafzali, 2004). This growth rate is very high and the population is young. To meet the requirements of this population, some types of agricultural and horticultural activities are encouraged which have been and are harmful for biodiversity in short and long term periods. Vegetation cover in Afghanistan has been modified significantly through millennia of human occupation. In a country where over 80 percent of the population relies directly on the natural resource base to meet their daily needs, widespread environmental degradation poses an immense threat to future livelihoods (UNEP, 2003).

Social issues such as low income, poverty and low levels of welfare and education result in land degradation through improper land use activities (Heshmati *et al.*, 2013). Meat is a major part of people's diet in Iran. Thus, a part of income in rural areas is obtained from animal husbandry such as sheep, goat, cow and even camel. On the other hand, the main income source for Nomads (Ashayer) is animal husbandry. Consequently, grazing fields, pastures, and forests is inevitable for those involved in animal husbandry. Meanwhile, our country is not well industrialized at the present and these types of income support the country to be less dependent on oil industry. Accordingly, we should seek approaches to fulfill the balance between the income from animal husbandry and our limited natural resources such as pastures, forests, meadows, etc. Furthermore, informing

people of the detrimental effects of overgrazing is very useful. Indigenous ecological knowledge (IEK) has played a key role in the economy and cultural development of human beings for millennia (Ghorbani *et al.*, 2013). Some projects (in state and private sector) should be assigned and implemented similar to those performed for pasture and forest restoration in the country during the past decades. So, the growing areas (habitats) of geophytes are expanded from the present ones to new ones in other parts of the country. In tow mountainous regions in Kerman province, the bulbs of *Fritillaria imperialis* were planted for the first time and their growth and blooming were successful and promising. These activities could guarantee conservation purposes in the same situations elsewhere in Iran. Meanwhile, the establishment of some stations for bulbous plants particularly in western and northern regions are proposed.

### **War and terrorism**

As covering the negative effects of war and terrorism is beyond the scope of this review, these factors are briefly presented here. War and terrorism have left an extensive imprint on landscapes throughout the world (Mannion, 2003). The vast region covering the arid and semi-arid lands of North Africa, the Middle East, and East and Central Asia -the Palearctic Desert- is the cradle of the Old World civilization. While they have given us most of our domestic animals and some of our most important crops, those arid lands have been devastated by wars, overgrazing, and the vagaries of climate for thousands of years (McNeely, 2003).

Conflicts and geopolitical forces are important drivers of land use and land cover change (Gibson, 2012). The many environmental impacts of hostility include the infrastructure necessary for the preparation of war, including training grounds, camps, barracks, weapon testing, etc. However, the immediate impact of war

and terrorism are usually sudden and dramatic and can be direct or indirect. Direct impacts include bomb and blast damage to settlements. Defoliation and ecosystem destruction, the dumping of the machinery of war, and the destruction of resources also occur (Mannion, 2003). The immediate impacts of war and terrorism are obvious. The effects on landscape can be as devastating as earthquakes or volcanic eruptions as buildings collapse and craters develop (Mannion, 2003). The war between Iraq and Iran which lasted for about 8 years also had some drastic effects on both countries' vegetation and inevitably on bulbous plants, as well. Since the main center of this war was restricted to southern, western and south-western parts of Iran which are the cradle for many bulbous plants, some habitat degradation occurred in these areas. For instance, it is believed that mourning iris (*Iris susiana*) is a bulbous species which has taken its name from Shoosh which is now a city in Khuzestan province. It should be noted that the nomenclature is somehow controversial as reported by Saad and Khuri (2003).

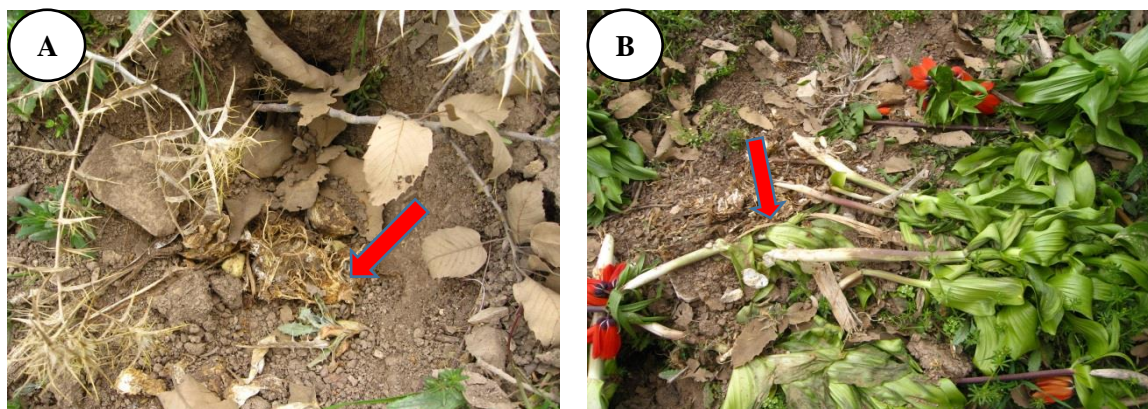
Currently some new waves of battles, conflicts, and clashes triggered by extremists and terrorist groups in the region particularly Syria and Iraq (and to some extent Afghanistan) and the newly emerged terrorist group called Daesh are all potential risks for vegetation cover and may affect the vegetation cover of Iran in border lines with these countries. Many decades of conflict have been mentioned as one of the main reasons for deforestation and widespread loss of vegetation cover in Afghanistan (UNEP, 2003). During over two decades of conflict, Afghanistan's natural resource base has been heavily damaged by military activities, refugee movements, over-exploitation, and a lack of management and institutional capacity. The past three to four years of drought have worsened this damage (UNEP, 2003). A greater number of bulbous and cormous species grow in the Middle East and south-eastern Europe in comparison to other

