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MARIA SARIKA, PANAYOTIS DIMOPOULOS & ARTEMIOS YANNITSAROS

Contribution to the knowledge of the wetland flora and vegetation of Amvrakikos Gulf, W Greece

Abstract

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The wetland complex of Amvrakikos Gulf is the largest and most diverse in Greece and one of the 11 Internationally Important Wetlands catalogued in the country, but its flora and vegetation has been only insuffiently known to date. The present study revealed that the wetland flora of Amvrakikos comprises 182 vascular plant taxa, of which 158 are reported for the first time. Five taxa *(Callitriche truncata* subsp. *truncata, Cyperus michelianus* subsp. *pygmaeus, Elymus hispidus* subsp. *graecus, Salvinia natans, Typha laxmanii)* are new records also for Epirus and one *(Glinus lotoides)* is a new record for both western Sterea Ellas and Epirus. The distribution of nine taxa *(Callitriche truncata* subsp. *truncata, Cotula coronopifolia, Cyperus michelianus* subsp. *pygmaeus, Eleocharis mitracarpa, Elymus hispidus* subsp. *graecus, Glinus lotoides, Rumex kerneri, Salvinia natans, Typha laxmanii)* of special chorological interest is considered more closely. The vegetation complex of Amvrakikos wetland consists of thirty-six plant communities of six habitat groups: communities of saline soils, communities of subsaline soils, freshwater communities (marshes, reed swamps), communities of soils periodically inundated by freshwater, communities without preference for a particular habitat type and riparian forests.

Introduction

The study of the Greek vascular plant flora has attracted the interest of botanists for many decades. During the 20th century, much botanical research has been conducted in terrestrial ecosystems, whereas until the early 1980s only a few aquatic ecosystems in Greece had been floristically and/or phytosociologically investigated (Petkoff 1910, Stephanides 1940, 1948a-b, Lavrentiades 1956, 1963, 1973, 1975, Wolff 1968, Gradstein & Smittenberg 1977, Babalonas 1979, 1980). Since then, aquatic ecosystems have been the subject of various floristic and phytosociological studies (for bibliographic details see Sarika-Hatzinikolaou & al. 2003). Recent research on the vascular plant flora of Greek coastal wetlands has been carried out in Macedonia (Karagiannakidou & al. 2000), Thraki (Drossos 1992), Epirus (Georgiadis & al. 1997) and NW Peloponnisos

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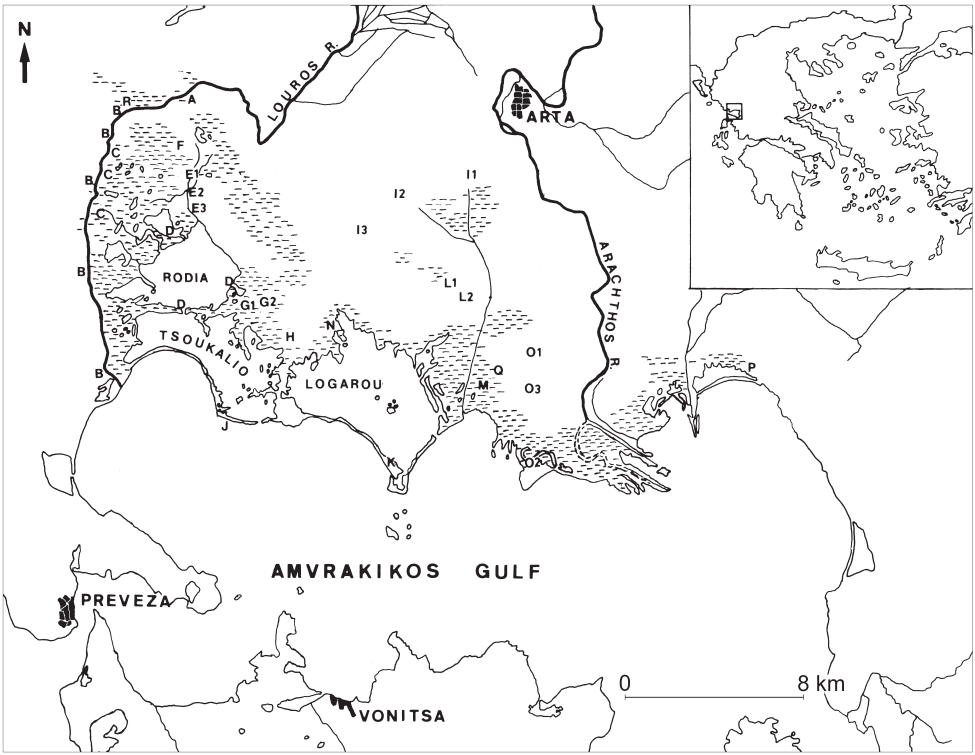


Fig. 1. Topographic map of the wetlands of Amvrakikos Gulf with the codes of the plant collection localities explained in the part "Material and methods".

(Georgiadis & al. 1990, Koumpli-Sovantzi 1991, Raabe & Koumpli-Sovantzi 2000). The only regional publication including floristic and vegetation data from Amvrakikos Gulf is that of Wolff (1968), which reports 45 plant species, four being aquatic, 23 hygrophilous, and six plant communities (five halophilous, one ammophilous).

This paper (a) provides a full inventory of the wetland flora of Amvrakikos Gulf and (b) gives a brief overview of its wetland vegetation communities.

Study area

Amvrakikos Gulf lies on the coast of W Greece at 38°51'-39°10'N and 20°40'-21°12'E (Fig. 1). It is an almost closed basin sheltered from the factors acting in the open sea and the largest gulf in the region (405 km^2) with one of the largest wetlands in Greece. Part of Amvrakikos wetland has been declared a RAMSAR site (one of the 11 Internationally Important Wetlands catalogued in Greece), a Special Protection Area and a Specially Protected Mediterranean Area (25 000 ha). Part of the gulf is also a Game Reserve.

The wetlands of Amvrakikos Gulf form a complex ecosystem comprising a lagoon system composed of three major lagoons in its northern part (Rodia, Tsoukalio, Logarou) between the double delta of the rivers Arachthos and Louros (Fig. 1), some smaller ones along the coastline (60 km^2), and a mosaic of various wetlands around these lagoons (salt marshes, brackish reed swamps, mudflats, spits) and along the rivers (periodically flooded plains, freshwater marshes, freshwater reed swamps, wet grasslands, riparian forests). Due to the diversity of wetland types, the diversity of plant and animal taxa is high.

