

ORIGINAL ARTICLE

Geological Diversity and its Importance on Biodiversity SW Safeen Mountain- Erbil, Kurdistan, North Iraq

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ABSTRACT

Geodiversity of SW Safeen Mountain composed of rock units, landforms, water resources and soil types. Rock units comprise limestone, dolostone, dolomitic limestone, marly limestone, marl, claystone, siltstone, sandstone and conglomerates. Many landforms recognized such as: mountain peaks, slopes, fractures, caves, undulated hills, and channels. Water resources include precipitation of rain and snow, as well as perennial and ephemeral channels, springs and wells. Soil type was classified to sandy, muddy and clayey soil. Geologic features and processes provides framework of life and offered many habitats such as: mountain peaks, fractures, caves and water channels. These habitats provides water and soil which contributed in growing grasses, flowering plants and trees for herbal animals and many birds, and provides nesting sites and safe shelters in the caverns between rocks and helps them in fast climbing of steep slopes. And also offering good resting places for falconiform birds, during their migration periods, and enabling them watching their prey. New species of a nocturnal gecko found inside the Shera Swar cave. And also many mammals and reptiles get benefits at habitats of this area. The aim of this study is to determine the relationships between geodiversity and biodiversity at the studied area and establishing protected area for geologic and biologic diversity and using it for education, scientific research, ecotourism and other sustainable development.

Keywords: geodiversity, biodiversity, habitats, Safeen Mountain, Kurdistan Iraq.

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INTRODUCTION

Geologist started using term "geodiversity" in the 1990s to describe the variety within abiotic nature. The major attention being given to biodiversity and wildlife conservation was simply reinforcing the long-standing imbalance within nature conservation policy and practice between biotic and abiotic elements of nature; several earth scientists coined the term geodiversity independently, as a natural twin to the "biodiversity" [1]. Geodiversity has been defined as "the link between people, landscape and their culture: it is the variety of geologic environments, phenomena and processes that make those landscapes, rocks, minerals, fossils and soils which provide the framework for life on earth" [2]. Also geodiversity (diversity of the geosphere) incorporates many of the environmental patterns and processes that are considered drivers of biodiversity [3]. The bedrock is viewed as the foundation of the ecosystem. Resources and processes sustain biotic resources and biosystems; these relationships are integrated at the ecosystem, community, species, organism, and cellular and genetic levels [4]. In recent decades, the relationships between geodiversity and biodiversity become more recognized by modern ecologists and natural resources specialists [4]. Many workers try to support above mentioned relationship [5], [6], [7], [8], and also two Iraqi workers [9] done similar study to show the relationship between geodiversity and biodiversity. The aim of this study is to investigate and correlate between abiotic and biotic elements at Safeen Mountain.

MATERIALS AND METHODS

Location: Safeen Mountain is located about 350 kilometers north east Baghdad city (Fig. 1), and 30 kilometers northeast Erbil city. Tectonically, it is located on an unstable zone, of high folded anticline [10].

Safeen Mountain is large asymmetrical, double plunging anticline, and there are small mountains such as: Shafi spi, which represents part of the flanks of Safeen Anticline and has SW dipping strata (Fig. 2). Studied area bordered from north east: by Safeen Mountain top, from south east: Darband komsban-Sartaka Mountain- Sari rash Escarpment- Peresh- Nawdari top, from north west: Salah al- din- Shaqlawa road, and from south east: Darband komsban road- upper Soulak village.

Climate: Mean annual rainfall of the study area is 650 mm, mean annual temperature 18 C°, and mean annual snowfall is less than 5.5 day/year, [11]. The climate of the area seems to be semiarid in the general sense, because the climate always wet for some (7) months (October to April), and dry in other (5) months (May to September).

Methodology: The sources of data presented in this study depend on the surveys and field trips to the safeen anticline, and numerous interviews with the local settlers of the area. Some of abiotic and biotic identification was done by field surveys, picture shot, and lab work. Another group of identification was from documents of Iraq Natural History Research Center and Museum- University of Baghdad specimens collected earlier from the studied area.

