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Symphyotrichum ciliatum in Romania: trends of spread and invaded plant communities

Abstract: *Symphyotrichum ciliatum* was reported as invasive in Romania in the early 1970s. In this study we have analysed its invasion history, current distribution in Romania, habitat preferences and the associated plant communities. Data recorded during our recent field work, as well as from herbaria and previously published papers, were used in the analysis. This data confirms its invasive character. Given the abrupt increase in the slope of the invasion curve during the last decade, we can assume that *S. ciliatum* is still far from reaching the saturation phase of its invasion in Romania. Habitats invaded by this species are mostly anthropogenic herb stands associated with rail and road transport networks, and the continental inland salt steppes. The classical methodology of the Zürich-Montpellier school was used for the field phytosociological research and the classification of the investigated communities was done using the deductive method. The phytocoenoses dominated by *S. ciliatum* were classified as derivate communities. The description of these communities included data about plant composition, synecology and distribution in the study area.

Keywords: Deductive method, Derivate communities, Distribution map, EUNIS habitats, Invasive neophytes

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1 Introduction

Symphyotrichum ciliatum (Ledeb.) G. L. Nesom (rayless alkali aster) is a species native to North America, ranging from the Rocky Mountains to Alaska, and the steppes of North Eurasia [1-3]. The phyletic origin of this species lies in the New World and its extension across the North Pacific into Asia is apparently relatively recent, during the *Pleistocene* [1].

Symphyotrichum ciliatum was first recorded in eastern Romania in 1967 in Tanacu village (Vaslui county) and on the lowland of the Bahlui River (along the railway lines), in Iaşi city (Iaşi county) and its discovery published 4 years later under the name of *Brachyactis ciliata* [4]. The same name was also later used in all floristic publications referring to this plant in Romania [5-9]. However, taxonomic research conducted by Nesom [1] led to the inclusion of this taxon in the genus *Symphyotrichum* Nees, sect. *Conyzopsis* (Torr. *et* Gray) Nesom, which currently is widely accepted by botanists [2, 3, 10-13].

Concerning its provenance in eastern Romania, it was assumed that *S. ciliatum* was introduced there from the former USSR by railway transport [4] or by naval means. However, spreading by wind cannot be excluded [5]. *S. ciliatum* is also known as an adventive plant species in other European countries including the Republic of Moldova [14, 15], Slovakia (since 1987) [11, 16, 17], Poland (since 2002) [10], and Hungary [13]. The species is also present in European Russia [15] and Ukraine [15, 18], but according to Greuter [12] it is native in both these countries.

S. ciliatum is an annual plant which can reach up to 60 cm in height and flowers between August and October [2, 8]. Its fertilisation is autogamous [10]. North American populations [1, 2], and European [11, 13], are diploid, 2x=14, which has been an important factor in shifting the European plants from the genus *Brachyactis* Ledeb. (x=9) to the genus *Symphyotrichum* Nees (x=7) [13]. Its achenes, accompanied by the pappus, are easily transported by wind [5] right up until the end of October, and seeds are capable of germination after up to ten years [10]. The late flowering and fruiting may be an important feature favouring invasion of *S. ciliatum* by widespread anemochorus seed dispersal during the autumn and winter when the most frequent and strongest winds are registered in Romania [19]. When seed maturity and the dispersal vector coincide, dispersal will be greater [20].

S. ciliatum has a very broad ecological tolerance [10]. According to Chifu *et al.* [7], it is a sub-heliophilous, meso-thermophilous, xero-mesophilous and neutrophilous species, with a large tolerance to variation in nitrogen content of the soil. It can also grow in drier habitats [10] although most authors [2, 3, 5, 8, 10, 21, 22] state that *S. ciliatum* usually prefers moist soils. Another important ecological feature of this species is its halophilous character [2-5, 11, 23]. Diaconescu (1978, unpublished data) supposed, but without experimental evidence, that appreciable amounts of iron oxides on railway embankments would promote growth of this plant.

In its natural habitat *S. ciliatum* grows in moist, brackish soils, prairies, steppes, salt marshes, summer-receding prairie ponds, solonchak meadows, damp riverbanks, irrigation channels, winter-salted highways, railroads, waste grounds [2, 3, 21, 22].

In Romania, the species was usually reported as growing in disturbed, ruderal habitats on moderately salty and moist soils [4, 5, 24]. On the Black Sea coast, *S. ciliatum* grows on wet salty sands [5]. In other European regions, the species has been reported in various disturbed habitats, usually on moist soils [10, 15, 16]. According to Bróż and Podgórska [10] and Szymański [25] in Poland, this species is found in open habitats with freshly disturbed substrate, such as: storage places of industrial waste, tailings ponds and their surroundings, along roads, railway tracks, ditches or small watercourses, on periodically flooded depressions, or on open ground with a mixture of clay and crushed Devonian limestone in some limestone quarries.

In phytosociological terms, a short time after the first identification of this species in eastern Romania (Moldavia), Pop and Viţălariu [4] described a new ruderal plant association named *Erigero canadensis-Brachyactetum ciliatae*, on generally humid and salty depression lands on the floodplain of the Bahlui river (eastern Romania). Other phytocoenoses of this association were subsequently recorded, in the same region [24, 26]. Dihoru [5] reported *S. ciliatum* on the coastline of the Black Sea, together with some other species ecologically adapted to the maritime sands. In the city of Cluj-Napoca (north-western-central Romania) it has recently been reported in the presence of some hygro-halophilous species [27]. In addition, *S. ciliatum* was recorded in Romania as an accompanying species with low values of abundance-dominance (AD) and constancy (K), in the structure of various ruderal plant communities [7, 28-31].

In Poland [10], populations of *S. ciliatum*, with various densities, are components of some unspecified pioneer anthropogenic communities. Szymański [25] also reported *S. ciliatum* as an accompanying species in unspecified communities of the order *Plantaginetalia majoris*, and especially of the alliances *Agropyro-Rumicion crispi* and *Spergulo-Oxalidion* (*Eu-Polygono-Chenopodion*). Nobis *et al.* [32] recorded this species in phytocoenoses of the association *Typhetum laxmannii*.

In Midwest North America, *S. ciliatum* was reported on alkaline and moderately to strongly saline soils as a weed in halophytic short and mid-height grasses classified as "*Distichlis spicata*-(*Hordeum jubatum*, *Poa arida*, *Sporobolus airoides*) Herbaceous Vegetation" [23].

Given its ability to spread, grow abundantly and tendency to form mono-dominant communities on lands well supplied with water and generally saline, *S. ciliatum* can be considered a dangerous adventive species in Romania which can affect native plant communities characteristic of such habitats [9, 27].

In this study, we aim to analyse the current data of spread history and habitat preferences during invasion of *S. ciliatum* in Romania and to classify communities dominated by *S. ciliatum* identified in eastern Romania (the historical province of Moldavia). We have applied the deductive method algorithm of syntaxonomic classification as published by Kopecký *et al.* [33]. Finally we aim to analyze the structural and ecological features of these plant communities from the study area.

2 Experimental Procedures

2.1 Data collection

To reconstruct the history of invasion of *S. ciliatum* in Romania all occurrence data in this country, up to 2011, were registered: recent unpublished records of the authors, between the years of 2009 and 2011, those from public herbaria (abbreviations according to Holmgren *et al.* [34]: BUAG, BUC, CL, I, IAGB, and IASI), and data from literature [5, 9]. Specimens collected during our field works are deposited in IASI. Repeated reports on the occurrence from the same locality and the same year were treated as a single record.

Habitats invaded by *S. ciliatum* were designated according to the European Nature Information System (EUNIS) classification [35].

Phytocoenoses dominated by *S. ciliatum* were investigated in the historical province of Moldavia (eastern Romania) during our recent field works on adventive plants (years 2009-2011). Relevés were registered in all places where we found *S. ciliatum* with a coverage greater than 60%. In addition, we also processed all previously published relevés with *S. ciliatum* as a dominant species. A total of 32 relevés were analyzed -14 newly recorded by us, and 18 taken from literature as follows: 14 relevés from Pop and Viţălariu [4], 3 from Oprea *et al.* [24], and 1 from Viţălariu *et al.* [26].

Phytosociological studies were conducted according to the classical methodology of the Zürich-Montpellier school [36-39]. In each relevé, the following data were recorded: geographic coordinates using eTrex Legend HCx GPS, relevé surfaces, total coverage (%), species composition, species abundance-dominance (AD), and vegetation height (cm). The relevé areas were between 4 and 50 m^2.

