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## Survey of Lichens of the Upper Plains and Foothills Region of Iraq

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### Abstract

Information available about Iraqi lichens is very limited. The current study is the first to investigate lichens in Nineveh and Northern Jazira districts located within upper plains and foothills region in Iraq. Lichens from many types substrates were gathered from four sites, three of which were located in Nineveh district and one in Northern Jazira district. Lichens were identified then classified based on their external appearance and internal anatomy as well as chemical spot tests. Results showed identification of 19 lichen species, 12 of them were crustose (its ratio equals 63.1%) and 5 squamulose (26.3%), while there were two foliose species (10.5%), no fruticose species were found. It was found that all recorded species were new for the two districts, and that two species were new records in Iraq: *Acarospora placodiiformis* and *Buellia zoharyi*. Distribution of recorded species showed variation between two districts and four study sites, the most dominant species were *Lecanora muralis* and *Fulgensia subbracteata*. Most of recorded genera were poor in species number. The largest genera was *Caloplaca* represented by three species, followed by the genera *Acarospora*, *Collema* and *Squamarina*.

## التحري عن اشنات اقليم السهول العليا والتلال السفحية في العراق

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### الملخص

ان المعلومات المتوفرة عن الأشنات في العراق محدودة للغاية، وتعد الدراسة الحالية هي الأولى التي تبحث في الأشنات المتواجدة في مقاطعتي نينوى والجزيرة العليا الواقعين ضمن منطقة السهول العليا وسفوح التلال في العراق. تم جمع الأشنات من موادها الاساس المتنوعة في أربعة مواقع، ثلاثة منها كانت في مقاطعة نينوى وواحدة تعود الى مقاطعة الجزيرة العليا. تم تشخيص الأشنات وتصنيفها على أساس مظهرها الخارجي وتشريحها الداخلي فضلا عن الاختبارات الكيميائية الخاصة بالاشنات. أظهرت النتائج تحديد 19 نوعاً من الأشنات، 12 منها كانت من النوع القشري (بلغت نسبتها 63.1%) و 5 انواع كانت تنتمي الى الانواع الحشفية (بلغت نسبتها 26.3%)، بينما كان هناك نوعان من الأشنات الورقية (بلغت نسبتها 10.5%)، ولم يتم العثور على أي نوع من الانواع الشجيرية. وجد أن جميع الأنواع المسجلة كانت جديدة للمقاطعتين قيد الدراسة الحالية، وكان هنالك نوعين من الاشنات تم تسجيلهما لأول مرة في العراق هما الاشن *Acarospora placodiiformis* و الاشن *Buellia zoharyi*. اظهر توزيع انواع الاشنات المسجلة في الدراسة الحالية تفاوتاً بين المقاطعتين المدروستين وكذلك اظهرت تبايناً واضحاً بين مواقع الدراسة الأربعة، وكانت انواع اشنات الأكثر انتشاراً هي النوع *Lecanora muralis* و *Fulgensia subbracteata*، وكانت معظم الأجناس المسجلة قليلة في عدد الأنواع، وكان أكبر الأجناس هو الجنس *Caloplaca* ممثلاً بثلاثة أنواع، يليه الاجناس *Acarospora* و *Collema* و *Squamarina*.

الكلمات المفتاحية/ الاشنات، التوزيع، الاشنات القشرية، مقاطعة نينوى، مقاطعة الجزيرة العليا.

## 1- Introduction

Lichenology is a very ancient science. The Swedish physician Eric Acharius is considered the father of lichenology, who coined terminology for some unique structures of lichens such as Soredia, Isidia and Cyphellae in early 1803 (Hale, 1983). The first scientist describe lichens as dual organism and that lichens formed from the association of a fungus (mycobiont) with an alga and/or cyanobacteria (photobiont) is the Swiss scientist Simon Schwender in 1867 (Ertz *et al.*, 2018; Lücking *et al.*, 2021). There are about 20,000 species of lichens in the world (Lücking *et al.*, 2017). This number will likely rise as regional investigations increase and testing methods advance (Calcott *et al.*, 2018). Approximately 8% of the *land surface on earth* is occupied by communities of *lichens* (Asplund & Wardle, 2017). Lichens are found in all parts of the world. They distribute in all environments with extreme conditions of cold and heat, as they extend from desert regions to tropical rainforests, inhabiting various substrates such as different types of rocks and soils, as well as bark of trees (Lõhmus *et al.*, 2023).

