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Contribution to the Biology and the Vegetation Ecology of Heracleum mantegazzianum Populations in West Transdanubia (Hungary)

Kovács, J. A.
BDF, Növénytani Tanszék
kja@deimos.bdtf.hu

Abstract. The study dealing with the development, spreading, ecology and cenological relation of *Heracleum mantegazzianum* invasive stands distributed alongside the stream Borzó, West Transdanubia (Hungary). It was demonstrated that the spreading strategy is influenced by the phenology and structure of populations, distinguished a juvenile phase and an adult phase (flowering and fruiting only once before senesting). The regenerative growth is restricted to the vegetative (juvenile) phase. The original diaspore spreading is the passive autochory, completed occasionally by the hydrochoric and antropochoric spreading.

The *H. mantegazzianum* stands phytosociologically belong to the classes of *Galio-Urticetea, Artemisietea, Molinio-Arrhenatheretea.* The ceno-ecological role of the species and the *Heracleum mantegazzianum* derivate community are well expressed by the ecology of the species *Aegopodium podagraria* and *Urtica dioica.* In the studied area, the Giant Hogweed populations prefer fresh and moist sites, moist roadsides, riparian habitats with good nutrient level realized by the alliance of *Senecion fluviatilis.*

Introduction

During the years 1993–1994, when we explored and studied the flora and vegetation of Vas county, overviewed and summarised the ecology, floristic composition and the distribution of natural, seminatural and antropogenous plant communities in the area of western Hungary, our attention was attracted by some tall giantiform plant populations of *Apiaceae*, spreaded alongside the stream Borzó, in fresh and moist sites, damp places and waste ground, forming sometimes dominant riparian stands between the localities Vép and Bozzai (HU: 8766/3, 4). After futher investigation on the interesting plant material, it has been registrated to the *Heracleum mantegazzianum* agg. (Kovács 1996, Kovács–Takács 1997).

At the III. Conference of the "Actually Studies on the Flora and Vegetation in Hungary" (Szombathely, 1999) we presented our first observations and results about the floristical, ecological and phytosociological aspects regarding the Giant Hogweed population in West Transdanubia. The present paper continues to give other scientific aspects, regarding especially the taxonomy, development, communities and vegetation ecology of the Giant Hogweed invasive populations naturalized alongside the stream Borzó (West Hungary).

Heracleum mantegazzianum is a native herbaceous species of the subalpine zone (from 1,700 to 2,300 m) in the Caucasus Mountains and south-west Asia, which became naturalized in Central Russia and Europe in the nineteenth century (Hegi 1965, Tiley et al. 1996). It was introduced to Western and Central Europe around 1850 as an ornamental plant into gardens and parks, from which the escapes and colonization have been realized along the watercourses in many countries (Lundström 1984, Clegg, Grace 1974, Pysek 1991). In the last decades the general distribution has increased especially alongside the river-banks, streams, damp places and waste grounds. Secondary spread reflects strong antropogenic influences on the landscape and occurs in wet meadows, eutrofied forests, roadsides, railway tracks, refuse dumps, generally nitrophilous sites and vegetation, fresh to moist sites with high nutrient levels.

Nowadays Giant Hogweed is considered in Europe as an invasive alien herbaceous perennial, as a neophyta and ergasiophyta species with a continuous increasing distribution, being found and marked in most European countries: Austria, Belgium, British Isles, Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, the Netherlands, Norway, Russia, Slovakia, Sweden, Switzerland, Ukraine (Andersen 1996, Clegg and Grace 1974, Ludström 1984, Oschmann 1996, Pysek 1991, Soó 1980, Tiley et al. 1996).

Taxonomical aspects

The type of species was described as *Heracleum mantegazzianum* by Sommier and Levier in 1895 (Brummitt 1968), nevertheless more descriptive names have been used: *H. giganteum* Fischer ex Hornem, *H. villosum* Fischer ex Sprengel, *H. speciosum* Weinm., *H. persicum* Desf. ex Fischer, *H. asperum* Bieb., *H. caucasicum* Steven, *H. stevenii* Manden., *H. pubescens* (Hoffm.) Bieb., *H. sibiricum* Sphalm etc. So, some confusions may exist in the earlier literature between similar related species. After Brummitt (1968) the taxonomy and nomenclature of naturalized Giant Hogweeds populations

from south-western Asia are not uniform. Morphologically the populations can be very variable and the *H. mantegazzianum* group probably includes also the distinct but occasionally naturalized types like *H. lehmannianum* Bungle, H. persicum Desf. and H. wilhelmsii Fischer et Avé-Lall.

