Vegetation types with Cladium mariscus (Cyperaceae) in Greece

Authors: Theocharopoulos, Michael, Georgiadis, Theodoros, Dimitrellos, Georgios, Chochliouros, Stergios, and Tiniakou, Argyro

MICHAEL THEOCHAROPOULOS, THEODOROS GEORGIADIS, GEORGIOS DIMI-
TRELLOS, STERGIOS CHOCHLIOUROS & ARGYRO TINIAKOU

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Abstract

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Populations of *Cladium mariscus* have been observed in twenty-nine localities, mainly in western
Greece, fourteen of which are new records. The species grows in a broad spectrum of habitats
(lakes, lagoons, shallow marshes, humid grasslands), depending on the presence of fresh water.
Correspondence factor analysis of phytosociological relevés identified seven different vegetation
types with *C. mariscus* in Greece, which are discussed in short.

Key words: autecology, phytosociology, wetlands, fresh water, distribution.

Introduction

Cladium mariscus L. is a robust perennial of the *Cyperaceae* that can reach up to 2.5 m in height.
It is a cosmopolitan taxon with its main distribution area in Europe and the Mediterranean, but is
also found in N Africa and W Asia (Meusel & al. 1965, Tutin & al. 1980). It grows in wetland en-
vironments in shallow ponds, on the shores of lakes, lagoons and water channels, and in the hu-
mid grasslands surrounding them.

For Greece, contrary to W and Central Europe (Balátová-Tuláková 1963, De Sloover 1970,
Rivas Martinez & al. 1980, Pautou & Girel 1981, Devvilez & Iserentant 1981), no complete data
exist on the distribution, ecology and syntaxonomic position of *Cladium mariscus* communities.
Information regarding its geographical distribution is limited mainly to Haláscy (1904). Pub-
lished phytosociological data for the species were available only from W Crete, including de-
scription of the Dorycnio recti-Cladietum marisci (Gradstein & Smittenberg 1977).

This paper deals with the present geographical distribution and ecology of *Cladium mariscus*
in Greece. It includes the preliminary results of Theocharopoulos & al. (2000).

Material and methods

Flora Hellenica (Strid & Tan 1997, 2002), Med-Checklist (Greuter & al. 1984-1989), Flora Europaea (Tutin & al. 1968-80, 1993) and Flora of Turkey and the East Aegean Islands (Davis 1965-85) were used for taxa identification and nomenclature.

For the phytosociological characterisation of the *Cladium mariscus* stands, 55 relevés were analysed, mainly during May-July, in the years 2001-02, following the Braun-Blanquet (1964) approach. These relevés, ranging in size from 40 to 100 m², were taken from the most representative stands of *C. mariscus* in thirteen areas of Greece (Table 1). All relevés were interpreted using the numerical (ordination) method of the correspondence factor analysis (Benzecri & al. 1976). The groups (Fig. 2) obtained by ordination, using presence or absence of taxa (Roux 1997), are presented in a phytosociological table (Table 2), produced with the software SORT 4.0.

Names of syntaxa are used according to Braun-Blanquet & al. (1952), Horvat & al. (1974), Gradstein & Smittenberg (1977), Meriaux (1981), Biondi (1989) and Rivas-Martínez & al. (2001).

Twenty-six soil samples (two per site) were taken from depths of 30 cm (the root limit of *Cladium mariscus*) to determine the grain size (Bouyoucos 1951) and the percentage of organic matter (Nelson & Sommer 1982). In addition, pH, conductivity and total water hardness (Rand & al. 1975) were measured from all sites. At sites without surface water (humid grasslands, shores of lakes, etc.), samplings were made from nearby water channels or by digging shallow holes beside the plants.

Results

1. Distribution of *Cladium mariscus* in Greece

The geographical distribution of *Cladium mariscus* follows the wetlands of W and NW Greece. Further southwards it extends to W Crete (Fig. 1). Stands were found on 29 sites, 14 of which (Lakes Voulkaria and Kaiafa, Lagoons Korission, Keri and Saltini, Alyki Aigiou, Agios Nikolaos and Vonitsa bays, Roumani/Nafplio, Kryoneri, Agia, Kalodiki, Kalogria marshes, and Gorge Prassiano) are new records for Greece.

