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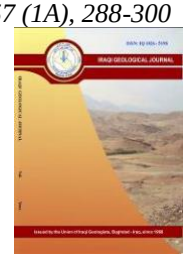

The Relation between Geodiversity and Biodiversity of Al-Salman Depression, Al-Muthana Governorate, Southern Desert of Iraq

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Abstract

The study area is located in the southern desert of Iraq, near the Al-Salman Depression, about 130 km southwest of Al-Samawa City. The Collection of data of this study depends mainly upon field surveys, sample collection of rocks, soil, plants, and animals besides interviews with locals as well as photographing of interesting aspects. The geodiversity of the study area comprises geological features, geomorphological features, soil types, and water resources. The exposed rocks of study area are composed mainly of carbonate rocks, in addition to marl, sandstone, and claystone, which belong to the Middle member of the Dammam Formation (L. Eocene). The main landforms found near the Al-Salman area are flat terrain, depressions (faidhats), wadis, caves, and sinkholes. Three types of soils were recognized; silty clay, clayey silt, and sandy soils. The main water resources are the ephemeral streams (wadis), and water wells in sinkhole, besides the mechanical and hand-dug wells. Geodiversity features formed many habitats in the study area such as Wadi Al-Owja, depressions (faidhats), flat terrain, and sinkhole. The present study reveals that biodiversity includes a wide diversity of plants, invertebrates, and vertebrates. Some species were restricted to certain habitat types in the study area, while other species proved to be more generalist.

Keywords: Al-Salman; Biodiversity; Geodiversity; Habitat; Southern desert; Iraq.

1. Introduction

The Geodiversity features provide the framework on the earth for life forms. Geodiversity comprises geological features, geomorphological features, Soil types, and water resources. Geological features include rocks, minerals, and fossils while the geomorphological features include landforms and natural processes. The geodiversity is the foundation of ecosystem services (Millennium Ecosystem Assessment, 2005). The geodiversity features form the land, ecosystems, and habitats on which the plants, animals, and humans live and thrive beside the different ecosystems that embrace different life forms (Gaston and Spicer, 2004; Kremen et al., 2018). Geodiversity and biodiversity are closely related and interact to shape landscapes and ecosystems (Yu and Yang, 2022).

Pandharinath (2022) highlighted the critical relationship between habitats and living organisms. Conservation and management of natural resources need to take care of both geodiversity and biodiversity (Gordon et al., 2021). Hunter et al. (1988), Beier and Brost (2010), and more recently (Crofts, 2019) found an intimate link between abiotic and biotic diversity. The results of the first two

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works led to the concept that biodiversity conservation might best be achieved by conserving geomorphological diversity. This concept has become known as the "Conserving Nature's Stage" approach using the metaphor of the biodiversity actors on a geomorphological stage. The concept is likely to be particularly relevant to protecting biodiversity in times of climate change. For the Middle East region, Zohary (1973) pointed out that plant life is strongly correlated with the topography and the shape of the landform. Some specific case studies of the links between geodiversity and biodiversity are provided in (Kassas and Girgis, 1965; Zohary, 1973; Orshan, 1986; Fakhireh et al., 2012; Osman et al., 2014; Stavi et al., 2016). In Iraq, some works on this issue were carried out only recently including Mohammad and Al-Zubaidi (2014, 2017), Al-Zubaidi et al. (2014, 2017), besides the study on the natural heritage of Sawa Lake of Awadh (2016).

Moreover, recently, some studies were done on the geoparks of northeastern Missan Province (Khalf et al., 2022) and Geopark between Makhul Mountain and Tigris River, north of Tikrit City, Middle Iraq (Talab, 2023). Al-Salman Depression has a very dry to semi-dry climate, and the climatic data provided by Al-Bayati (2021) and Al-Mousawi and Muhsen (2015) in Al-Samawa Station, (1988-2019) climatic records showed that the high and low values of maximum temperatures range from 45.10/ August to 17.26/ January and the annual rates of maximum temperature are 32.20°C. The high and low values of minimum temperatures range from 28.26/ July to 6.11/ January and the annual rate of minimum temperature was17.50°C. The annual rainfall is 95.80 mm/ year. The annual rate of relative humidity was 40.80 %. The annual rate of wind speed was 3.20 m/min. In Al-Nasiriya Station, (1988-2019) records showed that the high and low values of maximum temperatures range from 45.60/ August to 17.60/ January and the annual rate of maximum temperature was 32.80 °C. The high and low values of minimum temperatures range from 28.60/ July to 6.40/ January and the annual rate of temperature was 18.30°C. The annual rainfall was 122.00 mm/ year. The annual rate of relative humidity was 43.40 %. The annual rate of wind speed was 4.10 m/min.