The typical *H. mantegazzianum* forms are biennial or perennial monocarpic herbs, the stem up to 10 cm thick at the base and 2–5 m tall, hollow, ridged. The leaves blades up to 250–300 cm, ternately or pinnately divided in varying degree, pinnately lobed. Flowers in compound umbels up to 50 cm in diameter, with 50–150 unequal rays, the terminal umbel is largest, petals are white or rarely pinkish, the fruits 9–14 mm are glabrous or villous dorsally compressed with two wigned mericaps. Some of the main characteristics of the related taxa are the following (Brummitt 1968, Stace 1992):

Characters	H. mantegazzianum	H. pubescens	H. persicum
Stem height [cm]	200–500	60–80	80–250
Umbels wide [cm]	20–50	10–12	20–50
Umbels rays [No]	50–150	15–20	50
Leaves form	pinnate, ternate or simple, ternately to pinnately lobed	ternate to pinnate, the segments pinnately lobed	pinnate or ternate, the segments more divided

The botanical literature related to the Giant Hogweed populations naturalized mostly in Northern, Western and Central-Europe indicates them to belong to one taxon only, *H. mantegazzianum* Sommier et Levier. Earlier names used in different countries probably refer also to this taxon. Hybrids described in England and recorded also in Germany: *H. sphondylium* × *H. mantegazzianum* (Stace 1992, Oschmann 1996). Several references point out the relationship between chemical composition and photodynamic properties of furanocumarins that produced phytodermatitis in man (Camm et al. 1976, Tiley et al. 1996).

In Hungary data about the subspontaneous spreading and the first naturalized records of Giant Hogweed were indicated by Soó (1966 without localities) and published with localities (Zirc, Szombathely, Szarvas) also by Soó (1980, apud Priszter), and Priszter (1978). The main Hungarian references to the *Heracleum mantegazzianum* group are the following:

- 1925: "Established once near Budapest also the *H. persicum* Desf." (Jávorka, S. 1925, p. 792.)
- 1951: "*H. mantegazzianum* Somm. et Lev.: the leave blades are ternately or pinnately divided on 3–5 lobes, very larges (mostly 1,5–3,0 m), fruits villous and prickled, giant ornamental plant. *H. persicum* Desf.: once adv. (Bpest +)" (Soó, R., Jávorka, S. 1951, I. 425.)

• 1966: "*Heracleum persicum* Desf. 1840 (*H. trichocarpum* Borb 1879). Originated from Persia H., once ornamental plant, running wild (Budapest +), ephemerophyta" [...] "*H. Mantegazzianum* Somm. et Lev. 1894. Caucasian species, tall stature ornamental plant sometimes escaped. H. July–August, 2n: 22" (Soó, R. 1966, II. p. 487.)

• 1980: "*H. Mantegazzianum.* Subspontaneous in localities: Zirc, Szombathely, Szarvas (Priszter, Sz.)" (Soó, R. 1980, VI. p. 69. Addenda et corrigenda ad tomus I–IV.)

• 1994: "*H. mantegazzianum* (*H. sosnovskyi* ?). Frequent in the floodplain area of the river Tisza between Tiszabecs and Tiszacsécse" (Fintha, I. 1994, p. 130.)

• 1995: "Spreading of subspontaneous *Heracleum* species in Europe" (Terpó, A. 1995, Summary, p. 41.)

• 1996: "*Heracleum mantegazzianum* Sommier et Levier., Őriszentpéter: near the river Zala. ap. Bálint et al. 1993" (Balogh, L. 1996, Savaria 23/2, p. 299.)

• 1996: "*Heracleum mantegazzianum* Somm. et Lev., Vép-Bozzai, Szombathely-Kámon: spreading invasive populations" (Kovács, J. A. 1996., incl. Molnár, Zs. 1996/1997 Diss. p. 49.)

