Fl. Medit. 27: 111-116
doi: 10.7320/FlMedit27.111
Version of Record published online on 24 July 2017

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The disappearance of *Chara hellenica* (*Characeae*) from the only one known locality, Lake Bertonou in Corfu (Greece)

Abstract

Langangen, A.: The disappearance of *Chara hellenica* (*Characeae*) from the only one known locality, Lake Bertonou in Corfu (Greece). — Fl. Medit. 27: 111-116. 2017. — ISSN: 1120-4052 printed, 2240-4538 online.

The charophyte collected in Lake Bertonou in 2008 was later described as a new species, *Chara hellenica* (*Characeae*). It was also found in 2014, but not in 2015 and 2016. The reason for its disappearance is most probably runoff soluble such as phosphorus and nitrogen from Temploni landfill.

Key words: Charophytes, Temploni, water pollution, Greece.

Introduction

Corfu is situated in the Ionian Sea, close to the border of Albania. The island has several eutrophic fresh water lakes, especially in the central parts, and also some salt lakes and brackish water localities (Langangen 2010).

In 2008 a new species, *Chara hellenica,* from Lake Bertonou, near the village of Temploni, was found growing in dense stands and covering the bottom in shallow water (Fig. 1) (Langangen 2010). My observations were from land, in the northwestern part of the lake. The bottom in this lake is brown clayish soil. The lake has a rich bird life.

Chara hellenica has some unique characters which separate it from other species, especially the dioecious condition of a diplostichous species. The spine-cells also exhibit a key character, varying from single to pair and three together, and are commonly longer than the stem diameter. Also features of the bract-cells are special as the anterior are long and the posterior are rudimentary.

Material and methods

The island of Corfu was visited in 2008 (Langangen 2010), in June 2014, two times in 2015 and again in spring 2016 (see Table 1). The specific conductivity of the water was

Table 1. The measured abiotic parameters; specific conductivity, calcium, tot-P, phosphate, tot-N and nitrate.

Date	Specific conductivity µS/cm	Ca^{2+} mg/L	Tot-P mg/L*	$PO_4^{3-}P$ mg/L	Tot-N mg/L**	NO^{3-} /$NO^{2-}N$ mg/L
26.05.2008	**1200**	**170**	**-**	**-**	**-**	**-**
30.06.2014	**1380**	**200**	**0.23**	**-**	**17.2**	**-**
08.04.2015	**1400**	**236**	**0.12**	**-**	**5.0**	**-**
02.10.2015	**2380**	**140**	**0.39**	**-**	**64.1**	**-**
04.05.2016	**1200**	**200**	**0.12**	**0.085**#	**23.6**	**18.8**##

* uncertainty ±10%, **uncertainty ±15%, # uncertainty ±20%, ## uncertainty ±15%

Fig. 1. Lake Bertonou. In shallow water the bottom is covered with *Chara hellenica.* Photo 26.05.2008.

measured with a Milwaukee SM 301 EC meter, range 0-1990 µm/cm. Calcium was measured with Aqua Merck test kit.

Analyzes of phosphorus and nitrogen have been done by VestfoldLAB AS (www.vestfoldlab.no).

Geology

According to the geological map of Corfu (Higgins & Higgins 1996) the bedrock around Lake Bertonou is Triassic breccias. This kind of rock is a mixture of Triassic limestone and dolomites as well as gypsum. A similar area has been extensively examined on the mainland, south of Corfu between Gulf of Arta and Gulf of Patras (Zagana & al. 2011). This was a karstified area, which also is the case for the area around Temploni. Lake Bertonou is situated in a blind valley, 42 meters above sea level, with Temploni landfill to the west. The lake has, according to locals, an underground outlet which drains eastwards to Gouvia at the coast.

Results

Lake Bertonou is a highly eutrophic lake, surrounded by shrubs and with various aquatic plants.

In 2014 the water-level was low and no charophytes were found in the water, but on land, the dry bottom was covered with white, dried specimens of *C. hellenica*. The specimens were richly fertile with ripe, black oospores. These were the remains of stands of *C. hellenica* from the spring this year. Stones on the bottom were covered with filamentous green algae.

In 2015 I visited the lake two times, in April and in October. In April 2015 the water level was relatively high, but had been higher earlier in the year (Fig. 2). The shores were more or less covered with dense mats of filamentous green algae, partly hanging on the vegetation and floating in the surface. No charophytes were found. The brook coming in from northwest, in the area around the landfill, was flowing very high.

The green algae found were: *Ulothrix* sp., *Microspora* sp., and *Desmidium swartzii*.

