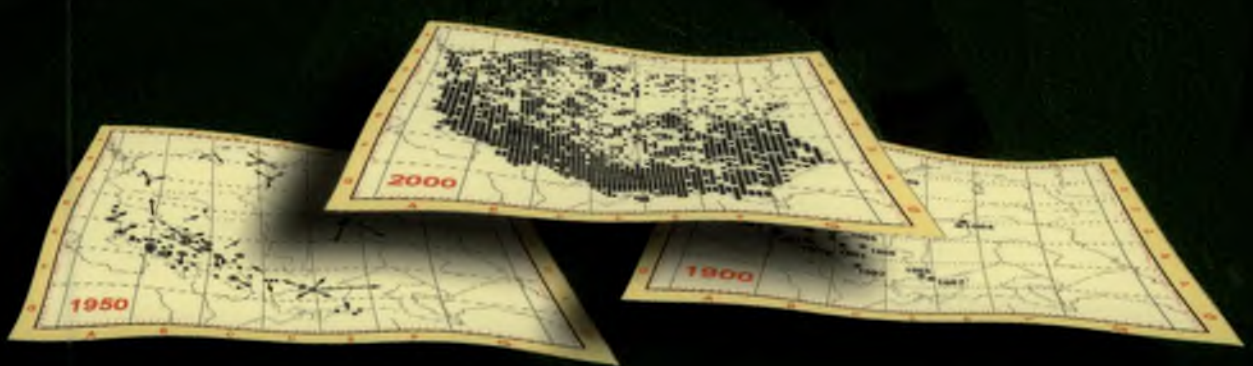
Barbara Tokarska-Guzik

The Establishment and Spread of Alien Plant Species (Kenophytes) in the Flora of Poland



Wydawnictwo Uniwersytetu Śląskiego • Katowice 2005

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To my husband

PRACE
NAUKOWE

UNIWERSYTETU
ŚLĄSKIEGO
W KATOWICACH
NR 2372

Barbara Tokarska-Guzik

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PART ONE

Theoretical overview

"The life success of each plant species hinges on not only the capability to settle passively in the places of its earlier occurrence, but also on the ability to actively conquer such places".

PACZOSKI 1933: *Podstawowe zagadnienia geografii roślin* [The fundamental issues of plant geography]

1. Introduction
The subject, objectives and the scope of this study:
The role of kenophytes in the flora as representations of the anthropogenic alteration of vegetation

The subject of this book falls within the theme of the synanthropisation[1] of vegetation cover. Connected representations of this directional process occurring on Earth under the impact of various forms of human activities, are the processes of the extinction of some species and the expansion of others, which have both accelerated in recent centuries and which are contributing to changes of the biological diversity of entire regions, countries or continents. A synthesis of the role of humans in the historic changes in landscape and vegetation cover was presented by KORNAŚ (1977a) in a multi-authored book entitled *Szata roślinna Polski* [The vegetation of Poland] and in other detailed papers (KORNAŚ 1982, 1983, 1990, 1996). Dynamic change in floras, its scale and rate – issues which have started to focus the interest of scientists and conservationists – became the main motive for undertaking this study.

Nevertheless, the interest taken by scientists in territorially-expanding plant species of foreign origin has its roots in ancient times and was conceived on the basis of an ever-increasing knowledge about useful plants, particularly those that are edible or poisonous, as well as on natural curiosity and a determination to learn about new, exotic species. Practical considerations were also important and the ambition which drives explorers, both past and contemporary, to search for new plants in newly discovered remote parts of the world. As early as in the ancient times, the body of knowledge accumulated by naturalists and philosophers such as Theophrastus, Dioscorides and Pliny was impressive in terms of volume and provided a source for copies, adaptations and reprints for the "herbalists" of the Middle Ages and Renaissance periods.

The studies of the floras which accompany people increased greatly from the beginning of the 19th century. The oldest works devoted to plants of foreign origin, however, date back to the 17th century. At this early date, an Italian botanist, Prosper ALPINUS published a work entitled *De plantis exoticis* (1627), where he gave descriptions of plants found in Europe but originating from America. Other proofs of naturalists' interest in such plants can also be found in the old herbals[2].

The phenomenon of invasion by alien newcomers in their new homelands was also noted by DARWIN (1859) in his work *On the origin of species*[3], as well as in the diaries of his journeys, and in

[1] Synanthropisation – is the process of change in plant cover (also in the fauna and the abiotic elements of the environment) brought about by human impact (for detailed definition see Chapter 2.2).

[2] For example, the Wrocław Herbarium collection (WRSL) has one of the oldest herbaria in Europe which was assembled by an Italian Sivius Boccon, dated 1674 (ROSTAŃSKI K. 1963). This includes a typical specimen of *Solidago canadensis* L. – a recent kenophyte (neophyte), distributed throughout Europe, and originating from North America.

[3] Among other examples, Darwin described the invasion of *Cardo de Castilla* (Spanish Cardoon) *Cynara cardunculus* L. brought to Buenos Aires in 1749, and which had taken over Argentina, Chile and Uruguay in eight decades (CROSBY 1999).

letters and research reports. More information testifying to the perception of the phenomenon and the consequences thereof, can be found in numerous notes and communications published in popular scientific journals[4].

The plants of foreign origin appearing in the floras of many regions of the world were called "the vagrants of our floras" (Crosby 1999 after Hooker 1864) or "new acquisitions" (Kamieński 1884a & b; Paczoski 1896), although they were sometimes called "newcomers and waifs" or "wandering plants" (Trzebiński 1930; Szulczewski 1931) or – in some special cases – "invaders" (Elton 1958).

Answers were sought to a number of essential questions. From where did the alien species arrive in the local flora? Is it an escape from any cultivation or has it been brought in accidentally? Which place does it occupy in the new homeland and what consequences result from its arrival?

Nevertheless, the greatest attention was attracted by the spectacular manner of the arrival of those alien plant species that colonised new territories rapidly and in great numbers[5]. Many of those immigrants soon became burdensome acquisitions in the local flora, sometimes even earning common names reflecting the violent manner of their invasion. One such example is *Elodea canadensis* (Canadian Waterweed) originating from North America, which conquered European inland waters in a "blitz" in the second half of the 19th century and the beginning of the 20th century, and which was called "the green ghost" (Faliński 2004 after Löns 1910). An Asian species *Impatiens parviflora* (Small Balsam), which dispersed over central Europe as a fugitive from botanic gardens having first established itself in ruderal communities and then succeeded in entering the forests, has been given a nickname of the "pushy Mongol" (Faliński 2004 after Naumann 1913). Similar associations had been provoked by the invasion of European plants in other continents. The native Americans of New England and Virginia called *Plantago major* (Greater Plantain) "Englishman's footprint", because in the 17th century they believed that this plant grew only "where the aliens set their feet and where it had not been known before their arrival in this country" (Crosby 1999).

The migrations of species occurring as the result of human activity which often assumed the characteristics of massive invasions ("ecological explosions"), and which led eventually to changes in vegetation, fauna and to economic damage, constituted the topic of a book entitled *The Ecology of Invasions by Animals and Plants* (1958), by Elton, a British ecologist, whose research in this field is considered to be classic. The date of the publication of the book can be regarded as the birth of **ecology of invasion** as a new scientific discipline.

Crosby (1999), describing the successful colonisation of the Globe by Europeans, even presented a hypothesis that the success of European imperialism has an underlying biological and ecological background ("ecological imperialism"). The same author, giving examples of spectacular invasions of the vast spaces of Australia or both Americas, makes ironic comments: "A rapid invasion of species of European 'weeds' disturbed American naturalists, even though most of these botanists themselves hailed from the same region as the plants concerned". Despite the great distance between these continents and Europe, the climate is similar in many regions, providing magnificent conditions for development of the European colonists, including plants, animals and people.

The actual scale of the exchange of species of synanthropic plants between regions of the world is considerable. The proportion of alien species naturalised (i.e. permanently established) in some local floras ranges from 20% to even as high as 50%. Particularly dynamic is the exchange between Eurasia and North America (Jäger 1988; Sukopp 1995; Kornaś 1996; Jackowiak 1999).

The invasions by plants, animals or fungi are one of the most pressing issues of nature considered on a global scale. Some authors even deem it to be the single most important problem in protecting the biodiversity in the 21st century (Carlton & Geller 1993; Vitousek *et al.* 1996, 1997; Mooney & Hobbs 2000). The International Convention on Biological Diversity contains a special provision calling upon country-signatories to fight alien invasive species which could be of danger to native habitats, communities or species. These circumstances have contributed

[4] E.g. a column in *Przyroda i Przemysł* [Nature and Industry], a weekly devoted to advancement of the natural sciences and their applications in industry, of 1872 published a note on the appearance of new plants after the Franco-Prussian War. This note was prepared on the basis of a study by de Vibraye (1870–1871) presented before the French Academy, in which the author describes the emergence of 157 new exotic plants in central France. He attributed their presence in a new territory to an accidental introduction of seeds from Algeria by the French cavalry. The author assessed this process as a permanent change in the flora because "these plants not only withstood one of the most severe winters but flourished abundantly in the areas once quite devoid of plants. Thus we can be quite sure that it is not a temporary phenomenon but that essentially some of the regions in France had their plant wildlife augmented by new flora".

[5] While describing the spreading of Spanish Cardoon, Charles Darwin stated: "I doubt whether there was any such case in history of native flora being invaded by an alien species on such a great scale" (Crosby 1999).

to an evident increase in the interest in these issues among the theoreticians and practitioners of nature conservation.

Studies devoted to the spread of alien plant species are becoming almost as fundamental a part of the protection of biological diversity as the compilation of "Red Lists" and "Red Data Books" of rare and endangered species (Medwecka-Kornaś & Piękoś-Mirkowa 1997). The lists of alien species are compiled along with the lists of invasive species which have entered natural and semi-natural communities, or – as weeds – the segetal communities. However, one will not be able to prevent their spread without knowledge of their biology and habitat requirements as well as their geographical ranges of distribution. For example many plant species took less than two centuries to invade and occupy the whole national territory of Poland (Zając A. & Zając M. 2001).

The initiatives taken up in many countries, as well as those undertaken on a European and/or global scale (e.g. the international programmes *Ecology of Biological Invasion*, *Global Strategy for Invasive Species*, *Global Invasive Species Programme*), have made studies of alien species, and in particular their extending distribution ranges, their ecology, and the effects exerted – an urgent and indispensable task.

Both in Poland and other European countries, studies on the migrations and distribution of alien plant species have a certain tradition[6], beginning from studies devoted to particular species, such as, for example, *Bidens frondosa* (Trzcińska 1961; Lhotská 1966, 1968), *Impatiens glandulifera* (Zając E.U. & Zając A. 1973; Beerling & Perrins 1993; Gudžinskas & Sinkevičienė 1995; Pyšek & Prach 1995; Dajdok *et al.* 2003; Drescher & Prots 2003), *Iva xanthifolia* (Guzik & Sudnik-Wójcikowska 1989; Gudžinskas 1991; Jehlík 1998) and *Reynoutria* (*Fallopia*) *japonica* (e.g. Conolly 1977; Alberternst *et al.* 1995; Seiger 1997; Bailey & Conolly 2000; Child & Wade 2000; Tokarska-Guzik *in press*) or regions (e.g. Holzfuss 1937; Gütte 1971; Lohmeyer & Sukopp 1992; Brandes & Sander 1995; Natali & Jeanmonod 1996; Adamowski *et al.* 2002), up to studies covering whole countries (e.g. Clement & Foster 1994; Jehlík 1998; Zając A. & Zając M. 2001; Essl & Rabitsch 2002; Preston *et al.* 2002; Pyšek *et al.* 2002).

The historical impact exerted by humanity on the vegetation cover, and the flora in particular, is best illustrated by examining two phenomena: the interactions between the two groups of species: native[7] and alien, and the comparison between the group of the oldest companions of humans (archaeophytes, so called oldcomers) and the newer alien types (kenophytes = neophytes, so called newcomers).

The issue of the origin and development of the distribution ranges of the oldest group of alien species occurring in Poland (i.e. archaeophytes) has been taken up by Zając in a basic monograph (1979) and in detailed reports (Zając 1983, 1987a & b, 1988), while the same considerations for more recent newcomers (i.e. kenophytes) should begin to be addressed by the detailed maps included in *Distribution Atlas of Vascular Plants in Poland* (Tokarska-Guzik 2001a & b; Zając A. & Zając M. 2001), as well as by the present monograph.

The main idea behind the present monograph is to investigate changes in synanthropic flora of Poland and to provide a synthesis of the knowledge accumulated to date on the development of the kenophyte flora of Poland. It is also an attempt to reconstruct the historic changes in the ranges of distribution of kenophytes in the territory of Poland. Additionally, those regions of Poland which are particularly endangered by the excessive invasion of alien species are indicated, and the "invasive species"[8] are specifically identified in the first ever comprehensive list of invasive kenophytes compiled for Poland.

These aims have been achieved by the following objectives:

- verifying and updating lists of kenophytes compiled for Poland and presenting an original, comprehensive catalogue of this group of species, with an associated database of biological, ecological, geographical and historical attributes and information;
- establishing the first floristic data (first records) for particular species of Polish kenophytes;
- studying the historic distribution of kenophytes and attempting to reconstruct the history of kenophyte floras on the basis of distribution maps, applying whenever possible a cartographic interpretation;
- attempting to reconstruct periods of immigration and spread of kenophytes (construed as cumulations or "migration waves") showing also how they depended on historic and geographical conditions;

[6] Outside Europe one can find numerous publications devoted to this issue (e.g. compare literature cited by Brundu *et al.* 2001 and Child *et al.* 2003).

[7] Similarly important issue is the problem of "apophytisation" of native species, and its following consequences in "invasibility" of this group of species beyoned their natural range (cf. Chapter 11 and 12).

[8] Invasive species – species of foreign origin, established in a primarily foreign area, producing fertile offspring, often in extraordinarily large numbers, dispersing over great distances from parental plants (Richardson *et al.* 2000); for terminology, see also Chapter 3 and 12.

- identifying and describing the different patterns of distribution of kenophytes in Poland;
- reconstructing the history of the introduction, establishment and spread of selected species;
- discussing dynamic trends in kenophyte distribution, examining routes and pathways of invasion and the factors supporting the conquest of various types of habitats, and identifying areas most vulnerable to invasion (with practical implications for nature conservation).

2. Review of studies on selected aspects of synanthropisation of the vegetation cover

2.1. The history of studies on alien plant species in Poland viewed against the situation in Europe as a whole

A short review of the history, research trends and main methods used to study alien plant species in Poland was the subject of one of the previous paper (TOKARSKA-GUZIK 2001a). The present chapter is a further attempt to provide a synthesis of different aspects of studies on alien plant species in Poland shown on wider perspective.

The discovery of America by Christopher Columbus in 1492 boosted the perpetual interest in new, and partially known plant species. Exotic plants were brought to the collections of the botanical gardens that were emerging at that time. As the result botanical gardens were quite often the very spots from where alien species started their spread into new territories, beyond their natural ranges of distribution. At the same time, together with the introduction of new plant species to garden collections, documentation such as publications and herbaria started to emerge.

One of the earliest herbal studies devoted, *inter alia*, to these alien newcomers was the 15th century work by Jan Stanko, a canon priest in Wrocław and Kraków, entitled *Antibolomenum*. The next century, saw the publication of a work by Hieronim Spiczyński (1542) under the title *O ziołach tutecznych y zamorskich y o mocy ich* [On herbs native and coming from overseas and their effects].

Information on alien species which the contemporary botanical science characterised as more recent newcomers, or kenophytes, was included in works by SIRENIUS[9] (SYREŃSKI 1613) and KLUK (1786, 1787, 1788). The latter author described several hundred "native wild plants and alien plants which could be of use in our country" ("rośliny krajowe dzikie oraz i cudzoziemskie, któreby w kraju pożyteczne być mogły"). Most of the species mentioned by Kluk were cultivated at that time (e.g. *Aesculus hippocastanum*, *Artemisia dracunculus*, *Bryonia alba*, *Clematis vitalba*, *Helianthus tuberosus*, *Hyssopus officinalis*, *Juglans regia*, *Robinia pseudoacacia*, *Rubus odoratus*, *Sedum album*, *Sinapis alba*) and are now considered to be naturalised in the flora of our country. For certain species, some details of their status outside the cultivated state are also included along with a description of the type of habitats entered by these species[10].

The studies of species of foreign origin were first included in a broadly defined discipline of studies in plant geography. Prior to Darwin's studies, i.e. roughly till the mid 19th century, most of the research activities concentrated around the collection of facts pertaining to the occurrence of species and the differentiation between the vegetation landscapes of the world (KORNAŚ & MEDWECKA-KORNAŚ 2002). In the 18th century, under the influence of work completed by Carl Linnaeus, the first floristic accounts appeared in Europe, to be continued in the centuries that followed (e.g. WILLDENOW 1787; FICINUS 1821; REICHENBACH 1842; PECK 1865; NYMANN 1878–1882; SCHULZE 1881; SCHMALHAUSEN 1886). The descriptions of foreign newcomers in these floras were also coupled with initial attempts to make inventories of plant species occurring in European towns, some of them made as early as the beginning of the 17th century (cf. JACKOWIAK 1990, 1993, 1998a; SUDNIK-WÓJCIKOWSKA 1987a, 1998a and references in those papers). The checklists of urban floras are of particular importance in studies of species of foreign origin because towns are usually the places where these foreign newcomers appear for the first time. The oldest studies of this type in Poland include works pertaining to the Warsaw region, published by Bernhardi in 1652 and Erndtl in 1730 (SUDNIK-WÓJCIKOWSKA 1987a)[11].

[9] For example, Sirenius mentioned *Acorus calamus* (Sweet-flag) using old Polish name: "calamus".

[10] e.g. *Acorus calamus* – regarded by both authors as occurring near water; *Ambrosia artemisiifolia* – species described by Kluk as occurring on sandy sites; *Datura stramonium* – as early as in the times of these authors, this plant commonly occurred in a wild state, near fences, on yards and courts; *Malva moschata* – found in scrub; *Mercurialis annua* – in orchards and grassy sites; *Portulaca oleracea* – a plant cultivated in gardens, capable of spreading on its own throughout garden sites.

[11] Systematic studies of urban floras started in Poland as early as at the end of the 19th century. These types of studies became very common in the 1970s. A review of the studies on the floras of Central European towns and the synthesis of the main findings are presented by JACKOWIAK (1998a) and SUDNIK-WÓJCIKOWSKA (1998a).

The stormy history of Poland, a country which practically went out of existence between the day of the abdication of King Stanislaus Augustus (25 November 1795) till the day it regained its independence (11 November 1918), being nothing more but a name (DAVIES 2001), did not favour any systematic collection of floristic data. Within that period, there were only floristic studies devoted to local floras (MATTUSCHKA 1776, 1777, 1779; KROCKER 1787, 1790, 1814, 1823; BESSER 1809; GÜNTHER *et al.* 1824; ADAMSKI 1828; SCHNEIDER 1837; WIMMER 1841; GRABOWSKI 1843; RITSCHL 1850 and others). These were mostly works by German naturalists and pertained to the areas which became included in the administrative borders of Poland after World War II.

The oldest systematic study of the flora of Poland is the work by Jakub Waga, who was one of the outstanding Polish botanists of the first half of the 19th century (ROSTAŃSKI K. 2001a). This work, published in 1847, includes "botanical descriptions of plants, both wild and cultivated in open areas, within the Kingdom of Poland" ("botaniczne opisy tak dziko jako i hodowanych pod otwartem niebem jawnokwiatowych Królestwa Polskiego roślin"). According to ROSTAŃSKI K. (2001a), this first comprehensive study of the flora of what was then called the "Congress" Kingdom of Poland was of the same level and form as other floras of vascular plants from the neighbouring areas of Prussia, Silesia (Polish), Galicia and Lithuania. WAGA (1847) listed a total of more than a thousand species of flowering plants including several dozens of those currently classified as kenophytes – at that time these were either already established or merely present in cultivation (cf. Chapter 5.2).

The development of naturalists' studies undertaken in Poland in the second half of the 19th century was associated with the short-lived activities of Szkoła Główna (a higher education establishment) opened in 1862, from which some botanists graduated: KARO (1867 – *Flora of the Warszawa region*, 1881 – *Flora of the Częstochowa region*) and ROSTAFIŃSKI, the author of a 1872 treatise *Florae Polonicae Prodromus*. At the same time, there were floras of the Pomeranian regions and towns (e.g. KLINGGRAEFF 1848, 1854, 1866), Silesia (UECHTRITZ 1865; FIEK 1881) and Polish Galicia (BERDAU 1859; KNAPP 1872). These publications are a valuable source for the first record data for many species of kenophytes (cf. Appendix A & B). The first half of the 20th century, up until the outbreak of World War II, saw further regional Floras published where authors, apart from describing native species, also included species of foreign origin. Particularly noteworthy were the works by German botanists providing information on flora composition and localities for many plant species from Silesia (SCHUBE 1901a, b–1930; SCHALOW 1931–1936) and Pomerania (e.g. ABROMEIT *et al.* 1898–1940). Rich material regarding the Silesian flora was summarised in a work by SCHUBE (1903b, 1904), and the Silesian flora was reputed to be one of the best known floras in Europe of that time[12] (SENDEK 1981). In Galicia (south-eastern Poland), an important work – but unfortunately unfinished – in the field of floristic research was *Conspectus Florae Galiciae Criticus* by ZAPAŁOWICZ (1906, 1908, 1911).

Another important source of information was the naturalists' journals, which began to be published as early as in the second half of the 19th century, such as: *Wszechświat*, *Pamiętnik fizjograficzny*, *Kosmos*, *Sprawozdania Komisji Fizjograficznej PAU*, *Dohrniana*, *Jahres-Bericht der Schlesischen Gesellschaft für vaterländische Cultur*. These journals published floristic notes and accounts of botanical trips across various regions of contemporary Poland, and also included – apart from the records of native species – new localities for many new alien species, coupled with their probable routes into new territories (UNVERRICHT 1847; REHMAN 1868; KRUPA 1877; KAMIEŃSKI 1879, 1884a & b; UECHTRITZ 1879, 1880; ŁAPCZYŃSKI 1882, 1887, 1888, 1889, 1890; RACIBORSKI 1884, 1885; BŁOŃSKI 1892; CYBULSKI 1894, 1895; SCHUBE 1901–1930; MEYER 1931, 1932; SCHALOW 1931–1936 and others).

Further systematic floristic inventories were completed in many regions of Poland in the 1960s and 70s. This period yielded many records and checklists contributing to local and regional floras.

An outline of the history of floristic studies as well as the main currents of research, taking into account or sometimes devoted exclusively to plants of foreign origin, are presented in Table 1. Particularly significant contributions were made by those studies which concentrated on recording the appearance of new species in local floras and gathering data on their stations. Articles published in a series *Studies of distribution ranges of synanthropic plants* by TRZCIŃSKA (1961), ŚWIEBODA (1963); TRZCIŃSKA-TACIK (1963); ZAJĄC E.U. & ZAJĄC A. (1973) and GUZIK & SUDNIK-WÓJCIKOWSKA (1989) are pioneering works on the reconstruction of the history of spread by the synanthropic newcomers. Much attention was also given to the classification of plants accompanying humans and to compiling checklists of species of foreign origin occurring in Poland (Table 1; Fig. 1).

[12] Silesia had its wildlife particularly well researched even earlier, because the first study of this area was published in the 17th century by Caspar SCHWENCKFELD (1600). More Silesian floras were published by MATTUSCHKA (1776, 1777, 1779), KROCKER (1787, 1790, 1814, 1823), WIMMER & GRABOWSKI (1827–1829), FIEK (1881), SCHUBE (1904) and PAX (1915), after MULARCZYK (2000).

Table 1. Selected papers concerning different aspects of synanthropisation and studies focussing specifically on alien plants occurring in Poland (in chronological order)

Type of study	Author/ year
Historical floras (regions, cities & towns)	
Congress Kingdom of Poland (Królestwo Polskie)	Waga 1847; Rostafiński 1872
Pomerania (Pomorze)	Klinggraeff 1848, 1854, 1866; Abromeit *et al.* 1898–1940; Decker 1911; Müller 1911; Holzfuss 1937; Steffen 1940
Silesia (Śląsk)	Wimmer 1841; Grabowski 1843; Fiek 1881; Schube 1903b
Galicia (Galicja)	Besser 1809; Knapp 1872; Zapałowicz 1906, 1908, 1911
Bolesławiec town and vicinity (Bytom Odrzański, Jedlina Zdrój, Oława & Wołów)	Schneider 1837
Poznań	Ritschl 1850
Kraków (Cracow) and surrounding area	Berdau 1859; Raciborski 1884; Krupa 1877, 1878; Żmuda 1920
Warszawa (Warsaw) and surrounding area	Erndtel 1730; Karo 1867; Łapczyński 1882; Cybulski 1894, 1895
Częstochowa town and surrounding area	Karo 1881
Przemyśl town and surrounding area	Kotula 1881
Babia Góra Mt.	Zapałowicz 1880
Tatry, Pieniny & Western Beskidy Mts.	Berdau 1890
New alien plant species	
Elodea canadensis	Kamieński 1879
Acorus calamus, *Amaranthus retroflexus*, *Chamomilla suaveolens*, *Conyza canadensis*, *Elodea canadensis*, *Galinsoga parviflora*, *Impatiens parviflora*, *Lycium barbarum*, *Xanthium spinosum*	Kamieński 1884a & b
New species recordered in the Warszawa province	Cybulski 1895
Rare and casual plants	Trzebiński 1930
Newcomers and wandering plants	Szulczewski 1931
Veronica filiformis	Kornaś & Kuc 1953
Newcomers in the flora of Białowieża Forest	Sokołowski 1967, 1970
Corydalis lutea	Berndt 1958
Achillea crithmifolia	Dąbrowska 1972
Bromus carinatus	Mirek 1982 (1984)
Veronica peregrina	Zając M. & Zając A. 1990
Eragrostis multicaulis	Guzik & Sudnik-Wójcikowska 1994
Chaerophyllum aureum	Oklejewicz 1999
Reynoutria x *bohemica*	Fojcik & Tokarska-Guzik 2000
For more see also appendix A and B	
First localities	
Lists of plant species together with their localities	Kornaś 1950, 1954; Urbański 1958; Żukowski 1959; 1960a & b; Tacik 1960; Fabiszewski & Faliński 1963; Sowa & Wójcik-Chrobok 1969; Rostański K. 1960, 1961; Schwarz 1961; Sowa 1962; Hantz 1967, 1972; Michalak 1968, 1971; Korniak 1968; Trzcińska-Tacik 1971a; Michalak & Sendek 1974–1975; Głowacki 1975; Wika 1975; Olesiński & Korniak 1980
Kenophytes in the flora of Lublin province	Fijałkowski 1973
Synanthropic grasses	Korniak 2002
Synanthropic floras	
Floras of cities: Poznań Gdańsk Szczecin Zielona Góra, Koszalin Łódź Kraków	 Krawiecowa 1951 Schwarz 1967 Ćwikliński 1970 Ćwikliński 1971 Sowa 1974 Trzcińska-Tacik 1979
Comparison of the urban floras on the example of some cities	Krawiecowa & Rostański 1976, 1981

Type of study	Author/ year
Floras of towns & settlements	Mowszowicz 1960; Skowrońska 1965; Michalak 1970; Schwarz 1971; Sendek 1971; Sowa 1971; Anioł-Kwiatkowska 1974; Hantz 1974; Szmajda 1974; Czaplewska 1975; Misiewicz 1978; Sendek & Wika 1979; Sowa & Nasiłowski 1978; Weretelnik 1979; Sowa & Warcholińska 1980; Misiewicz 1981; Sowa & Warcholińska 1981a, b & c, 1984a & b, 1987; Maciejczak 1988; Ćwikliński & Bartnik 1990; Tokarska-Guzik & Rostański 1997, 1998
Full cartographic description of the urban flora: Warszawa Poznań Jaworzno	 Sudnik-Wójcikowska 1987a Jackowiak 1990, 1993 Tokarska-Guzik 1999
Ruderal floras in the rural landscape of the North Podlasie Lowlands	Wołkowycki 1997
Regions – examples: Wielkopolska province Gorce Mts. Tatry Mts. Wielkopolski National Park Karkonoski National Park Lublin province Upper Silesia Industrial Region eastern part of the Gniezno Lake District Zaodrze (to the West of Szczecin) Słowiński National Park	 Szulczewski 1951 Kornaś 1957, 1966 Radwańska-Paryska 1963; Piękoś-Mirkowa & Mirek 1978 Szulczewski 1963; Żukowski *et al.* 1995 Rostański K. 1977, 1978 Fijałkowski 1978 Sendek 1981, 1984 Chmiel 1993 Zając A. *et al.* 1993 Piotrowska *et al.* 1997
Segetal flora	Wnuk 1976; Sowa & Warcholińska 1979; Warcholińska 1981, 1996; Wnuk *et al.* 1989; Siciński 1997, 2000; Latowski 1998, 1999; Trzcińska-Tacik 1996; Warcholińska & Siciński 1996; Warcholińska & Tyszkowska 2000 also Jackowiak & Latowski 1996, 2001; Misiewicz & Piotrowski (eds.) 1996; Rola 1996 and literature cited therein
Ruderal plant communities	
Regions	Kornaś 1952; Sowa 1971
Cities & towns	Fijałkowski 1963, 1967; Rostański K. & Gütte 1971; Anioł-Kwiatkowska 1974; Kępczyński & Zienkiewicz 1974; Zając E.U. 1974; Kępczyński 1975; Czaplewska 1980; Święs & Pleban 1981; Święs 1983
Special habitats	Czaplewska 1981
Alien plants in special habitats	
Railways and railway stations	Meyer 1931, 1932; Kornaś *et al.* 1959; Sowa 1966; Ćwikliński 1968, 1972a, 1974; Krawiecowa 1968a; Sendek 1969, 1973; Zając E.U. & Zając A. 1969; Latowski 1977; Ćwikliński 1984–1985; Wika 1984
Store yards (including ballast plants)	Helm 1881; Holzfuss 1936, 1941
Sea & river harbors	Rostański K. & Szotkowski 1973; Misiewicz 1976, 1985, 2001
Walls	Weretelnik 1973, 1982; Świerkosz 1993; Galera & Sudnik-Wójcikowska 2000a & b
Lists of alien plant species	
Kenophytes	Kornaś 1968b; Zając A. *et al.* 1998
Archaeophytes	Zając A. 1979, 1983, 1987a & b, 1988
Ephemerophytes	Rostański K. & Sowa 1986–1987
American trees and shrubs	Hereźniak 1992
Kenophytes of American origin	Sowa & Warcholińska 1994
Anthropophytes	Mirek *et al.* 1995, 2002
Naturalised alien plants – neophytes (excluding archaeophytes)	Tokarska-Guzik 2003a
Terminology & classification	
Classification of synanthropic plants	Kornaś 1968a, 1977a & b; Krawiecowa & Rostański 1972; Mirek 1981a
Neophytes & neophytism	Faliński 1968a & b, 1969

Type of study	Author/ year
Dictionary of synanthropisation of plant cover	Sudnik-Wójcikowska & Kożniewska 1988
Origin, history of expansion & the distribution of alien plants	
Archaeophytes	Zając A. 1979
Bidens melanocarpus (= *B. frondosa*)	Trzcińska 1961
Elsholtzia ciliata (= *E. patrini*)	Świeboda 1962
Rumex confertus	Trzcińska-Tacik 1963
Artemisia	Żukowski & Piaszczyk 1971
Salsola	Baradziej 1972
Trifolium patens	Loster 1972
Mimulus	Piękoś 1972
Corydalis lutea, Cymbalaria muralis, Impatiens glandulifera	Zając E.U. & Zając A. 1973
Amaranthus	Frey 1974
Oxalis	Hantz 1979
Iva xanthiifolia	Guzik & Sudnik-Wójcikowska 1989
Eragrostis pilosa	Sudnik-Wójcikowska & Guzik 1996
Oenothera	Rostański K. & Tokarska-Guzik 1998 and literature cited therein
Beckmannia eruciformis	Frey & Paszko 2000
Veronica peregrina	Zając M. & Zając A. 1990; Guzik & Paul 2000
Alien grass species in the Silesian Upland	Tokarska-Guzik & Nowak 2001
Threats to protected nature by alien plant species	
Anthropogenic plant communities in Białowieża Forest	Faliński 1966a
Alien plant species in natural communities	Kornaś & Medwecka-Kornaś 1968
Contribution of alien plant species in the flora of Opawskie Mountains	Krawiecowa 1968b
Anthropogenic changes in plant cover of Ojców Landscape Park	Michalik 1972, 1974
The nature of the Pieniny Mts. in face of the coming changes	Zarzycki 1982
Weed species from Śnieżnik Massif, the Bialskie and the Złote Mts.	Brej 2001
General and theoretical aspects	
Faliński 1966b, 1968a, 1969, 1971, 1972, 1998a & b, 2000a; Kornaś 1971, 1977b, 1981, 1982, 1983, 1990, 1996; Olaczek 1972, 1974, 1982; Krawiecowa & Rostański 1976; Sowa & Olaczek 1978; Trojan 1982; Jackowiak 1991, 1998a & b, 1999, 2000, 2003; Sudnik-Wójcikowska 1991, 1992, 1998a & b, 2000; Sudnik-Wójcikowska & Moraczewski 1998; Tokarska-Guzik 2001a; Kornaś & Medwecka-Kornaś 2002	
Distribution atlases	
Distribution Atlas of Vascular Plants in Cracow Province	Zając M. & Zając A. (eds.) 1998
Geobotanical Atlas of the Bug River Valley	Faliński *et al.* 2000
Atlas of distribution of vascular plants in Poland	Zając A. & Zając M. (eds.) 2001
Atlas of alien woody species of the Białowieża Primaeval Forest	Adamowski *et al.* 2002

The same broadening of the scope of studies pertaining to alien plants was developed by botanists in other parts of Europe and the wider world. The topics and scope of more than 900 papers indexed in Ecological Abstracts (1974–1993) were analysed by Pyšek (1995). He found that after a period of collecting floristic records about the occurrence of species of foreign origin, there was later an evident shift of emphasis to the issues of their biology and ecology, as well as a drive to more general (theoretical) papers.

Intensive studies were carried out, particularly in those parts of the world where the appearance of alien species occurred on a mass scale and endangered native vegetation cover (Australia, New Zealand, South Africa, the western coast of the United States, Hawaii). The number of studies on these topics is still increasing (up to some 100 publications each year).

In recent decades, as a part of Poland's commitment to international programmes, a certain number of studies undertaken in this country have concentrated on biological diversity. Nevertheless, the topics which are particularly current, as well as those pertaining to the recognition of the threats to native biodiversity from invasive or genetically modified plant

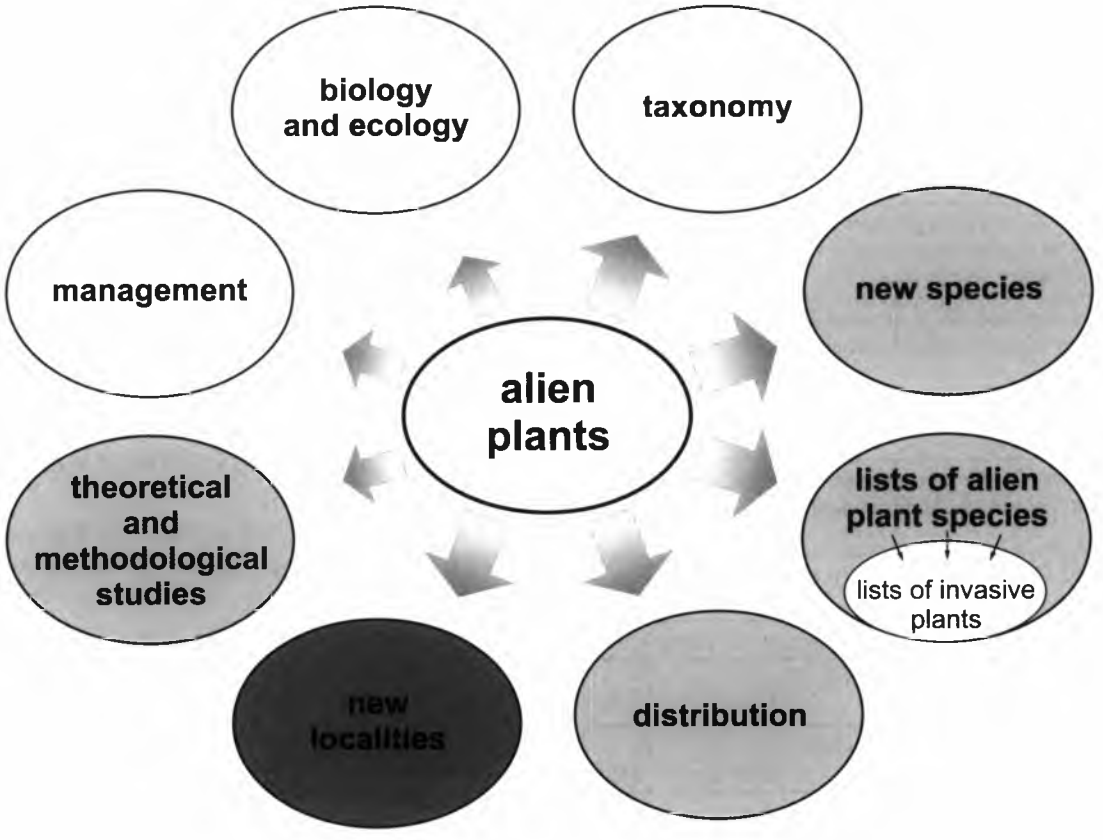


Fig. 1. Scope of studies pertaining to alien plants developed by botanists in Poland
The graph shows the situation referring to the period 1950–2000. Contribution of particular topics and scope of studies in the total number of papers analysed (n = 1074) is indicated in dark grey (significant), light grey (intermediate) and white (low or none)

species, still represent only a small proportion of the overall number of studies pursued (Wiśniewski 2003).

2.2. Synanthropisation: the essence of the process and the role of kenophytes in the changes occurring in the natural environment on Earth

Studies of alien plant species fall into the current general field of research concerning anthropogenic changes in vegetation. As early as in the 1960s, the discussion was initiated within regular symposia, devoted to various aspects of the synanthropisation[13] of vegetation cover (Faliński *et al.* 1998; Tokarska-Guzik 2001a) (Table 2).

[13] A definition of the term "synanthropisation" was proposed by Faliński (1966b, 1972): "Synanthropisation of vegetation is a part of directional changes occurring on Earth under the impact of human activities, manifesting themselves as replacing specific i.e. endemic components, with non-specific i.e. cosmopolitan, replacing native i.e. autochtonic components with newcomers i.e. allochtonic elements, replacing stenotopic components by eurytopic ones. In effect, it means replacing primary systems, conditioned by the joint effect of endogenic and exogenic factors, with secondary systems conditioned mainly by exogenic factors".

Also praiseworthy are studies of special topics undertaken by Polish botanists, which have already claimed their place in the overall achievements of biogeographical sciences, such as:
- monograph devoted to phytogeographical problems of vegetation in the Gorce Mts. (Kornaś 1955);
- model monograph pertained to anthropogenic transformations of vegetation in the Białowieża Primaeval Forest (Faliński 1966a);
- pioneering attempts at comparative analysis of floras of towns and settlements (Faliński 1971; Krawiecowa & Rostański 1976);
- methodological studies concerning the spatial structure of the flora of major cities (Jackowiak 1998a & b; Sudnik-Wójcikowska 1998a), including especially the model solution proposed by Jackowiak (1998a & b), who defines the city as a centre of crystallisation in a floristic-ecological space. Also works by Sudnik-Wójcikowska (1998a & b, 2000), confirming the indicative role of the flora with respect to the thermal conditions in an urban area;
- comparisons of the differences among rural floras in special areas treated as "environmental islands" such as Mediaeval strongholds (Celka 1999), settlements in agricultural-forest landscapes (Wołkowycki 2000), and abandoned industrial sites and areas (Rostański A. 1998a & b; Woźniak 1998; Cohn *et al.* 2001);

Table 2. Polish symposia on the synanthropisation of plant cover

Conference title	Place	Year
Synanthropisation of plant cover	Kraków	1965
Neophytism and apophytism of plant cover in Poland	Nowogród	1968
Synanthropic flora and vegetation of towns connected with their natural conditions, history and function	Wrocław	1970
Theoretical and methodical basis of the studies upon the synanthropisation of the plant cover	Białowieża	1971
Synanthropisation of plant cover in national parks and nature reserves	Białowieża	1971
Phytocoenosis degeneration under the influence of natural and anthropogenic factors	Łowicz	1974
Decline and extinctions of the native plant species in Poland	Kraków	1976
General problems of synanthropisation	Białowieża	1980
American plant species established in Poland	Łódź	1992
Mechanisms of anthropogenic changes of the plant cover	Poznań	1999
Phytogeographical problems of synanthropic plants	Kraków	2000
Invasive species in the flora and fauna of Poland against the background of the conservation of biological diversity	Kraków	2001

Sources: Faliński, Adamowski & Jackowiak (eds.) 1998; Ławrynowicz & Warcholińska (eds.) 1992; Jackowiak & Żukowski (eds.) 2000; Zając A., Zając M. & Zemanek (eds.) 2003.

– theoretical concepts (models) to interpret the phenomena of ecological and geographical expansion (Jackowiak 1999; Faliński 2000a, 2004) (cf. also Table 1).

Since the end of the 20th century, the phenomenon of synanthropisation, associated with human population growth, advances of technology, development of agriculture, industry and urban centres, has been attracting ever-increasing interest (Kornaś & Medwecka-Kornaś 2002). It has resulted in a number of detailed studies and reviews, pertaining to many aspects of this issue, important in various regions of the world[14]. Many authors highlight the fact that numerous papers which do not use the term "synanthropisation", deal essentially with the issues covered by the scope of the term: decreasing the diversity of nature and invasion by alien species. These issues are currently included in the study of the overall changes occurring on Earth and are coupled with calls to protect biological diversity (Kornaś & Medwecka-Kornaś 2002). The interest in biological invasions has been boosted recently because of the threat to native vegetation, but also because of the increasing likelihood of transgenic organisms penetrating natural communities in the wake of developments in genetic engineering (Daehler & Carino 2000; Zarzycki 2000a; Cronk & Fuller 2001).

Invasion by plants of foreign origin is considered, along with the fragmentation and degradation of natural communities, to be one of the leading threats to global-scale biodiversity (Abbott 1992; Kolar & Lodge 2001). Significant expenditure, borne in attempts to control invasive species and results of their invasions, prompted the Scientific Committee on Problems of Environment (SCOPE) to initiate a special research programme, called *Ecology of Biological Invasion* (1982), which was then continued under the framework of the *Global Strategy of Invasive Species* project (initiated in 1995). The effect of the SCOPE 37 programme includes a series of book publications covering the results of studies devoted to these issues (Groves & Burdon 1986; MacDonald *et al.* 1986; Mooney & Drake 1986; Drake *et al.* 1989; Di Castri *et al.* 1990; Mooney & Hobbs 2000). These books provide enormous lists of references from all over the world. The increased interest in the issue of biological invasion has brought about the development of other biological research programmes as well as the emergence of specialised international organisations and research groups. These include GISP – *Global Invasive Species Programme* and ISSG – *Invasive Species Specialists Group* (operating under the aegis of the International Congress of Nature Conservation of IUCN), which published a list of the most "dangerous" invasive species and a guide to "management" of invasive species (Mirek & Wołoszyn 2001). Monographic works focusing on various features of biological invasions were published and the specialist journal *Biological Invasions* was launched. A number of national and international conferences and seminars have been held, such as the Slovak conference *Inváze a invazne organizmy* (Eliáš 1997), a conference devoted to *Alien Organisms in Germany* (Doyle 1999) or the conference organised in 2001 in Kraków, on the *Invasive species in the flora of Poland in the context of the protection of biological diversity*, by the Natural Conservation Committee of the Polish Academy of Sciences.