• 1997: "*H. mantegazzianum* Somm. et Lev., Keszthely: spreading invasive populations" (Dancza, I. 1997, Kitaibelia 2 (2): p. 213.)

• 1997: "*H. mantegazzianum* Sommier et Levier, Vép-Bozzai: spreading invasive populations" (Kovács, J. A., Takács, B. 1997, Kitaibelia 2 (2): p. 222.)

• 2000: "*H. mantegazzianum* Somm. et Lev. (*H. sosnovskyi* Manden. ?). Subspontaneous in the floodplain area of the river Tisza between Tiszabecs and Tiszacsécse ap. Terpó, A. In: Fintha, I. 1994" (Simon, T. 2000, p. 290.)

After the year 2000, other new records have been indicated (Bauer 2001, Balogh et al. 2002). However, the main recent distribution patterns recorded in the Central European Mapping System are the following: 8766/3, 4 (Vép-Bozzai), 8773/1 (Zirc, Csesznek), 9269/1 (Keszthely), 8281/3 (Vácrátót), 8085/3 (Mátraszentistván), 7802/4 (Tiszabecs–Tiszacsécse). Terpó's opinion (1994, 1995) is interesting about the origin and registration of the records especially from the NE Hungary, alongside the river Tisza on the Hungarian–Ukrainian border region. It is possible that this plant material belongs to the *H. sosnowskyi* Mándenová. This species has been cultivated and used in Poland, Russia and Ukraine as forage silage for cattle. Subspontaneous populations have been also reported in Russia and Ukraine. The populations require further investigation. A summary about the Hungarian contributions is given by Dancza (2003).

Development and phenology

In order to have reliable and thorough documentation on the development and phenology of the Giant Hogweed plant individuals and stands, we organized field observation and laboratory studies on the plant material situated in the strictly floodplain area of the stream Borzó, between Vép and Bozzai with the field characteristics: altitude with 178–184 m, the mean annual temperature is 9.3 °C, the annual rainfall is 750 mm, wet, streamside riparian vegetation (West Transdanubia). The survey organized in the period of 1997 to 1999 mainly demonstrated that the populational structure shows a charecteristic composition because in every small population without the new annuals can be present biennal, triennal and also perennial plants (Kovács 1999). They differ morphologically and physiologically. One of the phenological characteristics of the perennial *H. mantegazzianum* plant individuals is that they have a vegetative, juvenile phase and another, adult phase (flowering and fruiting only once before senescing). The regenerative growth (after cutting etc.) is restricted only to the vegetative (juvenile) phase, the adult plants with leaves and flowers, after flowering and fruiting become senescence. This situation contributes to the realization of an own populational structure, which influences the strategy of spreading.

Our observation on the development and phenology has summarized the development of plant individuals from seeds, development of perennial individuals and the distribution of diaspore, the distribution of seedlings around the senesced mother plats (Figures 1–3).

The development of plant individuals from seeds, the seedlings and the juvenile phase establishment can be observed in Fig. 1. The initial growth from seeds, the seedling stage is generally slow, the seedlings emerge with cotyledons and the primary leaf in 7 to 8 weeks after a long winter frost period, the second leaf appearing after around 12 weeks (about 20 March), the juvenile phase finishes after 18 to 19 weeks (early May). The new true leaves and the leaves rosette develop from May to the end of June with a maximum vegetative development in the second part of June. The new (annual) plant individuals do not realize a generative phase. In the second and subsequent years, leaf growth becomes expansive, more competitive.

The development of perennial individuals (Fig. 2) in the vegetative phase (weeks 12 to 19, generally from 15th March to 30th April) is similar to the development of juvenile plants developed a year ago, but normally is followed by the generative phase (middle of June). Flowering depends on the plant vigour of previous vegetative growth, extends in the observed field from 10th to 25th June, the fruit ripening is realized during July and August, beginning with the main terminal umbel. The seed dispersal oc-

curs from August to the first part of October. It is very important, that after flowering and seed spreading the whole plant becomes senescent and including the roots also, normally dies. The flowering plants cut above the roots or having different damages, may survive in the same year and in the next vegetative season. The plants removed at the first node, can develop secondary flowering shoots, or following further disturbance, many individuals were able to produce a third inflorescence, without seed development. This regenerative growth also permits the grazing possibilities in the field (Andersen, Calov 1996).