RESULTS AND DISCUSSION

There are close relationship between geological and biological diversity near Safeen Mountain.

Geodiversity

The geodiversity of the SW Safeen Mountain comprises rock units of different formations (stratigraphy) exposed in studied area, land forms, natural processes, water resources and soil features.

Rock units: rock units or bedrock is viewed as the foundation of the ecosystem that includes abiotic and biotic elements. Rock units of SW Safeen Mountain deposited during Mesozoic and Cenozoic, comprises diver type of rock units such as: limestone, dolostone, dolomitic limestone, marly limestone, marl, claystone, mudstone, sandstone and conglomerates[12]; [13] , (Fig. 1), (Table- 1).

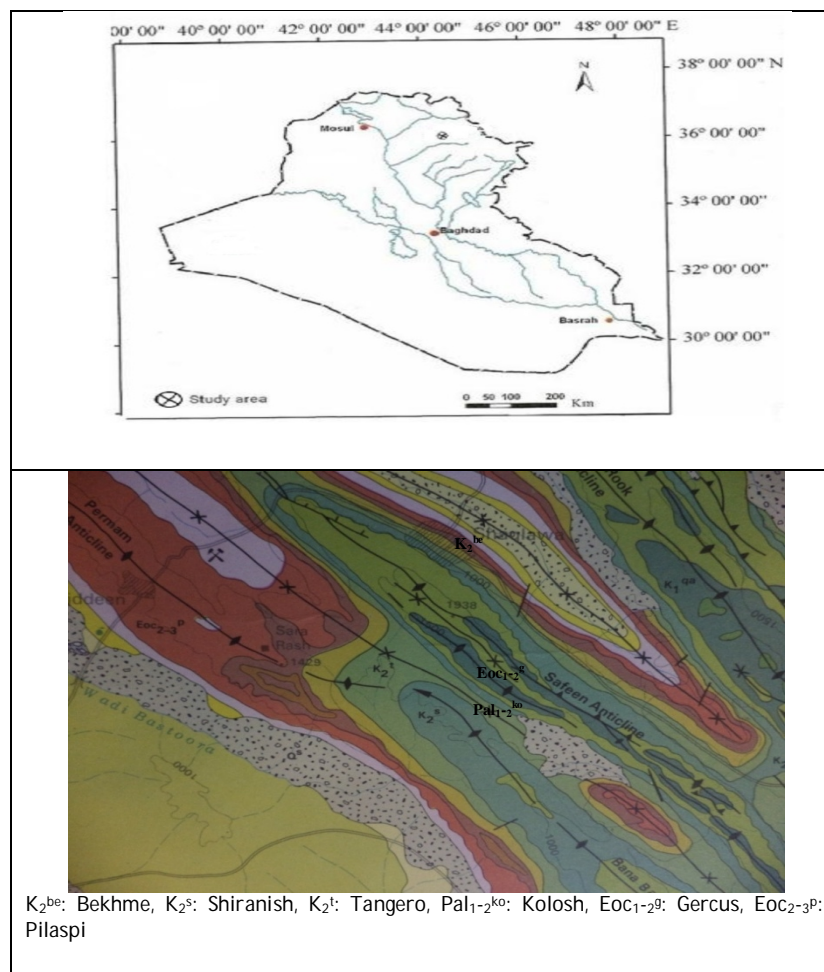


Fig. 1: Location and geologic map of the studied area (Sissakian, 1998).