2.2 Data analysis

The distribution map of *S. ciliatum* in Romania was made using the Universal Transverse Mercator (UTM) grid system [40, 41]. The Romanian territory is divided into squares of 100×100 km through vertical lines (columns) and horizontal lines (series). Western Romania is included in columns D-G and series P-U, and eastern Romania between columns K-Q and series J-P. Each basic square is subdivided into 100 elementary squares of 10×10 km. All records (*i.e.* points of occurrence, localities) of *S. ciliatum* were marked on the map based on the locality code within the 10×10 km squares [40]. The invasion curve, *sensu* Pyšek and Prach [42], of *S. ciliatum* in Romania was graphically represented by plotting cumulative number of records against time.

Habitats invaded by *S. ciliatum* in Romania were graphically represented, and the relationships between the number of years since the first registration and the number of types of invaded habitats were analyzed using Pearson correlation, with *ln-transformed values*. The program XLSTAT (version 2011) was used for the statistical analyses.

The degrees of fidelity of characteristic- and differential species of all syntaxa were established by comparing published data from Romania [7, 43, 44] with our own phytosociological observations from the study area. In some critical cases, major works from other European regions [45-51] were also considered, to clarify the diagnostic value of species.

Communities dominated by *S. ciliatum*, from eastern Romania, were classified after Kopecký *et al.* [33, 48, 49]. The analysed communities were further described as derivate communities (d.c.), *sensu* Kopecký and Hejný [33, 52, 53], if all the required criteria [33] were satisfied. Some types were represented by less than 5 relevés but still affiliated to certain higher syntaxa.

An overview of all analyzed communities was graphically represented on the basis of the syntaxonomic significance of diagnostic species of individual classes of the system applied in classifying communities, expressed in percentages [48, 49]. The communities identified on the basis of the relevés recorded by us were included within a phytosociological table.

To characterize the analyzed communities, the proportions of life forms and phytogeographical elements [8] were calculated using both the number of species and the cumulative mean coverage of the species from a given category. The mean indicator values for light (L), temperature (T), soil moisture (M), soil *p*H (R), nitrogen (N), and salt content (S) of soil were also assessed based on the number of species from a given category [54]. Species indicator values followed scales of Ellenberg *et al.* [55], with some modifications on plant halophilism according to Bucur *et al.* [56-58].

The comparison among plant communities dominated by *S. ciliatum* has been done both by the classical method, with special regard to the characteristic- and differential plant species [36-39], and by cluster analysis using PC-ORD software on the basis of absolute coefficients of representation (Q^{abs}) of syntaxonomic classes within the each relevé [33], with the Sørensen (aka Bray-Curtis) distance measure and the group average linkage method [59].

The system of syntaxonomic units from Romania and the names of the cited syntaxa in this paper follow Coldea [44]. The nomenclature of derivate communities is consistent with Kopecký *et al.* [33]. Plant nomenclature follows Tutin *et al.* [60, 61], except for *Symphyotrichum ciliatum* [1] and *Xanthium orientale* subsp. *italicum* [12].

3 Results

3.1 The distribution of Symphyotrichum ciliatum in Romania and the invaded habitat types

According to the data from literature and our recent field investigations, *S. ciliatum* has been reported so far in Romania from 92 localities (Figure 1). Of these, 30 were newly recorded during our field research, between 2009 and 2011, representing one third of the total records.

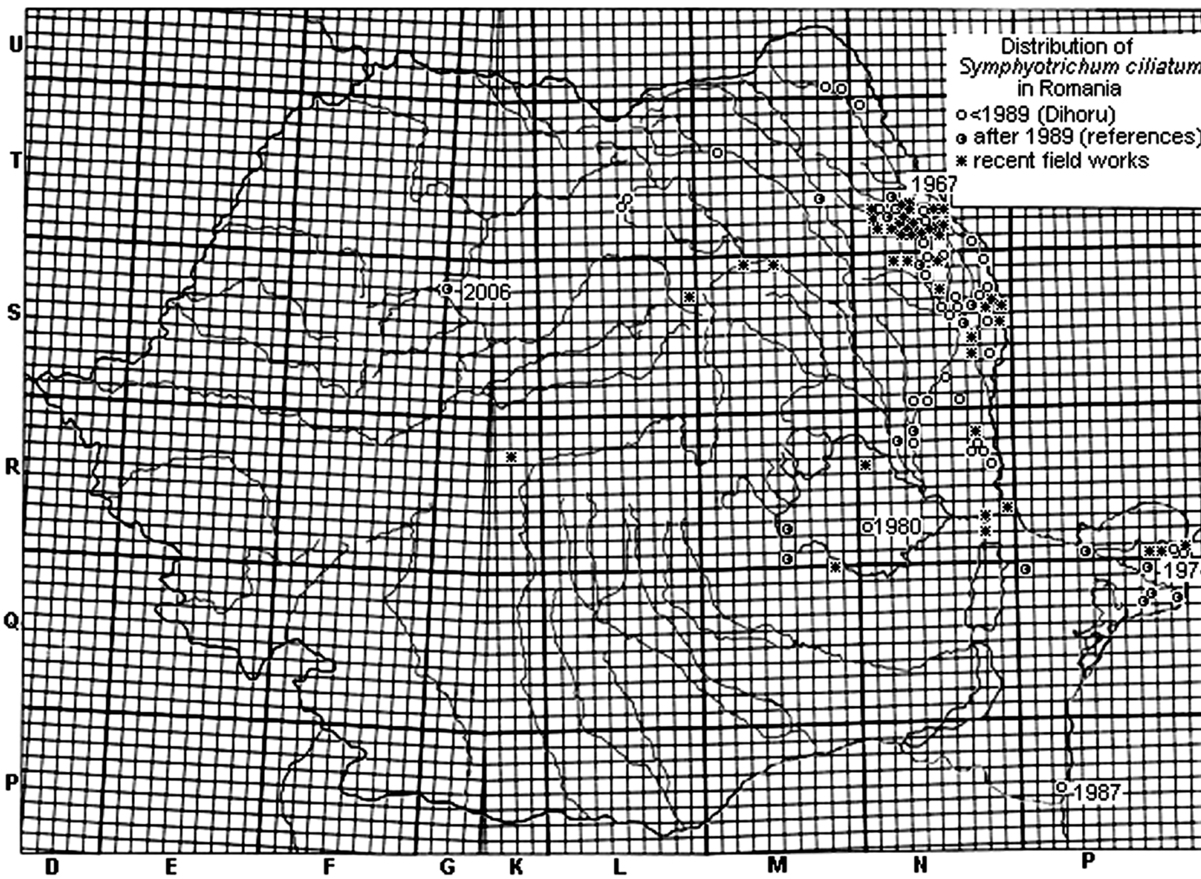

Figure 1. Distribution of *Symphyotrichum ciliatum* in Romania, between 1967 and 2011, on the UTM map. Years of the oldest records for different regions are indicated.

The greatest spread of this species was registered in Moldavia (75 localities), where it occurs mainly on depression lands along some rivers (*e.g.* Prut, Elan, Bârlad, Bahlui, Jijia), on generally wet and salty soils. The species was more common in the plain and plateaux regions, but it was also recorded in some mountainous areas (*e.g.* Dornişoara, Poiana Stampei, Gura Humorului - Suceava county, Piatra Neamţ, and Bicaz - Neamţ county). To a lesser extent, the species has spread into the north Dobrudja - Danube Delta (9 localities), south Dobrudja (1 locality), Muntenia (4 localities) and Transylvania (3 localities). Based on currently available data, *S. ciliatum* was not been found in Oltenia, Banat, Crişana and Maramureş historical provinces. The invasion curve (Figure 2) has increased constantly since 1967 (*i.e.* the first collection year), and in the last decade an abrupt increase in spread has been noted.

The number of individuals of *S. ciliatum* varied considerably depending on locality and habitat type from a few isolated individuals on roadsides in mountain localities, such as the Bicaz town, up to thousands of individuals grouped in large populations over tens or hundreds of square meters on ruderal, wet and salty fields, in localities from the plain regions.

There was a very significant positive relationship between the number of years since the first record and the number of different types of invaded EUNIS habitats ($r=0.82$, $F_{1,41}=86.16$, $P<0.0001$). Most commonly, *S. ciliatum* was found in anthropogenic herb stands (E5.1), habitats associated with rail and road transport networks (J4), and in continental inland salt steppes (E6.2). Other invaded habitats were: littoral sand and muddy sand (A2.2), unvegetated or sparsely vegetated shores with soft or mobile sediments (C3.6), periodically inundated shores with pioneer vegetation (E3.5), riparian and gallery woodland with dominant *Alnus*, *Betula*, *Populus* or *Salix* (G1.1), and trampled areas (H5.6) (Figure 3). It has not been reported yet in agricultural crops.