The spreading success of the *H. mantegazzianum* individuals, the species' competitive ability depends on the diaspora dispersal. An original way for seed dispersal is the passive autochory realized by the solitary old plants. We studied and demonstrated this by measuring the radial distribution of seedlings around the dead mother plants (Fig. 3). Counting the germinated seeds in the neighbourhood of old mother plants in an area of 900 cm^2, a great density of seedlings (80–92) has been found between 50–120 cm from the senesced stem of a mother plant. From this distance the number of seedlings decreases continuously especially after 200 cm. At 300 cm distance the percent of germinated seeds is very slow. The seedling production is influenced by the frost in winter period. In the studied area, the germination was very early in spring, during March, influenced by local temperature and light conditions. In a distance of 200 cm around the dead mother plant there was a high seedling density, able for new propagation.

The dying mother plants create favourable condition for the establishment of the new annuals. This "autochory", realized step by step, contributes to the slowly but efficient plant propagation and creates fragmentary populations in the disturbed field. The seeds are relatively heavy (12,000 g/1,000 mericarps), so after our observation the wind dispersal (the diaspore propagation in an anemochoric way) is less important. The long distance dispersal usually can be realized by "hydrochoric" and "antropochoric" form. The hydrochoric dispersal has a greater efficiency. The floating mericarps can be transported by water courses to long distance. This way occurs a central establishment of the popoulations in the Vép-Bozzai area. The antropochoric dispersal, realized by various human activities, like the use of cars, trucks, buildings, exchange of plant materials etc. plays an important role in the spread of populations. In the expansion of a population in the studied field, in a local area, all these dispersal types have been recognized. The realization of new populations starts usually by autochory. 5 to 6 dying mother plants ensure in cca 100 m^2 the development of a high density of seedlings, followed by new adults with high interspecific competition ability. The new plant group can remain dominant for few years, transforming

the original habitat conditions. The giant plants with high covering, shade the land ensuring the progress of colonization. The large populations by watercourses and different human activities (hydrochoric and antropochoric spreading) contribute to the realization of other populational fragment and new stands. The high seed production (about 5,500 diaspores in a primary umbel), the particular dispersal strategies, the huge persistent seed bank increase the species' competitive abilities.

Vegetation ecology and cenological relations

In order to establish the ecological and phytocenological role of *H. mantegazzianum* invasive populations in West Transdanubia, our survey has regarded the vegetation structure alongside the stream Borzó and surroundings, an area situated between the localities Vép and Bozzai-Bárdos (Vas county). The stream Borzó (or Kozár-Borzó) coming from the North, springs from the Kőszeg area, but from this region to the locality Vép, no plant of Giant Hogweed was found. The first plant individuals start to appear only after the Arboretum in Vép, after behind the small bridge and continuing their distribution to the Bozzai (see Vegetation map). In this section of the stream Borzó, about 19 plant communities have been mapped (Fig. 4) belonging to the freshwater aquatic vegetation, swamps, mesic meadows, moist and wet eutrophic grassland, roadside ruderal vegetation, antropogenous moist fringe vegetation, willow woodlands, temperate woodlands etc (see Vegetation map).

The populations of *Heracleum mantegazzianum* alongside the stream Borzó are the most frequent colonizers in disturbed habitats, open areas, occupated riparian sites and also invade the closed semi-natural and ruderal communities like: *Phragminetum communis, Filipendulo-Geranietum palustris, Tanaceto-Artemisietum, Urtico-Convolvuletum, Sambucetum ebuli, Salicetum albae-fragilis, Aegopodio-Alnetum* and uncultivated lands (Fig. 4, Vegetation map). The size of Giant Hogweed populations is variable in different plant communities, covering from 10–15% to 75–80%, realizing also stands for the own derivate community (DC: *Heracleum mantegazzianum*) (Tab. 1). It is interesting to note, that the populations from Vép to the bridge of Tanakajd can be considered the smallest, while others, especially those situated in the shaded, moist habitats, in northern exposition of the Bozzai section, the largest and very expressive. The highest density and covering are realized in the DC-community (75–90%) (Tab. 1).

