



Chara vulgaris L. (Charales) in springs on Amorgos island (Greece)

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ABSTRACT: A total of 19 springs were visited in 2012, 2013 and 2015. The springs are of different kinds, open or closed. *Chara vulgaris* was found in nine open springs, all situated on bedrock of flysch. Six of the springs contained *C. vulgaris* f. *longibracteata*, a form which is also found on several surrounding islands. Some of these springs also have a similar fauna of aquatic animals. This suggests that the islands are remains of a larger Aegean mainland, which de facto existed. It is difficult to explain how the charophytes have been dispersed to different springs on Amorgos. Charophytes are most commonly dispersed by water birds, which may have been the case on Amorgos. Another possibility is dispersal by human activities in and around the springs. The springs are small beauty spots in the landscape, and it is hoped that they will be cared for in the future.

KEYWORDS: Greece, Amorgos, springs, *Chara vulgaris* f. *longibracteata*

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INTRODUCTION

Amorgos is the easternmost island of the Cyclades. The climate is temperate with dry summers and rainfall from October to March.

The geology of the island is dominated by marble and flysch. Flysch is found between Katapola and Vroutsi in the southwest part of the island, and in a small area around Tholaria in the north (ROSENBAUM & RING 2007) (Fig. 1). Flysch is a sedimentary rock with layers of argil (clay), conglomerates and large masses of limestone (ANASTASSIOU 2012).

Through time the Aegean area has shifted between connection to and isolation from the neighbouring mainland (TRIANTIS & MYLONAS 2009). According to ANASTASSIOU (2007, 2012), Amorgos as it is today was formed around 700000 years ago, when surrounding landmasses submerged due to vertical tectonic movements.

In 1956, one of the strongest earthquakes ever recorded in Greece struck Amorgos. As a result, the water supply

was reduced, and several springs dried out (ANASTASSIOU 2012). But there are still many springs on the island (Amorgos map; www.terrainmaps.gr), and the purpose of the present work was to survey and describe springs with charophytes. According to the map company (www.terrainmaps.gr) "all information regarding springs, fountains and water tanks is primarily based on field research" (pers.comm. 2016).

MATERIAL AND METHODS

The island was visited by the author for the first time in 2012 and again in 2013 and 2015 (see Table 1). *Chara vulgaris* L. was first reported from Amorgos by LANGANGEN (2010a) after a find in 2008. The collected charophytes are deposited in the Herbarium of the Natural History Museum, University of Oslo (O) (THIERS 2016).

The nomenclature of *Chara* follows KRAUSE (1997).

Specific conductivity of the water was measured with a Milwaukee SM 301 EC metre (range: 0-1990 $\mu\text{m}/\text{cm}$)

and a Martini EC 60 metre (range: 0- 20 mS/cm). Calcium content was measured with an Aquamerck test kit.

RESULTS

Surveyed springs. Figure 1 show location of the surveyed springs, which are listed in Tables 1 and 2. Springs with *Chara vulgaris* are described in the text below. Localities without *Chara* are briefly treated under comments in Table 2.

Short descriptions of localities with *Chara vulgaris*.

Spring 1. Aghia Georgios Valsamites (by the road) (Figs. 5 and 6)

The spring is located ca. 300 m south of the crossroad to Valsamites monastery. The pool measures 3 x 2 m, is 20 cm deep and had vegetation of smooth flatsedge, *Cyprus laevigatus* L., in the opening (Fig. 5) and maidenhair fern, *Adiantum capillus-veneris* L., on the inside walls. *Chara vulgaris* dominated in 2012 and 2013 (Fig. 5), while only small colonies were present in 2015, as can be seen in Fig. 6, probably due to the early date.

Chara vulgaris varied considerably and some specimens in 2013 were up to 40 cm long and richly fertile with both unripe and ripe brown oospores.

Spring 2. Valsamites monastery

The water from the spring is collected in a pool just below an old watermill. The pool measures 2 x 10 m and is 0.5-1.0 m deep. This is the source of water for the monastery. *Chara vulgaris* covered all parts of the bottom where the sediment was thick enough. The water surface was covered with a thin green layer of *Cosmarium* sp. (Desmidiaceae).

