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RARE, ENDANGERED OR VULNERABLE PLANTS AND NEOPHYTES IN A DRAINAGE SYSTEM IN CROATIA

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In an extensive network of field and lateral drain channels, in the area of Turopolje and Črnec Polje, seven locally and generally rare, endangered or vulnerable plants were noted. These are: *Riccia fluitans* L., *Marsilea quadrifolia* L., *Utricularia vulgaris* L., *Sagittaria sagittifolia* L., *Eleocharis acicularis* L., *Leersia oryzoides* (L.) Swartz. *and Wolffia arrhiza* (L.) Hork. ex Wimm. On the banks of the channels a number of neophytes have established themselves, such as *Solidago gigantea* Aiton, *Helianthus tuberosus* L., *Amorpha fruticosa* L., *Echinocystis lobata* (Michx) Torr. et Gray *and Panicum dichotomiflorum* Michx. Traditional methods of channel maintenance, the irregular and mechanical removal of plant biomass from channels, are an important factor behind plant diversity and richness in the drainage systems.

Key words: drainage system, Upper Sava River Valley, Croatia, traditional methods of channel maintenance, rare plants, endangered plants, vulnerable plants, neophytes, *Riccia fluitans* L., *Marsilea quadrifolia* L., *Utricularia vulgaris* L., *Sagittaria sagittifolia* L., *Eleocharis acicularis* L., *Leersia oryzoides* (L.) Swartz, *Wolffia arrhiza* (L.) Hork ex Wimm., *Solidago gigantea* Aiton, *Helianthus tuberosus* L., *Amorpha fruticosa* L., *Echinocystis lobata* (Michx) Torr. et Gray, *Panicum dichotomiflorum* Michx.

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U prostranoj mreži poljskih i obodnih odvodnih kanala, u području Turopolja i Črnec polja, zabilježeno je sedam lokalno i općenito rijetkih, ugroženih ili osjetljivih biljnih vrsta. To su: *Riccia fluitans* L., *Marsilea quadrifolia* L., *Utricularia vulgaris* L., *Sagittaria sagittifolia* L., *Eleocharis acicularis* L., *Leersia oryzoides* (L.) Swartz *i Wolffia arrhiza* (L.) Hork. ex Wimm. Na nasipima kanala ustanovljena je nazočnost neofita, kao što su: *Solidago gigantea* Aiton, *Helianthus tuberosus* L., *Amorpha fruticosa* L., *Echinocystis lobata* (Michx) Torr. et Gray *i Panicum dichotomiflorum* Michx. Tradicionalne metode održavanja kanala, neredovito i mehaničko odstranjivanje biljne mase iz kanala, vrlo su značajne za biljnu raznolikost i bogatstvo vrsta u sustavu odvodnje.

Ključne riječi: sustav odvodnje, Gornja Posavina, Hrvatska, tradicionalni načini održavanja kanala, rijetke biljne vrste, ugrožene biljne vrste, osjetljive biljne vrste, neofiti, *Riccia fluitans* L., *Marsilea quadrifolia* L., *Utricularia vulgaris* L., *Sagittaria sagittifolia* L., *Eleocharis acicularis* L., *Leersia oryzoides* (L.) Swartz, *Wolffia arrhiza* (L.) Hork. ex Wimm., *Solidago gigantea* Aiton, *Helianthus tuberosus* L., *Amorpha fruticosa* L., *Echinocystis lobata* (Michx) Torr. et Gray, *Panicum dichotomiflorum* Michx.

INTRODUCTION

In countries with advanced technology, drainage and development have progressively reduced the areas of wetland, destroying characteristically rich associations of marsh plants, wildfowl and other adapted species, so that some rare species are in danger of extinction (PEREIRA, 1973).

In Croatia, this is particularly true of the Upper Sava River Valley region, from where, owing to land reclamation, natural aquatic and marshy habitats have nearly disappeared.

Numerous channels, however, which in this region are maintained irregularly and by traditional methods (cutting and removal of the biomass from the channels) have proved to be refuges for many plant species which have disappeared from the wider countryside, or are endangered. On the other hand, systems of open channels have allowed numerous neophytes to enter and spread.

Studies of the flora and vegetation in the drainage systems of a part of the Upper Sava River Valley began in the early 1980's (HULINA, 1982; 1985a; 1985b; 1989; 1990). This paper presents examples of locally and generally rare, endangered or vulnerable plant species and some neophytes recorded in the drainage systems investigated, illustrating the state of affairs in Croatia.