The stands with *H. mantegazzianum* alongside the stream Borzó belong to the phytosociological Classes of *Galio-Urticetea, Artemisietea* and

Molinio-Arrhenatheretea. They are characterized by the dominance of *H. mantegazzianum* followed by *Urtica dioica, Aegopodium podagraria, Glechoma hederacea, Galium aparine, Anthriscus sylvestris, Calystegia sepium, Rubus caesius* (Tab. 1). The typical stands have been incadrated in the Class of *Galio-Urticetea*, but some of them realize facies in the communities: *Urtico-Convolvuletum, Filipendulo-Geranietum palustris, Sambucetum ebuli* etc. Within the recorded samples, a small difference can be observed. In the samples 1–8, the Giant Hogweed A–D values are very high (75–90%), while in the samples 9–10, the A–D values arrive only to the 50%. The ecological role of *H. mantegazzianum* is well expressed by the constancy of the species: *Aegopodium podagraria* and *Urtica dioica.* They are useful ecological and cenological indicators for the derivate community. It means that the Giant Hogweed populations in the studied area prefer fresh and moist sites, moist roadside, riparian habitats with a good nutrient level (Kovács 1994, 1999), while eutrophication has occured by antropogenic influences realized mainly by the alliances *Senecion fluviatilis, Aegopodion podagrariae, Deschampsion* (degraded stands), *Arrhenatherion* (degraded stands).

Approaching ecological and cenological relations have been demonstrated in the British Isles, Germany and Czech Republic (Dierschke 1984, Oschmann 1996, Pysek 1994, Tiley et al. 1996), the invasive populations of *H. mantegazzianum* being included generally in the Classes of *Artemisietea* or *Galio-Urticetea.* We may also mention the work of Klauck (1988) from Germany, who proposed and described a new nitratophytic plant community, spreaded near settlements: *Urtico-Heracleetum mantegazzianii*, which are related to *Urtico-Aegopodietum* and have been included in the Ord. *Glechometalia hederaceae.* To accept this community in our case is questionable, because in the given rélevées there are separate different species.

Instead of this situation, in the original habitats of *H. mantegazzianum* in West Caucasian Mountains the cenological relations are totally different. The species belong to the Class *Betulo-Adenostyletea* spread with other mountain species like: *Vaccinium arctostaphylos, Rhododendron caucasicum, R. ponticum, Lilium caucasicum* etc.

Conclusions

The presence of subspontaneous *Heracleum mantegazzianum* populations from ornamental garden plants in Hungary has been recorded by Soó ap. Priszter (1966, 1980). The first escapes were related to the neighbourhood of Arboretums. Other escaped and naturalized populations originate from forage introductions. Therefore the plant materials taxonomically can be different.

The survey realized about the West-Transdanubian *H. mantegazzianum* stands near Vép-Bozzai, distributed alongside the stream Borzó, demonstrated interesting features of development, spreading, ecology and cenological relations. It was pointed out that the phenology of populations developed from seeds and perennial sources, distinguished juvenile, vegetative, generative, fruiting and dispersal phases. An original diaspore spreading is the passive autochory. 5 to 6 dying mother plants ensure on cca 100 m^2 the development of a high density of seedling. The dispersal especially for long distance is completed occasionally by hydrochoric and antropochoric spreading.

The stands with *H. mantegazzianum* along the stream Borzó phytosociologically belong to the Classes of *Galio-Urticetea, Artemisietea* and *Molinio-Arrhenathereatea.* The derivate community of *H. Mantegazzianum* mainly is characterized by the species: *H. mantegazzianum, Urtica dioica, Aegopodium podagraria, Glechoma hederacea, Galium aparine, Anthriscus sylvestris.* The ceno-ecological role of *H. mantegazzianum* is well expressed by the constancy of the species *Aegopodium podagraria* and *Urtica dioica.* The Giant Hogweed populations in the studied area prefer fresh and moist sites, moist roadsides, riparian habitats with good nutrient levels, realized especially by the alliance of *Senecion fluviatilis* and *Deschampsion* (degraded stands).

