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Теоретичні та прикладні питання

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EPILITHIC ALGAL COMMUNITIES OF DRY ROCKS OF THE NEGEV DESERT, ISRAEL

Ключові слова: Cyanoprocaryota, Cyanobacteria, Chlorophyta, Eustigmatophyta, species composition, new records, desert, rocks, Negev, Israel.

Abstract

Species and taxonomic composition of cyanobacteria and algae inhabiting rocks of different geological strata in the central and southern Negev Desert were studied by the cultural method. Thirty–two species of 27 genera belonging to three taxonomic divisions (Cyanoprocaryota — 22, Chlorophyta — 9, and Eustigmatophyta — 1) were identified. Twelve taxa were first recorded from Israel. In studied habitats, the most diverse and frequent taxonomic group were Cyanoprocaryota. They colonised all studied rock types (dolomite, sandstone, limestone, chalk, flint, gravel, granite, gneiss, and porphyry). Algal species diversity and occurrence on the investigated rock types were different. The highest occurrence of photosynthetic microorganisms was recorded on gravel, gneiss, porphyry, flint and dolomite. Granite seemed to be the most unfavourable substrate among all the investigated rock types. The most diverse taxonomic composition was recorded on dolomite: 14 species belonging to blue-green (Cyanoprocaryota, 11 species), green (Chlorophyta, 2 species) and yellow-green (Eustigmatophyta, 1 species) algae. The rocks

poorest in species number were porphyry and gravel (4 species each), and the most species-rich rock was flint (15 species). Our comparative analysis showed that assemblages of species inhabiting igneous granite and several sedimentary rocks (flint, dolomite, sandstone) display greater relatedness than assemblages of species compared between rocks of similar origin.

Introduction

In deserts, terrestrial (edaphic and lithophytic) cyanoprocaryotes and algae[1] play an important role with respect to the input of both carbon and nitrogen into the ecosystem [23, 26, 36, 37]. They occupy habitats ranging from soil to rock fissures and rock surface [14]. Lithophytic (epilithic and cryptoendolithic) algal communities have been reported from many regions of the world. Data concerning terrestrial algae of hot deserts of the World have been summarised in several publications, e.g. [3, 13, 18, 27]. In Israel, algological studies of xeric habitats mostly focused on the Negev Desert have been conducted during the last 35 years. Friedmann's work was the first published, a first short preliminary report on the Negev algal flora [12]. He noted the widespread occurrence of algae (mainly blue-green and green algae) in edaphic and rock habitats [14]. Recent publications on the desert algae of Israel mainly deal with microphyte community composition, physical and biological properties of the cryptogamic (mostly cyanobacterial) crusts that cover large areas in the southern regions of the country [6, 19, 20, 23, 25, 33, 35], and cytological and ecophysiological peculiarities of the species isolated from various terrestrial habitats [4, 16, 17, 24, 31]. However, our knowledge of the species diversity, not to speak about other aspects of biodiversity, of algae inhabiting dry desert rocks is still incomplete. In this paper we report on species (and taxonomic) composition of Cyanoprocaryota and algae inhabiting rocks of different lithological substrates in the Central and Southern Negev, and discuss their occurrence and distribution regionally and globally.

Material and methods

Study area. The Negev Desert forms an isosceles triangle with its base towards the north, running from a point near Gaza on the Mediterranean coast to the shores of the Dead Sea (Fig. 1). From these two points the sides of the triangle run some 200 kilometres south to the apex at Eilat, at the northern end of the Gulf of Aqaba. The altitude varies from 392 m below sea level at the coast of the Dead Sea to over 1000 m above the Mediterranean Sea level west of Makhtesh Ramon (Central Negev Highland). The greater part of the Negev is occupied by hills and mountains built of various Precambrian igneous rocks such as in the Southern Eilat region, and by mostly sedimentary rocks (Paleozoic sandstone, Mesozoic—Neozoic limestone, flint, chalk, soft shale, clays) in the southern and central Negev Mountains. Precambrian rocks include coarse-grained grey and rose granite, dar diorite, gabbro, banded gneiss, crystalline schist, dikes of violet porphyry, and other types). About half of the region is

[1] To avoid duplication of terms, «algae»and «algal»in the text are also implicit in Cyanoprocaryota unless as otherwise noted.