S. ciliatum has been previously reported growing with other more or less halophilous plant species, in various plant communities (Table 1), as an accompanying or dominant species. During our field investigation in

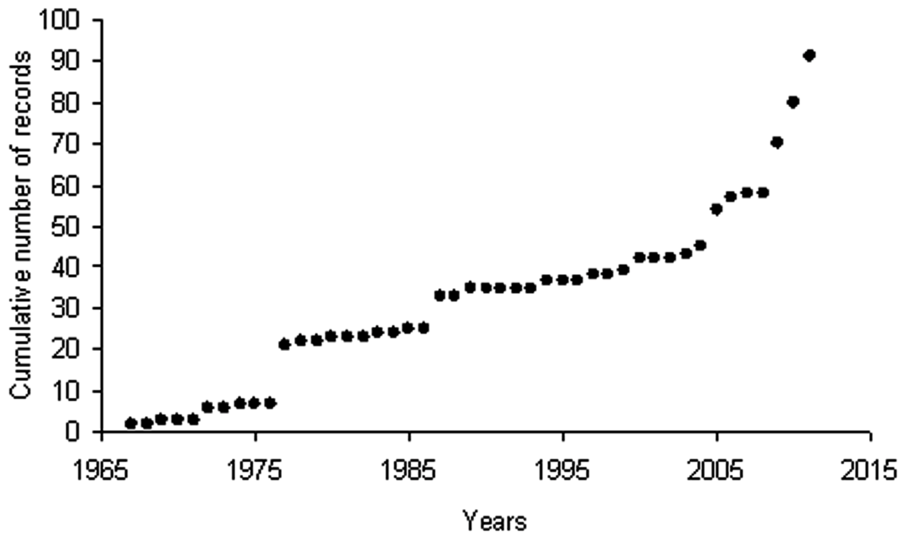

Figure 2. Invasion curve of *Symphyotrichum ciliatum* in Romania. Data are expressed as cumulative number of records (*i.e.* number of localities) per 10-years periods.

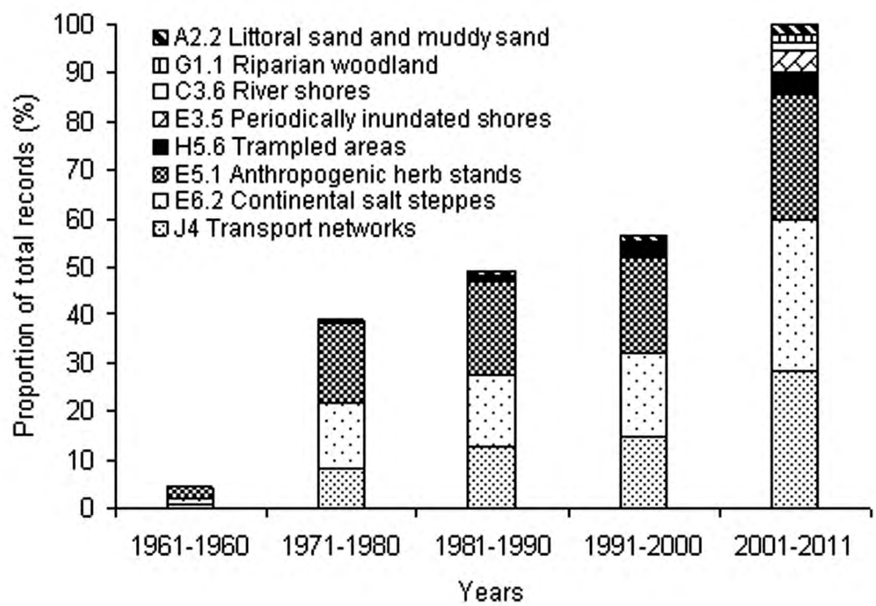

Figure 3. EUNIS Habitat types invaded over time, in Romania, by *Symphyotrichum ciliatum*. Data are expressed as percentages of total records per 10-years periods. EUNIS habitat names are abbreviated; for full names, see the text.

eastern Romania, we found *S. ciliatum* as a dominant species on temporary inundated and salty ground in certain phytocoenoses that could not be assigned to a previously described plant community.

3.2 Plant communities dominated by S. ciliatum in eastern Romania

Within the 32 relevés (location details of all relevés recorded during our field investigation is shown beneath Table 2) a total number of 100 plant species was recorded, varying between 8 and 40 species per relevé, with a mean ± standard difference (SD) of 20.3±7.8.

S. ciliatum was the leading species (*i.e.* dominant species which influences the entire physiognomy of the phytocoenoses) in all analyzed relevés, with several hundreds of individuals per square meter and cover up to 100% (Figure 4). *Atriplex prostrata* was subdominant in a single phytocoenosis, but commonly its cover was less than 10%.

Table 1. Plant communities with *Symphyotrichum ciliatum* in Romania, and associated EUNIS habitat types. Abundance-dominance (AD, minimum-maximum), and constancy (K) values for the species *S. ciliatum* are shown. Both data from literature and our field research were used.

Plant communities	**EUNIS habitat type**	**Total relevés**	**AD**	**K**	**Source of data**
Not specified	A2.2	-	-	-	[5]
Duchesneetum indicae	H5.6	10	+	r	[30]
Eragrostio poaeoides-Panicetum capillaris	J4	10	+	I	[29]
Panico capillare-Kochietum sieversianae	J4	13	+	II	[31]
Ambrosietum artemisiifoliae	E5.1 & J4	34	+	I	[own field research]
		7	+-1	III	[28]
Artemisietum annuae	E5.1	11	+	r	[own field research]
Berteroetum incanae	E5.1	19	+	I	[7]
Xanthietum spinosae	E5.1	20	+	r	[own field research]
Erigero canadensis-Brachyactetum ciliatae (treated as derivate communities dominated by *S. ciliatum*, in this paper)	E5.1	14	3-5	V	[4]
		3	2-4	V	[24]
		1	5	V	[26]
Derivate communities dominated by *S. ciliatum* (in this paper)	E6.2, E3.5	14	4-5	V	[own field research]

EUNIS habitat types: A2.2 – Littoral sand and muddy sand, E3.5 – Periodically inundated shores with pioneer vegetation, E5.1 – Anthropogenic herb stands, E6.2 – Continental inland salt steppes, H5.6 – Trampled areas, J4 – Habitats associated with rail and road transport networks.

Table 2. Plant communities dominated by *Symphyotrichum ciliatum* in eastern Romania, recorded during field work (2009-2011). Relevés no. 1-3: Communities classified within the alliance *Cypero-Spergularion salinae*, 4-6: Communities classified within the order *Scorzonero-Juncetalia gerardii*, 7-12: d.c. *Symphyotrichum ciliatum-[Bidentetalia tripartiti]*, 13: d.c. *Symphyotrichum ciliatum-[Malvion neglectae]*, 14: Transitional community between the alliances *Atriplicion nitentis* and *Malvion neglectae*.

Altitude (m, a. s. l.)	**43**	**45**	**42**	**19**	**20**	**18**	**145**	**73**	**67**	**9**	**120**	**79**	**80**	**67**
Aspect	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**E**	**SV**	**-**	**V**	**-**	**-**	**-**
Slope (°)	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**3**	**-**	**2**	**-**	**-**	**-**
Coverage (%)	**90**	**100**	**85**	**70**	**85**	**75**	**90**	**100**	**70**	**70**	**70**	**90**	**80**	**70**
Surface (m²)	**50**	**10**	**50**	**4**	**25**	**20**	**25**	**15**	**15**	**10**	**10**	**50**	**10**	**10**
Number of species	**10**	**8**	**11**	**9**	**9**	**20**	**15**	**14**	**11**	**13**	**11**	**14**	**18**	**21**
Relevé number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Dominant species														
Symphyotrichum ciliatum	5	4	5	4	5	4	5	5	4	4	4	5	4	4
Thero-Salicornietea														
Suaeda maritima (ch, 4)	+	-	+	-	-	-	-	-	-	-	-	-	-	-
Crypsidetalia aculeatae & Cypero-Spergularion salinae														
Chenopodium glaucum (ch, 3)	+	+	1	+	-	+	+	+	-	-	+	+	+	+
Atriplex prostrata (dif, 3)	+	3	1	+	1	+	.	+	-	-	-	-	1	+
Spergularia media (ch, 4)	+	+	+	+	-	+	-	-	-	-	-	-	-	-
Crypsis schoenoides (ch, 4)	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Crypsis aculeata (ch, 5)	-	+	-	-	-	+	-	-	-	-	-	-	-	-
Festuco-Puccinellietea														
Aster tripolium subsp. *pannonicus* (ch, 5)	+	-	+	+	-	+	-	+	-	-	-	-	-	-
Puccinellion limosae														
Puccinellia distans subsp. *limosa* (ch, 5)	-	+	-	-	-	+	-	-	-	-	-	-	-	-

continued **Table 2**. Plant communities dominated by *Symphyotrichum ciliatum* in eastern Romania, recorded during field work (2009-2011). Relevés no. 1-3: Communities classified within the alliance *Cypero-Spergularion salinae*, 4-6: Communities classified within the order *Scorzonero-Juncetalia gerardii*, 7-12: d.c. *Symphyotrichum ciliatum-[Bidentetalia tripartiti]*, 13: d.c. *Symphyotrichum ciliatum-[Malvion neglectae]*, 14: Transitional community between the alliances *Atriplicion nitentis* and *Malvion neglectae*.