The study area is located in the southern desert of Iraq, near Al-Salman Depression, about 130 kilometers southwest of Al-Samawa City (Fig. 1).

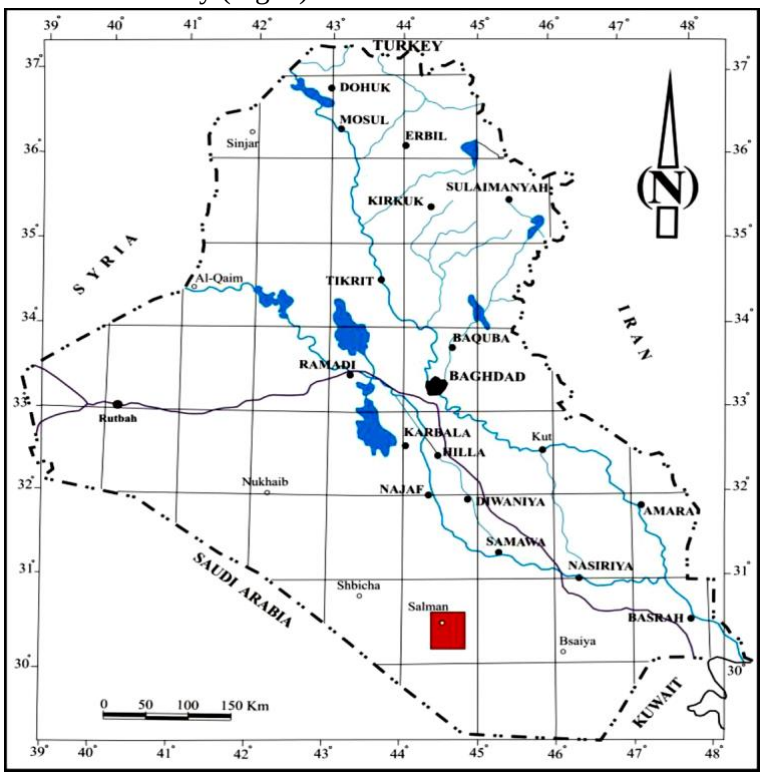

Fig. 1. Location map of the study area.

This vast area is inhabited by only two settlements; Al-Salman Town at the center and Al-Bussaya Nahiyah near the Saudi Arabian border. The study area lies approximately within Lat. 30.461397° - 30.512267° and long. 44.540538° - 44.907904° with elevation ranges 190-250m a.s.l. Al-Salman district falls within the Arabian Desert and East Sahero Arabian Xeric Shrublands (PA1303) ecoregion which is considered to be Critical/ Endangered (IMOE, 2018). It is an unprotected dry habitat with ephemeral streams running northeast. The landscape is dominated by desert plains; they include scattered low-growing vegetation (KBA Iraq, 2017). According to IMOE (2018), the biodiversity of this region is one of the least known in the country. Furthermore, the plant cover had received practically no study in recent years, especially during the flowering and growth of spring annuals after winter rains. It is thought that several uniquely adapted plants are expected to exist in the region.

Aim of study is to survey the geodiversity and biodiversity components and to reveal the relation between them for a better understanding of the importance of geodiversity to biodiversity in Al-Salman depression and surrounding areas, Al-Muthana Governorate, Southern Desert of Iraq.

2. General Geology of the study area

The main exposed rocks of the study area belong to the Dammam Formation (Eocene) (Fig. 2), (Sissakian, 2000). It comprises chalky dolomitic limestone, dolostones, marls, and shales. Dammam Formation is underlain by Rus Formation, which comprises anhydrite and carbonate (Jassim and Goff, 2006). According to the field surveys of this study, the main geomorphologic features are flat terrain, ephemeral streams (wadis), sinkhole, and depressions (faidhats). The flat terrain is part of the Iraqi southern desert, covered mainly by desert-varnished rock fragments of carbonate and chert, and is dissected by many wadies and includes some depressions.