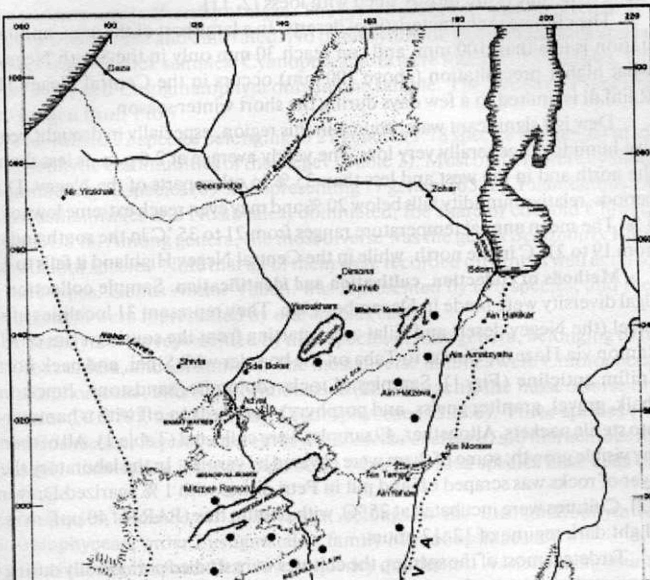

Fig. 1. Map of southern Israel with sampling sites

made up of rock outcrops, hamadas, red soils, gravelly slopes, and coarse desert alluvium. The valleys are mostly filled with loess [2, 11].

The climate is characteristic of deserts. In a large part of the area, annual precipitation is less than 100 mm, and can reach 30 mm only in the South Negev. Somewhat higher precipitation (above 100 mm) occurs in the Central Negev Highland. Rainfall is limited to a few days during the short winter season.

Dew is a significant water source in this region, especially in drought years. Relative humidity is generally very low. The yearly average at 2.0 p.m. is less than 40 % in the north and in the west and less than 35 % in other parts of the Negev. During dry periods, relative humidity falls below 20 % and may even reach extreme lows of less than 5 %. The mean annual temperature ranges from 21 to 35 °C in the south and east, and from 19 to 21 °C in the north, while in the Central Negev Highland it falls to 15 °C [2].

Methods of collection, cultivation and identification. Sample collection to study algal diversity were made in December 1996. They represent 31 localities of southern Israel (the Negev desert and Eilat area) starting from the southern rim of Makhtesh Ramon via Hazeva, Timna to Taba on the boarder with Sinai, and back north to the Znifim anticline (Fig. 1). Samples of rocks (dolomite, sandstone, limestone, flint, chalk, gravel, granite, gneiss, and porphyry) were broken off with a hammer and put into sterile packets. Altogether, 49 samples were collected (Table 1). All of them lacked any visible growth; some of them were covered by varnish. In the laboratory the surface layer of rocks was scraped off and put in Petri dishes with 1 % agarized Drew medium [22]. Cultures were incubated at 25 °C, with photon flux (PAR) of 40 μμE $m^{-2}sec^{-1}$ and a light:dark regime of 12 :12 hours.

To detect most of the species, the cultures were studied periodically during the first four months of cultivation. Light microscopy was performed by means of an Olympus BX-40 Photomicroscope. All species were identified in the living state. Identification was made according to the cited taxonomic treatises [1, 7, 8, 10, 15, 21, 22].

Table 1. **Number of the samples of different rock types which were collected and cultivated (I), and in which algae were found (II)**

Kind of rock	Number of samples		Number of species found			
	I	II	BG	G	YG	Total
Dolomite	10	8	11	2	1	14
Sandstone	9	6	11	1	—	12
Limestone	6	4	6	3	—	9
Flint	10	9	13	2	—	15
Chalk	4	3	4	1	—	5
Gravel	1	1	4	—	—	4
Granite	5	2	3	1	—	4
Gneiss	2	2	4	1	—	5
Porphyry	2	2	4	—	—	4

N o t e: blue-green (BG), green (G), and yellow-green (YG) algae.