parts of the world. If a circle be drawn with Istanbul as the center and taking in Greece and Bulgaria, Syria and the Lebanon, Persia and Afghanistan and neighboring countries, it can be seen that many of the most popular flowering bulbs are grown within these areas (Genders, 1973). Thus, there remains no doubt that war and terrorism are potential risks for bulbous species throughout the world and particularly for the area just mentioned above. Ultimately, some new approaches and solutions should be adopted and implemented to settle these devastating clashes for a more peaceful world and, consequently, a more biologically diverse planet.

#### ***Insects and diseases, rodents, birds, and small animals***

These biotic agents are also partly involved in the scenario of bulbous plants' genetic resource erosion. Some insects feed on the seeds of some species and the sexual propagation of these species is disturbed. As the seed is a bridge between generations and increases variation and diversity, the lack of seed formation is a threat for the host species. Fungi, bacteria, and viruses are the main diseases found in ornamental flower bulbs. The other less studied threatening group of biotic stresses is nematodes. Rodents are also important in this regard and should be taken seriously especially for the palatable organs under severe drought conditions. Some insects feed on the capsules and seeds of *Iris* species in Iran. Mice and even some kinds of birds such as chukar partridge or chukar (*Alectoris chukar*) are interested in tulip bulbs as a source of food. Deer and insects have been reported as two factors responsible for reducing the population of Turkey's cap lily (*Lilium superbum*) which is a rare lily species in Turkey. In addition to the threatening factors mentioned earlier, *F. imperialis* are at risk during and after blooming. Some rodents dig up the bulbs of this species for the hidden food source reserved in the bulbs (Fig. 7. A and B).





**Fig. 7. Bulb (A) and flowering plants (B) of *Fritillaria imperialis* damaged by rodents in Manesht Mountain of Ilam province**

The devastating factors mentioned in this contribution are the most important ones threatening the bulbous plant vegetation of Iran. Now that we have just passed 2010 as “The International Year of Biodiversity”, it seems that we shoulder a great responsibility for biodiversity conservation around the world. Thus, the following approaches are proposed for the fulfillment of this purpose in Iran:

1. Increasing the protected areas in Iran to conserve the existing species as efficiently as possible. The establishment of protected areas is a primary strategy to conserve biodiversity.

2. Gathering the species at the risk of extinction in Botanical Gardens and Research Centers for better conservation.

3. Providing people with scientific knowledge through propagating information in public media and encouraging them to contribute more in this regard.

4. Highlighting the decisive role of NGOs and increasing the number of these Non- Governmental Organizations in Iran.

5. Conducting researches on the various aspects of growth and development of these species including ecology, phenology, physiology, propagation, etc. to have a database for precise decisions.

6. It is highly recommended that the bulbous species of Iran be studied based on morphological and particularly molecular markers in order to attain a deep knowledge about them for upcoming researches at

national and international levels. The identification of the ploidy level of these species is proposed using modern techniques including flow cytometry and ploidy analyzer. The data available now date back to some years ago gathered by some botanists and are most probably incomplete. Little information is available about the natural breeding, mutation breeding, and the relationship among the species of some genera including *Tulipa* spp., *Iris* spp. and *Fritillaria* spp., which are rich in this regard. Thus, some state-sponsored comprehensive researches should be conducted in order to obtain reliable data for many application fields including horticultural, pharmaceutical, aesthetical, breeding, etc.

7. Following and implementing the rules assigned by the associated institutes such as IUCN, CBD, etc.

8. The measures proposed by UNEP should be put into effect.

9. More attempts should be made to restore the degraded ecosystems and fragmented habitats.

10. GIS and modeling findings should be applied efficiently.

11. Tissue culture and biotechnology application is vital and viable.

12. Improving tourism as a clean industry is of considerable importance.

13. Indigenous Ecological Knowledge is very important for involving people in the assigned programs.



Covering all of these suggestions is beyond the scope of this review article, so only the 11<sup>th</sup> and 12<sup>th</sup> suggestions are presented in some details here.

### ***Tissue culture and biotechnology***

We believe that biodiversity loss is a global concern not restricted to any single part of the world. Although this phenomenon occurs more seriously in developing countries, the people of the entire world derive benefits from this biodiversity and should, therefore, be responsible. Thus, some promising reports from Iran and other countries experiencing the same scenario are briefly presented here indicating the efforts of scientific media to somehow solve the problem.