2. Characteristics of the *Cladium mariscus* sites

Stands were found mainly near the coast, but two sites (Lakes Agras and Cheimaditida) are mainland basins of intermediate altitude (c. 500 m). These sites are supplied with fresh water from karstic springs.

Bioclimatically (Mavromatis 1980) all sites (Table 1) belong to the humid or semi-humid bioclimatic type, except Nafplio and Artaki, which belong to the semi-dry type. The average lowest temperature of the coldest months ranges from -4.2 C (Lake Cheimaditida) to +7.6 C (Lagoon Keri) .

Bedrock of the study areas is mainly limestone, while neogene formations (marls, siltstones, sandstones) and flysch are outcropping in some cases. Schists and gneisses are found in Lake Cheimaditida (Bornovas & al.1983). The soils develop mostly on alluvial deposits and on local peat formations (Christanis 1999). Analysis of the particle size distribution shows mainly sandy-loam and loamy-sand types. Organic matter content in these soil samples ranged from 3 to 56.7 % (Table 1).

Analysis of the physicochemical water parameters (pH, conductivity and $CaCO_3$) showed pH values ranging from 6.1 to 7.3, conductivity from 580 to 2530 ms/cm, and $CaCO_3$ from 215 to 2895 mg/lt (Table 1). The above pH values are normal for wetlands surrounded by limestone, since their chemical parameters are determined to a large extent by the surrounding bedrock. The high conductivity values indicate a large inflow of dissolved solids probably due to weathering of the surrounding limestone rocks. The relief of these rocks also facilitates the transport of inorganic matter into the wetlands. The high $CaCO_3$ values appear to confirm the karstic origin of the waters.
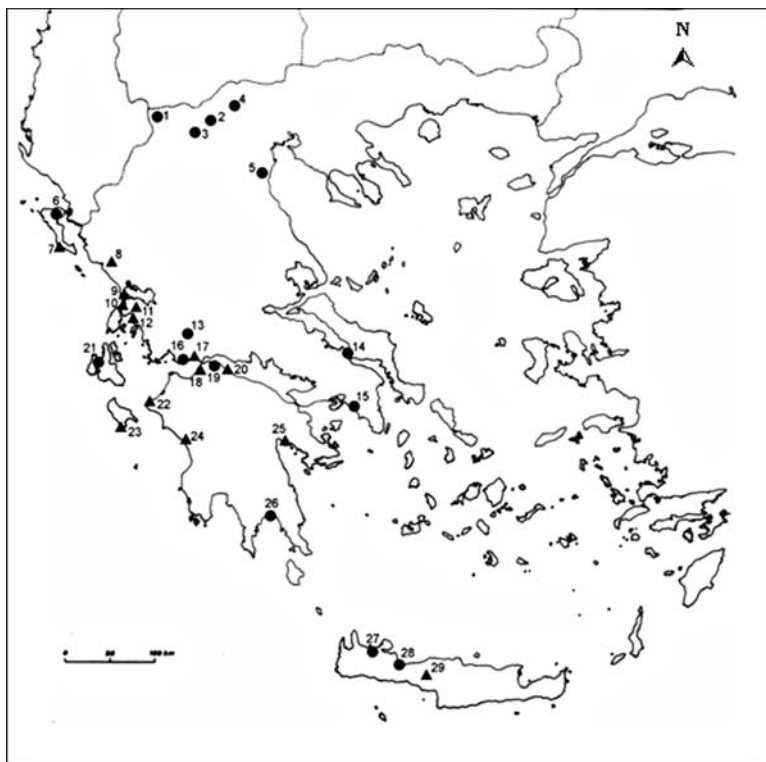
Fig. 1. Distribution of *Cladium mariscus* in Greece (▲ : new records, ● : old records) – 1: Ag. Germanos; 2: Lake Vegoritida-Lake Petron, 3: Lake Cheimaditida; 4: Lake Agras; 5: Litochoro; 6: Episkepsi, 7: Korission lagoon; 8: Kalodiki marsh; 9: Saltini lagoon; 10: Ag. Nikolaos bay; 11: Lake Voulkaria; 12: Vonitsa; 13: Lake Trichonida; 14: Artaki; 15: Phaliro, 16: Messolongi; 17: Krioneri marsh; 18: Agias marsh, 19: Psathopirgos; 20: Alyki Egiou; 21: Livadi; 22: Kalogria; 23: Keri lagoon; 24: Lake Kaiafa; 25: Roumani/Nafplio marsh; 26: Elos; 27: Lake Agias; 28: Georgioupoli; 29: Prassiano gorge.