Results

Species and taxonomic diversity of algae. The presence of algae was detected in 37 out of 49 samples collected and cultivated. No photosynthetic microorganisms appeared in cultures from 12 rock samples. Cyanoprocaryota were found in 33 samples; Chlorophyta in 13, and Eustigmatophyta only in one sample. The number of species per sample ranged from 1 to 7.

We identified 32 species belonging to 27 genera (1.18 species per genus) of algae in the lithophytic communities of the Negev (Table 2). Most of them were cyanobacteria, numbering 22 species (69 %) representing 17 genera (63 %). Filamentous forms (orders Oscillatoriales and Nostocales) dominated, the share of coccoid Chroococcales was 31.8 %. Among genera, the most diverse was the genus *Schizothrix* Kütz. ex Gom. with four species. Note that all of them were recorded on flint as well as on some other rock types. Genus *Nostoc* Vauch. was represented by two species, and the remaining genera were represented by one species each.

Chlorophyta were represented by nine species in nine genera, belonging to three classes, four orders, and six families. The most diverse families were Chlorococcaceae, Chaetophoraceae, and Klebsormidiaceae (22.2 % each), the most diverse order, Chlorellales (33.3 %), and the class, Chlorophyceae (55.6 %). Three species (*Klebsormidium dissectum*, *Leptosira terrestris*, *Stichococcus bacillaris*) are filamentous forms or can easily disintegrate into separate cells; other recorded species have cells of the coccoid type.

One species, *Monodopsis subterranea,* belongs to the Eustigmatophyta (class Eustigmatophyceae, order Eustigmatales, family Monodopsidaceae).

Most of the species found had low frequency quotients[2]. *Nostoc punctiforme* (F = 24.5 %), *N. linckia* (20.4 %), *Pseudophormidium edaphicum* (18.4 %), and *Schizothrix arenaria* and *Sch. friesii* (in both cases 16.3 %), proved to be the most widespread species in the studied samples.

Relationship of rock type to algal community. The various kinds of rock in our study evinced differences in occurrence, species diversity and taxonomic composition of epilithic communities. Comparison of the number of collected and cultivated samples with those where we observed algal growth yielded the following results: presence of photosynthetic microorganisms was recorded in the samples in 100 % of gravel, gneiss and porphyry, in 90 % of flint; in 80 % of dolomite, and in 75 % of chalk. Samples of sandstone and limestone were less populated: algae appeared in 66 % of each of these rock types. Granite turned out to be the most unfavourable substrate among the investigated rock types: only 40 % of granite samples were inhabited. The highest number of species (15) was found on flint, whereas gravel, granite and porphyry were the poorest in species (four in each case). As may be seen from Fig. 2, number of species found on different rock types was not related in a linear fashion to the number of samples examined.

Concerning taxonomic composition of algae found on different types of rocks, the highest taxonomic diversity was on dolomites: 14 species representing Cyanoprocaryota (11), Chlorophyta (2), and Eustigmatophyta (1) were found in samples of

Table 2. **The list of algae species found on different rock types in the Negev Desert**