[14] The increase in the interest in issues of synanthropisation was particularly great in Western and Central Europe, as a result of the remarkable devastation of vegetation in these parts of the continent. The transformation of vegetation resulting from human activities was taken up as topic of many scientific conferences and constituted the subject of numerous monographs, reviews and theoretical works (e.g. Thellung 1918–1919; Probst 1949; Sukopp 1962; Sukopp & Trautman 1976; Kornaś 1982; Olaczek 1982; Holzner *et al.* 1983; Wittig *et al.* 1985; Jäger 1988; Kowarik 1988, 1990; Lohmeyer & Sukopp 1992; Pyšek 1993; Jehlik 1998; Faliński *et al.* 1998 and others).

Biologists and ecologists from Germany, at a meeting in Berlin in April 1999, founded a research consortium on biological invasions. This group co-ordinates responses to the ever increasing problems caused by the invasion of non-native plants, animals, fungi and micro-organisms. These "new species" (*Neobiota*) can threaten the biodiversity within existing native species, alter the structure and function of ecosystems and can eventually cause severe economic and human health problems. The Neobiota group initiates and organizes conferences (e.g. *3rd International Conference on Biological Invasion Neobiota – From Ecology to Control*, Bern 2004) and related publications (KOWARIK & STARFINGER 2002; SEITZ & KOWARIK 2003; KÜHN & KLOTZ 2004).

An international event of major importance in the field is a conference held regularly under the title of *Ecology and Management of Alien Plant Invasions*, devoted to broadly defined issues of biological invasions (WAAL DE *et al.* 1994; PYŠEK *et al.* 1995; BROCK *et al.* 1997; STARFINGER *et al.* 1998; BRUNDU *et al.* 2001; CHILD *et al.* 2003).

The International Union for the Conservation of Nature IUCN in February 2001 published *Guidelines for the Prevention of Biodiversity Loss Caused by Alien Invasive Species*, focusing the interest of researchers on the development of studies to enable the slowing down or containment of the adverse effects of the invasion by alien species. In the same year under the auspices of *Global Invasive Species Programme Global Strategy on Invasive Alien Species* was developed (MCNEELY *et al.* 2001).

The role of science is critical in providing the information needed to develop a coordinated European policy (GENOVESI 2004). In order to respond to these needs a *European Strategy on Invasive Alien Species* (GENOVESI & SHINE 2004) has been approved by the Bern convention and supported by the European Council of Ministers (GENOVESI 2004).

As a result of the developments summarised above, the issue of invasion by alien species has developed into a separate channel of research, also using data from other disciplines of natural sciences (REJMÁNEK 1996; DAEHLER 2001). In recent years, studies of alien species have dealt with the various threats posed to natural vegetation by invasion by alien species (numerous basic studies devoted to the taxonomy, biology and ecology of alien species as well as to the mechanisms of invasion) and with the methods and techniques to control the spread of invasive species (cartographic studies of distribution ranges, monitoring, "management" and other methods to control these species). From among the voluminous list of papers, the most illuminating are those that attempt to show model descriptions of the phenomenon of invasion (SUKOPP & SUKOPP 1993, 1994; FALIŃSKI 1998a & c; JACKOWIAK 1999; LONSDALE 1999), papers devoted to forecasts of invasions (KOLAR & LODGE 2001; PYŠEK 2001) as well as those dealing with evolutionary processes resulting from invasion by alien species (DEN NIJSS *et al.* 1999; ELLSTRAND & SCHIERENBECK 2000; ZAJĄC A. & ZAJĄC M. 2000; ALLENDORF *et al.* 2001).

An important contribution to our knowledge of invasion has also been made by lists of alien species and by synthetic studies pertaining to particular regions, which commonly also provide rich collections of sources and references (e.g. CLEMENT & FOSTER 1994; GUDŽINSKAS 1997a, b, c & d, 1998a, b & c, 1999a & b, 2000a & b; PRESTON *et al.* 2002; PYŠEK *et al.* 2002; KÜHN & KLOTZ 2003; BOTOND & BOTTA-DUKÁT 2004). Another easily accessible and fast source of information is provided by many websites and home pages presenting both scientific papers and applied research studies, often with maps of growing secondary distribution areas and photographs familiarizing readers with "the perpetrator" and the scale of the phenomena caused by it.

However, in spite of a growing body of information accumulated in the last half-century on the spreading of alien plant species in various corners of the Earth, many questions have remained unanswered.

PART TWO

Terminology and methodology

3. Phytogeographical terminology and the classification of synanthropic plants used in Poland

One of the essential aspects of studies devoted to species of foreign origin is the problem of their status within a given flora.

The first attempts to provide a typology of species of foreign origin date back to the 19th century (CANDOLLE DE 1855; ASCHERSON 1883). The concept of the classification of floras and its terminology as adopted in Central Europe was elaborated by THELLUNG (1918–1919). This author discussed and defined terms such as "native", "introduced" and "alien" in French, German and English (SUKOPP 1998). The classification of synanthropic flora proposed by Thellung was applied in Poland by many authors[15], and modified by KORNAŚ (1968a, 1981), adopting the following basic criteria: origin, time of arrival and the degree to which a particular species is established (Fig. 2). According to KORNAŚ (1981), "plants of foreign origin (alien plants) are those species originating from areas other than that in which they are found, which have appeared in new habitats owing to intentional or unintentional introduction as a result of human activity".

In the Polish scientific literature in this field, the first attempt to gather and organize the existing terms and classifications of synanthropic plants is the work entitled *Słownik z zakresu synantropizacji szaty roślinnej* [Dictionary of terms used in the field of the synanthropisation of vegetation cover] (SUDNIK-WÓJCIKOWSKA & KOŹNIEWSKA 1988).

In many current English-language publications, criticism has been directed towards East European authors, particularly for introducing a multitude of new terms (TOKARSKA-GUZIK 2001a; PYŠEK *et al.* 2004). The classifications of synanthropic floras by various authors differ above all in the criteria adopted as well as in the scope and interpretation of the terms used[16].

In discussions by phytogeographers who study the topic of invasiveness, the terminological questions are regularly addressed, not only for purely semantic reasons, but also for practical purposes in order to make a comparative approach possible (PYŠEK 1995; RICHARDSON *et al.* 2000; TOKARSKA-GUZIK 2001a; CHMURA & SIERKA 2004; PYŠEK *et al.* 2004).

A comparison of the classification of synanthropic species accepted in Polish literature with those in English-language publications allows the group of species included in the present study to be correctly placed within the different systems currently applied (Appendix D).

The authors of one of the recent publications aiming at introducing a certain order to the "invasive" terminology (in particularly devoted to invasive plant species) suggested yet another, simplified classification in which the status of a species is determined on the basis of major barriers it has to overcome in the process of settling in a new territory (RICHARDSON *et al.* 2000; PYŠEK *et al.* 2004)[17] (cf. also Chapter 12). The proposed classification considers practical implications connected with the spread of non-native (alien) species beyond their natural ranges, their naturalisation in new homelands and the effects on nature and human economic activities. The authors of the above-mentioned papers do not

[15] Thellung's classification was first used in Poland by KRAWIECOWA (1951) in her pioneering work on synanthropic flora of Poznań.

[16] Terminologies and definitions in this field of research were compared in a large body of literature by PYŠEK (1995) and in Polish literature by SUDNIK-WÓJCIKOWSKA & KOŹNIEWSKA (1988).

[17] Besides the classification and terminology associated with definitions the authors give also the synonyms for particular terms.

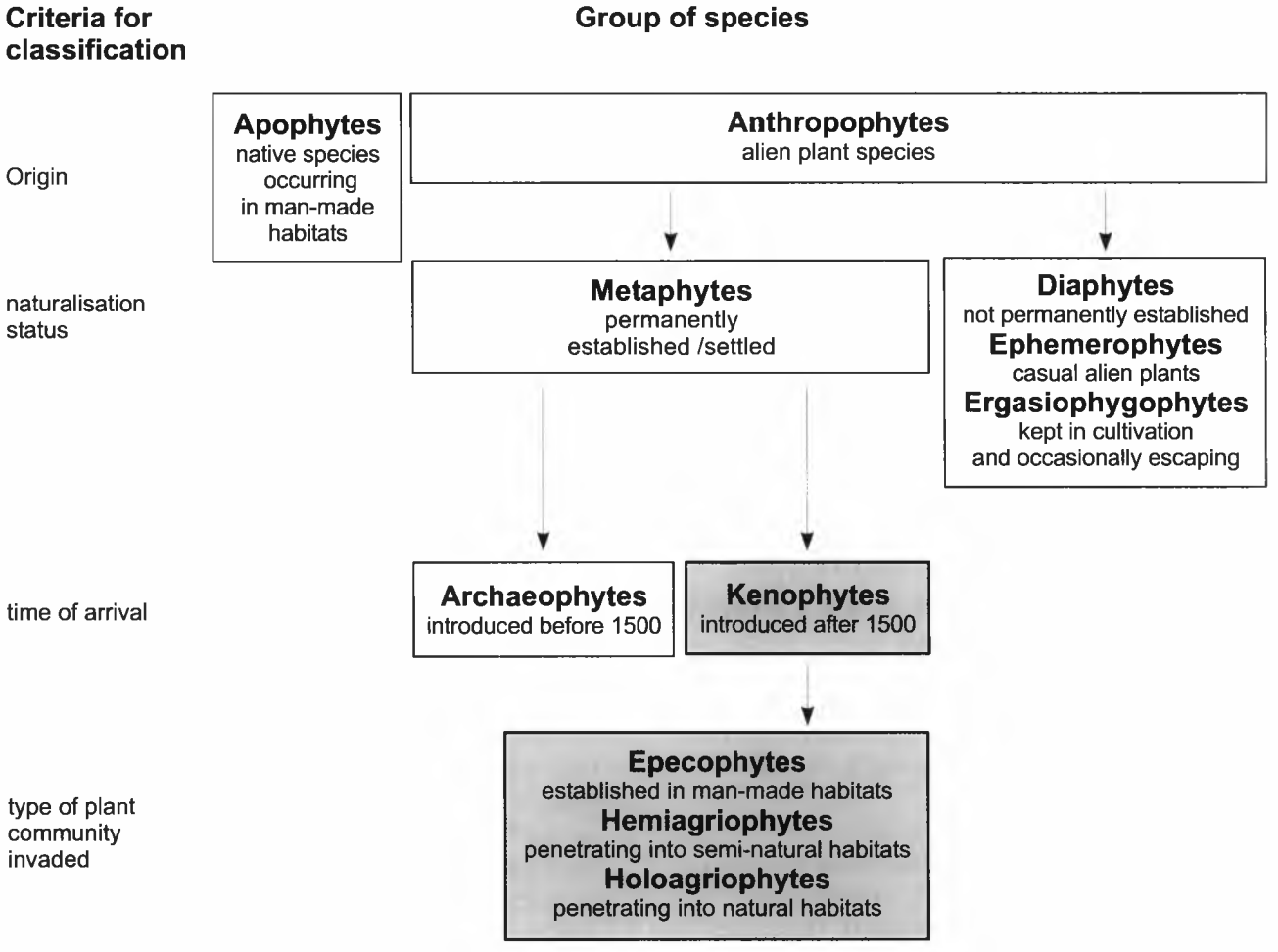


Fig. 2. Position of kenophytes in the geographical-historical classification of the synanthropic flora (KORNAŚ 1968a, 1981 after THELLUNG 1918/1919; TRZCIŃSKA-TACIK 1979)

consider the criterion of time (time of immigration) which although artificial still allows one to differentiate between processes in the floras which in the Middle Ages went differently compared with outcomes in modern times.

4. Materials and methods

4.1. Selection of species[18] and their status

Adhering to Thellung's classification of synanthropic plants as modified by KORNAŚ (1968a), this monograph pertains to **kenophytes**, i.e. species alien to the natural flora of a given region (in this case, of Poland), which arrived after the year 1500 and are now permanently established (→ metaphytes): in anthropogenic habitats (→ epecophytes), and sometimes penetrating into semi-natural communities (→ hemiagriophytes) or natural communities (→ holoagriophytes) (SUDNIK-WÓJCIKOWSKA & KOŹNIEWSKA 1988) (cf. Fig. 2; to compare terminology see also Appendix D).

The species included in this study were selected from two sources:
– *Kenophytes in the flora of Poland: list, status and origin* (ZAJĄC A. *et al.* 1998);
– *Flowering Plants and Pteridophytes of Poland, a checklist* (MIREK *et al.* 2002).

The list elaborated on the basis of these two references required changes and supplements, because the original lists of anthropophytes and kenophytes were somewhat outdated. For the purpose of the present study, it was therefore necessary to create an original and up-to-date catalogue of kenophytes occurring in Poland. This was developed on the basis of regional studies and personal research data (Appendices A and B).

The status of each alien species occurring in Poland has been critically assessed against the available historical floras and modern studies devoted to the issue of synanthropisation. The analysis has also utilised the publications by the following authors: KORNAŚ (1968a & b, 1981),

[18] The taxa covered in this study include units of various rank: species, subspecies and hybrid forms (cf. Appendices A and B). In the text, the whole group of taxa under study are termed "species", when referred to collectively.

MIREK (1981a), ROSTAŃSKI & SOWA (1986–1987), ZAJĄC A. (1979) and ZAJĄC A. *et al.* (1998).

In some cases, however, the practical application of the criteria adopted by these authors poses considerable difficulties. This pertains both to the species which, according to the present level of knowledge about their origin, cannot be validly classified as either native or alien to the flora of Poland[19], and to newcomers towards which certain doubts still exist as to the timing of their arrival and the degree of their establishment.

A species is included in the presented list when certain premises have been met:
- the species is alien throughout the whole of Poland (if it has even one station in Poland which is deemed to be natural, the species is not considered as alien);
- hybrids produced by "crossing" a native species with a species of alien origin are treated as alien taxa and henceforth included in the list[20].

The list presented does not include the following species of the genus *Oenothera*: *Oe. ammophila* Focke, *Oe. biennis* L. s.str. and *Oe. rubricaulis* Kleb., following the opinion of ROSTAŃSKI K. (1998, 2003), that these have been known in Poland (and in Europe) for a long time and they have not yet been found in North America.

The taxa which had been previously classified as kenophytes but have had their status changed in the most recent studies were also taken off the list. These are: *Malva alcea* L., a species which, according to the newest research should be regarded as an archaeophyte (CELKA 1998) and *Verbascum chaixii* Vill. subsp. *orientale* Hayek which had previously been included in the list of kenophytes (ZAJĄC A. *et al.* 1998), but has more recently been classified with the species which are not yet established (MIREK *et al.* 2002).

The complete list of the species studied is provided in alphabetic order in the concluding part of this monograph. The list of kenophytes has been divided into two major groups:
- Appendix A – kenophytes about which the most exhaustive information has been gathered, including the data on their distribution. This Appendix includes 174 species;
- Appendix B – kenophytes for which sufficient information on distribution has not yet been gathered (75 species); these species have been included in the geographical, historical and ecological analyses of the Polish kenophyte flora (Chapter 5). This Appendix includes a further 51 species of which are likely kenophytes but whose status is still under discussion. These species are mostly plants cultivated (planted) in a certain way (mostly tree species), which manifest a tendency to become "wild" and are considered established in some regions of Poland, but are still of uncertain status. Whenever this group is considered in the analyses, an appropriate note is made.

[19] In the newest edition of the critical checklist of vascular plants of Poland: *Flowering Plants and Pteridophytes of Poland – a checklist* (MIREK *et al.* 2002), such species have been separately treated as taxon of uncertain status in the Polish flora, likely to be anthropophytes.

[20] The same treatment has been applied to locally emerging new taxa of the genus *Oenothera*, which are hybrids between species which originated from North America and the species which ROSTAŃSKI K. (1998, 2003) regards as native.

4.2. Sources and characteristics of the floristic data used

In this monograph both the author's own records and those obtained by other researchers have been used, classified into three groups:
- unpublished,
- published,
- herbarium records.

The most significant and voluminous information on stations has been provided in unpublished materials sent to the database of the *Distribution Atlas of Vascular Plants in Poland* – ATPOL (ZAJĄC A. & ZAJĄC M. 2001), by botanists from all over Poland, and the records collected by the present author during floristic studies. In this monograph, the material collected by the author consists of floristic records (a total of 4 594 records), gathered in the course of field studies over a period of more than 10 years, and particularly within the period 1996–2003.

The herbarium materials collected during these studies have been deposited in the Herbarium of the Department of Plant Systematics of the Silesian University (KTU).

The records from published sources have been obtained from nearly 1 000 floristic and phytosociological publications from the last 200 years. Historical accounts were particularly important for the task of reconstructing changes in the distribution of individual kenophytes. Available works by Polish botanists, also by botanists from neighbouring countries undertaking research during the 19th and the beginning of the 20th century within the lands of contemporary Poland, were used for this purpose.

Herbarium collections – both Polish and in neighbouring countries (Herbaria in Berlin, Prague and Vienna) – provided some 6% of records on the occurrence of kenophytes in Poland. Also, in this case those data which help locate or verify the earliest records of particular species were particularly important.

The ATPOL database has over 66 000 records pertaining to kenophytes. A single record contains information on one species or a group of species. The predominating majority of records comes from unpublished sources (*ca.* 69%). Published data constitute *ca.* 25% of the overall number of records reflecting the enormous volume of modern recording compared with herbarium specimens.

In the case to analyse the oldest printed sources, primarily published in Latin, and of older German (often printed in Gothic type), and Russian sources, suitable reference dictionaries (e.g. ROSPOND 1951) were consulted in order to translate the geographic names and descriptions of sites, and also quite often it was necessary to locate old maps.

The majority of records collected in the database are from the last century (over 90%), whilst the data collected in the 19th century constitutes some 5%, while only 0.2% of records date back to the 18th century.

In evaluating the quality of data available at the start of this research project it should be noted that only 10–15% of the territory of Poland had then been studied more thoroughly (i.e. with a somewhat greater number of records per cartogramme unit) than the remnant part of the country. Thus, it was necessary to supplement the data, particularly by examining the oldest records which were then used to reconstruct the histories of the spread of various species. Another pivotal element which had to be decided was the evaluation of the status of a given species at a particular station (i.e. planted or spontaneously) which permits the reconstruction of the stages of its establishment in the flora of Poland.

It must nevertheless be emphasised, that the records of the last 100 years were used as the primary basis for the interpretation, as being the most reliable and comprehensive; it is also considered that they also allow for a proper assessment of the dynamic tendencies in the flora of kenophytes occurring in Poland.

4.3. List of kenophytes and the scope of the information collected in order to characterise them

The alphabetic list of species with their biological, geographical and historical characteristics was compiled in an Excel table and attached to the main text as Appendices A and B. The array gives the following elements of information for each species in the order listed below:

1. Taxonomy and nomenclature

The names of species and taxa of hybrid origin are adopted from *Flowering Plants and Pteridophytes of Poland, a checklist* (MIREK *et al.* 2002), including also the most frequently used synonyms. The names of the relevant families are provided for all species.

2. Biology and ecology

The life form of each species was determined on the basis of the RAUNKIAER system (1905). Out of more than a dozen, only the basic forms: phanerophytes, chamaephytes, hemicryptophytes, geophytes, hydrophytes and therophytes were selected for further analyses.

The remaining data on the biology of a species, such as manner of reproduction, pollination of flowers, dispersal of diaspores and life strategies were compiled from available sources (e.g. TUTIN *et al.* 1964–1986; GRIME 1977, 1979; FRANK & KLOTZ 1990) and the author's own observations.

3. Origin, history of expansion and current status

The information about the homelands of individual species and the time of their introduction into Europe, either accidental or for cultivation, was taken from the literature (the list of references used is provided in the notes explaining the abbreviations and symbols used in Appendices A and B). For each species, the information about its first record in Europe was collected (for species of European origin this is the first record outside its natural distribution range). The information on the first record in Poland is more detailed, indicating the location of the first station and the source of the data.

For 174 species of kenophytes for which sufficiently comprehensive data have been collected, the numbers of stations are given separately for consecutive periods of time (from 1700 to 1850, then 1851–1900, 1901–1950, and 1951–2003), also the total number of ATPOL squares where the species has ever been recorded (Appendix A).

The dynamic tendencies of species were assessed using the criteria suggested by ZARZYCKI *et al.* (2002), but in addition related to the author's own data on the number of stations analysed in the consecutive 50-year periods and the number of ATPOL squares where the species has been recorded.

Based on the number of ATPOL squares, it was possible to establish the categories of frequency in relation to the overall number of squares for Poland (n = 3646), i.e. categories 1 to 6 represent species recorded in the following numbers of squares:

1. 0.02 – 1.0% of squares
2. 1.1 – 10% of squares
3. 10.1 – 20% of squares
4. 20.1 – 40% of squares
5. 40.1 – 60% of squares
6. 60.1 – 100% of squares

The number of registered stations were then used to set up a detailed scale of frequencies (adapted to that applied by ZARZYCKI *et al.* 2002), namely:

1 – 14 stations – rare
15 – 50 stations – occasional
51 – 500 stations – occasional, locally frequent
501 – 6000 stations – frequent, locally abundant
> 6000 stations – abundant (common).

The current status of the species was determined by listing the habitats which the species colonises in the area of Poland.

The characteristics of the species was also supplemented by information on its invasiveness in other regions of the world (based on literature data: FERNALD 1950; HOLM *et al.* 1979; PERRINS *et al.* 1993; SHEVERA 1997; CELESTI GRAPOW & BLASI 1998; JEHLÍK 1998; KOWARIK 1999; LANDOLDT 2000; CELESTI GRAPOW *et al.* 2001; CRONK & FULLER 2001; FEDOROV 2001; UHERČIKOVÁ 2001; PYŠEK *et al.* 2002); also cited are the most significant published sources containing distribution maps.

4.4. Cartogrammes and their analysis

The cartogrammes were prepared in accordance with the requirements of the *Distribution Atlas of Vascular Plants in Poland* – ATPOL, adopting a 10 x 10 km square as the basic unit. The territory of Poland is thus placed in 3 646 such cartogramme fields (taking into account also parts of units along the national borders) (ZAJĄC A. 1978a & b; ZAJĄC A. & ZAJĄC M. 2001).

A detailed list of stations for individual kenophytes is included in the database of software dealing with kenophytes (ATPOL-KENO), which is an integral part of the ATPOL database. On the basis of the collected data and using an original software package called *The Regional Atlas of Plants* [Regionalny Atlas Roślin] – RAR[21], developed by Józef Gajda of the Institute of Information Technology of Jagiellonian University, distribution maps were prepared for 174 species of kenophytes occurring in Poland. Most of the maps have been published in the *Distribution Atlas of Vascular Plants in Poland* (ZAJĄC A. & ZAJĄC M. 2001), including 59 maps prepared as original maps by the author of the present monograph (TOKARSKA-GUZIK 2001b) and 18 maps in co-operation with other authors (CIACIURA *et al.* 2001b; CZARNA *et al.* 2001; ROSTAŃSKI K. & TOKARSKA-GUZIK 2001). The maps prepared for the remaining species also include inputs from the author of this monograph.

The set of distribution maps of Polish kenophytes has been supplemented by five more original maps, prepared for the following species: *Ailanthus altissima* (Mill.) Swingle (Chapter 7, Fig. 39), *Asclepias syriaca* L., *Medicago* x *varia* Martyn, *Sicyos angulata* L. and *Sisyrinchium bermudiana* L. em. Farw. (Appendix C).

In the case of species which were brought to Poland intentionally as useful plants, some of which are still under cultivation, there have been some difficulties in developing maps. Because of the method of collecting information for the ATPOL database (the status of a given species at particular stations was not recorded), and the variable descriptions of data in published records or herbarium data (in many cases the authors of records did not provide this information), it was impossible to differentiate between symbols on the cartogrammes or to select stations where the given species had appeared spontaneously. It should thus be kept in mind that for some species under cultivation, the relevant cartogramme can include both stations at which the species was deliberately introduced and those where the species entered unaided. For the same reason (without verifying the data in the field studies), some tree species were excluded from the cartographic part of the study, e.g. *Aesculus hippocastanum* and *Quercus rubra*, of which it is known that they spread spontaneously but also have a number of stations resulting from planned introduction (they have been included in Appendix B).

Two other groups of species were also excluded from the cartographic part. These are critical species which will require separate taxonomic studies, and the species for which the distribution data are incomplete and must be verified.

4.5. Use, interpretation and synthesis of data

The analysis of the kenophyte flora was completed for 300 species out of which two groups were separated: a group of 249 species firmly established in Poland (Appendices A and B), and 51 species which can currently be deemed to be established locally (these are mostly cultivated plants and those sometime growing in the "wild"; the species concerned were marked with "?"

[21] RAR is a software package that operates all functions of a database containing floristic data from a selected region of Poland (or from the whole of Poland). The software enables the administrator to add, delete, or modify records in the database and present them either as maps on a VDU or as printouts.

preceding the species name; cf. Appendix B). In every case, the number of species which were involved in the analysis is provided in the caption supporting the figure or table. When the graphs and diagrams were drawn, the principle of "double" (or "multiple") counting was adopted, if two (or more) categories are given for the same species. This principle covers both the origin (e.g. a species whose primary disjunctive range includes North America and Asia has been included in both categories of origin), manner of introduction (intentionally introduced and also accidentally brought in), and the manner of reproduction.

The data on the overall number of species in the Polish flora were taken from the newest edition of the critical checklist of vascular plants (Mirek *et al.* 2002), taking into account only the spontaneous flora and the cultivated species now growing in the "wild" (several hundred species which are only known as cultivated plants were thus omitted). Other sources used in the study are indicated in captions to the relevant tables and graphs.

The similarity between floras were determined through cluster analysis conducted by the Ward method of minimum variance (Marek 1988), using the Statistica 5.0 software package. The results obtained are presented in the graphic form of a dendrogram.

To increase the readability of graphs, some of them are presented in the form of a logarithmic function.

The collected cartographic data were used to draw up an analysis of the contemporary distribution of kenophytes in Poland and of the typology of their ranges (Chapter 6). The maps have been obtained by superimposing individual distribution maps on one another. On the basis of distribution maps for 174 kenophytes the species have been grouped according to the type of distribution in Poland. Comprehensive maps illustrating the distribution of groups of species (Chapters 6, 9 and 10) were drawn using the options of RAR software (cf. Chapter 4.4). In each basic cartogramme unit, an average number of species from distinguished group occurring there was calculated. The density of species in a cartogramme field is represented by the size of symbol used. Diameter of each circle reflects the number of species in a given cartogramme unit. The smallest point corresponds to 1 species in a square (e.g. Figures 25–36 were obtained when the second root of the diameter is taken as the measure of the number of species).

For the selected group of 25 species differing with respect to origin, biology and the represented type of spread within Poland, the histories of their expansion within Poland were reconstructed and presented in cartogrammes drawn for the consecutive time periods (Chapter 7):

1. prior to 1850
2. between 1851 and 1900
3. between 1901 and 1950
4. between 1951 and 2003.

PART THREE

Analysis and synthesis of data

5. Geographical and ecological characteristics of the flora of kenophytes in Poland

5.1. Proportion of kenophytes in the recent flora

5.1.1. General remarks

In the flora of Poland which now includes 3 554 taxa, 1 017 species of alien origin have been noted to date, amounting to 29% of its composition (Table 3; Fig. 3). Among the alien species, the following categories are distinguished: **archaeophytes**, or older newcomers (they constitute *ca.* 16% of all alien species and 4.5% of the entire flora) and more recent newcomers (79.7%), further divided into **kenophytes** – plants which are permanently established (29.5% of alien species and 8.4% of the entire flora respectively) and **diaphytes**, i.e. species not yet established (50.2% of alien species and 14.4% of the entire flora) (Fig. 3). The subject of this

Table 3. Composition of the vascular flora of Poland

Group of species	Number of species compiled from Mirek *et al.* 2002 and present author's sources
Native species	2537[1]
Alien species	1017
Diaphytes	511
Established aliens	460
archaeophytes	160
kenophytes	**300**
Species of uncertain status	46
Total	3554

[1] According to Mirek *et al.* 2000 and own sources. Among all taxa extinct species and probably extinct species are included. Several hundred ornamental and useful plants (trees, shrubs and perennials) frequently cultivated in Poland and listing in the critical checklist of vascular plants of Poland are excluded here.

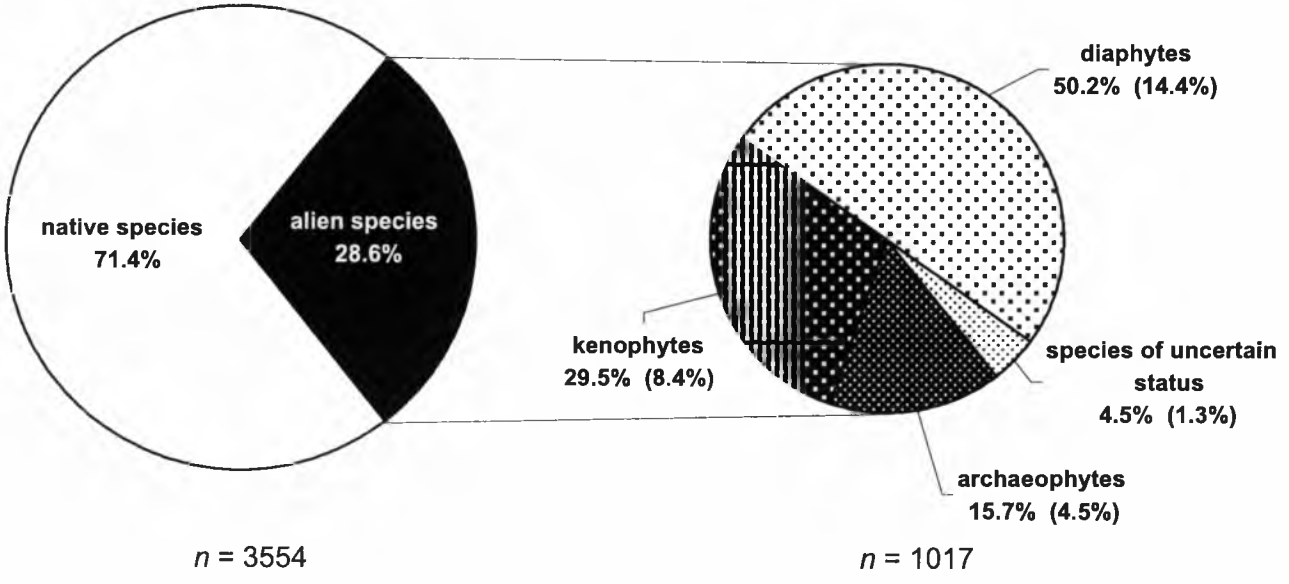


Fig. 3. Participation of alien species in the flora of Poland and composition of Polish alien flora

monograph is a group of 300 kenophytes including 9 taxa of subspecies rank, 2 varieties and 25 of hybrid origin (Appendices A and B).

5.1.2. Origin

The kenophytes occurring in Poland originate from five continents (Fig. 4). The majority of species came from different regions of Europe, including those from Southern Europe (Mediterranean or Sub-Mediterranean), from the south-eastern part of Europe, as well as species whose natural distribution ranges are limited to central regions of Europe, particularly the Alps (Fig. 4 & 5). An identifiable group among the more recent newcomers is one of those North American species which originate from areas with climatic conditions evidently close to conditions prevailing in Europe (Fig. 4).

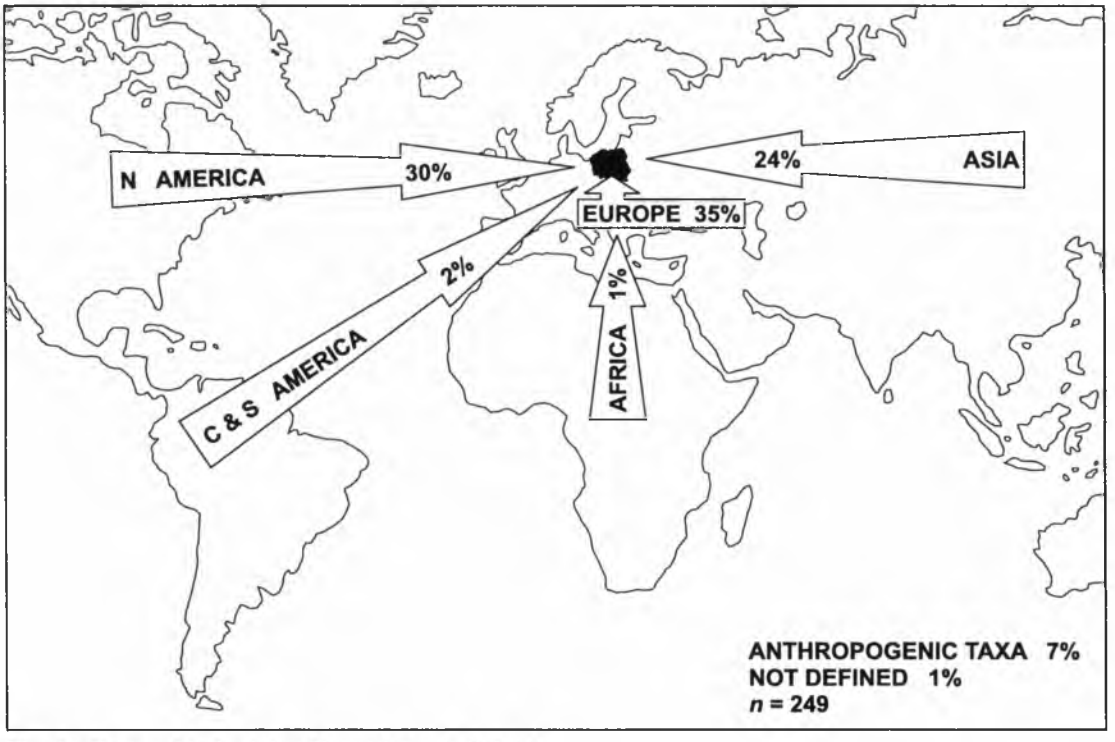


Fig. 4. Geographical origin of kenophytes in Poland

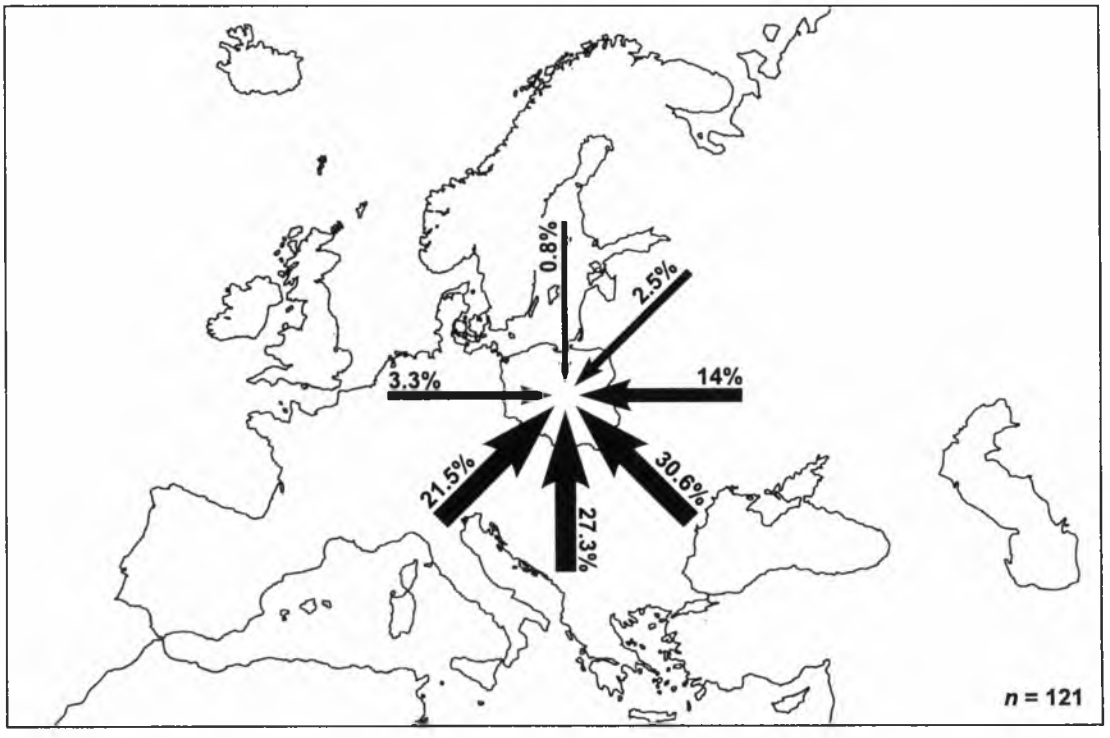


Fig. 5. Direction of origin of European elements in the kenophyte flora of Poland

Kenophytes coming from western and south-western Asia also have a relatively large share of the present flora of Poland.

In the group of 300 kenophytes covered in the present study, 25 taxa (8%) are species of hybrid origin. These are the hybrids which emerged spontaneously or which owed their existence to humans (i.e. cultivated species now growing in the wild). Particularly worthy of attention are 10 taxa of hybrid origin within the genus *Oenothera*, whose representatives sometimes form "swarms of hybrids" (Rostański & Szotkowski 1973).

5.1.3. Timing and method of arrival

The kenophytes reached Poland in different historic periods, beginning from the end of the 15th century; the older arrivals in this group have reached an advanced "age" of 400 years: albeit their number is few. Most of the kenophytes supplemented the flora of Poland in the 19th century (Fig. 6), either introduced intentionally or brought in accidentally.

5.1.4. Systematic groups

The kenophytes occurring in Poland are from 61 families (out of a total number of 188 families in the native flora), and from 169 genera. The majority of the taxa comprise a small number of species, namely: 110 genera with a single species, 33 with two, 13 with three; these groups combined constitute 92% of the genera described. At the other extreme, the genera with the greatest number of species are: *Oenothera* – 22, *Rosa* – 11, *Populus* and *Rubus* – 6 species each, *Amaranthus*, *Aster* and *Chenopodium* – 5 species each, and *Atriplex*, *Brassica*, *Bromus*, *Geranium*, *Mentha* and *Veronica* – 4 species each.

It has been found that in the flora of Poland, the most species-rich families are the same families which show high proportions of kenophytes, namely: Asteraceae – 46 species, Rosaceae – 37, Onagraceae – 23, Brassicaceae – 19, Fabaceae and Poaceae – 14 each (Table 4; Fig. 7 & 8). The most species-rich family – Asteraceae – includes, apart from kenophytes, equally numerous archaeophytes and ephemerophytes (Fig. 8 & 9). The families of Fabaceae,

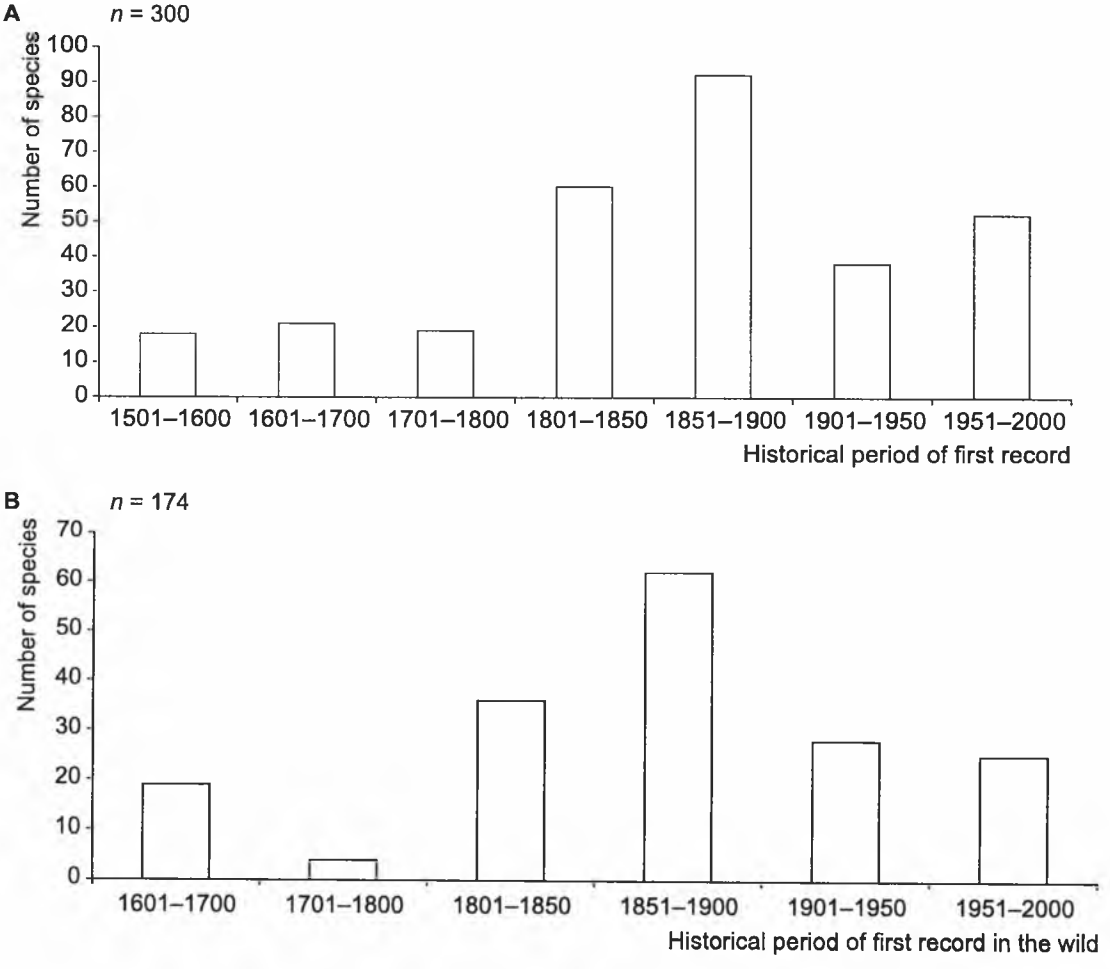


Fig. 6. Recording history of kenophytes in Poland:
A – data of first record from cultivation or from the wild have been taken into account,
B – exclusively data of first record from the wild have been taken into account

Table 4. Families which are richest in genera and species in the kenophyte flora

Family	Number of genus	[%]	Number of species	[%]
Asteraceae	27	16.0	46	5.3
Rosaceae	15	8.9	37	2.3
Brassicaceae	11	6.5	19	6.3
Fabaceae	11	6.5	14	4.7
Poaceae	9	5.3	14	4.7
Chenopodiaceae	5	3.0	13	4.3
Scrophulariaceae	5	3.0	9	3.0
Lamiaceae	5	3.0	8	2.7
Onagraceae	2	1.2	23	7.7
Salicaceae	2	1.2	9	3.0

Lamiaceae, Onagraceae, Polygonaceae, Amaranthaceae and Poaceae, Brassicaceae, Chenopodiaceae and Solanaceae, must evidently be deemed "synanthropic" with high percentages of species of alien origin and high proportions of kenophytes among them (Fig. 8 & 9). On the other hand, native species prevail in such families as Rosaceae and Cyperaceae and account for all species representing the family of Orchidaceae (53 species). Furthermore, all the species belonging to family Amaranthaceae in Poland are of alien origin (Fig. 8).

