Fabrizio Martini & Livio Poldini

The hemerophytic Flora of Friuli-Venezia Giulia (N.E. Italy)

Abstract

Martini, F. & Poldini, L.: The hemerophytic Flora of Friuli-Venezia Giulia (N.E. Italy). — Fl. Medit. 5: 229-246. — ISSN 1120 - 4052.

The situation of the hemerophytic flora of Friuli-Venezia Giulia in its adventitious, autapophytic and deuterapophytic components is here considered. For each of these the family composition, life and growth form spectrum, chorological spectrum, and subdivision into phytosociological classes are studied. The actual situation is compared to that before 1945 and the main reasons of the changes occurred in the emerophytic flora are discussed. A "diffusion index", expressing the capability of an adventitious species to spread within a territory is suggested. Finally the up-to-date list of the adventitious species found in the region after 1945 is provided.

Introduction

The diffusion and the role of the hemerophytic component in man-made habitats has been treated in a series of previous studies (Poldini & Vidali 1989, Poldini & al. 1991, Poldini & Martini 1993). We here present a synthetic overview for the whole Friuli-Venezia Giulia region, based on the data of the "Atlante Corologico delle piante vascolari del Friuli-Venezia Giulia" (Poldini 1991) and subsequent updates (Poldini & Vidali, in press).

As defined by Ahti & Hamet Ahti (1971), hemerophytes are plants that live in man-made (e.g. ruderal habitats) and in environments deeply and lastingly changed by man's action (cultivated fields, wastelands, quarries, road sides, etc.).

According to Holub & Jirasek (1967), hemerophytic species fall into either of two categories, defined on the base of their origin:

(1) Anthropochores (adventitious) plants, i.e. species which are not members of the autochthonous flora but have been intentionally or casually introduced by man. They correspond to the "Exotic species" sensu Viegi & al. (1973), which however include "cultivated exotic species that have not become spontaneous", here omitted as having been introduced intentionally and showing no tendency to spread.
(2) Apophytes, i.e. species of the autochthonous flora that occur more or less regularly in disturbed biotopes. They may be subdivided into autapophytes, shifting from primary to secondary habitats, and deuterapophytes, occurring only in secondary habitats.

Both anthropochores and deuterapophytes may be referred to as synanthropic species.

Anthropochores

179 athropochorous species occur in the flora of Friuli-Venezia Giulia. Of these, 22 are reported only in pre-1930 literature, and have not been found recently. For this reason we have excluded them from our considerations of the recent emerophytic element and used them only for comparison.

The recent adventitious element is thus represented by 157 species, or 5.8 % of the total flora of 2724 species (Poldini 1991); among these 75 have been recorded prior to 1945, 82 only later. The year 1945 is at the limit between two periods that differ in the dynamics and evolution of the anthropochorous flora: the end of World War II, a turning point for economy, commerce and technology, has had a major impact on the adventitious flora with regard to its origin, family composition and species number. Now trade routes have notably increased the number of neophyte species; on the other hand the substitution of traditional methods of cultivation by modern, intensive agricultural exploitation caused a depletion or total disappearance of many archaeophytes.

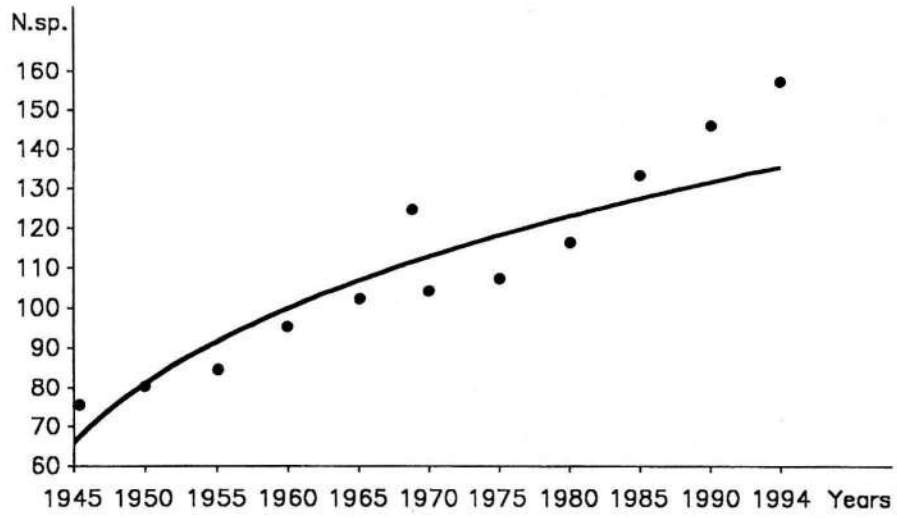


Fig. 1. Increase of the adventitious flora between 1945 and 1994 in the Friuli-Venezia Giulia region. N. sp. = number of species.

The core of the recent anthropochores is formed by members of the *Compositae*, *Gramineae*, *Cruciferae*, and *Amaranthaceae*, which account for almost half of the total number of species (49.1 %), followed by *Polygonaceae*, *Rosaceae*, *Euphorbiaceae*, *Onagraceae*, *Solanaceae*, and *Boraginaceae*, with a clearly subordinate role (Table 1).

Comparison with the pre-1945 situation shows a remarked increase of *Compositae* and *Gramineae*. The latter, in particular, have doubled (from 5.2 % to 10.9 %). Conversely the *Caryophyllaceae* (— 5.3 %), *Umbelliferae* (— 4.6 %) and *Labiatae* (— 3.3 %) have undergone notable decrease (Table 1).

Indeed, the anthropochores known only from the literature mainly belong to Old World *Caryophyllaceae, Brassicaceae, Umbelliferae,* and *Labiatae.*

Some of them, e.g. *Silene dichotoma, Lepidium perfoliatum, Brassica elongata,* and *Salvia napifolia,* had been recorded by Marchesetti (1882) for the Campo Marzio area of Trieste, a centre of commercial activities, at that time mainly directed to the Istrian inland, to the E. Mediterranean and Asia (hence the presence of Mediterranean and S.E. European species).

The change in main trade flow direction resulted in variations in the main areas of origin for the alien flora (Table 2). Before 1945 over 57 % of the species originated from the Old World, whereas 56 % of the elements of the current adventitious flora are native of America, mainly of N. America, while the contribution from Australia (0.6 %) remains negligible (Table 2).

The neophyte species found in the region after 1945 are listed in an appendix, each with its scientific name, origin, year in which it was first found (when known or inferred from specimens or literature), the author of the first record and the diffusion index (see below). The American species (58.5 %), mainly belonging to the *Compositae (Aster, Bidens, Ambrosia), Gramineae (Eragrostis, Panicum, Paspalum, Sporobolus)* and *Amaranthaceae (Amaranthus),* are clearly preponderant.