Taxon	1	2	3	4	5	6	7	8	9
Cyanoprocaryota									
Aphanocapsa cf. *incerta* (Lemm.) Cronb. et Kom.	+	+	+	+	—	—	—	—	+
Aphanothece castagnei (Brйb.) Rabenh.	—	—	—	+	—	—	—	—	—
Calothrix parietina (Nдg.) Thur. f. *nodosa* Erceg.	—	+	—	—	—	—	—	—	—
Chroococcidiopsis sp.	+	+	—	+	—	—	+	—	—
Gloeocapsopsis crepidinum (Thur.) Geitl. ex Kom.	—	—	+	—	—	—	—	—	—
Gloeothece confluens Nдg.	+	+	—	—	—	—	—	—	—
Leptolyngbya foveolarum (Rabenh. ex Gom.) Anagn. et Kom.	—	—	+	—	—	+	—	—	—
L. golenkinianum (Gom.) Anagn. et Kom.	—	—	—	—	—	—	—	+	—
Microcystis pulverea (Wood) Forti	—	+	—	—	—	—	—	—	—
Nodularia harveyana Thur.	+	—	—	+	—	—	—	+	—
Nostoc linckia (Roth.) Born et Flah sensu Elenk. f. *terrestris* Elenk.	+	+	+	-	+	+	—	+	+
N. punctiforme (Kьtz.) Hariot	+	+	+	+	+	—	+	+	—
Phormidium ambiguum Gom.	—	—	—	+	—	—	—	—	—
Porphyrosiphon luteus (Gom.) Anagn. et Kom.	—	+	—	—	—	+	—	—	—
Pseudophormidium edaphicum (Elenk.) Anagn. et Kom.	+	+	+	+	—	—	—	—	+
Rhabdoderma sp.	—	—	—	+	—	—	—	—	—
Schizothrix arenaria (Berk.) Gom.	+	+	—	+	+	+	—	—	—
Sch. friesii (Ag.) Gom.	+	+	—	+	+	—	+	—	+
Sch. Lennormandiana Gom.	—	—	—	+	—	—	—	—	—
Schizothrix sp.	—	—	—	+	—	—	—	—	—
Synechococcus elongatus Nдg.	+	—	—	—	—	—	—	—	—
Tolypothrix byssoidea (Hass.) Kirchn.	+	—	—	+	—	—	—	—	—
Eustigmatophyta									
Monodopsis subterranea (Boye-Pet.) Hibberd	+	—	—	—	—	—	—	—	—
Chlorophyta									
Bracteacoccus grandis Bischoff et Bold	—	—	+	—	—	—	—	—	—
Chlorella minutissima Fott et Novбk.	—	—	+	+	—	—	+	—	—
Chlorococcum pinguideum Arce et Bold	—	—	—	—	+	—	—	—	—
Diplosphaera chodatii *Bial. Emend. Visch.*	+	—	—	—	—	—	—	—	—
Klebsormidium dissectum (Gay) Lokhorst	—	—	—	—	—	—	—	+	—
Leptosira terrestris (Fritsch et John) Printz	—	—	+	—	—	—	—	—	—
Myrmecia biatorellae (Tsch.-Woess et Plessl) Boye-Pet.	—	—	—	+	—	—	—	—	—
Stichococcus bacillaris Nдg. s.l.	+	—	—	—	—	—	—	—	—
Tetracystis aggregata Brown et Bold	—	+	—	—	—	—	—	—	—
Total	14	12	9	15	5	4	4	5	4

N o t e (here and in the Table 3): 1 — dolomite; 2 — sandstone; 3 — limestone; 4 — flint; 5 — chalk; 6 — gravel; 7 — granite; 8 — gneiss; 9 — porphyry.

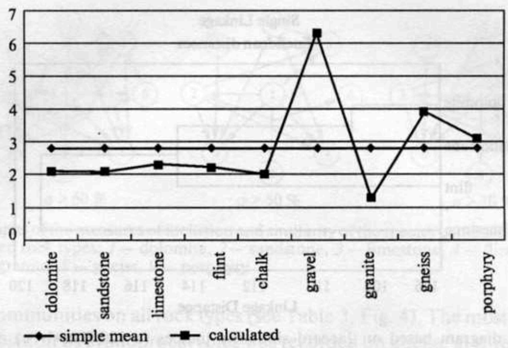

Fig. 2. Relationship between the proportions (%) of species found on different rock types and number of samples of the same type (a straight line shows simple mean of calculated ratios)

this rock. From the sandstone and limestone samples were identified 12 and 9 algal species, respectively. In the samples of porphyry and gravel only representatives of cyanoprocaryotes were found.