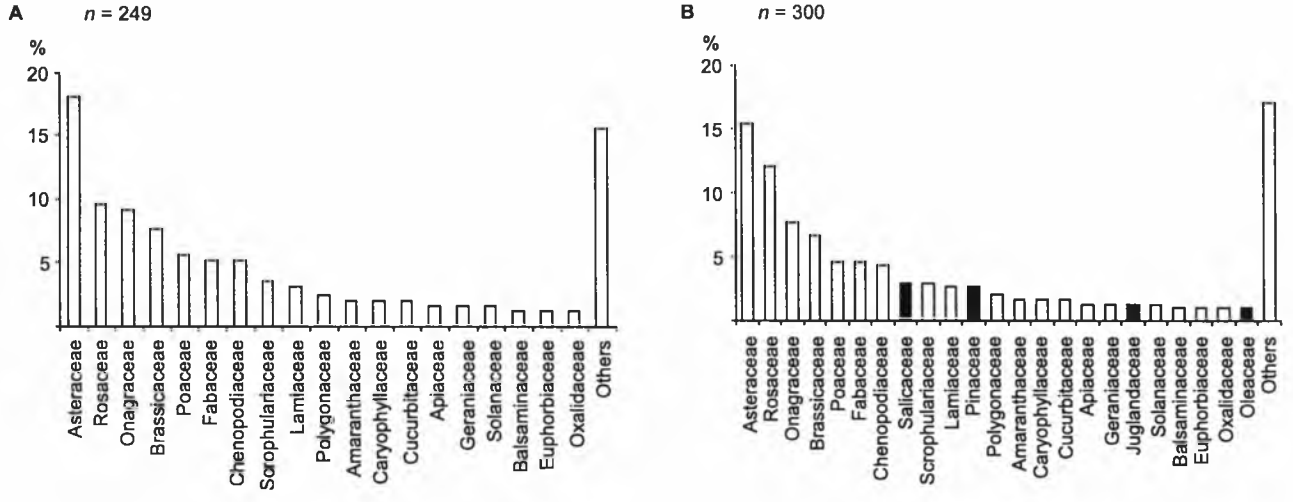


Fig. 7. The families most frequently represented in the kenophyte flora:
A – spectrum for permanently established species, B – spectrum including locally established species (Appendix A & B). Families shown in black differ between figures A & B

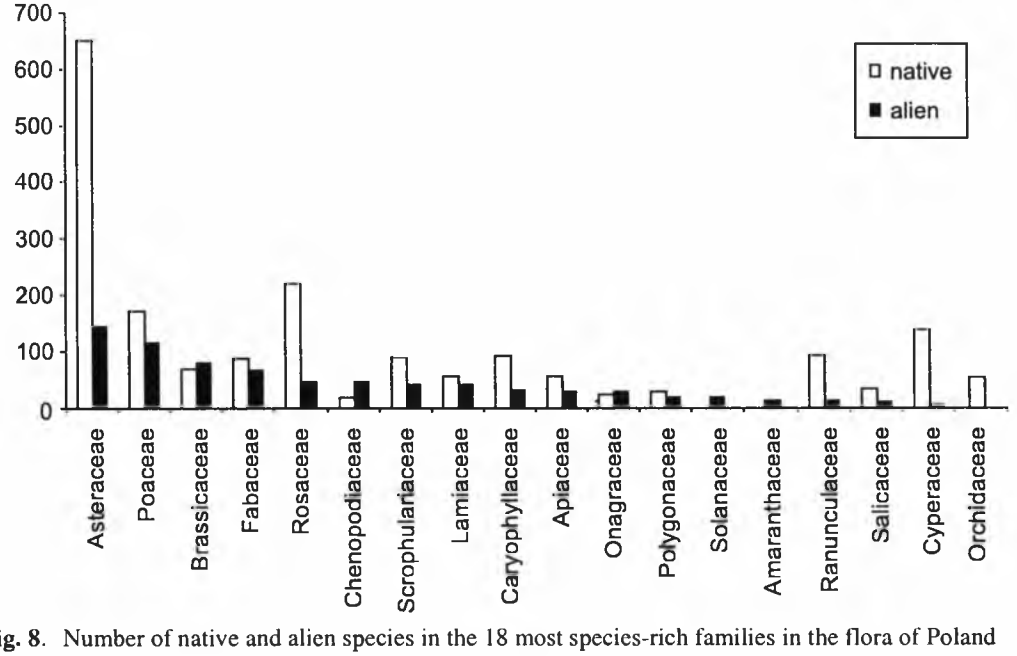


Fig. 8. Number of native and alien species in the 18 most species-rich families in the flora of Poland
Number of species for the Polish flora according to MIREK *et al.* 2002

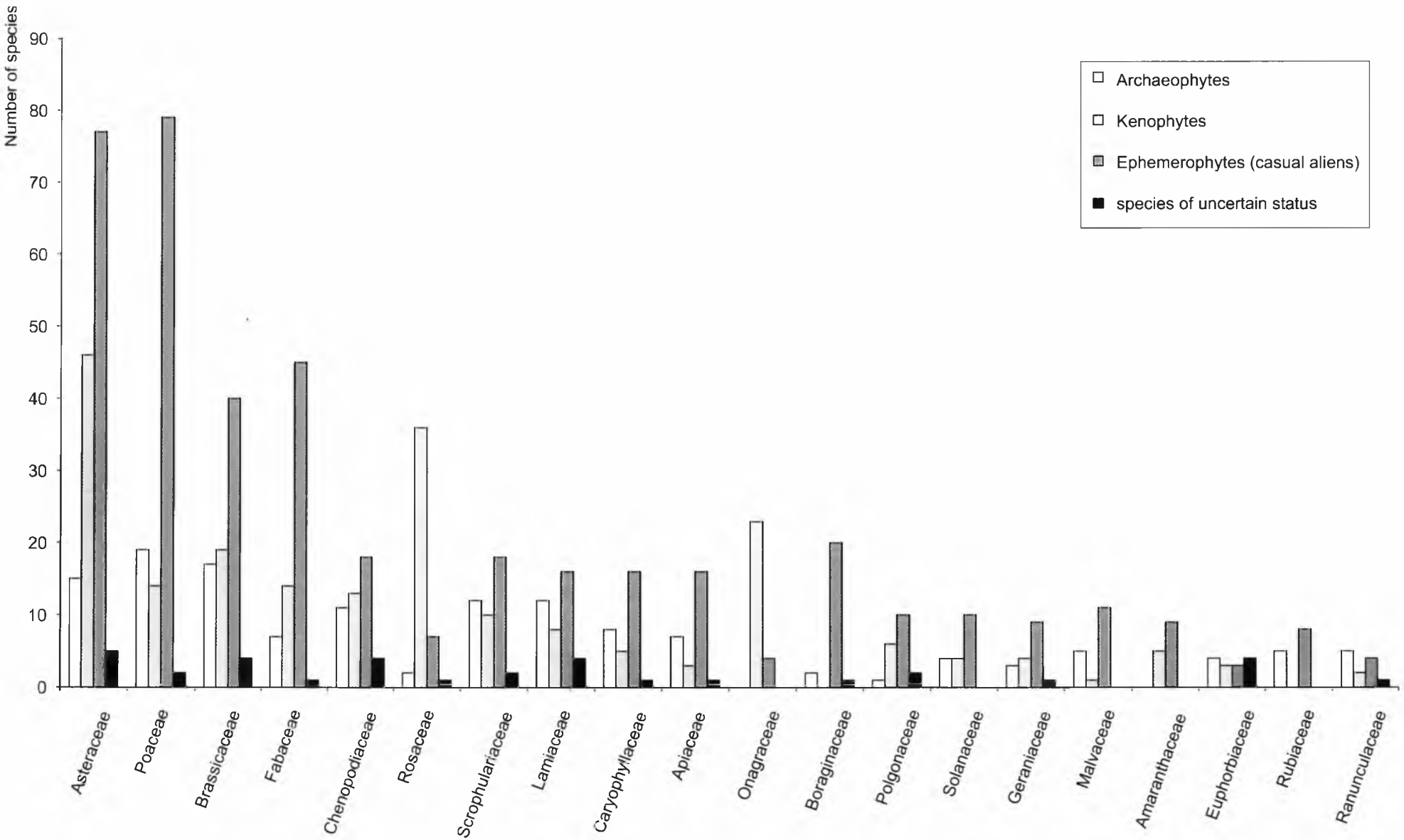


Fig 9. Number of alien species in the 20 most species-rich families in the flora of Poland
Number of species for the Polish alien flora according to MIREK *et al.* 2002 and present author's sources

5.1.5. Groups of life forms

Among the kenophytes studied, hemicryptophytes and therophytes predominate (Fig. 10). The relatively high proportion of woody plants among the kenophytes results from the inclusion within this group of the species listed in Appendix B (relatively often cultivated plants, returning to the "wild" or locally established). Interesting conclusions can be drawn from the analysis of the spectrum of life forms, considered in groups based on different historical and geographical aspects, viewed with respect to the whole flora of Poland. Therophytes are either the dominating or co-dominating life form among the anthropophytes. They constitute nearly 70% of all archaeophytes occurring in Poland, 60% of ephemerophytes, and more than 25% of kenophytes, while in the native flora they account for some 8%. Hemicryptophytes which predominate in the native flora (over 60%) also occur in a high proportion among anthropophytes and constitute *ca.* 30% of kenophytes and ephemerophytes, and more than 20% of archaeophytes. To summarize, the similarities in the patterns of frequencies of various life forms among all groups of anthropophytes should be emphasised and the difference in this respect from the native flora (Fig. 10) should be marked.

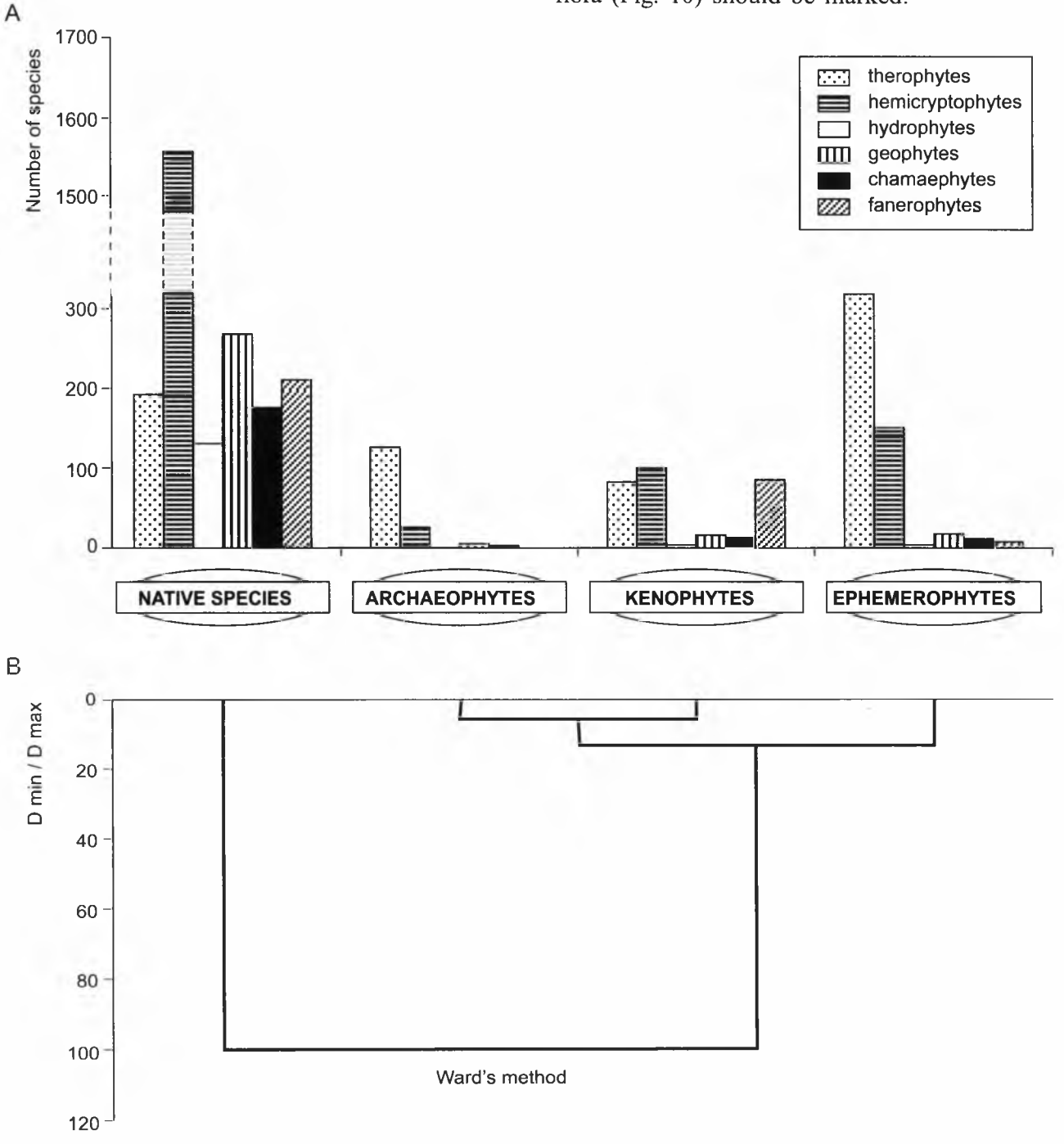


Fig. 10. A comparison of the participation of life-forms in the native and alien flora of Poland (**A**) and the similarity between floras (determined through cluster analysis conducted by the Ward method of minimum variance) (**B**)

5.1.6. Biological properties

The kenophytes occurring in Poland are mostly pollinated by insects, wind or are self-pollinating plants (Fig. 11). The proportions of apomictic plants are fairly low.

Among kenophytes occurring in Poland, the majority of species reproduce by generative processes, and some species also use various kinds of vegetative reproduction (Fig. 12). Seven species of kenophytes solely use the latter method: the aquatic plant *Elodea canadensis* and a rush-community species *Acorus calamus* (fragments of plants are carried by water or birds), and poplars[22] (which produce suckers; their breaking branches are also capable of taking root). The vegetative manner of reproduction is of essential importance

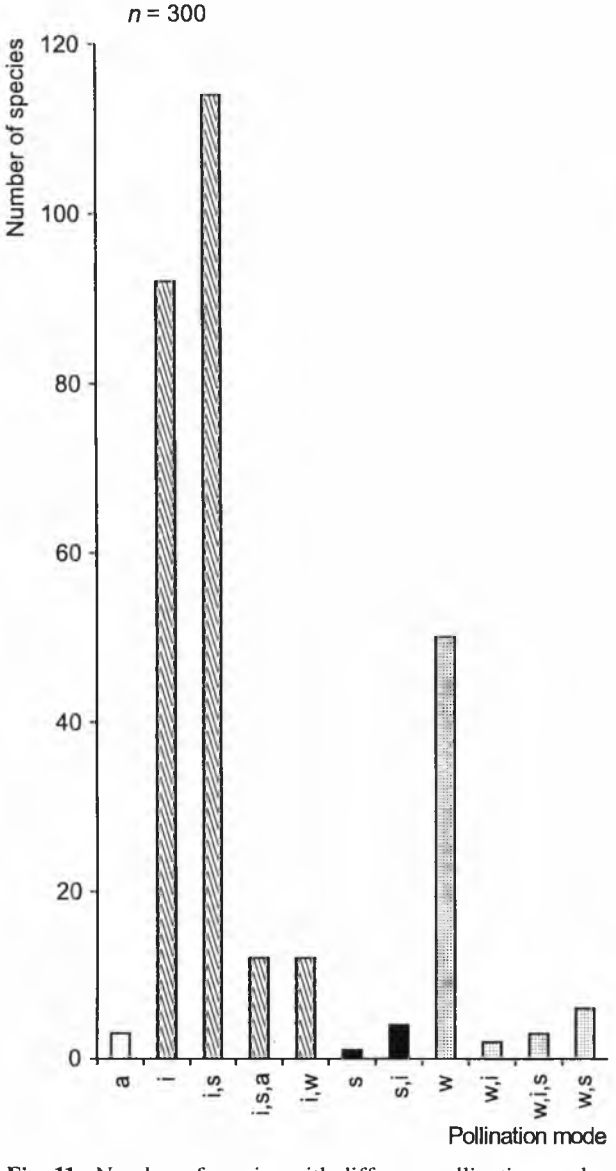


Fig. 11. Number of species with different pollination modes in the Polish kenophyte flora:
a – apogamic, **i** – insects, **s** – self-pollination, **w** – wind

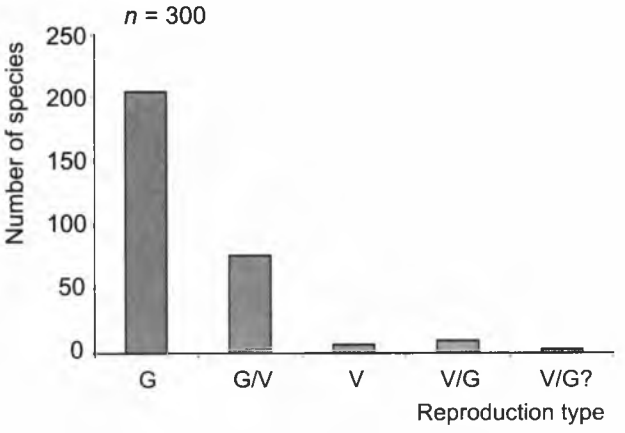


Fig. 12. Number of species with different reproduction types in the Polish kenophyte flora:
G – generative; **V** – vegetative

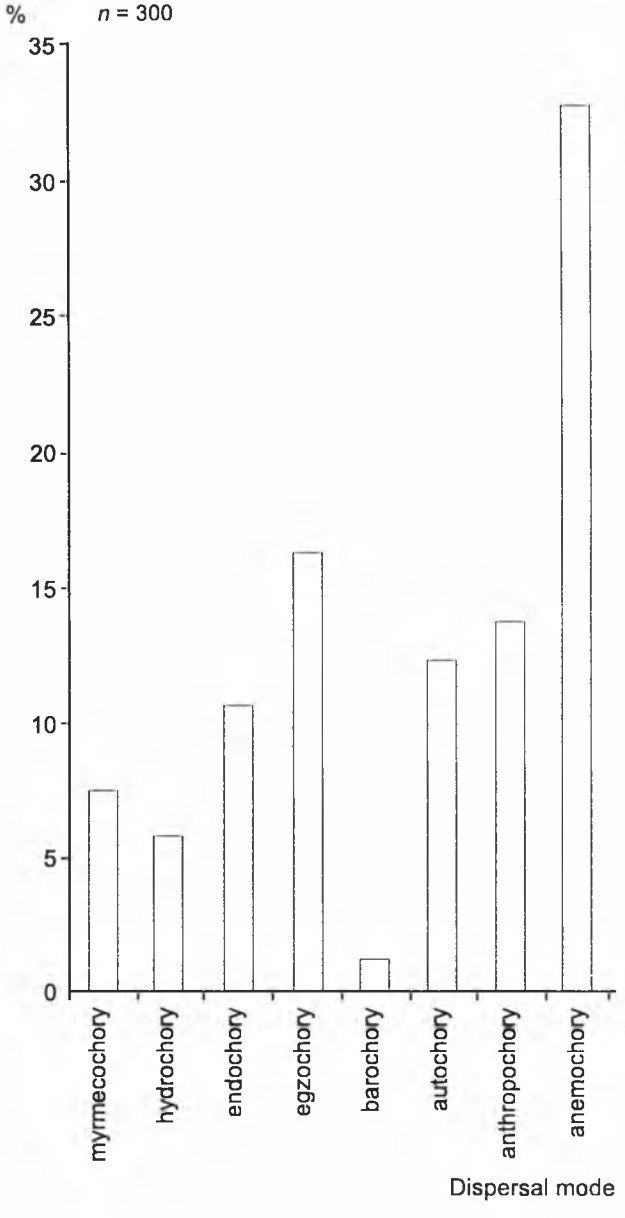


Fig. 13. Participation of species with different seed dispersal modes in the Polish kenophyte flora

[22] Poplars are dioecious trees with flowers of either sex. Although the seeds are viable only for a short time, they can germinate in an equally short time. The male clones are planted much more often than the female clones, because the latter produce enormous quantities of seeds with cottony tufts.

also in the expansion of the perennial plants of the genus *Reynoutria* (knotweed) and the species *Asclepias syriaca* and *Artemisia austriaca*.

In the spreading of this group of species, anemochory is of prime importance, with the latter reflecting the role of animals and humans in their migrations (Fig. 13).

Among the kenophytes, the species in which great competitive potential (type *C* life strategy) predominates have adapted to the circumstances where the impact of stress is low, and the competitiveness is limited by disturbances (type *C-R* strategy) and mobile pioneer species (type *R*) (Fig. 14).

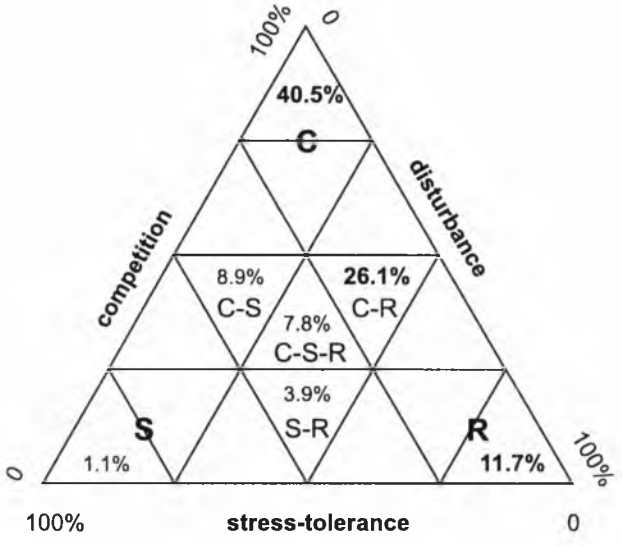


Fig. 14. Percentage of species showing particular life strategies (GRIME 1979) in the Polish kenophyte flora (n = 180):
C – the competitive strategy, R – the ruderal strategy, S – the stress-tolerant strategy

5.1.7. Frequency and status in the flora

Frequency analysis for the occurrence of kenophytes was undertaken for a group of 174 species for which representative data was obtained for the whole of Poland (cf. Chapter 4). The allocation of species to frequency classes was based on both the number of cartogramme squares where they appear and the number of recorded stations.

In the first case, the species recorded in less than 10% of the total number of ATPOL squares are the most numerous, whereas the species recorded in more than 60% to 100% of squares (i.e. on a large scale, or the whole of Poland) are least numerous (Fig. 15A).

However, frequency analysis based on the number of stations points to a significant proportion of frequently occurring (or even locally common)

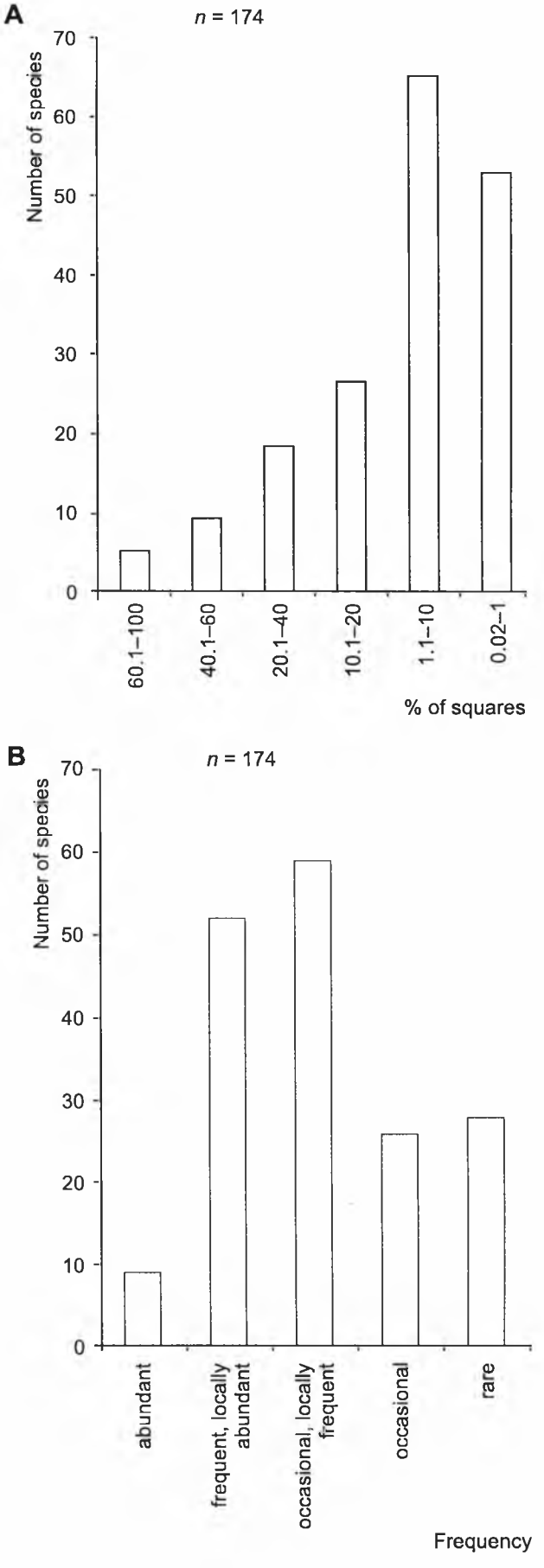


Fig. 15. Frequency distribution of kenophytes:
A – in relation to the number of ATPOL squares, B – in relation to the number of stations. Scale of frequencies: 1–14 stations – rare, 15–50 stations – occasional, 51–500 stations – occasional, locally frequent, 501–6000 stations – frequent, locally abundant, > 6000 stations – abundant (common)

kenophytes, whereas the groups of scattered or rare kenophytes are smaller (Fig. 15B).

The scales adopted permit the determination of the list of the abundant kenophytes (common), both with respect to the type of distribution in Poland, as well as, indirectly, to the numbers of population (Table 5). It was found that among the most common species are those which were accidentally transported from both the Americas and Asia and which established themselves in anthropogenic habitats. They are: *Chamomilla suaveolens* and *Conyza canadensis*,

Table 5. List of the abundant and most frequent kenophytes in Poland according to the number of 100 km square records and number of localities

I	Species	No of squares	[%]	No of localities up to year 2000	II	Origin	Way of introduction	Habitats
1	*Chamomilla suaveolens*	2 965	81.3	13 125	1	Am N & Asia E	UI	H
2	*Conyza canadensis*	2 929	80.3	11 600	2	Am N	UI	H
3	*Galinsoga parviflora*	2 726	74.8	10 932	3	Am S & C	UI/I	H
4	*Amaranthus retroflexus*	2 379	65.2	7 651	6	Am N & Am C	I/UI	H
5	*Veronica persica*	2 204	60.4	7 887	5	Asia SW	UI	H
6	*Oxalis fontana*	2 141	58.7	8 806	4	Am N, Asia E ?	UI	H
7	*Galinsoga ciliata*	2 021	55.4	6 777	8	Am C, Am S ?	UI/I	H
8	*Acorus calamus*	1 999	54.8	4 319	13	Asia C & S	I/UI	NS
9	*Robinia pseudoacacia*	1 957	53.7	7 067	7	Am N	I	NSH
10	*Senecio vernalis*	1 948	53.4	3 932	14	Eur SE & Asia W	UI	H
11	*Elodea canadensis*	1 847	50.7	3 681	15	Am N	UI/I	NSH
12	*Medicago sativa*	1 743	47.8	5 412	10	Asia SW	I	SH
13	*Impatiens parviflora*	1 681	46.1	6 730	9	Asia C & E	I	NSH
14	*Solidago gigantea*	1 668	45.7	5 348	11	Am N	I	NSH
15	*Juncus tenuis*	1 440	39.5	5 332	12	Am N	UI	SH
16	*Lupinus polyphyllus*	1 387	38.0	2 674	22	Am N	I	NSH
17	*Acer negundo*	1 379	37.8	3 523	17	Am N	I	NSH
18	*Solidago canadensis*	1 254	34.4	3 434	18	Am N	I	NSH
19	*Lycium barbarum*	1 224	33.7	2 634	23	Asia E Eur SE	I	NSH
20	*Lolium multiflorum*	1 174	32.2	2 792	21	Eur S & W, Afr N & Asia SW	I	SH
21	*Reynoutria japonica*	1 158*	31.8	3 004	20	Asia E	I	NSH
22	*Erigeron annuus*	1 133	31.1	3 557	16	Am N	I	SH
23	*Padus serotina*	1 134	31.1	2 564	24	Am N & Am S	I	NS
24	*Bidens frondosa*	1 068	29.3	3 142	19	Am N	UI/I	NSH
25	*Datura stramonium*	1 044	28.6	1 881	29	Am N, Asia?	I	H
26	*Diplotaxis muralis*	991	27.2	2 049	27	Eur S & W [Afr.]	UI	H
27	*Sisymbrium loeselii*	976	26.8	2 326	25	Eur SE & Asia C	UI	H
28	*Rudbeckia laciniata*	903	24.8	2 251	26	Am N	I	NSH
29	*Sisymbrium altissimum*	812	22.3	1 770	30	Eur SE & Asia C	UI	H
30	*Elsholtzia ciliata*	814	22.3	1 352	37	Asia E	I	H
31	*Helianthus tuberosus*	778	21.3	1 416	34	Am N	I	NSH
32	*Tanacetum parthenium*	734	20.1	1 179	43	Eur SE & Asia SW	I	H
33	*Bryonia alba*	728	20.0	1 328	38	Eur E & Asia W	I	NSH
34	*Lepidium densiflorum*	724	20.0	1 259	48	Am N	UI	H
35	*Sinapis alba*	716	19.6	1 416	35	Eur S	I	H
36	*Xanthium strumarium*	712	19.5	1 105	47	Eur/Am N ?	UI	H
37	*Echinocystis lobata*	708	19.4	2 047	28	Am N	I	NSH
38	*Rosa rugosa*	701*	19.2	1 299	40	Asia E	I	NSH
39	*Impatiens glandulifera*	675	18.5	1 574	32	Asia C	I	NSH
40	*Rumex confertus*	673	18.5	1 731	31	Eur SE & Asia W	UI	SH

Total number of squares in Poland = 3646

I – 40 most frequent kenophytes according to the number of recorded squares;

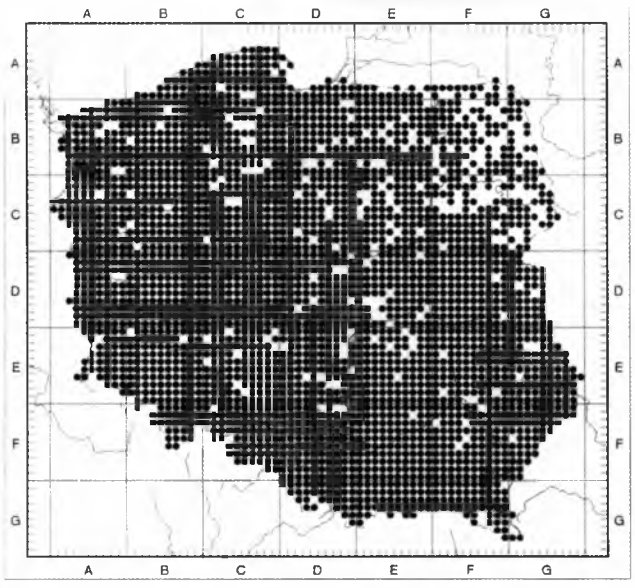
II – position of kenophytes according to the number of recorded localities:

red shading – 10 most frequent species: position 1–10;

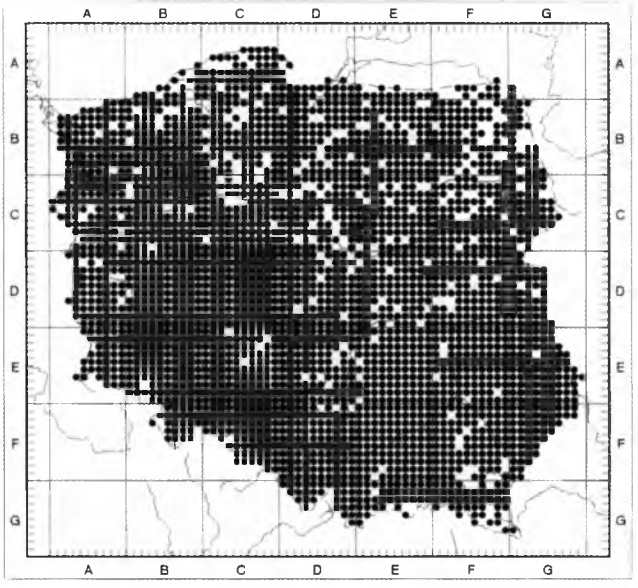
dark yellow shading – following 10 species: position 11–20;

light yellow shading – following 10 species: position 21–30

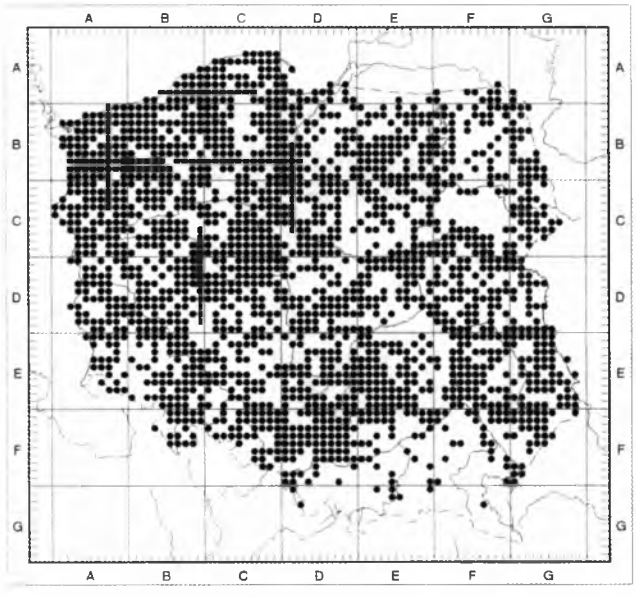
Abbreviations: I – intentionally, UI – unintentionally, H – human-made habitats (anthropogenic), S – seminatural habitats, N – natural habitats, * – indicates that number of squares recorded need to be verified.



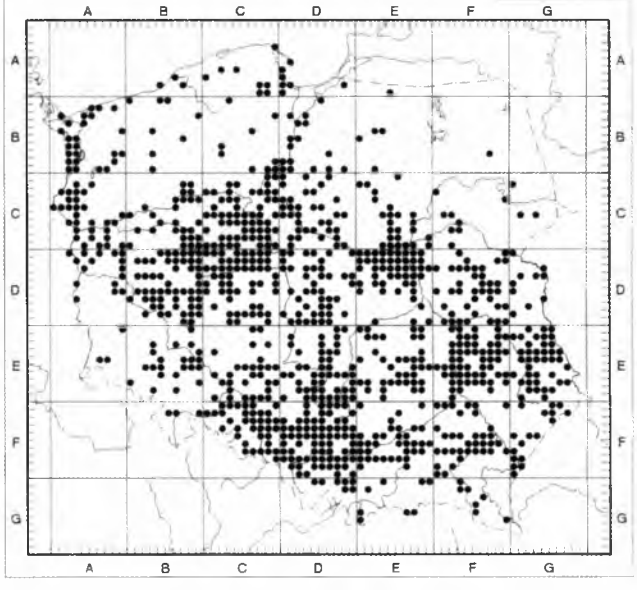
Chamomilla suaveolens (PURSH) RYDB.



Conyza canadesis (L.) CRONQUIST



Senecio vernalis WALDST. & KIT.

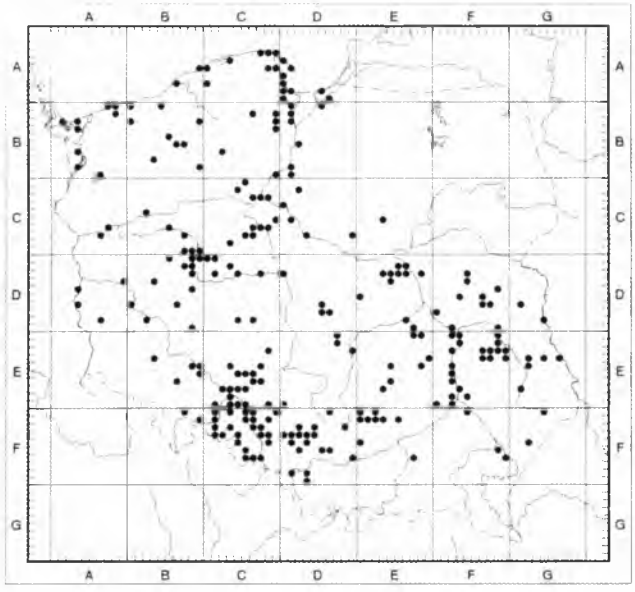


Sisymbrium loeselii L.

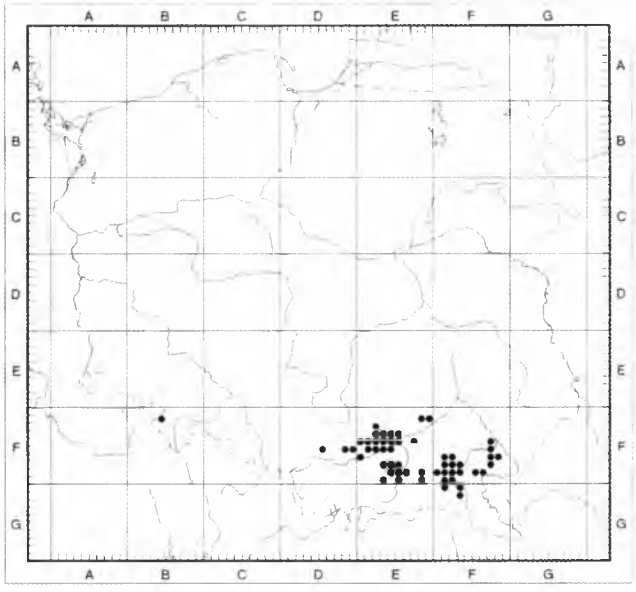
Fig. 16. Examples of kenophytes showing different degrees of abundance in the Polish flora: abundant and frequent species (after ZAJĄC A. & ZAJĄC M. 2001, supplemented)

recorded in over 80% of cartogramme squares, and *Galinsoga parviflora*, *Amaranthus retroflexus* and *Veronica persica*, recorded in 60–80% of ATPOL squares. Among Polish kenophytes these are also the species for which the highest numbers of stations have been recorded to date. The most frequently occurring species, which are even common in many areas include, among others: *Robinia pseudoacacia*, *Senecio vernalis*, *Solidago gigantea* or *Sisymbrium loeselii* (Fig. 16). Sparsely distributed but locally frequent species include for example: *Ambrosia artemisiifolia*, *Centaurea diffusa*, *Diplotaxis tenuifolia* and *Trifolium patens*, whereas examples of sparsely distributed to rare species might include: *Corydalis lutea*, *Oxalis dillenii*, *Mimulus moschatus* and *Impatiens capensis* (Fig. 17) (although on a local scale the last species may be included within the category of "frequent").

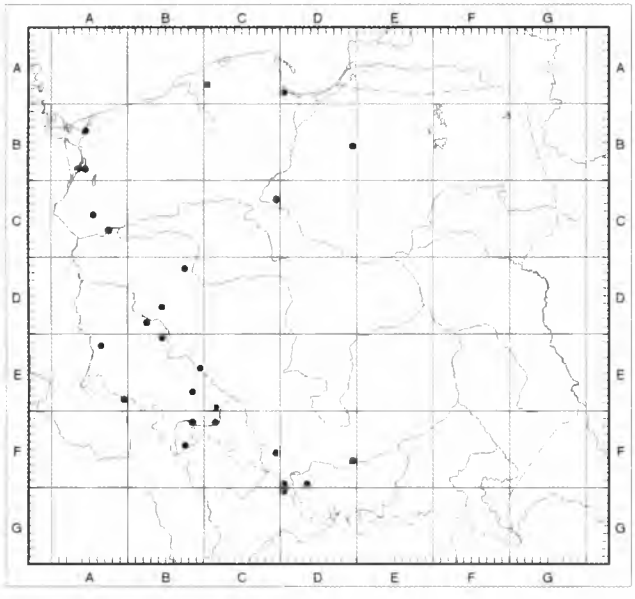
Analysing the types of habitats colonised by all the kenophytes included in the study, it should be noted that almost half of them limit their occurrence to anthropogenic habitats (Fig. 18). Most often, these are species that were accidentally introduced. The species capable of concurrent colonisation of natural and semi-natural habitats are relatively frequent and within this group the species intentionally introduced by humans predominate (Fig. 19). Least numerous are the species which established themselves in natural and semi-natural communities, by-passing the stage of colonising anthropogenic habitats (e.g. *Genistella sagittalis*, *Impatiens capensis*, *Lemna turionifera*, *Mimulus guttatus*).



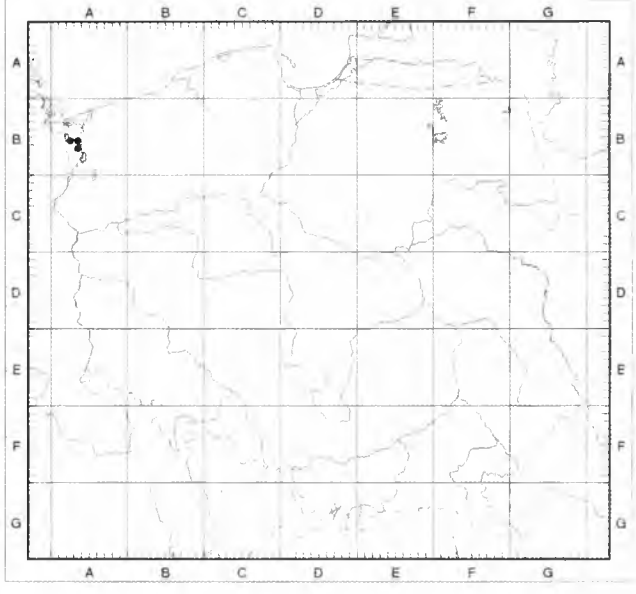
Diplotaxis tenuifolia (L.) DC.



Trifolium patens SCHREB.



Corydalis lutea (L.) DC.



Impatiens capensis MEERB.

Fig. 17. Examples of kenophytes showing different degrees of abundance in the Polish flora: occasional and rare species (*Diplotaxis tenuifolia*, *Trifolium patens* and *Corydalis lutea* after TOKARSKA-GUZIK 2001b; *Impatiens capensis* after ZAJĄC A. & ZAJĄC M. 2001)

When the types of colonised habitats are considered together with the manner in which they were introduced into Poland, one may draw the conclusion that the species introduced intentionally by humans show a tendency to colonise natural and semi-natural habitats, whereas those brought in unintentionally occupy anthropogenic habitats before any other. It seems that an explanation should be sought in the capacity of a species to adapt to the conditions faced in the new homeland. The species brought in on purpose by humans, remaining under cultivation for a long time, had the opportunity to develop ecotypes adapted to specific environmental conditions, and some of them were introduced directly into the "target" habitats, e.g. *Padus serotina* and *Quercus rubra* – to forests. On the other hand, the "success" of accidentally introduced species in anthropogenic habitats can be explained by some earlier adaptations (i.e. in their respective homelands) to live in transformed habitats: namely as a result of their apophytic potential[23] (cf. Chapter 12).

[23] Apophytism – the capacity of a species to migrate from its proper natural habitats to synanthropic communities developing in anthropogenic habitats. STARFINGER (1998) along with other authors is of the opinion, that the apophytism of a species within the limits of its natural range may be regarded as an indicator for its later success as an invasive species.