Adding the newly recorded anthropocores, for successive 5-year periods, the pre-existent ones, it is possible to estimate the numerical increase of the adventitious flora from 1945 up to now and to express it as a function of time (Fig. 1).

The life form spectrum of the recent adventitious flora is dominated by therophytes (57.5 %), followed by hemicryptophytes (19.4 %), phanerophytes (11.6 %), and geophytes (8.6 %), the chamaephytes (2.6 %) and hydrophytes (0.6 %) being less important. Among the growth forms, the scapose type is best represented (Table 3).

Table 1. Family composition of the pre-1945 and present adventitious flora.

Family	before 1945 %	present %	change %
Compositae	19.7	22.4	2.7
Gramineae	5.2	10.9	5.7
Cruciferae	12.5	9.6	-2.9
Amaranthaceae	6.2	6.4	0.2
Euphorbiaceae	4.1	3.2	-0.9
Polygonaceae	1.0	3.2	2.2
Rosaceae	3.1	3.2	0.1
Boraginaceae	4.1	2.5	-1.6
Onagraceae	1.0	2.5	1.5
Solanaceae	2.1	2.5	0.4
Balsaminaceae	-	1.9	1.9
Caryophyllaceae	7.2	1.9	-5.3
Chenopodiaceae	2.1	1.9	0.2
Labiatae	5.2	1.9	-3.3
Leguminosae	3.1	1.9	-1.2
Moraceae	3.1	1.9	-1.2
Commelinaceae	1.0	1.4	0.4
Crassulaceae	-	1.4	1.4
Cucurbitaceae	-	1.4	1.4
Cyperaceae	-	1.4	1.4
Oxalidaceae	1.0	1.4	0.4
Ranunculaceae	2.1	1.4	-0.7

Family	before 1945 %	present %	change %
Aceraceae	1.0	0.6	-0.4
Anacardiaceae	1.0	0.6	-0.4
Asclepiadaceae	-	0.6	0.6
Buddlejaceae	-	0.6	0.6
Cannabaceae	1.0	0.6	-0.4
Caprifoliaceae	-	0.6	0.6
Cuscutaceae	-	0.6	0.6
Frankeniaceae	-	0.6	0.6
Fumariaceae	1.0	0.6	-0.4
Hydrocharitaceae	1.0	0.6	-0.4
Hydrophyllaceae	1.0	0.6	-0.4
Iridaceae	-	0.6	0.6
Juncaceae	-	0.6	0.6
Liliaceae	-	0.6	0.6
Malvaceae	1.0	0.6	-0.4
Papaveraceae	1.0	0.6	-0.4
Phytolaccaceae	1.0	0.6	-0.4
Pteridophyta	-	0.6	0.6
Rutaceae	-	0.6	0.6
Scrophulariaceae	-	0.6	0.6
Simaroubaceae	1.0	0.6	-0.4
Umbelliferae	5.2	0.6	-4.6
Vitaceae	1.0	0.6	-0.4

The distribution of anthropochores over the territory obviously is inhomogeneous. In the last thirty years the Friuli Plain has seen a great development of intensive agriculture and associated drainage, but also an expansion of urban settlements and of the road system.

Table 2. Origin of the pre-1945 and present adventitious flora.

Origin	%	before 1945	%	%	present	%
		N. Am.	29.6		N. Am.	38.3
America	40.2	S. Am.	4.2	56.1	S. Am.	10.2
		N. + S. Am	6.4		N. + S. Am.	7.6
Asia	24.7			21.0		
Europe	23.7			13.3		
Mediterranean basin	9.3			6.4		
Africa	1.0			1.3		
Australia	-			0.6		
unknown	1.0			1.3		

Therefore it presents 9.2 % of anthropochores in its flora (including a single apophyte). 82.6 % of all anthropochores are found growing on the plain.

The situation of the Karst region, and particularly of the area near Trieste, has many features in common with that of the plain. However, besides the greater importance of the urban and industrial areas, some recent environmental changes are due to major digging works related to the construction of pipelines or other infrastructure. The anthropochore species make up for 6.2 % of the local flora, and 65.8 % of all adventitious species.

Table 3. Life form and growth form spectra for the present adventitious flora.

Life forms	Growth forms	%
Therophytes		**57.5**
	scapose	52.4
	reptant	2.6
	caespitose	1.9
	parasitic	0.6
Hydrophytes		**0.6**
Geophytes		**8.6**
	rhizomatous	5.3
	bulbous	3.3
Hemicryptophytes		**19.4**
	scapose	11.7
	biennial	3.9
	rosulate	1.9
	caespitose	1.9
Chamaephytes		**2.6**
	suffrutescent	1.3
	succulents	1.3
Phanerophytes		**11.6**
	scapose	3.9
	caespitose	3.2
	nanophanerophytes	2.6
	lianas	1.9

Table 4. Family composition of the present apophytic (autapophytic and deuterapophytic) component.

Family	Autap. %	Deuterap. %	Family	Autap. %	Deuterap. %
Compositae	15.7	14.4	Linaceae	0.9	-
Gramineae	11.3	14.4	Onagraceae	0.9	-
Leguminosae	9.5	5.9	Malvaceae	0.4	2.5
Caryophyllaceae	6.4	6.4	Papaveraceae	0.4	1.4
Labiatae	6.4	5.7	Dipsacaceae	0.4	0.7
Cruciferae	5.8	10.9	Resedaceae	0.4	0.7
Scrophulariaceae	4.1	5.2	Caprifoliaceae	0.4	0.3
Rosaceae	4.1	1.4	Convolvulaceae	0.4	0.3
Umbelliferae	3.6	3.1	Iridaceae	0.4	0.3
Liliaceae	3.2	3.1	Amaranthaceae	0.4	-
Ranunculaceae	2.8	1.0	Apocynaceae	0.4	-
Geraniaceae	2.2	2.8	Aristolochiaceae	0.4	-
Urticaceae	1.8	0.3	Hypericaceae	0.4	-
Rubiaceae	1.8	-	Oleaceae	0.4	-
Chenopodiaceae	1.3	4.2	Salicaceae	0.4	-
Boraginaceae	1.3	3.1	Saxifragaceae	0.4	-
Polygonaceae	1.3	2.4	Thymelaeaceae	0.4	-
Cyperaceae	1.3	0.3	Zygophyllaceae	0.4	-
Plantaginaceae	1.3	0.3	Fumariaceae	-	0.7

Family	Autap. %	Deuterap. %	Family	Autap. %	Deuterap. %
Equisetaceae	1.3	-	Primulaceae	-	0.7
Euphorbiaceae	0.9	2.1	Violaceae	-	0.7
Solanaceae	0.9	1.4	Araceae	-	0.3
Valerianaceae	0.9	1.1	Cuscutaceae	-	0.3
Campanulaceae	0.9	0.7	Oxalidaceae	-	0.3
Crassulaceae	0.9	-	Portulacaceae	-	0.3
Cucurbitaceae	0.9	-	Verbenaceae	-	0.3