AREA AND METHODS

The surface drainage systems, field and lateral drains, in the plains of Turopolje (cca 600 sq. km) and Črnec Polje (cca 900 sq. km) were investigated. These plains belong to the Upper Sava River Valley. They are situated in the north-western inland part of Croatia, along the banks of the Sava River and to the south-east of Zagreb (Fig.1).

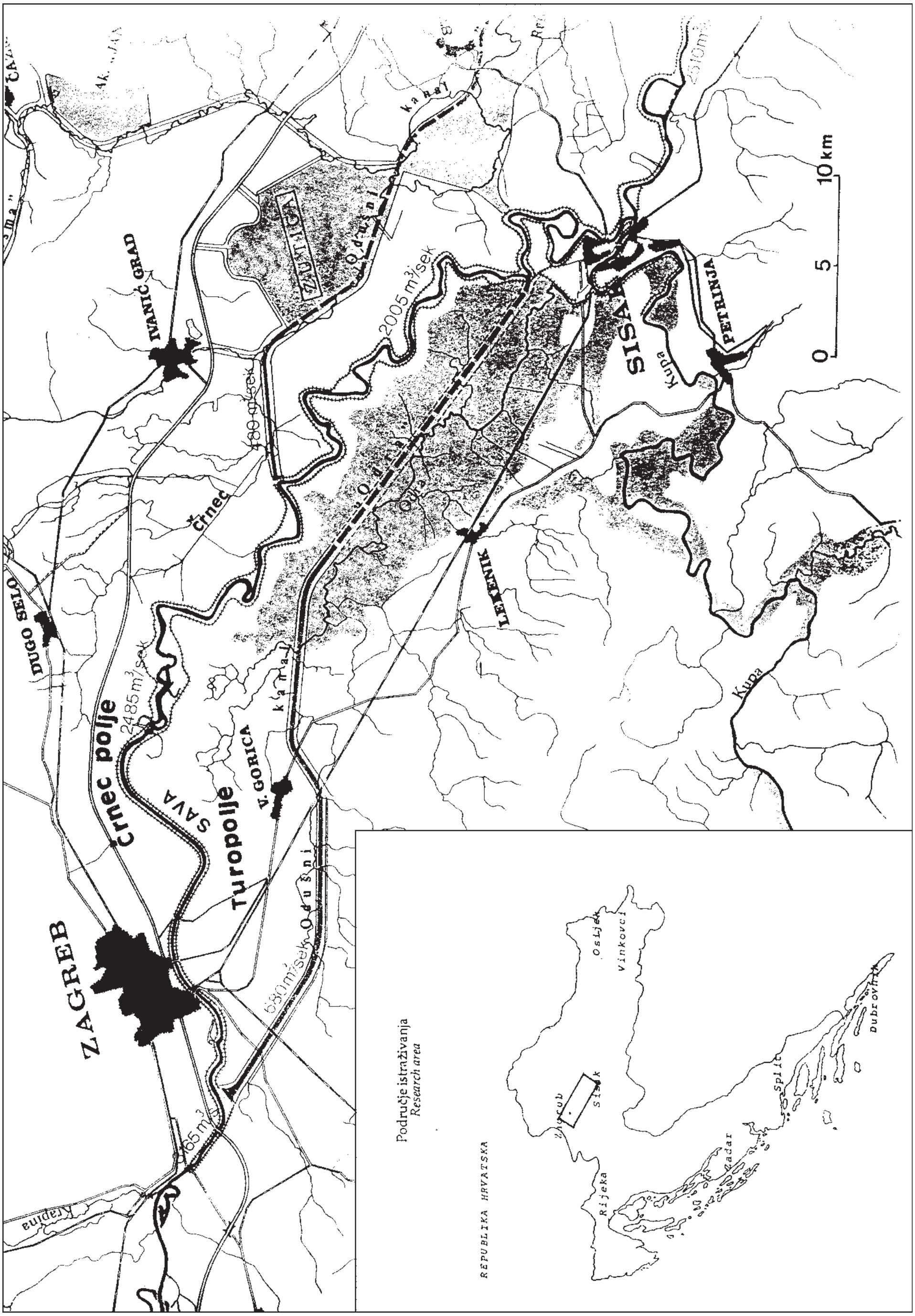
In the past the Sava river caused floods especially in spring and autumn. Thus the greater part of the area was originally wet and marshy.

During the last twenty years an extensive network of open channels for the protection of arable land against flooding has been built. In the Turopolje area between Zagreb and Sisak a 52 km long outlet canal, »Sava-Odra«, was built in 1972. Into this canal flows water from natural watercourses, which are partly regulated as collecting channels and which receive water from numerous field channels. In the period from 1980 to 1984, a drainage system of field, collecting and outlet channels, was constructed in Črnec Polje.