Most of the fungi which form lichens belong to ascomycetes (except few species that belong to basidiomycetes), as there are more than 30,000 species of ascomycetes, more than half of them form lichens. These lichenized- fungi differ from the non-lichenized fungi in terms of nutrition. Lichenized- fungi stimulate the photobiont to release sugars produced by photosynthesis to supply energy and ensure survival, growth and reproduction (Dobson, 2011). Lichens are important in many fields, some of which are used as food for humans and animals, some of them are used to obtain colors, perfumes and alcohol (Zhao *et al.*, 2021; Elkhateeb *et al.*, 2022), and some of them are evidence of air pollution (Yang *et al.*, 2023). In the medical fields, lichens were used in many European countries to treat stomach, coughs, diabetes, pulmonary tuberculosis, wounds and some skin diseases (Poulsen-Silva *et al.*, 2023; Kumar *et al.*, 2024).

The information available about lichens in Iraq is very limited compared to that in neighboring countries, especially Turkey and Iran, and there are a few publications concerned with the biodiversity of Iraqi lichens. The first publication was presented by Steiner, (1921) which included the results of the lichen identification of the Kurdistan, Mesopotamia, Prinkipo (in Turkey) and Syria regions. Another publication by the German scientist Schubert during his field work to collect lichens in 1969 (Schubert, 1973), and the third publication was presented by Poelt and Sulzer, (1974) on lichen *Buellia epigaea*. From recent studies on Iraqi lichens, there is a research by Aziz and Qadir , (2016) on lichens of Erbil governorate within Iraqi Kurdistan, they recorded 58 species, 30 new species were registered as a new records to flora of Iraq. Almola *et al.*, (2017) investigate the lichens present in Amadiya and Rowanduz districts of the mountainous region of Iraq, they were recorded 47 species of lichens, 37 of which were new records for Iraq. Karim *et al.*, (2021) put a list of all previous of Iraqi lichens which reached 236 species, their field survey added four new

lichen records. The most recent study on the lichen diversity in Iraq is a study conducted by Salih (2022) in the Mawat and Gapelon districts in northeastern Iraq, 22 lichen species were identified and recorded for the first time in Iraq.

### **Aim of study:**

Information on lichen diversity of Iraq is still lacking. Most of the studies were concentrated in the mountainous region, so the current study is the first to investigate the lichens present in the Nineveh and Upper Jazira districts which are located within the upper plains and & foothills region of Iraq. In addition, this study is complementary to previous studies aimed to identifying the species of lichens that are present in all parts of Iraq.

## **2- Materials and methods**

### **2.1- Description of study area**

According to Guest and Al-Rawi (1966), Iraq is divide into four main physiogeographic regions: the Mountains region (M), the Upper Plains and Foothills region (F), the Desert Plateau (D), the Lower Mesopotamian Plain (L). Our study concerns the Upper plains & foothills region (F).

#### **Upper plains & foothills region**

The steppic sub-montane belt between the 500 m. contour (in the north-east: the 800 m. contour on Jabal Sinjar, the outlying district of the region in the north-west) & the margin of the lower plain at the foot of the Jabal Hamrin. West of the Tigris the abrupt line of the Jabal Hamrin is carried on for some distance north-westwarde by Jabal Makhul which then gradually peters out in the region of Al-Hadhr (Hatra). From that point there is no sharp topographic feature to mark the lower margin of the upper plains and foothills region. But on the ground there is an abrupt transition from the deep reddish-brown soil of the now largely cultivated terrains below Sinjar to the thin grey gypsum desert soil further south. This feature provides a relatively well-defined physical boundary running in a north-westerly are from Jabal Makhul to the Syrian frontier. At its eastern end the foot of the Jabal Hamrin range runs increasingly near the Persian frontier as it approaches Mandali and finally crosses it near Badra, but it recrosses into Iraq again for a short stretch north of Amara in the vicinity of Tib.