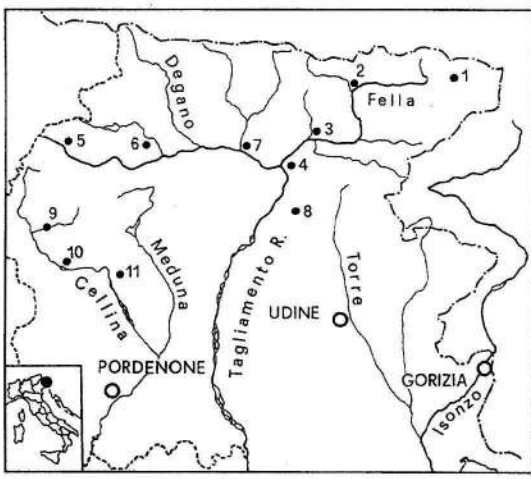
Table 5. Chorological spectrum of the present apophytic component.

Chorological groups	Autap. %	Deuterap. %
Eurymediterranean	25.1	36.9
Palaeotemperate	13.5	9.8
Eurasian	12.9	10.8
European	11.7	6.3
Eurosiberian	7.2	7.4
Circumboreal	6.7	4.9
Cosmopolitan	5.8	10.8
MediterAtlantic	3.6	2.8
S. E. European	3.6	1.0
Stenomediterranean	2.2	3.8
MediterPontic	2.2	0.7
Meditermontane	1.8	2.1
Pontic	1.3	1.7
S. Illyric	0.9	-
E. Alpine	0.5	-
Endemic	0.5	-
Subatlantic	0.5	-
Subtropical	-	0.7
Artic-Alpine	-	0.3

Table 6. Life form and growth form spectrum of the present apophytic component.

Life forms	Growth forms	Autap. %	Deuterap. %
Hemicryptophytes		**50.9**	**29.2**
	scapose	31.3	12.2
	biennial	7.6	10.8
	caespitose	5.8	4.5
	reptant	3.1	0.7
	rosulate	2.2	1.0
	climbing	0.9	-
Therophytes		**31.4**	**63.4**
	scapose	30.4	59.6
	reptant	0.5	2.4
	caespitose	0.5	1.0
	parasitic	-	0.3

Life forms	Growth forms	Autap. %	Deuterap. %
Geophytes		**10.8**	**6.7**
	rhizomatous	6.7	2.8
	bulbous	3.6	3.5
	root-budding	0.5	0.4
Phanerophytes		**4.1**	-
	caespitose	1.8	-
	nanophanerophytic	1.3	-
	scapose	0,5	-
	lianas	0.5	-
Chamaephytes		**2.8**	**0.7**
	suffrutescent	0.9	0.7
	succulent	0.9	-
	reptant	0.5	-
	frutescent	0.5	-



N.	Locality	Alt. m a.s.l.	Flora N. sp.	Antrop. %
1	Tarvisio	750	773	**1.7**
2	Pontebba	560	913	**2.0**
3	Moggio Ud.	330	928	**3.5**
4	Carnia	270	1120	**5.2**
5	Forni di S.	900	986	**1.9**
6	Ampezzo C.	560	935	**3.7**
7	Tolmezzo	320	1120	**4.3**
8	Gemona	270	1120	**5.2**
9	Claut	610	698	**2.0**
10	Barcis	410	922	**1.6**
11	Maniago	280	841	**3.8**

Fig. 2. Percentage of the adventitious flora as related to the total flora in some valleys of the Friuli Alps. 1-4: Fella Valley (Canal del Ferro); 5-8: Tagliamento Valley; 9-11: Cellina Valley (see text).

The mountain area is floristically less "polluted". Its flora includes 3.6 % of anthropochores (41.3 % of all anthropochores). Locally the anthropocore rate is very variable since the territory is vast and morphologically complex. Wide valley bottoms with tourist and industrial settlements, as in the areas of Tarvisio and Tolmezzo, host a notably higher concentration of adventitious species than the inner mountain areas, which are less affected by human action.

The anthropochore percentage in local floras along the main valleys of the Friuli Alps (per Operational Geographic Unit - OGM - as used for the Central European mapping scheme) is here shown as an example (Fig. 2). Anthropochore rates tend to decrease towards the upper part of the valley, but at an equal distance from the plain, anthropic influence is higher in broader valleys: Ampezzo Carnico, located around 30 km from the lower end of the valley, shows a floristic "pollution" rate almost twice as high as the town

of Claut, at an equal distance from the plain.

The overall hemerobiotic situation of the region Friuli-Venezia Giulia is shown in the isoporic map of Fig. 3, updating a similar map in Poldini & al. (1991); the isolines show the high concentration of anthropochores near the major towns and in the plain and Karstic area, more than in the mountain area.

Table 7. Phytosociological class spectrum of the present apophytic component.

Phytosociological class	Autap. %	Deuterap. %
Artemisietea	22.9	21.4
Chenopodietea	11.3	35.2
Molinio-Arrhenatheretea	9.8	1.4
Festuco-Brometea	9.5	0.7
Sedo-Scleranthetea	7.1	6.6
Agrostietea	5.8	3.5
Querco-Fagetea	4.9	-
Trifolio-Geranietea	4.5	0.3
Secalietea	3.6	15.1
Agropyretea	3.1	1.7
Thero-Brachypodietea	3.1	1.0
Thlaspietea	2.2	-
Bidentetetea	1.3	1.0
Parietarietea	1.3	-
Plantaginetea	0.9	4.9
Epilobietea	0.9	0.7
Ammophiletea	0.4	0.3
Cakiletea	0.4	0.3
Asplenietea	0.4	-
Betulo-Adenostyletea	0.4	-
Phragmitetea	0.4	-
Salicetea purpureae	0.4	-
unknown	5.4	5.9

Diffusion index

The ability to spread of a given anthropochorous species depends on environmental factors and the species' own adaptability.

Our data for each species include the number of basic areas in which it has been found and the year of its first discovery. Based on these, we have defined an easily calculated index to express the ability of an anthropochore to spread within a region. It expresses both the range conquered by the species and the time needed.

The diffusion index (Di) is expressed by the formula:

$$Di = (ax : 2at) + [(tx - t0 + 1) : (2tf - 2t0)]$$

where: ax = number of OGU (basic areas) in which the species occurs; at = number of total OGU; t0 = first year of the studied period; tx = year in which the species was discovered; tf = last year of the studied period.

The index varies between 0 and 1; its value is directly correlated with the diffusion speed shown by the species in the considered period of time.