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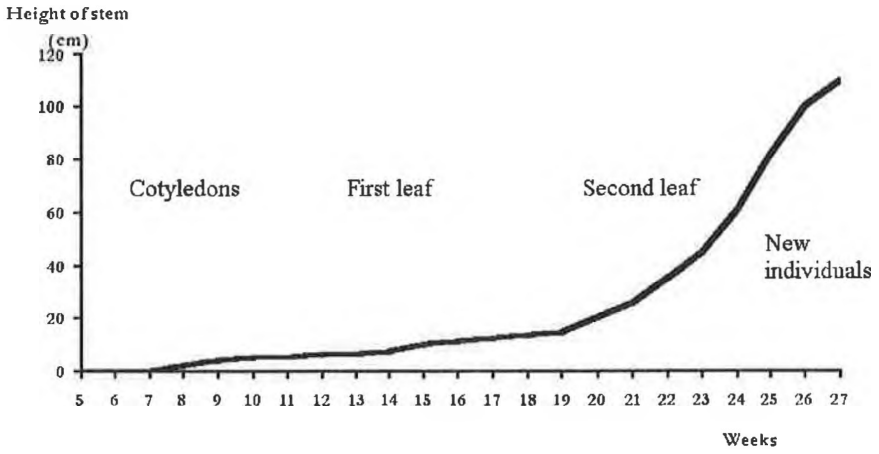

Fig.1 Development of plant individuals from seeds (10.03.–15.06. 1999)

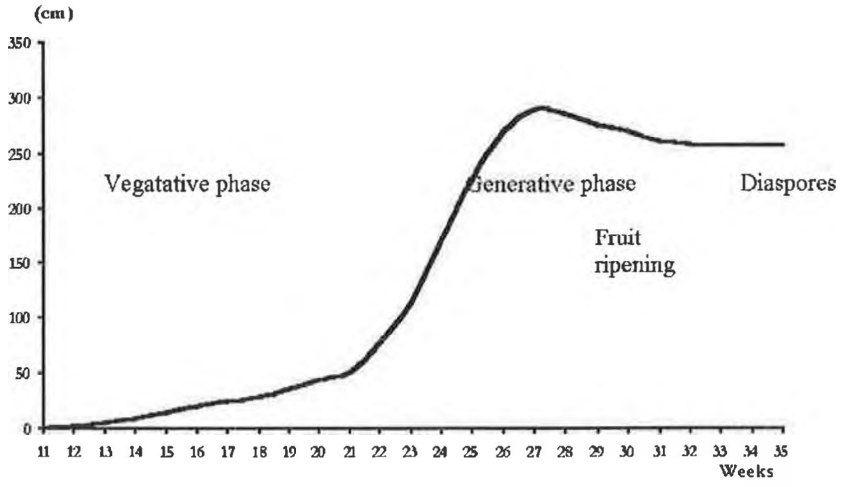

Fig.2 Development of perennial individuals (15.03.–31.08. 1999)

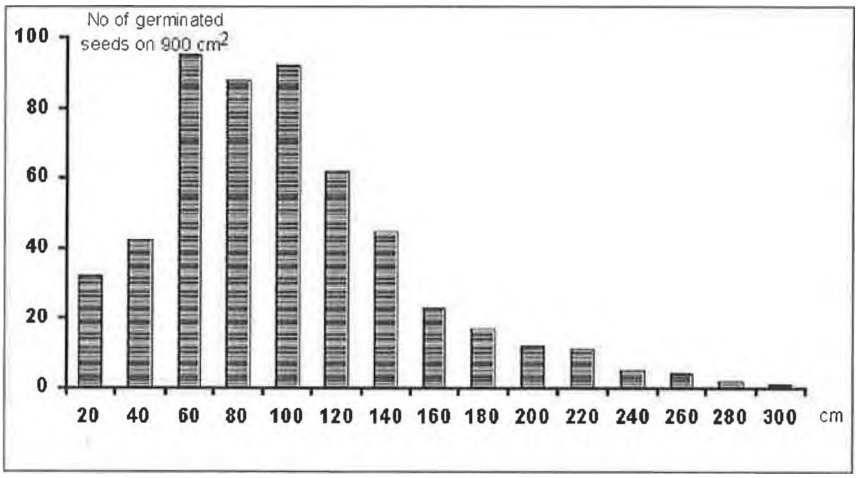

Fig.3 The distribution and distance of seedlings around the senesced mother plant