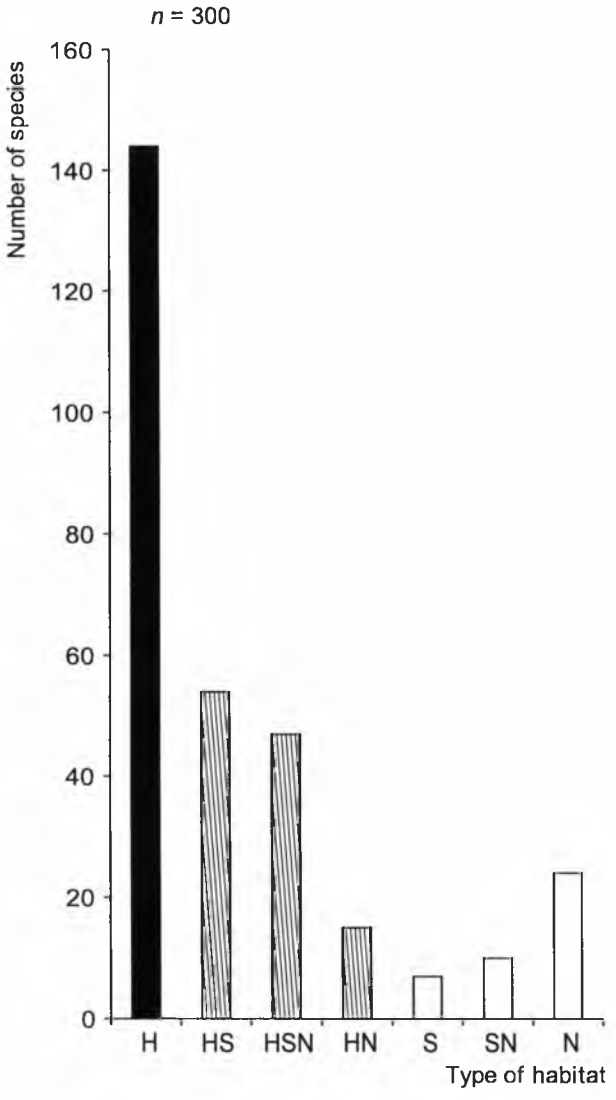


Fig. 18. Habitat preferences of kenophytes occurring in Poland:
H – human-made (anthropogenic), S – seminatural, N – natural

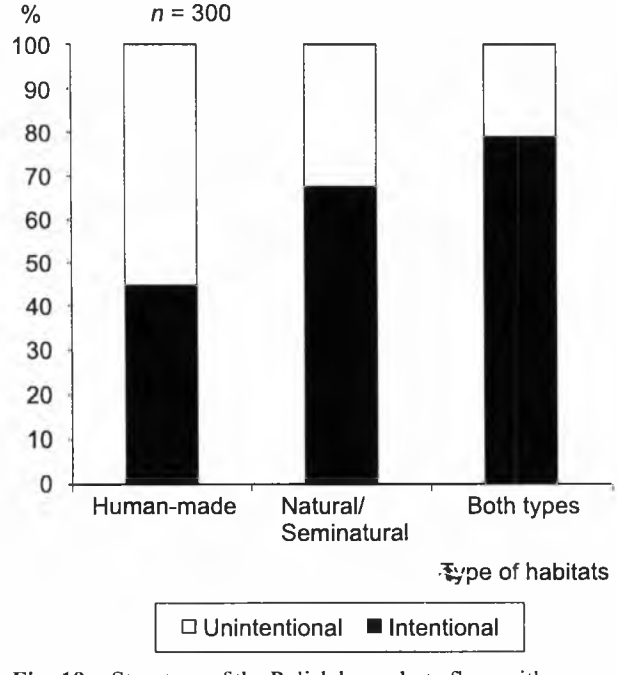


Fig. 19. Structure of the Polish kenophyte flora with respect to type of habitats and the presumed type of introduction into the country

5.2. Kenophytes in historical accounts of floras

5.2.1. "Old" floras

The available factual data in the form of historical floras from the 18th, 19th and 20th centuries together with preserved herbarium specimens allow only fragmentary reconstruction of the development of the flora with respect to the more recent newcomers into the present territory of Poland.

One of the oldest sources is the work by Syreński (Sirenius) (1613), who listed 16 species which are now regarded as relatively recent newcomers, as established in Poland: *Acorus calamus* (Sir. Vol. I/Chapter 3), *Chenopodium botrys* (Sir. Vol. III/Chapter 51), *Clematis vitalba* (Sir. Vol. I/Chapter 95 (2), *Datura stramonium* (Sir. Vol. V/Chapter 85), *Echinops sphaerocephalus* (Sir. Vol. III/Chapter 10), *Hesperis matronalis* (Sir. Vol. III/Chapter 65), *Hyssopus officinalis* (Sir. Vol. III/Chapter 23), *Inula helenium* (Sir. Vol. I/Chapter 16), *Lonicera caprifolium* (Sir. Vol. II/Chapter 94), *Lycopersicon esculentum* (Sir. Vol. V/Chapter 95), *Marrubium vulgare* (Sir. Vol. III/Chapter 25), *Physalis alkekengi* (Sir. Vol. III/Chapter 51), *Portulaca oleracea* (Sir. Vol. IV/Chapter 88), *Tanacetum parthenium* (Sir. Vol. III/Chapter 98), *Xanthium strumarium* (Sir. Vol. II/Chapter 78) and *Ambrosia artemisiifolia* (Sir. Vol. III/Chapter 50). The species mentioned above do not exhaust the list of alien plants included in the Sirenius work, but the remaining ones still require further studies in the fields of nomenclature and history.

Because of an almost complete absence of floristic data from the 17th century, and very scarce data from the 18th century, the reconstruction of historic floras of kenophytes is feasible but mostly only for the last 200–250 years.

The authors of old floras, studying different areas now falling within the borders of Poland, have listed a total number of 138 species out of the group of 300 species that have recently established themselves (Table 6; Fig. 20).

The flora published in the second half of the 18th century by Kluk (1786–1787–1788) included more than thirty kenophyte species. However, most of the species referred to in this work were either plants cultivated as medicinal plants, providing industrial raw materials, cultivated for food or fodder, or as decorative plants[24]. Only

[24] The *Dictionary* by Kluk (1786–1787–1788) included both native species: "proper native plants" ["proper native plants are only those which grow in any corner of our country, in the wild, unattended by humans"] ["rośliny właściwe kraiowe"] ["rośliny właściwe kraiowe są tylko te,

Table 6. Participation of kenophytes in the Floras of Poland and associated areas in different historical periods

Species	Syreński 1613	Kluk 1786–1788	Grabowski 1843	Waga 1847	Wimmer 1868	Rostafiński 1872	Fiek 1881	Knapp 1872	Berdau 1890	Abromeit *et al.* 1898–1940	Schube 1901–1930	Szafer *et al.* 1953
Acorus calamus	○	●	●	●	●	●	●	●	●	●		●
Datura stramonium	○	●	●	●	●	●	●	●	●	●	●	●
Portulaca oleracea subsp. *oleracea*	○	○●	○	○●	○●	●	●	□	●	●	●	●
Inula helenium	○	●	●		○●	●		●	●	●	●	●
Marrubium vulgare	○	○●	●		●	●	●	●	●	●	●	●
Mercurialis annua		●	●		●	●	●	●			●	●
Reseda luteola		○●	●	○	●	●	●			●	●	●
Ambrosia artemisiifolia	○	●								●	●	
Malva moschata		●					●			●	●	●
Picris echioides		●					●				●	●
Amaranthus retroflexus			●		●	●	●	●	●	●	●	●
Conyza canadensis			●		●	●	●	●	●	●	●	●
Senecio vernalis			●		●	●	●	●	●	●	●	●
Oxalis stricta			●		●	●	●	●	●	●	●	●
Veronica persica			●		●	●	●			●		●
Xanthium strumarium	○		●		●	●	●	●	●	●	●	●
Eragrostis minor			●			●	●				●	●
Cardaria draba			●		●		●	□	●	●	●	●
Geranium pyrenaicum			●		●	●	●	●		●	●	●
Chenopodium botrys	○		●	●	●	●	●	●			●	●
Geranium divaricatum			●		●		●	□			●	●
Sinapis alba		○	○●		○●	●	●			●	●	●
Bryonia alba		○	○		○	●	●	●	●	●	●	○●
Onobrychis viciifolia			○●			○●	●			●	●	○●
Medicago sativa			●		●	○●	●	○●	○●	●		○●
Atriplex hortensis		○		○●	○					○	○●	○●
Aster salignus			●		●							●
Helleborus viridis			●		●		●				●	○●
Salix acutifolia			●			●	○				○●	○
Syringa vulgaris		○	○	○	○●						○●	○
Sedum album		○			●		●	□	●		●	●
Lycium barbarum				○●		○●	○	○●				○●
Lolium multiflorum					●	○●	●				●	○●
Rudbeckia laciniata					○●	○●	●	●			●	○●
Xanthium spinosum					●	●	●	●	●	●	●	●
Cymbalaria muralis					●	●	●				●	●
Clematis vitalba	○	○				●	○●	□			●	●
Lathyrus nissolia					●						●	●
Ulex europaeus					●		●			●	●	○

←

które w któreykolwiek stronie kraju rosną same przez się dziko, bez ludzkiego pielęgnowania"], and "foreign plants, not known earlier" ["rośliny cudzoziemskie nieznaiome"]. The author gave the following description of this group: "Plants of three kinds of those earlier unknown to us will be described here, either those which could be kept in our country as useful plants, or plants whose parts could be used for meals, or as paints, medicines etc., or finally those which display extraordinarily curious aspects". ["Troiakie rośliny nieznaiome nam znajdą się tu opisane: albo takie, któreby pożyteczne w Kraiu utrzymywane być mogły: albo takie, których iakie części do stołu, lekarstw, farb, etc. zażywamy: albo nakoniec takie, które nadpospolitą osobliwość w sobie mają".].

Species	Syreński 1613	Kluk 1786–1788	Grabowski 1843	Waga 1847	Wimmer 1868	Rostafiński 1872	Fiek 1881	Knapp 1872	Berdau 1890	Abromeit *et al.* 1898–1940	Schube 1901–1930	Szafer *et al.* 1953
Galinsoga parviflora						●	●	●	●	●	●	●
Impatiens parviflora							●	●		●	●	●
Sisymbrium loeselii						●		●	●		●	●
Solidago canadensis						○●		●		●	●	●
Xanthium albinum						●	●			●	●	●
Bunias orientalis						●	●	□		●	●	●
Echinops sphaerocephalus	○					●	●	●			●	●
Erigeron annuus						●	●			●	●	●
Salsola kali subsp. *ruthenica*						●		●			●	
Helianthus tuberosus		○			○	○●	○●	○●			○●	○●
Hesperis matronalis subsp. *matronalis*	○	○				●	○	●	●		●	○●
Tanacetum parthenium	○		○			○●	●	●	●		●	○●
Brassica nigra					○	●				●	●	○●
Elsholtzia ciliata						●	○●	□			○●	●
Digitalis purpurea					○	○●	●	○●			●	○●
Diplotaxis tenuifolia						●	●			●	●	●
Calendula arvensis		○				●		●				●
Dianthus barbatus		○				○●	○●	□		●	○●	○●
Hyssopus officinalis	○	○				○●		□			●	○●
Artemisia austriaca						●		□				●
Asclepias syriaca						●						●
Lysimachia punctata						○●	●	●			●	○●
Petrorhagia saxifraga						●					●	●
Sicyos angulata						○●	●	○●			○●	○●
Chamomilla suaveolens							●				●	●
Elodea canadensis							●			●	●	●
Juncus tenuis							●			●	●	●
Solidago gigantea							●			●	●	●
Diplotaxis muralis							●	●		●	●	●
Aster novi-belgii							●			●	●	●
Medicago x *varia*							●	●		●	●	
Anthemis ruthenica							●				●	●
Atriplex tatarica							●			□	●	●
Brassica rapa subsp. *rapa*					○		●			●		
Geranium bohemicum							●	●	●			●
Geranium sibiricum							●					
Mentha rotundifolia							●					○●
Mimulus guttatus							●				●	●
Ornithogalum boucheanum							●				●	○●
Oxalis corniculata							●			●	●	●
Polycneum heuffelii							●					●
Rosa glauca							●			●	●	●
Rosa pimpinellifolia							●				●	●
Sedum spurium							●			●	●	○●
Silene conica							●			●	●	●

Species	Syreński 1613	Kluk 1786–1788	Grabowski 1843	Waga 1847	Wimmer 1868	Rostafiński 1872	Fiek 1881	Knapp 1872	Berdau 1890	Abromeit *et al.* 1898–1940	Schube 1901–1930	Szafer *et al.* 1953
Artemisia dracunculus	○	○				○		○●			●	
Bryonia dioica						○		●	●	○	●	○●
Amaranthus lividus								●				●
Sisymbrium altissimum									●	●	●	●
Vicia pannonica									●		●	●
Lupinus polyphyllus										●	●	○●
Aster novae-angliae										●		●
Aster tradescantii										●		●
Bromus japonicus										●		●
Bromus squarossus								□		●	●	●
Erucastrum gallicum										●	●	●
Silene dichotoma										●	●	●
Lonicera caprifolium	○	○			○					○●	○●	○●
Rubus odoratus										○●	○●	
Vitis vinifera		○					○			○●	○●	○
Cerasus mahaleb										○●	○●	○
Lonicera tatarica										○●	○●	○●
Myrrhis odorata			○		○			□			●	●
Galinsoga ciliata											●	●
Reynoutria japonica											●	○●
Anthoxanthum aristatum											●	●
Bidens frondosa											●	●
Lepidium densiflorum											●	●
Vicia grandiflora											●	●
Amaranthus albus											●	●
Artemisia annua											●	○●
Atriplex oblongifolia											●	●
Bidens connata											●	●
Centaurea diffusa											●	●
Erechtites hieracifolia											●	●
Euphorbia humifusa											●	●
Kochia scoparia								□			●	●
Lepidium virginicum											●	●
Physalis alkekengi	○							□			●	●
Potentilla intermedia											●	●
Reynoutria sachalinensis											●	○●
Sisyrinchium bermudiana											●	●
Lycopersicon esculentum	○	○		○							○●	○
Acer negundo											○●	○
Padus serotina										○		○●
Impatiens glandulifera											●	
Epilobium ciliatum												●
Erigeron ramosus												●
Rumex confertus												●
Alnus rugosa											○●	
Amelanchier spicata											○●	
Amorpha fruticosa											○●	

Species	Syreński 1613	Kluk 1786–1788	Grabowski 1843	Waga 1847	Wimmer 1868	Rostafiński 1872	Fiek 1881	Knapp 1872	Berdau 1890	Abromeit *et al.* 1898–1940	Schube 1901–1930	Szafer *et al.* 1953
Corydalis lutea											●	
Hordeum jubatum											●	
Mimulus moschatus											●	
Rosa rugosa											●	○●
Rudbeckia hirta											○●	○●
Sorbaria sorbifolia											○●	○●
Aster lanceolatus												●
Beckmannia eruciformis												●
Cuscuta campestris												●
Cuscuta trifolii												●
Erysimum marschallianum												●
Erysimum wahlenbergii												●
Genistella sagittalis												●
Linaria repens												●
Linum austriacum												●
Polycneum majus												●
Rumex longifolius												●
Solidago graminifolia												●
Trifolium patens												●
Vicia dasycarpa												●
Rumex patientia		○										○●
Amaranthus chlorostachys												○●
Cerasus vulgaris												○●
Elaeagnus angustifolia												○●
Malus domestica												○●
Mentha x niliaca												○●
Mentha spicata												○●
Pyrus communis												○●
Prunus domestica												○●
Ribes rubrum												○●
Robinia pseudoacacia		○				○	○			○	○	○
Aesculus hippocastanum		○	○	○		○				○		○
Quercus rubra												○
Juglans regia		○										○
Ailanthus altissima										○		○
Linum perenne												□
Oenothera glazioviana											□	
Parthenocissus inserta												○
Pinus banksiana												○
Pinus nigra												○
Pinus strobus												○
Rhus typhina												○
Rubus laciniatus											○	
Scutellaria altissima												□
Symphoricarpos albus												○

○ – cultivated plant; ○● – cultivated and escaping from cultivation / becoming wild; ● – occurs exclusively in the wild; □ – recorded in the flora of the region but outside the contemporary border of Poland;
without shading – species rare or occasional at the present time in Poland; yellow shading – species occasional to locally frequent at the present time; red shading – abundant species at the present time.

seven species: *Acorus calamus*, *Ambrosia artemisiifolia*, *Datura stramonium*, *Inula helenium*, *Malva moschata*, *Mercurialis annua* and *Picris echioides* were described by Kluk as those which occurred in the wild and were already established, while three more species: *Marrubium vulgare*, *Portulaca oleracea* and *Reseda luteola* – were described as plants which during his time were often either cultivated or returning to a wild state from cultivation.

The number of kenophyte species reported by particular authors, taking into account their increase in successive periods, depended first on the degree of knowledge about flora at that time as well as on the size of the described territory (Fig. 20 & 21). The species which are listed by all or by the majority of the historic authors quoted, are those oldest arrivals, which are now common throughout Poland (e.g. *Acorus calamus*, *Datura stramonium*), as well as the plant species which have been cultivated and have then often gone into a wild state (e.g. *Hysopus officinalis* and *Marrubium vulgare*).

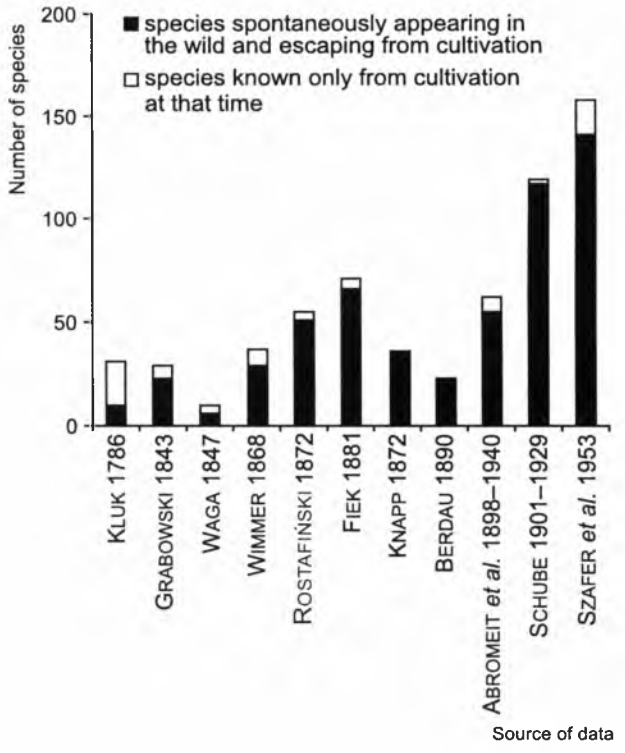


Fig. 20. Number of kenophytes recorded in historical floras of Poland and associated areas

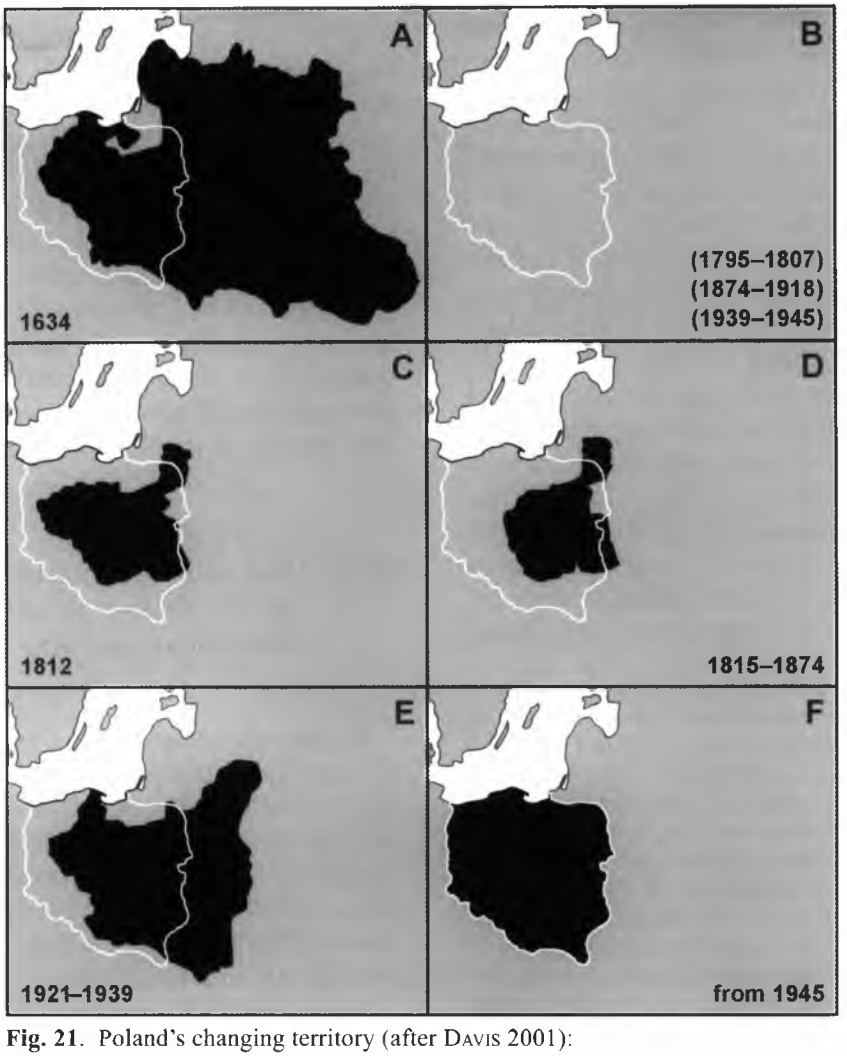


Fig. 21. Poland's changing territory (after DAVIS 2001):

A – Republic of Poland – Lithuania (990 000 km²), **B** – partition of Poland, **C** – Duchy of Warsaw (154 000 km²), **D** – Congress Kingdom of Poland (127 000 km²), **E** – Second Republic of Poland (389 720 km²), **F** – Republic of Poland (312 685 km²)

The Flora of the Congress Kingdom of Poland by WAGA (1847) reported 10 species of kenophytes (including 4 under cultivation), while *The Flora* published by ROSTAFIŃSKI (1872) listed as many as 55 such species, and the *Floras for Silesia and Pomerania* where records were systematically collected over long periods included 62 (ABROMEIT *et al.* 1898–1940), 71 (FIEK 1881) and 119 species (SCHUBE 1901 a, b–1930) (Table 6; Fig. 20). The guide *The Plants of Poland* [Rośliny polskie] published after World War II (SZAFER *et al.* 1953), with supplements covering those species of alien origin which the authors regarded as established and expanding their ranges in Poland, listed 141 species of kenophytes, plus 17 more species as cultivated plants which are now deemed to be established (locally at least).

5.2.2. The "oldest" arrivals among the kenophytes and the fairly recent ones

The compilation of the available historic data provides the source for a partial reconstruction of the historical floras of kenophytes, beginning from the 17th century (Table 7). Undoubtedly, such species as *Acorus calamus*, *Datura stramonium*, *Echinops sphaerocephalus*, *Marrubium vulgare*, *Sisymbrium loeselii* and *Tanacetum parthenium* were present in the 17th century flora of Poland.

Most of the species listed had been brought into Poland as useful plants (medicinal, food or fodder, decorative, honey-yielding or even poisonous)[25], perhaps much earlier than indicated by the first records. At the same time, the following species were recorded in Poland: *Ambrosia artemisiifolia*, *Artemisia dracunculus*, *Clematis vitalba*, *Chenopodium botrys*, *Hesperis matronalis*, *Hyssopus officinalis*, *Mercurialis annua* and *Portulaca oleracea,* again recorded primarily as cultivated plants or those returning to the wild state. Certain doubts can be raised with respect to *Diplotaxis tenuifolia* sporadically listed in the contemporary sources (cf. Appendix A). It is a plant long used in Europe as a vegetable (and still cultivated today), and perhaps at the time it was being referred to as a cultivated plant.

The subsequent centuries are characterised by a further increase in proportion of new arrivals in the flora of Poland. The first half of the 19th century was evidently marked by intensified inbound migration of alien species, although the highest "migration waves" were in the second half. Throughout the periods referred too, there is a remarkably high proportion of species of European origin (chiefly from the southern, south-eastern and south-western part of the continent) among the migrants. From the 16th century up to the first half of the 19th century, there was an evident predominance of species "flowing into" Poland from various regions of Europe and Asia. The first and second part of the 19th century showed a marked increase in the proportion of species originating from both Americas (but particularly North America) (Fig. 22; see p. 51). More recently, the proportion of taxa of hybrid origin, whose emergence has been assisted by humans either directly or indirectly, is on the increase in the flora of Poland.

In the analysis of life forms of kenophytes, made for subsequent historic periods, one should focus on the second parts of the 19th and 20th centuries, when kenophytes displayed the full spectrum of life forms (Fig. 23A & B; see p. 52). In the second part of the 19th century, therophytes predominated, as they were mostly brought in accidentally with dynamically developing transportation systems, while the second part of the 20th century (and particularly its last two decades) was the time when many new species were introduced into cultivation. This phenomenon reflected a growing human interest in new species of woody plants and perennials.

5.2.3. The most frequent kenophytes in the floras of subsequent historical periods

In the descriptions of the Polish flora up until the year 1850, the stations of 50 species of kenophytes had been recorded, although for most of the species these were the first stations (for 20 species) or species whose number of stations did not exceed 5 (another 20 species). Only 12 species had been recorded at between 5–11 stations prior to 1850 (Fig. 24; see p. 52).

In the next half-century, data on 3684 stations for 121 species were recorded. In the first half of the 20th century, more records were collected: 147 species at 9378 stations and 174 species at 196 910

[25] e.g. *Acorus calamus* – a medicinal plant ["the candied root fortifies the stomach against infections and 'bad' air" – KLUK 1786] ["korzeń smażony w cukrze na wzmocnienie żołądka, przeciwko zarażeniu i szkodliwemu powietrzu" – KLUK 1786], *Marrubium vulgare* – a medicinal plant also used as a spice, *Datura stramonium* – a poisonous plant ["careless ingestion causes loss of memory, mental confusion, indifference of senses, madness, [...] and a complete loss of the ability to perform in marital affairs" – KLUK 1786] ["nieostrożne zażycie przynosi utratę pamięci, pomieszanie rozumu, nieczułość zmysłów, szaleństwo [...] zupełną utratę sposobności do sprawy małżeńskiej" – KLUK 1786], *Echinops sphaerocephalus* – a melliferous plant sown by bee-keepers, *Tanacetum parthenium* – a decorative plant.

Table 7. Records of expansion of kenophytes in the historical floras of Poland and associated areas

Species	Introduction to Europe	First record for Central Europe	Introduction to Poland	First record for Poland	XVI	XVII	1/2 XVIII	2/2 XVIII	1/2 XIX	2/2 XIX	1/2 XX	2/2 XX
Chenopodium botrys		Ar		1613* 1829	?	•	?	?	..	.....	.....	.....
Hyssopus officinalis		*1594* 1819	XVII 1613*	1859	?	•	?	X	?	.....	.....	.....
Artemisia dracunculus		XVI Ar	XVI ?	1613* 1850	?	•	?	X	•	...	.....	.....
Ambrosia artemisiifolia		1863		1613* 1873	?	•	?	•	?	.....	.....	.....
Mercurialis annua		1767 Ar	XVI ?	XVIII 1825	?	?	?	•	•	.....	.....	.....
Portulaca oleracea		Ar		1613* 1837	?	•	?	•	..	.....	.....	----
Clematis vitalba	1663	1883	1613*	1847	?	•	?	X	•	.....	.....	----
Hesperis matronalis		XVI 1817	XVII 1613*	1837	?	•	?	X	•	.....	.....	::::::
Inula helenium		1819		1613* 1837	?	•	?	•	•	.....	----	::::::
Marrubium vulgare		Ar	XVI ?	1613* 1643	?	•	•	•	...	.....	.....	::::::
Diplotaxis tenuifolia		1597 Ar		1652 1836	?	•	•	•	•	.....	.....	::::::
Echinops sphaerocephalus		1613* 1809	XVI ?	1613* 1652	?	•	•	•	•	.....	.....	=====
Tanacetum parthenium		1561 Ar	XVI ?	1613* 1824	?	•	?	.....	•	.....	.....	=====
Xanthium strumarium		Ar		1613* 1837	?	•	?	?	•	.....	----	=====
Datura stramonium		1584	XVI ?	1613* 1652	?	•	•	...	..	.....	----	----
Sisymbrium loeselii		1654	XVI ?	1654	?	•	•	•	•	.....	.....	----
Acorus calamus	1557	1577	XVI	1613* 1652	?	•	•	...	...	.....	.....	----
Conyza canadensis		1646		1730 1825		?	•	•	...	.....	----	■■■■
Picris echioides		1836		XVIII 1836				•	•	•	.....	.....
Reseda luteola		Ar		XVIII 1825				•	..	.....	.....	.....
Malva moschata		Ar		XVIII 1885				•	•	.....	.....	.....
Geranium sibiricum		1840		1840					•	..	...	.....
Linaria repens		1825		1825					•	•	...	.....
Euphorbia humifusa		1813		1846					•	...	.....	.....
Helleborus viridis		XVIII 1819		1868					•	.....	.....	.....
Rubus armeniacus		XIX ?		1843					•	•	•	.....
Beckmannia eruciformis		1837		1837					•	..	...	.....
Geranium divaricatum		Ar		1840					..	.....	.....	.....
Bryonia dioica		1820 Ar		1847					•	..	.....	.....
Myrrhis odorata	XVI	1809		1837					•	...	.....	.....
Potentilla intermedia		*1652 ?* 1841		*1652 ?* 1841		?			•	.....	.....	----
Atriplex tatarica		1820 Ar		1847					•	.....	.....	----
Xanthium spinosum		1681		1849					•	.....	.....	----
Digitalis purpurea		1790		1809 1862					..	.....	.....	----
Cymbalaria muralis		1640 Ar ?		1837					•	.....	----	----
Mimulus guttatus		1824		1824					•	.....	----	----
Amaranthus lividus		Ar		1826				?	...	.....	.....	::::::

Species	Introduction to Europe	First record for Central Europe	Introduction to Poland	First record for Poland	XVI	XVII	1/2 XVIII	2/2 XVIII	1/2 XIX	2/2 XIX	1/2 XX	2/2 XX
Eragrostis minor		1819 Ar		1838					·	· · · · ·	· · · · · ·	= = = = =
Geranium pyrenaicum		1762		1837					·	· · · · · · · ·	▪ ▪ ▪ ▪	: : : : : : : :
Medicago x *varia*		XIX		1837					·	· · · · · · · ·	· · · · · ·	= = = = =
Onobrychis viciifolia	XVI	1837		1837					·	· · · · · · · · · ·	▪ ▪ ▪ ▪ ▪ ▪	= = = = =
Sinapis alba			XVII	1824				X	·	· · · · ·	· · · · · · · ·	═══
Bryonia alba		Ar	XVII	1824				X	· · ·	· · · · · ·	▪ ▪ ▪ ▪	═══
Helianthus tuberosus		1627		*1730 ?* 1872			?	X	·	· · ·	· · · · ·	═══
Elsholtzia ciliata		1847		*1829 ?* 1847					·	· · · · · · · ·	· · · · · · · · · ·	═══
Cardaria draba		*1652?* 1675 Ar		1837					·	· · · · · · · ·	▪ ▪ ▪ ▪	═══
Sisymbrium altissimum		1780		1843					·	· · · · ·	· · · · · · · ·	▬▬▬
Rudbeckia laciniata	1615	1787		1787					·	· · · · · · · ·	▪ ▪ ▪ ▪	▒▒▒▒
Erigeron annuus		1700		1830					·	· · · · · · · ·	· · · · · · · · · ·	▒▒▒▒
Lolium multiflorum		1837		1837					·	· · · · ·	· · · · ·	▒▒▒▒
Senecio vernalis		1726		1824				?	· · · · ·	· · · · · ·	▪ ▪ ▪ ▪	▒▒▒▒
Medicago sativa		XVI 1819		1832	?	?			· ·	· · · · ·	· · · · · ·	▒▒▒▒
Amaranthus retroflexus		1783		1801 1814					· · ·	· · · · · · · ·	▪ ▪ ▪ ▪ ▪ ▪	▬▬▬
Veronica persica		1809		1862					·	· · · · ·	· · · · · ·	▬▬▬
Oxalis fontana		1658		1809					· · ·	· · · · · ·	▪ ▪ ▪ ▪	▬▬▬
Galinsoga parviflora		1798		1807					·	· · · · · · · · · ·	▪ ▪ ▪ ▪ ▪ ▪	■■■■
Rubus odoratus	1635	1880	1806	1877				X		· ·	· · ·	· · · · ·
Asclepias syriaca	XVIII	1855		1872				?		· ·	· · ·	· · · · · · · ·
Sedum album			XVII	1868				X		· ·	· · · · ·	· · · · · · · ·
Lysimachia punctata		1819		1870					?	· · · · ·	· · · · ·	· · · · · · · ·
Oxalis corniculata		1576		1863					?	· · · · ·	· · · · · · · ·	· · · · · · · · · ·
Sicyos angulata		1868		1868					?	· · · · ·	· · · · ·	▪ ▪ ▪ ▪
Silene conica		1879		1879					?	· · · · ·	· · · · · · · ·	▪ ▪ ▪ ▪
Sedum spurium		1879		1880					?	· · · · ·	· · · · · · · ·	▪ ▪ ▪ ▪ ▪ ▪
Artemisia annua	1871	1881	1871	1881					?	· · · · ·	· · · · ·	▪ ▪ ▪ ▪ ▪ ▪ ▪ ▪
Anthemis ruthenica		1869		1869					?	· · · · ·	· · · · · · · ·	: : : : : : : :
Silene dichotoma		1841		1877					?	· · · · ·	▪ ▪ ▪ ▪ ▪ ▪	: : : : : : : :
Xanthium albinum		1822		1853					?	· · · · ·	· · · · · ·	= = = = =
Bunias orientalis		1856		1858					? ?	· · · · · · · ·	· · · · · · · · · ·	═══
Diplotaxis muralis		XVIII 1842 Ar		1851					?	· · · · ·	· · · · · · · · · ·	▒▒▒▒
Lycium barbarum	1769	1839	1847	1862					?	· · · · · · · ·	· · · · · · · ·	▒▒▒▒
Elodea canadensis		1836		1867					? ?	· · · · · · · · · ·	▪ ▪ ▪ ▪	▒▒▒▒
Solidago canadensis		1648		1872					?	· · · · ·	· · · · · · · ·	▒▒▒▒
Juncus tenuis		1795		1862					? ?	· · · · ·	▪ ▪ ▪ ▪	▒▒▒▒

Species	Introduction to Europe	First record for Central Europe	Introduction to Poland	First record for Poland	XVI	XVII	1/2 XVIII	2/2 XVIII	1/2 XIX	2/2 XIX	1/2 XX	2/2 XX
Solidago gigantea		1758		1853					?			
Impatiens parviflora		1837		1850					??			
Robinia pseudoacacia	1601	1824	XVIII 1806	1836 ? 1868				X	?			
Chamomilla suaveolens		1850		1862					??			
Echinops exaltatus		1897		1897								
Rubus allegheniensis		1890		1899								
Corydalis lutea		*ca.*2/2 XVIII 1884		1884								
Mimulus moschatus		1868		1879								
Oenothera glazioviana	1864	1866		1879								
Oenothera parviflora	1682 1768	1914		1938								
Oxalis dillenii		1865		1865								
Rubus laciniatus	1770	1885		1859								
Veronica peregrina		1760		1854								
Ornithogalum boucheanum	*ca.* XVI			1880								
Sisymbrium wolgense		1880		1896								
Vicia pannonica		1884 Ar		1884								
Petrorhagia saxifraga				1859								
Solidago graminifolia		XIX		1888								
Atriplex oblongifolia		2/2 XIX		1882								
Bidens connata		1865		*ca.*1874 1895								
Centaurea diffusa		1876		1878								
Lepidium virginicum		1697		1860								
Artemisia austriaca		1871		1871								
Physalis alkekengi		1866 Ar	1613*	1866	?	X	?	?	?			
Amaranthus chlorostachys		1872		1872								
Erigeron ramosus		XVIII / XIX		1888								
Kochia scoparia		XVIII 1811		1872								
Anthoxanthum aristatum		1805–1813		1866								
Oenothera depressa		1835		1894								
Parthenocissus inserta	1629	1884	1806	1884								
Rumex confertus		1873		1873								
Chenopodium strictum		XIX 1939		1891								
Impatiens glandulifera	1839	1855		1890								
Lepidium densiflorum		1883		1888								
Vicia dasycarpa				1898								
Bidens frondosa		1736		1869								
Lupinus polyphyllus		1877		1877								

Species	Introduction to Europe	First record for Central Europe	Introduction to Poland	First record for Poland	XVI	XVII	1/2 XVIII	2/2 XVIII	1/2 XIX	2/2 XIX	1/2 XX	2/2 XX
Acer negundo	1688	1699	1808	1899						•	• • • • •	
Padus serotina	1623	1825	1813	*1880 ?* 1900						•	• • •	
Reynoutria japonica	1823–1829	1886		1882						•	• • • • • • • •	
Galinsoga ciliata		1853		1876						• • •	• • • • • •	
Lathyrus nissolia		1903		1903						?	• • • • •	• • • • •
Erechtites hieracifolia		1700		1902						?	• • • • •	• • • • • • • • • •
Amaranthus albus		1723		1907						?	• • • • • • • •	: : : : : : : :
Reynoutria sachalinensis	before 1864	1869		1903						?	• • • • •	: : : : : : : :
Vicia grandiflora		1877		1907						?	• • • • •	
Oxybaphus nyctagineus		1843		1911							•	• •
Ailanthus altissima	1751	1874	1818	1931							•	• • • • •
Ambrosia psilostachya		1901		1901							• • •	• • • • •
Barbarea intermedia				1908							•	• • • • •
Sisyrinchium bermudiana		*1845 ?* 1863		1928							• •	• • • • •
Genistella sagittalis		1928		1929							•	• • • • •
Melilotus wolgica		1937		1937							• •	• • • • •
Thladiantha dubia		1917		1917							• •	• • • • • •
Veronica filiformis	1780	1838		1936							•	• • • • • •
Oenothera subterminalis		1856		1938							•	▪ ▪ ▪ ▪
Trifolium patens				1933							•	▪ ▪ ▪ ▪
Amaranthus blitoides		1893		1911							• • •	▪ ▪ ▪ ▪ ▪ ▪
Eragrostis pilosa		XIX 1939		1934							•	▪ ▪ ▪ ▪ ▪ ▪
Iva xanthiifolia		1842		1928							•	▪ ▪ ▪ ▪ ▪ ▪
Bromus carinatus		1912		1912							•	= = = = =
Epilobium ciliatum		1891		1917							•	
Rosa rugosa	1841	1950		1913 ?							• • •	
Echinocystis lobata		1904		1937							• • •	
Oenothera suaveolens		1805		1961								• •
Oenothera issleri		1949		1958								• • •
Oenothera jueterbogensis		1962		1973								• • •
Oenothera pseudochicaginensis		1959		1959								• • •
Oenothera punctulata		1969		1973								• • •
Chaerophyllum aureum				1809 ? 1994								• • • • •
Helianthus decapetalus		1910		1956								• • • • •
Helianthus laetiflorus		1959		1969								• • • • •
Lemna turionifera		1983		1994								• • • • •
Oenothera fallax		1917		1958								• • • • •

Species	Introduction to Europe	First record for Central Europe	Introduction to Poland	First record for Poland	XVI	XVII	1/2 XVIII	2/2 XVIII	1/2 XIX	2/2 XIX	1/2 XX	2/2 XX
Oenothera royfraseri		1963		1963								· · · · ·
Oenothera oakesiana	1614	1962		1962								· · · · ·
Heracleum mantegazzianum		1862		1973								·····
Heracleum sosnovskyi		2/2 XX		1980								·····
Oenothera canovirens		1907		1958								·····
Oenothera pycnocarpa		1958		1963								·····
Oenothera victorini		1961		1961								·····
Oenothera wienii		1937		1937								·····
Oenothera paradoxa		1967		1974								▪ ▪ ▪ ▪
Oenothera hoelscheri		1942		1942								▪▪▪▪▪▪▪▪

In this table only the information from the earliest record is given.
Further information is given in Appendices A and B.

Abbreviations used in the table:

Ar – species classified as an archaeophyte in some part of Europe

* – occurrence of species in Poland recorded by SYREŃSKI (1613) without specification of species status (i.e. whether in cultivation or in wild)

X – in cultivation

? – probably occurred in the wild, but may have only been cultivated

[1] – "old" cultivated plant, probably only in cultivation at that time

[2] – possible doubtful determination of the species at that time

Symbol	Nrs of localities for the species at the particular time	Symbol	Nrs of localities for the species at the particular time	Symbol	Nrs of localities for the species at the particular time
·	1–3	▪ ▪ ▪ ▪	161–240		1601–2000
· ·	4–6	▪▪▪▪▪▪	241–320		2001–4000
· · ·	7–10	▪▪▪▪▪▪▪▪	321–400		4001–6000
· · · · ·	11–40	:::::::::	401–800		6004–8000
·····	41–80	=====	801–1200		8001–10000
· · · · · ·	81–120		1201–1600		> 10000
·· ·· ·· ·· ··	121–160				

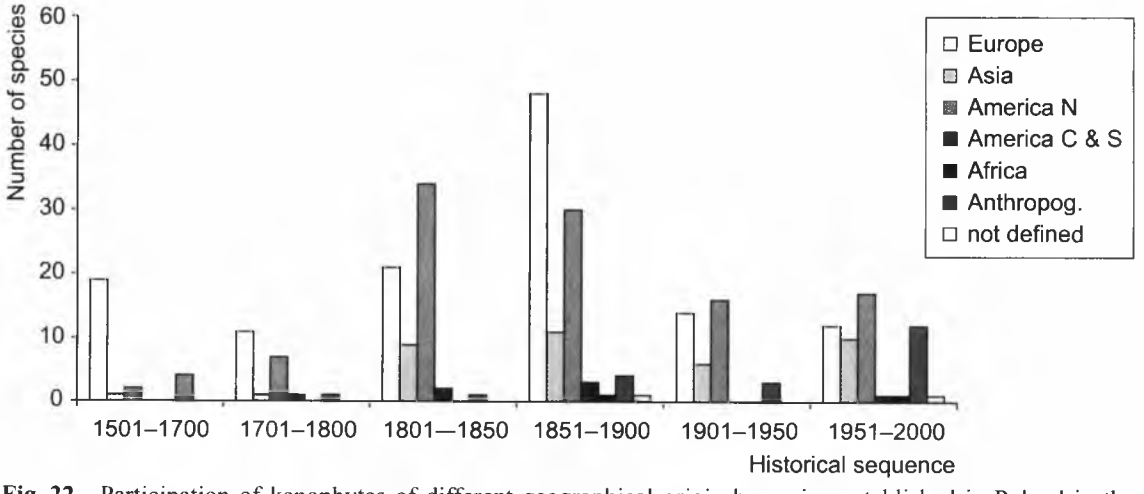


Fig. 22. Participation of kenophytes of different geographical origin becoming established in Poland in the historical sequence 1501–XX century

stations, respectively. The combined number of stations recorded for 174 species of kenophytes now exceeds 210 000 (Fig. 24; Appendix A).