Relevé number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Hordeum hystrix (ch, 4)	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Festucion pseudovinae														
Bupleurum tenuissimum (ch, 4)	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Scorzonero-Juncetalia gerardii														
Trifolium fragiferum (ch, 4)	+	-	-	-	-	-	+	-	-	-	-	-	-	-
Juncus gerardi (ch, 4)	-	-	+	+	+	+	+	-	-	-	+	-	-	-
Scirpus maritimus (dif, 3)	-	-	+	-	-	+	-	-	-	-	-	-	-	-
Lotus tenuis (ch, 4)	-	-	-	+	+	+	-	-	+	+	+	+	+	-
Bidentetea & Bidentetalia tripartiti														
Xanthium orientale subsp. *italicum* (dif, 3)	-	-	+	-	+	+	+	+	+	+	+	+	+	+
Bidens tripartita (ch, 5)	-	-	-	-	-	+	+	+	+	+	+	+	-	-
Polygonum lapathifolium (ch, 4)	-	-	-	-	-	+	+	+	+	+	+	+	+	-
Rumex conglomeratus (ch, 3)	-	-	-	-	-	-	+	-	-	-	-	+	-	-
Echinochloa crus-galli (ch, 3)	-	-	-	-	-	-	-	+	-	+	+	+	-	-
Chenopodium polyspermum (dif, 3)	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Potentilla supina (ch, 3)	-	-	-	-	-	-	-	-	-	+	-	+	+	+
Bidention tripartiti														
Pulicaria vulgaris (ch, 4)	-	-	-	-	-	+	-	+	-	-	-	-	-	+
Artemisietea vulgaris														
Dauco-Melilotion														
Daucus carota (ch, 4)	-	-	-	-	-	-	-	-	-	+	+	-	-	-
Festuco-Brometea														
Artemisia austriaca (ch, 4)	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Molinio-Arrhenatheretea														
Trifolium repens (ch, 3)	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Potentillo-Polygonetalia														
Agrostis stolonifera (ch, 4)	+	+	+	-	-	-	1	-	-	1	+	-	-	-
Inula britannica (ch, 3)	-	-	-	-	-	-	+	-	+	-	-	-	-	+
Althaea officinalis (ch, 3)	-	-	-	-	-	-	+	-	-	-	-	-	-	+
Rorippa sylvestris (ch, 4)	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Potentilla reptans (ch, 4)	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Rumex confertus (ch, 4)	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Galio-Urticetea														
Rumex obtusifolius (dif, 3)	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Stellarietea mediae														
Polygonum aviculare (ch, 3)	+	+	+	-	+	+	+	-	+	-	-	-	+	+
Amaranthus retroflexus (ch, 4)	-	-	-	-	+	-	-	-	-	-	-	-	-	+
Ambrosia artemisiifolia (ch, 4)	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Matricaria perforata (ch, 4)	-	-	-	-	-	-	-	-	+	-	-	-	-	+
Setaria pumila (ch, 4)	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Sisymbrietalia														
Atriplex tatarica (ch, 4)	-	-	-	+	-	+	-	-	-	-	-	-	-	-
Conyza canadensis (ch, 4)	-	-	-	-	-	-	-	-	-	-	-	-	+	+
Malvion neglectae														
Verbena officinalis (ch, 3)	-	-	-	-	-	-	-	+	-	+	-	+	+	-
Malva neglecta (ch, 5)	-	-	-	-	-	-	-	-	-	-	-	+	+	+
Xanthium spinosum (ch, 4)	-	-	-	-	-	-	-	-	-	-	-	-	+	+
Atriplicion nitentis														
Artemisia annua (ch, 4)	-	-	-	-	-	-	-	+	-	-	-	-	+	+
Atriplex patula (ch, 3)	-	-	-	-	-	-	-	-	-	+	-	-	-	+
Iva xanthifolia (ch, 5)	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Eragrostetalia														

continued **Table 2**. Plant communities dominated by *Symphyotrichum ciliatum* in eastern Romania, recorded during field work (2009-2011). Relevés no. 1-3: Communities classified within the alliance *Cypero-Spergularion salinae*, 4-6: Communities classified within the order *Scorzonero-Juncetalia gerardii*, 7-12: d.c. *Symphyotrichum ciliatum-[Bidentetalia tripartiti]*, 13: d.c. *Symphyotrichum ciliatum-[Malvion neglectae]*, 14: Transitional community between the alliances *Atriplicion nitentis* and *Malvion neglectae*.

Relevé number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Portulaca oleracea (ch, 4)	-	-	-	-	-	+	-	-	-	-	-	+	+	+
Polygono arenastri-Poëtea annuae														
Plantago major (ch, 4)	-	-	-	-	-	+	+	+	1	-	-	+	+	1
Lolium perenne (dif, 3)	-	-	-	-	-	-	+	-	+	-	-	-	-	1
Other species (non-diagnostic)														
Cuscuta campestris	-	-	-	-	+	+	-	-	-	-	-	-	+	-
Plantago lanceolata	-	-	-	-	-	-	-	-	-	+	-	-	+	.
Beta trigyna	-	-	-	-	-	-	-	-	-	-	-	-	-	+

ch – characteristic species, dif – differential species (the numbers attached to these symbols indicate the values of species fidelity).
Place and date of relevés: **1, 2, 3** – Găgeşti (Vaslui county), clogged ponds, along the Elan River (46º19′30.74′′N, 27º58′23.71′′E; 46º19′27.83′′N, 27º58′24.33′′E; 46º19′25.07′′N, 27º58′27.72′′E, respectively), 08.08.2010; **4** – Oţetoaia-Lunca Banului (Vaslui county), Prut River floodplain (46º34′32.49′′N, 28º10′42.04′′E), 09.08.2010; **5** – Lunca Banului (Vaslui county), Prut River floodplain (46º35′50.27′′N, 28º10′37.82′′E), 09.08.2010; **6** – Stănileşti (Vaslui county), Prut River floodplain (46º36′19.95′′N, 28º10′56.91′′E), 11.09.2011; **7** – Grieşti-Ţibăneşti (Iaşi county), on the floodplain of a tributary of the Sacovăţ River, in the South of Iaşi county (46º54′08.52′′N, 27º22′41.51′′E), 13.08.2009; **8** – Dumeşti (Iaşi county), the bank of a pond along of a tributary of Bahlui River (47º10′07.33′′N, 27º19′44.99′′E), 15.08.2009; **9** – Scopoşeni (Iaşi county), ditch, beside the road (47º07′44.41′′N, 27º24′28.34′′E), 04.08.2009; **10** – Barboşi-Galaţi (Galaţi county), silted channel (45º24′28.79′′N, 27º59′44.48′′E), 07.08.2010; **11** – Munteni de Sus (Vaslui county), muddy ground in a tributary valley of the Vaslui River (46º41′24.05′′N, 27º46′09.49′′E), 26.08.2010; **12** – Guşiţei-Dimitrie Cantemir (Vaslui county), disturbed wet grassland grazed by domestic geese, on the Elan River floodplain (46º27′42.54′′N, 28º01′50.57′′E), 08.08.2010; **13** – Guşiţei-Dimitrie Cantemir (Vaslui county), disturbed grassland grazed by domestic geese, on the Elan River floodplain (46º27′31.91′′N, 28º01′53.24′′E), 08.08.2010; **14** – Lungani (Iaşi county), disturbed wet grassland grazed by domestic geese and pigs, on the floodplain of a tributary of Bahlueţ River (47º13′10.90′′N, 27º09′36.26′′E), 04.08.2009.