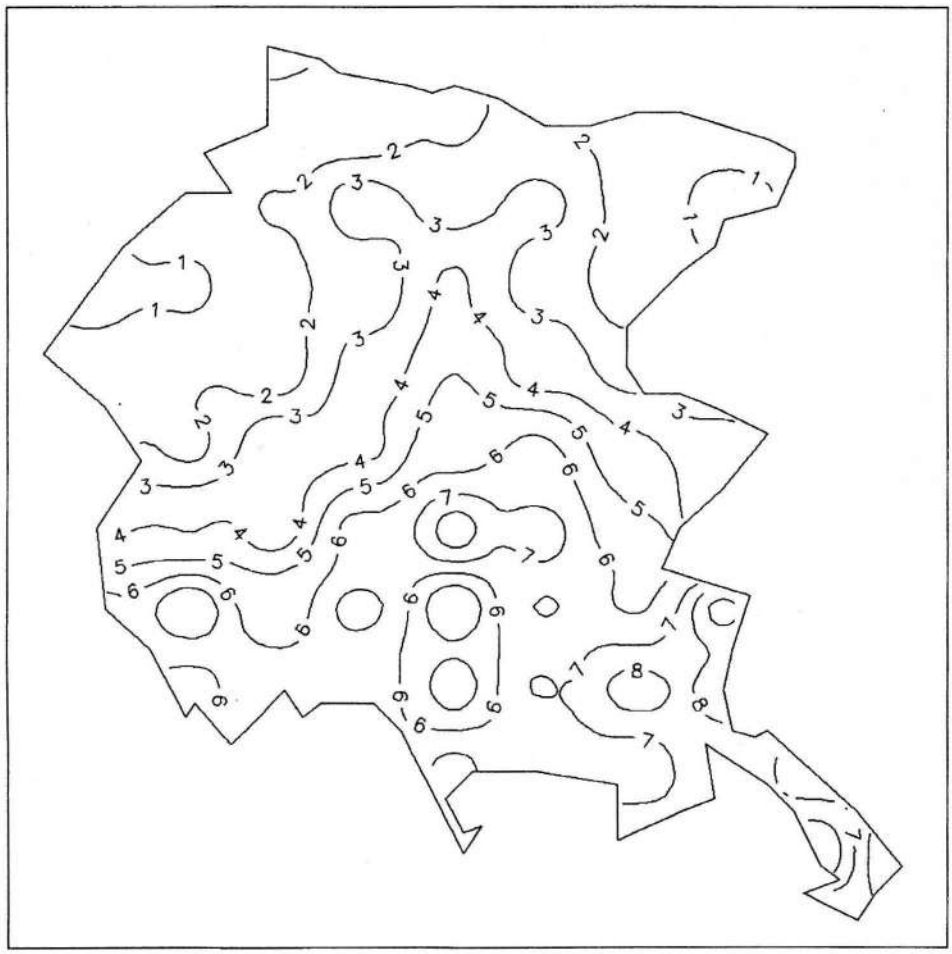


Fig. 3. Isoporic map of the anthropophytic species (values in percentage) (see text).

The index does not account for different ecological conditions. Some adventitious species, like the psammophilous *Cenchrus longispinus* and *Aster squamatus*, occur in well defined habitats, which limits their spreading potential. In much cases the diffusion index should better be calculated on the basis of the real presence of favourable habitats, not of the total number of OGU.

Most adventitious species occur in ruderal sites, usually widely present within a territory, though not equally frequent in plains and mountain areas.

The diffusion index permits on one hand to quantify and compare the diffusion ability of different anthropochores in a territory during a given period of time; on the other hand, to compare between the diffusion of single species, or groups of species, in different periods of time or territories.

Table 8. Examples of declining *Secalinetea* species in Friuli-Venezia Giulia. - rr = very rare (present in up to 5 % of the OGU); r = rare (present in up to 10 % of the OGU); nc = not common (present in up to 20 % of the OGU); qc = quite common (present in up to 30% of the OGU); c = common species (present in up to 70 % of the OGU); l = known only from literature (probably extinct).

Species	1896-1897	1897-1899	1905-1906	1994
Adonis aestivalis	nc	r	r	l
Adonis flammea	nc	-	r	rr
Anthemis arvensis	c?	c	c	c
Apera spica-venti	rr	nc	r	r
Aphanes arvensis	rr	r	r	r
Buglossoides arvensis	c	c	c	c
Caucalis platycarpos	nc	r	qc	rr
Centaurea cyanus	nc	-	c	ac
Consolida regalis	cc	-	c	c
Galium tricornutum	c	nc	r	rr
Kickxia spuria	nc	nc	nc	l
Lathyrus nissolia	nc	r	nc	l
Legousia hybrida	nc	nc	-	r
Legousia speculum-veneris	c	c	c	c
Myosotis arvensis	c	c	c	c
Papaver argemone	c	c	ac	qc
Polycnemum majus	qc	qc	-	l
Scandix pecten-veneris	nc	nc	nc	r
Silene gallica	nc	-	nc	rr
Silene noctiflora	r	r	rr	r
Stachys annua	c	c	c	r
Thymelaea passerina	nc	r	r	r
Vaccaria pyramidata	c	-	nc	rr
Vicia lutea	qc	nr	-	l
Vicia peregrina	r	rr	r	l

The diffusion index values for the anthropochore species recorded since 1945, as relating to the period 1945-1994, are given in the appendix. Species first recorded after 1991, or present in a single basic area, only have not been considered.

The highest index values characterize recently introduced species that have already become widespread, like *Senecio inaequidens, Sporobolus neglectus,* and *Conyza albida.* Despite their long-lasting presence on the territory, *Ambrosia coronopifolia, Scutellaria altissima, Sisymbrium loeselii, Aster lanceolatus, Commelina virginica, Erucastrum gallicum* have a very limited diffusion and therefore a very small Di value. Most species belong to a central group with intermediate diffusion and appearance time values.

Apophytes

Of the 511 presently found apophytic species, 43.8 % are autapophytes, 56.2 % deuterapophytes. The *Compositae, Gramineae, Leguminosae, Labiatae* and *Scrophulariaceae* are the best represented families; the *Rosaceae* are more frequent among the autapophytes, the *Cruciferae* and *Chenopodiaceae* among the deuterapophytes (Table 4).

The chorological spectrum (Table 5) shows some peculiarities. The Eurymediterranean, Palaeotemperate, Eurasiatic, European, Eurosiberian, Circumboreal and Cosmopolitan chorotypes are best represented in both groups, but while the mesothermic chorotypes

(sensu Poldini & al. 1991) prevail among the autapophytes, among the deuterapophytes by the macrothermic elements dominate thus showing a great thermophily.

Fig. 4. Isoporic map of the deuterapophytic species (values in percentage) (see text).

The chorological spectrum of apophytes differs substantially from that of the regional flora as a whole (Poldini 1991), in which the mediterranean-montane geoelement, here representing only 2.1 %, is dominant with 12.7 %.