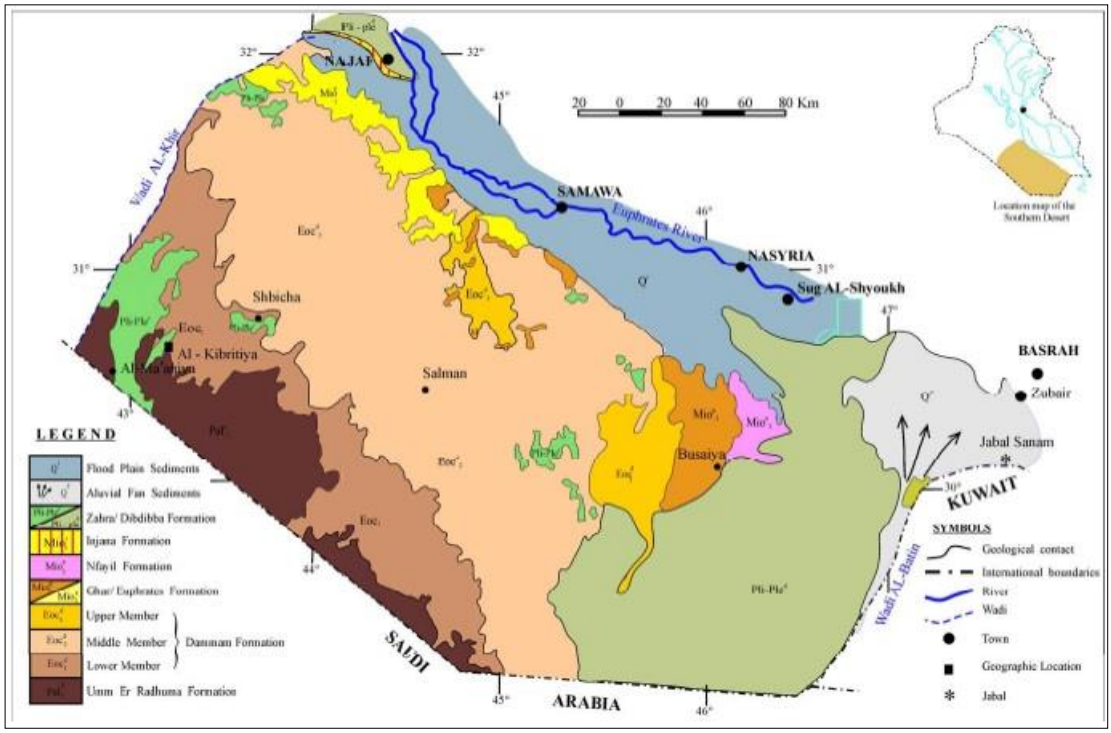

Fig. 2. Geologic map of the study area (after Sissakian, 2000)

3. Materials and Methods

The collection of data for this study depended mainly upon field surveys, specimen collections of rocks for slide preparations to the polarized microscope, soil, plants, animals as well as invertebrates, and sighting of the animals and plants in their natural environments by direct visual observations,

interviews with shepherds, farmers, and locals in Al-Salman Depression and the surrounding areas. Photomicrographs were taken to help in the identification of animal and plant species. Field trips were 8, lasted collectively for 33 days, and were carried out from January 2014 to February 2019. Bird field records were obtained using rapid assessment through the species-list method (MacLeod et al., 2011). In situ, work was two shifts of 2-3 hours per 2-6 days spent in the area. For other biotic groups' direct collection, sighting, or photographing was used. The abiotic and biotic identification were done in the field and in the laboratory using relevant keys. Thin sections had been prepared to analyze the petrography of some rocks. Soil texture was determined by a feel test (Whiting et al., 2003).

4. Results and Discussion

Field surveys of the study area focus on the relation between geodiversity and biodiversity as well as on habitat description. The following data were recognized:

4.1. Geodiversity

The Field surveys of Al-Salman Depression and adjacent areas showed many geologic features, geomorphologic features, soil features, and water resources.