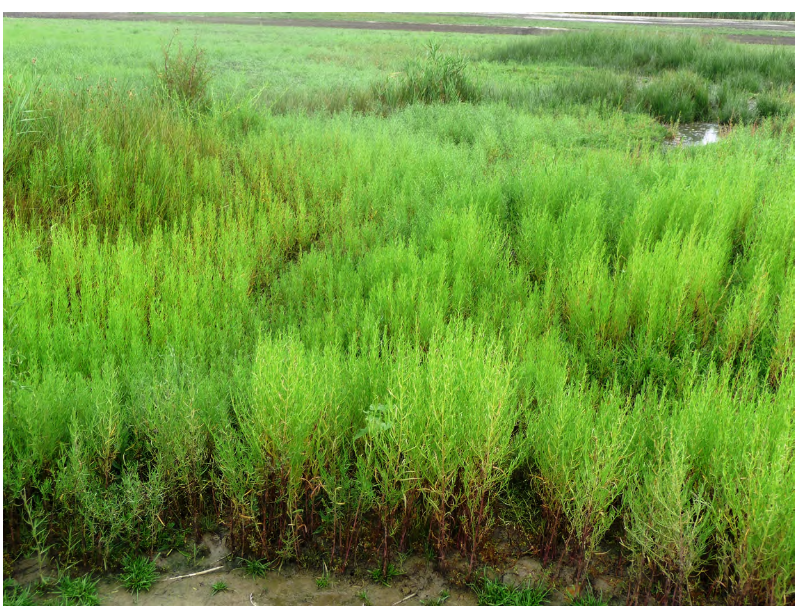

Figure 4. Phytocoenosis dominated by *Symphyotrichum ciliatum*, in Găgeşti village (Vaslui county), on a clogged pond along the Elan River.

The phytocoenoses were quite dense at their maximum development, and more or less bi-layered. The lower layer, up to 10-40 cm high, with cover up to 20-30% was represented by various species depending on the habitat. This lower layer was more obvious after drying of temporarily flooded lands in late spring and early summer, before the massive germination and growth of *S. ciliatum* plants. The upper layer, of 30 - 60 cm height, with a cover of 40-100%, reaches a maximum development in late summer and in autumn at the flowering and fructification of *S. ciliatum*.

Therophytes clearly prevailed in the structure of life forms of all phytocoenoses (61% of species with a cover of 96% per relevé), while hemicryptophytes represented on average 24% of life forms and and had only 4% of the vegetation cover. Other life forms were less represented (Figure 5).

Eurasian (42% per relevé) and adventive (21% per relevé) species dominated the phytogeographical spectrum of all phytocoenoses (Figure 6). Adventive species clearly prevailed in the *cover* (93% per relevé).

The analyzed phytocoenoses were quite similar regarding the preferences to light (coefficient of variability, CV=3.1%), temperature (CV=4.7%), soil *p*H (CV=3.6%), and (to some extent) soil nitrogen content (CV=9.1%), but quite different regarding the preferences to soil moisture (CV=13.7%), and especially to soil salinity (CV=32.4%) (Figure 7). A large number of species (52%) had a wide tolerance to soil *p*H.

The stands were found in 11 localities from the eastern Romania (Moldavia historical province), between 9 and 145 m a.s.l., in steppe and forest-steppe vegetation zones, in various disturbed habitats, on plains or slightly inclined lands. The soils were usually temporary flooded and, given the presence of both facultative and obligate halophilous plants (see below), generally saline.

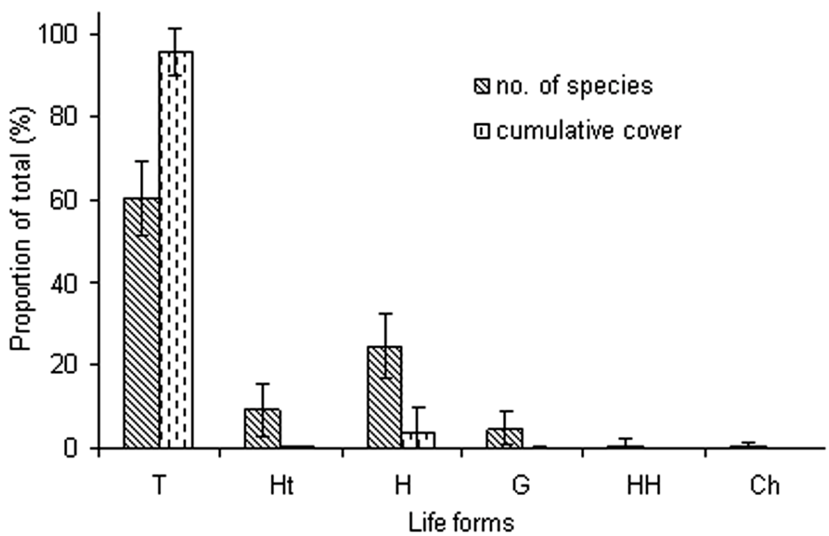

Figure 5. Mean values (± standard differences) of life forms in phytocoenoses dominated by *Symphyotrichum ciliatum*, from eastern Romania (Ch – chamaephytes, G – geophytes, H – hemicryptophytes, Ht – hemitherophytes, HH – helo-hydatophytes, T – therophytes).

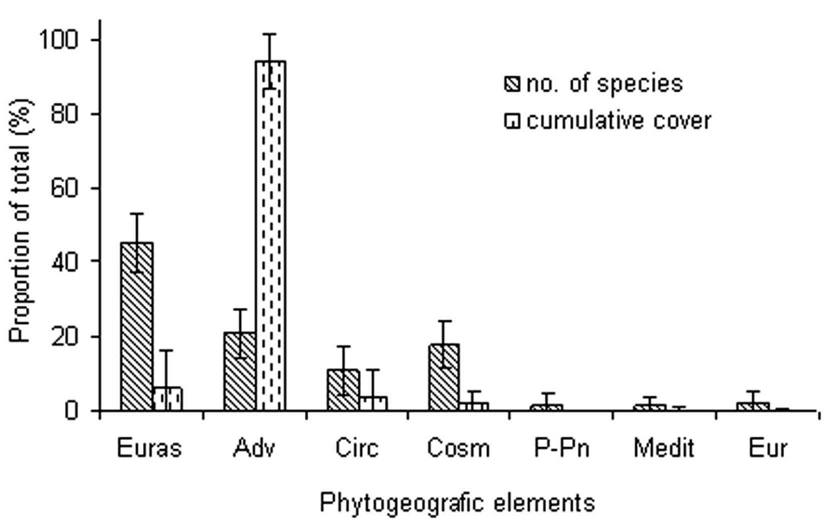

Figure 6. Mean values (± standard differences) of phytogeographical elements in phytocoenoses dominated by *Symphyotrichum ciliatum*, from eastern Romania (Adv – Adventive, Circ – Circumpolar, Cosm – Cosmopolitan, Eur – European, Euras – Eurasian, Medit – Mediterranean, P-Pn – Pontic-Pannonian).

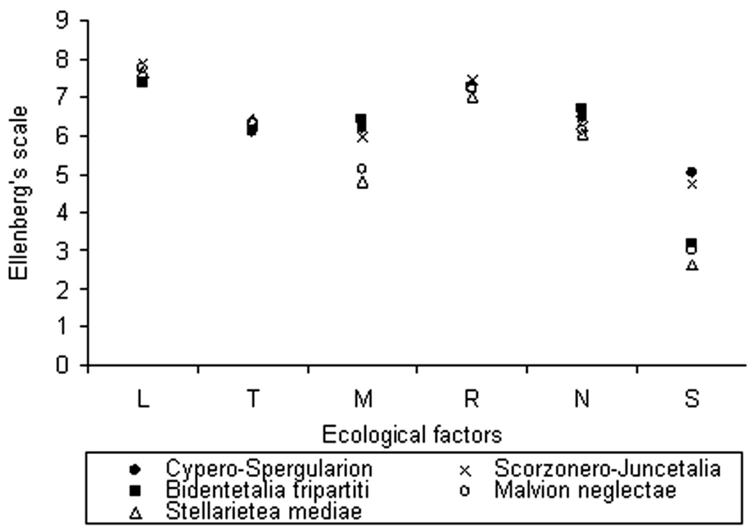

Figure 7. The average values of ecological indices in phytocoenoses dominated by *Symphyotrichum ciliatum*, which were affiliated to various syntaxa (L – light, T – temperature, M – soil moisture, R – soil *p*H, N – soil nitrogen content, S – soil salinity). Only communities with at least 3 relevés were represented.

A total number of 10 species in the studied phytocoenoses are obligate halophytes (*Aster tripolium* subsp. *pannonicus*, *Atriplex littoralis*, *Crypsis aculeata*, *Crypsis schoenoides*, *Hordeum hystrix*, *Juncus gerardi*, *Lotus tenuis*, *Puccinellia distans* subsp. *limosa*, *Spergularia media*, *Suaeda maritima* subsp. *maritima*). One third of species were preferential halophytes or salt-tolerant species, while about one third of species were non-halophilous.