The life form and growth form spectrum are substantially similar: both groups are mainly represented by therophytes and hemicryptophytes, although scapose therophytes are more important among deuterapophytes ((59.6 %) and hemicryptophytes predominate among autapophytes (50.9 %) (Table 6).

A comparison based on phytosociological classes (Table 7) shows that 75 % of autapophytes originate from 9 such classes, but the deuterapophytes from only 4. Among deuterapophytes a greater share comes from *Chenopodietea*, *Secalinetea*, and *Plantaginetea*, which are fully synanthropic classes, while the natural or semi-natural, mainly herbaceous, coenoses of *Molinio-Arrhenatheretea*, *Festuco-Brometea*, *Sedo-Scleranthetea*, *Agrostidetea*

contribute numerous autapophytes. *Artemisietea* are rich in apophytes of both kinds. The share of apophytes from wood fringes *(Trifolio-Geranietea)* and woods *(Querco-Fagetea)* is less important (Table 7).

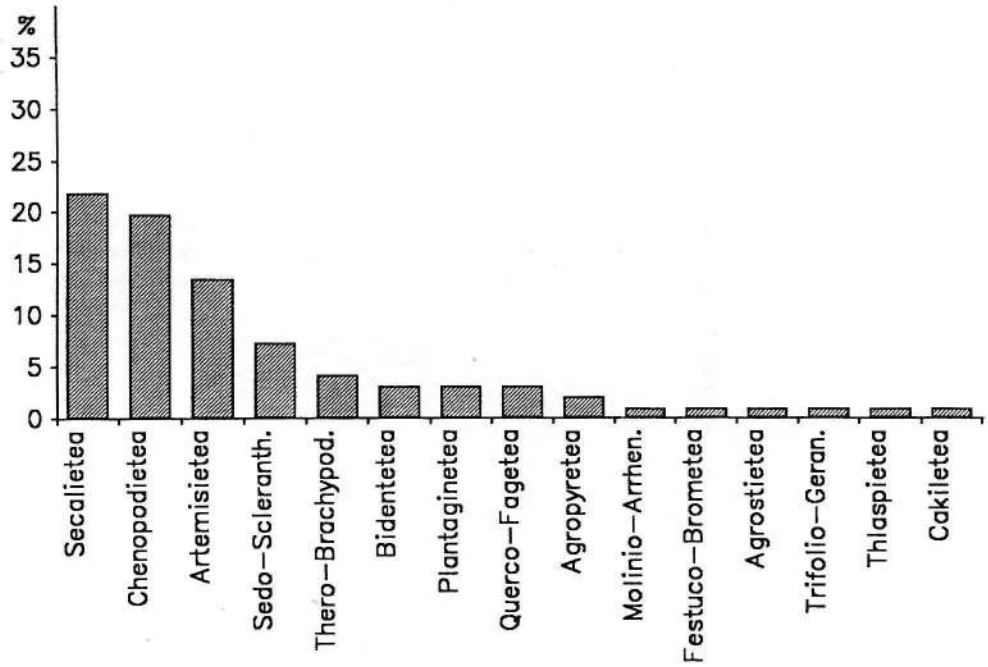


Fig. 5. Phytosociological spectrum of the apophyte element known only from pre-1945 literature.

With respect to the chorological and biological spectrum, family composition and phytosociological affinity, autapophytes show a more diverse origin than deuterapophytes in terms of the natural biota from whichthey originated

Autapophytes are more evenly distributed over the territory, while deuterapophytes faithfully retrace the distribution patterns of anthropochorous species, thei presence being enhanced by the proximity of urban settlements, traffic ways and agricultural activities (Fig. 4).

Some Apophytes that have been recorded in the older literature back to the beginning of this century have not been reconfirmed in recent times. This is the case of 96 species (17 autapophytes and 79 deuterapophytes), mainly of the *Leguminosae* (16.7 %), *Compositae* (10.4 %), *Gramineae* and *Umbelliferae* (9.4 % each), *Chenopodiaceae* (7.3 %), *Cruciferae*, and *Ranunculaceae* (6.4 % each); most of them are scapose therophytes (65.6 %) and scapose hemicryptophytes (19.8 %), with prevailing the euri- and stenomediterranean chorotypes (37.5 % and 16.7 %, respectively). The prevalence among these species of *Secalinetea* elements (21.9 %) over these from *Chenopodietea* (19.8 %) and *Artemisietea* (13.5 %) is phytosociologically relevant (Fig. 5). This reflects the fact that many archaeophytes, that are disappearing and likely already extinct in the region, belong to the *Secalinetea*. Genera like *Anchusa, Adonis, Silene,* and *Anthemis,* said in the classic floras (Marchesetti 1896-1897, Pospichal 1897-1899, Gortani 1905-1906) to be frequent in

cultivated areas, are nowadays almost inexistent or reduced to a small number of species. The development of modern agricultural techniques, and the decline or disappearance of traditional crops such as oats, rye, flax, hemp, appear to have thoroughly affected the hemerophytic flora.

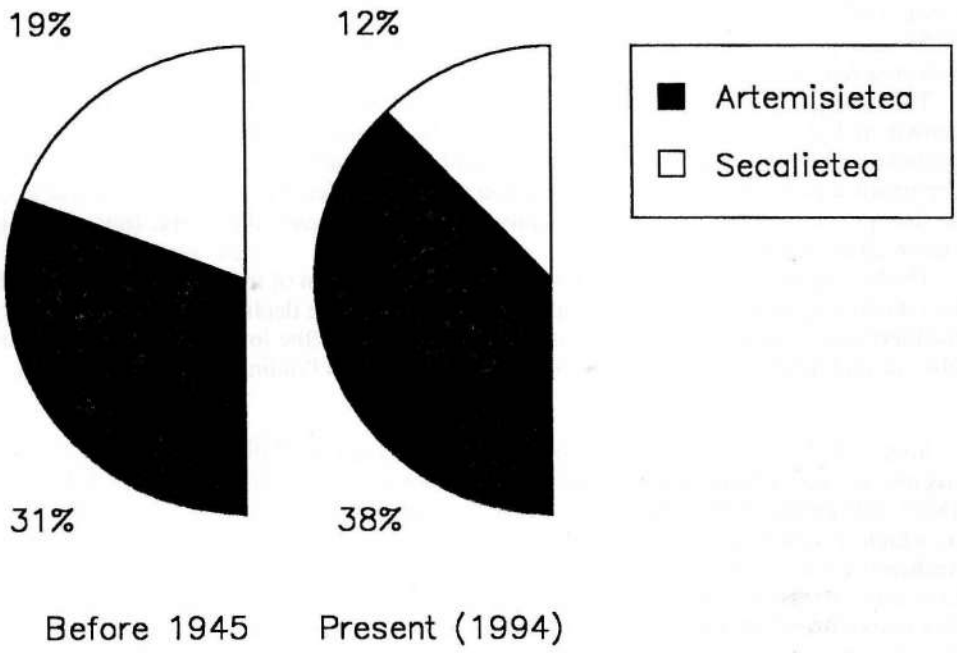


Fig. 6. Change of the ratio of *Artemisietea* vs. *Secalietea* species in the Friuli-Venezia Giulia region during the last 50 years.