Plate- 1

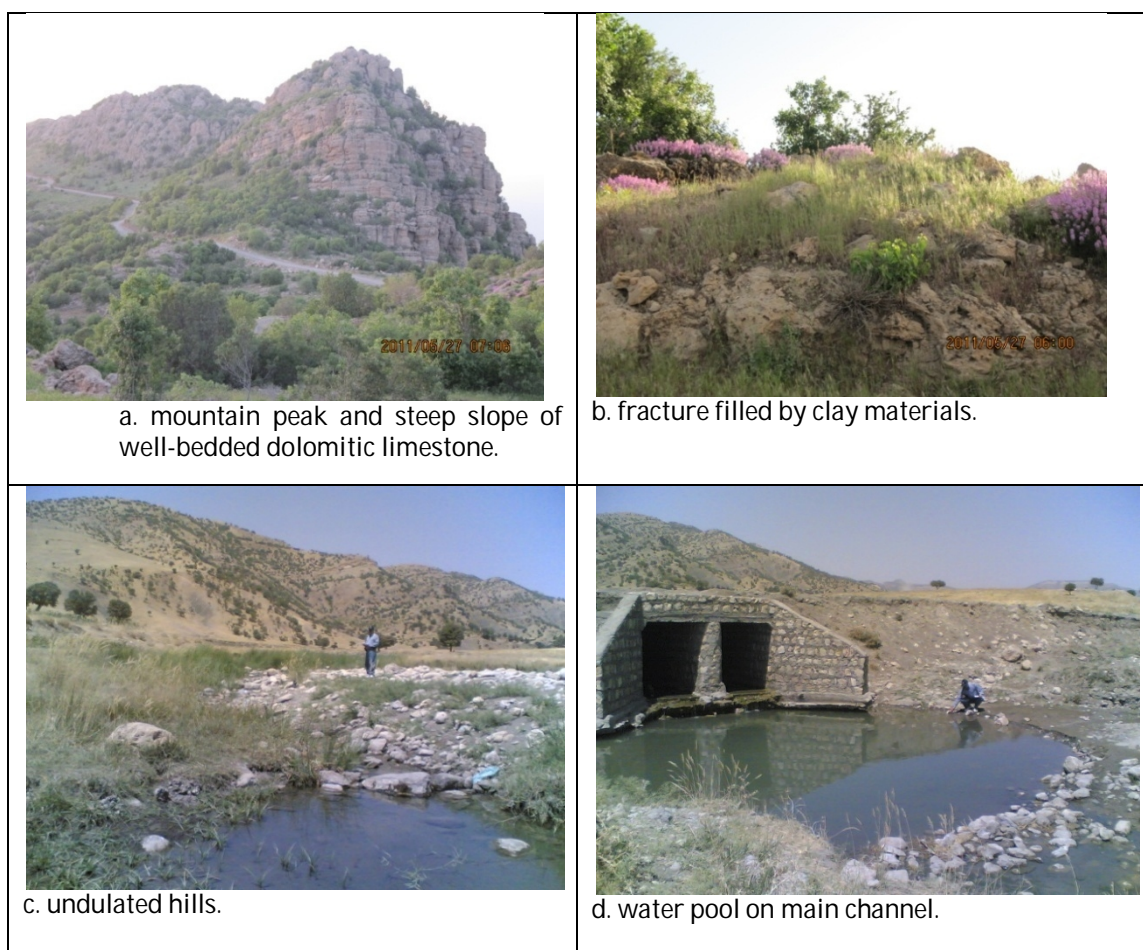


Table- 1: Age, thickness and description of rock units sw Saifeen Mountain.

Age	Formations	Thickness	Description
M-L. Miocene	Pilaspi	70m	Crops out in permam anticline and on the limbs of saifeen anticline. Consists of well- bedded limestone, occasionally dolomitic. In the upper most part, conpressions of chert and iron oxides may occur. In the base a horizon of cherty pebble conglomerate.
M. Eocene	Gercus	220m	Consists mainly of red and brown color claystone, mudstone, siltstone and sandstone. In the upper part a tongue of limestone (Avana Formation) occur.
Paleocene- L. Eocene	Kolosh	500m	Consists mainly of black and gray color claystone, shale, sandstone and siltstone, few thin horizon of conglomerate may occur. In the upper part a tongue of dolomitic limestone (Khurmala Formation) occur.
Maastrichtian	Tangero	200m	Consists mainly of green to kaki color claystone , sandstone and siltstone with few horizons and lenses of conglomerate in the upper part.
Maastrichtian	Shiranish	100m	Upper part consists of marl and marly limestones with very thin horizon of silicified limestone. Lower part consists of well- bedded and hard limestone and clayey limestone.
Campanian	Bekhme	150m	Exposed only at saifeen anticline. Consists of well- bedded limestone, massive dolostone and dolomitic limestone.