3. Vegetation types with *Cladium mariscus* in Greece

For the ordination of the 55 relevés with *Cladium mariscus* we used presence-absence data. The factor correspondence analysis (Fig. 2) allowed us to distinguish seven vegetation types where *C. mariscus* plays a constitutive or differentiating role: (1) *Elymus farctus-Cladium mariscus* community, (2). *Saccharum ravennae*-Cladium mariscus community, (3). Dorycnio recti-Cladietum marisci, (4) *Eupatorium cannabinum-Cladium mariscus* community, (5) *Carex riparia-Cladium mariscus* community, (6) Cladietum marisci, (7) *Schoenoplectus lacustris-Cladium mariscus* community.

The distribution of the vegetation groups on Axis 1 (from left to right) of Fig. 2 shows a transition from "terrestrial" to "aquatic" ecosystems, while Axis 2 (from bottom to top) seems to be related to both altitude and latitude.

3.1. *Elymus farctus-Cladium mariscus* community (Fig. 2: group I; Table 2)

This community is found mostly in the southern area of the coastal marsh Livadi (Artaki-Euboea area), in small stands on sandy-loam soils with fresh water layers, usually close to shallow soil channels. The differential taxa are *Juncus maritimus, Dittrichia viscosa, Cirsium creticum, Agrostis stolonifera, Lolium perenne* and *Rumex conglomeratus,* while *Elymus farctus* shows high

Table 1. Bioclimatic, geological, pedological and physicochemical data of the sampling sites.

Relevé Nr	Locality / altitude	Bioclimatic type	Geological substrate	Organic matter %	Particle size	pH	Physicochemical parameters of the water Conduct. µS/cm	CaCO$_3$ mg/l
1-6	Marsh Artaki / 3 m	semi-dry / temperate	alluvial deposits & limestone	4-15	sandy-loam /silty-loam	7.2	630	290
7, 9, 10	Lake Kaiafa / 40 m	sub-humid / temperate	alluvial, marine deposits & limestone	3-56.7	sandy-loam /loamy-sand	6.8	2530	660
8, 11, 12, 15	Bay Agios Nikolaos / 10 m	humid / temperate	alluvial deposits & limestone	6-13.5	sandy-loam	7.2	680	276
13, 14	Lagoon Saltini / 2m	humid / temperate	alluvial deposits & limestone	9-27.2	sandy-loam /loamy-sand	6.9	1170	258
16-18	Trichonida Lake / 18 m	sub-humid / temperate	alluvial deposits, flysch & limestone	6-15	sandy-loam	6.1	710	215
19-25	Lagoon Korission / 4 m	humid / temperate	alluvial, marine deposits & limestone	12.8-17	sandy-loam /loamy-sand	7.1	610	287
26-29	Lagoon Keri / 3 m	humid / hot	alluvial deposits & limestone	5-19	sandy-loam	7.3	580	295
30-32	Marsh Roumani Nafplio / 5 m	semi-dry / temperate	alluvial deposits & limestone	12-23	sandy-loam	6.1	1758	2895
33-39	Lake Agras / 500 m	sub-humid / severe	terrestrial deposits & limestone	8-20	sandy-loam	7.3	640	385
40-45	Cheimaditida Lake / 800 m	sub-humid / severe	alluvial deposits, schists & gneisses	16-25	sandy-loam loamy	6.9	1290	270
46	Marsh Kryoneri / 1m	sub-humi / temperate	alluvial deposits & limestone	7-38	sandy-loam	6.8	2370	460
49	Marsh Agia / 1 m	sub-humid / temperate	alluvial deposits	11-35	sandy-loam /loamy-sand	6.8	985	385
47, 48, 50-55	Lake Voulkaria / 0.5 m	humid / temperate	alluvial deposits & limestone	12-48	sandy-loam	6.6	1530	447

cover values. The location of this community close to the seashore together with sandy-loam/silty-loam soils favours the presence of the above ammophytic species.

Characteristic in this community is the presence of *Carex hispida,* which grows in small groups, and (with the exception of *Phragmites australis*) the absence of Phragmitetea species. The presence of the subnitrophilous species *Hordeum murinum, Stellaria media, Galium aparine* and *Bromus sterilis* is due to human impact. Most of the marsh has been drained and transformed to intensively cultivated agricultural land, meadow and pasture.