4.1.1. Geologic features

these include rocks and minerals. The exposed rocks, in the study area near Al-Salman Depression, are composed mainly of carbonate rocks, in addition to marl, sandstone, and claystone. The middle member of the Dammam Formation (M. Eocene) is the main exposed rock bed unit in the study area, which comprises thick-bedded and massive limestones alternating with soft limestones and shelly limestones (Jassim and Al- Jiburi, 2009). The current study selected four limestone samples and thinned sections to study them. A polarized microscope study shows that the limestone is composed of micrite, microspar, and sparry calcite. Some of them contain broken fossils (Fig. 3).

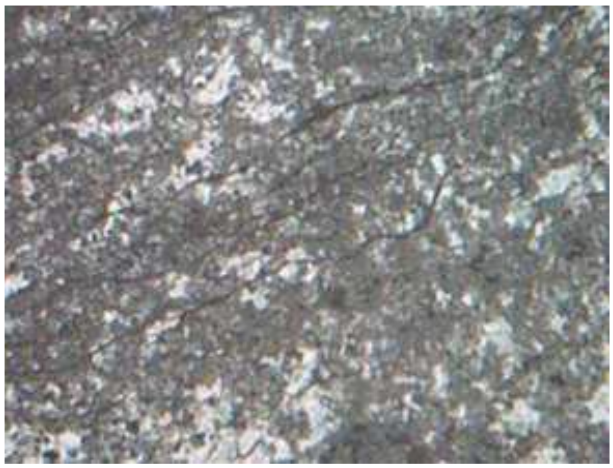

Fig. 3. limestone under polarized microscope.

Other exposed rock bed units, in the study area, belong to Zahra Formation (Pliocene- Pleistocene), which comprises sandstone, limestone, and claystone. Dammam Formation is underlain by rock beds of Rus Formation (Early Eocene) which comprises anhydrite and limestone (Sissakian et al. 2013). Karstification is the main active process to form many depressions that result after dissolution of soft limestone and anhydrite. During wet periods that were beginning from E. Pliocene to Early Miocene, large quantities of subsurface limestone and anhydrite were dissolved by percolating water. The Rus Formation (about 50- 75 m thick) is dissolved by water from the study area and surrounding areas

(Sissakian et al., 2013). The dissolution of anhydrite of the Rus Formation in addition to the lower part soft limestone of the Dammam Formation caused the collapse of the middle and upper parts of the Dammam Formation, therefore large depressions were continuously developed, such as Al- Salman, Hadaniya, Shawiya, Rifaaya, and others.

4.1.2. Geomorphologic features

It includes many landforms, such as flat terrain (Plate1), depressions (faidhats), ephemeral streams (wadis), caves, and sinkholes (Fig. 4).