Landforms: Landforms of study area resulted from both erosion and deposition on structural elements. Field survey showed many landforms such as: mountain peaks, slopes, fractures, caves, undulated hills, and channels.

Mountain peaks: Safeen Mountain is considering the highest topographic feature in the area; reach to 1974 meters above sea level. It is asymmetrical anticline, plunging toward North West. Safeen Mountain represents the core of anticline; consist of limestone and dolostone of Bekhme and Qumchuqa. To the south west ward of Safeen there are other mountains such as Shafi spi, Mizquata, Nawdari and Sara rish. Their elevation range from 1019 to 1429m above sea level. The peak of them composed of well- bedded partly dolomitized limestones that are highly resistant to erosion (plate 1- a).

Slopes: there are steep slope near the top of mountains on limestone and dolomitic limestone of Qamchuqa, Bekhme and Pilaspi Formations, and moderate slope on marley limestone of Shiranish Formation and on clastic of Gercus Formation, and gentle slope on weakness clastic rocks of Tanjero and Kolosh.

Caves: The caves of studied area are naturally formed, when slightly acidic rain water dissolves carbonate rocks of Bekhme, Shiranish and Pilaspi Formations along joints and fractures.

Fractures: in this study includes fractures, joints and bedding Planes. Many fractures presents on the limestone and dolostone bed rocks of Bekhme, Shiranish and Pilaspi Formations. These fractures may be deepening and widening due to solution effects, then after filled by clay materials (plate 1- b).

Undulated hills: some undulated hills occurred between Safeen and other mountains. These hills composed of green and kaki color sandstone and claystone of Tanjero Formation, and of gray and black color sandstone and claystone, which are easily eroded rocks (plate 1- c).

channels: there are two types of drainage pattern of channels in the studied area; parallel drainage pattern is running from the top of mountain to the bottom on high resistant carbonate rocks (limestone and dolomitic limestone), and the dendritic drainage system is running on homogeneous and weakness clastic rocks of Tanjero, Kolosh and Gercus Formations, between undulated hills and within flat areas [14]. The direction of main channels such as; Sartaka and Toaska parallels to the mountain axis. These channels deposited gray sand sediments and gravel (up to 90x60x45 cm) (plate 1- c), and the channel width reach to 30 m. The large size and width shows high discharge and high energy of transportation during rainy seasons. Some of these channels are perennial and others ephemeral.

Water Resources: water resources of studied area comprise Precipitation of rain and snow, springs and wells. Mean annual rainfall about 650 mm, mean annual snowfall is less than 5.5 day/year [11]. Climate always wet for some (7) months (October to April). Flow water controlled by geology and geomorphology, particularly during rainy days from top of mountains (reach to 1974 m a. s. l.) via minor channels carved on carbonate rocks of Bekhme, Shiranish and Pilaspi Formations along joints and fractures to the main valleys occurred between mountains (less than 900 m a. s. l.) on the weakness clastic rocks of Tanjero and Kolosh Formations. Many springs flows annually and formed water pools on main channels (plate 1- d). also some wells drilled by modern machine range in depth from 40-200 meters, and some hand- dug water wells range in depth from 8-10 meters. These water uses by plants and animals and by human for agriculture and domestic uses.

Soil type: (refer to sediments) It is produced by chemical, physical and biological weathering processes acting to break down exposed rocks on mountains and their flanks. And may be formed directly from bedrock, or from transported sediments such as channel sediments. According to field surveys, the soil of studied area, depends mainly on the erosion products of parent rock units, can be classified to sandy, muddy and clayey soil. Soil materials derive during erosion of clastic rock beds within Tangerang, Kolosh and Gercus Formations. Also clayey materials can be derives from carbonate rock beds (marley limestone and limestone) of Beckme, Shiranish and Pilaspi Formations when dissolves by acidic rain or acidic runoff.

Habitats:

Geologic features and processes near Safeen Mountain provides framework of life and offered many habitats such as: mountain peaks, fractures, caves and water channels.