Chara vulgaris was up to 19 cm long, richly fertile and with ripe brown oospores.

Spring 3. Aghia Marina

The water is turbid and collects in a large pool 1.5 m deep. Dense stands of *Chara vulgaris* cover the bottom. The pool is surrounded by thick vegetation of common reed, *Phragmites australis* (Cav.) Trin. ex Steud., and the trees *Thuja* sp. and *Ficus carica* L.

Chara vulgaris is up to 35 cm long, relatively heavily encrusted, richly fertile and with ripe brown oospores.

Spring 4. Aghia Katerina

As can be seen in Fig. 7, the spring is built with a portal and a lower pool. Two plants, triangular club-rush, *Schoenoplectus triquetet* (L.) Palla, and *Adiantum capillus-veneris* L., fill up much of the spring. When we visited the locality, the water level was very low, and most of the charophytes had dried up and were partly fragmented. All specimens of *Chara* were sterile.

Spring 5. Aghia Anna

The water from the spring is collected in a pool measuring

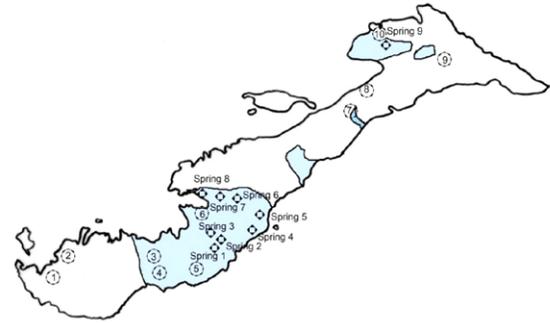


Fig. 1. Location of the surveyed springs on Amorgos. The blue areas are flysch and the white are mainly marble (limestone). Localities with *Chara vulgaris* are indicated by squares with the spring's number, while ones without charophytes are indicated by circles with the spring's number.



Fig. 2. The closed well in Mavri Mytthi, built as a tower.

5 x 4 m with a depth of 1.2 m situated under a big locust tree, *Ceratonia siliqua* L. The water from the spring is used to irrigate a garden with citrus trees [*Citrus limon* (L.) Burm.]. The bottom was filled with dense stands of *Chara vulgaris*. In addition, we found *Spirogyra* sp. (Zygnemataceae) and *Cosmarium* sp.

Chara vulgaris was up to 30 cm long, richly fertile and with ripe brown oospores.

Spring 6. Milies

Milies is a small plateau on the footpath from Hora to Katapola. Water emerges from the ground and with surrounding oak trees this is a very pretty area. There are two springs with the same construction, a portal with a

Table 1. Springs with *Chara vulgaris*. Locality, date, specific conductivity, calcium, oospores and geographical position after Google Earth. The localities are marked with a square and the spring's number.

Spring no.	Locality	Date	Specific conductivity, $\mu\text{m/cm}$	Ca ²⁺ mg/l	Ripe oospores	Position
1	Aghia Georgios Valsamites (by the road)	29.6.12	1040	80	Yes	36°48'16.81"N, 25°52'42.33"E
	-	24.9.13	1170	72	Yes	
	-	23.4.15	-	-	-	
2	Valsamites monastery	24.9.13	1090	96	Yes	36°48'30.35"N, 25°52'36.24"E
3	Aghia Marina	24.9.13	1070	80	Yes	36°48'42.63"N, 25°52'8.28"E
4	Aghia Katerina	24.9.13	1850	120	Sterile	36°49'21.78"N, 25°53'10.44"E
5	Aghia Anna	24.9.13	1040	104	Yes	36°49'36.91"N, 25°54'19.05"E
6	Milies 1	28.6.12	1090	56	Yes	36°50'9.43"N 25°53'5.42"E
		21.9.13	Dry		-	
	-	12.4.15	1180	64	No	
	Milies 2	28.6.12	1010	144	Yes	36°50'9.43"N 25°53'5.42"E
	-	21.9.13	1320	136	Yes	
-	12.4.15	1140	64	Yes		
7	Marmaros (Milies 3)	12.3.15	1440	160	No	36°50'1.63"N, 25°52'42.97"E
8	Ta Nera (Katapola)	29.6.12	2520	-	No	
		20.9.13	2490	192	No	36°50'11.84"N, 25°51'30.49"E
		-	14.4.15	2700	120	No
9	Lefkes (Tholaria)	22.9.13	1040	112	Sterile	36°54'51.61"N 25°58'51.89"E

drinking receptacle and a connected pool (Figs. 8 and 9). We call them Milies 1 (the spring nearest Hora) and Milies 2 (that nearest Katapola). Milies 2 has the most stable supply of water.