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The present research was carried out in the northern part of the gulf comprising lagoon and wetland ecosystems. The study area was selected because of its high habitat and vegetation type diversity and its consequently higher floristic diversity compared to the southern part of the gulf, where no rivers exist and thus silt deposits are not extensive.

The largest and most characteristic lagoons of Amvrakikos Gulf, viz. Rodia (15 km^2), Tsoukalio (17 km^2) and Logarou (28 km^2), are located in the western part of the double delta and are separated by salt marshes, temporarily flooded or wet salt plains with halophytic vegetation (Fig. 1). Covering c. 3200 ha, these salt marshes form one of the largest uniform habitats of this type in Greece. The lagoons are connected to the main gulf by small openings and are bordered by elongated deposits (spits), the substratum of which consists mainly of foraminifer shells.

Extensive brackish reed swamps, possibly the largest in Greece, occur in the northern part of Rodia Lagoon, while a network of freshwater marshes, freshwater reed swamps and wet grasslands grows along the floodplains of river Louros. The extensive riparian forests, which once delineated the lower reaches of the rivers, have been reduced to small isolated stands scattered throughout the area. The largest uniform extent of this vegetation type occurs in the area situated between the river Louros and Louros village. The presence of small hills in the area (Mavrovouni hill east of Rodia, and Salaora hill between Tsoukalio and Logarou) adds to the diversity of the Amvrakikos wetland complex. Predatory birds nest in these hills as their evergreen sclerophyllous scrub vegetation with scattered trees offers safe shelter.

Amvrakikos Gulf is considered to be a tectonic trough of the Adriatic-Ionian zone filled in from bottom to top with lacustrine marly sediments of the Neogene and large Quaternary, mainly alluvial, deposits transferred by the rivers Arachthos and Louros. Ridges of the sea base occur between these deposits representing the elevations of Salaora and Koronisia and the limestone hills of Vigla, Preveza and Arta. Structurally, Amvrakikos Gulf and the plain of Arta develop on an old permeable rock system surrounded by two extensive lateral strips of impermeable rocks (flysch and Neogenic rocks). The basins of rivers Arachthos and Louros develop on flysch and limestone, respectively. The soil types of the lagoon and salt marsh beds are sandy-clay, clay, silty-clay, silt, peat, and marly-humus (Anonymous 1984).

Based on Emberger's (1955, 1959) and Sauvage's (1963) bioclimatic classifications, the study area belongs to the humid Mediterranean bioclimatic zone with mild winters almost free of frost and snow. The climatic data (1976-88) originate from the meteorological station of Arta. According to Bagnouls & Gaussen's (1953) xerothermic index ($X_m = 44.6$), the area has a weak meso-Mediterranean bioclimate, with a dry period lasting from June to September.

Material and methods

The present study is based on the data collected during fieldwork from 1989-92 and 2000-02. For the study of the wetland flora 412 plant specimens were collected and identified mainly according to "Flora europaea" (Tutin & al. 1968-80, 1993). The nomenclature follows mainly Greuter & al. (1984, 1986, 1989), Tutin & al. (1968-80, 1993) and Strid & Tan (1997, 2002).

The floristic list is based on the first author's *(SM)* collections, which are deposited in her personal herbarium kept at ATHU. Families, genera and species are listed in alphabetical order within the traditional major systematic groups. Taxa preceded by an asterisk (*) were previously reported from the area by Wolf (1968). The collection numbers appear in the list in parentheses after the collection localities. The indication *"obs."* means that the record is based on field observation. Information regarding collection sites, habitat preferences and ecological status, based on our own field observations, is given for each taxon.

The identification and description of the prevailing vegetation types is based on 61 relevés made in 2000-01 using the phytosociological approach after Braun-Blanquet (1964) and Westhoff & van der Maarel (1978).

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The collection localities in Amvrakikos Gulf are coded (A-S) and shown in Fig. 1 (except S, which is located outside the mapped area). The collecting dates, the collection numbers and the codes of the localities (according to Fig. 1) are summarized below:

A: River Louros, wet or submerged habitats along the riverbed, near the village Petra, 29.9. 1990, *SM 280, 281, 284, 286;* 1.11.1990, *SM 312-315, 317-319;* 10.5.1991, *SM 568, 569, 571, 573, 574-578, 580-586;* 11.5.1991, *SM 605;* 20.6.1991, *SM 722-724;* 9.10.1991, *SM 847-850, 852, 853;* 10.10.1991, *SM 876;* 5.6.1992, *SM 983-985*.

B: River Louros, riverbed, from Petra village down to the estuary, 10.10.1991, *SM 874-884*.

C: Floodplains east of the river Louros, freshwater marshes, freshwater reed swamps, wet grasslands, 11.8.1989, *SM 49-53, 56, 57, 59, 60-63;* 5.9.1989, *SM 90;* 29.9.1990, *SM 278, 279, 288, 289, 290-296;* 1.11.1990, *SM 321-324;* 3.11.1990, *SM 389, 390;* 8.10.1991, *SM 842-846, 854;* 5.6.1992, *SM 986-989, 990-996;* 17.7.2000, *SM 2064-2072;* 27.10.2000, *SM 2113-2123;* 18.5.2001, *SM 2179-2187;* 19.5.2001, *SM 2189-2198*.

D: Rodia lagoon, salt marshes in the N, S and SE parts of the lagoon, 29.3.1990, *SM 144, 145, 147-150;* 3.11.1990, *SM 375-378, 380, 382-388;* 11.5.1991, *SM 587, 588, 592-594;* 21.6. 1991, *SM 725-728, 730-733;* 10.10.1991, *SM 885-889, 890-894*.

E: Salt marshes surrounding the village of Strongili.

E_1: Enclosure (5 ha) housing five water buffalo, near the village of Strongili, 39°07'79"-95"N, 20°48'76"-83"E, 17.7.2000, *SM 2055;* 17.5.2001, *SM 2149-2161;* 19.5.2001, *SM 2199-2207*.

E_2: Outside the water buffalo enclosure, along the fencing, 39°07'79"-82"N, 20°48'74"-79"E, 17.8.1989, *SM 54, 65, 66;* 17.7.2000, *SM 2056-2061;* 17.5.2001, *SM 2162-2178*.

E_3: West of Agia Ekaterini hill, 39°07'16"N, 20°47'59"E & 39°07'14"N, 20°47'59"E, 27.10. 2000, *SM 2096, 2097*.