The occurrence of different taxonomic groups of algae in the samples of the studied rock types varied. The only species of Eustigmatophyta discovered was recorded on dolomite. In the samples of dolomite, sandstone, limestone, flint, chalk, granite and gneiss we found various species of Chlorophyta (Table 2). Cyanoprocaryota were the most diverse and frequent taxonomic group in the studied samples, since they were isolated from all rock types examined. Species and generic diversity, as well as frequency of lithophytic cyanoprocaryotes, was highest on flint (13 species in 10 genera); dolomite and sandstone had 11 species in nine genera in each case. The relationship between coccoid and filamentous species on dolomite, sandstone and limestone were about the same: 35 to 65 %, and on flint, 30 to 70 %. The ratios of Oscillatoriales : Nostocales on dolomite, sandstone, and limestone were 1:1.3; 1.3:1, and 1:1, respectively. On flint, the share of Oscillatoriales was twice as that of Nostocales. Chalk, gravel, and gneiss had poor species composition, and representatives of Chroococcales have not been found there.

The distribution of species on rock types was also dissimilar. Of all species, 56.3 % were recorded from one rock type only. Further 15.6 % of species occurred on two or three rock types. *Chroococcidiopsis* sp. inhabited dolomite, sandstone, flint, and granite; *Aphanocapsa incerta*, *Schizothrix arenaria* and *Pseudophormidium edaphicum* were distributed on five rock types, and *Schizothrix friesii* — on six. The most widespread were species of *Nostoc*: *Nostoc punctiforme* was found on all studied rock types except gravel and porphyry, *Nostoc linckia*, on all rock types except flint and granite. Com-

[2] Frequency quotients were calculated as $F = a/A$, where a — number of samples where species was found; A — total of studied samples.

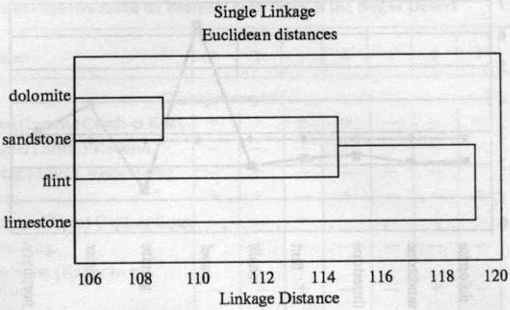

Fig. 3. Cluster diagram based on Jaccard similarity indices (a 100 %/a+b+c) of the species composition of algae found on rock types studied

parison of the lists of species found on different rock types using the Jaccard similarity index (JSI) and the measures of inclusion and similarity allows us to draw some conclusions. We were able to use JSI for the comparison of dolomite, sandstone, limestone, and flint. In other cases the difference in the number of species overshadowed differences in species composition. The JSI attested that each rock type examined had a fairly characteristic species composition. Dolomite and sandstone were most similar (Fig. 3), limestone had the lowest rate of resemblance in its species composition of algae. The measures of inclusion and similarity method [32] can be applied to the comparison of lists of species with great differences in their number. We found that species inhabiting dolomite and sandstone rocks contributed to the formation of

Table 3. **Measures of inclusion and similarity (%) of the species composition of algae found on the studied rock types**

K (A,B)	K (B,A)								
	1	2	3	4	5	6	7	8	9
1	100	66.7	44.4	53.3	80.0	50.0	75.0	60.0	100
2	57.1	100	44.4	40.0	80.0	75.0	75.0	40.0	100
3	28.6	33.3	100	26.7	40.0	33.3	100	40.0	75.0
4	57.1	50.0	44.4	100	60.0	33.3	100	40.0	75.0
5	28.6	33.3	22.2	20.0	100	50.0	50.0	40.0	50.0
6	14.3	25.0	11.1	6.7	40.0	100	0	20.0	25.0
7	21.4	25.0	22.2	26.7	40.0	0	100	20.0	25.0
8	21.4	16.1	22.2	13.3	40.0	25.0	25.0	100	25.0
9	28.6	33.3	33.3	20.0	40.0	25.0	25.0	20.0	100

N o t e: K (A,B) = c/B·100 %; K (B,A) = c/A·100 %; A — the number of species found in A; B — the number of species found in B; c — the number of species common to A and B.