Upper plains & foothills region is sub-divided into five districts as follow: Nineveh, Upper Jazira, Arbil, Kirkuk and Persian Foothills. Our study concerns the Nineveh (symbolized by FNI) and upper Jazira (symbolized by FUJ) districts, three sites were selected within FNI (Bandwaya village, Jabal Maqlub and Mandan bridge) and one site within FUJ (Zewiya village) (Figure 1).

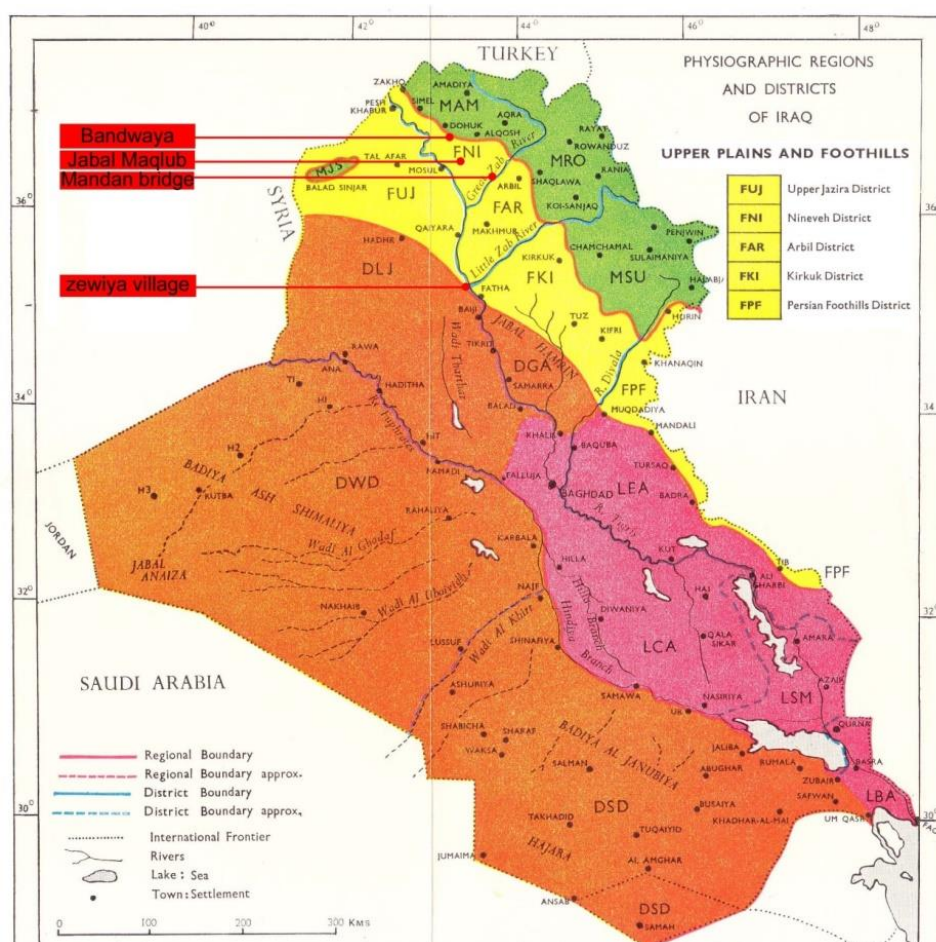


Fig. 1: Regions map of Iraq as mentioned in (Guest and Al-Rawi, 1966) including the study sites

## 2.2- Collection and preservation of lichens

Lichens from many types of rocks and soil substrates have been gathered from January to May during the 2024 season from 4 sites, of which 3 sites located in Nineveh district and 1 located in Upper Jazira district (Table 1). The field work was carried out according to what was mentioned in Dobson (2011) as follows: Samples of lichens growing on rocks were collected using an iron chisel and hammer, species that grow on soils were collected with a stainless putty knife. The samples were left at room temperature until drying. Samples then placed on papery sheets inside packet (15 cm X 10 cm) with details of the sites, collection date, substratum, which then preserved at biology herbarium / College of Sciences/ Mosul University. Samples and anatomical sections were photographed using a Sony HX 20V camera and the coordinates for each location were determined using the available GPS technology.