3.2. *Saccharum ravennae-Cladium mariscus* community (Fig. 2: group II; Table 2)

This community grows in damp hollows among the sand dunes with shallow freshwater layers. It is dominated by *Saccharum ravennae* and *Schoenus nigricans* and shows a variant with *Juncus subulatus* and *Carex extensa.* It is found in the coastal marsh of Lake Kaiafa, Lake Korission, and the coastal area between Agios Nikolaos bay and Saltini lagoon. At these sites *Cladium mariscus* participates with various cover values. It can reach such a dominance that it hinders the growth of the above taxa, especially the small *S. nigricans* with high demand of light*,* and forms dense homogeneous stands with only a few *Phragmites australis* individuals. These are humid grasslands with few or many damp places and plentiful organic matter, forming peat in places.

By the presence of *Rumex conglomeratus, Lythrum junceum, Pulicaria dysenterica* and *Dittrichia viscosa* this community can be assigned to the alliance Molinio-Holoschoenion. A related association with a similar floristic composition but without *Cladium mariscus* (Eriantho
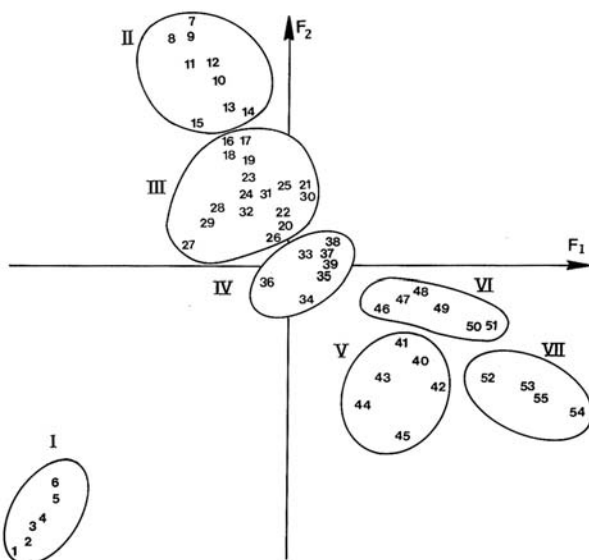
Fig. 2. Ordination diagram (axis 1, 2) of the fifty-five relevés with *Cladium mariscus* with the seven vegetation types (here in Roman numerals) distinguished.

ravennae-Schoenetum nigricantis (Pign. 1953) Gehu 1984) has been previously recorded from Corfu Island (Biondi 1989).

3.3. Dorycnio recti-Cladietum marisci Gradstein & Smittenberg 1977 (Fig. 2: group III; Table 2)

Stands of this vegetation type appear on wet, muddy soils on alluvial deposits on shores of freshwater lakes or lagoon environments fed with fresh water. *Cladium mariscus* populations with 50-80 % cover co-exist with the tall legume *Dorycnium rectum*. The following taxa of the Molinio-Holoschoenion give the association its physiognomy: *Dittrichia viscosa, Rumex conglomeratus, Juncus inflexus, Carex distans* and *Pulicaria dysenterica*.

The Dorycnio recti-Cladietum marisci was found in four areas, each with its own local variant: (a) Korission lagoon, along the southwest shore, variant with *Typha latifolia*; (b) Keri lagoon, along the southwest shore, variant with *Carex divisa*; (c) Lake Trichonida, on the south shore (Ag. Triada-Dafnias), in abandoned cultivations and irrigation channels, variant with *Equisetum telmateia*; (d) Roumani marsh close to Nafplio, mainly in scattered places with permanent humidity and along small non-paved irrigation channels between cultivations, variant with *Equisetum arvense*.

