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Plant communities of the class *Charetea fragilis* FUKAREK ex KRAUSCH 1964 in Slovakia: new information on their distribution and ecology

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Abstract: In Slovakia, plant communities of the class *Charetea fragilis* are relatively rare and few recorded. Up to now, seven plant communities documented by only 14 phytosociological relevés have been mentioned from the territory of Slovakia. New plant community *Nitelletum syncarpae* CORILLION 1957 and further three stoneworts plant communities (*Charetum vulgaris* CORILLION 1957, *Charetum fragilis* FIJALKOWSKI 1960 and *Charetum hispidae* CORILLION 1957) were documented by 14 phytosociological relevés during our research in last years. New ecological and distribution data are presented in this paper.

Keywords: macroscopic algae, *Charetea fragilis*, vegetation, ecology.

Introduction

Within the Central Europe, plant communities of the class *Charetea fragilis* with dominance of macroalgae (e.g. *Chara* sp., *Nitella* sp.) belong to relatively rare and few documented. There is not any information about these communities from Ukraine, insufficient data are known from Hungary and Czech Republic, and relatively more information is available from Austria and Germany (cf. KRAUSE & LANG 1977; ZAHLHEIMER 1979; SOLOMAKHA 1995; BORHIDI 2003; HUSÁK 1995, 2001; SCHRATT 1993). More complex data on the *Charetea fragilis* were presented only from Poland (TOMASZEWICZ 1979).

Recent knowledge on coenology of macroscopic algae of *Charales*, as well as information on their ecology and distribution in the territory of Slovakia is incomplete (cf. OŤAHEĽOVÁ 2001). The data from Slovakia concerning the *Charetea fragilis* recorded until the end of 2001 have been summarized by OŤAHEĽOVÁ (l.c.). She presented 7 associations within this class and they were documented by 14 phytosociological relevés. More than one relevé was documented only in case of associations *Charetum fragilis*, *Charetum hispidae* and *Charetum vulgaris*. Since, only one relevé of the *Charetum hispidae* was published by MALOVCOVÁ-STANÍKOVÁ (2003) from surroundings of the Hlohovec.

Therefore, the main aim of this work is to bring more comprehensive data on the distribution and ecology of the *Charetea fragilis* communities in the territory of Slovakia.

Material and methods

The data were collected during 2000–2004 within the research of aquatic vegetation of several localities in central Slovakia (mainly Muránska planina Mts. and their surroundings, and Veľká Fatra Mts.), and Podunajská rovina lowland (southern Slovakia).

The phytosociological relevés were made according to the Zürich-Montpellier approach using the adapted Braun-Blanquet's scale (BARKMAN et al. 1964). The rates of 2m (low abundance and cover about 5%), 2a (cover 5–12.5%) and 2b (12.6–25%) are presented in the abbreviated forms as M, A and B in the tables. All relevés were stored using the TURBOVEG database software (HENNEKENS 1996a) and the phytosociological tables were processed by MEGATAB (HENNEKENS 1996b). Using the TWINSPAN software (HILL 1979), the divisive polythetic method of classification was carried out in order to detect the variability of plant communities. New recorded relevés are presented in Table 1. All known relevés of the *Charetea fragilis* from the territory of Slovakia are presented in the abbreviated synoptic table (Table 3; columns with more than 5 relevés are presented in percentage, the others in the number of relevés with the species' presence).

Values of both water reaction (pH) and conductivity are presented in Table 2. They were measured directly in the field only in selected localities by instruments WTW pH/Cond 340i, Radelkis Conductometer OK – 114 and

EUTECH Instruments CyberScan pH 300. Conductivity values are calculated to 20 º C temperature (SJÖRS 1952).

The names of vascular plants follow MARHOLD & HINDÁK (1998) and the ones of the *Charales* follow KRAUSE (1997). The names of the aquatic plant communities of the class *Charetea fragilis* are presented according to papers of OŤAHEĽOVÁ (2001) and KRAUSE (1997). The other names of plant communties with the name of author(s) and the year of the first valid description are mentioned at least once.