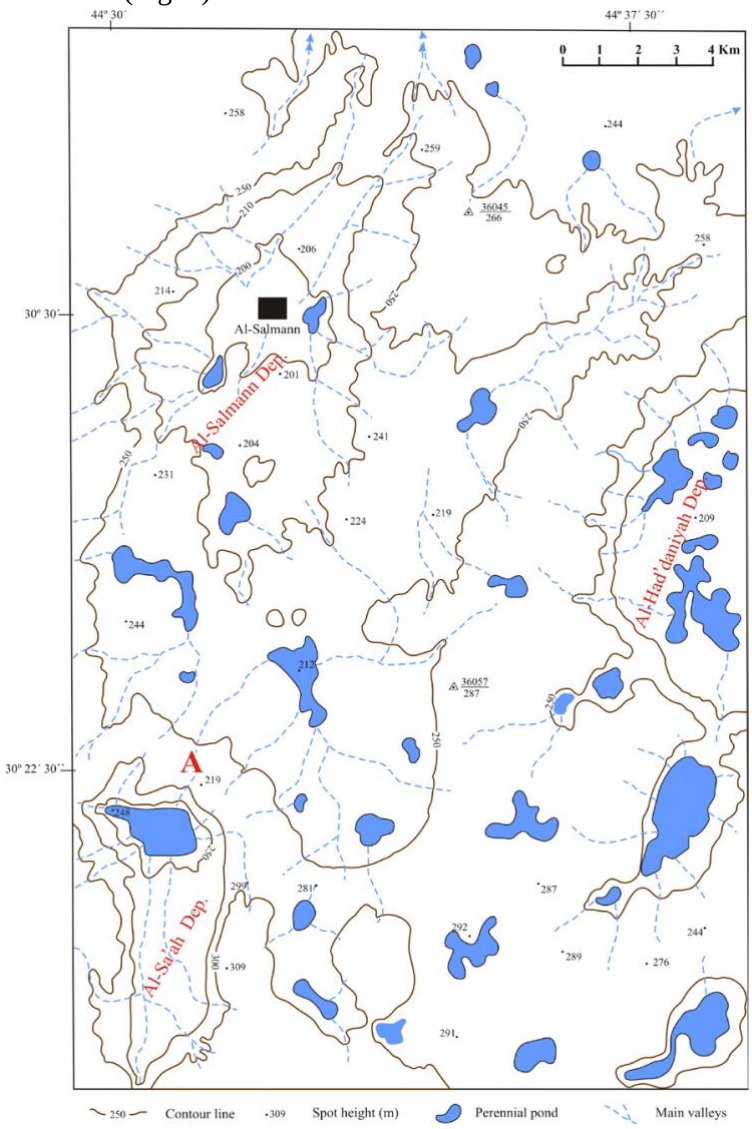

Fig. 4. showed some landforms of study area (after Sissakian et al., 2013).

- Flat terrain

  The study area represents flat terrain that increases in elevation toward the west and southwest. It is covered by large limestone rock fragments, more than 20 cm long, are composed of recrystallized limestone, packed to each other, coated by desert varnish, with a very low amount of soil between them. Medium limestone rock fragments, more than 10 cm long, composed of limestone, scattered between the thin soils (Plate- 1).



Plate 1. flat terrain covered by desert varnish and sarir

- Depressions (Faidhats)
  Some of the depressions of the study area can be classified as "collapse doline" (White and White 2006). They are developed due to the dissolving of evaporate (anhydrite) of the Umm Er Radhuma Formation (Palaeocene) and the Rus Formation (E. Eocene), in addition to soft limestone of lower rock of the Dammam Formation (Early Eocene) (Al-Mubarak and Amin, 1983). The main depressions of the study area are Al- Salman, Hadaniya (lower and upper part), Shawiya, Riffaaiya, and Al-Khfayat. The depressions, locally called "faidhat" have oval or circular shapes and the major trend is North-South (Sissakian et al., 2013). The floor of depressions is covered by clayey silt, silty clay, or sandy soil and contains rock fragments decreasing in size from the rim toward the center of depressions (Plate 2)



Plate 2. Lower part of Faidhat Hadaniya

- Wadis
  The flat terrain of the study area is dissected by many wadis (ephemeral streams), such as Wadi Al-Owja (Plate 4), Wadi Al-Jil, and Wadi Aqrawi. The wadis are controlled by topography and structure, the slope is toward the northeast. The joint system and large segments of wadis have northeast and north direction. The flow of the main valleys of the study area is to the northeast.
- Caves
  The exposed rock of the Dammam Formation comprises hard recrystallized limestone on the uppermost flat terrain while softer limestone and shelly limestone appeared on the slope of large wadi. After heavy rainfall, soft limestone may be dissolved by solutions to form natural caves on the sides of the wadis and some small cave has been burrowed by animals. (Plate 4 a, b).



Plate 3. Wadi Al-Owja



a- Natural cave



b- small cave burrowed by animals

Plate 4. (a) Natural cave and (b) small cave burrowed by animals.

- Sinkhole

  It is located about 9 km east of Al- Salman town center and locally named "Bir Al- Wajaj" (Plate 5), the diameter of the aperture ranges from 16-30 m, and become wider at the lower part, the depth of water level is about 20 m below the surface and was used for irrigation, upper part of the well composed of Quaternary sediments while the lower part composed of fragmented limestone of the Dammam Formation (Plate 5).