There are many techniques available for the conservation of the plant genetic resources of rare and endangered species. These include micropropagation, seed germination and regeneration from callus, embryo rescue, and cryopreservation. Micropropagation in bulbous plants, as an alternative to the conventional methods for vegetative propagation, attracts much attention due to its advantages including fast multiplication (Chang *et al.*, 2000).

Banciu *et al.* (2010) investigated the *in vitro* propagation of the critically endangered species of *Scilla autumnalis* L. The plant is protected in the National Red List of higher plants in Romania. *In vitro* propagation was optimized by Al-Gabbiesh *et al.* (2006) for the two endangered species of *Iris* namely, *I. petrana* and *I. atrofusca*. A tissue culture protocol was also developed for the mass propagation of *Lilium speciosum* Thunb. var. *gloriosoides* Baker, a native and rare perennial bulbous plant only known at altitudes of 150-660 m in northern Taiwan (Chang *et al.*, 2000).

Several propagation techniques were used to find a practical and fast method of propagation for *Fritillaria persica* in Turkey. This comprehensive research was done after some scientists warned that the species should be protected against

extensive collection (Vedat Ulug *et al.*, 2010). It should be noted that the bulbs of this species, which is difficult and slow to propagate, is exported to the Netherlands, Germany, England, the US, Japan, and Denmark.

It is already reported that *Fritillaria* species are at the risk of extinction in Iran (Ebrahimi *et al.*, 2006). Indirect somatic embryogenesis from petal explants was used for micropropagation of *F. imperialis*, an endangered bulbous plant in Iran (Mohammadi-Dehcheshmeh *et al.*, 2008). Indirect organogenesis of *F. imperialis* has been reported by Rahimi *et al.* (2013). A protocol for the micropropagation of "Susan-e-Chelcheragh", *Lilium ledebourii* (Baker) Boiss has been developed while studying the effects of growth regulators, sucrose concentration, harvesting season, and cold treatment (Azadi and Khosh-Khui., 2007). A Somatic embryogenesis protocol has also been established for the regeneration of this species by using new vegetative microscales and the transverse thin cell layer (tTCL) of young bulblet roots as the explant source (Bakhshai *et al.*, 2010). This species is critically endangered as mentioned earlier. Farahmand (2007), Farahmand *et al.* (2007) and Farahmand and Khosh- Khui (2009) investigated twin-scaling, chipping and micropropagation of two *Narcissus tazetta* L. populations locally known as Narges-e-Shahla and Narges-e-Meskin. They developed asexual propagation methods and optimized a protocol for *in vitro* propagation of these two populations of *Narcissus tazetta*, which are fortunately under governmental protection in some provinces such as Fars and Khuzestan. Biotechnology could also be used as an efficient tool for germplasm conservation particularly for endangered species (Paunescu, 2009).

### ***Improving the tourist industry***

Tourism has long been considered a 'clean industry', without any considerable negative

effects on the environment (Van der Duim and Caalders, 2002). However, this image is now outdated. Most parties are aware of the possible negative impacts and see the need for action (UNEP, 2000). At the same time, tourism is able to contribute to a growing awareness of the value of nature (Urry, 1992), and hence, to public support for the protection of biodiversity (Van der Duim and Caalders, 2002). Biodiversity is vital for tourism. Coasts, mountains, rivers, and forests are major attractions for tourists around the world. Wildlife and landscapes in mountainous areas are important attractions for tourists (WTO, 2010). The development of tourism can also be a way to make nature reserves economically viable and to provide employment and income for the local population (UNEP, 2000). In this manner, it can provide a viable alternative to other more damaging activities such as slash and burn agriculture, cattle farming, hunting, wood collection, mining and the like (Collins, 1998., Ross and Wall, 1999).

Iran holds myriads of attractions from the point of view of ecotourism. One of the most outstanding features of Iran is its unique nature boasting thousands of plant and animal species, some of which are rare and endemic. Ornamental bulbous plants of Iran have particular tourism appeals for nature enthusiasts from all around the world. The presence of winter, summer, spring and autumn-flowering species

among them makes this group of plants spectacular, particularly during spring, autumn, and winter when the mountains and plains in Iran are covered with them and become scenic. Thus, conserving this biodiversity is a prerequisite for a viable and dynamic tourist industry.

### Conclusion

In conclusion, inappropriate herbivory and overgrazing during the growth and flowering season, mechanization, land use change, drought, road construction, mining activities, urban expansion, plant material overexploitation, habitat fragmentation and ecosystem degradation, conversion of habitats for agricultural and horticultural purposes, lack of protection rules, illegal and uncontrollable bulb and cut flower harvesting as a source of income for native poor people, changing the pastures to dry farmlands, pest and disease attacks, and, to a lesser extent, war and terrorism are the main factors threatening flower bulbs of Iran as national and international heritage. As the natural multiplication rate of many ornamental bulbs are low, and, at the same time, the rate of extinction and eradication is high, some steps should be taken according to the suggestions presented here at local, national, and international levels to conserve these invaluable natural resources for current and future generations.

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