3.4. *Eupatorium cannabinum-Cladium mariscus* community (Fig. 2: group IV; Table 2)

This community is found in the SW of the artificial Lake Agras, sometimes in very dense stands. The community grows on rich organic soils often flooded in winter. The presence of *Juncus inflexus, Pulicaria dysenterica, Cirsium creticum, Carex distans, Lythrum junceum* and *Agrostis stolonifera* allows the *Eupatorium cannabinum-Cladium mariscus* community to be placed in the Molinio-Holoschoenion alliance. The community forms a variant with *Molinia coerulea.*

3.5. *Carex riparia-Cladium mariscus* community (Fig. 2: group V; Table 2)

This community is found as shore vegetation in two small areas NW of Lake Cheimaditida. It is characterized by *Carex riparia* which, together with *Cladium mariscus,* forms fairly dense

Table 2. Communities mit *Cladium mariscus* – 1: *Elymus farctus-Cladium mariscus* community; 2: *Saccharum ravennae-Cladium mariscus* community; 3: Dorycnio recti-Cladietum marisci; 4: *Eupatorium cannabinum-Cladium mariscus* community; 5: *Carex riparia-Cladium mariscus* community; 6: Cladietum marisci; 7: *Schoenoplectus lacustris-Cladium mariscus* community.

Additional, occasional species: *Carex pendula* (21, 52: 1, 25: +), *Cirsium arvense* (33, 35, 39: +), *Nymphaea alba* (51: +, 54, 55: 1), *Paspalum paspalodes* (53: +, 54: 2, 55: 1), *Silybum marianum* (1, 2: +)*, Bromus sterilis* (1: 2, 3: 1), *Centaurium erythraea* (7, 12: +), *Holcus lanatus* (8:1, 14: +), *Brachypodium sylvaticum* (7, 31: +), *Plantago major* (26:1, 32: r), *Urtica dioica* (1: r), *Sisymbrium officinale* (2: +), *Centaurea solstitialis* (4: +), *Tamarix parviflora* (8: +), *Ulmus minor* (12: +), *Mentha longifolia* (12: 1), *Gladiolus* sp. (12: 1), *Oenanthe silaifolia* (12: 1), *Smilax aspera* (14: +), *Pistacia lentiscus* (15: +), *Inula crithmoides* (15: +), *Arundo donax* (16: +), *Fraxinus ornus* (16: r), *Hydrocotyle vulgaris* (20: 1), *Vitex agnus-castus* (21: +), *Carex otrubae* (26: 1), *Scirpoides holoschoenus* (30: 1), *Melilotus officinalis* (31: 1), *Sinapis arvensis* (31: +), *Prunella vulgaris* (32: +), *Melissa officinalis* (32: 1), *Trifolium fragiferum* (32: +), *Salix cinerea* (32: +), *Hypericum perforatum* (35: +), *Galium verum* (39: +), *Equisetum ramosissimum* (49: +), *Solanum dulcamara* (53: +), *Veronica beccabunga* (54: 2).

Relevé number	123456	111111 789012345	11112222222222333 67890123456789012	3333333 3456789	444444 012345	444455 678901	5555 2345
Number of species	111111 965225	111111111 380158345	1111112111111 223 52126310179149640	1111 11 4760925	112111 832632	11111 960111	1111 6421
Plot size (x 10 m2)	155485 0	168451418 0 0 0	55455565555115855 00	1111111 0000000	555555	511511 00 00	5555
Total vegetation cover (x 100%)	111111	111111111	11111111111111111	1111111	111111	111111	1111
Date (Year/month/day)	000000 222222	000000000 111111111	00000000000000000 11111111111111111	0000000 1111111	000000 111111	000000 222222	0000 2222
	000000 555555	000000000 767676766	00000000000000000 44455555555555888	0000000 7777777	000000 777777	000000 666666	0000 6666
	222222 888888	222101011 646565655	22211111112222000 77766666667777222	2222222 1111111	222222 000000	211211 166366	1111 6666
Water depth (cm)						256156 000000	1200 0555
Community	1	2	3	4	5	6	7

Characteristic and differential taxa of the vegetation types:

	1	2	3	4	5	6	7
Cladium mariscus	444324	422525554	33355555544324454	4345445	454534	345455	3222
***Elymus farctus-Cladium mariscus* community**							
Elymus farctus	232552	---------	-----------------	-------	------	------	----
Juncus maritimus	++++++	-------+	-------------13----	-------	------	------	----
Carex hispida	2-21-1	---------	--------------11-	-------	------	------	----
Lolium perenne	-1+-1-	---------	-----------------	---+---	------	------	----
***Saccharum ravennae-Cladium mariscus* community**							
Saccharum ravennae	------	222142131	++------+-----11+	-------	------	------	----
Schoenus nigricans	------	114112111	---+-----1-------	-------	------	------	----
Juncus subulatus	------	1211+----	------+----------	-------	------	------	----
Carex extensa	------	1121-----	-----------------	-------	------	------	----
Cynanchum acutum	------	++1---1--	-----------------	-------	------	------	----
Dorycnio recti-Cladietum marisci							
Dorycnium rectum	------	-1-------	11-+-1+-++1222211	-------	------	-++-+-	----
Equisetum telmateia	------	---------	232--------------	-------	------	------	----
Periploca graeca	------	----11---	111-----------+--	-------	------	------	----
Typha latifolia	------	---------	---+++111+-------	-------	------	------	----
Stachys palustris	------	---------	----111----------	-------	1-----	------	----

```
Relevé number                             111111   11112222222222333   3333333   444444   444455   5555
                            123456   789012345   67890123456789012   3456789   012345   678901   2345

Carex divisa                ------   ---------   ------1--11111---   -------   ------   ------   ----
Aster tripolium             ------   -1----1--   ----------111----   -------   ------   ------   ----
Orchis laxiflora            ------   ---------   ----------+-1----   -------   ------   ------   ----

Equisetum arvense           ------   ---------   --------------111   -------   ------   ------   ----
Picris echioides            ------   ---------   --------------111   -------   ------   ------   ----
Aster squamatus             ------   ---------   --------------1-1   -------   ------   ------   ----
Verbena officinalis         ------   ---------   ---------------+1   -------   ------   ------   ----
Potentilla reptans          ------   ---------   ---------------+1   -------   ------   ------   ----
```

Eupatorium cannabinum-Cladium mariscus community

```
Eupatorium cannabinum       ------   ---------   111-------------   1122212   1111--   -+----   ----
Satureja vulgaris           ------   ---------   ----------------   +++-+1-   ------   ------   ----
Juncus articulatus          ------   ---------   ----------------   -++111+   +-----   ------   ----
Molinia coerulea            ------   ---------   ----------------   121----   ------   ------   ----
```

Carex riparia-Cladium mariscus community

```
Carex riparia               ------   ---------   ----------------   -------   222222   ------   ----
Cyperus flavescens          ------   ---------   ----------------   -------   322221   ------   ----
Lycium europaeum            ------   ---------   ----------------   ------1   --1-+-   ------   ----
Ononis spinosa              ------   ---------   ----------------   -------   --rr+-   ------   ----
Calamagrostis epigejos      ------   ---------   ----------------   -------   --++-+   ------   ----
```

Cladietum marisci

```
Phragmites australis        321222   ++11+1+11   3-3+1-112233341+1   -------   ++11--   522322   2322
```

Schoenoplectus lacustris-Cladium mariscus community

```
Schoenoplectus lacustris    ------   ---------   ----------------   -------   +-11-1   ----+-   3333
```

Molinio-Holoschoenion vulgaris

```
Dittrichia viscosa          ++---+   12111+211   --+1111+111221+--   -------   ------   ------   ----
Rumex conglomeratus         1-1-+-   -+---+---   +--+1-++-11-1--+-   -r-----   ------   ------   ----
Pulicaria dysenterica       ------   ----+1-21   ----1---------1+1   111--+1   -+++--   -1-1--   ----
Juncus inflexus             ------   ---1--1--   --------------2-1   --++-+-   ------   ------   ----
```

Holoschoenetalia and Molinio-Arrhenatheretea

```
Cirsium creticum            1+11++   +1+++++++   1212+11---1111222   1111111   +-+111   ++----   ----
Agrostis stolonifera        122222   ---------   --------------+++   333----   -+-+11   ------   +---
Lippia nodiflora            ------   1-1--1---   ----1-----------   1+---++   11-1--   ------   ----
Lythrum junceum             ------   -1--+1-1-   -21---------1-1++   11111-1   ------   ------   ----
Carex distans               ------   ---------   1+++--1++1--1----   ++1++++   ----1-   ------   ----
Cynodon dactylon            ------   ---------   --------------+--   -------   --+-11   ------   ----
Juncus effusus              ------   ---------   ----------1------   -------   ------   ------   +---
```

Magnocaricion elatae and Magnocaricetalia

```
Samolus valerandi           ------   -------1-   ----1-1--11------   -------   11111-   --+---   ----
Lycopus europaeus           ------   ---------   ------1-------111   -1+--1-   11+1-+   1--+--   ----
Althaea officinalis         ------   ---------   ----------------+   -------   1-+---   ------   ----
Galium palustre             ------   ---------   ----------------   -++---+   1-+-11   -+--+-   ----
```