Plate 5: Sinkhole

4.1.3. Types of Soil

The soil texture of the study area was identified by a feel test according to (Whiting et.al, 2003). When the moist soil rubs between the fingers, it is sand when it feels gritty, silt if it is smooth, and clays if it is sticky. A mentioned test showed three types of soil textures: Silty clay soil between medium limestone rock fragments on the flat terrain, sometimes the thickness of soil may be more than 5 cm on the west of Hadaniya Depression and on the Wadi Al- Owja sides; or filled deep joint plane and fracture in the Wadi Al- Owja. Clayey silt soil, in the Hadaniya and Rifaaiya Depressions, covered a large area

of the floor of the depression, which may be more than 5 m according to drilled water well in the Hadaniya Depression. Sandy soil occurs either in the Shawiya Depression (faidhat) as a trapped dune around the Tamarix trees or on the small hill between large rock fragments near Faidhat Al-Shawiya.

4.1.4. Water Resources: Rainwater is the main source of water in the study area. During heavy rains, a large amount of water flows from the wadis (ephemeral streams) to the depressions (Ma'ala, 2009). The major trend of wadis of the study area is towards the northeast almost parallel to each other, but may be changed to the northwest, or may be ending in the depression (Sissakian et al., 2012). Wadi Al- Owja, Bir Al-Wajaj, Hadaniya, Riffaaya, and other depressions are characterized by the accumulation of high amounts of water for many days after rain. Many water wells have been drilled, either hand dug such as Hadaniya well, about 20 m deep and the water level about 14 m below the earth's surface, or mechanical wells such as Shawiya well, about 140 m deep and the water level of about 120 m.

4.2. Biodiversity

It is clear that no representatives from fishes (Class Pisces) and amphibians (Class Amphibia) could be recorded in this study. This reflects the xeric nature of the study area. Rivers or permanent water bodies are completely absent in the area. Only ephemeral streams after heavy rains shower which is mainly in November to March could be seen and still for a short period. Limited agricultural activities practiced by the people of Al-Salman town depended completely on water recovered from the drilled wells using water-effective irrigation systems to cultivate wheat, barley, and vegetables. In general, the Al-Salman area encounters a wide diversity of plants, invertebrates, and vertebrates. The area was poorly studied in regard to biodiversity, maybe because of its remote location. The present results are only preliminary and obviously, there is a need for more detailed study of the area indicating presence of a large gap in our knowledge on the biodiversity of the area.

4.3. Habitat Description and Associated Animals and Plants

EEA (2017) defined the habitat as a place where plants or animals normally live, characterized primarily by its physical features and secondarily by the species of plants and animals that live there. According to these requirements, four habitats can be recognized in Al-Salman Depression: Flat terrain, depressions (faidhats), ephemeral streams (wadis), and sinkhole.

4.3.1. Flat terrain

The following were recognized:

a) Mammals: *Vulpes vulpes* L. 1758, *Felis silvestris* Schreber, 1777, *Jaculus jaculus* L., 1758.

b) Birds: *Aquila nippalensis* (Hodgson, 1833), *Falco tinnunculus* L., 1758

c) Reptiles: *Mesalina brevirostris* Blanford, 1874, *Cerastes gasperetti* Leviton & S. Anderson, 1967, *Uromastyx aegyptia* subsp. *microlepis* Arnold, 1980.

d) Plants: the dominant species are; *Astragalus spinosus* (Forssk.) Muschl., *Erodium* spp., *Schismus barbatus* (Loefl. ex L.) Thell., *Gymnarrhena micrantha* Desf.

The flat terrain covers wide areas of the southern desert, which is elevated from the northeast to the southwest. It includes many wadis (ephemeral streams) and depressions. The flat terrain contains implicitly the highlands and hills surrounding or adjacent to the depressions (faidhat) and wadis that provide a suitable environment for falcons to rest and monitor their prey in wadis and faidhats. The flat terrain is covered by solid crystalline limestone fragments with a desert varnish, which are compacted enough to reduce the amount of soil, thus helping provide a suitable environment for the living and breeding of wheatear. Locally the flat terrain is covered by separated rock fragments and between them silty clay or muddy soil, which helps in growing wild wheat, which became food for many birds and

also provided a suitable environment for the spiny-tailed lizard (locally named Dhab) which dig its hole in the silty clay soil. The scattered small to medium rocky fragments over the vast flat terrain which measured more than 25 cm provide shelter used for hibernation during cool winters for many invertebrate species like beetles, spiders, scorpions, and to a lesser extent centipede. Small geckoes like *Bunopus tuberculatus* Blanford, 1874 also were found to hibernate using the small caverns of the rock underside which make with ground surface enough space for these animals to stay hibernating away from the climate conditions and allows for fresh ventilation at the same time as the available space is not completely closed due to indentations at the edges of the caverns.