The composition of the kenophyte flora expressed in the number of recorded localities has also changed over the periods studied (Table 8). The species most often recorded in the mid-19th century was *Senecio vernalis*, but the rate of its expansion was slow, hence it "dropped" down the list of the most frequent kenophytes (this species prefers certain types of habitats, such as rubble heaps and railway tracks). At the beginning of the 20th century the highest number of stations was recorded for *Amaranthus retroflexus*, which is also a species recorded among the most frequent kenophytes of the last 200 years. *Conyza canadensis* and *Chamomilla suaveolens* are two species, presently common in Poland, which have been

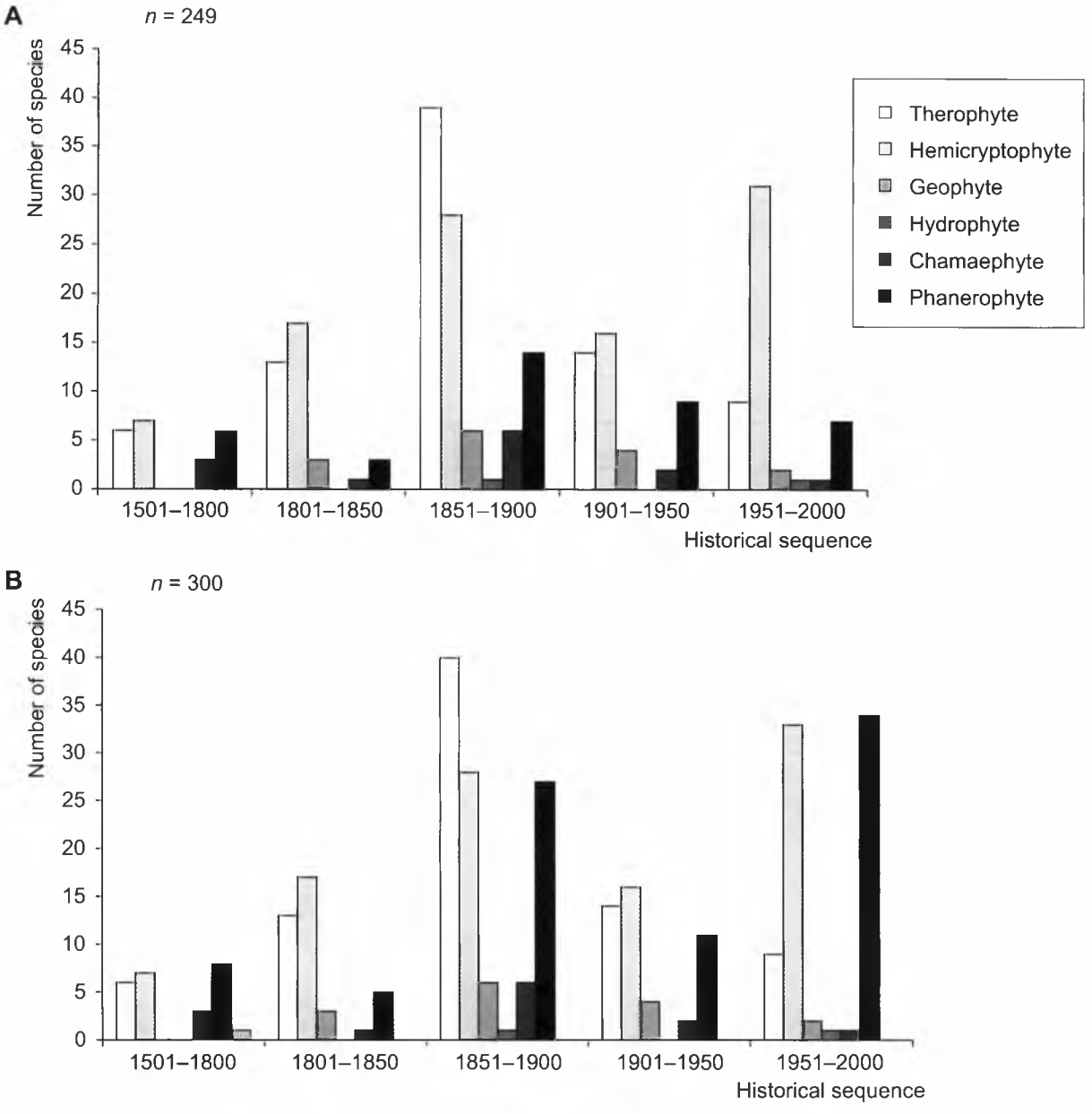


Fig. 23. Participation of kenophytes of different life forms becoming established in Poland in the historical sequence 1501–2000

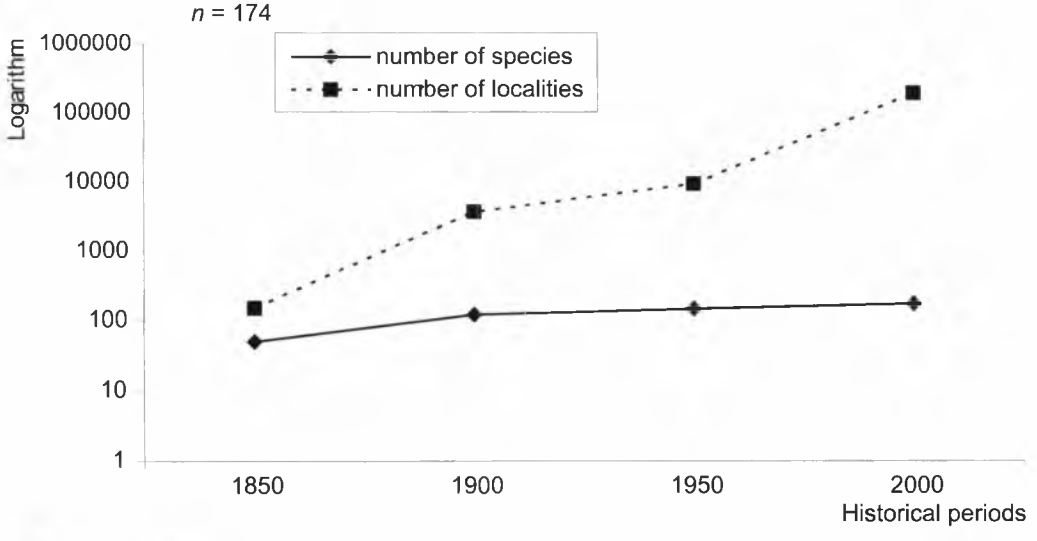


Fig. 24. Changes in species number and cumulative number of localities in the historical sequence 1850–2000

Table 8. The most frequent kenophytes in the floras of the four historical periods: before 1850, 1851–1900, 1901–1950, and after 1951
For more explanations see the text

up to 1850

Species	Numbers of localities
Senecio vernalis	11
Amaranthus lividus	9
Acorus calamus	8
Amaranthus retroflexus	**8**
Bryonia alba	8
Conyza canadensis	8
Oxalis fontana	8
Marrubium vulgare	7
Datura stramonium	6
Digitalis purpurea	5
Medicago sativa	5
Reseda luteola	5

1851–1900

Species	Numbers of localities
Amaranthus retroflexus	**169**
Marrubium vulgare	147
Elodea canadensis	140
Onobrychis viciifolia	140
Galinsoga parviflora	135
Xanthium strumarium	130
Datura stramonium	128
Senecio vernalis	119
Bryonia alba	115
Oxalis fontana	111
Conyza canadensis	106
Acorus calamus	88

1901–1950

Species	Numbers of localities
Onobrychis viciifolia	323
Amaranthus retroflexus	**291**
Silene dichotoma	289
Marrubium vulgare	255
Chamomilla suaveolens	254
Galinsoga parviflora	253
Elodea canadensis	226
Xanthium strumarium	225
Geranium pyrenaicum	220
Senecio vernalis	219
Juncus tenuis	206
Datura stramonium	205
Conyza canadensis	206

1951–2000

Species	Numbers of localities
Chamomilla suaveolens	13 125
Conyza canadensis	11 600
Galinsoga parviflora	10 932
Oxalis fontana	8 806
Veronica persica	7 887
Amaranthus retroflexus	7 651
Robinia pseudoacacia	7 067
Galinsoga ciliata	6 777
Impatiens parviflora	6 730
Medicago sativa	5 412
Solidago gigantea	5 348
Juncus tenuis	5 332
Acorus calamus	4 319

recorded at a relatively high number of stations compared with other kenophytes occurring in Poland.

6. Current types of distribution of kenophytes in Poland

This analysis of the distribution of kenophytes was based on data collected for 174 species (cf. Chapter 4, Appendix A).

Migrations of alien plant species which have spread across Poland since the end of the 15th century have covered the whole national territory of contemporary Poland. The distribution map representing the density of these species throughout the country does not reveal any areas "free" of these newer arrivals (newcomers), but does show that there are regions where they are concentrated: the Vistula river valley, the Silesian Upland (particularly the Upper Silesian Industrial Region), and – above all – the large urban centres of Szczecin, Gdańsk, Gorzów Wielkopolski, Toruń, Poznań, Łódź, Warszawa, Wrocław, Opole, Lublin, Gliwice, and Kraków (Fig. 25).

Many kenophytes (69 species) occurring in Poland have stations distributed throughout the country and thus they do not represent any particular type of range. These are common species (e.g. *Chamomilla suaveolens*, *Conyza canadensis*, *Galinsoga parviflora*, *G. ciliata*, *Tanacetum parthenium* and *Veronica persica*) as well as species occurring sporadically, sometimes those species which are frequent locally (e.g. *Oxalis corniculata*, *Physalis alkekengi* and *Sinapis alba*) and rare species that to-date have only been found at single stations. This group also includes species whose stations are concentrated in certain regions, being reported less often in other regions. Such a mosaic type of distribution results

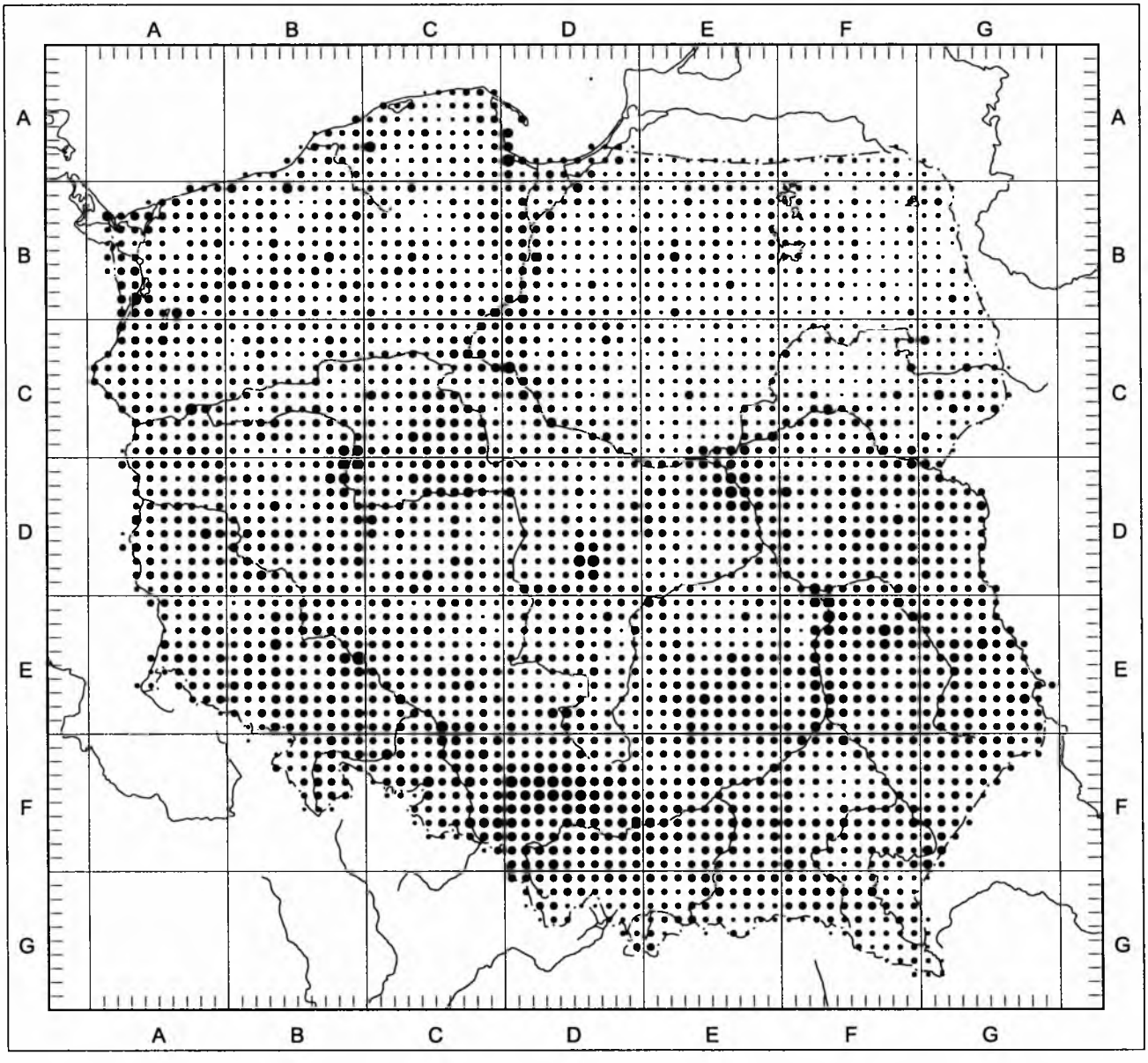


Fig. 25. Concentration of 174 species of kenophytes in Poland

The size of dots shows the number of the species occurring in each cartogramme unit (10 × 10 km square). The largest dot (BE49 Wrocław) indicates 126 species per unit. For more explanation see the text

principally from local habitat conditions. For example, *Acorus calamus*, a species common throughout Poland, is less frequently noted in the regions lacking habitats specific to this species (e.g. within the Kraków–Częstochowa Upland which is dissected by the Vistula and Oder rivers watershed, or in the Dynów Foreland which is a typical farmland area with a limited area of riverine or lacustrine bank habitats).

On the other hand, *Amaranthus retroflexus*, a species equally common in Poland, is rare in elevated mountain locations, in north-eastern Poland and in parts of the Kaszubskie Lake District. The main limiting factor for the occurrence of this species in the Carpathians and north-eastern Poland is climate. The aforementioned areas are also characterised by a low level of anthropisation of the environment, and they are largely covered by forests, wetlands and bogs.

The distribution of species such as, for example, *Helianthus tuberosus*, *Hesperis matronalis*, *Hyssopus officinalis* and *Marrubium vulgare* coincides with the areas where they are (or have been) often cultivated.

However, detailed analysis of the distribution maps pertaining to individual species has permitted the classification of 105 species of kenophytes into groups representing specific types of distribution ranges in Poland.

6.1. Kenophytes with stations scattered throughout Poland except for in certain regions

Two groups of kenophytes are classified here which:

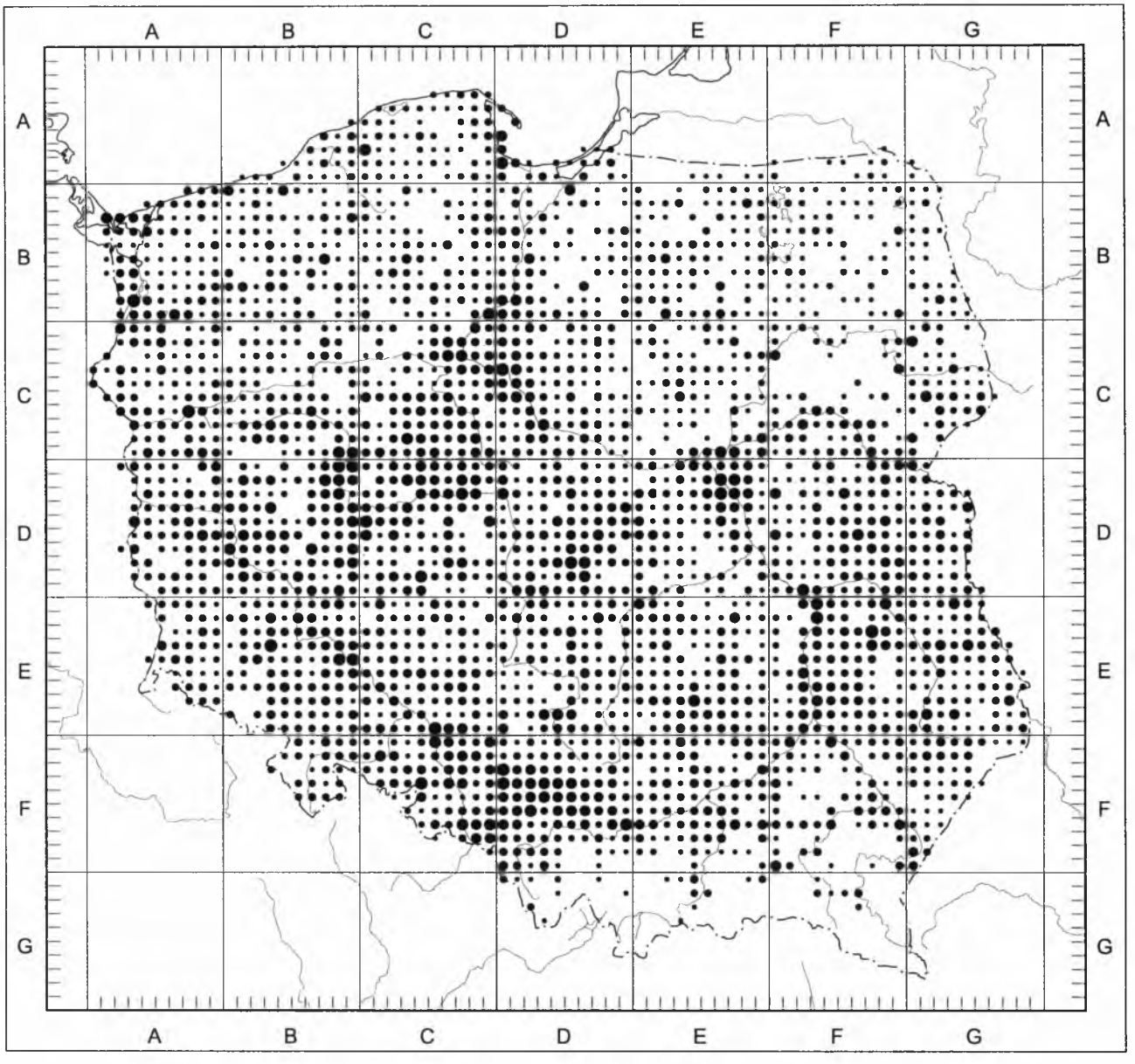


Fig. 26. Concentration of 12 species of the *Sisymbrium altissimum* group in Poland
The size of dots shows the number of the species occurring in each cartogramme unit (10 × 10 km square). The largest dot indicates 12 species per unit. These species are frequent on the whole territory of the country except the Carpathians

– do not enter the Carpathians – *Sisymbrium altissimum* group (Fig. 26),
– either do not occur or are rare in the Carpathians and in the north-eastern part of Poland – *Diplotaxis tenuifolia* group (Fig. 27).

6.1.1. *Sisymbrium altissimum* group

This type of distribution is represented in Poland by 12 species (Fig. 26):

Amaranthus chlorostachys
Amaranthus lividus
Anthemis ruthenica
Eragrostis minor
Kochia scoparia
Lycium barbarum
Padus serotina
Portulaca oleracea
Senecio vernalis
Sisymbrium altissimum
Sisymbrium wolgense
Xanthium strumarium

These species are mostly those which have been brought in accidentally from south-eastern Europe and western Asia, but less often from central or eastern Asia, or from both Americas. The feature common to all these species is that their occurrence is limited to thermophilous anthropogenic habitats (principally various types of waste lands in urban areas or railway tracks, but also within fields of root crops). Only two species in this group occur outside ruderal and segetal communities and also in plant communities of semi-

-natural or natural character. These are: *Lycium barbarum* – a shrub found in thermophilous scrub and forest edge herb communities (it even forms a specific community of *Lycietum halimifolii*), and *Padus serotina*, most often found in pine forests or mixed forests, oak woods and in forest plantations with a predomination of pines (actually the community into which it was originally introduced by foresters – cf. Chapter 7).

The factors limiting the spread of the species of this group in the Carpathians are, above all, temperature[26] and overall habitat conditions. Even in the cases of species whose oldest stations were found in the Carpathian Foothills (*Amaranthus chlorostachys*, *Anthemis ruthenica* and *Kochia scoparia*), no further expansion in the Carpathians was observed; the expansion has been directed rather into other upland or lowland parts of Poland.

Sporadic penetration into the Carpathians by some species from this group predominantly follows the main river valleys (of the Vistula, Dunajec and San rivers), even though these mountains are generally rather accessible (low elevations, numerous roads and rail routes). The Outer Western Carpathians is the region into which at least some of the species concerned will penetrate in future (e.g. *Padus serotina*), due to the relatively high density of human population and intensity of farming, combined with the proximity of the areas of the Silesian Upland which are already much disturbed by human activities.

6.1.2. *Diplotaxis tenuifolia* group

Amaranthus blitoides
Ambrosia artemisiifolia
Anthoxanthum aristatum
Artemisia annua
Atriplex tatarica
Bryonia dioica
Centaurea diffusa
Clematis vitalba
Diplotaxis tenuifolia
Lepidium virginicum
Reseda luteola
Robinia pseudoacacia
Vicia grandiflora

This group is composed of 13 species, originating from south and south-eastern Europe and from North America, which prefer areas with a relatively warm climate (Fig. 27). Their spread in Poland has been attributed to accidental or purposeful initial introductions into built-up areas or on railway routes (e.g. *Amaranthus blitoides*, *Ambrosia artemisiifolia*, *Atriplex tatarica*, *Centaurea diffusa*, *Diplotaxis tenuifolia* and *Lepidium virginicum*). The species originating from North America (*Amaranthus blitoides*, *Ambrosia artemisiifolia* and *Lepidium virginicum*) have been accidentally brought into Poland from western or southern Europe, where they established themselves earlier (as indicated by the earliest records).

In Poland, these three species are associated principally with urban habitats, railway-related sites and farmlands. *Clematis vitalba*, *Robinia pseudoacacia* and *Vicia grandiflora* also colonise thermophilous grasslands and shrublands.

The overall shape of the ranges of these species is affected primarily by temperature. The species are scattered over the entire national territory, except for north-eastern Poland (the southern part of the Old Prussian Upland and the Masurian Lake District) and higher sections of the Carpathians. Apart from larger towns, their densities are also lower in north-western Poland (the Koszalin Coast region and Polanowska Upland) (Fig. 27). The climate of these areas, and particularly of the Masurian Lake District is cooler, compared with other parts of Poland, and the vegetation season there is the shortest (200–190 days).

This type of distribution range also partly reflects the differences between the climatic zones of Europe and their associated landscape and vegetation zones. Furthermore, these areas are the least densely populated parts of Poland and are mostly covered by forests.

6.2. Kenophytes with scattered stations over the whole territory of Poland, with concentrations of more frequent stations in some regions

Among the great number of kenophytes distributed throughout Poland, at least three groups of species can be selected which show a markedly higher occurrence in the following regions:

- south-west Poland (particularly the Silesia-Cracow Upland) and south-east Poland (particularly the uplands of southern Poland: Małopolska, Lubelska and Roztocze Uplands) – *Bunias orientalis* group (Fig. 28);
- south-west Poland – *Geranium pyrenaicum* group (Fig. 29);
- southern and south-east Poland – *Echinocystis lobata* group (Fig. 30).

[26] Average annual temperature in the following vegetation zones according to the altitude above sea level fluctuates from (+8°C) +6°C in the foreland zone to 0°C (–2°C) in the alpine zone.

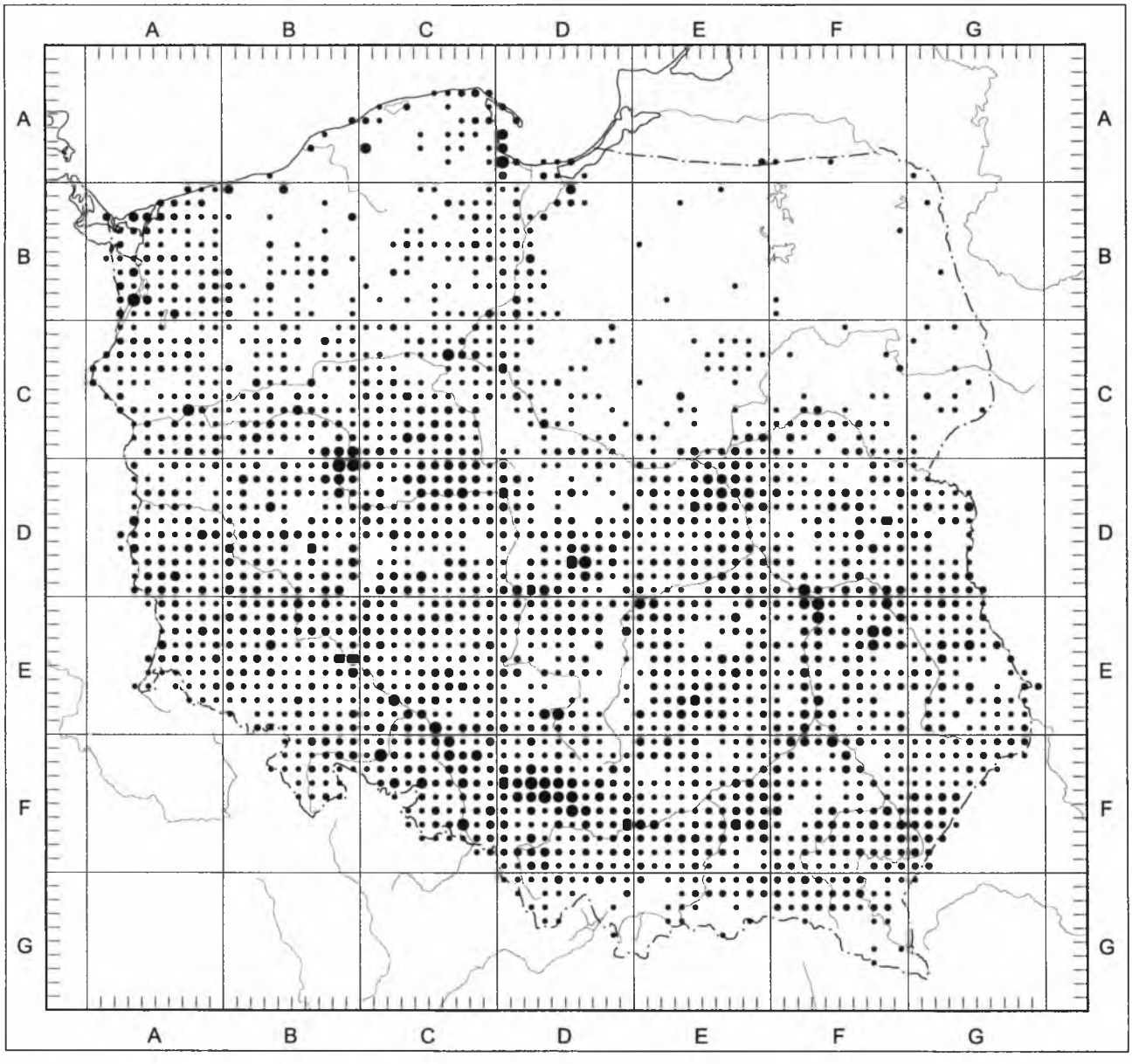


Fig. 27. Concentration of 13 species of the *Diplotaxis tenuifolia* group in Poland

The size of dots shows the number of the species occurring in each cartogramme unit (10 × 10 km square). The largest dot indicates 10 species per unit. These species are frequent on the whole territory of the country except for higher parts of the Carpathians as well as parts of the north-eastern and north-western Poland

The species classified in these groups are further characterised by concentrations within major towns: Gdańsk, Poznań, Łódź, Szczecin, Warszawa, and Wrocław.

6.2.1. *Bunias orientalis* group

Bunias orientalis
Cardaria draba
Echinops sphaerocephalus
Epilobium ciliatum
Impatiens parviflora
Juncus tenuis
Lupinus polyphyllus
Parthenocissus inserta
Reynoutria japonica
Rudbeckia laciniata
Sisymbrium loeselii

This group includes 11 species originating from south-eastern Europe and various regions of Asia, as well as from North America. They are mostly kenophytes which have succeeded in establishing themselves not only in synanthropic communities but also in semi-natural and natural ones.

Possibly the species of indigenous European origin expanded in Poland using two routes, gradually expanding their ranges from east to west, and in addition being accidentally transported by long-distance means of transport, most often around the main railway hubs. The reconstruction of the stages of the expansion permits the assumption that the latter of the two methods

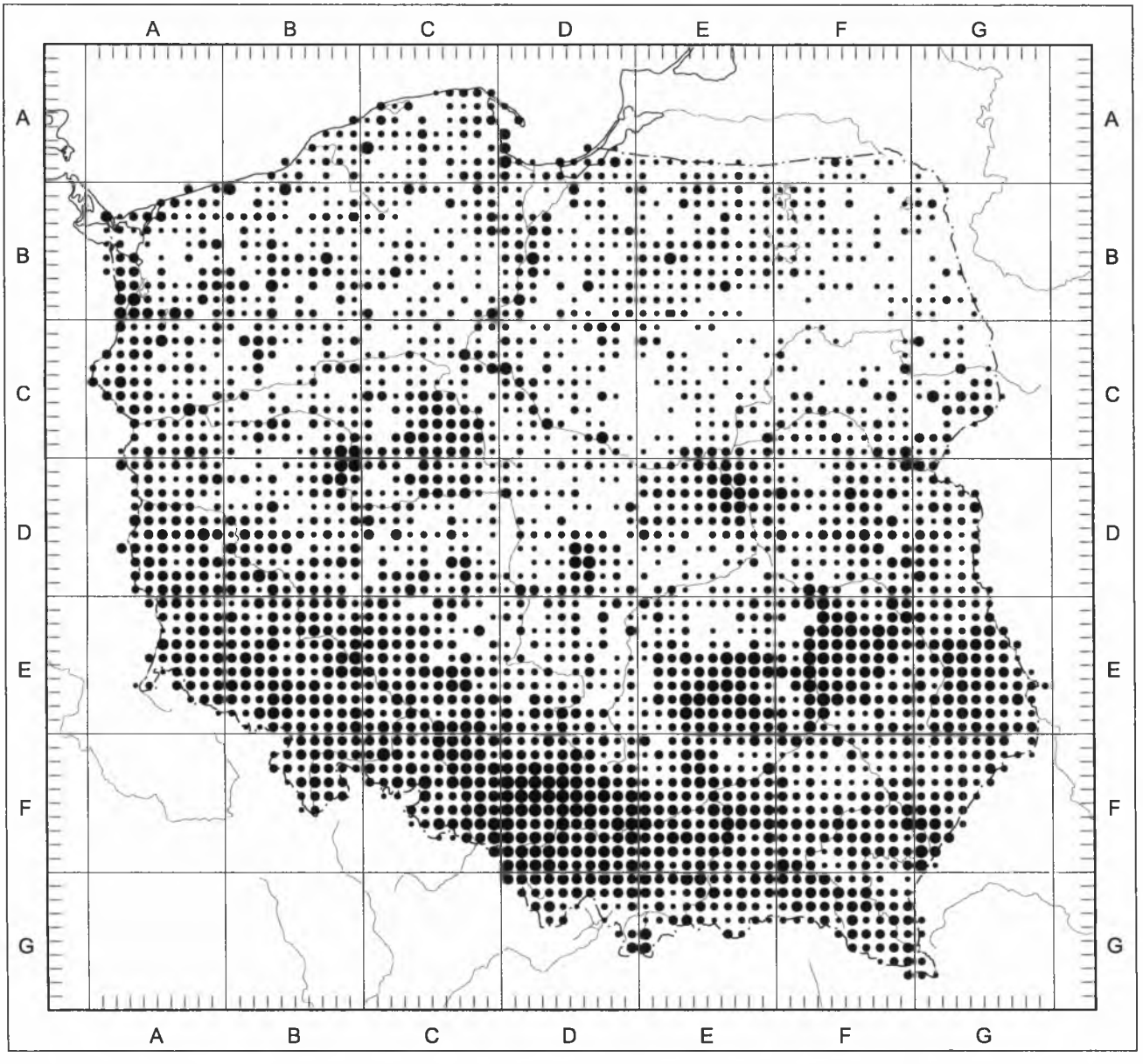


Fig. 28. Concentration of 11 species of the *Bunias orientalis* group in Poland
The size of dots shows the number of the species occurring in each cartogramme unit (10 × 10 km square). The largest dot indicates 11 species per unit. These species are frequent on the whole territory of the country, particularly in the Southern Polish Uplands

was primarily instrumental, particularly in the initial stages of the dispersion of these species. Apart from various types of ruderal habitats, these kenophytes are found in grasslands, meadows, and pastures.

However, the species whose homelands are in distant continents such as eastern Asia or North America, have mostly been carried intentionally into Europe as cultivated plants (*Epilobium ciliatum* and *Juncus tenuis* are the only exceptions). They dispersed, colonising ruderal communities near farmland, and – with the passage of time – established themselves in shrublands and various types of forest communities.

The regions of concentrations of the *Bunias orientalis* group of species reflect the history of their spread in the territory of Poland (there being concentrations around the oldest sites reported, and additionally they are related to the presence in a given region of the habitats which they prefer (Fig. 28).

6.2.2. *Geranium pyrenaicum* group

Geranium pyrenaicum
Hercleum mantegazzianum
Reynoutria sachalinensis
Rosa rugosa
Sedum spurium
Silene dichotoma
Solidago canadensis
Vicia dasycarpa
Vicia pannonica

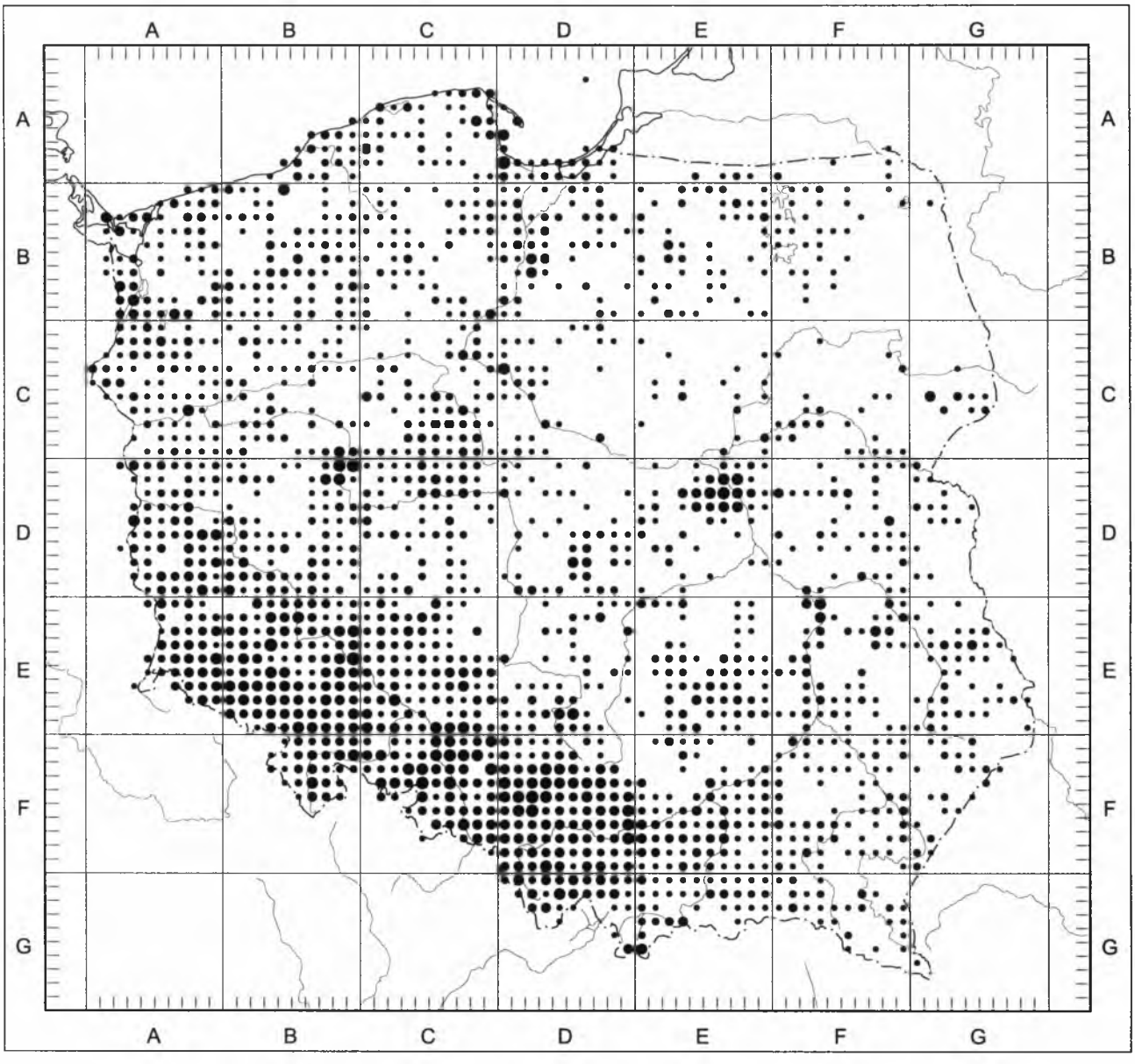


Fig. 29. Concentration of 9 species of the *Geranium pyrenaicum* group in Poland

The size of dots shows the number of the species occurring in each cartogramme unit (10 × 10 km square). The largest dot indicates 8 species per unit. These species are frequent in most areas of Poland, particularly in the south-western part

This group includes 9 species of various origins and manners of introduction concentrated in south-west Poland. The density of their sites probably links with the history of their spread. For most of them this history started with an accidental or intentional introduction into this part of Poland. The factors supporting their colonisation of new sites were essentially climatic conditions (long period for growth) (Fig. 29).

6.2.3. *Echinocystis lobata* group

Echinocystis lobata
Erigeron annuus
Erigeron ramosus
Iva xanthiifolia
Lolium multiflorum
Medicago sativa
Solidago gigantea
Thladiantha dubia

The origin of the species classified into this group is North America (the only exception is the Asian species, *Medicago sativa*). The only species introduced accidentally is *Iva xanthiifolia*; other species were intentionally introduced by humans as useful plants (mainly as ornamental or fodder plants). The common occurrence of these species in south-east Poland could perhaps result from the fact that they are fairly often only cultivated in this region. Further spread can be facilitated by habitat conditions: the presence of river valleys (particularly in the case of *Echinocystis lobata*, *Erigeron annuus* and *Solidago gigantea*) and the existence of habitats preferred by the species of the group

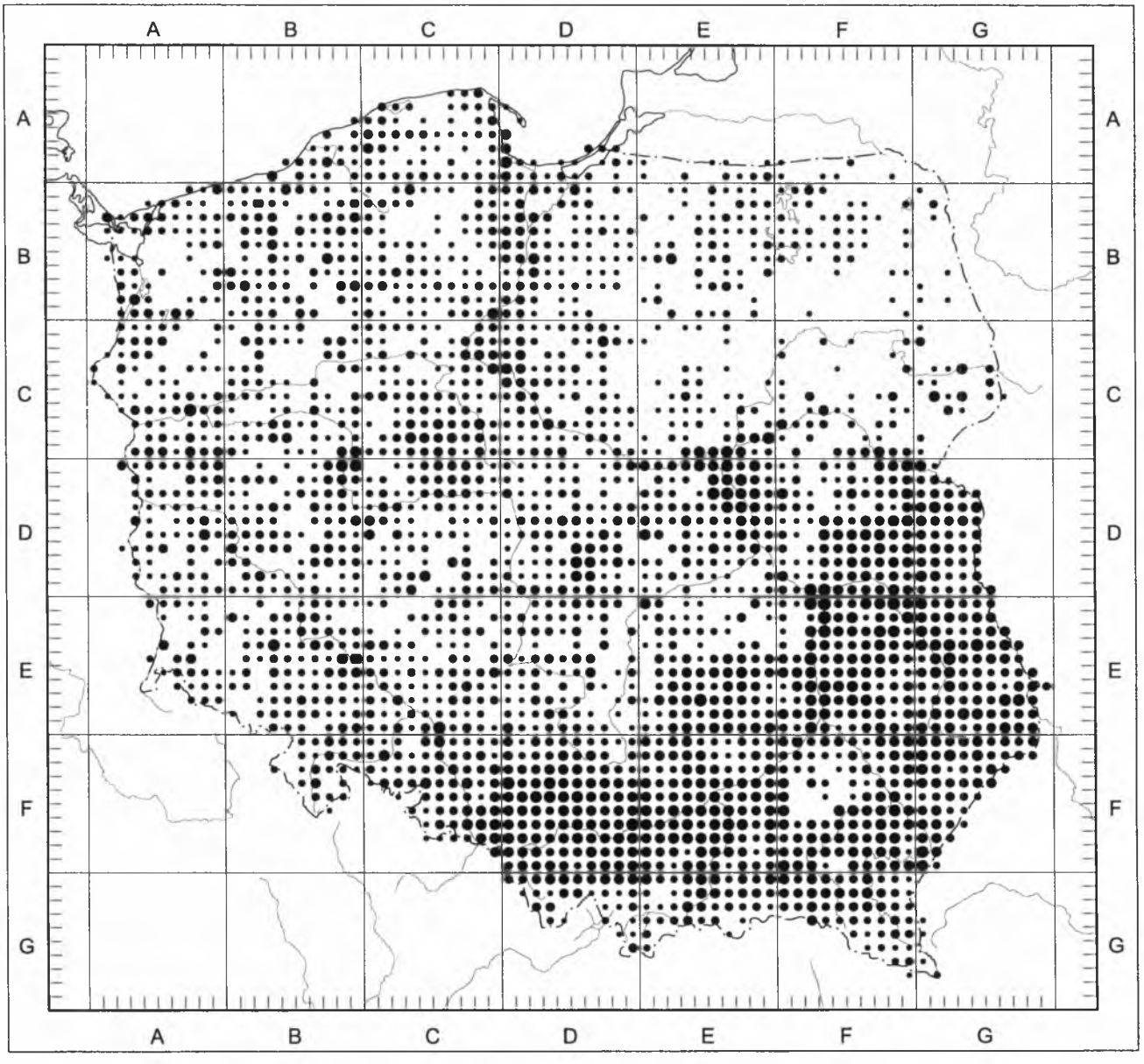


Fig. 30. Concentration of 8 species of the *Echinocystis lobata* group in Poland

The size of dots shows the number of the species occurring in each cartogramme unit (10 × 10 km square). The largest dot indicates 8 species per unit. These species are frequent in most areas of Poland, particularly in the south-eastern part

(e.g. ruderal sites, particularly in villages and smaller towns) (Fig. 30).

6.3. Kenophytes (contemporarily) reaching their limit of distribution in Poland

6.3.1. Western limit

Artemisia austriaca
Beckmannia eruciformis
Elsholtzia ciliata
Heracleum sosnowskyi
Lemna turionifera
Rumex confertus

This group includes 5 species originating from south-east Europe and south-west Asia, and one species of North American origin (*Lemna turionifera*).

