

# A New *Chara* Locality in the Protected Area of the Galilee Mountains, Israel

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**Abstract** A new locality of *Chara* is described from the Nevoria pool, Upper Galilee region of Israel. The associated algal diversity is revealed, and ecological assessment aquatic environment is obtained with bio-indication methods. Algal community includes ten species two of which are charophytes *Chara gymnophylla* A. Braun and *Spirogyra* sp. The charophytes are found in mass growths in the studied pool. Bio-indication and chemical variables characterize the pool environment as eutrophic, low- to middle organically polluted, belonging to water quality Class II-III. The water is fresh, temperate, low alkaline, and well saturated with oxygen. Seasonality of algal community and water quality show a higher organic pollution in March caused by recreation impact at the end of the rainy season. The water is appreciably clearer in November at the end of the dry season, accompanied with a decrease of algal diversity. We recommend the Nevoria pool as reference site for monitoring of natural aquatic object in the Upper Galilee Mountains, for which *Chara gymnophylla* can be used as a climatic indicator.

**Keywords** *Chara*, ecology, bio-indication, pool, Upper Galilee Mountains, Israel

## 1. Introduction

The *Chara* species (Charophyta, Charales) as macroscopic autotrophic algae may be very important components of vegetation in several types of water bodies and may be used as a bio-indicator of ecosystem state, water quality, and ecosystem recovery and reservoir management efficiency. Diversity of this group in the Eastern Mediterranean is studied in initial stage. The *Chara* species prefer alkaline water environment which forms on the carbonates that are very distributed in studied region. This environment gives us more chance to find new, unstudied aquatic objects in which can be identified charophyte algae. The most important

localities can be found in the mountain areas because altitude play the major role in historical species diversity forming process [1] especially it can be interesting in the Upper Jordan River basin, which placed in two different slopes of the Jordan Rift Valley [2,3].

Israel is partly situated in the eastern part of the Mediterranean region and partly within African-Eurasian Dry Zone [4]. Its territory contains several regions with diverse environmental features within its relatively small area. Based on this environmental diversity, we can assume the great diversity of algae of continental water bodies of Israel and in particular charophytes. The history of the study of Israel charophytes has been recently described [5], and we continue finding of new existing localities of charophytes that hitherto not been detected. Close related regions, such as Turkey, also give us charophyte algae new localities that we studied in respect of species diversity and bio-indication of its environment [6,7].

This paper is on a new locality of *Chara*, a rare and so far poorly studied genus of higher algae macrophytes in Israel. We assessed *Chara* habitat on the basis of complex study of algal diversity, indicator species and water chemistry.

## 2. Materials and Methods

### 2.1. Sampling and Laboratory Studies

Material for this study comes from six living and six fixed algological samples, eighteen samples of macro-charophytes and three samples of water that were collected during two field trips in November 2012 and March 2013 in the Nevoria natural pool.

Algological samples were collected by scratching and scooping, placed in 15 ml plastic tubes, and partly fixed with 3% neutral formaldehyde solution, as well as partly not fixed and transported to the laboratory in the ice box.

The *Chara* samples were treated with 2-3% HCl to remove calcium carbonate. After washing several times

with distilled water the material was studied with Nikon stereomicroscope with distilled water the material was air-dried on cover glasses and mounted in Naphrax®. The structure elements were observed with Nikon with digital camera, DinoLight camera, and light microscopes (LM) in the Institute of Evolution, University of Haifa and the Central Siberian Botanical Garden with help of international handbooks [8,9]. Charophyte and microscopic algae abundance were assessed as abundance scores according 6-score scale [10].

Algae and cyanobacteria were studied with the SWIFT and OLYMPUS dissecting microscopes under magnifications 740x–1850x from three repetitions of each sample and were photographed with a DC (Inspector 1). The diatoms were prepared by the peroxide technique [11] modified for glass slides [12] and were placed in the Naphrax® resin from two repetitions of each sample.

Temperature was measured with a thermometer. Acidity (pH), conductivity (EC), and TDS were measured with HANNA HI 9813-0. This meter has a full-spectrum pH measurement range. The Electrical conductivity range goes to 4.00 mS cm<sup>-1</sup>. The TDS ranged from 0 to 1999 mg l<sup>-1</sup>. Measurements were made by adding the probe into the water till the reading was stabilized. The concentration of N-NO<sub>3</sub> was measured with HANNA HI 93728.

Index saprobity *s* was calculated according to [13]. Index of aquatic ecosystem sustainable was calculated according to [10,14] as (1):

$$\text{WESI} = \text{Rank S} / \text{Rank N-NO}_3 \quad (1)$$

Where: Rank S – rank of water quality on the Sladeček's indices of saprobity; Rank N-NO<sub>3</sub> – rank of water quality on the nitric-nitrogen concentration (Table 1).

If WESI is equal to or larger than 1, the photosynthetic level is positively correlated with the level of nitrate concentration. If the WESI is less than 1, the photosynthesis is suppressed presumably according to toxic disturbance [10].