F: Salt steppes between the villages Petra and Strongili, 39°08'49"N, 20°48'49"E, 17.7.2000, *SM 2050-2054*.

G: Near the village of Vigla.

G_1: Salt marsh, southwest of Vigla village, 17.7.2000, *SM 2062, 2063*.

G_2: *Arundo donax* stand, 39°05'01"N, 20°52'41"E, 28.10.2000, *SM 2134-2145*.

H: Salt steppe on the left side of the road joining the villages Vigla and Salaora, 39°04'24"N, 20°52' 53"E, 27.10.2000, *SM 2108-2112*.

I: Drainage canals.

I_1: Near the village of Kostaki, 2.11.1990, *SM 341-347, 384*; 11.5.1991, *SM 596-605, 607;* 10.10.1991, *SM 895*.

I_2: Near the village of Kalovatos, 2.11.1990, *SM 339, 350, 351a;* 11.10.1991, *SM 896-902, 905, 907*.

I_3: Near the village of Rahi, 2.11.1990, *SM 372-374*, *351*, *352*; 11.8.1991, *SM 903, 904, 909-911;* 28.10.2000, *SM 2148*.

J: Tsoukalio lagoon spit, 39°02'08"N, 20°49'45"E, 27.10.2000, *SM 2098-2100*.

K: Koronisia, 27.10.2000, *SM 2101-2107*.

L: Near the village of Psathotopi.

L_1: Irrigation ditch, 18.7.2000, *SM 2084-2090*.

L_2: Abandoned fishery pond 18.7.2000, *SM 2091-2095*.

M: Salt steppe in the area of Paleokopria (about 2.8 km from the inlet of Phidokastro), 17.7. 2000, *SM 2082, 2083*.

N: Logarou lagoon, salt marshes in the northwest part of the lagoon, 2.11.1990, *SM 354-360, 362, 364a, 365, 366, 369, 370;* 11.10.1991, *SM 913-918*.

O: Near the village of Neochorion. Ditches, reed swamps, salt steppes.

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O_1: Ditches and reed swamps near an abandoned eel fishery, 39°03'51''N, 20°58'36''E, 28.10.2000, *SM 2124-2132*.
O_2: Salt steppe, 39°01'17''-53''N, 20°59'08''E, 28.10.2000, *SM 2133*.
O_3: Ditch along the road to Paleokopria in the abandoned puddy field area, 17.7.2000, *SM 2079, 2080*.

P: Koprena inlet, salt marshes, northwest of the village Menidion, near the Argilos lagoon, 17.9.1989, *SM 106-119, 146;* 30.3.1990, *SM 155, 156, 158-163a, 164, 166;* 31.10.1990, *SM 299-309, 311*.

Q: Kamatira's farm, 39°03'32''N, 20°57'39''E, 17.5.2001, *SM 2208-2212*.

R: Ditches in the area of Fraxias, 30°09'50''-53''N, 20°46'86''E, 18.5.2001, *SM 2188*.

S: Lake Vroma, 16.7.2000, *SM 2046-2049*.

Results and discussion

1. List of the wetland vascular plants of Amvrakikos Gulf

Pteridophyta

Azollaceae

Azolla filiculoides Lam. – B *(883),* I_1 *(373),* D *(388, 733, 890).* Floating carpets on the water surface.

Equisetaceae

Equisetum ramosissimum Desf. – I_1 *(348),* G_2 *(2144),* L_1 (*2084*). Along the margins of ditches.

Salviniaceae

Salvinia natans (L.) All.
A *(853, 985b),* B *(880),* C *(842, 1137)*. Floating on river Louros, floodplains and ditches.

Angiospermae

Dicotyledones

Amaranthaceae

Amaranthus graecizans L. – G_2 *(2135).* Shady places in hedges and roadsides.
Amaranthus hybridus L. – G_2 *(2134)*. Shady places in hedges and roadsides.

Boraginaceae

Heliotropium halacsy Riedl – N *(359).* Dry places, usually on roadsides. Endemic of western Greece.
Myosotis sicula Guss. – C *(995, 2179).* Wet grasslands.

Callitrichaceae

Callitriche stagnalis Scop. – L_1 *(2085).* Stagnant water in ditches.
Callitriche truncata Guss. subsp. *truncata* – C *(2182*). Inundation zone of the river Louros, submerged.

Cannabaceae

Humulus lupulus L. – I_3 *(908).* Damp scrub along ditches.

Caryophyllaceae

Cerastium glomeratum Thuill. – C *(2184),* P *(157).* Waste and open places, fallow fields.
Polycarpon tetraphyllum (L.) L. – C *(2186).* Temporarily flooded depressions along the margins of freshwater marshes in the inundation zone of the river Louros.
Sagina apetala Ard. subsp. *apetala* – E_1 *(2157)*. Wet places in salt steppes.

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**Spergularia salina* J. Presl & C. Presl – E_1 *(2161b),* E_2 *(2178b).* Salt marshes, sometimes in ruderal places near the coasts.

Ceratophyllaceae

Ceratophyllum demersum L. – A *(284, 317, 585, 724),* B *(881),* C *(49, 293, 322, 844),* I_2 *(350, 907),* I_3 *(372, 910).* Submerged in freshwater marshes and ditches.

Chenopodiaceae

**Arthrocnemum macrostachyum* (Moric.) K. Koch – L_2 *(2093a).* Salt marshes and salt steppes.

Atriplex patula L. – P *(302).* Saline and sandy soils near the coast, waste grounds near villages.

**Atriplex portulacoides* L. – J *(2100a),* N *(917),* P *(113, 301).* Sandy beaches, saline flats and salt marshes.

**Atriplex prostrata* Boucher ex DC. – A *(280),* J *(2099a),* L_2 *(2092),* N *(365).* Saline or subsaline soils and wet sand by the sea, in waste places and salt marshes.

Atriplex tatarica L. – G_2 *(2139),* H *(2110).* Shady places in hedges and roadsides, inland saline flats.

Chenopodium ambrosioides L. – I_2 *(899).* Waste places along ditches.

**Halocnemum strobilaceum* (Pallas) M. Bieb. – N *(357, 914),* P *(166).* Salt marshes and coastal saline flats.

Salicornia europaea L. – D *(382),* E_2 *(2177),* E_3 *(65),* H *(2111),* N *(915),* Q *(109, 306).* Salt marshes and salt steppes.