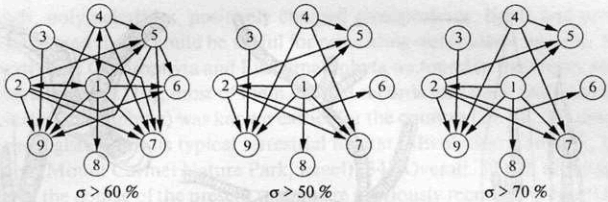

Fig. 4. Orgraphs of the measures of inclusion and similarity of the species composition of algae found on the studied rock types: *1* — dolomite, *2* — sandstone, *3* — limestone, *4* — flint, *5* — chalk, *6* — gravel, *7* — granite, *8* — gneiss, *9* — porphyry

epilithic communities on all rock types (see Table 3, Fig. 4). The most particular species composition of cyanoprocaryotes was recorded on gneiss: at threshold y σ 50 % it had only one connection of inclusion, and at y σ 70 % gneiss lost all connections with lists of species of other rock types. Connections (Fig. 4) between the list of species inhabiting hard igneous rock granite and a number of sedimentary rocks (flint, dolomite, sandstone) proved to be firmer than those between rocks of similar petrology. Thus, the physical and chemical peculiarities of the rock do not seem to be the major factor determining the species composition of litophytic algae.

Discussion

Terrestrial algal rock communities exist under the conditions of drastic temperature changes, high insolation, and periodical desiccation. Species forming such communities must to possess ecological and physiological adaptations that enable them to survive in extreme conditions. Prokaryotes are much better adapted to environmental extremes than eukaryotes [9]. Consequently, cyanobacteria make up the bulk of species diversity of arid lithophytic habitats. Novichkova-Ivanova [27] in her monograph on terrestrial algae of the Sahara—Gobi arid area showed that the relationship between the proportions of blue-green (BG) and green (G) algae in the regional floras of this area could serve as an index of aridity. According to original data and those generalized from the literature by the author, in terrestrial habitats of the Sahara—Gobi area this index was in the range of 1.9 : 1 in the Irano—Turanian region and up to 3.6 : 1 in the Saharo—Sindian region. Our data corroborate the conclusions of Novichkova-Ivanova. For the Negev this ratio is 2.4 : 1. Species composition of algae found on the Negev rocks had much in common with results for rock-living algae of other hot arid regions of the world. Seventy—two percent of species found in the Negev are known from deserts of Asia, Africa, and America. Among them *Nostoc linckia*, *Nostoc punctiforme*, *Synechococcus elongatus*, *Nodularia harveyana*, *Tolypothrix byssoidea*, *Schizothrix arenaria*, *Sch. friesii*, and *Sch. lenormandiana* are characteristic for dry rocks. *Tolypothrix byssoidea* is perhaps the most widespread species on tropical and subtropical limestones [28]. *Chroococcidiopsis* is a well-known genus from cold and hot arid lithophytic habitats [5]. *Chroococcidiopsis* sp., isolated from quartz flints collected in the Negev [16], had thickened cell envelopes containing sporopelline-like