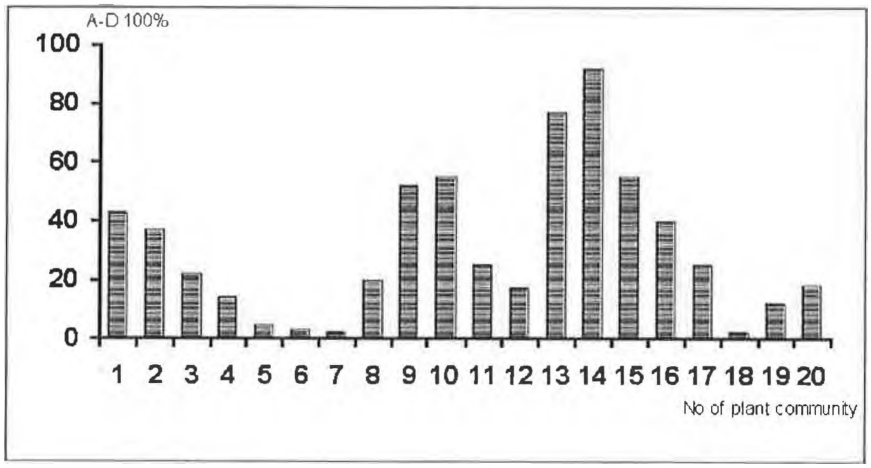

Fig.4 Cenological relations of Heracleum mantegazzianum populations alongside the stream Borzó

Table 1. The *Heracleum mantegazzianum* Galio-Urticetea derivate community alongside the stream Borzó between Vép-Bozzai (West Transdanubia, Hungary, 06–07. 1999).

Sample No	1	2	3	4	5	6	7	8	9	10	K
Covering (%)	100	100	100	100	95	95	90	90	85	85	
Species Count	20	17	14	15	18	24	22	23	27	20	
Diagnoses species											
Heracleum mantegazzianum	5	5	5	5	5	5	4	4	3	3	V
Urtica dioica	1	1	1	1	+	1	2a	1	2b	2b	V
Aegopodium podagraria	+		+	+	1	+	+	1	1	1	IV
Calystegia sepium		+		+	1		1	1	1	+	IV
Anthriscus sylvestris	+		+	+				+		+	III
Galio-Urticetea											
Galium aparine	2a		+	1	1	2a	1	+	2a	2a	V
Glechoma hederacea	+	2a	+	+			2a	+	1	+	IV
Rubus caesius		+		1	1	1		2a	1		III
Impatiens glandulifera		+	+			+	+				II
Chaerophyllum bulbosum					+	+		+	+		II
Althaea officinalis	+		+				+		+	+	II
Tanacetum vulgare	+						1		1		II
Echinocystis lobata				+	+		1			1	II
Artemisietea vulgaris											
Artemisia vulgaris		+				+		+	+		III
Elymus repens	+	1			+		1		1		II
Arctium lappa	+		+			+		+			II
Ballota nigra		+		+	+	+			+		II
Molinio-Arrhenatheretea											
Poa trivialis	+			+	+			+	1	1	III
Arrhenatherum elatius		+				+			1		II
Vicia cracca		+			+	+	+				II
Ranunculus repens	+					+			+	1	II
Dactylis glomerata		+	+		+		+				II
Lysimachia nummularia	+			+		+		+			II
Galium mollugo	+	+			+		+	+			II
Molinietalia											
Symphytum officinale	+		+					1	+		II
Deschampsia caespitosa						+	1	+		1	II
Filipendula ulmaria						+	+		1	+	II
Phragmiti-Magnocaricetea											
Phragmites australis						+	+		+	1	II
Typha latifolia						+	+		1	1	II
Phalaris arundinacea	2a			+	1		1	1	2a		II
Mentha longifolia	+							1		+	II
Lysimachia vulgaris	+							+	+	+	II
Epilobium hirsutum		+	+				+	+	+		II
Varia											
Galeopsis tetrahit	+	+			+	+					II
Inula britannica							+	+	+	+	II
Solidago gigantea	+		+	+						1	II