All these species, except for *Heracleum sosnowskyi*, have gradually extended their range from east to west (Fig. 31), using various routes of spread. *Artemisia austriaca* penetrates mainly along railway routes (cf. also Chapter 7), *Elsholtzia ciliata* has colonised available ruderal sites in built-up areas, where it has also been sown (because of the urban-like transformation of Polish villages, this species has lost its old stations in many localities – cf. also Chapter 7). *Rumex confertus* has used river valleys (of the Bug and Vistula rivers) in the initial stages of migration only to continue also along transport routes (cf. also Chapter 7). The aforementioned *Heracleum sosnowskyi* has been intentionally introduced as

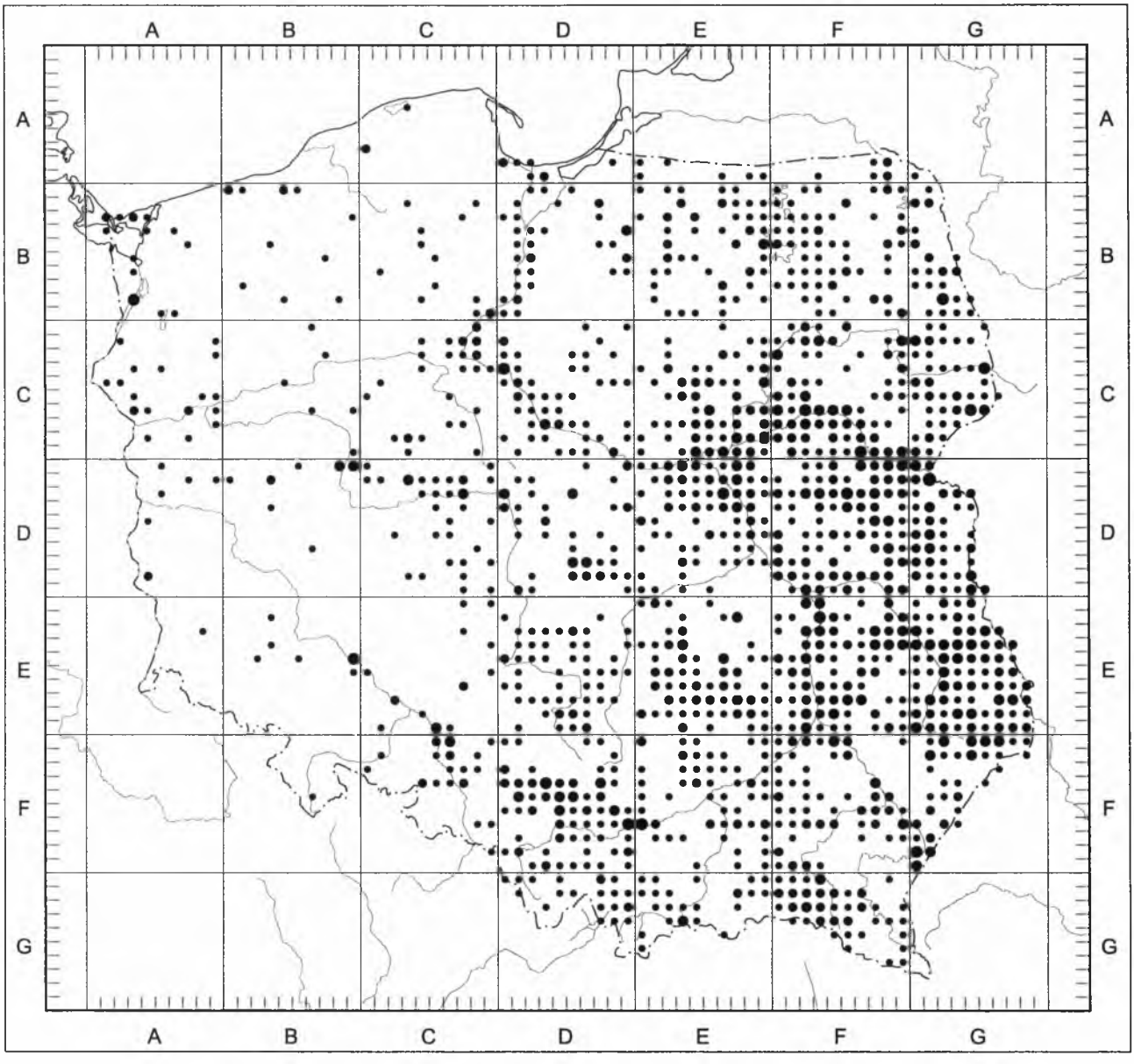


Fig. 31. Concentration of 6 species of kenophytes in Poland currently showing a western range limit
The size of dots shows the number of the species occurring in each cartogramme unit (10 × 10 km square). The largest dot indicates 5 species per unit. The concentration of these species occurs mainly in the Central and Eastern Polish Lowlands (Southern Podlasie Lowland), Polesye and Western Wolhynia

a fodder plant into north-eastern and south-eastern Poland, where it continues to colonise areas near the fields where it was previously cultivated.

The areas with an evident concentration of species of this group include the middle and eastern parts of the Polish Lowlands (the South-Podlasie Lowland), Polesye and the Wolhynia Upland (Fig. 31).

6.3.2. Eastern limit

Anthoxanthum aristatum
Corydalis lutea
Digitalis purpurea
Cymbalaria muralis
Malva moschata
Mimulus guttatus
Myrrhis odorata
Ornithogalum boucheanum
Petrorhagia saxifraga
Picris echioides
Rubus armeniacus
Rubus laciniatus
Sedum album
Sedum spurium
Silene conica
Solidago graminifolia
Vicia pannonica

This is one of the larger groups (17 species), showing a common type of range in Poland. The group covers both those kenophytes which have reached their eastern limit of distribution, and the species which are still penetrating eastwards and for which Poland is a transit area in their further spread (Fig. 32). Most of species classified into

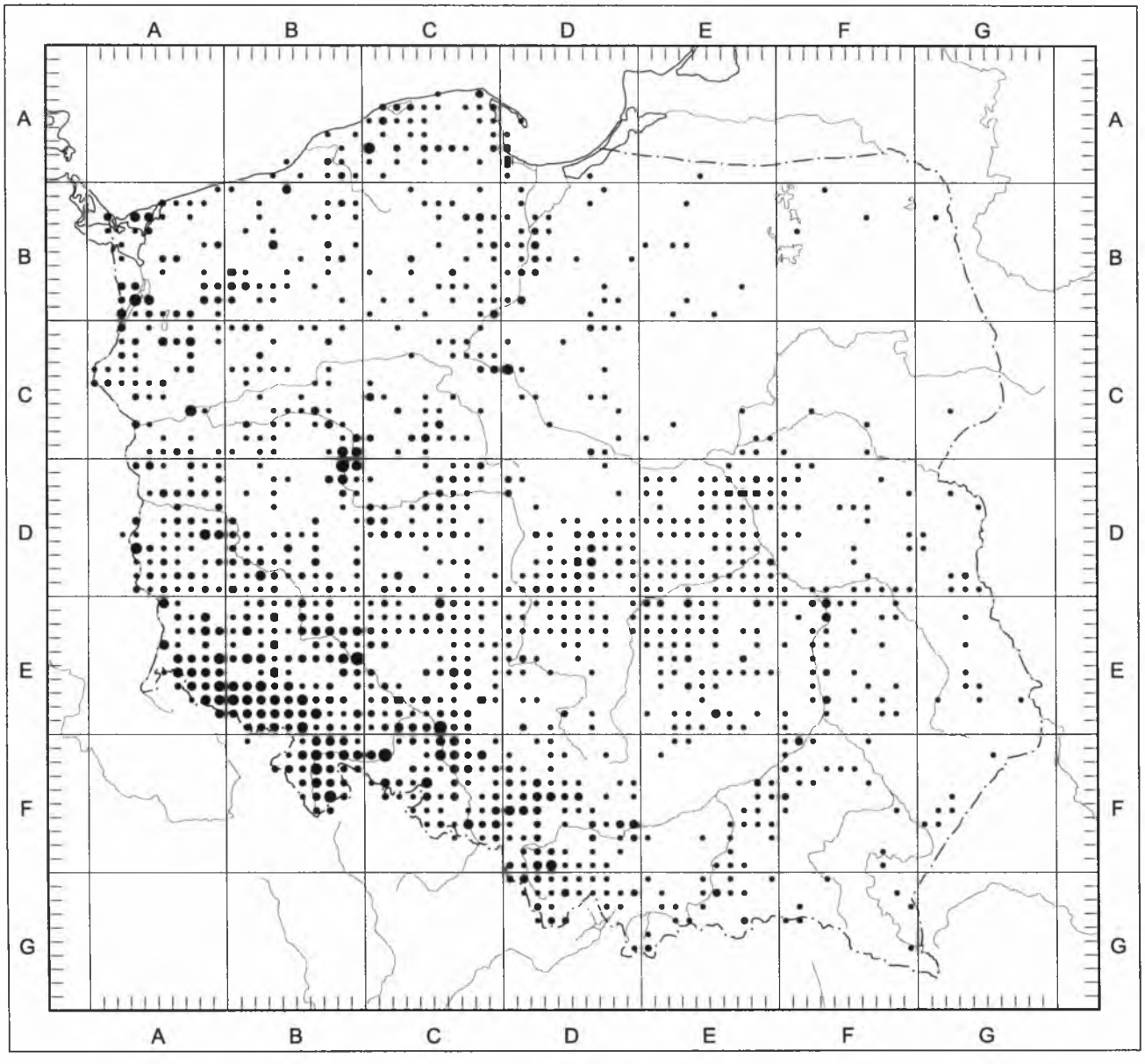


Fig. 32. Concentration of 17 species of kenophytes in Poland currently showing an eastern range limit
The size of dots shows the number of the species occurring in each cartogramme unit (10 × 10 km square). The largest dot indicates 10 species per unit. The concentration of these species occurs mainly in the Sudety Mts. and their hinterlands

this group originate from western, southern or south-east Europe. The kenophytes of Asian or North-American origin show a similar type of range of distribution as those of European origin. This implies that they have a similar history of establishment and further spread in Europe. They are plants which have been accidentally brought into the western or southern parts of the European continent and have then established there. In most cases their spread in Europe continues from west to east. A large group of species arrived in Poland from Germany and the area which is now the Czech Republic.

In the "Eastern limit" group of species, those associated with the Sudety Mountains: *Cymbalaria muralis* (cf. Chapter 7), *Digitalis purpurea*[27] (cf. Chapter 7), and *Sedum spurium*, as well as two species of a specific distribution range type, limited to the Sudety Mts. and Western Pomerania: *Mimulus gutattus* (cf. Chapter 7) and *Myrrhis odorata*, are particularly noteworthy.

6.3.3. Northern limit

Chenopodium botrys
Erechtites hieracifolia
Geranium divaricatum
Helleborus viridis
Lysimachia punctata
Oenothera glazoviana
Oenothera subterminalis
Trifolium patens

[27] *Digitalis purpurea* occurs also in western part of the Carpathians.

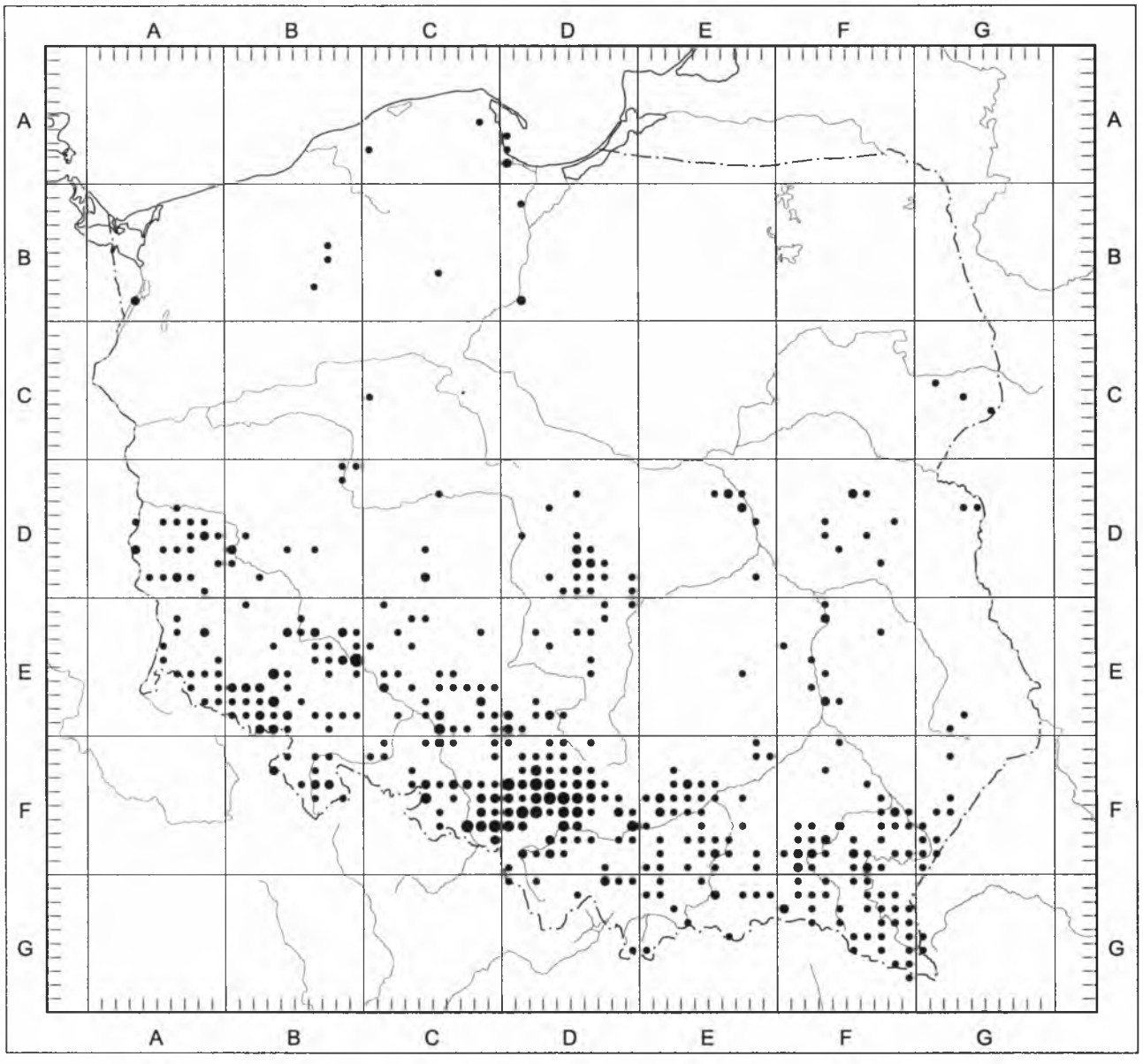


Fig. 33. Concentration of 10 species of kenophytes in Poland currently showing a northern range limit

The size of dots shows the number of the species occurring in each cartogramme unit (10 x 10 km square). The largest dot indicates 5 species per unit. The concentration of these species occurs in the Silesian Uplands, Silesian Lowlands, some regions of Sudety Mts. and some of the Carpathians (Bieszczady Mts.)

Veronica filiformis
Veronica peregrina

The ten species included in this group have a characteristic type of range (Fig. 33). As a rule, their occurrence is limited to one or several regions of southern Poland (e.g. *Erechtites hieracifolia* which shows a concentration of sites in the Silesian Lowland and in the Racibórz Basin; *Trifolium patens*, recorded from the Carpathian Foothills and in the adjacent area of the Sandomierz Basin, *Veronica filiformis* found in the eastern parts of the Carpathians within the borders of Poland). These are also the species associated with a specific type of habitat (e.g. *Erechtites hieracifolia* is found principally on clearings and forest edges; *Trifolium patens* and *Veronica filiformis* grow principally on moist and moderately moist meadows).

The centres of distribution of these species in Poland (as well as outside its borders) are also associated with warmer regions. However, *Veronica filiformis*, occurring in Poland in mountains and foreland areas, evidently avoids a dry climate.

Among the kenophytes occurring in Poland it is difficult to distinguish those which while expanding from the north or north-east, reach the southern limit of their distribution range in Poland. This results from the fact that only a few species (cf. Chapter 5) have come to Poland from these directions. The routes through which most of the North American newcomers arrived in Poland most often lead through western and southern Europe and not – as one would expect – through sea routes from the Baltic Sea. There is an example of one species (*Beckmannia eruciformis*) whose proliferation across Poland has

probably occurred from the Baltic coast towards the central regions (at least in the early stages of the spread). The only species now more abundant in the northern part of Poland are *Bidens connata* and *Oxalis dillenii*.

6.4. Kenophytes associated with river valleys

A dozen or so newer arrivals now established in Poland manifest an affinity with river valleys. The valleys have provided (and still do provide) migration corridors used by alien species in the course of their progress into a new territory.

The association with entire river valleys or their parts characterises the following kenophytes:

Acer negundo
Bidens frondosa
Clematis vitalba
Diplotaxis tenuifolia
Echinocystis lobata
Eragrostis albensis
Erigeron annuus
Oenothera depressa
Oenothera x hoelscheri
Rumex confertus
Salsola kali subsp. *ruthenica*
Solidago canadensis
Solidago gigantea
Xanthium albinum
Xanthium spinosum

This type of distribution is principally conditioned by the biological and morphological features of the species concerned. In their respective

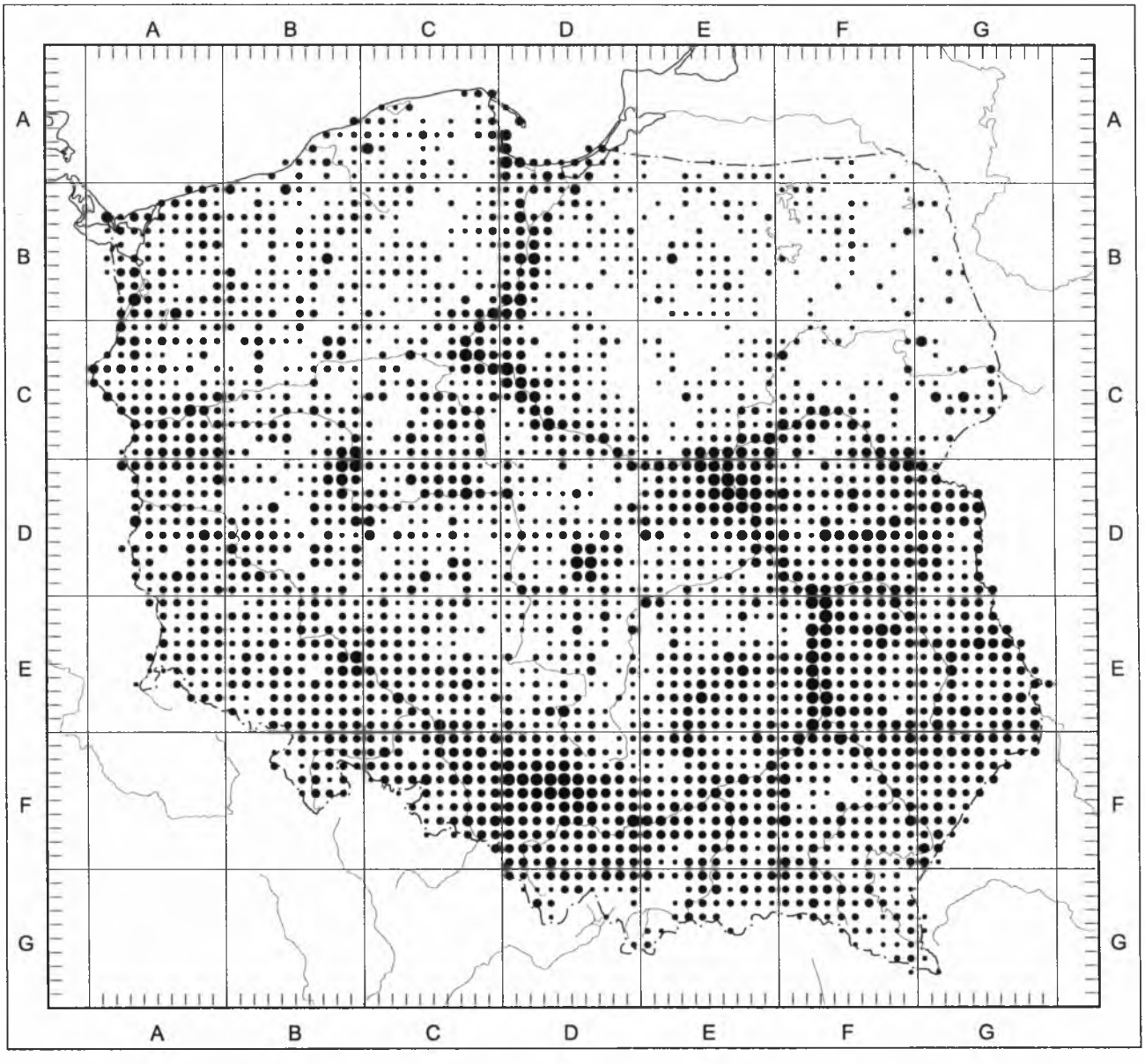


Fig. 34. 15 species of kenophytes in Poland currently showing a concentration along the main river valleys (i.e. the riparian corridor plants)

The size of dots shows the number of the species occurring in each cartogramme unit (10 × 10 km square). The largest dot indicates 15 species per unit

homelands they are also closely associated with habitats and communities close to rivers (riverine woods and shrubs, reed or rush communities, therophyte communities on sand and gravel alluvial substrates) and they take advantage of the pioneering conditions created by rivers (alluvia, valley edges, river bank cliffs) (Fig. 34).

In this group, an additional sub-group can be distinguished of 6 species specific to the valleys of two large rivers of Poland: the Vistula and Bug rivers (Fig. 35). These are:

Eragrostis albensis
Oenothera depressa
Oenothera x hoelscheri
Rumex confertus
Salsola kali subsp. *ruthenica*
Xanthium albinum

In their original distribution ranges these plants are also associated with river valleys and their specific habitats along major rivers: sand/mud alluvia (e.g. *Eragrostis albensis*) and sand steep banks and scarps (e.g. *Oenothera depressa*, *Salsola kali* subsp. *ruthenica* and *Xanthium albinum*).

Their migration and continuing invasion of still further territories in Poland is closely linked with habitat conditions provided by large rivers. Both the Vistula and Bug rivers are regarded as still only slightly disturbed by humans, and the dynamic and diverse natural processes present in this environment support plant migration. Additionally, some anthropogenic factors (river engineering of some stages, location of settlements and towns in river valleys, transport routes crossing rivers, etc.) facilitate the migration of plant species both along and across river valleys. These conditions are used by alien species which implement the subsequent

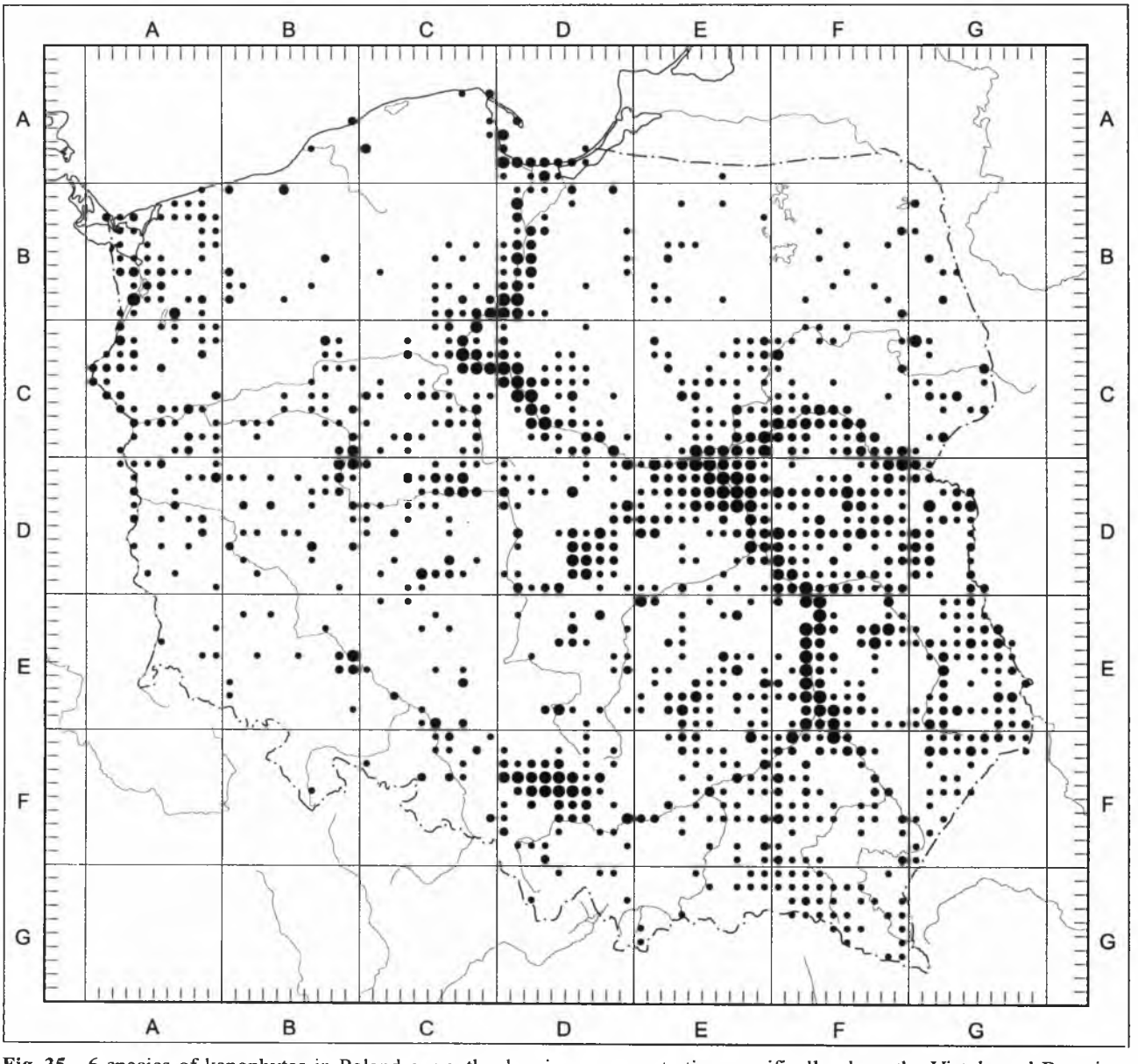


Fig. 35. 6 species of kenophytes in Poland currently showing a concentration specifically along the Vistula and Bug river valleys (i.e. the riparian corridor plants)

The size of dots shows the number of the species occurring in each cartogramme unit (10 × 10 km square). The largest dot indicates 6 species per unit

phases of their invasion along the river valley (penetrating into a new territory through a corridor created by a river). At least some of the species next arrive in adjacent areas, taking over other habitats (e.g. *Rumex confertus* and *Salsola kali* subsp. *ruthenica* – cf. also Chapter 7) or follow the reverse course moving from ruderal habitats into riverine ones (as was probably performed by *Oenothera depressa* and *Oe.* x *hoelsheri*[28]).

6.5. Kenophytes associated with urban areas and railway routes

Ailanthus altissima
Amaranthus albus
Ambrosia artemisiifolia
Ambrosia psilostachya
Atriplex tatarica
Amaranthus blitoides
Centaurea diffusa
Eragrostis minor
Euphorbia humifusa
Iva xanthiifolia
Linaria repens
Melilotus wolgica
Oenothera paradoxa
Oxybaphus nyctagineus
Parietaria pensylvanica
Potentilla intermedia

This group is represented by 16 species, mostly introduced accidentally (less often introduced

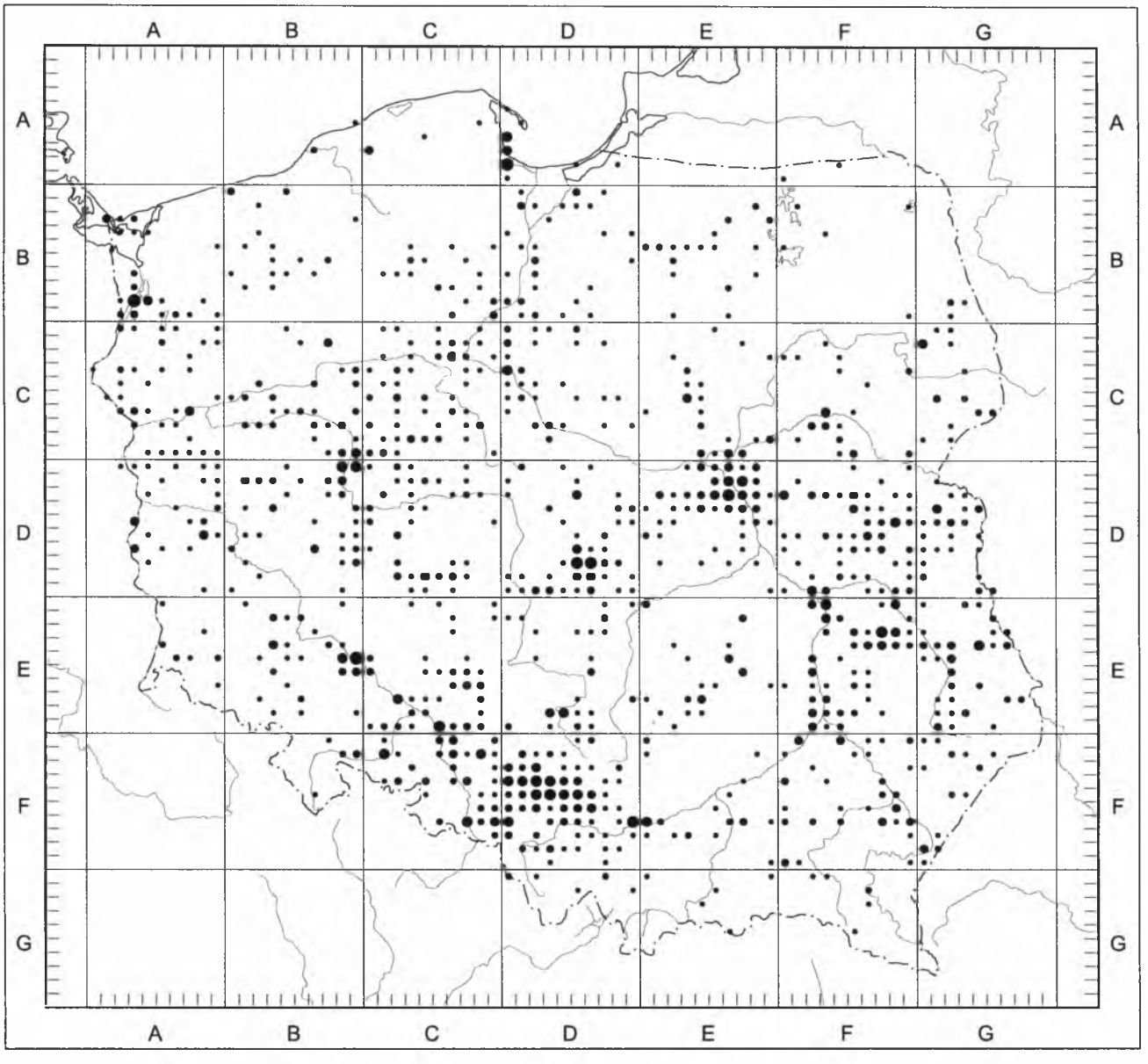


Fig. 36. Concentration of 15 species of kenophytes in Poland currently showing an association with urban areas, railways and roads
The size of dots shows the number of the species occurring in each cartogramme unit (10 × 10 km square). The largest dot indicates 14 species per unit

[28] *Oenothera* x *hoelsheri* is a hybrid resulting from hybridisation of *Oe. biennis* or *O. rubricaulis* (thus species frequently occurring in Poland both on sandy wastelands and on cliffs along rivers) with North American species *Oe. depressa.*

intentionally) with consignments of cereal grain, poultry fodders, soya-beans, oil crops, wool, or with garden materials (including those introduced to botanical gardens) and with ballast. Even though they originate from various parts of the globe they share a preference for warm and dry habitats. In their respective homelands they usually grow in steppes (*Atriplex tatarica*, *Centaurea diffusa*, *Melilotus wolgica*), prairies and deserts (*Amaranthus albus*, *Ambrosia artemisiifolia*, *Iva xanthiifolia*), but also in dry anthropogenic habitats.

In Poland and in the rest of Europe, they occur – outside their natural range – in the regions with sub-continental climatic features or in habitats which meet their ecological requirements, such as roadsides, wastelands, and railway embankments.

They have found particularly suitable conditions for development in urban locations and on railway embankments. These sites have provided the stepping stones for their repeated leap-frogging into new areas. The distribution of species in this group reflects the location of urban centres (particularly large metropolises) and the network of railway routes (Fig. 36; cf. also Chapter 10).

7. The history of the spread of selected kenophyte species in the territory of Poland

For the 25 species of kenophytes the probable course of spread within the territory of Poland has been reconstructed and the stages of their expansion documented by means of maps. Out of the group of 174 species for which detailed information has been collected to-date (Appendix A), examples of groups of species which have different biology, origin and manner of introduction include:

- cultivated woody plants with a range of different origins,
- cultivated herbaceous plants with a range of different origins,
- plants accidentally introduced with a range of different origins.

The following additional criteria were employed:

- time of intentional/accidental introduction,
- types of habitats colonised,
- current status (established or invasive),
- abundance of floristic data.

7.1. The history of the spontaneous spread of cultivated woody plants as the result of "domesticating" species

***Acer negundo* L.** [syn.: *Negundo aceroides* Moench; *N. fraxinifolia* Nutt.; *Negundo negundo* Karst.]

Box-elder; Ashleaf Maple

Aceraceae

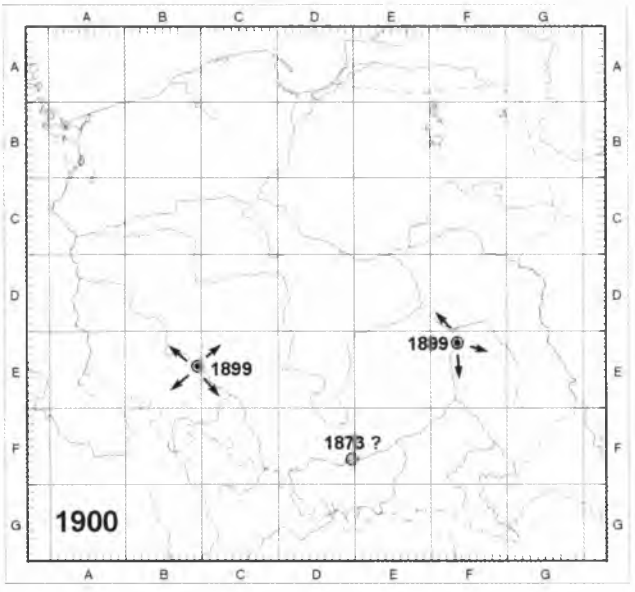
Biology: woody dioecious plant, anemogamous. Winged fruits dispersed by wind, seeds germinate easily. May also spread by suckers.

Native range: North America, where it is one of the most common American maple species (Hitchcok *et al.* 1961). Its range extends from the eastern seaboard to the west coast, whilst to the north it reaches Canada and to the south, Guatemala. It has a continuous distribution reaching California to the south-west, Alberta to the north, Massachusetts to the north-east, Florida to the south-west and New Mexico to the south (Little 1971; Scoggan 1978). In its native habitats it grows in humid and wet areas along the banks of water bodies, being a dominant component of humid forests in some areas (Mohlenbrock & Voigt 1959).

Secondary range: Eurasia reaching as far as western Siberia (Adamowski 1995), with the highest concentrations of stations in Central Europe. Outside Poland it has spread in Saxony, Thuringia, in Austria, Czech Republic and Slovakia, France, north-eastern Slovenia, in northern and central Italy and in the south-eastern part of the British Isles (Lohmeyer & Sokopp 1992; Bocker & Dirk 1998; Benkert *et al.* 1998; Hardtke & Ihl 2000; Uherčiková 2001; Pyšek *et al.* 2002; Stace 1997; Nejc 2001; Pignatti 1982). It is especially abundant along the tributaries of big rivers (on the Rhine, Dubai, Vistula and in southern part of the continent on the Sawa) and in cities, e.g. in Warsaw (Sudnik-Wójcikowska 1987a), Rome (Celesti Grapow 1995), Berlin (Kowarik 1992), Uzhorod (Protopopova & Shevera 2002) and Donetsk (Burda 1997). Its current widespread introduced range can be attributed to its use on a mass scale, as a tree grown in parks and along boulevards in the 19th and the first part of the 20th century. In some European countries it is considered to be an invasive species (cf. Appendix A).

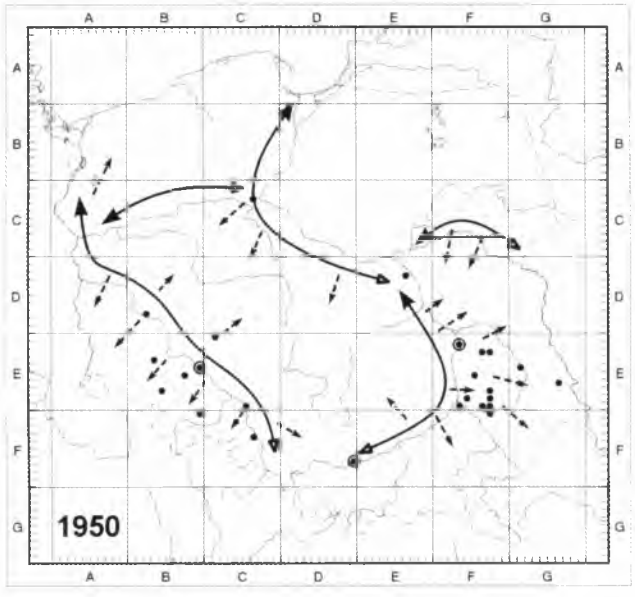
History of spread:

Europe: introduced as a decorative plant in 1688 in the Fulham Garden in England (Wein 1931). Subsequently it was introduced into the Nether-



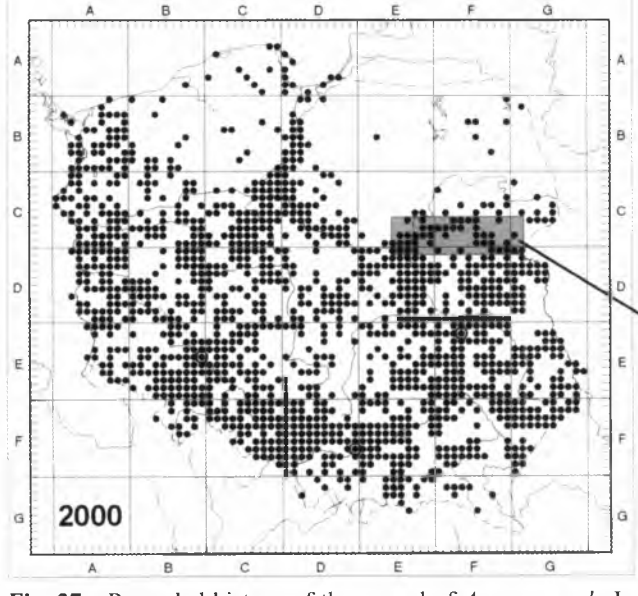
Introduction and initial phases of colonisation:
turn of the 18th century: first plantings in parks and gardens

- ◉ first presumably spontaneous localities of occurrence: Wrocław BE49 (BAENITZ, *herb.* PRC, W, WRSL); Puławy FE03 (BERDAU, *herb.* LBL)
- ◎ Kraków DF69 (BOEHM 1873) – dubious record: the author did not register the status of the species in this locality; most probably the record refers to a locality from cultivation
- naturalisation and spread close to sites of cultivation



Start of invasion phase:
transition from ruderal habitats to riverside poplar-willow forest habitats and occupation of "bridgeheads" in river valleys

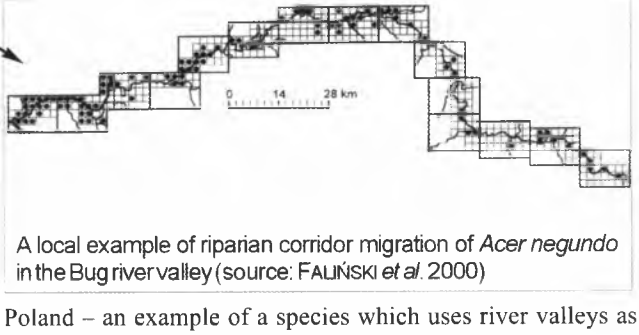
- main directions of spread
- simultaneous further spread near sites of cultivation and formerly occupied localities
- as well as migration "out of river valleys" on to adjacent anthropogenic habitats



Subsequent phases of invasion:
range increase and stabilisation by:

- migration along river valleys
- colonisation of further ruderal habitats (fallow land, urban wasteland, railway territory)

(the map after ZAJĄC A. & ZAJĄC M. (eds.) 2001 – slightly supplemented)



A local example of riparian corridor migration of *Acer negundo* in the Bug river valley (source: FALIŃSKI *et al.* 2000)

Fig. 37. Recorded history of the spread of *Acer negundo* L. in Poland – an example of a species which uses river valleys as spreading corridors

lands (1690), Germany and Czechoslovakia (1699) (WEIN 1931; LOHMEYER & SUKOPP 1992) and in Hungary (1872) (BALOGH 2001).

Poland: probably introduced at the turn of the 18th and 19th centuries (KORNAŚ 1968b). It is known that the species was introduced to Cracow Botanical Garden in 1808 (HEREŻNIAK 1992). Subsequent occurrences of this species have been reported in parks in Krzemieniec (1810) and in Niedźwiedź near Cracow (1813) (SENETA 1994). Initially it was planted deliberately, as a fast growing tree. The earliest occurrences of this species refer probably to stations where it was first introduced, e.g. Sznabel, near 1880 *herbarium materials*, WA – Warsaw gardens (after SUDNIK-WÓJCIKOWSKA 1987a). For this reason, an accurate determination of when the species first occurred in the wild is difficult. Undoubtedly, the stations recorded after World War II are spontaneous (Fig. 37). The tree is still grown along roads and in parks due to its undemanding habitat requirements and resistance to drought and frost.

Habitats: willow-poplar carrs, broad-leaved or mixed woods, pine-oak-birch stands and forest plantations, also anthropogenic habitats: fallow lands, roadsides, near cottages, rubble heaps, walls, refuse tips, neglected parks and gardens, hedges, cemeteries, lawns, urban wastelands, tramway tracks, railway tracks and embankments and industrial wastelands (spoil heaps and sedimentation ponds).

Dynamics: although this species has been recorded in Europe for more than 300 years, it has undergone an evident invasion only within the last 100 years, and in Poland only for the last 50–60 years. In some regions of Poland (Wielkopolska) the expansion of this species has been recorded only in the last 30 years (ŻUKOWSKI *et al.* 1995). Currently, it is common in most of the territory of Poland (more than 3500 stations in 1379 ATPOL squares), but rarer in the north of Poland (Western Pomerania, Kuiavian region – Kujawy), particularly rare in the north-east (Warmia and Mazury) and at higher elevations in the mountains (Tatra Mts., Bieszczady Mts.) (Fig. 37). Reported by KORNAŚ *et al.* (1996) from the Western Carpathians as a species established in riverine carrs although only occurring rarely.

The distribution of the Ashleaf Maple in Poland has a characteristic feature in that it reflects the courses of major river valleys (ŻUKOWSKI *et al.* 1995; FALIŃSKI *et al.* 2000; ZAJĄC A. & ZAJĄC M. 2001) (cf. also Chapter 6). It is currently invading new sites.

Padus serotina (Ehrh.) Borkh. [syn.: *Prunus serotina* Ehrh.]

Rum Cherry

Rosaceae

Biology: a tree reaching heights of up to 20 m; in Europe usually of shrub-like form. Flowers in racemose inflorescences, pollinated by insects. Drupe-type succulent fruits with a fleshy pericarp dispersed by fructivorous birds and some mammals.

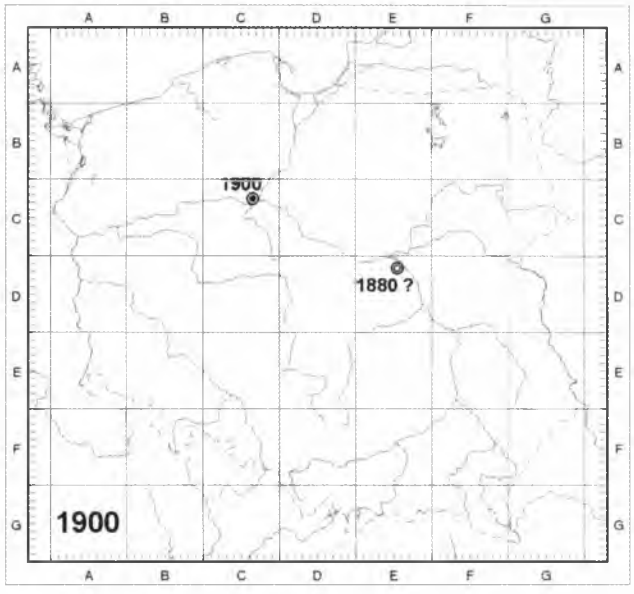
Native range: central and eastern part of North America (Ontario and Quebec and southwards to Texas and Florida) where it grows in woods and clearings, floodplains and thickets by roadsides (CRONK & FULLER 2001) and the northern part of South America (from Mexico to Guatemala).

Secondary range: central Europe, above all the Netherlands, south-eastern France, Germany, Poland and some regions in Austria; reported also in northern Italy, Hungary, Romania, Czech Republic and England (STARFINGER 1997).