Results

Survey of plant communities

Charetea fragilis FUKAREK ex KRAUSCH 1964
  Nitelletalia flexilis KRAUSE 1969
  Nitellion syncarpae-tenuissimae KRAUSE 1969
    Nitelletum syncarpae CORILLION 1957
Charetalia hispidae SAUER ex KRAUSCH 1964
  Charion fragilis KRAUSCH 1964
    Charetum fragilis FIJALKOWSKI 1960
    Charetum hispidae CORILLION 1957
  Charion vulgaris (KRAUSE et LANG 1977) KRAUSE 1981
    Charetum vulgaris CORILLION 1957

Characteristics of plant communities

Nitelletum syncarpae (Table 1, relevé 14)

This community was found only in one locality in the channelized former side arm of the Danube River – Chorvátske rameno (river oxbow) in Bratislava. *Nitella syncarpa* builts a species-poor and homogenous submerged stands (cf. JURSA & OŤAHEĽOVÁ 2005) in transition zone between aquatic and littoral marsh vegetation in the shallows (depth 10–50 cm) along the water-body. Bed is gravelly and covered by a thin layer of the fine-grained sediment. Usually, amphiphytes such as *Eleocharis palustris*, *Myosotis scorpioides* agg., and *Veronica anagallis-aquatica* replace stoneworts vegetation in the margins of water-body. In the deeper water it is zoned by the *Potametea* stands, notably *Myriophyllum verticillatum*, *Najas marina*, and *Hippuris vulgaris* f. *submersum*. Bed of canal is the rest of Danube river oxbow, after regulation made ca 30 years ago. Water is stagnating during the most periods of the year. Water flows slowly only during the short period, when the Danube has high water level. Detected conductivity was relatively high (860 µS/cm) and water reaction was alkaline (cf. Table 2). Aquatic vegetation is occasionally reaping. Because artificial channel is located in an urban area, fishing and man activities are intensive.

***Charetum fragilis* (Table 1, relevés 2–5)**

Stands of this association were found on three localities in the Pannonian area (in wider surroundings of the Bratislava and in the artificial water reservoir near the Tachty village) and in one locality within the Western Carpathian Mts. (near the Dolný Harmanec, Veľká Fatra Mts). Up to now, all known data on occurrence of this association have been published from inundation area of both Danube and Morava rivers in the Pannonian area. There was not any phytosociological relevé from the Carpathian area (OŤAHEĽOVÁ 2001). However, the occurrence of *Chara globularis* in this area is known [e.g. ditches with water within fens complex E from the Príbovce village, near fishponds, 9.6.2000, leg.: Richard Hrivnák, det. Š. Husák; fens in the locality Suché doly, Biele vody (cf. Table 2) and surroundings of the Zlatno village]. The stands are built mainly by hydrophytes and helophytes in the shallow waters. The *Charetum fragilis* grows in stagnating, relatively clear, shallow or deeper waters (sometimes up to 3 m depth). The bottom is built by sandy or gravely sediments, which are rare overlaid by a thin organic material. *Chara globularis* grows in fen pools too, where it does not build a large or continuous stands. Water reaction was alkaline, values of conductivity were between 518–705 µS/cm (cf. Table 2).

***Charetum hispidae* (Table 1, relevé 1)**

Under suitable conditions the giant alga *Chara hispida* can form dense underwater meadows. Stands are usually very species-poor, only a few other hydrophytes of the *Potametea* are associated. *Chara globularis* was also noticed. The community is confined to standing waters which are generally mesotrophic to eutrophic and base-rich (pH 7.5–8.2), occasionally slightly saline (cf. OŤAHEĽOVÁ 2001). Vegetation of this kind has scattered distribution in lowland open waters including artificial examples water bodies like the sand-gravel pits. Usually the water-depth is 0.5–1.3 m, but in highly transparent water *Ch. hispida* can penetrate to considerable depths (7.5 m, cf. HORECKÁ 1994).

***Charetum vulgaris* (Table 1, relevés 6–13)**

The big species and ecological diversity is typical of this community. Stands grow from the planare to the montane belts in natural as well as the artificial biotopes. Artificial water reservoirs, gravel pits, fishponds and fen pools are typical biotopes for this community. It was detected in stagnating, mesotrophic to eutrophic, relatively shallow or medium deep water. Water reaction (pH) was from slightly alkaline to alkaline. The relatively high values of water conductivity were measured (528–813 µS/cm, see Table 2). The area of the *Charetum vulgaris* stands is relatively small, often only 1–2 m^2 (mainly in case of fen pools). Stands are affected by the vegetation growing in the surroundings of stoneworts' pools or in littoral of water reservoirs. Several aquatic plant species, as well as marsh and mire species are typical for the *Charetum vulgaris* stands (see Table 1).