## 2.2. Description of the Study Site

The Nevoria natural pool is placed in the upper part of the Upper Galilee Mountains (Figure 1) on altitude about 690 m above sea level with coordinates 33°00'036 N, 35°30'567 E on the western slope of the rift valley near the Dalton settlement. It is small, about 6-15 m in diameter and up to one m deep (Figure 2), filled by natural rainy waters during winter from the small stream Ein Nevoria that is right tributary of the Dalton stream, which followed to the Hatsor stream, the right tributary of the Upper Jordan River in the Northern part of Israel. While the Dalton and Hatsor streams (in the upper part) are winter streams only, the Nevoria pool is permanent. Pool is located on a forested north faced hillside of the Galilean Mountains with *Pinus halepensis* near the First Synagogue protected historical site, and used for recreation, year-round, but mostly in summer. Climatic condition of the Nevoria basin area is the most high and humidly in the Upper Galilee Mountains with mean annual rainfall about 800 mm. Annual mean solar radiations in the pool area is rather high, about 182-189 kg-calories cm<sup>2</sup> year<sup>-1</sup> [15], like in the Judean Mountain and even in the upper Negev Desert. Therefore environment is very favorable for the development of photosynthetic plants, like *Pinus halepensis* in the forest, as well as *Nymphaea* in the studied Nevoria pool [16], and charophyte algae which are truly photosynthetic organisms.



Figure 1. The Nevoria pool locality in the Upper Galilee Mountains, Israel.

### 3. Results and Discussion

#### 3.1. Chemical Composition of the Pool Water

Chemical variables were measured in two seasons: at the end of summer and at the end of winter. Table 1 show that environment variables are fluctuated in small range and reflected fresh, low alkaline, low to temperate temperature, and low polluted waters [10,14] which saturated by oxygen rather enough. Index of saprobity S is fluctuated between 1.45 in summer and 1.60 in winter, reflect Class II to III change during the rainy period.

**Table 1.** Chemical and biological variables of the Nevoria pool in 2012-2013

Variables	November 2012, summer	March 2013, winter
Conductivity, mS cm <sup>-1</sup>	0.43	0.70
N-NO <sub>3</sub> , mg l <sup>-1</sup>	0.1	1.2
pH	7.4	6.9
Total Dissolved Solids (TDS), mg l <sup>-1</sup>	307	499
Temperature	16.5	15.7
O <sub>2</sub> mg l <sup>-1</sup>	n.a.	5.3
O <sub>2</sub> %	n.a.	61.8
Index saprobity S	1.45	1.60
WESI	1.50	0.80
No. of Species	9	10

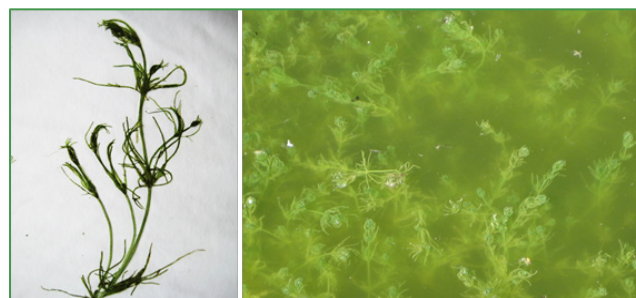
#### 3.2. Diversity and Ecology of Algae

We revealed ten species of algae (Table 2) diversity of which is rather constant during the seasons. Studied pool surface was covered by macrophyte alga *Chara gymnophylla* (Figure 3), which was more abundant in winter. Structural elements and thallus habitat show (Figures 3 and 4), that our samples are in the typical diagnosis frames. It is also widely distributed species in the Mediterranean countries and some climatic similar dry regions [17] (algaebase.org). Species is simply separated from the other members of the genus *Chara* as we revealed by AFLP analysis [18]. The sterile *Spirogyra* sp. was dominant in pool especially during rainy period.

Massive *Chara* growth is correlated with organic enrichments of the water during rainy period that can give large nutrient base for charophytes development. Charophyte species *Chara gymnophylla* has wide distribution in Israel [5] over Mediterranean climatic zone [19] but in the Upper Galilee Mountains it is only one water body which it is inhabited. Other identified species in the pool were mostly diatoms that attach macrophytes, filamentous algae and stones in the pool.



**Figure 2.** The Nevoria pool in March 2013 (winter).



**Figure 3.** *Chara gymnophylla*: 1 – view of thallus, 2 – massive growth in the Nevoria pool



**Figure 4.** *Chara gymnophylla*: 1 – axis with stipulodes and base of whorl, 2 – axis with axial cortex

### 3.3. Bio-indication of the Studied Pool Environment

We use bio-indication methods in purpose to characterize of the pool water quality and ecosystem sustainable. As can be seen in Table 2, the water quality defined by bio-indication is the same that show by water chemistry (Table 1). In addition we can characterize pool as eutrophic with prevailing of organisms with autotrophic type of nutrition, which are mostly attached of substrate.