**Salsola kali* L. – K *(2102).* Sandy places in salt marshes and saline flats near coasts.

**Salsola soda* L. – J *(2100b),* K *(2104),* N *(366).* Sandy places in salt marshes and steppes.

**Sarcocornia fruticosa* (L.) A. J. Scott – D *(64),* E_3 *(2097),* J *(2100c),* O_2 *(2133),* K *(2105),* P *(110).* Salt marshes and salt steppes.

**Sarcocornia perennis* (Mill.) A. J. Scott – N *(365, 916),* P *(11, 164, 307),* J *(2099b),* L_2 *(2093b),* M *(2081),* E_1 *(2055b, 2149a).* Wet sand near coasts and salt marshes.

**Suaeda maritima* (L.) Dumort. – G_1 *(2062),* L_2 *(2095),* K *(2101),* J *(2098).* Sandy places in salt marshes and salt steppes.

Suaeda vera Forssk. ex J. F. Gmel. – K *(2107b).* Wet sandy and saline soils in salt marshes and salt steppes.

Compositae

Aster squamatus (Spreng.) Hieron. – L_1 *(2124),* L_2 *(2133b),* N *(369).* Salt steppes.

**Aster tripolium* subsp. *pannonicus* (Jacq.) Soó – D *(375, 887),* H *(2108),* K *(2101),* P *(303).* Salt marshes, damp places by roads and ditches.

Bellis annua L. subsp. *annua – (160).* Damp open places.

Conyza albida Willd. ex Spreng. – G_2 *(2138).* Dry places on roads.

Cotula coronopifolia L. – P *(147, 588, 728),* E_1 *(2152),* P *(161).* Salt steppes, wet grasslands, widespread.

Dittrichia viscosa (L.) Greuter subsp. *viscosa* – A *(312),* N *(913),* P *(309).* Disturbed and waste places.

**Inula crithmoides* L. – K *(2102),* P *(108, 304).* Sandy places in salt marshes and salt steppes.

Lactuca saligna L. – H *(2109).* Salt steppes.

Pulicaria dysenterica (L.) Bernh. – C *(51),* G_2 *(2127),* O_1 *(2127).* In wet grasslands and in damp, places along ditches or roadsides.

Xanthium strumarium L. – C *(2121).* Disturbed places.

Convolvulaceae

Calystegia soldanella (L.) R. Br. – K *(2103).* Sandy shores.

Calystegia sepium (L.) R. Br. – C *(2072b).* Usually climbing on *Phragmites australis*, freshwater reed swamps.

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Cruciferae

Rorippa sylvestris (L.) Besser – C *(2189).* Wet grasslands.
Nasturtium officinale R. Br. – A *(849, 584),* I_1 *(342, 600).* Slowly moving water.

Gentianaceae

**Centaurium tenuiflorum* (Hoffmanns. & Link) Fritsch – E_2 *(2178a),* F *(2054),* Q *(2212).* Damp grassy places in temporarily inundated plains and inland saline flats.
Centaurium erythraea Rafn subsp. *erythraea* – O_1 *(2132).* Muddy soils along ditches.

Geraniaceae

Geranium dissectum L. – E_1 *(2161a),* E_2 *(2198a).* Grassy subsaline flat places.

Haloragaceae

Myriophyllum spicatum L. – I_3 *(352, 903).* Ditches.

Labiatae

Lycopus europaeus L. – O_1 *(2131).* Wet or muddy soils along ditches.
Mentha aquatica L. – C *(90).* Freshwater marshes, temporarily flooded plains.
Mentha longifolia (L.) Hudson – C *(obs.).* Wet grasslands.
Mentha pulegium L. – C *(50),* I_2 *(902).* Damp places along ditches, by roadsides, wet grasslands and temporarily flooded plains.

Leguminosae

Medicago minima (L.) Bartal. – A *(573).* Disturbed, slightly damp rocky places.
Securigera securidaca (L.) Degen & Dörfler – C *(2194).* Waste places by roadsides.
Trifolium campestre Schreb. – A *(569).* Disturbed, damp places.
Trifolium dalmaticum Vis. – A *(574).* Waste, disturbed places.
Trifolium repens L. subsp. *repens* – C *(56).* Wet grasslands.
Trifolium resupinatum L. – A *(568).* Wet places.

Lythraceae

Lythrum salicaria L. – A *(878).* Along watercourses and margins of freshwater marshes.

Malvaceae

Abutilon theophrasti Medik. – C *(2116).* Places disturbed by grazing in the inundation zone of river Louros.

Molluginaceae

Glinus lotoides L. – C *(2113a).* Temporarily inundated plains along the margins of freshwater reed swamps.

Nymphaeaceae

Nymphaea alba L. – C *(292, 846).* Freshwater marshes.

Oleaceae

Fraxinus angustifolia subsp. *oxycarpa* (Willd.) Franco & Rocha Afonso – L_1 *(obs.),* R *(obs.).* Damp or wet soils along ditches.

Plantaginaceae

**Plantago coronopus* L. subsp. *coronopus* – E_1 *(2153).* Wet grasslands with halophytic vegetation.
Plantago major subsp. *intermedia* (DC.) Arcang. – D *(383).* Wet grasslands with halophytic vegetation.

Platanaceae

Platanus orientalis L. – A *(obs.),* L (*obs.*), R *(obs.).* Damp or wet soils along ditches, damp open places, wet muddy places by the river Louros.

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Plumbaginaceae

Limonium narbonense Mill. – D *(380, 886),* E_1 *(2154),* E_2 *(66, 2166),* P *(146, 299).* Salt marshes and wet grasslands with halophytic vegetation.

Polygonaceae

Persicaria hydropiper (L.) Spach – I_1 *(343),* I_2 *(897).* Along ditches.

Persicaria maculosa S. F. Gray – A (*847*), I_2 *(896).* Margins of watercourses.

Persicaria salicifolia (Willd.) Assenov – B *(875).* Margins of watercourses.

Polygonum aviculare L. – E_2 *(54).* Wet grasslands with halophytic vegetation.

Rumex conglomeratus Murray – A *(314, 579),* C *(996),* D *(378),* E_1 *(2150).* Wet or damp places along watercourses, wet grasslands with halophytic vegetation, margins of freshwater marshes.

Rumex crispus L. – A *(580).* Damp places.

Rumex cristatus DC. – G_1 *(2145).* Salt marsh.

Rumex kerneri Borbás – A *(313).* Damp places.

Rumex pulcher L. subsp. *pulcher* – D *(592),* I_1 *(597),* P *(370).* Damp, usually disturbed places.