In October 2015 the water level was very low (Fig. 3). The level was at least 2-2.5 m lower than in April. The water was turbid, brownish green and no plants or charophytes were found in the water or on the bottom. Along the shore there were several places with green/brown cover of *Microcystis viridis*, *Euglenia* sp., *Monomorphina* (*Phacus*) sp. The dryer parts were more or less covered by dense vegetation of *Cyperus michelianus* (L.) Link. and *Alopecurus aequalis* Sobol. The growth of these plants was very fast as the area was under water in April. Shrubs and small trees which earlier grew in the water are now without leaves. On shrubs and trees around the lake there are still remains of brown, dried green algae hanging meters above the ground (e.g. *Microspora* sp.) The inlet brook is now dry.

On May 2016 the water level was high. The water was turbid, and the surface along the shores were more or less covered with cushions of algae, e.g. *Tribonema* sp. No charophytes were found.

Fig. 2. Lake Bertonou. Shore on the eastern part of the lake. The watersurface and vegetation is covered with filamentous green algae. Photo 08.04.2015.

Fig. 3. Lake Bertonou and the landfill. Photo 02.10. 2015.

Discussion

As can be seen from figure 1 *Chara hellenica* formed dense stands in the northwestern part of the lake in 2008. This was presumably also the situation in June 2014 when I found large areas on land with white, dried specimens of the charophyte. In 2015 and 2016 there were no finds of any charophytes, not in the water or on land. The water was now turbid and brownish green in colour.

The lake is situated in a lime rich area as can be seen from the measured values of calcium (Table 1). In Sweden the average *Chara*-lake (calcareous lake) had an average calcium value of 62 mg/L (Forsberg 1965). In Lake Bertonou the values were 2-4 times higher.

Specific conductivity is a measure of the total content of electrolytes in the lake. Swedish calcareous lakes reported by Forsberg (1965) had conductivity values between 200-550 µS/cm. In calcareous lakes in the island of Evia (Greece) the measured values were 500-1320 µS/cm (Langangen 2010a). In lake Bertonou these values varied from 1200-2380 µS/cm.

The water level of the lake varied through the year due to precipitation, evaporation and drainage through an underground outlet. In Lake Bertonou the water level was low in fall. This variation in water level will affect the ecology of the lake and the growth of charophytes which developed during the spring and early summer.

Nitrogen and phosphorus are important major elements for normal metabolism in plants and animals. Phosphorus is necessary for the growth of water plants and algae in the lake. Forsberg (1965) found that charophytes grew luxuriant in lakes with tot-P values below 20 µm/L. In highly eutrophic lakes with a high content of phosphorus he found no charophytes. Blindow (1988) found that *Chara hispida* and *C. tomentosa* grew well in phosphorus concentration at 1 mg/L. Instead she proposed light limitation as a reason for decline of charophytes during eutrophication. Eutrophication is most often caused by runoff from agriculture, fertilizer and garbage. The high values of phosphorus and phosphate-P in Lake Bertonou is most probably caused by runoff from Temploni landfill (see below).

In Lake Bertonou the tot-P values are 0,12-0,39 mg/L, values within tolerance limits for charophytes.

Nitrogen is found in many forms in lakes - nitrate, nitrite and ammonia. Total-N is the sum of these constituents and organically bounded nitrogen. In the Norwegian guide to environmental conditions (WDF 2015), the lake type *lime rich, dystrophic (humic?)* is most similar to Lake Bertonou. In such lakes the ecological conditions are good if the value of tot-N is below 1325 µg/L. If the value is above 2025 µg/L the conditions are very unfavorable for charophytes. In Lake Bertonou these values were much higher, between 5,0-64,1 mg/L (5000 µg/L – 64100 µg/L). In 2016 the value of nitrate-N was 18.8 mg/L (18800 µg/L). These high values must be due to runoff from the Temploni landfill.

It has been generally understood that phosphorus has been the cause of the decline of charophytes in fresh waters. In contrast to this Lambert & Davy (2011) found that the concentration of nitrate -N strongly affected the growth of charophytes. In the field they found that a concentration of 0.5 mg/L NO_3-N gave optimal growth, which also was supported in growth experiments with *Chara globularis*. At values above 8 mg/L the plants became red and necrotic. In my one observation from 2016, the value of nitrate-N was 18.8 mg/L, well above the necrotic concentration.

The disappearance of *Chara hellenica* from Lake Bertonou is most probably caused by runoff from Temploni landfill, as indicated by the increased values of nitrogen and phosphorus. This runoff has resulted both in the high concentration of nitrate -N and turbid brown green water in both 2015 and 2016.

The visible change of the water quality is most likely the reason why *Chara hellenica* is no longer found. It is to be hoped that if the heavy pollution of the lake is stopped, the lake can be restored, and if oospores have survived in the bottom sediments, that the charophyte will return.

The Temploni landfill has been registered as illegal by the European Commission (EU) since at least 2007 (EU 2015a, 2015b).

Acknowledgement

The English text has been edited by Professor Henry Mann, Newfoundland, Canada.

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