Milies 1

In 2012 and 2013 there was little water in this spring, the pool was dry, but the drinking receptacle still had some water, with both living and dried specimens of *Chara vulgaris*. Both years the alga was richly fertile and had ripe brown oospores.

In 2015 the pool (measuring 2 x 3 m and 1 m deep) was filled with water and densely clotted with *Chara*.

The alga was up to 60 cm long and partly covered with a filamentous green alga, *Spirogyra* sp. *Chara vulgaris* was richly fertile, but without ripe oospores.

Animals we observed included diving beetles (*Dytiscus* sp.), water striders (*Gerris* sp.) and tadpoles.

Milies 2

This spring is the most interesting and best preserved spring on Amorgos.



Fig. 3. Closed wells at Asfondilitis.



Fig. 4. The Katapola spring in the town, which has water of high quality. The water flows through an ancient aqueduct.

The drinking receptacle measures 2 x 0.5 m and is ca. 0.5 m deep. On all our visits, it was filled with water and a mixture of brooklime, *Veronica beccabunga* L., and the filamentous green algae *Mougeotia* sp., *Oedogonium* sp. and *Cladophora* sp. The walls were covered with the fern *Adiantum capillus-veneris*.

Chara vulgaris was commonly very richly fertile and with ripe brown oospores.

The pool measures 1 x 2 m and is ca. 0.5-1 m deep with crystal clear water. The shaded sides are covered with *Adiantum capillus-veneris*, and the pool is filled with dense stands of *Chara vulgaris* (Fig. 10). The above-mentioned filamentous algae are also present.

Chara vulgaris was richly fertile all three years and had ripe brown or black oospores. In 2012 someone tried to clean the pool, with the result that dried and charophytes were left around it. This was not the case in 2013 and 2015.

Animals present included frogs and dragonflies.

Spring 7. Marmaros (Milies 3)

The spring is on the same footpath as Milies, but closer to Katapola. A small brick house has been built around the spring, and it is full of water inside. In front there is a drinking receptacle that measures 0.5 x 2 m and is 30 cm deep. In the two first years it was dry, but in 2015 it was full of *Chara vulgaris*.

Chara was relatively poorly developed, 10-15 cm long, fertile but with no ripe oospores. Some of the specimens showed a phenotypic similarity to *Chara globularis* Thuiller. Mixed with the charophytes was fertile *Mougeotia* sp.

Spring 8. Ta Nera (Katapola)

The water from this spring is collected in three small pools (Fig. 11). *Chara vulgaris* filled up all the chambers in 2012 and 2013. The specimens were up to 30 cm long, not encrusted, fertile, but did not have ripe oospores.

In 2015 the pools were cleaned of soil and sand, and most of the bottom sediment was removed. We found only a few specimens of *Chara* in one of the chambers.

On all our visits, filamentous green algae, *Mougeotia* sp. and *Cladophora* sp, floated on the surface and mixed with *Chara*.

Spring 9. Lefkes (Tholaria)

The spring is situated close to the town of Tholaria, and it has a beautiful view of the town of Aigali. As can be seen from the photo, the wall surrounding the spring is painted white, and the spring has three small drinking receptacles and one well (Fig. 12). The water in the well is crystal clear and very good for drinking. The fern *Adiantum capillus-veneris* was found growing on the walls inside the two chambers to the left in the photo. In addition, we also found *Spirogyra* sp., *Cosmarium* sp., and *Navicula* sp. (a diatom). Honeybees collected water in this spring.

This spring seems to be in active use, as it was recently cleaned, and the bottom sediments, soil and sand were then removed.