Primulaceae

Anagallis arvensis L. var. *arvensis* – C *(2185).* Wet grasslands, seasonally inundated flats. Both varieties as distinguished by Leblebici (1978) occur in the study area. Apart from the cited specimen of var. *arvensis* (with an orange-red corolla), var. *caerulea* (L.) Gouan (with a blue corolla) has been observed more often and in bigger populations.

Samolus valerandi L. – O_2 *(2073).* Sandy place in salt steppe.

Ranunculaceae

Ranunculus marginatus d'Urv. – C *(2180),* P *(158).* Wet grasslands in the inundation zone of river Louros, depressions temporarily flooded with brackish water.

Ranunculus ophioglossifolius Vill. – I_1 *(603).* Along ditches, local.

Ranunculus peltatus subsp. *baudotii* (Gordon) C. D. K. Cook – C *(2114).* Freshwater marshes.

Ranunculus sceleratus L. subsp. *sceleratus* – A *(850, 983).* Wet places along watercourses.

Rosaceae

Potentilla reptans L. – C *(obs.).* Wet grasslands.

Salicaceae

Populus alba L. – A *(obs.),* I *(obs.),* R *(obs.).* Wet muddy places by the river Louros, damp places along ditches.

Populus nigra L. – A *(obs.),* I *(obs.),* R *(obs.).* Wet muddy places by the river Louros, damp places along ditches.

Salix alba L. – A *(obs.),* C *(obs.),* I *(obs.),* O *(obs.),* R (*obs.*), S *(obs.).* Damp or wet places along ditches, damp open places, wet grasslands, muddy places by the river Louros.

Salix fragilis L. – A *(obs.),* C *(obs.),* I *(obs.),* O *(obs.),* R *(obs.),* S *(obs.).* Damp or wet places along ditches, damp open places, wet grasslands, muddy places by the river Louros.

Scrophulariaceae

Cymbalaria muralis P. Gaertn. & al. subsp. *muralis* – P *(112, 155).* Stone wharf.

Veronica anagalloides Guss. – C *(994, 2198b).* Freshwater marshes and reed swamps.

Tamaricaceae

Tamarix hampeana Boiss. & Heldr. – E_2 *(2056b).* Moist or slightly inundated places.

Tamarix smyrnensis Bungle – D *(384).* Salt steppes, ditches, usually near the lagoons in places temporarily inundated with brackish water.

Tamarix tetrandra Pallas ex M. Bieb. – D *(145),* P *(163a).* Salt steppes, usually near the lagoons in places temporarily inundated with brackish water.

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Verbenaceae

Lippia nodiflora (L.) Michx. – C *(2064).* Wet, grassy places in temporarily inundated plains.
Verbena officinalis L. – I_1 *(345),* I_2 *(900).* Along ditches and roadsides.

Ulmaceae

Ulmus minor Mill. – L_1 (*obs.*). Damp or wet places along ditches.

Umbelliferae

Apium nodiflorum (L.) Lag. – A *(281, 318, 583),* I_1 *(341).* Along watercourses, usually on muddy banks.
Berula erecta (Huds.) Coville – I_1 *(599).* Along watercourses, usually on muddy banks.
Bupleurum flavum Forssk. – E_2 *(2061).* Inland subsaline grassy flats.
Crithmum maritimum L. – J *(2107a).* Maritime rocks and sandy places near the sea.
Eryngium creticum Lam. – C *(53).* Waste places and places disturbed by grazing.
Foeniculum vulgare subsp. *piperitum* (Ucria) Cout. – C *(52).* Disturbed, dry places by roadsides.
Oenanthe aquatica (L.) Poir. – C *(2117).* Freshwater marshes in the inundation zone of the river Louros.
Oenanthe fistulosa L. – A *(576a),* C *(989, 2190).* Wet places and in shallow water.
Oenanthe lachenalii C. C. Gmel. – I_1 *(601).* Damp soil by ditches.
Oenanthe silaifolia M. Bieb. – A *(576b).* Wet places.
Torilis nodosa (L.) Gaertn. s. l. – P *(162).* Open usually dry places, by ditches, on roadsides.
Tordylium apulum L. – A *(571).* Sligthly damp, rocky places.
Tordylium officinale L. – A *(575).* Sligthly damp, rocky places.

Monocotyledones

Alismataceae

Alisma lanceolatum With. – A *(5829),* C *(279, 2065).* In shallow water and in freshwater marshes.
**Alisma plantago-aquatica* L. – C *(294, 321),* O_3 *(2125).* Freshwater marshes, ditches.

Butomaceae

Butomus umbellatus L. – C *(993).* Freshwater reed swamps.

Cyperaceae

Carex divisa Huds. – P *(159).* Seasonally flooded soils by brackish water.
Carex divulsa Stokes – L_1 *(2087).* Damp soils along ditches.
Carex otrubae Podp. – S *(2047).* Shallow water and muddy soils.
Cyperus fuscus L. – O_1 *(2126).* Slightly damp soils in shady places along ditches.
Cyperus laevigatus L. subsp. *laevigatus* – O_1 *(2128),* O_2 *(2074).* Slightly damp soils in shady places along ditches.
Cyperus longus L. – A *(577, 992),* C *(2067).* Muddy banks of river Louros, freshwater reed swamps.
Cyperus michelianus subsp. *pygmaeus* (Rottb.) Asch. & Graebn. – C *(2066, 2115).* Temporarily inundated plains disturbed by grazing.
Eleocharis mitracarpa Steud. – C *(986, 2192).* Wet grasslands in the inundation zone of river Louros.
Eleocharis palustris (L.) Roem. & Schult. subsp. *palustris – A (581).* Muddy banks.
Scirpus cernuus Vahl – E_2 *(2167),* F *(2051).* Inland subsaline grassy flats.
Scirpus lacustris L. subsp. *lacustris – C (288b, 390),* S *(2046).* Freshwater reed swamps.
Scirpus litoralis Schrad. – E_2 *(2169),* Q *(2209).* Reed thickets in brackish water.
**Scirpus maritimus* L. subsp. *maritimus* – C *(2191),* E_1 *(2199),* F *(2050),* G_1 *(2063a),* Q *(2208).* Brackish and freshwater reed thickets.

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Gramineae

Aeluropus littoralis (Gouan) Parl. – E_1 *(2203),* E_2 *(2058).* Subsaline grassy plains.

Alopecurus creticus Trin. – C *(991,2193),* F *(2052),* M *(2082).* Wet grasslands and temporarily inundated plains by freshwater, subsaline grassy flats.