4.3.2. Faidhat (Hadaniya, Al-Shawiya, Al-Rifaeiya)

The following were recognized:

a) Mammals: *Vulpes ruppelli* (Schinz, 1825), *Meriones crassus* Sundevall, 1842

b) Birds: *Hypocolius ampelinus* Bonaparte, 1850, *Streptopelia turtur* (Linnaeus, 1758), *Lanius* spp.

c) Reptiles: *Spalerosophis diadema cliffordi* (Schlegel, 1837), *Eryx jaculus* (L., 1758)

d) Plants: the characteristic plants are *Ziziphus nummularia* (Burm.f.) Wight & Arn., *Lycium shawii* Roem. & Schult. and *Zilla spinosa* (L.) and for lesser extent *Haloxylon salicornicum* (Moq.) Bunge ex Boiss. at the faidhat boundary.

Many depressions (locally called faidhat) occurred in the wide flat terrain of the southern desert of Iraq. Many ephemeral streams (wadis), during rainy days, flow toward the depressions and deposit mud, silt, and sand in addition to rock fragments. Sediment thickness is proportional to the depth of depression. The deeper depression may be having a greater thickness of the sediments. The type of plant community in a depression corresponds to the type of sediment that exists and the amount of available water. In Faidhat Hadaniya, which has muddy (silty clay) soil of large thickness, more than 10 meters, Arabian boxthorn, and Wild Jujube are growing in addition to many types of annuals. In Faidhat Al-Shawiya, the soil is sandy, and Wild Jujube is mainly growing. In Faidhat Al- Khufayat, which has a low thickness of soil and a low amount of water, small plants are growing on it. Many faidhats were cultivated with wheat and barley in addition to a few types of vegetables.

The Faidhat is a flat low ground gathering silty clay sediments (muddy soil) coming from the neighboring heights. It originated from a sinkhole that is widened through subsidence incidents and becomes, over a long time-scale; a wide shallow depression as it receives huge amounts of sediments accumulated over years raises its thickness steadily. The resulting soil is rather relatively fertile and permits to support shrub trees (*Z. nummularia* and *L. shawii*) and different kinds of annual and perennial plants especially in the rainy years. This situation encourages locals to cultivate limited areas with wheat and barley using modern agricultural practices like Pivot and Sprinkler irrigation systems. This type of plant cover supports the thriving of many animal species of insects (mainly *Adesmia* spp. beetles, *Psammotermes hypostoma* (Desneux) and *Microcerotermes* sp. termites), reptiles (*Eryx jaculus* and *Platyceps ventromaculatus*(Gray, 1834)), birds (*Coturnix coturnix* (Linnaeus, 1758), *Lullula arborea* (Linnaeus, 1758) and *Luscinia svecica* (Linnaeus, 1758)) and herbivorous mammals (*Meriones libycus* Lichtenstein, 1823, *Jaculus jaculus* and *Lepus capensis arabicus* (Ehrenberg, 1833)).

4.3.3. Wadi Al-Owja

The following were recognized:

a) Mammals: *Hystrix indica* Kerr, 1792, *Canis lupus* Linnaeus, 1758, *Hyaena hyaena* (Linnaeus, 1758)

b) Birds: *Oenanthe leucopyga* (Brehm, 1855), *Corvus ruficollis* Lesson, 1830

c) Reptiles: *Mesalina brevirostris* (Blanford, 1874), *Ptyodactylus hasselquistii* (Donndorff, 1798)

d) Plants: *Pallenis hierochuntica* (Michon) Greuter, *Fagonia bruguieri* (DC.) Christenh. & Byng, *Tamarix aphylla* (L.), Karst, and *Rhanterium epapposum* Oliv.