We found *Chara vulgaris* in all three drinking receptacles, but the specimens were generally poorly developed and small, only up to 5 cm long.

Animals observed included mosquito larvae and water striders (*Gerris* sp.).

Table 2. Springs without charophytes. Locality, date, specific conductivity, calcium, comments and geographical position after Google Earth. The localities are marked with a circle and the spring's number.

Spring no.	Locality	Date	Specific conductivity, $\mu\text{m/cm}$	Ca ²⁺ mg/l	Comments	Position
1	Kalotaritissa	13.4.15			Two closed springs.	36°47'18.67"N, 25°46'0.64"E
2	Mavri Mytthi Fig. 2	13.4.15			High tower with underground water (closed).	36°48'13.37"N, 25°46'47.97"E
3	Skeparnies (south of-)	13.4.15	820	24	Closed spring, but has an oblong drinking receptacle with water along one side. Yellow green water.	36°47'57.03"N, 25°49'44.34"E
4	Kamari (beside the road to Mouroos bay)	13.4.15	1320	60	Open tanks with dense growth of filamentous green algae.	36°47'36.56"N, 25°49'37.31"E
5	Korakia	13.4.15			Dry spring.	36°48'12.44"N, 25°52'2.71"E
6	Katapola/ Minoan	14.4.15	1330	96	Small, open spring without vegetation.	36°49'21.37"N, 25°51'52.50"E
7	Asfondilitis Fig. 3	14.4.15	450	40	Big area with at least eight round stonewells. One open drinking receptacle with water meant for domestic animals. Without vegetation.	36°52'15.09"N 25°57'1.22"E
8	Ano Potamos	14.4.15			Big closed spring. In front there is a bowl containing turbid water filled with filamentous green algae.	36°53'32.27"N 25°58'20.52"E
9	Apos Dhrys	14.4.15	1490	136	Big area with many closed wells and springs. One open spring without vegetation.	36°54'41.41"N, 26° 0'7.96"E
10	Tholaria (west of)	14.4.15			Open spring, but dry when inspected.	36°54'50.71"N 25°58'37.15"E
	Katapola Spring Fig. 4	21.9.13			Closed spring in centre of the town.	In Katapola town

Chara vulgaris and its variation

Most of the specimens collected belong to *Chara vulgaris* f. *longibracteata* Kützing.

This variety has a regular, diplostichous, aulacanthous cortex. The spine-cells are papillous. Branchlets are normally long. Anterior bract-cells and bracteoles are very long, up to more than 10 times the length of the oogonium. The form name refers to this character (Fig. 10). This form is found in springs 1, 2, 3, 5, 6 and 8.

The fertility of *Chara vulgaris* in these springs is very high, and ripe brown oospores are common.

The specimens from spring 4 (Aghia Katerina) lack cortex on the branchlets and are similar to *Chara gymnohylla*. In spring 8 (Ta Nera), the variety has only two corticate branchlet segments. These two localities

have a higher content of electrolytes measured as specific conductivity. The fertility in these two springs seems to be lower than in the other springs. No ripe oospores had developed.

In spring 7 (Marmaros), some specimens on shallow water showed a phenotypic similarity to *Chara globularis*.

In the springs with a good supply of water, *Chara vulgaris* dominated the vegetation (Fig. 13). In some springs, ones which are in active use and have been cleaned, the growth was considerably reduced.

DISCUSSION

Amorgos is rich in springs and wells. Of the 19 springs we visited, nine have vegetation of *Chara vulgaris*. The



Fig. 5. *Chara vulgaris* dominated in 2012 and 2013. Photo 29.6.2012.



Fig. 6. The spring on 13.4.2015.



Fig. 7. The spring at Aghia Katerina, which must have been an important water source, but on our visit it was nearly dry.