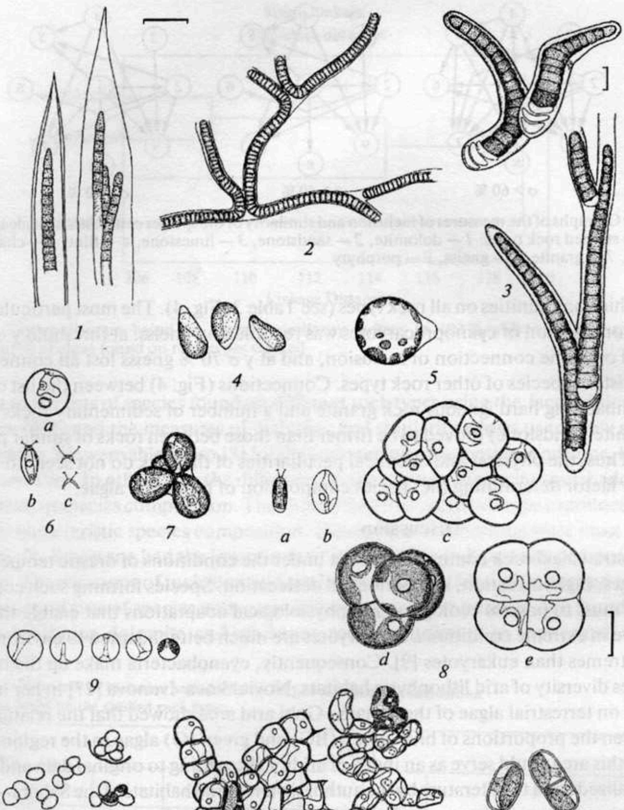

Plate. Taxa newly recorded from Israel: *1 — Schizothrix arenaria* (Berk.) Gom.; *2 — Plectonema golenkinianum* Gom.; *3 —* C*alothrix parietina* (Nдg.) Thur. f. *nodosa* Erceg.; *4 — Monodopsis subterranea* (Boye-Pet.) Hibberd, *5 — Bracteacoccus grandis* Bischoff et Bold; *6 — Chlorococcum pinguideum* Arce et Bold: *a* — vegetative cell, *b* — zoospore, *c* — zoospore papilla; *7 — Myrmecia biatorellae* (Tsch.-Woess et Plessl) Boye-Pet.; *8— Tetracystis aggregata* Brown et Bold: *a* — zoospore, *b* — young cell, *c* — agglomeration of adult cells, *d* — adult cells in tetraedric tetrade, *e* — adult cells in isobilateral tetrade; *9 — Chlorella minutissima* Fott et Novбk.; *10 — Diplosphaera chodatii* Bial. emend. Visch.; *11 — Leptosira terrestris* (Fritsch et John) Printz; *12 — Klebsormidium dissectum* (Gay) Lokhorst (scale bars 10 мм; all figures except of Fig. 3 have the same scale) compounds, polysacharides, positively charged glycoproteins, lipids and proteins. Authors presumed that it could be useful for preventing water losses by cells. All the representatives of Chlorophyta and Eustigmatophyta we found in the Negev are typical terrestrial species [10]; most of them are first records for Israel. Only *Stichococcus bacillaris* (Chlorophyta) was known earlier for the country [29, 30, 34], and only once it was registered in its typical terrestrial habitat («Evolution Canyon», Lower Nahal Oren, Mount Carmel Nature Park, Israel) [34]. Overall, 59.4 % of the species identified in the course of the present study were previously recorded in Israel in terrestrial habitats. New records for Israel are: *Schizothrix arenaria* (Plate, Fig. 1), *Leptolyngbya golenkinianum* (Plate, Fig. 2), *Calothrix parietina* f. *Nodosa* (Plate, Fig. 3), *Monodopsis subterranea* (Plate, Fig. 4), *Bracteacoccus grandis* (Plate, Fig. 5), *Chlorella minutissima* (Plate, Fig. 9), *Chlorococcum pinguideum* (Plate, Fig. 6), *Diplosphaera chodatii* (Plate, Fig. 10), *Klebsormidium dissectum* (Plate, Fig. 12), *Leptosira terrestris* (Plate, Fig. 11), *Myrmecia biatorellae* (Plate, Fig. 7), and *Tetracystis aggregata* (Plate, Fig. 8). Of these, *Sch. arenaria*, *M. subterranea*, *B. grandis*, *Ch. minutissima*, *Ch. pinguideum*, *D. chodatii*, *K. dissectum*, *L. terrestris*, *M. biatorellae*, and *T. aggregata* are cosmopolitan species known from terrestrial (e.g. rock) habitats. *C. parietina* f. *nodosa* was described from calcareous rocks in Croatia. Marine species *Leptolyngbya golenkinianum* has been found on gneiss rocks near the Eilat underwater observatory on the bank of the Gulf of Aqaba.

Our study showed that the most preferable rock types for algal colonization are flint, dolomite and sandstone which harboured 71.9 % of the revealed species. Our results support Friedmann's conclusion [12] that the rock substrates most favorable for algae are light-colored with a porous structure. Precisely, the porous rocks are able to soak up and retain moisture, and to support balanced temperature conditions in a hot desert microclimate [13].