### Table (1) Study sites

Dis trict	ite nu	Site	Notes on the site	Coord inate
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	number			
Nineveh (FNI)		Bandwaya village	located in the north of Iraq in the Nineveh Governorate, it follows the Alqosh sub-district, and it is located west of Alqosh, about 5 km away from it	36° 73' 96" N 43° 3' 70" E
		Jabal Maqlub	lies 35 km to the northeast of Mosul in northern Iraq, on this mountain there is the monastery of Mar Matta	36° 48' 94" N 43° 44' 34" E
		Mandan bridge	located 32 km northeast of Mosul, in the district of Bardarash, where the plains meet with the Khazar River	36° 26' 79" N 43° 62' 8" E
Upper Jazira (FUJ)		Zawiya village	located on the western side of the Tigris River, Makhoul mountain passes from the western side, and it follows the district of Baiji- Salah El-Din Governorate.	35° 20' 51" N 43° 32' 15" E

### 2.3- Identification of specimens

Lichens were identified based on their external appearance and internal anatomy as well as chemical spot tests. The external appearance of the species was studied using binocular microscope. The internal anatomy of thallus and other features like fruiting bodies were studied using compound microscope. The chemical spot tests were done using the following chemical reagents :

1. K- test (10% aqueous potassium hydroxide).
2. C- test (aqueous calcium hypochlorite).
3. KC- test (carried out by adding solution K to the sample piece then adding solution C after 30 seconds).
4. PD- test (Para-phenylene diamine).

The previous tests were done on cortex and/ or medulla by removing a piece of lichen and placing it on a filter paper, then a drop of the test solution was added, the color change was observed or not. Lichen specimens were identified using the identification keys mentioned in the following references: (Brodo *et al.*, 2001; Nash *et al.*, 2001; Zhurbenko, 2003; Nash *et al.*, 2004; Nash *et al.*, 2007; Rosentreter *et al.*, 2007; Mangold *et al.*, 2009; Smith *et al.*, 2009; Dobson, 2011; McCune, 2012; Nimis, 2016; Parizadeh & Garampalli, 2017, Poengsungnoen *et al.*, 2021).

### 3- Results and discussion

#### List of recorded lichen species , habitat and their distribution

Note: All recorded species are new for the two districts; \* = First record in Iraq; FNI= Nineveh district; FUJ= Upper Jazira district.

**1. *Acarospora cervina* A. Massal.**

Growth type is squamulose; found on exposed calcareous rock, recorded in FNI: site 2

**\*2. *Acarospora placodiiformis* H. Magn.**

Growth type is Crustose, on gypsum soil, recorded in FUJ: site 4

**3. *Aspicilia calcarea* (L.) Mudd**

Growth type is crustose; cover large area on hard limestone and shale rocks, recorded in FNI: sites 1&2

**\*4. *Buellia zoharyi* Galun**

Crustose (Placodioid), on gypsum soil, recorded in FUJ: site 4

**5. *Caloplaca aurantia* (Hoffm.) Hafellner**

Growth type is crustose; found on limestone in sunny sites, recorded in FNI: site 1

**6. *Caloplaca biatorina* (A. Massal.) J. Steiner**

Growth type is crustose; found on calcareous rocks, recorded in FNI: site 1

**7. *Caloplaca murorum* (Ach.) Th.Fr.**

Growth type is crustose; found on limestone, recorded in FNI: site 1

**8. *Collema fuscovirens* (With.) J.R. Laundon**

Growth type is foliose; found on calcareous rocks or on mosses in sunny sites, recorded in FNI: site 1

**9. *Collema tenax* (Sw.) Ach.**

Growth type is foliose; found on various soils, recorded in FUJ: site 4

**10. *Diploschistes diacapsis* (Ach.) Lumbsch**

Growth type is crustose, found on soil of open habitat, recorded in FNI and FUJ: sites 3 & 4