Discussion

Recently eight plant communities of the *Charetea fragilis* are known from the territory of Slovakia (Tab. 3. and Fig. 1). This number is similar or lower than in the surrounding countries – Czech Republic (7, cf. HUSÁK 1995), Poland (19, cf. TOMASZEWICZ 1979), Hungary (3, cf. BORHIDI 2003, HRIVNÁK & HUSÁK 2004), and Austria (10, cf. SCHRATT 1993). The majority of relevés was recorded in the *Charetum vulgaris*. In the phytosociological material from Slovakia we distinguished two main groups (see synoptic Table 3): **i/** stands developed on mesotrophic or eutrophic natural biotopes (e.g. fen pools) and artificial habitats from (planare) colline to montane belt, with the presence of hygrophytes e.g. *Equisetum palustre*, *Juncus articulatus*, *Veronica beccabunga* (IIa); **ii/** stands of eutrophic, often artificial biotopes in planare to colline (montane) belt, rich in nutrients with the presence of typical eutrophic plant species including hydrophytes e.g. *Eleocharis palustris* agg., *Lemna minor*, *Sparganium erectum*, *Typha latifolia* (IIb). *Charetum fragilis* belongs to relatively well documented, too, growing mainly in planare belt of lowlands and basins.

The *Nitelletum syncarpae* has not been mentioned from Slovakia up to now. It is not known neither from Hungary nor from Austria (SCHRATT 1993, BORHIDI 2003) in contrast to Germany (www.lanaplan.de/makrophyten; POTT 1992, ut *Nitelletum syncarpo-tenuissimae* KRAUSE 1969). Dominant species *Nitella syncarpa* was detected within the Danube valley in Chorvátske rameno (river oxbow) near Bratislava (JURSA & OŤAHEĽOVÁ 2005) and in the upper part of Danube in Germany (ZAHLHEIMER 1979). It occurs from southern Sweden, across Central Europe to the Alps, mainly in the western part of this territory. *Nitella syncarpa* grows in shallow waters of lakes, reservoirs and gravel ditches (KRAUSE 1997). Neutral and moderate alkaline water reaction was detected (cf. KRAUSE 1997), similarly as in the locality near Bratislava.

All of these vegetation types are tend to expand into the newly created to the man-made aquatic habitats, such as canals and denuded gravel pits. They are poorly competitive and are soon replaced by stronger competitive communities of the classes *Lemnetea*, *Potametea* or *Phragmito-Magnocaricetea* (KRAUSE 1997, HRIVNÁK et al. 2004). Disturbances, such as mowing or clearing of bottom may favour the local spread of this vegetation.

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Appendix 1: Species in one relevé only (Tab. 1.)

E_1: *Alopecurus aequalis* (relevé 4: 2a), *Batrachium rioinii* (4: 2a), *Batrachium* sp. (9: 1), *Bidens tripartitus* (4: +), *Carex flava* (7: +), *C. panicea* (8: +), *Eleocharis acicularis* (14: 2a), *E. palustris* agg. (11: 1), *E. quinqueflora* (13: +), *Equisetum fluviatile* (12: +), *Eriophorum angustifolium* (8: 2a), *Glyceria notata* (7: 1), *Groenlandia densa* (3: 2a), *Lythrum salicaria* (10: 2a), *Mentha aquatica* (10: 2a), *Myosotis scorpioides* agg. (14: 1), *Persicaria lapathifolia* subsp. *tomentosa* (4: +), *P. lapathifolia* (10: r), *Potamogeton natans* (12: +), *Ranunculus repens* (6: +), *R. sceleratus* (4: +), *Schoenoplectus tabernaemontani* (13: 2a), *Sparganium erectum* (12: +).

E_0: *Bryum* sp (12: +), *Campylium stellatum* (13: +), *Drepanocladus fluitans* (13: +).

Appendix 2: Localities of relevés (Tab. 1.)