Alopecurus geniculatus L. – E_1 *(2207),* E_2 *(2163).* Subsaline grassy plains.

**Alopecurus myosuroides* Huds. – I_1 *(607),* P *(156).* Disturbed places.

Arundo donax L. – G_2 *(2143).* In ditches, local.

Bromus intermedius Guss. – P *(119).* Damp, saline ground.

Crypsis aculeata (L.) Aiton – C *(2113b),* E_2 *(2056a).* Temporarily inundated depressions disturbed by grazing and damp, grassy subsaline places.

Crypsis alopecuroides (Piller & Mitterp.) Schrad. – C *(2118).* Seasonally wet places.

**Cynodon dactylon* (L.) Pers. – A *(848a),* K *(2106),* N *(364a).* Dry open places, wet ground by roadsides.

Cynosurus echinatus L. – G_2 *(2141),* P *(118).* Grassy places along ditches, by roadsides.

Digitaria sanguinalis (L.) Scop. – G_2 *(2142),* I_1 *(346b),* I_2 *(898).* Wet sandy places along ditches.

Echinochloa crus-galli (L.) Beauv. – C *(2119).* Seasonally wet, disturbed places.

Elymus hispidus subsp. *graecus* Melderis – P *(305a).* Dry, usually sandy or stony ground.

Elymus elongatus (Host) Runemark – N *(358).* Maritime sands and salt marshes.

Elymus pycnanthus (Gordon) Melderis – P *(305b).* Maritime sands and shingles.

Gaudinia fragilis (L.) Beauv. – E_1 *(2205),* E_2 *(2164).* Inland damp, grassy subsaline soils.

**Hordeum marinum* Huds. var. *marinum* – C *(63),* D *(68),* E_1 *(2202),* E_2 *(2172),* N *(912),* P *(115).* Wet grassy or sandy places.

Imperata cylindrica (L.) Raeusch. – I_1 *(347).* Open sandy habitats, by ditches.

Lolium multiflorum Lam. – E_1 *(2155),* I_1 *(605).* Damp, grassy subsaline soils, on roadsides and by ditches.

Lolium rigidum Gaudin subsp. *rigidum* – E_1 *(2206),* E_2 *(2165).* Sandy ground in damp, grassy subsaline flats.

Lophochloa cristata (L.) Hyl. var. *cristata* – A *(605).* Dry, open places.

Lophochloa hispida (Savi) Jonsell – C (*62*). Open, disturbed, moderately wet places.

**Parapholis incurva* (L.) C. E. Hubb. – E_2 *(2149b).* Usually wet, sandy, subsaline soils on grassy flats.

Paspalum distichum L. – A *(848b),* C *(59, 2068),* G_2 *(2142b).* By watercourses, wet meadows and freshwater marshes.

Phalaris arundinacea L. subsp. *arundinacea* – A *(578).* Wet places, shallow water.

**Phragmites australis* (Cav.) Trin. ex Steud. – C *(291),* D *(144),* I_3 *(909),* N *(362),* P *(311).* Reed thickets.

Poa trivialis L. subsp. *trivialis* – I_1 *(60).* Damp places and disturbed ground along ditches.

Polypogon monspeliensis (L.) Desf. – C *(62),* D *(725),* E_1 *(2200),* E_2 *(2170).* Damp places, especially near the sea or in subsaline grasslands.

**Puccinellia festuciformis* (Host) Parl. subsp. *festuciformis* – E_2 *(2173),* L_2 *(2094).* Salt marshes and subsaline wet, grassy places.

Saccharum ravennae (L.) Murray – I_1 *(344).* By the water, on coastal sands.

Setaria pumila (Poir.) Schult. – C *(287).* Wet meadows, damp places by roadsides.

Hydrocharitaceae

Hydrocharis morsus-ranae L. – A *(852),* B *(879),* C *(296, 324a, 843).* Floating on water, ditches and freshwater marshes.

Iridaceae

Iris pseudacorus L. – I_1 *(598).* In shallow water along ditches.

Juncaceae

Juncus acutus L. subsp. *acutus* – C *(61),* D *(67, 376, 587, 726, 889),* E_2 *(2175),* P *(114, 308).* Maritime sands, damp, saline/ subsaline inland soils.

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Juncus fontanesii subsp. *pyramidatus* (Laharpe) Snogerup – O_1 *(2075),* S *(2048)*. Wet, muddy places.

Juncus gerardi Loisel subsp. *gerardi* – E_2 *(2057), (2176).* Salt marshes and damp saline or subsaline grassland inland.

Juncus hybridus Brot. – E_2 *(2168),* I_1 *(602),* O_1 *(2077).* Wet usually saline or subsaline habitats.

Juncus inflexus L. – S *(2049).* Wet grassland and damp, open habitats.

**Juncus maritimus* Lam. – E_1 *(2201),* E_2 *(2171),* G_1 *(2063b),* N *(360),* P *(300)*. Salt marshes and saline meadows.

**Juncus subulatus* Forssk. – D *(727),* M *(2083),* O_1 *(2076),* P *(117).* Salt marshes and other saline or subsaline grassy habitats.

Juncaginaceae

Triglochin bulbosa subsp. *laxiflora* (Guss.) Rouy – F *(2053),* H *(2112)*. Wet subsaline grasslands.

Lemnaceae

Lemna gibba L. – A *(825b, 984b),* I_3 *(911b).* Floating in freshwater.

Lemna minor L. – B *(884),* C *(295, 323, 854, 2070),* D *(386, 892),* I_2 *(349),* I_3 *(374, 911).* Floating in freshwater.

Lemna trisulca L. – A *(985a),* C *(2069).* Floating under the water surface.

Potamogetonaceae

Potamogeton crispus L. – I_2 *(351a).* Ditches.

Potamogeton nodosus Poir. – A *(315, 722, 876),* I_1 *(596, 895),* I_2 *(339, 905)*. Watercourses.

Potamogeton pectinatus L. – A *(286, 319, 723),* B *(882),* D *(387, 593, 731, 891),* I_3 *(351, 904).* Watercourses of the area.

Potamogeton pusillus L. – A *(586a),* D *(594a, 730, 893).* Watercourses.

Ruppiaceae

Ruppia cirrhosa (Petagna) Grande – D *(150, 385, 595, 732),* N *(918),* P *(106).* Saline water, usually near the sea.

Ruppia maritima L. – D *(149, 885),* E_1 *(2156).* Saline water near the sea or temporarily flooded subsaline soils.