Mountain peaks: At Mountain peaks and steep slopes Because of its low temperature the spring grasses and flowering plants such as *Hordeum* sp. , *Vulpia* sp. *Ferulago* sp. *Papaver* sp. *Iris* sp. *Allium* , *Adonis* and *Campanula* sp. exist for longer time make a typical habitat for wild goat *Capra aegagrus* and many birds , such as: rock partridge (*Alectoris chukar*) and Seesee partridge (*Ammoperdix griseogularis*), Nuthach (*Sitta europea*) and snow finch *Montifringilla nivalis* helps them in fast climbing of steepe slopes of carbonate rocks, to the mountain peaks when feel danger, and provides nesting sites and safe shelters in the caverns between rocks. And also offering a good resting places for falconiform birds, during their migration periods, such as Egyptian Vulture (*Neophron percnopterus*) , Golden eagle (*Aquila chrysaetus*), and

Kestrel (*Falco tinnunculus*) and enabling them watching their prey like brown hare *Lepus capensis* and certain small mammals eg. Squirrel *Sciurus anomalus*.

Fractures: fractures may be filled by clay materials which contributes for growing certain plants like : (Ballot) Oak tree and pistacia Walnut, Fig and terebinth, etc. (Table- 2); beside a plenty of wild flowering plant, Many birds (Woodpeckers, *Dendrocopos syriacus* golden oriole *Oriolus oriolus* and long tailed Tit, *Aegithalos caudatus*) Mammals (Squirrel, *Sciurus anomalus*. Common red fox, *Vulpes vulpes*. And Weasel, *Mustela nivalis*) and Reptiles, (Snake, *Macrovipera lebetina*. Green lizard, *Lacerta media*. Agama, *Laudakia nupta*) can be nesting and breeding on or in-between these trees and bushes. Bee also gets benefits from this habitat to build their hives at fractures of carbonate rocks in addition of collecting the nectar from wild plant flowers.

Caves: caves within carbonate rocks (Limestone, dolostone and marly Limestone) represents good living and breeding places and help in protection and hiding, bats, scorpions, gecko and spiders. New species of a nocturnal gecko (*Asccus saffinae*) and also (*Cyrtopodion heterocercus*) found inside the Shera Swar cave, between oak trees, after sunset, at an elevation of 1800m above sea level, in Safin Mountain, Erbil province, Kurdistan of Iraq, [15]. Also some birds will choose caves for building their nests (Nuthatch, *Sitta europaea*. House Martin, *Delichon urbica*. Rock Dove, *Columba livia*.) [16].

Water channels: There are many of water channels flow toward the south and finally reach main Pastora valley, and others flows towards north east. These water channels and their banks provide water and soil (sediments) for growing certain plants, and represent favorable sites for living and breeding for many mammals (Asiatic Jackel, *Canis aureus* and Rodentia), reptiles (Snake, *Coluber jugularis* Lizards, *Lacerta media* & *Ophisops elegans* and Turtles, *Mauremys sp.*) and birds (Blackbird *turdus merula*), Warbler, Wagtail and Wren, some water pool on these channel help in living and breeding of fishes (*Capoeta*) and Amphibians *Rana ridibanda*.

Biodiversity

An International Convention on Biodiversity was first proposed in 1974 and during the 1980s. International recognition of the need for biosphere conservation led to the UN Convention on Biodiversity agreed at the Rio Earth Summit in 1992, ratified in 1994 and signed by over 160 countries. Biodiversity is not just about numbers of species or ecosystems but about the countless interactions between them [17]; [18]. In regard to Safeen Mountain, biodiversity tentatively comprises many species of flora and fauna that could be identified by the authors including 16 common plants (Trees, Bushes and flowers), 8 reptiles, 19 birds and 15 mammals [19]; [20]; [21]; [22]; [23]. Unknown number of different kinds of invertebrates, fungi and other macro- and sub macroscopic organisms are in need to be studied and identified.