**11. *Fulgensia subbracteata* (Nyl.) Poelt**

Growth type is crustose; found on siliceous rocks, soil, mosses or some other lichen species, recorded in FNI and FUJ: sites 2, 3 & 4

**12. *Lecanora muralis* (Schreber) Rabenh.**

Growth type is crustose; widespread on all kinds of rocks, recorded in FNI and FUJ: sites 1,2 & 4

**13. *Lobothallia praeradiosa* (Nyl.) Hafellner**

Growth type is crustose; found in dry, sunny rocks, recorded in FNI: sites 1 & 2

**14. *Placocarpus schaereri* (Fr.) Breuss**

Growth type is crustose; grew on limestone, recorded in FNI: site 1

**15. *Psora decipiens* (Hedwig) Hoffm.**

Growth type is squamulose; found on calciferous soil and terricolous mosses, recorded in FNI and FUJ: sites 3 & 4

**16. *Squamarina cartilaginea* (With.) P. James**

Growth type is squamulose; found on calcareous rocks, also found on terricolous mosses, recorded in FNI and FUJ: sites 3 & 4

**17. *Squamarina lentigera* (Weber) Poelt**

Growth type is squamulose; found on calciferous and sandy soil, recorded in FNI: site 3

**18. *Toninia sedifolia* (Scop.) Timdal**

Growth type is squamulose; found on limestone rocks and soil, recorded in FNI and FUJ: sites 3 & 4

**19 . *Verrucaria macrostoma* Dufour ex DC.**

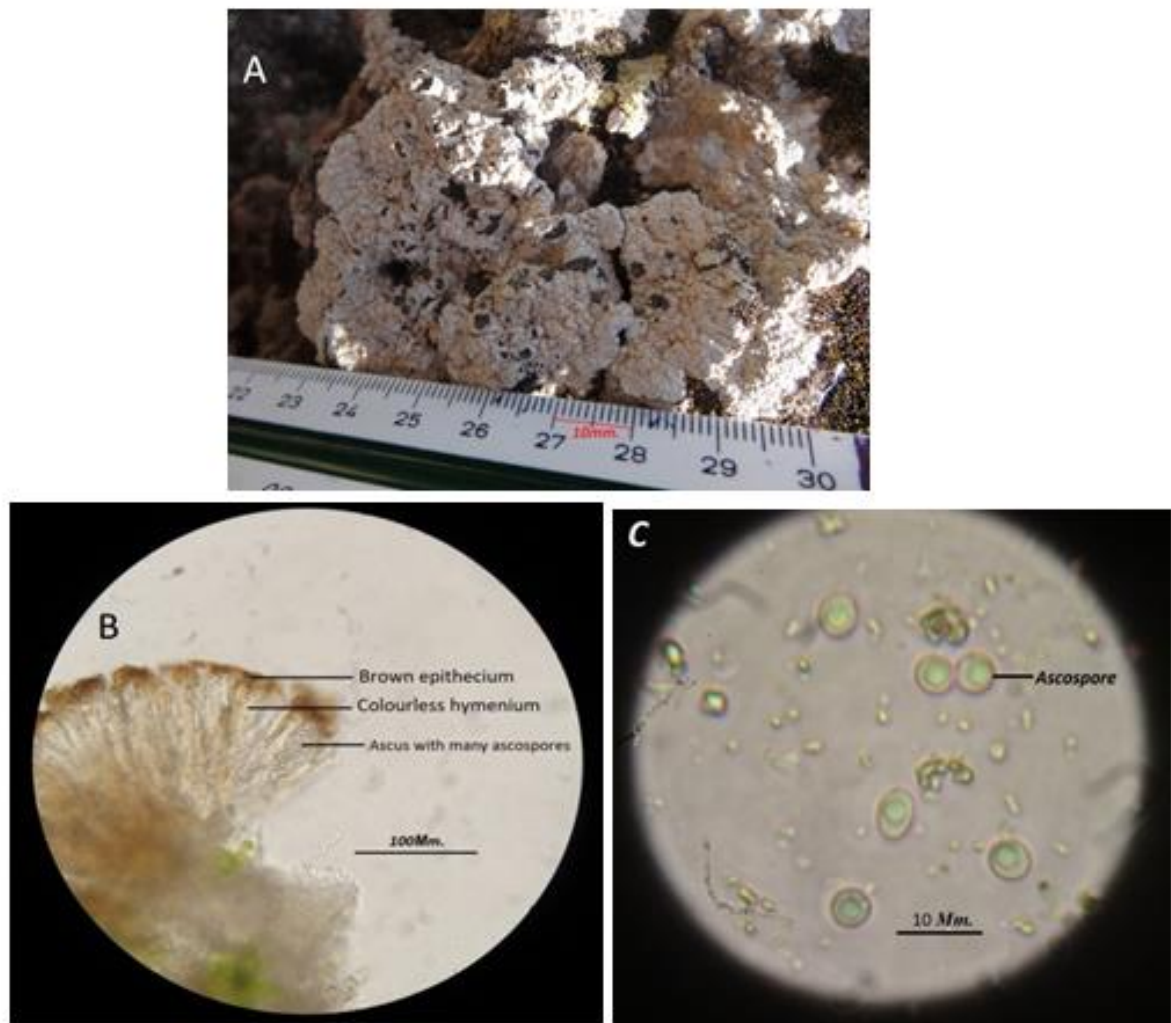
Growth type is crustose; found on hard limestone, recorded in FNI: site 1