History of spread:

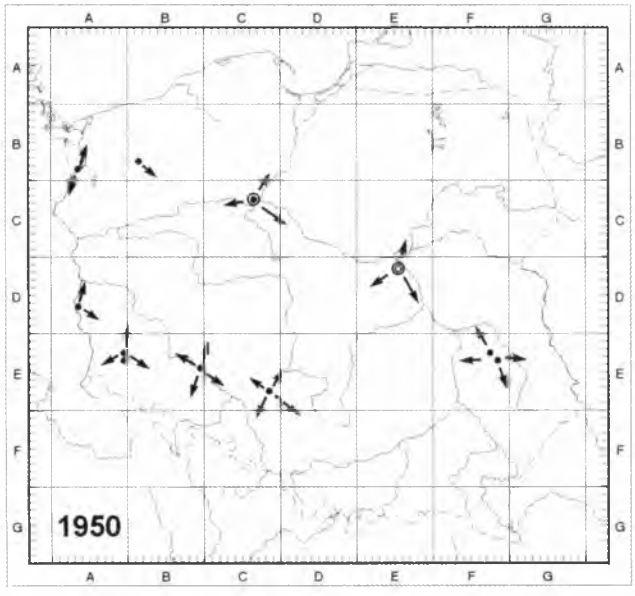
Europe: belongs to the earliest tree plants brought to Europe from North America. 1623 or 1629 is cited as the oldest date of the introduction, when the tree was grown in the Paris area (STARFINGER 1997). Initially grown as a decorative tree in parks, since the late 19th century it has been applied in forestry (such applications as wood production in poor soils or enriching the humus layer in forest plantations, especially of coniferous trees). In the first half of the 20th century, and in the 1980s, it was planted on a large scale in the Netherlands, Germany and in Poland. The first spontaneous stations of this species were recorded in a relatively short time from its introduction, after *ca.* 30 years (KOWARIK 1992). Currently, in a number of countries it is considered an invasive species entering natural and semi-natural habitats, including protected ones (CRONK & FULLER 2001).

Poland: for a long time cultivated in parks and gardens as a decorative tree, quite often planted in forest as undergrowth, and subsequently sowed by birds. In 1813, it was recorded in the collection of the garden in Niedźwiedź near Cracow (HEREŻNIAK 1992). Although the oldest dates recorded in contemporary Poland only go back to the late 19th century (Fig. 38), it may be judged that the species started spreading before that period. This assumption is supported by dates referring to eastern Germany, when it was introduced to cultivation in 1796, and the first "wild" station was recorded in 1825 (KOWARIK 1992). In addition, the localisation of subsequent stations recorded in Poland (north-west and south-west of Poland) in an area belonging at that time to Germany, allows



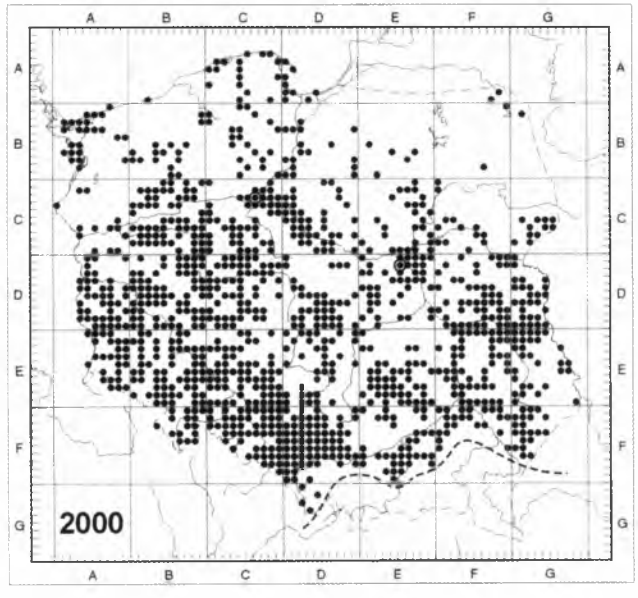
Introduction and initial phases of colonisation:
turn of the 18th century: first plantings in parks and gardens

- first presumably spontaneous locality of occurrence: Bydgoszcz CC26 (Bock 1900)
- Warszawa ED16 (Sudnik-Wójcikowska 1987a) – a dubious record; most probably the record refers to a locality from cultivation



Naturalisation:
naturalisation and spread near sites of cultivation; numerous introductions in cultivated forest plots in many regions of the country have contributed to the naturalisation of this species

spontaneous spread from sites of cultivation



Invasion:
massive introductions (performed as a part of forest management plans) and simultaneous rapid (for a tree species) unaided spread (the fruits are dispersed by birds), which have jointly led to the occupation of the major part of the country within a period of 50 years

local range limit

(the map after Zając A. & Zając M. (eds.) 2001 – slightly supplemented and modified)

Fig. 38. Recorded history of the spread of *Padus serotina* (Ehrh.) Borkh. in Poland – an example of a species which owes its naturalisation in the new homeland to man and birds

for presumptions on the first stages of the expansion of this species in Poland and for formulation of the hypothesis that the species spread mainly in Poland from west to east, and around sites where the species was cultivated and introduced. **Habitats:** oak-hornbeam woods, pine forests and mixed coniferous forests, pine and oak-pine stands. **Dynamics:** the species has staged a rapid expansion in the last half-century, the process being facilitated by foresters who simultaneously introduced it into many forests. Currently, it occurs throughout Poland except for the Carpathians, rarer also in north-eastern regions (recorded in 2564 stations in 1134 ATPOL squares) (Fig. 38; cf. also Appendix A).

Ailanthus altissima (Mill.) Swingle [syn.: *A. glandulosa* Desf.]

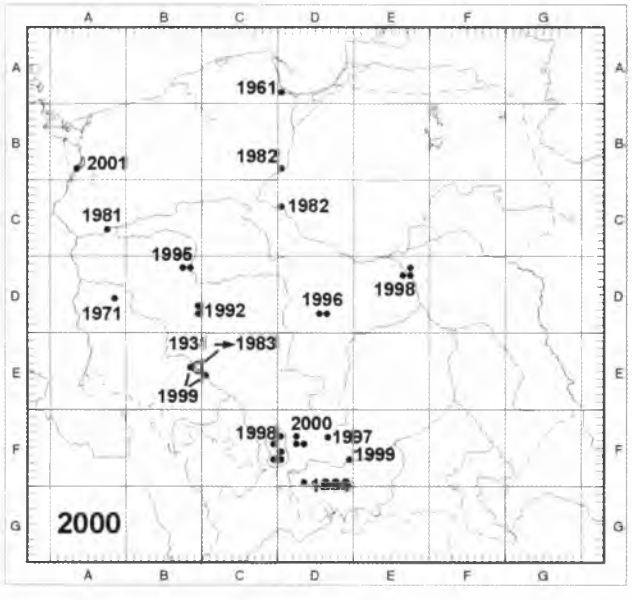
Tree-of-heaven, ailanthus, Chinese sumac, stinking sumac

Simaroubaceae

Biology: tree with polygamous flowers, usually unisexual, growing rapidly and producing great numbers of seeds. Fruits setting as early as between the 10th and 15th year of life. Winged fruits dispersed by wind and water. Capable also of reproduction by suckers.

Native range: north-eastern China

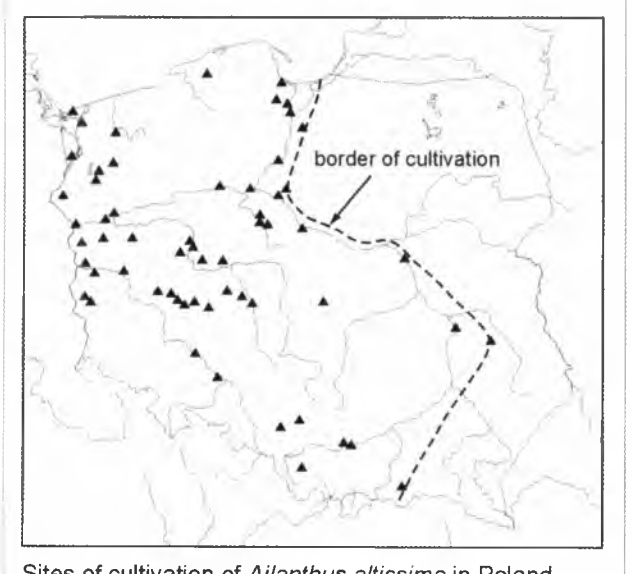
Secondary range: Europe, especially its southern part. Currently, a species is naturalised in the Mediterranean area, where it spreads from urbanised areas along roads, also entering maquis. In central Europe its spontaneous stations are concentrated mainly in cities with specific climatic features, for example in London, Prague, Berlin,



Introduction:
turn of the 19th century first plantings in parks and gardens

○ oldest recorded localities of occurrence (MEYER 1931) are from Wrocław BE49; they probably refer to sites of its cultivation

Initial phases of spread:
spontaneous spread from cultivation sites, exclusively near locations where it was planted



Sites of cultivation of *Ailanthus altissima* in Poland (source: PACYNIAK 1976)

Fig. 39. Recorded history of the spread of *Ailanthus altissima* (Mill.) Swingle in Poland – an example of a species making use of urban "heat islands" in its naturalisation process

Dresden, Leipzig and other German towns, and in Uzhorod (KUNICK 1990; STACE 1997; HARDTKE & IHL 2000; PROTOPOPOVA & SHEVERA 2002).

Apart from Europe, the synanthropic range includes also Australia, the south-eastern part of North America, and Central and South America (LAUENER 1996).

History of spread:

Europe: introduced to Europe by Jesuit Pére d'Incarville in mid-18th century. Introduced into Great Britain in 1751, by Peter Collinson who received the seeds from Pére d'Incarville (LAUENER 1996). At the same time (1760) the tree was also brought into Italy, to the botanical garden in Padua (PIGNATTI 1982). Subsequent introductory dates are cited by LOHMEYER & SUKOPP (1992): 1780 for Central Europe and PYŠEK *et al.* (2002) who recorded 1874 as the first date of the occurrence of the species in the area of what is now the Czech Republic. In 1902 it was recorded in the wild in Germany (KOWARIK 1995a). After the World War II *Ailanthus altissima* colonized ruins of bombed towns. For example, it was recorded in Berlin (SCHOLZ 1957), Stuttgart (KREH 1955), and in Poland in the town of Wrocław (Prof. K. ROSTAŃSKI, *pers. comm.*).

Due to its adaptive capacity to grow in dry habitats, in heavily polluted areas, it was grown alongside other trees in many European and American cities. The unpleasant smell of the staminate flowers growing on separate trees resulted in a number of trees in Paris and American cities being cut down in the early 20th century. Apart from its natural range, once introduced, it rapidly colonises unusable land and all free areas, especially in towns where a hot climate prevails. In many cases it becomes a "pest tree" (LAUENER 1996). In Italian towns it is currently one of the most frequent species of foreign origin (CELESTI GRAPOW & BLASI 1998; CELESTI GRAPOW *et al.* 2001). LANDOLDT (2000) describes the rapid expansion of this tree in Zürich, where it was not invasive before 1980 (in 1988 it was recorded in 29 studied squares, and after 10 years it occurred in as many as 66 squares). In warmer Slovakian areas it occurs along the Dubai River, migrating from ruderal habitats to forest boundaries (UHERČIKOVÁ 2001). Considered as noxious and widely spread "pest" (FERNALD 1950; CRONK & FULLER 2001; PYŠEK *et al.* 2002) (cf. Appendix A).

Poland: brought to Poland in the early 19th century. Became established in cultivation throughout most of Poland, excluding its eastern and north-eastern part (PACYNIAK 1976). It has spread spontaneously in recent years, in cities where it was previously planted (Fig. 39).

Habitats: saplings and young specimens usually grow under walls in cracks between flagstones, on neglected lawns, in hedges, on tramway or railway tracks and on refuse tips. Outside urban areas, single stations have been recorded in open oak-hornbeam woods (ŻUKOWSKI *et al.* 1995) and beech woods (TOKARSKA-GUZIK, *pers. obser.*), where it regenerates both through vegetative and generative processes.

Dynamics: In the most recent 20 years the number of stations in Poland has increased from 6 to 28. The tendency to spread is above all evident in large towns, and its sustenance or possible invasion of new sites will depend principally on climatic factors. The species is not fully frost resistant and long not yet lignified annual shoots freeze during severe winters. The initial stages of expansion are currently being observed in Poland.

Clematis vitalba L.

Traveller's-joy

Ranunculaceae

Biology: strong climbing plant with shoots up to 10 m long; fruits – achenes with flight apparatus, which consist of the style elongating after fertilisation, covered with feathery hairs.

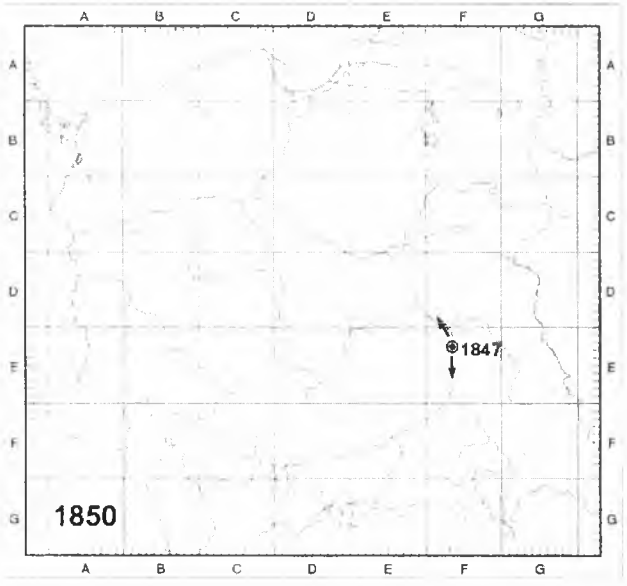
Native range: central, western and southern Europe (to the north it reaches the Netherlands; in the British Isles it is considered a native species in Wales and southern England (STACE 1997)). Also occurs in northern Africa, Asia Minor and the coast of the Caspian Sea (GOSTYŃSKA-JAKUSZEWSKA 1985).

Secondary range: southern Australia, New Zealand, North America; in Europe naturalised in Ireland, Scotland, Germany, Denmark and in Poland. Apart from its natural range it has the status of a widely spread invasive species in many countries, posing a threat to the natural vegetation (CRONK & FULLER 2001).

History of spread:

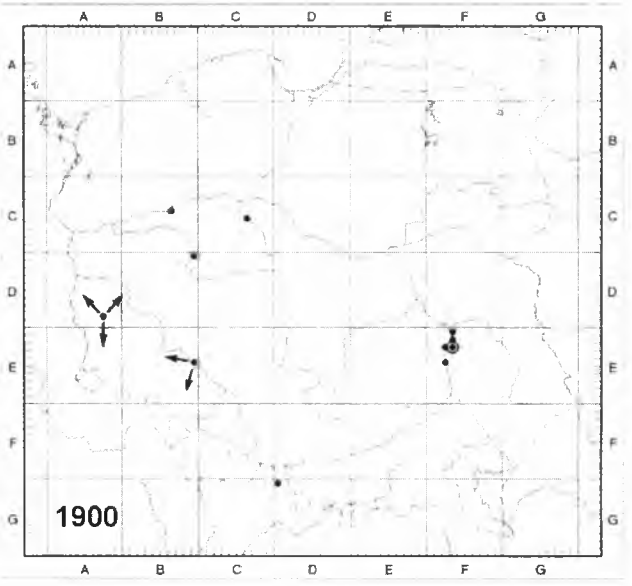
Europe: used as a decorative climbing plant in palaces and garden establishments, often spreading into the wild from these places. For example, it was recorded in Germany as a cultivar in 1663 and 20 years later (in 1883) in the first "wild" station (KOWARIK 1995a). After the World War II, the Traveller's-joy occurred in the ruins of bombed towns, for example in Canterbury (UK) (KENT 1951), in western Germany (KREH 1955), in Gdańsk (SCHWARZ 1961) and in Wrocław (both towns in Poland) (Prof. K. ROSTAŃSKI, *pers. comm.*).

Poland: brought into Poland as early as in the 17th century, or even earlier. SIRENIUS (SYREŃSKI 1613) and subsequently KLUK (1786) report the Traveller's-joy as a plant cultivated in Poland (cf. Appendix A and Chapter 5.2). ŁAPCZYŃSKI (1889) describes this species as spreading beyond its managed confines and occurring along the Vistula River (Solec, Janowiec, Kazimierz) or "tending to be naturalised".



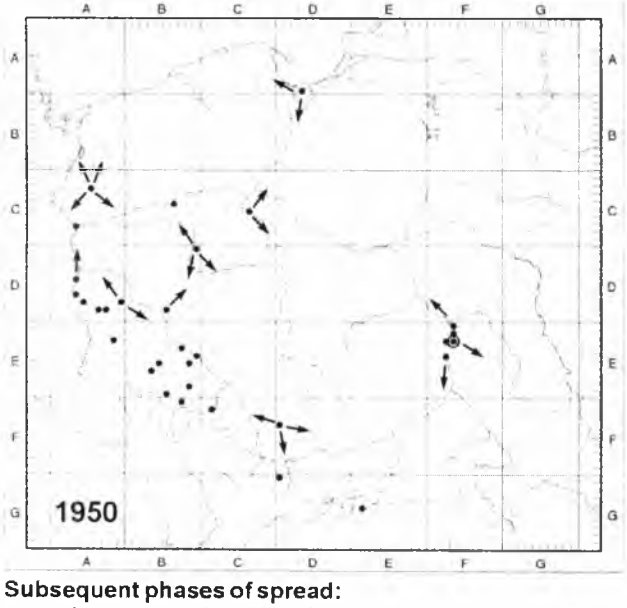
Introduction and initial phases of colonisation:

- 17th century – imported into the country as a decorative creeper (SYREŃSKI 1613)
- 18th century – subsequent introductions into parks and gardens (KLUK 1786)
- ⊛ first presumably spontaneous locality of occurrence: Kazimierz on the Vistula FE23 (WAGA 1847)
- naturalisation and spread close to sites of cultivation



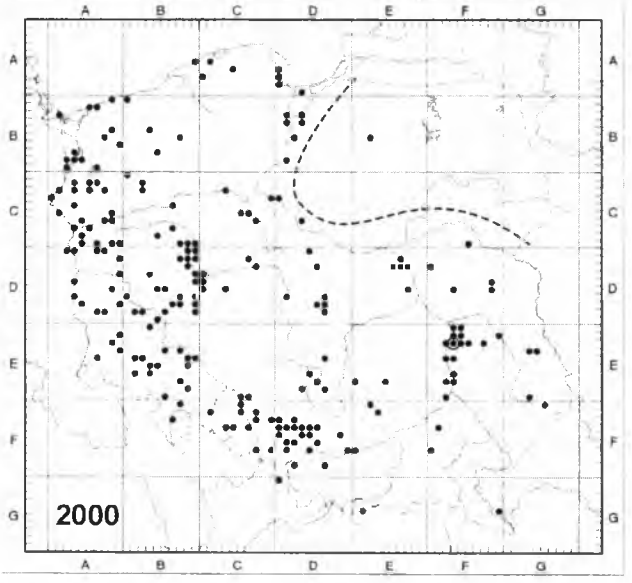
Start of spread:
naturalisation from cultivation with simultaneous continuing introduction; occupation of "bridgeheads" at edges of river valleys

- simultaneous further spread near sites of cultivation



Subsequent phases of spread:
range increase and stabilisation by colonisation of suitable habitats in river valleys and ruderal habitats:

- occupation of new localities, especially in the south-western part of the country



The current distribution reflects the link of this species with individual segments of river valleys (see also Chapter 6) as well as with warm semi-natural and anthropogenic habitats:

- the current north-eastern range limit of this species is delineated by the river valleys of the Vistula and the Bug rivers

Fig. 40. Recorded history of the spread of *Clematis vitalba* L. in Poland – an example of a species escaping from "romantic" gardens

In subsequent years this species was recorded as growing "wild" near places of cultivation across the middle section of the Vistula River and in the western and south-western part of Poland. **Habitats:** sunny slopes with thermophilous vegetation, forest edges, principally oak-hornbeam, stony sites (GOSTYŃSKA-JAKUSZEWSKA 1985); also on ruderal sites: near cottages, wastelands, railway tracks and embankments; around garden allotments and in neglected historical parks. This is a characteristic species of communities of the *Rhamno-Prunetea* class, locally also of the *Pruno-Ligustrietum* association (MATUSZKIEWICZ 2001).
Dynamics: since the first records of occurrence, the number of records built up slowly till the mid-20th century, whilst a more striking increase in

records appeared only after 1950 (Fig. 40; Appendix A). Currently, the species occurs frequently in Western Pomerania and Lower Silesia, reaching eastwards to Puławy, Kazimierz on the Vistula and Chełm (Fig. 40). Recorded on a single station in the Śnieżnik mountain massif (Szeląg 2000). Recorded to-date from 354 stations in 216 ATPOL squares. It is currently invading new sites.

7.2. The history of the spread of useful herbaceous plant species: how medicinal and decorative plants have established themselves in the flora

7.2.1. Examples of species of European origin

Cymbalaria muralis P. Gaertn., B. Mey. & Scherb. [syn.: *C. cymbalaria* Wettst.; *Linaria cymbalaria* (L.) Mill.; *Antirrhinum cymbalaria* L.]

Ivy-leaved Toadflax

Scrophulariaceae

Biology: hemicryptophyte, capable of anchoring on vertical walls, owing to stolons and roots growing at leaf-bases. After blossom is shed, the pedicel elongates and through a negative heliotropism mechanism pushes the fruit into the substrate (e.g. into a crack in a wall), being an example of geocarpy (Buliński 2000); the species disperses also through anemo- and anthropochory.
Native range: southern and south-western Europe: the Southern Alps, the Dinaric Mts., central and southern Italy and Sicily (Webb 1972) where it grows in rock cracks. It has been also reported in North Africa and western Asia (Wojewoda 1963).
Secondary range: central and northern Europe as far as southern Scandinavia; in Eastern Europe in St. Petersburg; in Ukraine (Fedorov 2001; Protopopova & Shevera 2002).

History of spread:
Europe: probably a cultivar already grown in many regions of Europe by the early 18th century. According to Świerkosz (1993, after Segal 1969), this species started migrating from natural habitats in limestone rock in the Mediterranean basin in ancient times. In central Europe it was recorded in the 17th century, dispersing slowly along the valleys of large rivers, e.g. the Rhine. Lohmeyer & Sukopp (1992) quote 1644 as the oldest date for the occurrence of the species outside its native range in the Netherlands. An even earlier date, namely 1640, is quoted by Stace (1997) for the British Isles. Currently, this species is naturalised in many regions where it occupies such habitats as cracks in walls, pavements and stony and regulated (covered with bricks) river banks.
Poland: the determination of when the species arrived in Poland is difficult (Zając E.U. & Zając A. 1973). The first citations go back to the first half of the 19th century, and further more numerous dates go back to the second half of that century (Fig. 41). The first stations for the Ivy-leaved Toadflax were recorded in the Sudety Mts. and in north-western Poland. There is no certainty that the initial dates refer to plants which had moved into the "wild" and naturalised or whether these records refer only to cultivated plants (Zając E.U. & Zając A. 1973). Undoubtedly, as stated by the authors referred to above, *Cymbalaria muralis* spread spontaneously after 1870. A number of authors attribute this process to the plant spreading from sites of cultivation. Other authors (Świerkosz 1993) state that the expansion of its range can be linked to its migration along river valleys. Recent studies conducted in Lower Silesia support the hypothesis of the anthropogenic origin of the majority of stations of this species (Szczęśniak & Świerkosz 2003).
Habitats: occurs in secondary habitats, above all on old walls, less often on rubble, on roadsides and railway tracks and embankments. A species which indicates the *Potentillion caulescentis* order of crevice-related communities on fairly well-lit limestone substrates (Matuszkiewicz 2001) and dominant in the *Cymbalarietum muralis* community.
Dynamics: in Poland the species occurs in the Sudety Mts., in Silesia, Pomerania, Mazovia and Wielkopolska at 350 stations registered to-date in 165 ATPOL squares (Fig. 41, Appendix A). The number of stations of this species, after an evident increase noted in the decades from 1960 to 1980, has not maintained this kind of strong tendency.

Furthermore, many of the earlier recorded stations have not been confirmed recently, which could suggest a gradual retreat of the species. According to Szczęśniak and Świerkosz (2003), this fact should be attributed to the progressively rarer cultivation of this plant in Poland, as well as to the intentional removal of plants from old walls during restoration measures. Buliński (2000) even indicates the necessity for protecting its scarce stations in the Pomerania region.

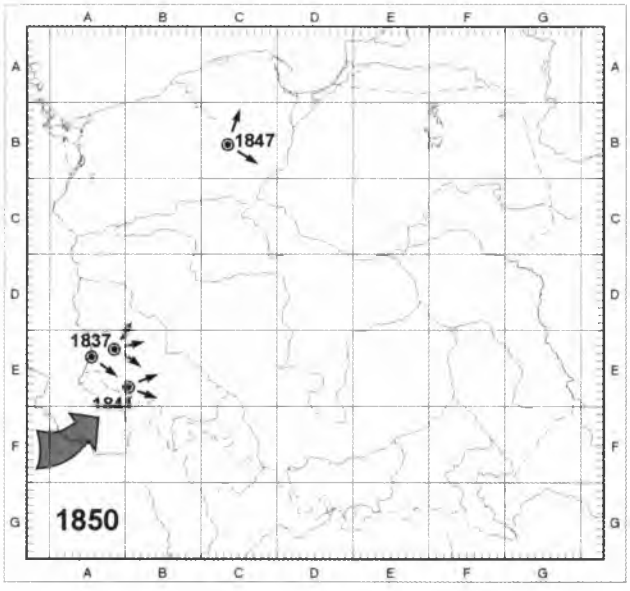
Digitalis purpurea L.

Foxglove

Scrophulariaceae

Biology: biennal or annual plant[29], characterised by very high production of fine seeds dispersed by wind.

[29] In the original distribution range this plant is either biennal or perennial (Hantz 1993; Stace 1997).

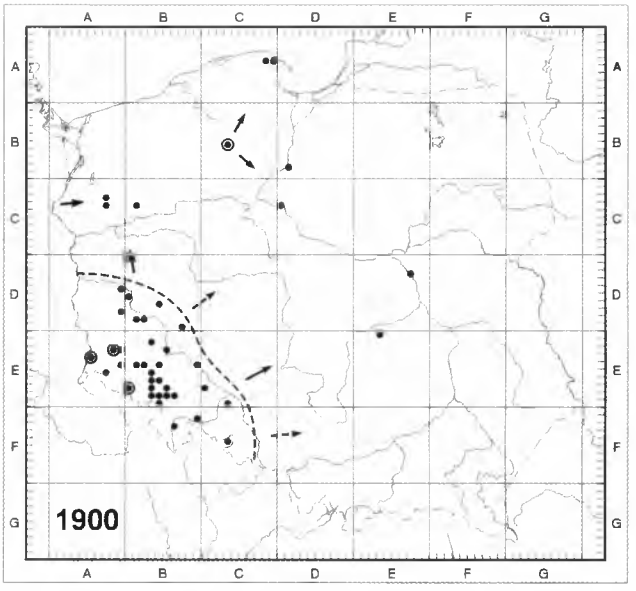


First recorded localities of occurrence:

◉ Sudety Mountains: Bolesławiec AE28, Zgorzelec AE35 (SCHNEIDER 1837), Karpniki BE70 (WIMMER 1841), Western Pomorze: Chojnice AC53 (HAUB 1847) – ATPOL sources

naturalisation and spread near sites of cultivation

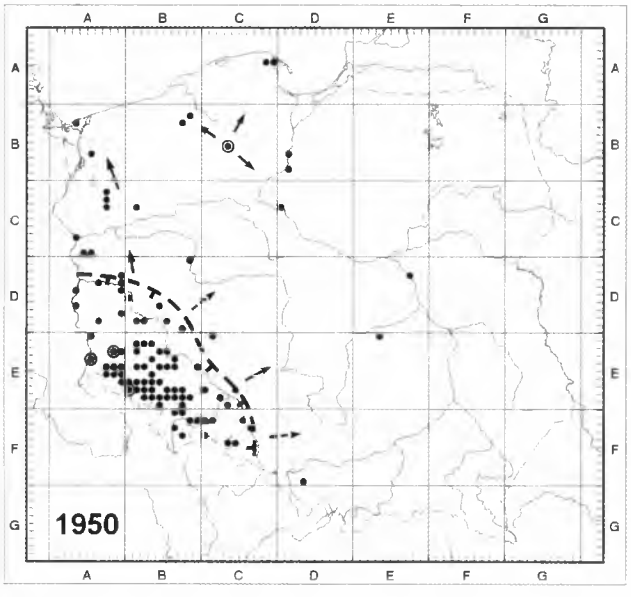
probable direction of origin of this species in Poland



Start of spread:
occupation of new localities and development of the range in south-western Poland

regions of clustered occurrences

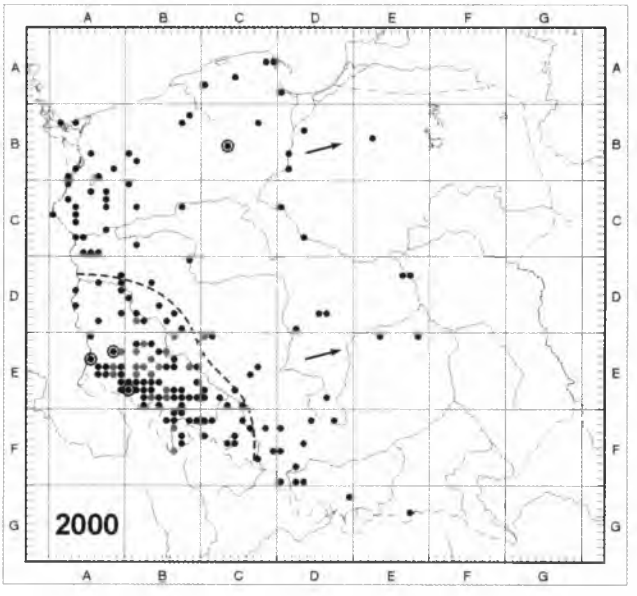
spread of the species in easterly and north-easterly direction



Subsequent phases of spread:
range increase and stabilisation

occupation of new localities in the region of their initial concentration

further spread of the species east and north-east up the Vistula river valley



The current distribution of this species is concentrated mainly in the region of the Sudety Mountains (see also Chapter 6):

a direction of expansion appearing distinctly in the 1980s

a tendency towards gradual loss of localities (localities not confirmed in current studies in the Lower Silesia by SZCZĘŚNIAK & ŚWIERKOSZ 2003)

(the map after ZAJĄC A. & ZAJĄC M. (eds.) 2001 – slightly supplemented and modified)

Fig. 41. Recorded history of the spread of *Cymbalaria muralis* P. Gaertn., B. Mey. & Scherb. in Poland – an example of a species requiring specific habitats for naturalisation

Native range: south-western, western and central Europe, including mountainous areas of southern Europe: Sardinia, Corsica and the Pyrenees. To the north it reaches the British Isles and southern Iceland with isolated stations in the south-western and western part of the Scandinavian Peninsula. In central Europe it is more scarce, occurring primarily in Austria, Switzerland and Germany (HANTZ 1993).

Secondary range: North America, southern Australia, New Zealand and North Africa. According to MEUSEL *et al.* (1978), the so-called potential limit of the occurrence of this species in Europe reaches the eastern limits of the continent. Commonly cultivated and going into the wild state in the European part of Russia, on the south-eastern coast of the Baltic and Crimea (FEDOROV 2001).

History of spread:

Europe: a plant cultivated for a long time in Europe as a decorative or medicinal plant, including beyond its natural range; entering the wild state in some areas. In the area of former Czechoslovakia it was recorded for the first time in 1790 (PYŠEK *et al.* 2002).

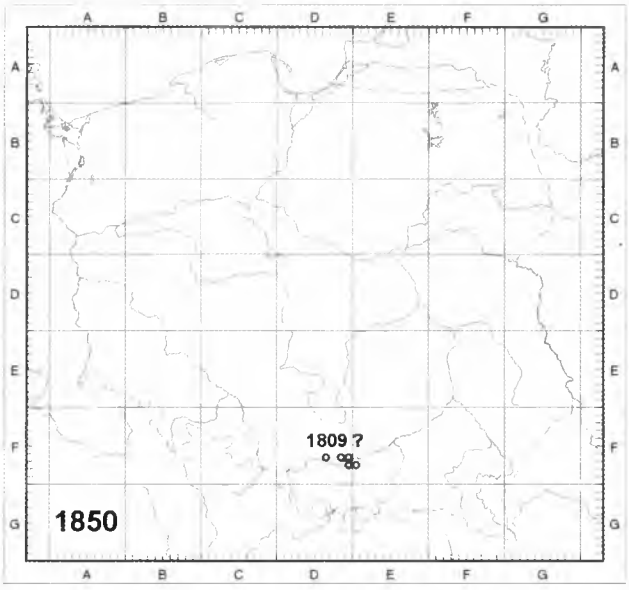
Poland: CYUNEL described the distribution of this species in Poland as early as in 1965. She presented stations in the mountains, as opposed to those in lowlands, as those that most corresponded to natural ones. The historic records from Cracow area provided by BESSER (1809), DEMBOSZ (1841), BERDAU (1859) or ROSTAFIŃSKI's stations (1872) in the Warsaw area were probably ephemeral. The Sudety Mts. and the Beskid Śląski and Mały Mts. are the primary and oldest areas of Poland where the species has spread (Fig. 42). The plant was already known in these areas in the second half of the 19th century (HANTZ 1993). The station on the Klimczok mountain, in the springs of the Biała River in the Beskid Śląski is considered the oldest one in Poland. After that, the species dispersed in the Beskid Mały, Tatras, Karkonosze, Orlickie, Złote and Bystrzyckie Mts. (RADWAŃSKA-PARYSKA 1950; STECKI 1952; PELC 1958; KUCOWA 1963; CYUNEL 1965). RADWAŃSKA-PARYSKA (1950) and CYUNEL (1965) made attempts to solve the issues of the origin of the station in the Beskid Mts. It is supposed that seeds of *D. purpurea* moved to Lower Silesia together with transported spruce seeds (CYUNEL 1965 after Bukowiecki 1950). They may also originate from the mountain plant garden located on the Klimczok. Remaining stations in Poland, including those from Wielkopolska and the Baltic coast have their origin in cultivations in gardens located near houses (SZULCZEWSKI 1951; HANTZ 1987; FILINGER 1992). It is often cultivated as a decorative and medicinal plant and then progresses into the wild state, or simply disperses on its own from its previous stations to new areas. In such areas the decision on the nativeness of the species is difficult (FILINGER 1992). MEUSEL *et al.* (1978) consider south-western Sweden, Denmark, the Netherlands, a part of eastern Germany and several isolated places in Poland as areas of the synantrophic occurrence of this species as a kenophyte (neophyte). These authors treat the whole area of Poland to Finland in the north and Romania and the former Yugoslavia to the south, as potentially an area where this species occurs as ephemerophyte. RADWAŃSKA-PARYSKA (1950) considered the possibilities of the artificial origin of the station of *D. purpurea* in the Tatra Mts. and the following hypothesis. She thinks that the distribution of the Foxglove shown in the map of its range suggests that the Polish stations could be the easternmost outposts of this Atlantic plant. As the climate dried, its range might have retreated westwards. Relict islands remain in Poland in areas with sufficiently high humidity, i.e. above all in montane areas affected by the ocean.

According to FILINGER (1992), the conditions occurring in the Baltic coast region meet these conditions: he found the presence of the Foxglove in forests similar to acidophilous beech forest, in the area of the Słowiński National Park. However, these hypotheses have not been satisfactorily justified, and it is best understood as an undoubtedly alien species in Poland's flora dispersed from areas of cultivation[30].

Habitats: open spruce forests, scrub, felling sites and windfalls, also grasslands and dwarf mountain pine scrub as well as anthropogenic habitats. In the Sudety Mts. and Beskidy Mts., the species forms its own association, *Digitali-Epilobietum* belonging to the *Epilobietea angustifolii* class, for which it is a characteristic species (WOŻAKOWSKA-NATKANIEC 1985; HANTZ 1993). This association occurs in felling sites left after acidophilous beech forest and fir-spruce in the lower montane zone.

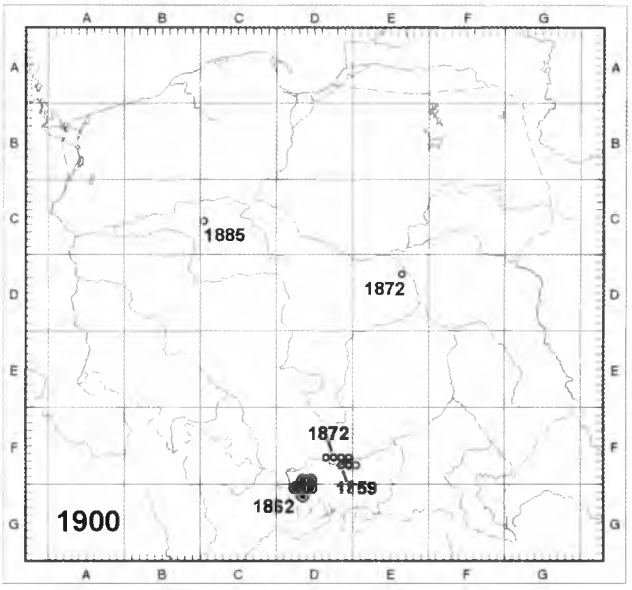
Dynamics: in Poland, most of the stations of this species are concentrated in the western and south-western parts of the country (Sudety Mts., Beskid Śląski Mts. and Beskid Żywiecki Mts.) (Fig. 42). In the Karkonosze Mts., the species was recorded as early as the 19th century (FIEK 1881; SCHUBE 1903b, 1904), and occurs there at the elevation of 850 m a.s.l. (ROSTAŃSKI K. 1977); in the Tatra Mts. – between 1190 and 1240 m a.s.l. (RADWAŃSKA-PARYSKA 1950). Some of the isolated stations in eastern Poland still retain their ephemeral character. The species has to date been recorded on 341

[30] This is a difficult plant to assess because it characteristically appears after disturbance (e.g. felling) increases light in woodlands. Once the site goes back to normal, *Digitalis purpurea* retreats into the seedbank, where it can persist for many years without being seen as abundant minute seeds (GRIME *et al.*1988).



First recorded localities of occurrence:

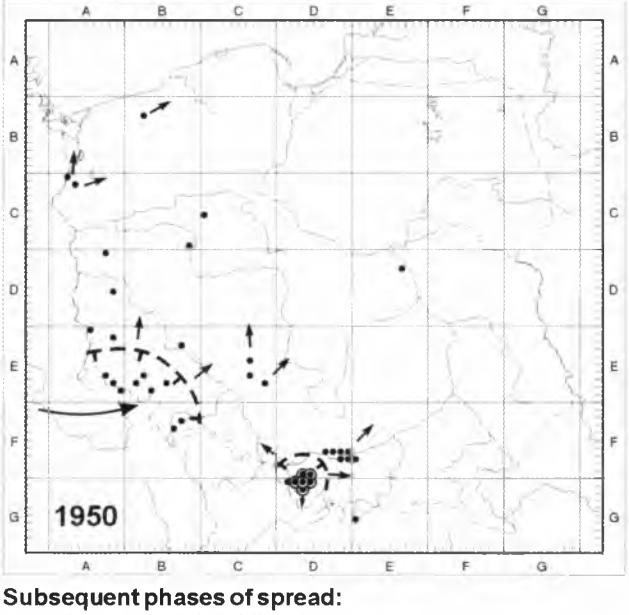
- historical localities from the vicinity of Kraków (BESSER 1809)



Start of spread:
naturalisation and spread near sites of cultivation

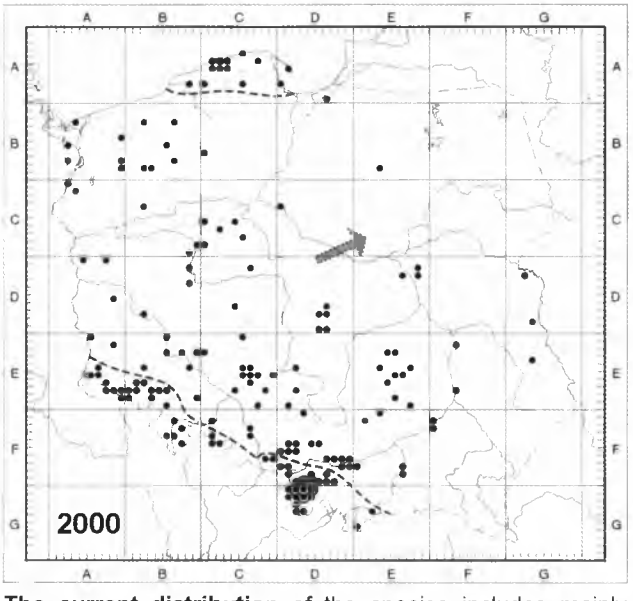
- localities from the vicinity of Kraków: DF66-69, 78, 79, EF70 (DEMBOSZ1841; BERDAU 1859; ROSTAFIŃSKI 1872), Warszawa ED26 (ROSTAFIŃSKI 1872) and Wągrowiec CC50 (NOWICKI 1885) that were ephemeral in character (escapes from cultivation; see the text)
- ◉ the oldest localities in the Silesian Beskid

the appearance of the species in this regions is liked to its accidental import with spruce seed or escape from garden cultivation (mountain plant garden atop the mountain of Klimczok)



Subsequent phases of spread:
range increase and stabilisation

- spread and range stabilisation in the Beskidy and Sudety mountain ranges
- further spread of the species east and north-east (here the main source of its diaspores are sites of concurrent cultivation)
- probable direction of arrival of this species in Sudety Mts.



The current distribution of the species includes mainly the regions of the Sudety Mountains, the western Carpathian Mountains and the Baltic Coast, where the appearance of localities of its occurrence may be linked with accidental importation and further spread – with spontaneous range expansion (see also Chapter 6):

- areas of concentration of localities
- probable direction of further spread

(the map after ZAJĄC A. & ZAJĄC M. (eds.) 2001 – slightly supplemented and modified)

Fig. 42. Recorded history of the spread of *Digitalis purpurea* L. in Poland – an example of a subatlantic species enlarging its range of occurrence in an easterly direction

stations in 169 ATPOL squares (cf. Appendix A). In many regions of Poland there has been renewed interest in this plant as a decorative plant to be used in gardens, which may in the future result in an increase in the number of stations.

Echinops sphaerocephalus L.

Glandular Globe-thistle
Asteraceae

Biology: perennial plant dispersing seeds through exozoochory, anemochory and myrmecochory. Sometimes planted as honey-producing or decorative plant.
Native range: south-eastern Europe: especially Pokucie and Podole where it occurs in the Dniester ravines and its tributaries (Rostański K. 1971).
Secondary range: southern and central Europe, reaching the Caucasus and Siberia (Rostański K. 1971).

History of spread:
Europe: plant brought and long cultivated in many European regions (sown by beekeepers); going into the wild state near areas where it is grown. The level of naturalisation of this species in some areas of central Europe led to its consideration as a possibly an indigenous species (Lohmeyer & Sukopp 1992).
Poland: probably occurred in Poland as early as in 16th century. Referred to for the first time by Sirenius (Syreński 1613) (cf. Chapter 5.2). Before the end of the 19th century found in several stations; in the first half of the 20th century the number of stations increased to 90. The reconstruction of the pattern of spread of this species allows for its classification as one of the oldest of the kenophytes to arrive. It might even be supposed to have been introduced accidentally or brought into Poland even in earlier centuries (Fig. 43).
Habitats: slopes, scrub, roadsides, boundary strips, railway embankments, rubble. A characteristic species of the *Onopordenion acanthii* suballiance and of the *Onopordetum acanthii* association (Matuszkiewicz 2001).
Dynamics: occurring fairly often as early as in the beginning of the 20th century; the number of stations have increased significantly in the last half-century. Up until the present time it has been recorded on 910 stations in all, in 489 ATPOL squares. Currently scattered across the whole of Poland, locally rarer, e.g. in mountains (Kornaś *et al.* 1996; Szeląg 2000) (Fig. 43 and Appendix A). Gradually colonises new sites.