We use Table 2 with Index saprobity S value that we calculated on the base of species abundance scores and species-specific index s (after [20] model) and nitrate concentration data (Table 1) for ecosystem state index WESI calculation. Thus, winter WESI is 0.80, while summer WESI is 1.50. Can be seen that ecosystem was in good condition during summer than in winter rainy season when was impacted by the organic enrichments come from the catchment area as a result of recreation. This situation is similar to that of the Upper Jordan River previously examined by us [3] where the pollution coming from the catchment area pollute the water more in winter than in summer.

**Table 2.** Algal diversity with abundance scores and species ecological preferences (according to [10,21]) in the Nevoria pool in 2012-2013

Taxa	2012	2013	Hab	T	Reo	pH	pH range	Sal	D	Sap	S	Aut-Het	Tro
<b>Charophyta</b>													
<i>Chara gymnophylla</i> A.Braun	5-6	6	B	-	-	-	-	-	-	o	1.2	-	-
<i>Spirogyra</i> sp. ster.	6	6	B	-	-	-	-	-	-	-	1.0	-	-
<b>Chlorophyta</b>													
<i>Pseudopediastrum boryanum</i> (Turpin) E.Hegewald	-	1-3	P-B	-	st-str	ind	-	i	-	o-a	2.1	-	-
<b>Ochrophyta</b>													
<i>Amphora ovalis</i> (Kützing) Kützing	1	2	B	temp	st-str	alf	6.2-9.0	i	sx	a-b	1.5	ate	e
<i>Gyrosigma acuminatum</i> (Kützing) Rabenhorst	1-2	1-2	B	cool	st-str	alf	-	i		o-x	1.9	ate	e
<i>Navicula viridula</i> (Kützing) Ehrenberg	1-4	1-4	B	-	st-str	alf	-	hl	es	o	2.2	ate	e
<i>Cocconeis placentula</i> Ehrenberg	2-3	2-3	P-B	temp	st-str	alf	5.5-9.0	i	es	o-b	1.3	ate	e
<i>Caloneis bacillum</i> (Grunow) Cleve	1	1-2	B	temp	st-str	alf	-	i	es	o	1.3	ats	me
<i>Gomphonema parvulum</i> (Kützing) Kützing	1-3	2-3	B	temp	str	ind	6.2-8.5	i	es	x	2.3	hne	e
<i>Nitzschia vermicularis</i> (Kützing) Hantzsch	1-2	1-2	B	-	str	alf	-	i		o	2.2	-	o-e

Note: Ecological types (Hab): B, benthic; P-B, planktonic-benthic. Temperature (T): cool, cool water inhabitant; temp, temperate waters inhabitant; Streaming and Oxygenation (Reo): str, streaming waters inhabitant; st-str, low streaming waters inhabitant. Acidity (pH): ind, indifferent; alf, alkaliphil. pH rank: pH amplitude in which species was found. Halobity (Sal): i, oligohalobious-indifferent; hl, oligohalobious-halophilous. Saprobity (D): es, euryasaprob; sx, saproxen. Saprobity (Sap): o, oligosaprob; o-a, oligo-alpha-mesosaprob; o-x, oligo-xenosaprob; o-b, oligo-beta-mesosaprob; a-b, alpha-beta-mesosaprob; x, xenosaprob. S: species-specific Index saprobity according Sládeček. Nitrogen uptake metabolism (Aut-Het) [21]: ats, nitrogen-autotrophic taxa, tolerating very small concentrations of organically bound nitrogen; ate, nitrogen-autotrophic taxa, tolerating elevated concentrations of organically bound nitrogen; hne, facultatively nitrogen-heterotrophic taxa, needing periodically elevated concentrations of organically bound nitrogen. Trophic state (Tro) [21]: me, meso-eutrathentic; e, eutrathentic; o-e, oligo- to eutrathentic (hypereutrathentic).

## 4. Conclusion

Charophytes study in Israel is in initial stage. The Nevoria pool as new studied locality in protected area of the First Synagogue site in the Upper Galilee Mountains can be characterize as natural, fresh, low alkaline with low organic polluted waters that inhabit by ten algal species from which the charophytes *Chara gymnophylla* (Characeae) and *Spirogyra* sp. ster. (Zygnemataceae) were rather dominated. The species *Chara gymnophylla* is distributed over the

Mediterranean phytogeographic realm and therefore can be used as distinct climatic indicator. It is important for the Eastern Mediterranean territory because this small area is represented by four phytogeographic realms and sharp change of altitude and climatic variables. The Nevoria pool ecosystem is slightly impacted in winter as a result of recreation. The quality of pool water assessed as fresh, low alkaline, low to temperate temperature, and low polluted waters that enough saturated by oxygen with Index of saprobity S of 1.45 and 1.60, reflect Class II-III. Therefore,

the new *Chara* locality in protected area of the Upper Galilee can be monitored with using of chemical and bio-indication methods. The Nevoría pool must be protected from excessive recreation, representing more awareness of visual information for visitors.

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