Phragmition communis and Phragmitetalia

```
Typha angustifolia          ------   ---------   ----------------1   -------   ------   122-21   2334
Sparganium erectum          ------   ---------   ----------------   -------   ------   -+-1++   +111
```

Phragmito-Magnocaricetea

```
Mentha aquatica             ------   ------111   ---2111-11----11-   -------   +1111-   111+-1   ----
Apium nodiflorum            ------   ---------   ----111---------   -------   ------   -++111   -+--
Iris pseudacorus            ------   ---------   ----------1-----   -------   ------   ---+-+   ----
Oenanthe fistulosa          ------   ---------   -----------2-1--   -------   ------   -+----   ----
Lythrum salicaria           ------   ---------   ---------------+--   -------   -+----   111+1+   +---
Lysimachia vulgaris         ------   ---------   ----------------+   -------   ------   -+1-+1   ----
Alisma plantago-aquatica    ------   ---------   ----------------   -------   +++---   ------   ++++
```

Relevé number	111111 123456	11112222222222333 789012345	3333333 67890123456789012	444444 3456789	444455 012345	5555 678901	2345
Other species							
Hordeum murinum	1+1++1	---------	-----------------	-------	------	------	----
Gastridium ventricosum	11-+11	---------	-----------------	-------	------	------	----
Stellaria media	111--1	---------	-----------------	-------	------	------	----
Calystegia sepium	111111	-----1111	11--11+1+111112-1	1111111	--1---	111111	11++
Galium aparine	222212	----1----	----1-1-1-1+--11-+	-------	------	------	----
Cirsium vulgare	r-r--r	---------	-----------------	-+-----	----++	------	----
Polypogon monspeliensis	+1----	---------	-----------------	-------	+-+1--	------	+---
Daucus carota	-----+	-1-------	-1+-----------+1-	------+	------	------	----
Juncus acutus	------	+--2--+-+	---+--+++1-+---++	-------	------	------	++++
Lotus corniculatus	------	-1---+--1	--------------1-1	-------	------	------	----
Rubus sanctus	------	-+-+++---	211-+++---+--1+1+	+------	------	------	----
Myrtus communis	------	----2++11	---1--rr-r-------	-------	------	------	----
Rubia peregrina	------	---------	1----111-1-----++	-------	------	------	----
Cyperus longus	------	---------	--------1+------	-------	+-1---	------	++-1
Epilobium hirsutum	------	---------	----------+-----+	+1-++1+	--+--+	11----	11--
Poa trivialis	------	---------	--------------1-	-------	------	------	1+1-

stands with a Magnocaricion elatae physiognomy. It grows on slightly boggy substrates which are flooded at least during winter.

3.6. Cladietum marisci Zobrist 1935 (Fig. 2: group VI; Table 2)

This syntaxon is characterized by the dominance of *Cladium mariscus,* which forms dense, impassable stands, together with *Phragmites australis* and *Typha angustifolia.*

The Cladietum marisci is found in the marshes of Agia and Kryoneri, in small stands at water depths of 5-25 cm. It is also found in Lake Voulkaria where *Cladium mariscus* forms extensive stands in a 100 m wide zone around the lake, at water depths of less than 80 cm. At water depths exceeding 50-60 cm, which are less favourable for *C. mariscus*, the species forms a floating platform composed of it's root network, which may or may not be associated with other species (common reed in particular, see also Devvilez & Iserentant 1981).

In Greece, the above syntaxon is best placed in the Phragmition communis alliance, as indicated by the occurrence of *Lysimachia vulgaris, Apium nodiflorum, Lythrum salicaria.*

3.7. *Schoenoplectus lacustris-Cladium mariscus* community (Fig. 2: group VII; Table 2)

Stands of this type are characterized by *Schoenoplectus lacustris* and *Phragmites australis.* *Cladium mariscus* participates in small groups. The community belongs to the Phragmition alliance, as shown by the presence of *Typha angustifolia, Alisma plantago-aquatica* and *Sparganium erectum.* It is found in Lake Voulkaria, mostly in the north-western and southern areas of the lake, in very wide zones.