The plant composition was also different among the analyzed phytocoenoses. Halophilous species, diagnostic for classes *Thero-Salicornietea* and *Festuco-Puccinellietea*, were most numerous (44 - 78%) in 6 phytocoenoses (relevés 1-6, Table 2). Nitro-hygrophilous species of the class *Bidentetea tripartiti* predominated (27 - 43%) in the other 6 phytocoenoses (relevés 7-12, in Table 2), while diagnostic species of the class *Stellarietea mediae* were most numerous (27 - 50%) in 20 phytocoenoses. Species diagnostic for classes *Molinio-Arrhenatheretea*, *Polygono arenastri-Poëtea annuae*, *Artemisietea vulgaris* and other syntaxa were less represented.

All the 32 phytocoenoses dominated by *S. ciliatum* were syntaxonomically classifiable (i.e. the coefficient of representation of diagnostically valueless species, Qh < 0.5). Using the algorithm of the deductive method, the phytocoenoses were grouped in seven types of plant communities, briefly described below. An overview, expressing syntaxonomic importance of diagnostic species of classes participating in the plant composition of the seven communities is shown in Figure 8.

(1) Communities classified within the alliance *Cypero-Spergularion salinae* (relevés 1-3, Table 2). These are hygrophilous, ± nitrophilous, halophilous, pioneer communities, with a low biodiversity (8-11 species per relevé), situated on moist, salty alluvia, of some clogged ponds. Diagnostic species of the class *Thero-Salicornietea* prevail in plant composition and have the highest syntaxonomic significance.

(2) Communities classified within the order *Scorzonero-Juncetalia gerardii* (relevés 4-6, Table 2). These are meso-hygrophilous, moderately nitrophilous, halophilous communities, with a pretty low biodiversity (9-20 species per relevé). They are situated on salty soils, in strongly disturbed hygro-halophilous grasslands. Diagnostic species of the class *Festuco-Puccinellietea* are the best represented in the plant composition.

(3) D.c. *Symphyotrichum ciliatum-[Bidentetalia tripartiti]* (relevés 7-12, Table 2). These are hygro-nitrophilous, slightly halophilous, pioneer communities, with a pretty low biodiversity (11-21 species per relevé), situated on moist, eutrophic grounds. Diagnostic species of the class *Bidentetea tripartiti* prevail in the plant composition and have the highest syntaxonomic significance.

(4) D.c. *Symphyotrichum ciliatum-[Stellarietea mediae]* (relevés 2, 4 - 9, 12 and 14, in Pop and Viţălariu [4], relevés 1 - 3, in Oprea *et al.* [24]). These are ruderal communities, richer in species (19-31 per relevé), mesophilous, nitrophilous, and much weaker halophilous. They have fewer diagnostic species of halophilous or hygro-nitrophilous vegetation. In contrast, diagnostic species of the class *Stellarietea mediae* are the most numerous, and have higher syntaxonomic significance. In addition,

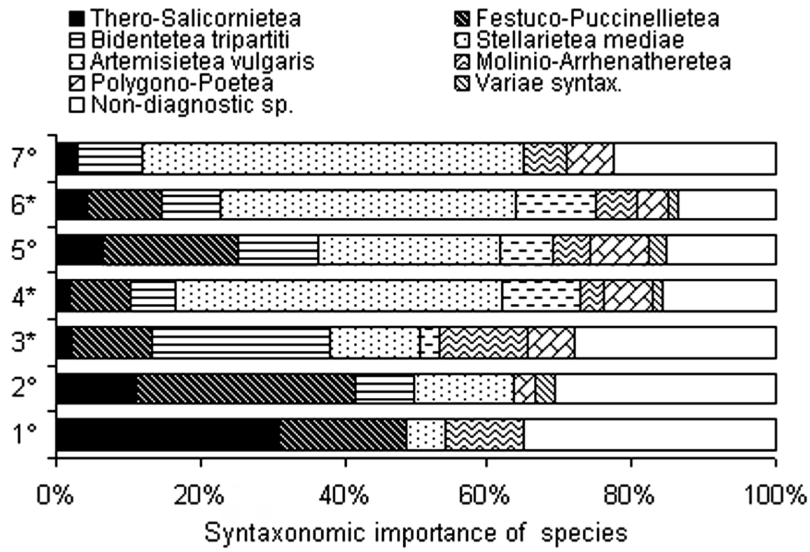

Figure 8. Syntaxonomic importance of the diagnostic species of the classes participating in communities dominated by *Symphyotrichum ciliatum*, in eastern Romania. The values represent absolute coefficients of representation (Q^{abs}) of classes per relevé, expressed in %. On the left, are serial numbers of the communities described in the text (* at least 5 relevés, ° less than 5 relevés). Both relevés from literature and own field research were used.

the species of the class *Artemisietea vulgaris* are well represented.

(5) Transitional communities between the class *Stellarietea mediae* and the order *Scorzonero-Juncetalia gerardii* (relevés 3 and 10, in Pop and Viţălariu [4]). These are ruderal, mesophilous, hygro-halophilous communities, dominated by *S. ciliatum*. They were identified in ruderal places, on slightly salty soils, from the Bahlui River valley. The diagnostic species of the classes *Stellarietea mediae* and *Festuco-Puccinellietea* are relatively equally well represented in the plant composition.

(6) D.c. *Symphyotrichum ciliatum-[Malvion neglectae]* (relevé 13, in Table 2; relevés 1, 11 and 13, in Pop and Viţălariu [4]; synthetic list 2, in Viţălariu *et al.* [26]). These are ruderal communities which differ from d.c. *Symphyotrichum ciliatum-[Stellarietea mediae]* by a greater representation of the diagnostic species of the alliance *Malvion neglectae*. In addition, the halophilous plant species are more numerous.

(7) Transitional community between the alliances *Atriplicion nitentis* and *Malvion neglectae* (relevé 14, Table 2). This type differs from the community (6) through a larger participation of the diagnostic species of the alliance *Atriplicion nitentis*. Among the communities dominated by *S. ciliatum*, this is the weakest halophilous.

The dendrogram resulting from cluster analysis (Figure 9) showed 5 groups of relevés with more than 50% similarity, which included the studied phytocoenoses according to the value of the absolute coefficients of representation (Q^{abs}) of the individual classes within the each relevé. (a) Three very similar halophilous phytocoenoses within the alliance *Cypero-Spergularion salinae*). (b) Halophilous phytocoenoses within the order *Scorzonero-Juncetalia gerardii*), which proved to be more heterogeneous. (c) Nitro-hygrophilous phytocoenoses of the d.c. *Symphyotricum ciliatum-[Bidentetalia tripartiti]*), with a similarity of ca. 64%. (d) Phytocoenoses transitional from ruderal vegetation (*Stellarietea mediae*) to halophilous grasslands (*Scorzonero-Juncetalia gerardii*). (e) The remaining ruderal communities, *i.e.*, d.c. *Symphyotrichum ciliatum-[Stellarietea mediae]*, d.c. *Symphyotrichum ciliatum-[Malvion neglectae]*, and the community classified within the alliances *Atriplicion nitentis* and *Malvion neglectae*.

4 Discussion

4.1 Symphyotrichum ciliatum – an invasive adventive plant species in Romania

Symphyotrichum ciliatum was officially reported as an invasive plant species in Romania from the early 1970s shortly after the first record of its presence in 1967, in Iaşi city (Iaşi county), and Tanacu village (Vaslui county) [4]. The spread of this species in Romania appears to have been rapid from the outset. However, we consider that this may be an artefact, due to the species remaining undetected for a certain period between the time of its introduction and first collection records.