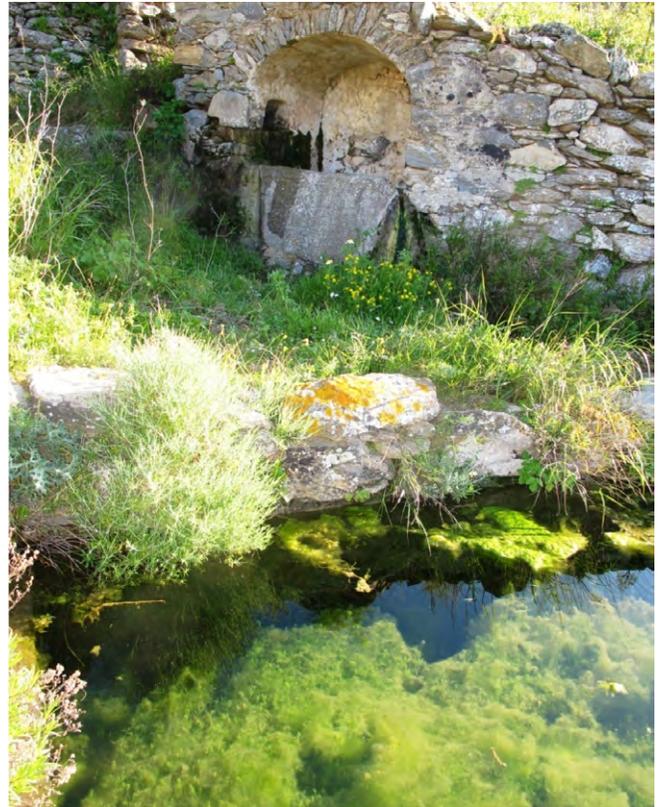


Fig. 8. The Milies 1 spring and pool. Photo 12.4.15.



Fig. 9. The Milies 2 spring and pool. Photo 12.4.15.

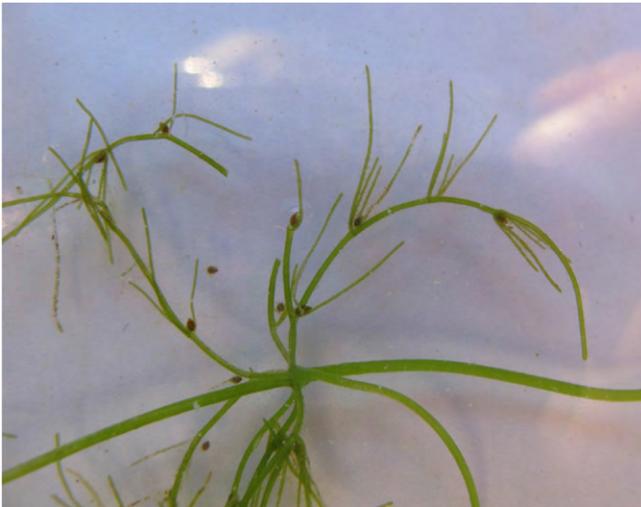


Fig. 10. *Chara vulgaris* f. *longibracteata*. A branch with branchlets. The anterior bract-cells and bracteoles are very long. Specimen from Milies (2013).



Fig. 13. Part of the pool in Mieleis 2, which is full of *Chara vulgaris*.



Fig. 11. The Ta Nera spring, with three chambers. Along the walls inside grew the fern *Adiantum capillus-veneris*.



Fig. 12. The Lefkes spring, which has three small drinking receptacles and one well, as can be seen in the photo.

growth of this alga is very good in the springs which are more or less undisturbed (Fig. 13), its fertility is high in them and ripe oospores are common (Table 1). In active springs such as Ta Nera (only in 2015) and Lefkes, the charophytes have been weeded, but not yet eradicated. As long as there is one oospore or vegetative part left, the species is potentially capable of filling the locality again (GRANT & PROCTOR 1972). The observed variation among the specimens from the different springs is low and presumed to be ecologically induced, e.g., due to the water level in the spring and not genetically dictated. In six of the nine springs with *Chara vulgaris*, we found f. *longibracteata*.

Chara vulgaris is a cosmopolitan species (CORILLION 1957; KRAUSE 1997). In Greece it is reported by LANGANGEN (2004, 2007, 2008, 2010a, 2010b, 2012, 2013, 2014). It is found on many of the southern Aegean islands around Amorgos, e.g., on Evia, Chios, Samos, Ikaria, Cos, Rhodes, Crete, Melos and Sifnos. It is not reported by KOUMPLI-SOVANTZI (1997) or RAABE & KOUMPLI-SOVANTZI (2000, 2002). *Chara vulgaris* f. *longibracteata* (Kützing) H.Groves & J.Groves is the typical form on all the islands mentioned above.