**3.1- Description of the new records**

**1. *Acarospora placodiiformis* H. Magn.**

Thallus crustose (placodioid) with diameter up to 8 cm, greenish-yellow, with a thick layer of white pruina. Areoles convex, contiguous with semi-immersed, lecanorine, rounded apothecia. Apothecia 1-6 mm in diameter, with a slightly concave, black disc, thalline margin is a thick. Section of apothecium showed the following layers: brown epithecium; colourless hymenium; colourless hypothecium. Asci contain a large number of spores, clavate, with a distinct apical dome. Ascospores simple, hyaline, subglobose, 4-5 x 3-5  $\mu$ . Photobiont chlorococcoid (Figure 2). All chemical spot tests are negative. This species found on gypsum soil in open situations. Nimis (2016) showed that *A. placodiiformis* is a xeric subtropical species found on weathered gypsum in open situations, mostly below the montane belt.



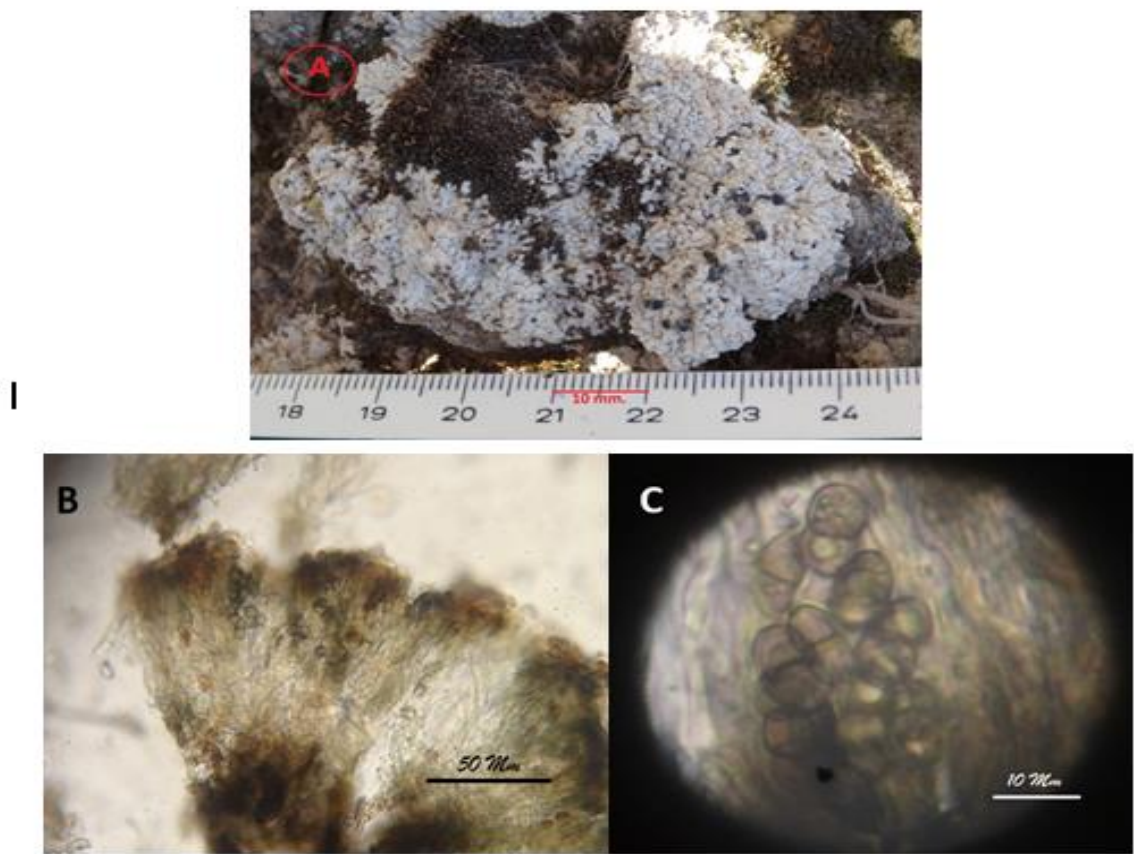


**Figure (2)** *Acarospora placodiiformis*

A- Thallus colony    B- Longitudinal section in apothecium    C- Ascospores

## 2. *Buellia zoharyi* Galun

Thallus rosette (3-6 cm.), crustose and lobate at margins (placodioid), white, pruinose; apothecia lecideine, sessile, reached 2.5 mm diam; with a black, sometimes white-pruinose, smooth and horizontal to slightly convex disc, excipulum carbonized and inspersed with abundant crystals in the outer part, paler in the inner part; epithecium black to dark brown; hymenium colourless, hypothecium dark brown; Asci 8-spored, clavate, ascospores uni-septate, *Buellia* type 12–14 × 7–8 µm, brown, oblong-ellipsoid, constricted at septum. Photobiont chlorococcoid (Figure 3). Chemical tests: K+ yellow for cortex, all the other tests are negative. Grow well on gypsum soil.