Depending on the amount of rain fall, flora of wadis varies from year to year (Siddiqui and Al-Harbi, 1995; Osman et al., 2014). During the fall of sudden rains, the surface water flows in the course of the valley's rocky basin in the form of violent torrents, causing flash floods. They may continue flowing for several successive days many times during the rainy season. Basin almost devoid of herbs but there are few scattered *Z. nummularia* shrub trees in the midline of the basin. Their roots were uncovered for a depth of about 60-70 cm by Indian porcupine *Hystrix indica* in an attempt to reach the root to eat them probably for the water needs as well as food.

Few *Capparis spinosa* L., 1753 are present as well. Both sides of wadis support growing of small plants like *Fagonia* spp., *Koelpinia linearis* Pall., and *P. hierochuntica*. The dominant plants include *Z. nummularia*, *T. aphylla*, and *R. epapposum*. The upper and middle parts of Wadi Al-Owja are composed of interbeddeding of hard limestone and marl rock bed units. The latter are washed by water and solutions to form some small caves that provided the living and breeding places for some birds. Wild animals such as red fox, wolf and hyena try to widen these small caves to be suitable for their living requirements. Besides the caves, wolves' feces have been seen. Thin silty clay sediments have been formed between large rock fragments and in the fractures and joint planes of the wadi, on which few plants are grown. In the rainy days and later, significant amounts of water may accumulate in the wadi and deposit silty clay sediments that help the growth of plant cover in addition to Wild Jujube.

4.3.4. Sink holes (Bir Al-Wajaj)

The following were recognized:

a) Mammals: not seen

b) Birds: *Columba livia* (Gmelin, 1789), *Passer domesticus* (Linnaeus, 1758)

c) Reptiles: *Ptyodactylus* sp.

d) Plants: *Adiantum capillus-veneris* L. (Pteridaceae).

The unique typical sinkhole occurs in the study area, which is located at the east of Al-Salman Town, locally named "Bir Al- Wajaj". "Bir" means well in Arabic Language as the lower part is covered by water. The upper part is composed of quaternary sediments, while the middle part is composed of fragmented limestone and the lower part is covered by water. The main distinguished features of the sinkhole are the availability of water around the year; the appearance of the fissures and fractures between the fragmented limestone on the internal walls of the middle part; the cylindrical shape and steep slopes of internal walls, which may be more than 90 degrees, in addition to the widening of the walls of the middle part which make it unreachable to these places from any potential enemies; the low amount of sunlight entering the sinkhole caused decreasing the inside temperature of the sinkhole comparing with the outside during hot dry seasons and vice versa during rainy cold seasons.

The above features helped some birds (Rock Dove C. *livia* and House Sparrow P. *domesticus*) and other animals to rest, nest and breed within the Bir Al- Wajaj sinkhole. The presence of two birds in the only sinkhole (Bir Al-Wajaj) and one plant species (A. *capillus-veneris*) in a man-made well in Hadaniya Depression is related to fact that the biodiversity components were not well adapted to such habitat. The general landscape of the area is mainly Hamada flat terrain dissected at certain places by faidhats or wadis, while the sinkhole did not have enough period of geologic time to allow animals and plants to adapt to this habitat. In this context, Sissakian et al. (2022) mentioned that karstification in the Southern desert of Iraq is still an active process. Although no reptile species was recorded through authors' observations, it is likely that the snake *Eryx jaculus* and the gecko *Ptyodactylus hasselquistii* (Donndorff, 1798) to be present.

5. Conclusions

The present results indicate that the geodiversity of study area includes geologic features (carbonate rocks, marl, sandstone and claystone) and geomorphologic features (flat terrain, depressions (faidhats), ephemeral streams (wadis), caves and sinkhole), type of soil, and water resources which have contributed in development of many habitats to attain their unique groups of biotic components. Four habitats have been recognized in Al-Salman Depression: Flat terrain, depressions (faidhats), ephemeral streams (wadis), and sinkholes. Results on biodiversity of the area revealed that most species are generalists in distribution among the habitats present, but some species are intimately linked to a certain habitat.

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