All channels have a very shallow gradient causing water to flow slowly with occasional periods of stagnation, which promotes silting. The water level in the channels is the highest in spring and autumn and lowest in summer. Most of the channels have an extremely favourable light and thermal regime. Maintenance of the channels is irregular; for the most part, plant biomass is physically and mechanically destroyed. No herbicides are used.

The macrohydrophytes of the drainage system in the Turopolje area have been investigated since 1978 and in Črnec Polje since 1986.

The nomenclature of plant species follows EHRENDORFER (1973).


ZAGREB
SAVA
Crnec polje
Turopolje
V. GORICA
DUGO SELO
IVANIĆ GRAD
Črnec
ŽUTICA
LEKENIK
SISAK
PETRINJA
Kupa
Odušni kanal
2485 m³/sek
2005 m³/sek
680 m³/sek
0 5 10 km
Područje istraživanja
Research area
REPUBLIKA HRVATSKA
Rijeka
Zadar
Split
Dubrovnik
Osijek
Vinkovci

RESULTS

a) Rare, endangered or vulnerable plants in drainage system

Botanical investigations in the area of Turopolje and Črnec Polje have shown a number of rare, endangered or vulnerable plants species to be important colonisers in the drainage systems. The following plant species are selected as examples:

1. *Riccia fluitans* L. *(Ricciaceae)*

The liverwort (*Riccia fluitans)* is almost cosmopolitan and is characteristically found in eutrophic water (COOK, 1974). In some parts of Europe *R. fluitans* is a vulnerable plant (LANDOLT *et al*., 1982; NIKLFELD *et al*., 1986).

R. fluitans is very rare along the lowland riversides in Croatia (Zl. PAVLETIĆ, 1968). In the study area, only one locality (Mahovo in Črnec Polje) of *R. fluitans* was noted (1992). It exists there as a submerged living waterform. Small clones of dense *R. fluitans* occur at a depth of 10 to 30 cm on the muddy bottom of the channel. It is accompanied by *Lemna minor, Elodea canadensis, Potamogeton crispus* and *Glyceria fluitan*s.

An investigation of the content of heavy metals in plants from the drainage system in Črnec Polje has shown that *R. fluitans* can absorb large concentrations of zinc, cadmium, copper and lead (HULINA *et al*., 1993). Thus the presence of *R. fluitans* in the drainage system in Črnec Polje is important both as a rare locality in Croatia and for the decontamination of polluted water.

2. *Marsilea quadrifolia* L. *(Marsileaceae)*

The fern *M. quadrifolia* is an aquatic and semiaquatic plant species of Mediterranean-Submediterranean to Eurasian-Continental (OBERDORFER, 1970) or Circumpolar (HEJNY, 1960) distribution. As a hydrophyte it grows in mesotropic to eurotropic waters (DUBINA, 1981).

In Europe *M. quadrifolia* represents a rare species, included in Red List floras (AYMONIN, 1975; LANDOLT *et al*., 1982; NIKLFELD *et al*., 1986; WRABER & SKOBERNE, 1989; ŠEGULJA, 1994).

According to literature data (SCHLOSSER & VUKOTINOVIĆ, 1869; KOŠČEC, 1913; ROSSI, 1924; HORVATIĆ, 1931) the species *M. quadrifolia* was once a very common and frequent plant in Croatia. Recently its natural distribution in Croatia has been declining (SCNEIDER-JACOBI, 1990; HULINA, 1993).

However, similarly to the situation in Slovakia (HUSAK & OTAHELOVA, 1986), *M. quadrifolia* in the study area thrives in man-made habitats, in newly dug channels. It was found in the »Sava-Odra« channel on a gravelly bottom. In the bank belts of this channel *M. quadrifolia* enters stands of *Leersia oryzoides* and *Eleocharis acicularis*, while towards the middle of channel it forms a very dense monospecies cover (HULINA, 1985).

In the area of Črnec Polje *M. quadrifolia* was found in shallow water on bottoms rich in clay and silt. It forms more or less monospecies communities or appears in the *Potametum pectinati* and *Sagittario-Sparganietum emersi* (HULINA, 1993).

3. *Utricularia vulgaris* L. *(Lentibulariaceae)*

The species *U. vulgaris* is an insectivorous plant of boggy ground. Though generally of North-Eurasian distribution, *U. vulgaris* is not a frequent plant. LANDOLT *et al*. (1982) consider it vulnerable.