The distribution of this form is interesting, since the islands are scattered over a very large area. As an explanation, it is suggested that the distribution is a result of the fact that these islands were once part of a bigger mainland, and the alga survived in small springs. Migratory water birds are important in the dispersal of charophytes (PROCTOR 1959; DE VLAMING & PROCTOR 1968) and may have been responsible for their distribution over longer distances. In the case of Amorgos, it is not so easy to understand how *Chara vulgaris* has been distributed locally on the island. It is possible that the alga's distribution has been influenced by local birds or human activities in connection with the springs. ZANEVELD (1941) cites DALECHAMPS (1587), who wrote that the inhabitants of Lyon, France used a

plant called “Chara” to polish plates and other domestic utensils.

The typical habitat of *Chara vulgaris* is ephemeral water bodies. BLAŽENČIĆ & RADOTIĆ (1982) report the species from pits “resulting from excavation of earth used for brick making”.

Chara vulgaris is a freshwater species which occasionally occurs in brackish waters. CORILLION (1957) refers to such species as “halophiles accidentelles”. Studies show that the species is able to regulate turgor (KIRST *et al.* 1988). In the surveyed area, we found *Chara vulgaris* in brackish water on Naxos (LANGANGEN 2004), Sifnos (LANGANGEN 2007), Evia (LANGANGEN 2009) and Crete (LANGANGEN 2012).

The localities on Amorgos are freshwater localities; most of them are very rich in electrolytes, as can be seen from the measured values of specific conductivity (Tables 1 & 2). This can be partly explained by the very high values of calcium, which is a result of the surrounding bedrock’s nature.

Another interesting aspect of some of the springs is the animal life. We observed aquatic animals in two springs, Milies and Lefkes. Animals observed in springs on Amorgos include the beetle *Dytiscus* sp., the water strider (*Gerris* sp.), mosquito larvae, dragonflies, tadpoles and frogs (CISNEROS-HEREDIA 2007). Some of the same animals were found in the Zevs spring on Naxos. This may indicate an earlier connection.

CONCLUSION

This work focuses on the charophytes found in springs on Amorgos, a Cycladic island. The springs are very small water sources, and several of them have been closed and rebuilt as wells or fountains. The purpose of the present work was to register and describe the vegetation of charophytes in these springs. A total of nine springs with charophytes were found on Amorgos, the only species being *Chara vulgaris*, with *f. longibracteaata* as the common type. This is interesting because the given form has also been found on several neighbouring islands. As this is new knowledge, similar surveys should be done on other islands in the Aegean sea. Such surveys could make an important contribution to understanding the distribution of charophytes on each island and connections between the different islands, both historical and ecological.

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Botanica SERBICA



REZIME

Chara vulgaris L. (Charales) u izvorima ostrva Amorgos (Grčka)

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Ukupno 19 izvora posećeno je tokom 2012., 2013. i 2015. godine. Izvori su različitog tipa, otvoreni ili zatvoreni. *Chara vulgaris* je nađena u devet otvorenih izvora na flišu kao tipu podloge. U šest izvora pronađena je *C. vulgaris* f. *longibracteata*, forma koja je, takođe, nađena na nekoliko okolnih ostrva. Neki izvori sadrže i sličnu faunu vodenih životinja. Ovo može da ukaže da ostrva predstavljaju ostatke velikog Egejskog kopna, koje je de facto postojalo. Teško je objasniti kako su se hare rasule do različitih izvora na Amorgosu. Hare se obično rasejavaju pomoću vodenih ptica, što može biti slučaj i na Amorgosu. Druga mogućnost su ljudske aktivnosti oko izvora. Izvori su mali biseri lepote u pejzažu i nadajmo se da će se o njima brinuti u budućnosti.

KLJUČNE REČI: Grčka, Amorgos, izvori, *Chara vulgaris* f. *longibracteata*