Note: For relevés, the header data are listed in the following order: orographical unit (Cerová vrchovina Mts. – CV, Horehronské podolie basin – HP, Muránska planina Mts. – MP, Podunajská rovina lowland – PR, Slovenský raj Mts. – SR, Stolické vrchy Mts. – SV, Veľká Fatra Mts. – VF); the nearest town or village; locality and habitat; altitude (m); relevé area (m^2); total cover (%); depth of water column (cm); flow classes (S – stagnating, LF – low velocity < 30 m/s, MF – medium velocity 30–70 m/s, HF – high velocity > 70 m/s); sediment classes (R – rock, A – artificial material, S – sand or gravel, F – fine inorganic material, O – detritus and other

organic material, ? – indeterminate); date; author(s) of relevé (DB – Drahoš Blanár, RH – Richard Hrivnák, JK – Judita Kochjarová, HO – Helena Oťaheľová, JV – Jarolsav Vlčko).

1. PR; Senec; Slnečné jazerá, S margin of lake, sand-gravel ditch (used for recreation); 124 m; 20; 100; 50–80; S; S; 31. 5. 2001; HO.
2. PR; Bratislava; Štrkovecké jazero, central part of the lake, sand-gravel pit; 130 m; 4; 80; 250–300; S; S; 30. 7. 2001; HO.
3. PR; Hamuliakovo; left seepage canal of the Hrušovská zdrž water reservoir; 129 m; 20; 90; ca 60; S, LF; S, F; 8. 8. 2001; HO.
4. CV; Tachty, S; water reservoir, S margin; 129 m; 15; 100; 2–5; S; F, O; 2. 7. 2003; RH.
5. VF; Dolný Harmanec; outfall of the Rakytovská dolina valley, water reservoir nearby a small hydro-electric power plant; ca 520 m; 25; 90; ca 1; S; ?; 17. 10. 2002; JK.
6. VF; Ružomberok, S; Jazierske travertíny, pool below the water-works building; 595 m; 24; 90; 50–60; S; ?; 5. 10. 2004; JK.
7. VF; Necpaly, ESE; near the forester´s cottage up of the village, gravel ditch on the alluvium of the Necpalský potok; 537 m; 12; 100; 2–10; S; S; 26. 8. 2001; RH.
8. HP; Zlatno, S; outfall of the Zlatnica valley, fen pool; ca 740 m; 3; 85; 6–15; S; O; 14. 9. 2000; DB, RH.
9. SR; Dedinky, W; water reservoir near the forester´s cottage Piesky; 810 m; 16; 90; 10–30; LF; S, F; 12. 7. 2001; RH.
10. SV; Muránska Lehota, W; upper fishpond, littoral; ca 375 m; 13; 85; 40–130; S; O; 14. 9. 2000; DB, RH.
11. MP; Červená Skala, S; outfall of the Trsteník valley, shallow ditches in limestone guarry; ca 805 m; 8; 80; 5–10; S; S, O; 14. 9. 2000; DB, JK, RH.
12. MP; Nová Maša, N; water reservoir Sosninka, litorál; 755 m; 13; 85; 50–80; S; ?; 7. 9. 2000; DB, RH, JK.
13. HP; Predajná, E; Predajnianska slatina (fen) Nature reserve, fen pool; 450 m; 6; 100; 1–8; S; O; 22. 6. 2000; RH, JV.
14. PR; Bratislava, Petržalka; Chorvátske rameno river oxbow, bridge near Fedinová street; 133 m; 1,5; 90; S; 10–40; ?; 13. 6. 2002.

Appendix 3: Resources of relevés in synoptic Table 3

I – HRIVNÁK et al. (2001); IIa – OŤAHEĽOVÁ (2001, tab. 13, rel. 10); HRIVNÁK (2002, tab. 7, rel. 79); tab. 1, rels 6–9, 13; IIb – OŤAHEĽOVÁ & HUSÁK (1992, rel. 1); OŤAHEĽOVÁ (l.c., tab. 13, rel. 13); HRIVNÁK (l.c., tab. 7, rels 78, 80); tab. 1, rels 10–12; III – OŤAHEĽOVÁ (l.c., tab. 13, rels 2–4); tab. 1, rels 2–5; IV – OŤAHEĽOVÁ (l.c., tab. 13, rel. 8); V – OŤAHEĽOVÁ (l.c., tab. 13, rel. 9); VI – tab. 1, rel. 1; OŤAHEĽOVÁ (l.c., tab. 13, rels 5–6); MALOVCOVÁ-STANÍKOVÁ (2003); VII – tab. 1, rel. 14; VIII – OŤAHEĽOVÁ (l.c., tab. 13, rel. 7).