According to the literature data (SCHLOSSER & VUKOTINOVIĆ, 1869; KOŠČEC, 1913) *U. vulgaris* used to be present in Croatia in natural habitats that have disappeared. Now it appears very abundantly in the *Lemno-Utricularietum vulgaris* in the drainage system in Črnec Polje and in some places of the »Sava-Odra« channel. This abundance can be interpreted by the competitiveness and stress-tolerance of *U. vulgaris* (MURPHY *et al*., 1990).

In the study area *U. vulgaris* was not found outside the drainage systems.

4. *Sagittaria sagittifolia* L. *(Alismataceae)*

The species *S. sagittifolia* has Euroasian-Submediterranean distribution (GARCKE, 1972). As a helophyte it is adapted to a wide range of water depths and to alteration from a watery to a terrestrial ecophase. Its growth in a terrestrial ecophase demonstrates its adaptability to variable habitats as well as its capacity to survive under relatively dry conditions (HROUDOVA, 1980).

According to LANDOLT *et al*. (1982) and NIKLFELD *et al*. (1986) *S. sagittifolia* is an endangered plant.

In the study area it is found only in the channels of Črnec Polje. There it is the most conspicuous and abundant plant, which builds the ass. *Sagittario-Sparganietum emersi.* In the Turopolje area it was not found.

5. *Eleocharis acicularis* L. (*Cyperaceae*)

The needlerush (*Eleocharis acicularis*) is particularly interesting because of its wide ecological plasticity (in respect of humidity and substrate reaction) and its very narrow coenological niche (HEJNY, 1960).

Data relating to its distribution in Europe variously call it »scattered throughout the area« (PERRING *et al*. 1964; GARCKE, 1972), »regionally vulnerable« (NIKLFELD *et al*., 1986) or »vulnerable« (LANDOLT *et al*., 1982).

In the drainage system of the area investigated *E. acicularis* is a very frequent species. It develops on sand banks and sandy-silty islets near the banks of the »Sava–Odra« channel and in the drainage system of Črnec Polje. *E. acicularis* also establishes mixed stands with *Marsilea quadrifolia*, *Agrostis stolonifera* and *Leersia oryzoides.*

From the viewpoint of management, it is interesting that HEJNY proposes (1984) the planting of *E. acicularis* for the irrigation system in Egypt so as to form a continuous cover to act as barrier halting the spread of weeds.

6. *Leersia oryzoides* (L.) Swartz (*Poaceae*)

In the literature *L. oryzoides* is listed as a comparatively rare species of Central Europe, of the temperate climatic belt of Asia and North America, and as a frequent weed in the crops of rice and maize in Southern Europe (HEGI, 1906). There-

fore, every find of this plant is of interest both from the plant-geographical point of view as well as from economic standpoint (potential arable land weed).

L. oryzoides is a rare species according to CLAPHAM *et al*. (1968), GARCKE (1972), KLOETZLI (1990), an endangered one according to LANDOLT *et al*. (1982), and a vulnerable one according to NIKLFELD *et al*. (1986).

In the »Sava-Odra« canal and the channels of Črnec Polje *L. oryzoides* is predominant in the *Leersio-Bidentetum* association. In the form of a belt about 1 m wide this association alternates along the channels with other stands of marshy vegetation.

L. oryzoides appears as a pioneer species, growing over the bare banks of these young alluvia of sand and gravel and even over mere silt.

L. oryzoides is present in the study area in its upright form with normally developed inflorescence, indicative of, as a rule, a longer wet ecophase period (HEJNY, 1960). A normally developed inflorescence is a precondition for the formation of seeds, which is a significant factor in the generative spread of the wild rice. In spite of that, the channels are the only sites in the area investigated where the wild rice was found.

7. *Wolffia arrhiza* (L.) Hork. ex Wimm. (*Lemnaceae)*

W. arrhiza is a very attractive plant because it is the smallest flowering plant known to science.

W. arrhiza is a Mediterranean-Atlantic floral element (GARCKE, 1972). It is found in Africa, Southwest Asia and Europe. It has its northern limit at the isotherm of 150 days of mean temperatures above 10 °C and reaches the tropics where it avoids the warmest regions (maximum temperature of the warmest months not more than 28 °C (LANDOLT, 1982).

This species is considered rare (HESS *et al*., 1972; CLAPHAM *et al*., 1968, and others), or even extinct (NIKLFELD *et al*., 1986).