**Figure (3) *Buellia zoharyi***

A-Thallus colony    B- Longitudinal section in apothecium    C- Ascospores

**3.2- Classification of recorded lichen species**

Lichen specimens collected in Nineveh and Upper Jazira districts revealed 19 species distributed in 14 genera. The genera were distributed into 10 families belonging to 7 orders, the largest order were Lecanorales, which were represented by 3 families, then Teloschistales, which were represented by two families. All orders belong to the class Lecanoromycetes except Verrucariales which belongs to the class Eurotiomycetes. All previous taxa belong to the phylum Ascomycota, as shown in the table (2).

**Table (2) Classification of recorded lichen species**

Phylum	Class	Order	Family	Genera	Species
Ascomycota	Eurotiomycetes	Verrucariales	Verrucariaceae	<i>Placopsis</i>	<i>schaereri</i>

Phylum	Class	Order	Family	Genus	Species
	Crustaceae	Acariales	Acarosporaceae	<i>Verrucaria</i>	<i>macrotoma</i>
				<i>carpus</i>	<i>ri</i>
	Lecanoromycetes	Acarosporales	Acarosporaceae	<i>Acarospora</i>	<i>placodiiformis</i>
					<i>cervina</i>
		Ostropales	Graphidaceae	<i>Diploschistes</i>	<i>diacapsis</i>
		Pertusariales	Megasporeaceae	<i>Aspicilia</i>	<i>calcareosa</i>
				<i>Lobothallia</i>	<i>praeradiosa</i>
		Lecanorales	Lecanoraceae	<i>Lecanora</i>	<i>muralis</i>
			Psoraceae	<i>Psora</i>	<i>decipiens</i>
		Lecanorales	Ramalinaceae	<i>Squamaria</i>	<i>cartilaginea</i>
					<i>lentiginosa</i>
				<i>Toninia</i>	<i>sedifolia</i>
		Peltigerales	Collemaaceae	<i>Collema</i>	<i>fuscovirens</i>
					<i>tenax</i>
		Teloschistales	Physciaceae	<i>Buellia</i>	<i>zoharyi</i>
			Teloschistaceae	<i>Caloplaca</i>	<i>aurantiaca</i>
					<i>biatorina</i>
					<i>murorum</i>
				<i>Fulgensia</i>	<i>subbracteata</i>

Classification source (Smith *et al.*, 2009).