Discussion and conclusions

Cladium mariscus is a thermophilous species (Devvilez & Iserentant 1981). It prefers lakes, lagoons, shallow marshes and wet meadows over limestone, all with groundwater levels close to the soil surface. Periods of flooding are possible. The creeping rhizome of *C. mariscus* is only poorly anchored in the soil, and this makes it sensitive to fluctuations in groundwater level. The plant grows in waters of karstic origin that are rich in calcium carbonate ($CaCO_3$).

Communities of *Cladium mariscus* are found on soils rich in organic matter, as well as on sandy and gravely mineral substrate with sandy-loam and loamy-sand layers. They also grow in water of varied pH, from alkaline to neutral, but generally at depths of less than 80 cm, where their root networks form floating platforms. *C. mariscus* shows a broad ecological tolerance, invading various plant communities. Communities with *C. mariscus* form two principal types as regards their aspect, origin and structure:

(1) "Aquatic" communities. – These develop on the water surface by the centripetal progression of its roots, which form a floating raft. In most cases, the Cladietum marisci is initially very dense and paucispecific, even monospecific, and a very significant quantity of litter is accumulated. *Cladium mariscus* may be accompanied by other species with high biomass production, e.g. common reed, which participates in structuring the floating carpet. The presence of *Schoenoplectus lacustris-C. mariscus* communities is limited to small inland locations usually bordering reed populations and periodically flooded wetlands.

(2) "Terrestrial" communities. – These originate from invasion of *Cladium mariscus* in pre-existing vegetation. *C. mariscus* tolerates a certain variation in the physicochemical parameters of the vegetation groups into which it penetrates, such as formations of the Molinio-Holoschoenion and Magnocaricion elatae alliances described above. In the *Saccharum ravennae-C. mariscus-* and *Eupatorium cannabinum-C. mariscus* communities *C. mariscus* can penetrates species-rich stands with initially a characteristic species composition. It gradually becomes very dense and dominant and finally the species diversity can become extremely poor. In Dorycnio-Cladietum marisci and the *Elymus farctus-C. mariscus* community a low diversity of species is maintained.

The *Saccharum ravennae-Cladium mariscus* community, which grows in wet hollows of sand dunes, forms an original floristic assemblage threatened by possible changes in water level. Like the *Eupatorium cannabinum-C. mariscus* community, which grows in mainland basins at intermediate altitudes on wet organic soils, it might be considered as stable.

The Dorycnio recti-Cladietum marisci with its different local variants has the widest distribution. We found stands on alluvial soils that remain wet during summer, probably due to capillary rising of ground water. It grows in water bodies along channel banks, wet hollows, or inland areas and forms small, fairly dense populations.

The *Elymus farctus-Cladium mariscus* community is found near the sea in a transitional position between the Molinio-Holoschoenion and Agropyrion juncei alliances of the class Ammophiletea, as shown by its floristic composition and ecological conditions.

The *Carex riparia-Cladium mariscus* community constitutes a transition between aquatic and terrestrial communities. *Carex riparia* has a Eurasian, Suboceanic and Sub-Mediterranean distribution (Balátová-Tuláčková 1995) where, on wet substrates, it competes successfully with *C. mariscus* while in drier conditions its competitive capacity is reduced.

Cladium mariscus is the principal component of the priority Natura 2000 habitat type 7210: Calcareous fens with *C. mariscus* and *Carex davalliana* (Directive 92/43/EEC, European Commission DG. XI 1996). This habitat type is influenced both by hydrological changes in the main wetland and soil erosion at its borders. *C. mariscus* is sensitive to both changes in hydrological conditions and human influences (land reclamation, extensive cultivation, tourism, fires and water pollution). In many areas populations of *C. mariscus* are reduced dramatically and severely endangered (Lake Cheimaditida, Keri lagoon, and Roumani/Nafplio, Artaki and Kalodiki marshes). It also appears in other habitat types, e.g. 'humid dune slacks' (Natura 2000 code: 2190). The healthiest populations were observed at Lake Agras, Voulkaria (where the largest populations were found), Kaiafa, the Saltini and Korission lagoons, and Agios Nikolaos bay.

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Address of the authors:
M. Theocharopoulos, T. Georgiadis, G. Dimitrellos, S. Chochliouros & A. Tiniakou, Botanical Institute, Division of Plant Biology, Department of Biology, University of Patras, GR-26500 Patras, Greece; e-mail: georgiad@upatras.gr