Since the 50's, several localities of this rare plant have been described in Croatia (DEVIDÉ, 1956a; KRAJNČIĆ & DEVIDÉ, 1982; HULINA, 1989; KRAJNČIĆ, 1989). One of these localities and the only one in the study area (HULINA, 1989) is located in stagnant water at the edge of the »Sava-Odra« channel in Turopolje. This botanical rarity has probably been brought here on the feet of migratory wading birds.

b) Neophytes in the drainage systems

In the study area, on the banks of the drainage systems the following neophytes have established themselves:

1. *Solidago gigantea* Aiton (*Asteraceae*)

The North-American species *S. gigantea*, known in Europe as a »planta hortifuga«, grows luxuriantly on hedge banks and on waste ground. In Croatia it has been known since SCHLOSSER & VUKOTINOVIĆ's reports (1857). Up to now it has been locally abundant and widely distributed especially at stream sides (MARKOVIĆ, 1979).

In some places on the banks of the »Sava-Odra« canal the species *S. gigantea* develops pure and dense stands. In the drainage system of Črnec Polje it is not present as yet.

2. *Helianthus tuberosus* L. (*Asteraceae*)

This neophyte was noted as a wild growth in Croatia in 1857 (SCHLOSSER & VUKOTINOVIĆ, 1857)

At present the species *H. tuberosus* is expanding (MARKOVIĆ & LUKAČ, 1994). It spreads via intentional cultivation for its edible tubers but also »sua sponte« by fence-rows, roadsides and on waste ground, mostly on rich lowland soils.

The species *H. tuberosus* appeared on the banks of the »Sava-Odra« canal in 1991.

3. *Amorpha fruticosa* L. (*Fabaceae*)

The species *A. fruticosa* was introduced in Croatia from Hungary at the beginning of this century in order to bind the soil in railway embankments. From those embankments it has spread to lowland forests. Today it is widely distributed in the continental part of Croatia.

The species *A. fruticosa* has created a large, dense belt at the edge of the channels in Črnec Polje. There it is a very aggressive plant and successfully pushes out other plants typical of a wet habitat. On the banks of the channels in Turopolje the species *A. fruticosa* has been rather poorly represented to date.

4. *Echinocystis lobata* (Michx.) Torr. et Gray (*Cucurbitaceae*)

The species *E. lobata* is of North – American origin and has become naturalised in the regions of Central and South-Eastern Europe (TUTIN, 1968).

Since 1949 (DEVIDÉ, 1956b), *E. lobata* has been spreading in the lowland parts of Croatia, where a number of localities has been recorded (DUBRAVEC, 1993).

On the banks of the »Sava-Odra« canal, the species *E. lobata* was first observed in 1982 and in the drainage system of Črnec Polje in 1993; since then it has turned from an invader into a very aggressive member of the bank vegetation (*Cuscuto-Convolvuletum*).

5. *Panicum dichotomiflorum* Michx. (*Poaceae*)

The grass *P. dichotomiflorum* is an annual arable weed and ruderal plant of American origin with a limited distribution in Europe (EHRENDORFER, 1973; HAEFLIGER & SCHOLTZ, 1980).

This grass was not known in Croatia until 1985, when it was found in Central Croatia in maize fields, on field paths and boundaries (HULINA, 1985b, ILIJANIĆ & MARKOVIĆ, 1986), as well as on the banks of the open channels in Turopolje (HULINA, 1985b) where it is not an aggressive plant for the time being.

The species *P. dichotomiflorum* is a potentially dangerous weed (ALEX, 1982), thus requiring attention.

DISCUSSION

Plants and plant communities of aquatic, wet and marshy habitats in Europe are particularly endangered (AYMONIN, 1975; 1980; EBER & SCHAEFERL, 1978; LANDOLT *et al.*, 1982; LANDOLT, 1988; NIKLFELD *et al.*, 1986; and others). Hence a need has grown to preserve some of the natural freshwater vegetation. Nature also cares for

the survival of the living world. That is to say, it is characteristic of the living world that some species are more stable and more adaptable that others. Some aquatic and semiaquatic plants possess great vitality and the ability to compensate for lost natural habitats by artificial ones. The bottom, sides and banks of channels, in relation to the quantity and quality of water, give them an opportunity.

The literature confirms the importance of channels for plant diversity, richness and preservation (HANBURY, 1986; REICHOLF, 1976; WADE *et al*., 1986; WINTGFIELD & WADE, 1988; and others).