The search results showed the identification of 19 lichen species, 12 of them were crustose (its ratio is equal to 63.1%) and 5 squamulose (26.3%), while there were two foliose species(10.5%), no fruticose species were found. After

investigating of the previous studies of Iraqi lichens publications, it was found that two species investigated in this study were a new records in Iraq: *Acarospora placodiiformis* and *Buellia zoharyi*. Both species were collected from Upper Jazira district (FUJ). All recorded species were new for the two districts. The continuous registration of new lichen species in Iraq is due to the lack of studies related to the investigation of lichens as there are very few publications available on this topic, all of them are mentioned in the introduction of our study.

The distribution of the recorded species was variable, the most dominant species were *Lecanora muralis* and *Fulgensia subbracteata* Which showed its presence in three sites. *Lecanora muralis* can be described as an ubiquitous crustose lichen, it grows all over the world including Europe, Asia, North America, South Africa, Africa, Macronesia, Oceania and Australasia (Nash *et al.*, 2001). The genus *Fulgensia* is also worldwide distribution, mostly in arid subtropical areas (Smith *et al.*, 2009). The wide distribution of these species is possibly due to their ability to occupy wide range of substrate like rocks, basalt, sandstone and limestone, in addition to its ability to withstand drought. Six other species were found in two of the district sites, which are the species (*Aspicilia calcarea*, *Diploschistis diacapsis*, *Lobothallia praeradiosa*, *Psora decipiens*, *Squamarina lentigera* and *Toninia sedifolia*). The remaining eleven species showed a narrow range in their spread and distribution, as their presence was recorded in one of the four sites only, these species are (*Acarospora cervina*, *Acarospora placodiiformis*, *Buellia zoharyi*, *Caloplaca biatorina*, *Caloplaca aurantia*, *Caloplaca murorum*, *Collema fuscovirens*, *Collema tenax*, *Placocarpus scheererii*, *Squamarina lentigera* and *Verrucaria macrostoma*).

The results of the investigation of lichens in this study recorded 19 species distributed in 14 genera. The largest genera was *Caloplaca* represented by 3 species, followed by the genera *Acarospora*, *Collema* and *Squamarina* (each of which represented by 2 species). The reason for the large number of species of the genus *Caloplaca* related to the large number of its known species. Kondratyuk *et al.*, (2020) states that the genus *Caloplaca* is the largest genus in Teloschistaceae family. Kirk *et al.* (2008) indicated that there are more than 510 known species of this genus. The class *Lecanoromycetes* was the largest as this class is the largest of the lichen classes (Stenroosa *et al.*, 2019).

As for the distribution of species in the two districts, the results showed that six species were found in both districts, namely the species (*Diploschistis diacapsis*, *Fulgensia subbracteata*, *Lecanora muralis*, *Psora decipiens*, *Squamarina cartilaginea* and *Toninia sedifolia*). Three species were found only in the Upper Jazira district, which are the species (*Acarospora placodiiformis*, *Buellia zoharyi* and *Collema tenax*), while the remaining 10 species were found only in the Nineveh district. The clear variations in the numbers of the recorded lichen species between Nineveh and Upper Jazirah districts or between the four

study sites can be attributed to various factors such as yearly temperature and rainfall, pollutant ratio, and substrate chemistry.

#### 4- Conclusion

There were clear variations in the numbers of the recorded lichen species between Nineveh and Upper Jazirah districts or between the four study sites. Most of the genera were poor in number of species. The largest genera was Caloplaca. The class Lecanoromycetes was the largest.

#### 5- Conflict of interests

The authors declared no conflicting interests.

#### 6- Sources of funding

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