Conclusions

Since the end of World War II, the hemerophytic component of the flora of Friuli-Venezia Giulia in common with many other parts of Europe, has undergone profund changes. These changes may be attributed to a number of factors, the most important of which are:

- changes in the main trade flow directions;
- generalized spread of intensive agriculture, associated wetland drainage and decline or disappearance of traditional crops;
- expansion of urban settlements, road systems, and industrial and commercial areas;
- natural spread of woodland over wide areas following changes of ecological conditions that favour macrothermic elements.

These factors have affected the quantity and quality of the hemerophytic flora, e.g. through the rarefaction or disappearance of many Old World, especially archaeophytes from the Mediterranean Basin and Asia Minor that belong to the *Secalinetea*.

The decline of *Secalinetea* species, by about 26 % since before 1945 is due to a number of factors, including the sifting of seeds, changes in cultural methods, the use of pesticides

and the lack of crop rotatiòn, factors which has a less negative effect on the *Artemisietea* species.

The New World anthropochores on the contrary have notably increased. At present, almost 60 % of the adventitious species are natives of America, belonging mainly to the *Compositae*, *Gramineae*, and *Amaranthaceae*. Elements such as *Sporobolus neglectus*, *Conyza albida*, and *Senecio inaequidens*, whose diffusion index shows the highest values (0.5), are particularly invasive. Moreover, as most neophytes belong to the class *Artemisietea*, this class has seen an increase of c. 40 % since 1945.

The change in the rate of *Secalinetea* vs. *Artemisietea* species in the post-war period is shown in Fig. 6. Since archaeophytic status is not always clearly mentioned in the geobotanical literature and standard floras, and because the Eurimediterranean cereal field vegetation and the Irano-Turanian vegetation are similar (Ferro 1990), we have considered archaeophytes to be approximately equivalent to *Secalinetea* members, thus enabling statistical evaluation.

The lack of quantitative data for the past makes rarefaction of many *Secalinetea* species less obvious than the complete disappearance of others. The declining species are mainly mediterranean elements in the wide sense, locally linked to the lowland plain, and karstic plateau, and following a karstic chorological pattern (sensu Poldini & Martini, in press).

Some of the most meaningful examples are given in Table 8, where the listed frequencies were obtained, when possible, from Marchesetti (1896-1897), Pospichal (1897-1899) and Gortani (1905-1906), frequency being based on the number of basic areas (OGU) in which a given species occurred or still occurs. Despite some exceptions such as *Anthemis arvensis*, *Buglossoides arvensis*, *Myosotis arvensis*, *Consolida regalis*, and *Legousia speculum-veneris* which are still common, in general one observes a more or less marked rarefaction of species. *Caucalis platycarpos*, *Stachys annua*, and *Vaccaria pyramidata*, once common or quite common at least in some areas (Friuli lowland plain, Karst), have become very rare; others have probably disappeared, as e.g. *Adonis aestivalis*, *Kickxia spuria*, *Vicia lutea*, and *Vicia peregrina*. One should add that the floristic data on which present day frequency has been estimated do not account for specimen number: frequency assessment is in terms of territorial distribution only, not of population size.

There are many threatened species among the apophytes, most of which are related to a macrothermic chorotype such as the mediterranean *(Reseda phyteuma, Medicago arabica, Linum nodiflorum, Althaea hirsuta, Hyoscyamus niger, Verbascum sinuatum, Misopates orontium, Knautia integrifolia, Picnomon acarna)*, pontic *(Alcea pallida, Anchusa officinalis, Anthemis austriaca, Achillea pannonica)*, or more rarely the S.E. European *(Marrubium incanum)*.

Acknowledgements

Financial support was provided by the Italian Ministry of Public Instruction (40 %), to L. Poldini. We wish to thank Dr Katia Terpin for the English translation.

References

Ahti, T. & Hamet Ahti, L. 1971: Hemerophilous flora of the Kuusamo district, northeast Finland, and the adjacent part of Karelia, and its origin. — Ann. Bot. Fenn. **8**: 1-91.

Cecconelli, E. 1975: *Cenchrus longispinus* Fernald sull'alto litorale adriatico occidentale. — Delect. sem. et sporar. Orto bot. Ist. tecn. geom. G. G. Marinoni Udine **26**: 3-13.

— 1976: Stazioni di *Echinocystis lobata* (Michx.) Torrey et Gray nel Friuli orientale e sua distribuzione in Europa. — Delect. sem. et sporar. Orto bot. Ist. tecn. geom. G. G. Marinoni Udine **25**: 3-18.

Cohrs, A. 1953-54: Beiträge zur Flora des nordadriatischen Küstenlandes. — Feddes Repert. Spec. Nov. Regni Veg. **56(1)**: 66-96 (1953); **56(2)**: 97-143 (1954).

— 1963: Flora des nordadriatischen Küstenlandes mit besonderer Berücksichtigung von Friaul, den Julisch und Karnischen Alpen. — Feddes Repert. Spec. Nov. Regni Veg., **68(1)**: 12-80.

Ferro, G. 1990: Revisione della vegetazione segetale mediterranea ed europea dell'ordine *Secalietalia* — Braun-Blanquetia **6**: 5-59.

Fenaroli, L. 1964: Il *Panicum dichotomiflorum* Michx. nuova infestante delle colture di mais in Italia. I° Origine, descrizione e avventiziato. — Maydica **9**: 34-40.

Fornaciari, G. 1964: Appunti sulla flora del Friuli. Osservazioni fatte nel 1962 e nel 1963. — Giorn. Bot. Ital. **71**: 596-599.

— 1968: Aspetti floristici e fitosociologici della laguna di Grado e del suo litorale. — Acc. Sci. Lett. Arti Udine, ser. VII **6**: 1-199.

Gandolfo Michelini, G. 1993: Segnalazioni Floristiche Italiane: 729. *Erysimum cheiranthoides* L. (Cruciferae). — Inform. Bot. Ital. **25**: 53.

Gortani, L. & M. 1905-06: Flora friulana con particolare riguardo alla Carnia. — Udine.

Holub, J. & Jirásek, V. 1967: Zur Vereinheitlichung der Terminologie in der Phytogeographie. — Folia Geobot. & Phytotax. **1**: 69-113.

Marchesetti, C. 1882: Florula del Campo Marzio. — Boll. Soc. Adriat. Sci. Nat. **7**: 1-14.