The plant component in channels, however, is a dynamic system, characterised by the expansion and retreat of plant species and plant communities (HEJNY, 1985; KUFLIKOWSKI, 1986). In this context, it is not easy to answer the question of how to achieve and sustain in a channel that stage of the plant component which would optimally reflect the richness of the flora and the natural beauty of the area, while at the some time keep the channel working.

Relevant examples from Croatia show, that channels with irregular and traditional maintenance offer large possibilities for the occurrence and distribution of plants, among them aquatic and semiaquatic autochthonous rare and endangered as well as neophyte species. Consequently, it may be concluded that according to the present knowledge of the state of affairs, the traditional, manual and mechanical maintenance of channels is most favourable from the standpoint of nature conservation.

CONCLUSION

It may be concluded that:

1. The drainage system in part of the Upper Sava Valley (Croatia) supports the occurrence and distribution of locally and generally rare, endangered or vulnerable plants. These are: *Riccia fluitans, Marsilea quadrifolia, Utricularia vulgaris, Sagittaria sagittifolia, Eleocharis acicularis, Leersia oryzoides* and *Wolffia arrhiza.*

2. On the banks of the drainage system a number of neophytes have established themselves. The plant species *Solidago gigantea, Helianthus tuberosus, Amorpha fruticosa, Echinocystis lobata* and *Panicum dichotomiflorum* are of greatest importance.

3. Irregular maintenance and traditional methods are important factors for plant diversity and richness in the drainage system.

REFERENCES

ALEX, J. F., 1982: Canada. In: HOLZNER, W., M. NUMATA (eds.) Biology and ecology of weeds, 309–331. Dr. W. Junk Publishers, The Hague-Boston-London.

AYMONIN, G. G., 1975: La regression des vegetaux hygrophiles en Europe. C. R. 100-Cong. Soc. Sav. II, 271–282, Paris.

AYMONIN, G. G., 1980: Une estimation du degré de modification des milieux naturels: L'analyse des regression dans la flore. Bull. Soc. bot. Fr. 127, Lettres bot. (2), 187–195.

CLAPHAM, A. R., T. G. TUTIN & E. F. WARBURG, 1968: Excursion Flora of the British Isles, 2. ed. Cambridge Univer. Press.

COOK, C. D. K., 1974: Water Plants of the World. Dr. W. Junk b. v. Publishers, The Hague.

DEVIDÉ, Z., 1956 a: A new locality of *Wolffia arrhiza* in Croatia (Croat.). Acta Bot. Croat. XIV-XV, 184–186.

DEVIDÉ, Z., 1956 b: *Echinocystis lobata* (Michx.) Torr. et Gray, A new adventitious plant of the Croatian flora (Croat.) Acta Bot. Croat. XIV–XV, 186–187.

DUBINA, D., V., 1981: Poširenija, ekologija ta cenologija *Marsilea quadrifolia* L. na Ukrajini. Ukr. Bot. žur. **38**(1), 27–32.

DUBRAVEC, K., 1994: O raširenosti vrste *Echinocystis lobata* (Michx.) Torr. et Gray *(Cucurbitaceae)* u Hrvatskoj. Simpozij Pevalek, Flora i vegetacija Hrvatske, 19–23.

EBER, G. & C. SCHAEFER, 1978: Ein Feuchtgebiets-Managementplan und seine Ausfuhrung, Natur und Landschaft, **53** Jg. 7/8, 215–223.

EHRENDORFER, F., 1973: Liste der Gefässpflanzen Mitteleuropas, Gustav Fischer Verlag, Stuttgart.

GARCKE, A., 1972: Illustrierte Flora, Verlag Paul Parey, Berlin-Hamburg.

HAEFLINGER, E. & H. SCHOLZ, 1980: Grass Weeds 1, Documenta CIBA-GEIGY, Ltd. Basel.

HANBURY, R. G., 1986: Conservation on canals: a review of the present status and management of British navigable canals with particular reference to aquatic plants. Proc. 7th Symp. on Aquatic Weeds EWRS/AAB, 143–150.

HEGI, G., 1906: Illustrierte Flora von Mitteleuropa, I., München.

HEJNY, S., 1960: Ökologische Charakteristik der Wasser- und Sumpf-pflanzen in den Slowakischen Tiefebenen (Donau und Theissgebiet), Verlag der Slowakischen Akad. d. Wissenschaften, Bratislava.

HEJNY, S., 1984: The Vegetation of the Nile River Banks and of the Irrigation Systems in Egypt as an Agricultural Complex, Acta Bot. Slov. Acad. Sci. Slovacae, Ser. A. Suppl. 1, 49–64.