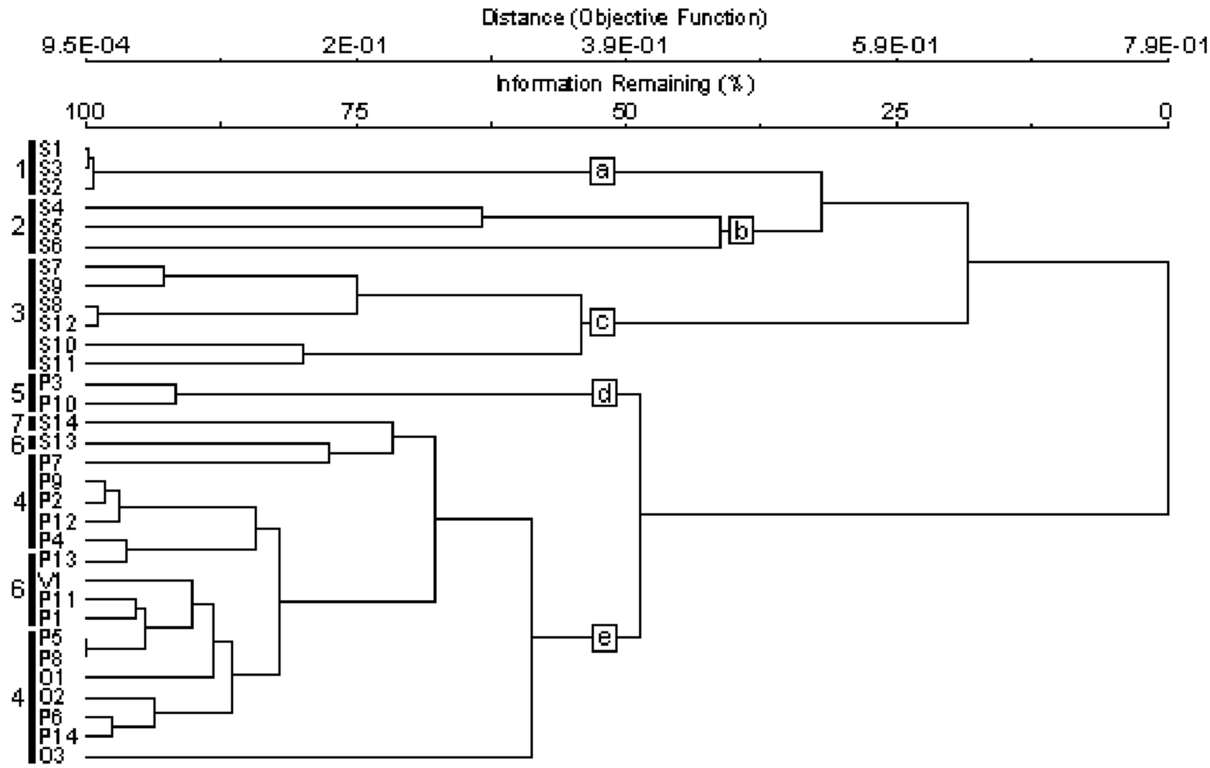

Figure 9. The dendrogram derived from cluster analysis based on the absolute coefficients of representation (Q^{abs}) of classes within each relevé, using the Sørensen (aka Bray-Curtis) distance measure and the group average linkage method: a-e – groups with more than 50% similarity; on the left are serial numbers of communities described in the text. Both relevés from literature and own field research were used: S_{1-14} – own field work (2009 – 2011), P_{1-14} – Pop and Viţălariu [4], O_{1-3} – Oprea *et al.* [24], V_1 – Viţălariu *et al.* [26].

The species has a vigorous potential to grow among native species in various habitats and to quickly spread throughout Moldavia (eastern Romania) and to penetrate the Carpathian Mountains [5]. It has also been found within other provinces of the country, for example Dobrudja, including the Danube Delta, Muntenia [5], and Transylvania [27]. Dihoru [5] drew up the first distribution map of this species in Romania based on data from literature and his own investigations, with 28 points of presence of *S. ciliatum* (using the UTM system), corresponding to a total of 35 localities (Moldavia – 32 localities, Dobrudja, including the Danube Delta – 2 localities, and Muntenia – 1 locality.

In the last two decades, the number of localities where this species has been identified has almost tripled, and the number of types of invaded EUNIS habitats also has constantly increased. Today, the greatest spread in Romania is still in the eastern regions but, given the abrupt increase in the slope of the invasion curve for the last decade, we can assume that *S. ciliatum* is still far from reaching the saturation phase of its invasion in Romania.

All types of habitat invaded by *S. ciliatum*, both in Romania and other European regions, *e.g.* Slovakia [16], and Poland [10, 25], are characterized by anthropogenic or natural disturbances. In Romania, as in the species native area, it invades not only the typical ruderal habitats, but also saline ones. Although in the adventive flora of Romania there are also other species able to invade disturbed habitats of saline soils (*e.g.*, *Conyza canadensis*, *Hordeum jubatum*, *Xanthium orientale* subsp. *italicum*, *X. spinosum*, *Trigonella caerulea*, *etc.*) [9] *S. ciliatum* seems to be the most aggressive among them.

Based on the very significant positive relationship between the number of years since the first record in Romania and the number of different types of invaded habitats, as well as on its wide ecological tolerance, one can assume that a certain diversification of invaded habitat types could be expected in the future (for example, it could invade agricultural fields).

According to our results, in *ca.* 12% of the total number of localities where it has been reported in Romania so far, *S. ciliatum* was the dominant species in various plant communities.

4.2 Classification of communities dominated by Symphyotrichum ciliatum

The concept of derivate communities [33, 48, 49, 52, 53], enables the classification of plant communities dominated by one (rarely several) diagnostically valueless species in higher syntaxa on the basis of the degree of representation of respective syntaxa. These communities cannot be described as plant associations, or sociologically saturated communities (which approximately correspond to plant associations) [52], because they are formed predominantly of species with a wide coenological amplitude and they lack their own diagnostic species [33, 48, 49, 52].

Among the dominant (leading) species of derivate communities, many neophytes with recent invasion across Europe can be found [45, 46, 50, 52, 62, 63]. *S. ciliatum* is such a neophyte and it currently shows clear tendencies of broaden its area of invasion and diversification of invaded habitats and plant communities. In the Romanian phytosociological literature [4, 7, 43], it was considered as a diagnostic plant species for the ruderal vegetation of slightly salty soils, within the alliance *Brachyaction ciliatae* Pop and Viţălariu 1971 (see below). Although Pop and Viţălariu [4] classified the ruderal communities dominated by *S. ciliatum* within a new plant association, namely *Erigero canadensis-Brachyactetum ciliatae*, we consider that there is no clear evidence, based on the analysis of a larger number of relevés, that this species has a narrow coenological specialization in the invaded areas. Our results, as well as data from literature [5, 10], can confirm that *S. ciliatum* is able to invade various plant communities. In this paper we have treated it as an invasive species without a definite diagnostic value for a particular syntaxon, leading us to reconsider the association described by Pop and Viţălariu [4] and to classify the respective phytocoenoses as derivate communities.

The application of the deductive method for classification of plant communities requires that in the study area a sufficiently accurate system of higher syntaxa has been previously built by the inductive way (*i.e.* by the classical method of the Zürich-Montpellier school), and that these syntaxa are characterized by their own diagnostic characters [33]. In Romania phytosociological research initiated in the first half of the last century has covered the whole country and in recent decades some valuable phytosociological regional and national syntheses [7, 43, 44] have been published. The system of phytosociological alliances, orders and classes used in this paper follows the system of Coldea [44], which is in turn consistent with the systems used in Central Europe [45-47]. There is not yet a phytosociological database in Romania enabling statistical determination of fidelity coefficients for diagnostic species (see [51, 64-66] for methods of fidelity determination and the importance of this concept in syntaxonomic classification) for higher syntaxa (alliances, orders, classes) represented in the vegetation of Romania. As Kopecký *et al.* [33] suggested, we have established the degrees of fidelity of characteristic and differential species by comparing published data with our own observations from the study area.

Some comments are necessary regarding two of the species treated here as diagnostic of the alliance *Cypero-Spergularion salinae*, namely *Chenopodium glaucum*, and *Atriplex prostrata*. The first is a halophilous plant species with weak to moderately salinity tolerance [56, 58, 67], growing on soils with soluble salts between 65 and 530 mg per 100 g soil, with a optimum of 470 mg per 100 g soil (on the soil surface) [56]. *Ch. glaucum* has been reported as a characteristic species for both alliances *Cypero-Spergularion salinae* and *Chenopodion glauci* [43, 44]. Since this species was accompanied, in our records, by some obligate halophytes (e.g. *Suaeda maritima*, *Spergularia media*, *Crypsis schoenoides*, *C. aculeata*) we treat it here as characteristic of the first alliance, but with a medium value of fidelity coefficient. The second, *Atriplex prostrata*, is very weak to strongly halophilous, and grows on soils usually ruderalized, with soluble salts between 65 and 2410 mg per 100 g soil, with a optimum of 1040 mg per 100 g soil (on the soil surface) [56]. According to Sanda *et al.* [43] and Coldea [44], *A. prostrata* is a characteristic species of the alliance *Chenopodion glauci*. In Romania, it can also have high constancy in some pioneer halophilous communities of the alliance *Cypero-Spergularion salinae*, such as *Heleochloetum schoenoides* [44, 68]. We consider that this species can be treated as a differential of the *Cypero-Spergularion salinae*. In Slovakia, both species are considered characteristic of this alliance [69].

By applying the algorithm of the deductive method described by Kopecký *et al.* [33], we identified seven different types of communities dominated by *S. ciliatum* in eastern Romania, of which three were described as individual types of phytocoenon. The other four types, which do not meet all criteria to be described as derivate communities [33] (there were less than 5 relevés) were also classified as certain higher syntaxa, in order to better circumscribe the diversity of plant communities invaded by this neophyte in the study area.