— 1896-97: Flora di Trieste e de' suoi dintorni. — Trieste.

Martini, F. & Poldini, L. 1987: Segnalazioni floristiche dalla regione Friuli-Venezia Giulia. II. — Gortania, Atti Mus. Friul St. Nat. Udine **9**: 145-168.

— & — 1988: Segnalazioni floristiche dalla regione Friuli-Venezia Giulia. III (32-46). — Gortania, Atti Mus. Friul. St. Nat. Udine **10**: 145-162.

— & — 1991: Segnalazioni floristiche dalla regione Friuli-Venezia Giulia. IV (47-65). — Gortania, Atti Mus. Friul. St. Nat. Udine **13**: 137-156.

— & Polli E. 1992: Osservazioni sulla flora del Carso triestino e isontino (Italia nordorientale). — Gortania, Atti Mus. Friul. St. Nat. Udine **14**: 151-166.

Melzer, H. 1968-69: Beiträge zur Flora von Kärnten. — Verh. Zool.-Bot Ges. Wien **108/109**: 127-137.

— 1983: Neues zur Flora des nordadriatischen Küstenlandes (Italien). — Linzer biol. Beitr. **14**: 209-221.

— 1984: Beiträge zur Flora von Friaul-Julisch Venetien und angrenzender Gebiete (Italien, Jugoslawien). — Gortania, Atti Mus. Friul. St. Nat. Udine **6**: 175-190.

— 1987: Beiträge zur Flora von Friaul-Julisch Venetien (Italien) und Slowenien (Jugoslawien). — Linzer biol. Beitr. **19**: 377-388.

— 1988: Über *Eragrostis frankii* C. A. Meyer ex Steudel, *Polygonum pensylvanicum* L. und weitere pflanzenfunde in Friaul-Julisch Venetien (Italien). — Linzer biol. Beitr. **20**: 771-777.

— & Bregant, E. 1989: Neues zur Flora von Friaul-Julisch Venetien, Slowenien und Kroatien. — Gortania, Atti Mus. Friul. Storia Nat. Udine **11**: 161-176.

Mezzena, R. 1986: L'erbario di Carlo Zirnich (Ziri). — Atti Mus. Civ. St. Nat. Trieste **38**: 1-519.

Pignatti, E., Pignatti, S. & Poldini, L. 1983: *Cyrtomium fortunei* J. Sm., neu für die italienischen Ostalpen. — Bot. Helv. **93**: 313-316.

Pignatti, S. 1982: Flora d'Italia. 3 voll. — Bologna.

Poldini, L. 1963: Nuove segnalazioni per la flora advena di Trieste. — Ist. Bot. Univ. Trieste, pubbl. n. 13: 1-16.

— 1980: Catalogo floristico del Friuli-Venezia Giulia e dei territori adiacenti. — Stud. Geobot., **1(2)**: 313-474.

— 1982: Segnalazioni floristiche italiane: 182. *Coreopsis lanceolata* L *(Compositae).* —

Inf. Bot. Ital., **14**: 291.
— 1984: Addenda ed Errata/Corrige al "Catalogo floristico del Friuli-Venezia Giulia e dei territori adiacenti" Stud. Geobot. **1(2)**: 313-474 (1980), pp. 8.
— 1991: Atlante corologico delle piante vascolari nel Friuli-Venezia Giulia. — Udine.
— & Martini, F. in press: Analisi dei modelli distributivi della flora del Friuli-Venezia Giulia. — Webbia.
— & Vidali, M. 1984: Segnalazioni floristiche dalla regione Friuli-Venezia Giulia. — Gortania, Atti Mus. Friul. St. Nat. Udine **6**: 191-202.
— & — 1989: Studio dell'antropizzazione del Carso triestino e goriziano mediante l'uso della Banca Dati Floristica. — Inform. Bot. Ital. 21: 224-234.
— & — in press: Addenda ed Errata/Corrige all' "Atlante corologico delle piante vascolari del Friuli-Venezia Giulia. — Gortania, Atti Mus. Friul. St. Nat. Udine.
—, Martini, F., Ganis, P. & Vidali, M. 1991: Floristic databanks and the phytogeographic analysis of a territory. An example concerning northeastern Italy. — In: Nimis, P. L. & Crovello, T. J. (ed.) Quantitative Approaches to Phytogeography. - Tasks for Vegetation Science **24**: 159-181. The Hague, Boston, London.
Pospichal, E. 1897-99: Flora des österreichischen Küstenlandes. Leipzig u. — Wien.
Viegi, L., Cela Renzoni, G. & Garbari, F. 1974: Flora esotica d'Italia. — Lavori Soc. Ital. Biogeogr. **4**: 120-220.

Appendix

Appendix. List of the adventitious species found in Friuli-Venezia Giulia after 1945.
Di = diffusion index (see text);
(1) specimen of this species were collected by Poldini in 1963 (TSB!) and identified as *B. radiata* (Poldini 1963); (2) the date has been inferred from Fenaroli (1964: 39, fig.10).