HEJNY, S., 1985: Expansion and retreat of aquatic macrophyte communities in south Bohemian fishponds during 35 years (1941–1976), Vegetatio **59**, 243–245.

HESS, H. E., E. LANDOLT & R. HIRZEL, 1967: Flora der Schweiz, Bd. 1, Birkhauser, Basel-Stuttgart.

HORVATIĆ, S., 1931: Die verbreitetsten Pflanzengesellschaften der Wasser- und Ufervegetation in Kroatien und Slavonien. Acta bot. **6**, 91–108.

HROUDOVA, Z., 1980: Occurence of *Sagittaria sagittifolia* at different depths of water. Folia Geobot. Phytotax. 15/4, 415–419.

HULINA, N., 1982: The contribution to the knowledge of aquatic vegetation in the drainage system of Turopolje area (Croat.). Agr. Consp. Sci. **59**, 303–312.

HULINA, N., 1985a: Marshland vegetation of the drainage system in the Turopolje area (Croat.), Agr. Consp. Sci. **68**, 37–46.

HULINA, N., 1985b: Species *Panicum dichotomiflorum* Michx. – new weed in Jugoslavia (Croat.), Frag. herb. Jugoslav. **14**(1–2), 113–120.

HULINA, N., 1989: A survey and analysis of the flora in the Turopolje area (Croat.), Acta Bot. Croat. **48**, 141–160.

HULINA, N., 1990: Aquatic weeds in open channels in the Upper Sava River Valley. Proc. 8th Symp. EWRS on Aquatic Weeds, 123–129.

HULINA, N., 1993: Syntaxonomical range of *Marsilea quadrifolia* L. *(Marsileaceae)* in Posavina, Croatia. Acta Bot. Croat. **52**, 65–73.

HULINA, N., LJ. ĐUMIJA & M., BUJAN, 1993: The content of heavy metals in aquatic and swampy plants from drain-system of the Upper Sava River valley (Croat.). Agr. Consp. Sci., **58**, 75–82.

HUSAK, Š. & H. OTAHELOVA, 1986: Contribution to the Ecology of *Marsilea quadrifolia* L. Folia Geobot. et Phytotax., **21**(1), 85–89.

ILIJANIĆ, LJ. & LJ. MARKOVIĆ, 1986: *Panicum dichotomiflorum* Michaux in the surroundings of Zagreb. Acta Bot. Croat. **45**, 137–139.

KLOETZLI, F., 1990: Eine Vegetation mit erstaunlicher Vielfalt. Ber. Bot. Zool. Ges. Liechtenstein-Sargans-Werdenberg, **18**, 75–86, Vaduz.

KOŠČEC, F., 1913: Florula čazmanskih mlaka i rijeke Čazme. Glas. Hrv. Prirod. Druš. **25**(2), 83–96.

KRAJNČIĆ, B. & Z. DEVIDE, 1982: Rasprostranjenost vodenih leća (*Lemnaceae)* u sjevernoj Hrvatskoj. Acta Bot. Croat. **41**, 175–180

KRAJNČIĆ, B., 1989: Distribution of *Lemnaceae* in the region of Istria and first discovery of flowering *Wolffia arrhiza.* Ber. Geobot. Inst. ETH Stiftung Rbel, **55**, 81–88.

KUFLIKOWSKI, T., 1986: Development and structure of the Goczalkowice reservoir ecosystem. X. Macrophytes. Ekol. pol. **34**(3), 429–445.

LANDOLT, E., 1982: Distribution pattern and ecophysiological characteristics of the European species of the *Lemnaceae*. Ber. Geobot. Inst. ETH Stiftung Rübel, **49**, 127–145.

LANDOLT, E., 1988: Der Schutz der Flora in der Schweiz. Inform. Bot. Ital. **20**(1), 389–403.

LANDOLT, E., H. P. FUCHS, CH. HEITZ & R. SUTTER, 1982: Bericht über die gefährdeten und seltenen Gefässpflanzen der Schweiz (»Rote Liste«), Ber. Geobot. Inst. ETH Stiftung Rübel **49**, 195–218.

MARKOVIĆ, LJ., 1979: Neofiti kao šumski korovi u poplavnim područjima kontinentalne Hrvatske. I. Jugoslavensko savjetovanje o suzbijanju korova u šumarstvu. Sarajevo, 21–29.

MARKOVIĆ, LJ. & G. LUKAČ, 1994: Fitocenološka pripadnost sastojina čičoka (*Helianthus tuberosus* L. s.l.) u zapadnoj Hrvatskoj. Simpozij Pevalek, Flora i vegetacija Hrvatske, 63–69.