Sparganiaceae

Sparganium erectum L. subsp. *erectum* – C *(289, 845, 987, 2071)*. Shallow water in freshwater marshes.

Sparganium erectum subsp. *neglectum* (Beeby) Schinz & Thell. – B *(877).* Shallow water along the river Louros.

Typhaceae

Typha angustifolia L. – C *(988, 2072b, 2120).* Freshwater marshes.

Typha domingensis (Pers.) Steud. – C *(57, 290, 389),* D *(377),* O_1 *(2129),* O_3 *(2079a)*. Shallow water in ditches.

Typha latifolia L. – O_3 *(2079b)*. Shallow water in ditches.

Typha laxmannii Lepech. – O_1 *(2078, 2130),* O_3 *(2080).* Shallow water in ditches and reed swamps.

Zannichelliaceae

Cymodocea nodosa (Ucria) Asch. – P *(107)*. Submerged in shallow saline water.

Zannichellia palustris subsp. *pedicellata* (Wahlenb. & Rosèn) Arcang. – C *(2183),* D *(148, 594b, 894),* Q *(2210)*. Submerged in still, fresh or brackish water.

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2. Comments on the flora

The wetland vascular plant flora of Amvrakikos Gulf includes 182 taxa (146 species, 32 subspecies, 4 varieties) of 114 genera and 50 families. Of the 45 plant taxa listed by Wolff (1968), seven hygrophytes were not found in the study area during our research. The taxa in the floristic catalogue are new records for Amvrakikos Gulf except 24 (marked with an asterisk) previously reported from the investigated area by Wolff (1968).

The occurrence of nine taxa is of special chorological interest and considered more closely:

– *Callitriche truncata* Guss. subsp. *truncata:* References for Greece are few and scattered. *C. truncata* s.l. is known only from Lefkas (Halàcsy 1901), Corfu (Kerkira) (Halàcsy 1901 as *C. autumnalis* L.), NW Peloponnisos (Raabe & Koumpli-Sovantzi 2000) and Mesolongi (Wolff 1968), while subsp. *truncata* has been recorded from Attiki (Koumpli-Sovantzi & Vallianatou 1994), the Tokmakia islets near the NE coast of Lesvos (Edmondson 1982) and from Lesvos itself (Bazos & Yannitsaros 2004).

– *Cotula coronopifolia* L.: This S African species is known only from a few localities in W Greece (Hoffmann 1968, Hansen 1986, Koumpli-Sovantzi 1986, Georgiadis & al. 1990, Sarika-Hatzinikolaou & al. 1992, 1993, Georgiadis & al. 1997) and the island of Lesvos (Hansen & Nielsen 1993). It was recorded from Epirus for the first time by Sarika-Hatzinikolaou & al. (1992, 1993), from the lagoons of Rodia and Koprena and later from the Acheron Delta by Georgiadis & al. (1997). A new locality is added here (near the village Strongili).

– *Cyperus michelianus* subsp. *pygmaeus* (Rottb.) Asch. & Graebn.: The European range of this taxon is restricted to Greece (De Filipps 1980). According to Raus (1991), the first and only European records were from Thessaly (Haussknecht 1899) and the Ionian Islands (Halacsy 1908), until Koumpli-Sovantzi & Vallianatou (1985) added a third record from Lake Lysimachia in Etoloakarnania. Presently, several new Greek localities are known (Raus 1991, Drossos 1992, Boteva & Wolf 2000), most of them situated further north. There are no previous records of this taxon from Amvrakikos Gulf or Epirus.

– *Eleocharis mitracarpa* Steud.: The only previous Greek records of this taxon are from the E Aegean Island of Kos (Tan 1985) and Lake Pamvotis, Epirus (Sarika-Hatzinikolaou & al. 1994). Its finding in the wetlands of Amvrakikos Gulf confirm its presence in mainland Greece and the westernmost known limits of its distribution.

– *Elymus hispidus* subsp. *graecus* Melderis: The finding of this subspecies endemic to SE Greece (Melderis 1980) in the area extends its known range northwards.

– *Glinus lotoides* L.: According to Tan (1997) this species has a scattered distribution in Greece and is fairly rare. There are no previous records from Amvrakikos Gulf and the adjacent area (including Epirus and Etoloakarnania).

– *Rumex kerneri* Borbás: According to Snogerup & Snogerup (1997) this species is rather common in the mountains of Central and N Greece but rarely found at lower altitudes.

– *Salvinia natans* (L.) All.: This species was known from a few localities in Macedonia (Lavrentiades 1956, Pavlidis 1985, Papastergiadou 1990, Drossos 1992) and Lake Avilaria near Vonitsa-Etoloakarnania (Sarlis 1990). In our study area it was found in Louros river and adjacent ditches during 1991 and 1992 but not since.

– *Typha laxmanii* Lepech.: The only previous record of this very rare species in Greece is from marshy places near Leptokaria, Macedonia (Zaganiaris 1940).

3. Vegetation

Thirty-six plant communities have been recognized in the wetland vegetation complex of Amvrakikos Gulf as a result of our phytosociological studies (Sarika & al., in prep.). Depending on their habitat characteristics, these can be placed into the following major groups: a) communities of saline soils, b) communities of sub-saline soils, c) freshwater communities (marshes, reed

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swamps), d) communities of soils periodically inundated by freshwater, e) communities without particular habitat preference, and f) riparian forests.

3.1. Communities of saline soils

Salt marsh vegetation is well-developed covering an extensive area in the studied wetlands. It grows around lagoons and in estuaries, in flat, flooded, muddy zones directly influenced by seawater. Communities characterized by the perennial halophytes *Sarcocornia fruticosa, S. perennis* and *Juncus maritimus* contribute to the physiognomy of the salt marsh vegetation. With the exception of the annual *Salicornia europaea,* which temporarily covers large areas, the communities have a rather restricted distribution and occur as patches or in small zones.

3.2. Communities of subsaline soils

The vegetation of less saline, wet or flooded soils, which occurs further inland, is more diverse and composed of various communities. Where Rodia Lagoon penetrates inland, in shallow sites with brackish water, *Phragmites australis* forms a vast, dense and uniform reed swamp, possibly the largest in Greece, where no other species participate in its floristic composition. A vegetation unit with *Scirpus maritimus* grows mainly along the shores of Rodia Lagoon. This occurs either in sites directly connected with the lagoon and flooded periodically, or inland in wet or slightly inundated soils (marshy places around the villages of Petra and Strongili). In the same area, communities dominated by *Juncus maritimus* and *J. gerardi* colonize subsaline flats on soils saturated with surface or underground water, thus creating impressive dense grasslands. Dense meadows with *Ruppia maritima* exist in permanently submerged places (Tsoukalio, Rodia and Logarou) where the freshwater flow or distance from the sea reduces salinity.