Flora: Flora of Safeen Mountain reflects the geographical position of the mountains, highland plains, and valley. Consequently, the biogeography denomination is characterized by a mantle of vegetation, medium-sized trees (bushes), such as *Quercus sp.* table- 2, wide variety of wooded bushes, shrubs and grass, such as *Ranunculus sp.* *Papaver sp.*, *Adonis aestivalis*, *Tamarix sp.*, *Imperata cylindrica*, *Rhus coriaria*, and *Chaenomeles lagenaria*. Grasses such as *Hordeum sp.*

Table- 2: Common Trees and Bushes of Safeen Mountain.

Scientific name	Common name, local name
<i>Quercus sp.</i>	Oak, Ballot
<i>Morus alba</i>	White mulberry
<i>Rubus sp.</i>	Dewberry
<i>Crataegus sp.</i>	Zaaror
<i>Cupressus sempervirens</i>	Sarow
<i>Acer cinerascens</i>	Asfendan
<i>Prunus amygdalus</i>	Loze
<i>Salix sp.</i>	Sufsaf
<i>Juglans regia</i>	Jouze-Walnut.
<i>Pistacia eurycapa</i>	Terebinth
<i>Ficus carica</i>	Fig

Fauna: The fauna is well-represented by a variety of invertebrate and vertebrates, although their situation and ecological composition is hardly known. Among the invertebrates, wide variety of beetles, ants, spiders, and scorpions are found, all of which are specially adapted to the mountain climate.

The conspicuous vertebrates are the wild goat and Roe Deer constituting the largest herbivores Brown Hare and Euphrates Jerboa representing the medium- small sized herbivores. Among the carnivores is Stripped Hyena, Wild cat, Wild Boar and Foxes, table- 3.

Table- 3: Mammals of Saffin Mountain, and IUCN Red List Category, (LC) Least concern, (NE) Near threatened, (VU) Vulnerable, (EN) Endangered, (EX) Extinct [24].

Scientific name	Common name
<i>Vulpes vulpes</i>	Common Red Fox
<i>Hyaena hyaena</i>	Striped Hyena
<i>Felis silvestris</i>	Wild Cat
<i>Sus scrofa</i>	Wild Boar
<i>Sciurus anomalus</i>	Squirrel
<i>Mustela nivalis</i>	Weasel
<i>Capra aegagrus</i>	Wild Goat
<i>Lepus europaeus</i>	Brown Hare
<i>Canis aureus</i>	Asiatic Jackal
<i>Hystrix indica</i>	Indian Crested Porcupine
<i>Meles meles</i>	Badger
<i>Apodemus sylvaticus</i>	Common Field Mouse
<i>Rattus rattus</i>	House or Black Rat
<i>Mus musculus</i>	House Mouse
<i>Lutra lutra</i>	Otter
<i>Lynx lynx</i>	Common Lynx
<i>Pipistrellus kuhlii</i>	Bat
<i>Plectus sp.</i>	Long eared Bat
<i>Castor fiber</i>	Beaver (EX)
<i>Dama mesopotamica</i>	Fallow deer (EX)
<i>Capreolus capreolus</i>	Roe deer (EX)
<i>Acinonyx Jubatus</i>	Cheetah (EX)
<i>Panthera leo</i>	Asiatic lion (EX)
<i>Ursus arctos</i>	Brown bear (LC)
<i>Panthera pardus saxicolor</i>	Leopard (EN)
<i>Capra aegagrus</i>	Wild goat (VU)
<i>Ovis ammon</i>	Red sheep (NT)

The birds of Saffin Mountain are represented by a valuable diversity among them are the Rock Partridge, Seesee partridge and Wood peckers, table- 4; in addition of the birds which can be seen flying over the area during the migration period from other countries like: Woodcock, Spotted Redshank, Cuckoos Nightjar, Persian Bee – eater; and an ample variety of small birds who build their nests in the rocks and sparse vegetation.

Table- 4: Avifauna diversity of Safeen Mountain, and IUCN Red List Category, (LC) Least concern, (VU) Vulnerable [24].