MURPHY, K. J., B. RORSLETT & I. SPRINGUEL, 1990: Strategy Analysis of Submerged Lake Macrophyte Communities: an International Example, Aquatic Botany, **36**, 303–323.

NIKLFELD, H., G. KARRER, W. GUTERMANN & L. SCHRATT, 1986: Rote Listen gefährdeter Pflanzen Österreichs, Grüne Reihe des Bundesministeriums für Gesundheit und Umweltschutz, Bd.5. Wien.

OBERDORFER, E., 1970: Exkursions flora, Eugen Ulmer, Stuttgart.

PAVLETIĆ, ZL., 1968: Flora mahovina Jugoslavije. Inst. za bot. Sveuč. u Zagrebu.

PERRING, F. H., P. D. SELL & S. M. WALTERS, 1964: A flora of Cabridgeshire, Cambridge.

PEREIRA, H. C., 1973: Land use and water resources in temperate and tropical climates. Cambridge University Press.

REICHHOLF, J., 1976: Dämme als artenreiche Biotope. Natur und Landschaft, **51**. Jg, 7/8, 209–212.

ROSSI, LJ., 1924: Građa za floru južne Hrvatske. Prirod. istraž. Hrvatske i Slavonije. Jugoslav. Akad. 15, 1–219.

SCHLOSSER, J. & LJ., VUKOTINOVIĆ, 1857: Syllabus florae Croaticae. Zagreb.

SCHNEIDER-JACOBY, M., 1990: Verbreitung und Gefährdung typischer Wasserpflanzen Arten in der Sava Stromaue im Bereich des geplanten Naturparks »Lonjsko Polje«. Acta Bot. Croat. **49**, 125–136.

ŠEGULJA, N., 1994: *Marsilea quadrifolia* L. In: ŠUGAR, I. (ed): Crvena knjiga biljnih vrsta Republike Hrvatske, Ministarstvo graditeljstva i zaštite okoliša, Zavod za zaštitu prirode, Zagreb, 307–308.

TUTIN, T. G., 1968: *Echinocystis lobata* (Michx.) Torren et Gray. In: TUTIN, T. G., V. H. HEYWOOD, N. A. BURGES, D. H. VALENTINE, S. M. WALTERS, D. A. WEBB: Flora Europaea, **2**, Univ. Press Cambridge.

WADE, P. M., L. VANHECKE & R. BARRY, 1986: The importance of habitat creation, weed management and other habitat disturbance to the conservation of the rare aquatic plant, *Callitriche truncata* Guss. subsp. *occidentalis* (Rony) Schotsm. Proc. 7th Symp. on Aquatic Weeds EWRS/AAB, 389–394.

WINTGFIELD, M. & P. M. WADE, 1988: Hatfield Chase: The loss of drainage channel habitat. Naturalist 113, 21–24.

WRABER, T. & P. SKOBERNE, 1989: The Red Data List of Threatened Vascular Plants in Socialistic Republic of Slovenia (Slov.). Nature Conservation, 14–15, 1–429, Ljubljana.

SAŽETAK

Rijetke, ugrožene ili osjetljive biljne vrste i neofiti u sustavu odvodnje u Hrvatskoj

N. Hulina

Prije 20-tak godina u dijelu Gornje Posavine, Turopolju i Črnec polju, izgrađena je vrlo prostrana mreža poljskih i obodnih odvodnih kanala. Održavanje tih kanala je neredovito i pretežno se biljna masa iz njih odstranjuje mehanički. U takvim uvjetima održavanja zabilježeno je sedam lokalno i općenito rijetkih, ugroženih ili osjetljivih biljnih vrsta. To su: *Riccia fluitans* L., *Marsilea quadrifolia* L., *Utricularia vulgaris* L., *Sagittaria sagittifolia* L., *Eleocharis acicularis* L., *Leersia oryzoides* (L.) Swartz, *Wolffia arrhiza* (L.) Hork ex Wimm. Na nasipima kanala ustanovljena je nazočnost neofita. Među zabilježenim neofitima od većeg su značenja vrste: *Solidago gigantea* Aiton, *Helianthus tuberosus* L., *Amorpha fruticosa* L., *Echinocystis lobata* (Michx) Torr. et Gray i *Panicum dichotomiflorum* Michx.

Tradicionalne metode održavanja kanala, neredovito mehaničko odstranjivanje biljne mase iz njih, važan su čimbenik za biljnu raznolikost i bogatstvo odvodnog sustava. Takav način održavanja kanala je najpovoljniji i s obzirom na zaštitu prirode.