4.3 Similarities and differences among the analyzed communities

Plant communities dominated by *S. ciliatum* are similar in some respects, by the presence of various facultative or obligate halophilous species, by their pioneer character reflected in the high share of therophytes, by similar preferences to light, temperature, soil *p*H, soil nitrogen content, and by predominance of Eurasian and adventive phytogeographic elements in their species composition.

However, they are quite different in species diversity, composition, and preferences for soil moisture and salinity. More halophilous communities, with a higher proportion of diagnostic species of the classes *Thero-Salicornietea* and *Festuco-Puccinellietea*, develop on lands less disturbed by anthropogenic factors, as against the less halophilous communities with a higher proportion of diagnostic species of the classes *Bidentetea tripartiti* (on excessively wet lands, with accumulation of nitrates), or *Stellarietea mediae* (on drier lands, more or less rich in nitrates), having a marked anthropogenic character. The lowest species diversity was found in the most halophilous communities, due to the saline stress tolerated by only a small number of species [7, 44].

The dendrogram derived from cluster analysis proves the distinctiveness of those communities characterised by a predominance of diagnostic species of the classes *Thero-Salicornietea*, *Festuco-Puccinellietea*, *Bidentetea tripartiti* and *Stellarietea mediae*, respectively. However, communities affiliated to the class *Stellarietea mediae* and to the lower syntaxa of this class were not separated by the cluster analysis. So, phytocoenoses of d.c. *Symphyotrichum ciliatum-[Malvion neglectae]*, as well as those transitional between the alliances *Atriplicion nitentis* and *Malvion neglectae* were attached to different sub-branches of d.c. *Symphyotrichum ciliatum-[Stellarietea mediae]*. Therefore, all these communities could be named, *sensu lato*, as d.c. *Symphyotrichum ciliatum-[Stellarietea mediae]*, but this is not permitted by the rigorous application of the deductive method [33], which requires the continuation of the algorithm for finding the optimal name of a community at the level of hierarchically lower syntaxa, whenever the coefficient of representation of characteristic and differential species of a higher syntaxon is lower than the coefficient of representation of characteristic and differential species of subordinated syntaxa multiplied by the coefficient of preference of a lower rank.

4.4 Syndynamic aspects

By analysing plant composition, life forms and ecological features of the derivate communities with *S. ciliatum*, one can deduce that they have resulted by invasion of this species in various plant communities, both natural (*Thero-Salicornietea*, *Festuco-Puccinellietea*) and anthropogenic (*Stellarietea mediae*, *Bidentetea tripartiti*), under conditions of some natural or anthropogenic disturbances, *e.g.* draining or silting of ponds, periodic flooding and filing of alluvia on floodplains, mobilization of soil, eutrophication, and excessive grazing. The species do not penetrate into closed perennial vegetation. Disturbance is one of the most important factors promoting exotic invasion, as it reduces population density in the native communities resulting in the increase of resource availability and less competition for invaders from residents [70-73].

In the invaded communities, during the growing season but especially towards the autumn, hundreds of individuals of *S. ciliatum* per square meter with considerable coverage, can massively dominate these communities and overwhelm the resident species. In addition, plant debris can remain until the following spring, impeding seeds germination of annual species (both native and invader) favouring the resident perennial plants. Decomposition of litter during the following months can contribute to increase the soil trophicity, which favours nitrophilous species. Thereby the normal succession of vegetation can be impeded or disturbed by the invasion of *S. ciliatum*, as has been shown for other adventive plants in long term experiments with permanent plots [74, 75]. After cessation of the disturbing factors the abundance and dominance of *S. ciliatum* will decrease markedly, as for other herbaceous invasive therophytes [74, 76, 77] and, on wet and salty fields, by increasing the share of perennial species the analysed phytocoenoses may evolve into more stable halophilous communities, such as *Astero tripoli-Juncetum gerardii*, widespread in the study area [7] or in other similar communities from the class *Festuco-Puccinellietea*.

4.5 About the alliance Brachyaction ciliatate Pop et Viţălariu 1971

Pop and Viţălariu [4] described the alliance *Brachyaction ciliatate*, classified into the order *Onopordetalia acanthii*, from the class *Artemisietea vulgaris*, in order to incorporate the ruderal phytocoenoses related to slightly salty soils with a series of adventive species (*e.g. Ambrosia artemisiifolia*, *Amaranthus albus*, *A. blitoides*, *Artemisia annua*, *Galinsoga parviflora*, *Iva xanthifolia*, *Lepidium virginicum*), or Eurasian elements (*e.g. Xanthium strumarium*). The alliance *Brachyaction ciliatae* differs from other alliances of the order *Onopordetalia acanthii* through a series of „differential halophilous species", such as *Aster tripolium* subsp. *pannonicus*, *Crypsis schoenoides*, *Hordeum hystrix*, *Juncus gerardi*, *Lotus tenuis*, and *Puccinellia distans*. In this alliance, Pop and Viţălariu [4] classified their new plant association, *Erigero canadensis-Brachyactetum ciliatae*. Subsequently, some Romanian authors [7, 28, 43] included within this alliance two other plant associations, namely *Ivaetum xanthiifoliae*, and *Ambrosietum artemisiifoliae*. However, these last two plant communities, given their therophytic nature and plant composition, can be incorporated into the alliance *Atriplicion nitentis* [47, 78, 79], and better treated as derivate communities (for *Ivaetum xanthiifoliae,* see [50]).

Both syntaxa (association, alliance) described by Pop and Viţălariu [4] differ from the communities of the order *Onopordetalia acanthii* (the class *Artemisietea vulgaris*), not only through their tolerance to salt-affected soils, but also through the predominance of therophyte species. In our opinion, these traits do not permit their subordination to the class *Artemisietea vulgaris*, which includes biennial and perennial ruderal (or semiruderal) vegetation [44, 45, 47, 80]. All the above mentioned species considered as characteristic for the alliance *Brachyaction ciliatae* [4, 7, 43], are in fact diagnostic species of the class *Stellarietea mediae*, or of various other syntaxa subordinated to this class [44, 45, 47, 80]. Even Dihoru [5] noticed that the plant communities installed on maritime wet and salty sands (on the Black Sea coast), with *S. ciliatum* cannot be ascribed to the order *Onopordetalia acanthii*. Unfortunately, only a short list of species was given without complete description of the plant communities. The alliance *Brachyaction ciliatae* remains a questionable syntaxon, without its own characteristic species, and previously unjustifiably classified in the order *Onopordetalia acanthii*, class *Artemisietea vulgaris*.

By the ruderal and weak halophilous character of subordinated communities, the alliance *Brachyaction ciliatae* overlaps another alliance previously described from Hungary, namely *Matricario chamomillae-Chenopodion albi*. The latter includes plant communities which usually colonize abandoned crops and ruderal places, on slightly salty soils, usually flooded in spring, but drier and saltier in summer [45, 46, 81]. According to Mucina [45], the characteristic species of this alliance is *Myagrum perfoliatum*, absent in all phytocoenoses analyzed by us. Many other species were indicated by various authors as differential for *Matricario chamomillae-Chenopodion albi* [45, 46]. Some of these species (*e.g. Atriplex prostrata*, *A. tatarica*, *Chenopodium glaucum*, *Crypsis schoenoides*, *Lotus tenuis*, *Potentilla supina*) were also present in the communities analyzed by us. However, it was not possible to classify any one of these communities in the alliance *Matricario chamomillae-Chenopodion albi*, by applying the algorithm of the deductive method.

5 Conclusions

Symphyotrichum ciliatum is a neophyte which arrived a few decades ago in Romania, and it currently shows clear tendencies of broaden its area of invasion and diversification of invaded habitats and plant communities.

The species invades not only typical ruderal habitats but also the saline ones. Most commonly, it was found in anthropogenic herb stands, habitats associated with rail and road transport networks, and in continental inland salt steppes.

In ca. 12% of the total number of localities where it has been reported in Romania so far, *S. ciliatum* was the dominant species in various plant communities. These communities were classified in seven different types, of which three were described as individual types of phytocoenon, namely: d.c. *Symphyotrichum ciliatum-[Bidentetalia tripartiti]*, d.c. *Symphyotrichum ciliatum-[Stellarietea mediae]*, and d.c. *Symphyotrichum ciliatum-[Malvion neglectae]*. The other four types, which were represented by less than 5 relevés, were affiliated to certain higher syntaxa in order to better circumscribe the diversity of plant communities invaded by this neophyte.

The alliance *Brachyaction ciliatae* Pop *et* Viţălariu 1971 was evaluated as a questionable syntaxon without its own characteristic species and previously unjustifiably classified in the order *Onopordetalia acanthii*, class *Artemisietea vulgaris*.

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