Totally, this study documented 32 species from the Negev Desert of Israel including 12 taxa newly recorded for Israel. We demonstrated a differential distribution of species according to different rock types. The ensemble of the described species ranged across extremely xeric environments, but they displayed rock specificity, thereby combining climatic and lithologic adaptive radiation.

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ЕПІЛІТНІ УГРУПОВАННЯ ВОДОРОСТЕЙ
СУХИХ СКЕЛЬ ПУСТЕЛІ НЕГЕВ, ІЗРАЇЛЬ

Стаття присвячена результатам вивчення видового і систематичного складу водоростей, що колонізують гірські породи різного геологічного походження у центральній і південній частинах пустелі Негев. Методом культур було виявлено 32 види водоростей, що належать до 27 родів з трьох відділів (*Cyanoprocaryota* — 22, *Chlorophyta* — 9, *Eustigmatophyta* — 1). Дванадцать видів водоростей вперше наводяться для територии Ізраїлю. Синьозелені водорості виявилися найрізноманітнішою та найпоширенішою групою в досліджених місцезростаннях. Вони знайдені на поверхні усіх досліджених типів гірських порід: доломітах, пісчаниках, вапняках, крейді, кремені, гравії, граніті, гнейсі і порфірі. Різноманітність і трапляння водоростей на різних породах були неоднакові. Найчастіше фотосинтезуючі мікроорганизми траплялися на гравії, гнейсі, порфирі, кремені та доломіті. Граніт виявився найменш придатним для водоростей субстратом серед досліджених типів гірських порід. Найрізноманітніший систематичний склад водорослей виявлено на поверхні доломіту — тут знайдено 14 видів водоростей з трьох відділів: *Cyanoprocaryota* (11 видів), *Chlorophyta* (2) і *Eustigmatophyta* (1). За видовим різноманіттям водоростей найбіднішими були порфір і гравій, на них ідентифіковано по 4 види, найбагатшим видами субстратом виявився кремень (15 видів). Як показали міри включення, між списками видів, що заселені на гірських породах різного геологічного походження (вулканічні та деякі осадові), спостерігається більше відношень подібності, ніж між списками видів водоростей, знайдених на породах спільного походження.

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ЭПИЛИТНЫЕ СООБЩЕСТВА ВОДОРОСЛЕЙ
СУХИХ СКАЛ ПУСТЫНИ НЕГЕВ, ИЗРАИЛЬ

Статья посвящена результатам изучения видового и систематического состава водорослей, населяющих горные породы различного геологического происхождения в центральной и южной частях пустыни Негев. Методом культур было выявлено 32 вида водорослей, относящиеся к 27 родам из трех отделов (*Cyanoprocaryota* — 22, *Chlorophyta* — 9, *Eustigmatophyta* — 1). Двенадцать видов водорослей впервые указываются для территории Израиля. Синезеленые водоросли оказались наиболее разнообразной и часто встречающейся группой в исследованных местообитаниях. Они обнаружены на поверхности всех исследованных типов горных пород: доломитах, песчаниках, известняках, меле, кремнии, гравии, граните, гнейсе и порфире. Разнообразие и встречаемость водорослей на различных породах были неодинаковы. Чаще всего фотосинтезирующие микроорганизмы встречались на гравии, гнейсе, порфире, кремнии и доломите. Гранит оказался наименее пригодным для обитания водорослей субстратом среди исследуемых типов горных пород. Наиболее разнообразный систематический состав водорослей выявлен на поверхности доломита — здесь обнаружено 14 видов водорослей из трех отделов: *Cyanoprocaryota* (11 видов), *Chlorophyta* (2) и *Eustigmatophyta* (1). По видовому разнообразию водорослей наиболее бедными оказались порфир и гравий, на них обнаружено по 4 вида, наиболее богатыми видами субстратов — кремний (15 видов). Как показали меры включения, между списками видов, населяющих горные породы различного геологического происхождения (вулканические и некоторые осадочные), наблюдается больше отношений сходства, чем между видовым составом водорослей, обнаруженных на породах сходного происхождения.