3.3. Freshwater communities

In the floodplains of Louros river, luxuriant aquatic vegetation colonizes the freshwater marshes (communities of free-floating, floating-leaved, and submerged aquatic macrophytes) and reed swamps (communities of emergent herbaceous aquatic macrophytes / helophytes). This vegetation type develops in two more or less distinctive strips (vegetation of freshwater marshes and vegetation of freshwater reed swamps) between the riverside and the dyke separating the floodplain from Rodia Lagoon. Freshwater reed swamps comprise various associations. Freshwater marshes are dominated by the floating-leaved *Nymphaea alba,* while communities of pleustophytes with a dominance of *Lemna gibba, Hydrocharis morsus-ranae* or submerged aquatic macrophytes, e.g. *Ranunculus peltatus* subsp. *baudotii* and *Callitriche truncata,* occur both in the stands with *Nymphaea alba* and in the openings within the reed belt. Aquatic macrophyte communities in freshwater grow also within the ditches of the broader area, in slow-flowing or stagnant water. In freshwater habitats the communities prevailed by either *Callitriche truncata* or *Phragmites australis* and *Typha laxmanii* are of special interest due to the restricted and scattered distribution of their character species in Greece.

3.4. Communities of soils periodically inundated by freshwater

Along the flooded riparian zone of river Louros, a peculiar vegetation type develops on the occasionally inundated open land when the water recedes. This type is represented by a mosaic of short-lived dwarf rush (Isoeto-Nanojuncetea) and creeping communities (Molinio-Arrhenatheretea) that grow on soils with fluctuating water content. The latter are reminiscent of trodden plant carpets and are known as ‘flood swards’. The sites where they flourish are covered with water from time to time, although they may not be waterlogged for months or even several years. The surface area they occupy varies from one year to another depending on the weather and the length of time the soil is inundated. The species participating in the floristic composition of dwarf rush communities except the prevailing *Cyperus michelianus* subsp. *pygmaeus* and *Paspalum distichum* are: *Eleocharis mitracarpa, Glinus lotoides, Trifolium resupinatum, Juncus hybridus, Ranunculus marginatus, Puccinellia festuciformis, Cotula coronopifolia, Cyperus longus, Scirpus maritimus, Alisma plantago-aquatica, Sparganium erectum* and *Lippia nodiflora*.

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The creeping communities are dominated by species such as *Mentha pulegium, M. longifolia* and *Potentilla reptans* and form a patchwork along with communities of *Cyperus longus*. These creeping plants have runners that spread out along the soil surface, quickly covering the bare earth and sending down roots wherever it is damp enough. Other species occurring in this habitat are *Rorippa sylvestris, Trifolium repens* subsp. *repens* and *Juncus inflexus*.

Water level changes are known to influence species distribution and diversity, and ecosystems with permanently low water level usually host rich flora and vegetation. It is also known that in wetlands with periodically lower water levels, new or ephemeral habitats are formed and rare plant taxa often appear (Rorslett 1991). During our research, the following plant taxa with restricted distribution in Greece were recorded in the study area: *Azolla filiculoides, Callitriche truncata* subsp. *truncata, Eleocharis mitracarpa, Glinus lotoides* and *Salvinia natans*.

3.5. Vegetation without particular habitat preference

In Amvrakikos Gulf, scrubs with *Tamarix hampeana* and the community dominated by *Juncus hybridus* and the annual xenophyte *Cotula coronopifolia* are not spatially or ecologically restricted to only one habitat type. They exist in various habitats and cover large areas. These vegetation units should be characterized as eurytopic regarding salinity, as they occur in sites where the soils and water are salty, brackish, or even fresh (scrubs with *T. hampeana*). The wet meadows dominated by the nitrophilous adventive *Cotula coronopifolia* and the dwarf *Juncus hybridus* are widely distributed on soils with various degrees of salinity, throughout the study area. However in sites influenced directly by seawater they are species-poor and characterized by weak structure. Where the lagoons penetrate inland in sites affected by freshwater inflows, these meadows, in contrast, are more species-rich with higher soil coverage. Apart from the dominant *Cotula coronopifolia* and *Juncus hybridus,* the following species also participate in their floristic composition: *Sarcocornia perennis, Polypogon monspeliensis, Limonium narbonense, Alopecurus geniculatus, Gaudinia fragilis, Juncus maritimus, Scirpus cernuus, Plantago coronopus, Sagina apetala, Hordeum marinum, Bellis annua, Anagalis arvensis, Spergularia salina, Trifolium resupinatum, Parapholis incurva* and *Aeluropus littoralis*.

Tamarix hampeana scrubs constitute a substantial vegetation unit in the wetlands of the study area and are used as pastures. The scrubs are particularly representative in the floodplains of the Louros river. They thrive in wet or temporarily inundated saline or subsaline soils along the wetland margins, mainly on their outer sides and along the riverbank, where they participate in the riparian vegetation. In sites totally unaffected by seawater, *T. hampeana* stands are dense and individual plants are vigorous, their canopy creating a thick, impenetrable vegetation layer. In such sites many species are observed within the understorey; constituent species are: *Juncus acutus, J. maritimus, J. gerardi, Limonium narbonense, Cotula coronopifolia, Aster tripolium, Lolium multiflorum, L. rigidum, Rumex conglomeratus, Polypogon monspeliensis, Oenanthe fistulosa, Hordeum marinum, Torilis nodosa, Atriplex patula, Trifolium resupinatum, Sarcocornia perennis, Anagalis arvensis, Alopecurus creticus, Aeluropus littoralis, Puccinellia festuciformis*.

3.6. Riparian forests

Hygrophilous woody vegetation grows along the rivers and rivulets in the area surrounding Amvrakikos Gulf and also in places where the underground water level allows their continued growth. Taxa prevailing in these forests are *Populus alba, P. nigra, Salix alba, S. fragilis, Ulmus minor, Alnus glutinosa, Platanus orientalis* and *Fraxinus angustifolia* subsp. *oxycarpa*. Apart from a few localities, this vegetation type is severely degraded due to grazing and cutting. The hygrophilous Mediterranean *Fraxinus angustifolia* forest community occurs in the study area only in scattered relics of larger forests once present in the area.

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