Species	Origin	Year	Reference	Di
Amaranthus blitoides S.Watson	NAm	1983	Melzer (1984)	0.41
Amaranthus bouchonii Thell.	NAm	1992 TSB	lg. Danelutto	0.52
Amaranthus lividus L.	SAm	1960	Zirnich in Mezzena (1986)	0.20
Amaranthus tamariscinus Nutt.	NAm	1989	Melzer & Bregant (1989)	0.48
Ambrosia coronopifolia Torrey & A. Gray	NAm	1946	Zirnich in Cohrs (1953)	0.08
Ambrosia trifida L.	NAm	1959	Zirnich in Cohrs (1963)	0.19
Aristida gracilis Elliot	NAm	1979 TSB	Poldini (1980)	0.38
Asclepias syriaca L.	NAm	1976 TSB	Poldini (1980)	0.37
Aster novae-angliae L.	NAm	1987	Costalonga in Martini & Poldini (1987)	0.49
Aster squamatus (Spreng.) Hieron	C & SAm	1977 TSB	Poldini (1980)	0.43
Aster vimineus Lam.	NAm	1985	Danelutto in Martini & Poldini (1987)	0.45
Bidens subalternans DC. (1)	SAm	1963 TSB	Melzer (1987)	0.25
Bidens vulgata L.	NAm	1952	Zirnich in Cohrs (1953)	0.17
Bilderdykia aubertii (L. Henry) Moldenke	CAs	1950	Zirnich in Cohrs (1953)	0.17
Bromus willdenowii Kunth	SAm	1955	Zirnich in Cohrs (1953)	0.17
Buddleja davidii Franch.	WAs	1945	Zirnich in Mezzena (1986)	0.15
Cenchrus longispinus (Hack.) Fern.	NAm	-	Cecconelli (1975)	-
Chenopodium probstii Aellen	Aus	1981	Melzer (1984)	0.41
Commelina communis L.	EAs	1962	Fornaciari (1968)	0.30
Conyza albida Willd.	TropAm	1977 TSB	Poldini (1984)	0.53
Conyza bonariensis (L.) Cronq.	TropAm	1954	Zirnich in Cohrs (1963)	0.15
Coreopsis lanceolata L.	NAm	1983	Poldini (1982)	0.41
Coronopus didymus (L.) Sm.	SAm	1983	Melzer (1984)	0.46
Cuscuta campestris Yunker	NAm	1979 TSB	Poldini (1980)	0.41
Cyperus esculentus L.	Med & SWEur	1989	Bertani in Martini & Poldini (1991)	0.47
Cyperus rotundus L.	S & SWEur	1992	Martini & Polli (1992)	-
Cyrtomium fortunei J. Sm.	EAs	1979	Pignatti E. et S. & Poldini (1983)	0.42
Dicrocephala integrifolia (L. f.) O. Kuntze	TropAs	1991	Danelon & Costalonga in Poldini (1991)	-
Echinocystis lobata (Michx) Torr. & Gray	NAm	-	Cecconelli (1976)	-
Eragrostis frankii C. A. Meyer ex Steudel	NAm	-	Melzer (1988)	-
Eragrostis pectinacea (Michx.) Nees	NAm	-	Melzer (1988)	-
Erigeron karvinskianus DC.	NAm	1978 TSB	Poldini (1991)	0.37
Erucastrum nasturtiifolium (Poir.) O. E. Schulz	SWEur	1987	Poldini in Martini & Poldini (1987)	0.47
Erysimum cheiranthoides L.	Euras.	1992	Gandolfo Michelini (1993)	0.50
Euphorbia prostrata Aiton	NAm	1984	Melzer (1984)	0.45
Frankenia pulverulenta L.	Stenomed	1990	Melzer & Bregant (1989)	0.48
Galinsoga ciliata (Rafin.) Blake	SAm	-	Poldini (1963)	-
Gaura biennis L.	NAm	1986	Pavan & Costalonga in Martini & Poldini (1987)	0.44
Gypsophila perfoliata L.	SEEur	1981	Melzer (1983)	0.40
Helianthus rigidus (Cass.) Desf.	NAm	1955	Zirnich in Cohrs (1963)	0.15
Heliotropium suaveolens M. Bieb. subsp. *suaveolens*	SEEur	1963	Zirnich in Mezzena (1986)	0.23
Iberis amara L.	CEur-Subatl.	1955	Zirnich in Cohrs (1963)	0.15
Iberis umbellata L.	Stenomed	1970	Zirnich in Mezzena (1986)	0.29
Impatiens balfourii Hook.	Himalaya	-	Melzer (1968-69)	-
Impatiens glandulifera Royle	Himalaya	1962-63	Fornaciari (1964)	0.35
Impatiens parviflora DC.	EAs	-	Poldini (1980)	

Species	Origin	Year	Reference	Di
Ipheion uniflorum (Lindley) Raf.	SAm	1992 TSB	lg. Favretto	-
Juncus tenuis L.	NAm	1955	Zirnich in Mezzena (1986)	0.30
Lepidium virginicum L.	NAm	1955	Zirnich in Cohrs (1963)	0.39
Lonicera japonica Thunb.	EAs	1955	Zirnich in Cohrs (1963)	0.30
Oenothera erythrosepala Borb.	Eur?	-	Poldini (1991)	-
Oenothera grandiflora L'Her.	Eur?	-	Poldini (1991)	-
Oxalis articulata Sauvigny	SAm	1982 TSB	Poldini (1984)	0.42
Panicum dichotomiflorum Michx (2)	NAm	1963	Grancini & Lorenzoni in Fenaroli (1964)	0.34
Panicum gattingeri Nash	NAm	1983	Melzer (1984)	0.47
Paspalum dilatatum Poiret	SAm	1984	Melzer (1984)	0.44
Paspalum paspaloides (Michx) Scribn.	Neotrop	1964	Zirnich in Mezzena (1986)	0.26
Phalaris aquatica L.	Stenomed	1980	Costalonga in Martini & Poldini (1991)	0.39
Polygonum pensylvanicum L.	NAm	-	Melzer (1988)	-
Ptelea trifoliata L.	NAm	-	Pignatti (1982)	-
Reynoutria japonica Houtt.	SEAs	1954	Zirnich in Mezzena (1986)	0.22
Reynoutria sachalinensis (Schmidt Petrop.) Nakai	SEAs	1956	Zirnich in Mezzena (1986)	0.16
Rubus laciniatus Willd.	?	1989	Bruna in Martini & Poldini (1991)	0.47
Rubus phoenicolasius Maxim.	EAs	1989	Melzer & Bregant (1989)	0.47
Rudbeckia hirta L.	NAm	-	Poldini (1991)	-
Scutellaria altissima L.	Pontic-pannon.	1947 TSB	Pignatti (1982)	0.08
Sedum sarmentosum Bunge	EAs	1990	Melzer & Bregant (1989)	0.48
Sedum spurium M. Bieb.	SWAs	1985	Mezzelani & Martini in Martini & Poldini (1987)	0.50
Senecio inaequidens DC.	SAf	1973 TSB	Poldini (1980)	0.55
Sicyos angulatus L.	NAm	1984	Mezzelani in Poldini & Vidali (1984)	0.46
Sideritis montana L.	Medit.-turanic	1988	Polli in Martini & Poldini (1988)	0.46
Silphium perfoliatum L.	NAm	1982	Pavan in Poldini & Vidali (1984)	0.40
Sisymbrium loeselii L.	CAs	1947	Zirnich in Cohrs (1953)	0.08
Sisymbrium strictissimum L.	CEur	1989	Vidali & Poldini in pubbl.	0.47
Sisyrinchium bermudiana L.	NAm	1990	Bartole & Nardini in Martini & Poldini (1991)	0.48
Solanum sarrachoides Sendtn.	SAm	1955	Zirnich in Cohrs (1963)	0.15
Solanum sublobatum Willd. ex Roem. & Schultes	SAm	1958	Zirnich in Cohrs (1963)	0.21
Solidago canadensis L.	NAm	-	Poldini (1980)	-
Sporobolus neglectus Nash	NAm	1984	Melzer (1984)	0.53
Sporobolus vaginiflorus (Torr.) Wood	NAm	1955	Zirnich in Mezzena (1986)	0.26
Tagetes minuta L.	SAm	1949	Poldini (1963)	0.12
Veronica peregrina L.	NAm	1970	Zirnich in Mezzena (1986)	0.31

Address of the authors:
Dr F. Martini, Prof. L. Poldini, Dipartimento di Biologia dell'Università degli Studi di Trieste, Via L. Giorgieri 10, I-40127 Trieste, Italy.