Scientific name	Common name
<i>Alectrois chukar</i>	Rock Partridge
<i>Ammoperdix griseogularis</i>	Seesee Partridge
<i>Columba livia</i>	Rock Dove
<i>Dendrocopos syriacus</i>	Syrian woodpecker
<i>Corasis garrulus</i>	European Roller
<i>Turdus merula</i>	Black bird
<i>Columba p. palumbus</i>	Wood Pigeon
<i>Streptopelia turtur</i>	Turtle-Dove
<i>S. senegalensis</i>	Palm dove
<i>Clamator glandarius</i>	Great Spotted Cuckoo
<i>Tyto alba</i>	Barn Owl
<i>Athene noctua bactriana</i>	Little Owl
<i>Troglodytes troglodytes</i>	Wren
<i>Sitta europaea</i>	Nuthatch
<i>Aegithalos caudatus</i>	Long tailed Tit
<i>Upupa e. epops</i>	Hoopoe
<i>Motacilla alba</i>	Wagtail
<i>Neophron percnopterus</i>	Egyptian Vulture
<i>Aquila c. chrysaetus</i>	Golden Eagle
<i>Aquila chrysaetos</i>	Golden eagle (LC)
<i>Aquila heliaca</i>	Imperial eagle (VU)
<i>Sylvia atricapilla</i>	Blackcap – Warbler
<i>Gyps fulves</i>	Griffon vulture (LC)
<i>Otis tarda</i>	Great bustard (VU)

The other vertebrates of this environment are the reptiles, most remarkably are Lizards and Snakes, table- 5.

Table- 5: Common Reptiles and Amphibians of Safeen Mountain, and Category of IUCN Red List, (LC) Least concern, (VU) Vulnerable [24].

Scientific name	Common name
<i>Rana ridibunda</i>	Frog
<i>Bufo viridis</i>	Green toad
<i>Neurergus crocatus</i>	Kurdische bergbachmolche (VU)
<i>Triturus vittatus</i>	Banded newt (LC)
<i>Clemmys caspia</i>	Caspian terrapin
<i>Cyrtopodion scaber</i>	Keeled rock gecko
<i>Eublepharis angramainya</i>	Fat-tailed gecko
<i>Lacerta media</i>	Green lizard
<i>Cyrtopodion hetrocercus</i>	Cave gecko
<i>Asccus saffinae</i>	Saffin cave gecko
<i>Macrovipera lebetina</i>	Viper
<i>Coluber jugularis</i>	Whip snake
<i>Natrix tessellate</i>	Water snake
<i>Malpolon monspessulana</i>	Montpellier snake

Many species of large mammals was extinct from the studied area and other was threatened (table-3), and also some avis and amphibian were threaten (table- 4), (table- 5) near Safeen Mountain due to human activities and habitat loss. this study are recommend to establishing protected area for geologic and biologic diversity and using it for education, scientific research, ecotourism and other sustainable development.

CONCLUSIONS

Geodiversity of SW Safeen Mountain comprises, rock units, landforms, water resources and soil types. Rock units comprise limestone, dolostone, dolomitic limestone, marly limestone, marl, claystone, siltstone, sandstone and conglomerates. Field survey showed many landforms such as: mountain peaks, slops, fractures, caves, undulated hills, and channels. Water resources comprise precipitation of rain and snow, as well as perennial and ephemeral channels and springs. Soil type was classified to sandy, muddy and clayey soil. Geologic features and processes near Safeen Mountain provides many habitats such as: mountain peaks, fractures, caves and water channels, that contributed in growing grasses, flowering plants and trees for herbal animals and many birds , and helps them in fast climbing to the mountain peaks when feel danger, and provides nesting sites and safe shelters in the caverns between rocks. And also offering good resting places for falconiform birds, during their migration periods, and enabling them watching their prey. New species of a nocturnal gecko (*Asccus saffinae*) found inside the Shera Swar cave. And also many mammals and reptiles get benefits at habitats of this area. Many species of large mammals was extinct from the studied area and other was threatened , and also some birds and amphibian were threatened near Safeen Mountain due to human activities and habitat loss. This study are recommend to establish protected area to conserve geologic and biologic diversity and using it for education, scientific research, ecotourism and other sustainable development.

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