Tab. 1. The *Charetea fragilis* plant communities.

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Number of species	7	4	7	13	3	4	7	6	3	8	7	5	5	4
Community	VI	III	III	III	III	II	II	II	II	II	II	II	II	VII
Dominant species of the class *Charetea fragilis*														
Chara hispida	5	.	.	.	.	.	.	.	.	.	.	.	.	.
Chara globularis	1	4	4	5	5	.	.	.	.	.	.	.	.	.
Chara vulgaris	.	.	.	.	.	5	5	5	5	5	5	5	5	.
Nitella syncarpa	.	.	.	.	.	.	.	.	.	.	.	.		5
Lemnetea														
Myriophyllum spicatum	1	+	.	.	.	.	.	.	.	.	.	.	.	.
Lemna minor	.	.	.	+	+	.	.	.	.	.	.	.	.	.
Potametea														
Najas marina	1	A	.	.	.	.	.	.	.	.	.	.	.	.
Potamogeton pusillus agg.	A	.	+	.	.	.	.	.	.	.	.	.	.	.
Potamogeton pectinatus	+	.	.	1	.	.	.	.	.	.	.	.	.	1
Zannichellia palustris	.	1	1	.	.	.	.	.	.	.	.	.	.	.
Batrachium trichophyllum	.	.	1	.	.	+	.	.	.	.	.	.	.	.
Callitriche palustris agg.	.	.	+	.	.	.	.	.	.	r	.	.	.	.
Phragmito-Magnocaricetea														
Veronica anagallis-aquatica	.	.	.	1	.	.	.	.	.	.	r	.	.	.
Alisma plantago-aquatica	.	.	.	r	.	.	.	.	.	1	r	.	.	.
Typha latifolia	.	.	.	1	+	.	.	.	.	.	+	.	.	.
Veronica beccabunga	.	.	.	.	.	+	+	.	.	.	.	.	.	.
Other species														
Algae fil.	1	.	1	+	.	.	.	.	.	1	.	.	.	.
Juncus articulatus	.	.	.	+	.	.	1	1	.	.	1	.	.	.
Equisetum palustre	.	.	.	.	.	.	+	+	r	.	.	.	.	.
Agrostis stolonifera	.	.	.	.	.	.	+	.	.	B	+	.	.	.

Legend: III – *Charetum fragilis*, II – *Charetum vulgaris*, VI – *Charetum hispidae*, VII – *Nitelletum syncarpae* (ordering of plant communities is the same as in the table 3).

Tab. 2. Conductivity and pH of water in selected localities of the *Charetea fragilis* vegetation.

Locality relevé number in Table 1	Date	Conductivity µS/cm	pH in water	Community/ Species
2	7.9.2004		8.45	ChF
5	28.10.2004	518	7.88	ChF
6	5.10.2004	594	8.63	ChV
8	29.10.2004	813	7.28	ChV
10	10.9.2004	528	8.2	ChV
14	5.10.2004		7.67	NS
*Kačkava valley	20.6.2001	-	7.85	ChaVul
**Suché doly	29.10.2004	705	7.31	ChaGlo
***Biele vody	29.10.2004	624	7.31	ChaGlo

Legend: ChF – *Charetum fragilis*, ChV – *Charetum vulgaris*, CHaGlo – *Chara globularis*, ChaVul – *Chara vulgaris*, NS – *Nitelletum syncarpae*; * locality N from the Tisovec town, fen pool about 1 m^2, altitude ca 770 m; **locality NW from the Tisovec town, fen pool about 1 m^2, altitude 598 m; ***locality Muráň, Biele vody, altitude 490 m.

Tab. 3. Abbreviated synoptic table of the *Charetea fragilis* plant communities in Slovakia.