Conium maculatum		+	.	.	+	+				II
Scrophularia umbrosa	.	.	.	.	.	+		+		II
Equisetum sylvaticum				+	+	+			+	+ II
Persicaria hydropiper						+		I	+		II
Lamium maculatum		+	+	.	.	+	+	.	+		II

Species present only in one-two samples: Poa pratensis + (1), Caltha palustris + (9), Ranunculus ficaria + (2), Poa annua + (8), Heracleum sphondylium + (5), Cichonum intybus 3 (4), Lamium album + (3), Galium verum + (2), Taraxacum officinale + (4), Humulus lupulus + (8), Cirsium vulgare + (3), Saponaria officinalis + (7), Angelica sylvestris + (6), Calamagrostis epigeios + (6), Humulus lupulus + (10)

Vegetation map

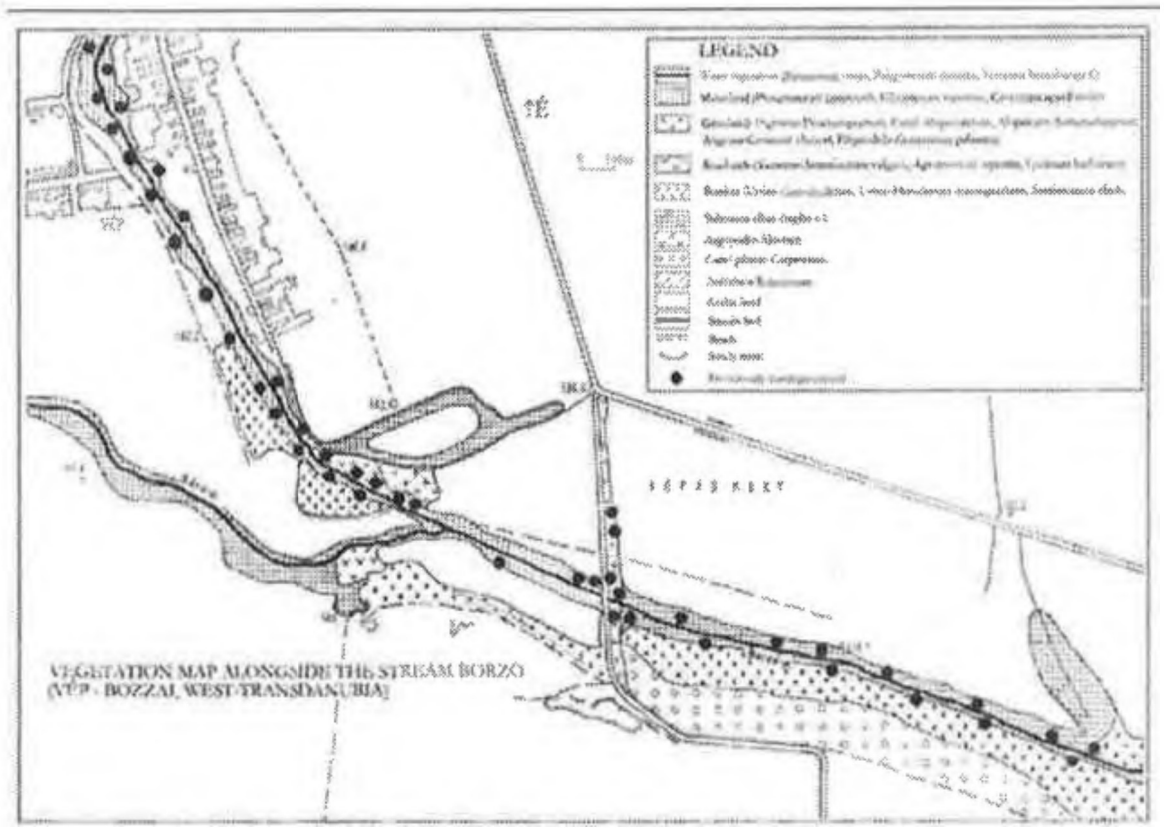
LEGEND
VEGETATION MAP ALONGSIDE THE STREAM BORZÓ
(VÉP - BOZZAI, WEST-TRANSDANUBIA)

Photo: *Heracleum mantegazzianum* Sommier et Levier giant plant individual alongside the stream Borzó (Vép-Bozzai)