Plant community	I	IIa	IIb	III	IV	V	VI	VII	VIII
Number of relevés	1	7	7	7	1	1	4	1	1
Dominant species									
Nitella mucronata	1	.	.	.	.	.	.	.	.
Chara vulgaris	.	100	100	.	.	.	.	.	.
Chara globularis	.	.		100	.	.	1	.	.
Chara contraria	.	.			1	.	.	.	.
Chara tomentosa	.	.			.	1	.	.	.
Chara hispida	.	.			.	.	4	.	.
Nitella syncarpa	.	.			.	.	.	1	.
Nitellopsis obtusa	.	.			.	.	.	.	1
Diagnostic species of plant communities and their floristical and ecological variants									
Equisetum palustre	.	43			.	.	.	.	.
Veronica beccabunga	.	29			.	.	.	.	.
Phragmites australis	.	29			.	.	.	.	.
Sparganium erectum	.	.	29		.	.	.	.	.
Alisma lanceolatum	.	.	29		.	.	.	.	.
Lythrum salicaria	.	.	29		.	.	.	.	.
Lemna minor	.	.	43	57	.	.	1	.	.
Veronica anagallis-aquatica	.	.	29	14	.	.	.	.	.
Eleocharis palustris agg.	.	.	43	14	.	.	.	.	.
Alopecurus aequalis	.	.		29	.	.	.	.	.
Batrachium trichophyllum	.	14		29	.	.	.	.	.
Zannichellia palustris	.	.		29	1	.	.	.	.
Typha laxmannii	.	.			1	1	.	.	.
Myosotis scorpioides agg.	.	.			.	.	.	1	.
Eleocharis acicularis	.	.			.	.	.	1	.
Aquatic macrophytes (*Lemnetea minoris*, *Potametea*)									
Ceratophyllum demersum	1	.		14	.	.	.	.	.
Myriophyllum verticillatum	.	14		14	.	.	.	.	.
Myriophyllum spicatum	.	14		14	.	.	1	.	.
Groenlandia densa	.	.	29	43	.	.	.	.	.
Potamogeton crispus	.	.	14		.	.	.	.	.
Callitriche palustris agg.	.	.		14	.	.	.	.	.
Potamogeton pusillus	.	.	14	14	1	.	1	.	.
Najas marina	.	.	14	14	.	.	2	.	.
Potamogeton pectinatus	.	.	14	14	.	.	1	1	.
Marsh species (*Phragmito-Magnocaricetea*)									
Typha latifolia	1	.	57	14	.	.	.	.	.

Butomus umbellatus	.	.	29	29	.	.	.	.	.
Alisma plantago-aquatica	.	.	14	14	.	1	.	.	.
Other marsh species									
Juncus articulatus	.	29	29	14	.	.	.	.	.
Agrostis stolonifera	.	14	14	14	.	.	.	.	.
Bidens tripartita	.	.	14	14	.	.	.	.	.
Persicaria lapathifolia	.	.	14	14	.	.	.	.	.

Legend: I – *Nitelletum mucronatae*, II – *Charetum vulgaris*, III – *Charetum fragilis*, IV – *Charetum contrariae*, V – *Charetum tomentosae*, VI – *Charetum hispidae*, VII – *Nitelletum syncarpae*, VIII – *Nitellopsidetum obtusae*.

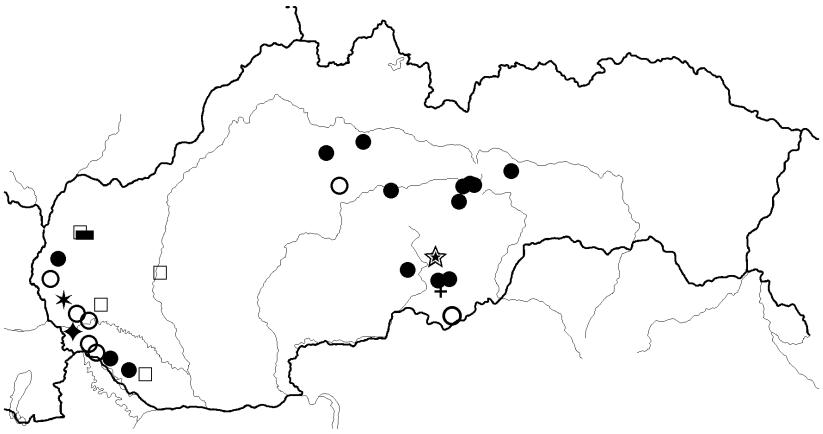

Fig. 1 Distribution map of the *Charetea fragilis* plant communities in Slovakia (Legend: ✯ *Nitelletum mucronatae*, ✦ *Nitelletum syncarpae*, ○ *Charetum fragilis*, □ *Charetum hispidae*, ▬ *Nitellopsidetum obtusae*, ✶ *Charetum contrariae*, + *Charetum tomentosae*, ● *Charetum vulgaris*).