7.2.2. Example of species of Asian origin

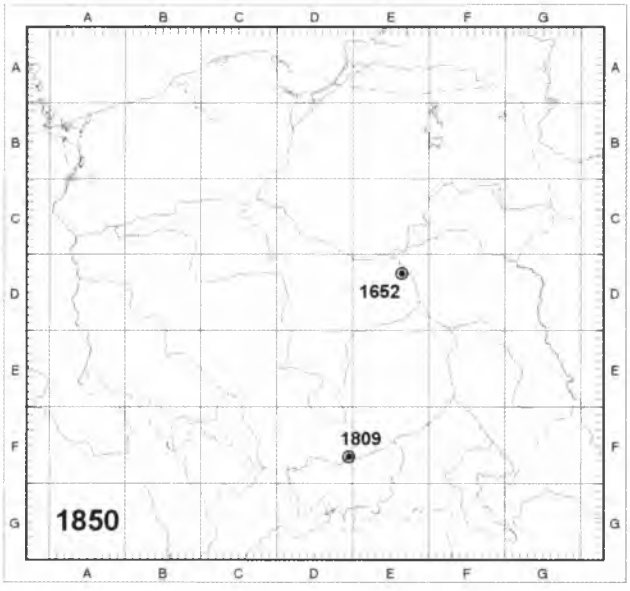
Elsholtzia ciliata (Thunb.) Hyl. [syn.: *E. patrinii* (Lepech.) Garcke; *E. cristata* Willd.; *Sideritis ciliata* Thunb.; *Mentha partinii* Lepech.]

Lamiaceae

Biology: annual plant dispersing through anemochory, zoochory and anthropochory.
Native range: central part of the former Soviet Union, central and eastern Asia (Grodzińska 1985) where this species occurs in the fields, along riverbanks, along forest roads; also cultivated. General distribution has been given by Fedorov (2001).
Secondary range: central Europe (excluding the British Isles – Stace 1997) and North America.

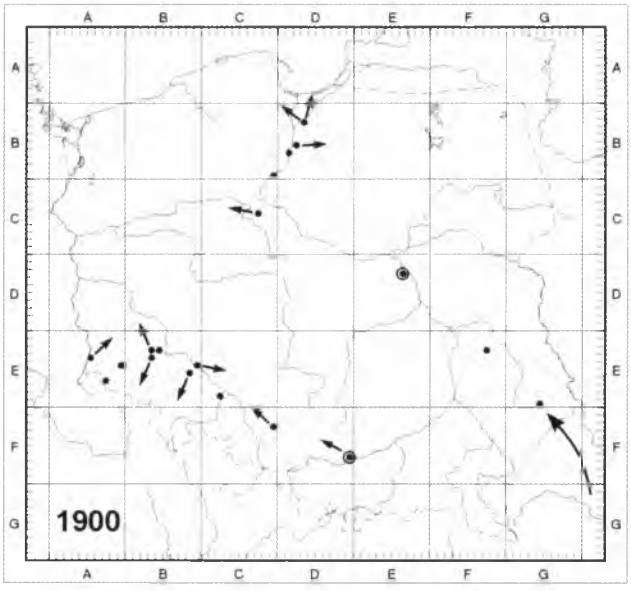
History of spread:
Europe: species once grown, especially by Slavs as a health-giving plant (Krawiecowa 1951), progressed to the wild state near sites of cultivation and introduced accidentally into a number of European regions, possibly via Poland. Previously recorded in Lithuania by Górski in 1830 (after Gudžinskas 1998a). Recorded for the first time in Czech Lands in 1853 (Pyšek *et al.* 2002).
Poland: first stations evident from the first half of the 19th century (Fig. 44, see p. 80). In 1872 the plant was found again in the Warsaw area by Rostafiński, and in 1873 it was recorded by Karo (*herbarium*[31]: UW and W) in the Łosice area (eastern Poland). In the foreland of the Carpathians it was collected in 1877 in the Przemyśl area (Kotula, *herb.* KRAM). Up until the end of the 19th century it was recorded in 65 stations. In the 1930s it was common in villages, and along roadsides in the Dynowskie and Przemyskie Plateau (Batko 1934). In the central part of the Carpathians it was found in the 1950s in the Gorce Mts., in Gubałowskie plateau and in the Polica range (Guzikowa 1972). In the Pieniny Mts. it was found by Zarzycki (1969). In the Beskid Żywiecki it was less common, up to an altitude of 500 metres (Białecka 1982).
Habitats: roadsides, around cottages, ruderal sites.
Dynamics: scattered across the lowlands, occurring more often in the north-east and east of Poland (Fig. 44). An evident increase in the number of stations appeared in the second half of the 20th century. In subsequent years the species has gradually expanded its range moving from east to west. Kornaś (1950) reported *E. ciliata* from

[31] Acronyms of names of herbaria are introduced in explanations to Appendices A and B.



Introduction and first records:
– 17th and 18th centuries: first mentions of the presence of this species in the territory of Poland (SYREŃSKI 1613)

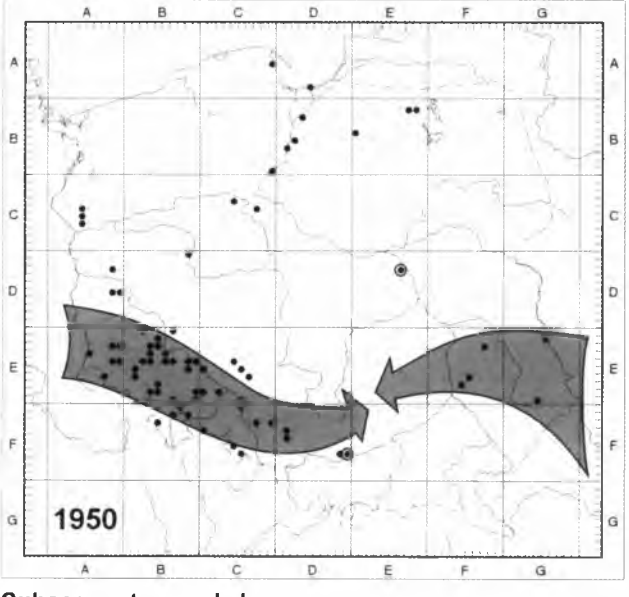
◉ first recorded localities of occurrence: Warszawa ED16 (from SUDNIK-WÓJCIKOWSKA 1987a), Kraków DF69 (BESSER 1809)



Start of spread:
occupation of new localities in south-western Poland and in the upper Vistula valley which were probably located in the vicinity of cultivation sites

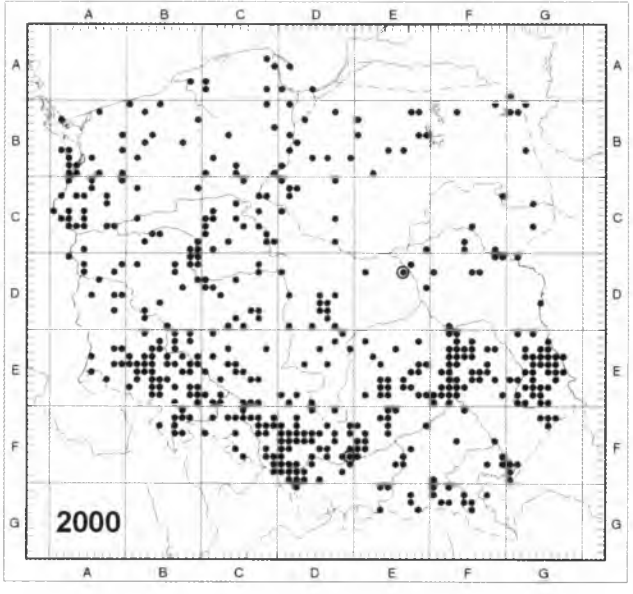
directions of further spread

direction of importation of species from south-eastern Europe



Subsequent spread phases:
range increase
– a tendency to an increase in the density of localities, mainly in south-western Poland

the main migration fronts



The current distribution of this species is linked to upland areas and to sites of cultivation

(the map after ZAJĄC A. & ZAJĄC M. (eds.) 2001 – slightly supplemented)

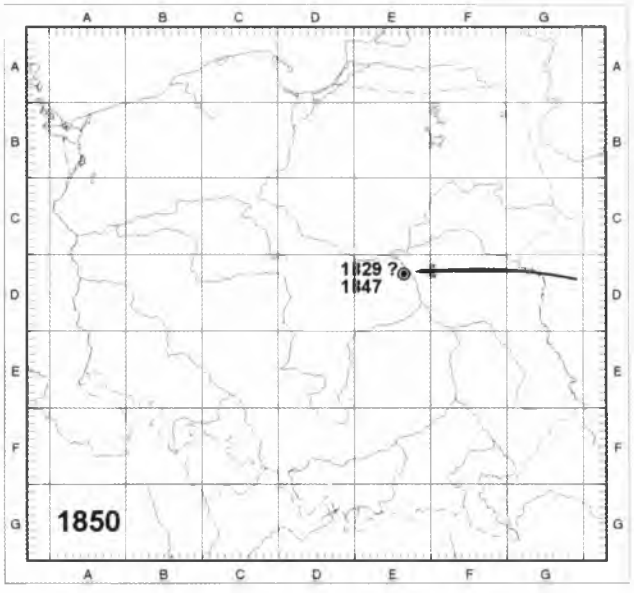
Fig. 43. Recorded history of the spread of *Echinops sphaerocephalus* L. – one of the oldest kenophytes in the Polish flora

the area around Cracow as a common plant, occurring locally on a massive scale and expanding its range. Similar characteristics were provided by GUZIKOWA (1972), i.e. presenting it as a species expanding across Poland, with migration from east to west (1352 stations recorded in 814 ATPOL squares). In most recent years there has been a tendency for decreasing population numbers in the previously known stations and even a total disappearance in some stations, because of the elimination from the landscape of Polish villages and small towns representing the habitats preferred by this species (cf. also Chapter 6).

Impatiens glandulifera Royle [syn.: *I. Roylei* Walp.]

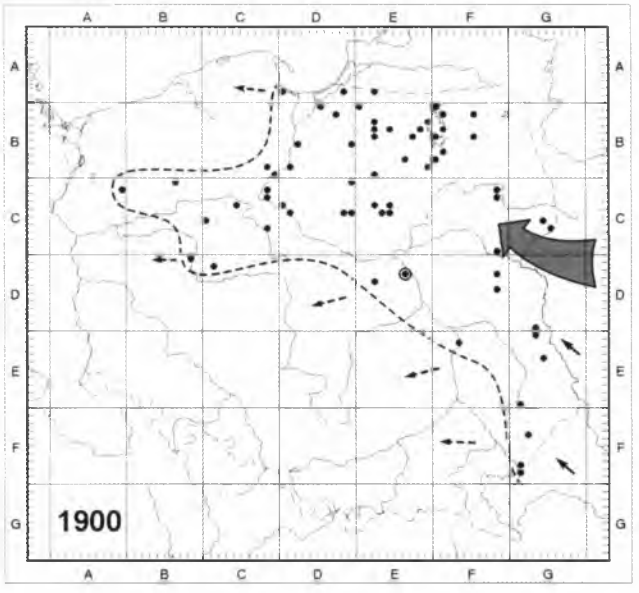
Indian Balsam

Balsaminaceae



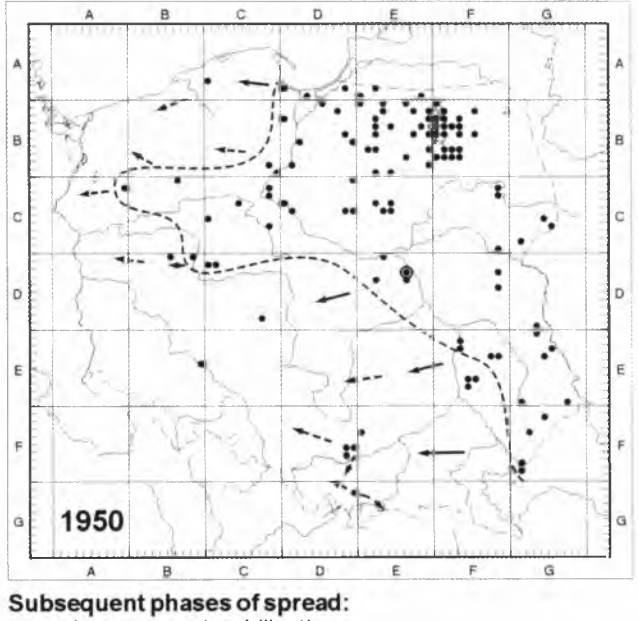
First recorded localities of occurrence:

- Warszawa DF16 (from WAGA 1847 and SUDNIK-WÓJCIKOWSKA 1987a), for these first localities the plant was probably growing after escape from cultivation or accidental import with long-range transport of goods



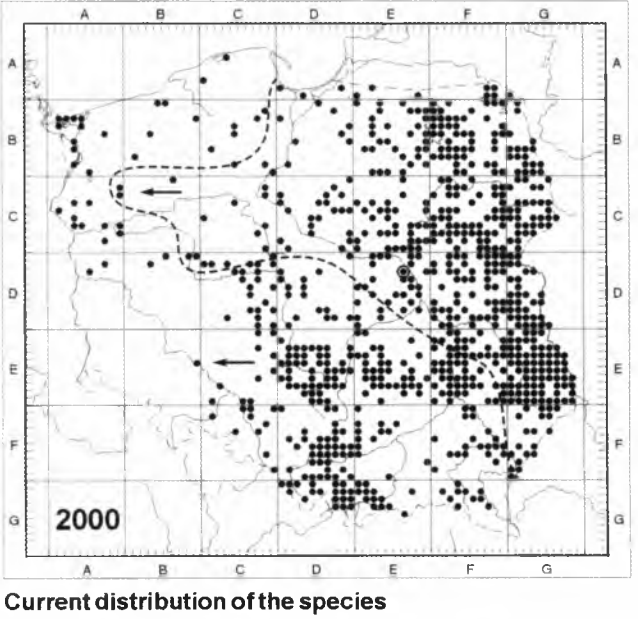
Start of spread:
migration of the species from the east towards the west: occupation of new localities, mainly in the north-eastern part of the country

- main direction of arrival of the species in Poland
- migration of the species from Ukraine
- contemporary range limit
- direction of further expansion



Subsequent phases of spread:
range increase and stabilisation:
a tendency to an increase in density of localities in north-eastern Poland

- further spread of the species to the west



Current distribution of the species

- a direction of spread appearing distinctly in the 1980s

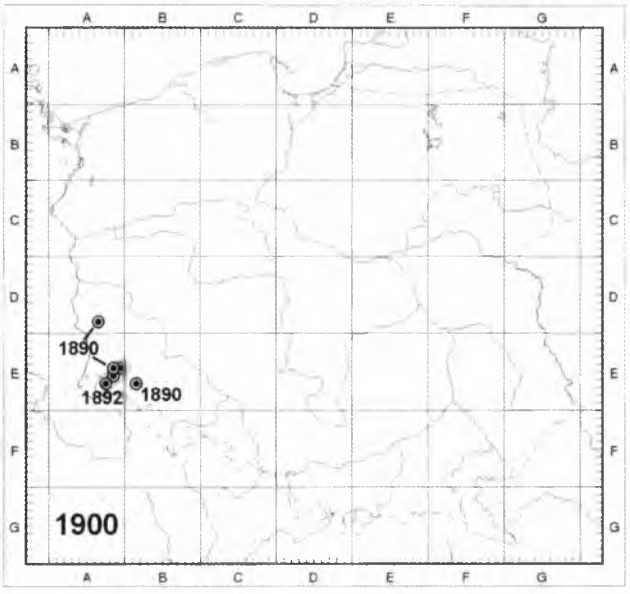
Currently a tendency to the gradual of localities was recorded under a whole range of species in Poland

Fig. 44. Recorded history of the spread of *Elsholtzia ciliata* (Thunb.) Hyl. in Poland – an example of a species transiently enlarging its range in a westerly direction

Biology: annual plant with high level of seed production. Diaspores disperse via two ways: by autochory[32] and by allochory: through wind, animals and water.

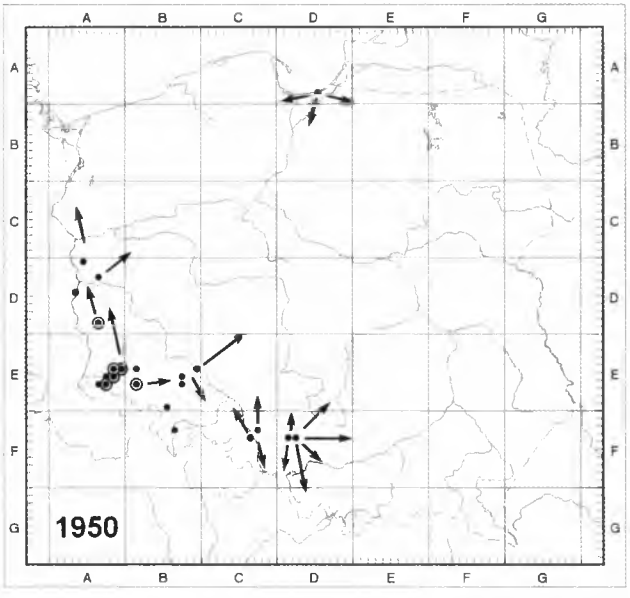
Native range: the Himalayas and eastern India where it grows in humid riparian forest at an altitude 1800–3000 m a.s.l. (LHOTSKÁ & KOPECKÝ 1966).

[32] In the case of the Balsams, autochory is implemented through the process called ballochory, where a ballistic mechanism causes throwing out (hurling) of diaspores following the abrupt release of a tension in the fruit and triggering movements of the pericarp walls (PODBIELKOWSKI 1995).



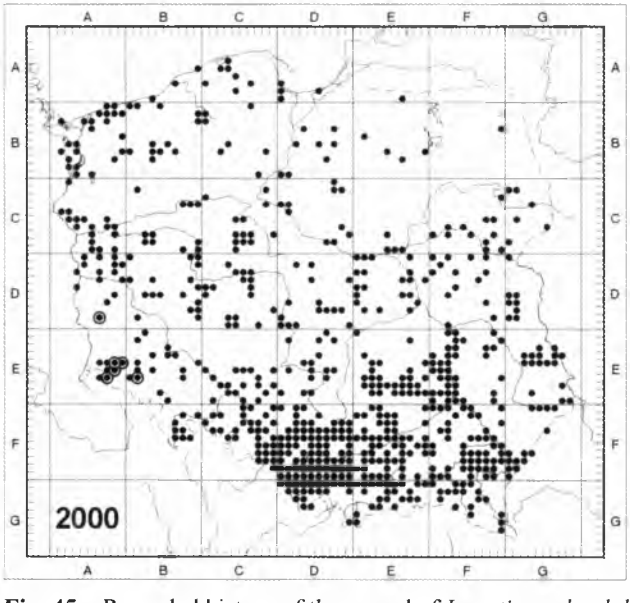
First recorded localities of occurrence, probably escapes from cultivation:

- the Sudety Mountains: Siodło AD86, Płóczki Dolne AD48, Stępnica AD48 and Płonina BE61 (SCHUBE 1903b)



Start of spread:
naturalisation close to cultivation sites:

- occupation of new localities, especially in the south-western part of the country
- directions of spread



Subsequent phases of spread:
range increase and stabilisation
further naturalisation from cultivation sites and autonomous spread from previously occupied localities

Current wide distribution of the species in the territory of Poland with regions of clustered occurrences in the southern part of the country

Fig. 45. Recorded history of the spread of *Impatiens glandulifera* Royle in Poland – an example of an ornamental garden plant escaping into ruderal habitats and migrating into riverside habitats

Secondary range: central and northern Europe (extending by central Scandinavia).

History of spread:
Europe: the history of the expansion of the Indian Balsam in Europe started in the first half of the 19th century since it was cultivated as a decorative and medicinal plant in the gardens of universities, convents or monasteries, and later on also in private gardens. The first information on the cultivation of this species in Europe dates back to 1839, from the botanical garden in Kew (Great Britain) (Lhotská & Kopecký 1966; Zając E.U. & Zając A. 1973), and after that it was recorded in Austria: Linz area (1845), Vienna (1871), Innsbruck (1880) (Drescher & Prots 2003).

Since then it has been grown in the gardens of a number of European countries and it spread to nearby ruderal habitats and next to riparian ones. The first spontaneous, wild stations were recorded in England (Middlesex) in 1855 (Perrins *et al.* 1993), in Austria in 1898 (over the Weidling River near Klosterneuburg) (Drescher & Prots 2003).

In many countries it is referred to as a serious and widespread weed invading semi-natural or natural habitats (Cronk & Fuller 2001). In England it was given weed status as long ago as 1898 and currently it is considered as the most invasive and common species of the genus (Perrins *et al.* 1993).
Poland: first stations of plants which progressed into the wild state in Poland were recorded by Schube (1903b) in Lower Silesia in 1890 (Fig. 45). By 1940, spontaneous occurrences of the Indian Balsam were recorded in 21 squares, mainly in south-western Poland and an isolated station in northern Poland, in the Wiślane Marshland (Mierzeja Wiślana). After that in the subsequent 40 years, this species also expanded in southern, south-eastern and central Poland as well as in Pomerania. Few stations had been recorded in north-eastern Poland until 1980.
Habitats: human-made habitats such as: built-up areas, cemeteries, allotments, refuse heaps, urban wastelands, abandoned fields, and more often in drainage and roadside ditches. It is also recorded from more natural habitats, namely: scrub, forest edges and most frequently from riparian habitats (Tokarska-Guzik 2003a & c). It has been noted from the Odra river valley in riverside, and periodically in the flooded forests of *Alno-Padion*, but the biggest stands were classified as *Impatienti-Calystegietum*, which prefers semi-shaded forest edges, not far from the river (Dajdok *et al.* 1998, 2003). It has been described also from poplar-willow carrs *Salici-Populetum* (Jasnowski 1961, Zając E.U. & Zając A. 1973). It forms an aggregative community in the association class of *Artemisietea vulgaris* (Matuszkiewicz 2001).

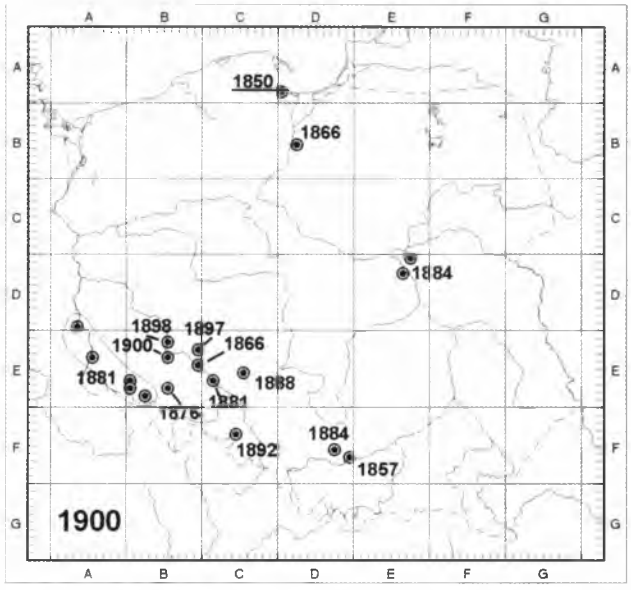
Dynamics: in Poland it is still cultivated and crossing into the wild state; dispersing spontaneously from newly colonised sites. The number of sites began to increase in the 1960s, and a remarkable growth thereof has appeared since the 1970s (Fig. 45). At present, it is scattered throughout the national territory (1574 stations in 675 squares) (cf. Appendix A). The regions of its frequent and massive occurrence are located in the southern part of Poland: the Carpathians, Silesian Upland, Kraków–Częstochowa Upland, the southern part of the Silesian Lowland and Małopolska part of Vistula river valley. The species prefers river valleys (particularly mountain and foreland rivers), occurring often along the upper course of the Vistula and Odra rivers and their tributaries, e.g. often found along the Soła, San, Wisłoka, Skawa and Olza. The species still colonises new sites in many regions, particularly along rivers.

Impatiens parviflora DC.

Small Balsam
Balsaminaceae

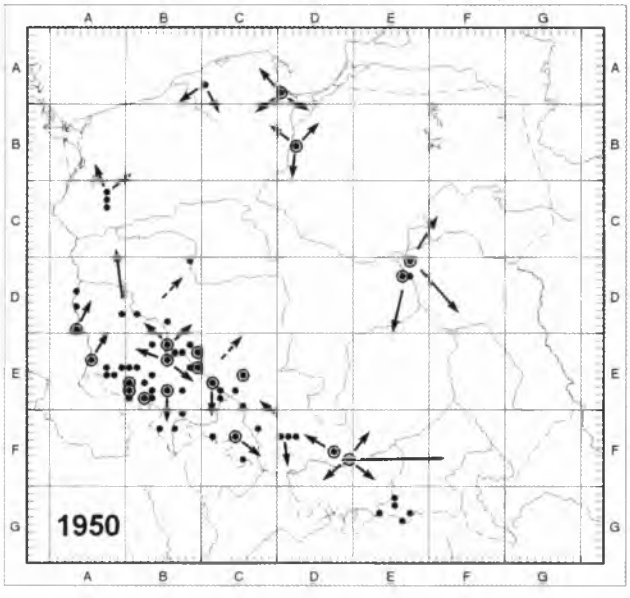
Biology: annual plant which produced a high number of seeds. As in the previous species, the diaspores disperse in two ways: autochorically (as a result of ballochory) and allochorically through wind, animals and water.
Native range: southern Asia, Siberia, Mongolia and Turkistan.
Secondary range: central and northern Europe excluding northern and western Scandinavia.

History of spread:
Europe: the first map of the synantrophic range of this species in Europe was developed by Meusel *et al.* (1978), citing the earliest dates for the occurrence of this species in Europe: 1834 (Russia), 1837 (Germany), 1848 (Great Britain). In the mid-19th it was already observed in a number of localities in western and central Europe. Kamieński (1884b) considered that the species was introduced accidentally by travellers and described the migration route as follows: "the plant was moved to Western Europe by sea, which was a considerably longer route than by land, and even today transport by this route is very difficult". Other botanists state that the Small Balsam is a refugee from botanical gardens.
Poland: it was recorded for the first time in Poland in 1850, in the Gdańsk area (Meusel *et al.* 1978), whilst subsequent records cite the Wiślane Marshland (northern Poland) in 1866 (Klinggraeff 1866). At the same time, the station of the Small Balsam was noted in the Cracow (Ullepitsch *herb.* B) and Wrocław areas (Uechtritz *herb.* W) (Fig. 46). In the Warsaw area it was found by Kamieński (1884b) in parks



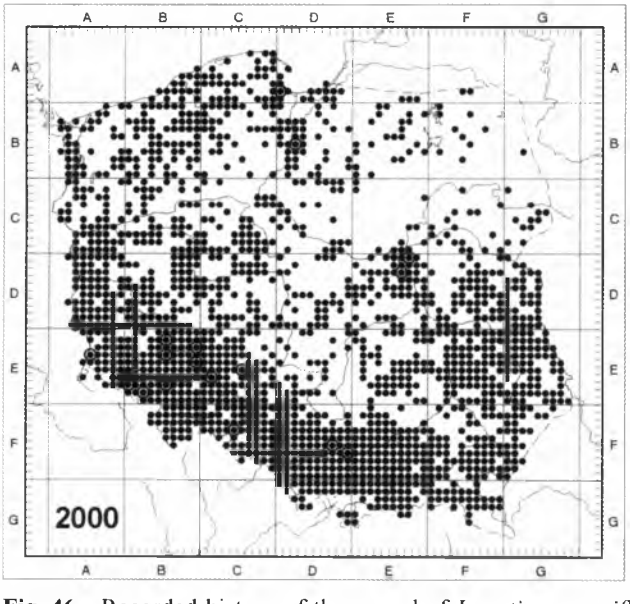
Start of spread:

- first recorded localities of occurrence: environs of Gdańsk DA80 (MEUSEL *et al.* 1978), Vistula Żuławy (North Poland) (KLINGGRAEFF 1866) as well as Kraków DF69 (ULLEPITSCH, *herb.* B) and Wrocław BE49 (UECHTRITZ, *herb.* W)



Subsequent phases of spread:
range increase and stabilisation

- rapid occupation of new localities, especially in south-western Poland
- directions of spread



Current wide distribution of the species in the territory of Poland with regions of clustered occurrences in the south-western, southern and south-eastern parts of the country

Fig. 46. Recorded history of the spread of *Impatiens parviflora* DC. in Poland – a species escaping from botanical gardens, becoming established in ruderal habitats and naturalised in forests as the "obtrusive Mongol"

and gardens. In former floristic papers it was reported as a species occurring in ruderal places (KLINGGRAEFF 1885; ABROMEIT *et al.* 1898), but as early as in the 1950s it was also found in various types of forests, mainly deciduous ones.

Habitats: Forests (oak-hornbeam, ash-alder riparian carrs, willow-poplar carrs, beech forests, mixed coniferous forests, oak-pine forests), and anthropogenic habitats: parks, cemeteries, garden allotments, wastelands, cottage yards, refuse tips and railway tracks and embankments. A characteristic species for the *Alliarion* alliance (MATUSZKIEWICZ 2001); sometimes a separate association with the predominance of Small Balsam is distinguished as *Impatientetum parviflorae*.

Dynamics: by the end of the 19th century it had been reported from 35 localities in 19 ATPOL squares. Massive expansion of *I. parviflora* started in 1960s, and up to the present date it has been recorded in over 6730 localities in 1681 squares (cf. Appendix A). ZAJĄC-SYCHOWA (1971) describes the species as widespread in the lowlands and in lower mountain regions (in the Gorce Mts. it reaches an elevation of up to 610 m a.s.l., in the Sącz region – of up to 480 m a.s.l.), in gardens, near fences, on roadsides, and is also found upon streams and in humid, shadowy sites.

Currently it is widespread throughout the national territory of Poland, although more common in the southern part, and rarer in the north-east. Often found in the Ciężkowice Foothills (Western Carpathians) where it grows in ruderal habitats but also in forests (KORNAŚ *et al.* 1996), and in the Beskid Żywiecki Mts. (BIAŁECKA 1982), the Beskid Śląski and Beskid Niski. Accidentally introduced into lower locations in the Tatry Foothills, the maximum elevation recorded in the Tatra Mts. is 1150 m a.s.l. (PIĘKOŚ-MIRKOWA & MIREK 1978). In the Karkonosze National Park the species was recorded in stations at 950 m a.s.l. (ROSTAŃSKI K. 1977). SZELĄG (2000) reported this species from the Śnieżnik mountain massif and Bialskie Mts. as often occurring in lower sites, and permanently established in deciduous forests and scrub. GUZIKOWA (1972) reconstructed the spread of this species in the Pieniny Mts., referring to the earliest records by PAWŁOWSKI (1925) from Szczawnica and by KULCZYŃSKI (1928) from the Krościenko locality. Its penetration into the Pieniny National Park occurred from the villages, particularly along the tourist trails from Szczawnica and Krościenko on Sokolica Mt. In the early 1970s, the species was widespread in the region and not only in ruderal habitats but also in osier beds upon the Dunajec and Krośnica rivers and in natural forest habitats on the eastern side of the Park. This species does not occur in the Bieszczady National Park (ZEMANEK & WINNICKI 1999). It is extending its range eastward: first recorded in the Ukraine in 1908 (Dr M. SHEVERA, *pers. comm.*). In Poland it is an invasive species (cf. Appendix A).

Reynoutria japonica Houtt. [syn.: *Fallopia japonica* (Houtt.) Ronse Decraense; *Polygonum cuspidatum* Siebold & Zucc.; *P. zuccarinii* Small; *Polygonum sieboldii* hort. non DC.; *Pleuropterus cuspidatus* (Sieb. & Zucc.) Moldenke; *P. zuccarinii* (Small) Small; *Tiniaria japonica* (Houtt.) Hedberg]

Japanese Knotweed

Polygonaceae

Biology: a conspicuous rhizomatous perennial plant, dioecious with dioecious or gynomonoecious flowers, spreading mainly through vegetative processes (TOKARSKA-GUZIK, *in press*, cf. references therein).

Native range: includes Japan, Korea, Taiwan, northern China where it occurs in humid, open areas on hills and mountains, on roadsides, and on the banks of ditches (TADE ZOKU 1965; BAILEY 1999). In addition, it often occurs in grassy communities formed by *Miscanthus sinensis* (CRONK & FULLER 2001). It grows on various soils, colonising even volcanic soils (OHWI 1965; BAILEY 1999).

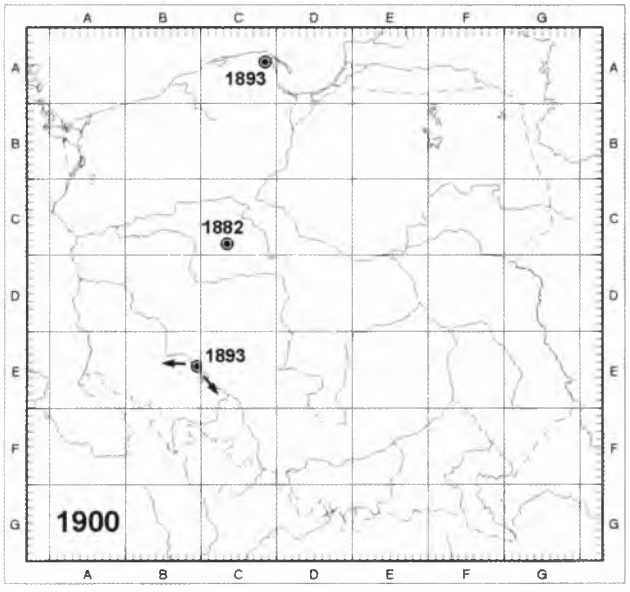
Secondary range: extended to Europe, Canada, USA, New Zealand and some areas in Australia. Maps developed to date include Europe (JALAS & SUOMINEN 1988) and some specific European countries: the Czech Republic (SLAVIK 1986), the UK (CHILD & WADE 1999, 2000), Poland (ZAJĄC A. & ZAJĄC M. 2001) and the US and Canada (SEIGER 1997).

It is frequent in a number of European countries, more so in the northern and central part of the continent. BEERLING *et al.* (1995) state that its current distribution is determined by climatic factors. The northern boundary demarcates a combination of factors such as the length of the vegetative season and minimum temperatures in winter (BEERLING 1993). Water availability in soil and temperature delineate the southern boundary. Although in Europe its range is contained between a latitude of 42°N and 63°N, and its natural range is between 22°N and 45°N, it is analogous climatic zone (BEERLING *et al.* 1995).

In some European countries (England, Germany) it is considered a widespread invasive species, also entering natural and semi-natural habitats (CRONK & FULLER 2001) (cf. Appendix A).

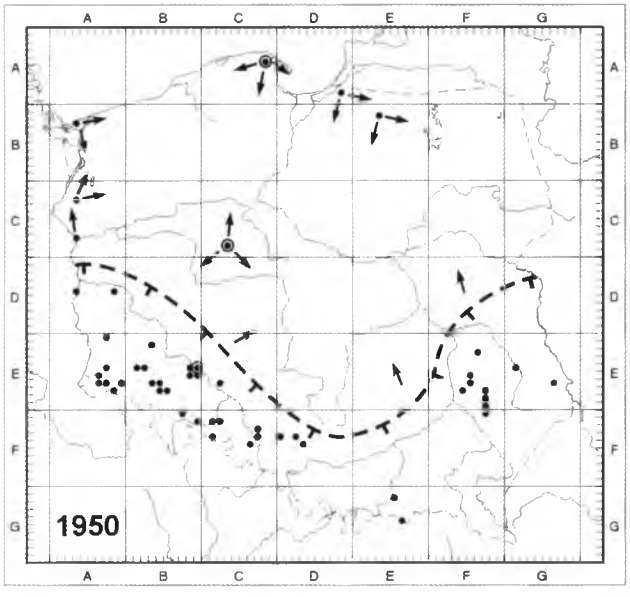
History of spread:

Europe: brought to Europe as a decorative plant, probably by Philippe von Siebold who stayed in Japan from 1823–1829. In 1847, Japanese Knotweed won a golden medal award bestowed by The Society of Agriculture & Horticulture in



First recorded localities:

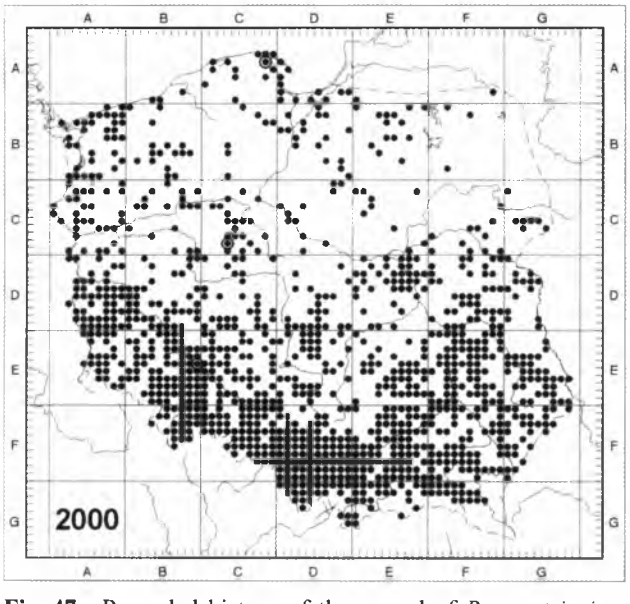
- West Poland: Gniezno CC83 (CYBICHOWSKI *herb.* POZ), Wrocław BE49 (BAENITZ *herb.* WU), North Poland: Darzlubie CA48 (GRAEBNER 1894)



Subsequent phases of spread:

occupation of new localities, predominantly in the southern part of the country

directions of further spread



The current distribution of this species is an effect of fast spread rate, especially in river valleys where it forms compact monospecific phytocoenoses which often occupy extensive areas in the habitats of former willow-poplar forests and thickets. It also occurs commonly in urban areas and railway territory (the map after ZAJĄC A. & ZAJĄC M. (eds.) 2001 – slightly supplemented)

Fig. 47. Recorded history of the spread of *Reynoutria japonica* Houtt. in Poland – an example of an invasive plant using vegetative reproduction to spread

Utrecht, as the most interesting decorative species of the year (BAILEY & CONOLLY 2000), and as early as in 1848 it was commercially available. The re-introduction of *R. japonica* to a number of European countries was probably launched by the nursery in Leiden (the Netherlands), which offered seedlings for botanical gardens with a 25% discount.

The first receipt of seedlings of *Polygonum sieboldii* in the Botanical Garden in Kew (England) from Leiden, was recorded in the catalogues on October 9, 1850. Botanical gardens, gardeners who sung its praises in professional magazines and private collectors all played an essential role in the dissemination of this species (BAILEY & CONOLLY 2000).

Detailed information on the occurrence of *R. japonica* in a wild state in Europe is scarce (BAILEY 1999). HEGI (1910) published information on the application of this plant for stabilising dunes being followed in Helgoland, which was published as early as in 1861, and these efforts continued. The earliest incidents of "escapes" of *R. japonica* from cultivation areas were reported in Germany (the Rhur area) and Great Britain (Wales) where the plant was introduced onto coal and slag heaps (CONOLLY 1977; BAILEY 1999). In Germany it was also used by hunters as camouflage for raised stands (BAILEY 1999 after ALBERTERNST *et al.* 1995). 1886 is reported as one of the first dates in the UK, when *R. japonica* escaped from its areas of cultivation (HOLLINGSWORTH & BAILEY 2000). Until the late 19th century there were only seven stations of *R. japonica* in the British Isles (CONOLLY 1977). Since 1940, the number of the stations has been growing rapidly (CHILD & WADE 1999).

Poland: the first station for *R. japonica* in Poland dates back to the second half of the 19th century. Stations were reported by CYBICHOWSKI (*herb.* POZ) in 1882 in Gniezno; by BAENITZ in 1893 in Wrocław (*herb.* WU) and by GRAEBNER (1894) in the same year in Darzlubie (Baltic Coast) (Fig. 47). SCHUBE (1903b, 1904, 1905, 1908, 1910) reported the location of a dozen of so stations occurring in Lower and Upper Silesia. These dates may not be complete as *R. japonica* had undoubtedly more stations, including western and central Europe, especially in large cities, in the first half of the 19th century (Professor R. Olaczek, *pers. comm.*). In the 1960s the number of stations increased to 342 and it continues to grow (Fig. 47).

Habitats: within the limits of its secondary distribution range it occurs principally in anthropogenic habitats, such as roadsides, railway embankments, various urban and industrial wastelands, in parks, cemeteries, gardens, but also in habitats of natural types: on river banks, forest edges (particularly of disturbed carrs) and edges of scrub.

This species shows wide tolerance towards types of soil: it has been recorded on soils within the range of reaction from pH 3 to pH 8.5 as well as on saline, polluted or contaminated soils (RICHARDS *et al.* 1990).

Dynamics: fairly widespread over the whole national territory, reaches elevations of 750 m a.s.l. in the Karkonosze Mts., in Działy Orawskie – 535 m a.s.l. and in the Tatra Mts. – 860 m a.s.l. (ZAJĄC A. 1992), or even 1000 m a.s.l. (PIĘKOŚ-MIRKOWA & MIREK 1978). In Poland a total of 3004 stations of this species were identified in 1158 ATPOL squares[33] (cf. Appendix A). The greatest concentrations of these are observed in the southwestern and southern parts of Poland (Fig. 47), where apart from anthropogenic habitats it also enters riparian habitats forming compact phytocoenoses. The enormous potential of this species for spreading through vegetative means, combined with its rapid growth and a capacity to adapt to diverse or even extreme habitat conditions, often invading and holding large areas, have resulted in this species earning the status of invasive plant and nuisance "weed" (TOKARSKA-GUZIK *in press*). It still continues to colonise new sites, on a massive scale in many regions (cf. also App. A and Chapter 12).

7.2.3. Examples of species of American origin

Echinocystis lobata (F. Michx.) Torr. & A. Gray

Wild Cucumber

Cucurbitaceae

Biology: annual plant with climbing shoot and spiny fruits; dispersal involves seeds, fruits and shoots.

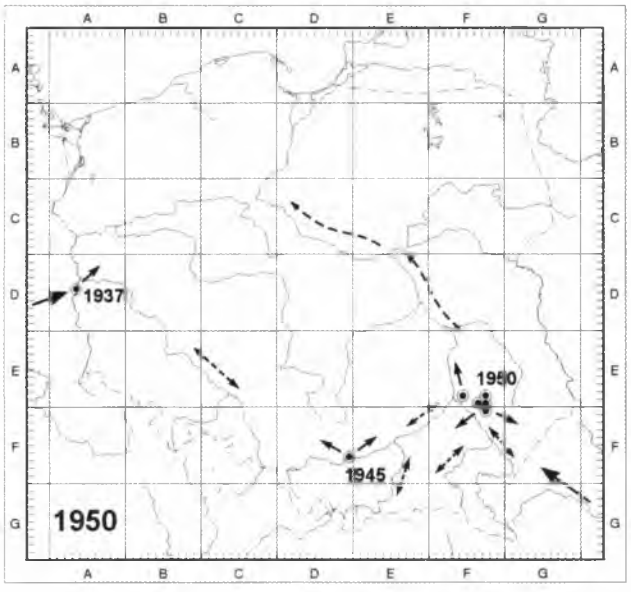
Native range: eastern part of North America.

Secondary range: Central Europe (absent in England) and Asia.

History of spread:

Europe: the plant was brought as a decorative species at the turn of 19th and beginning of the 20th century. Specimens which had moved into the

[33] The distribution needs certain verification because of probable erroneous records at some stations of the *R.* x *bohemica* hybrid as *R. japonica*. Nevertheless, it is definitely the most frequently recorded species of this genus in the Polish flora.



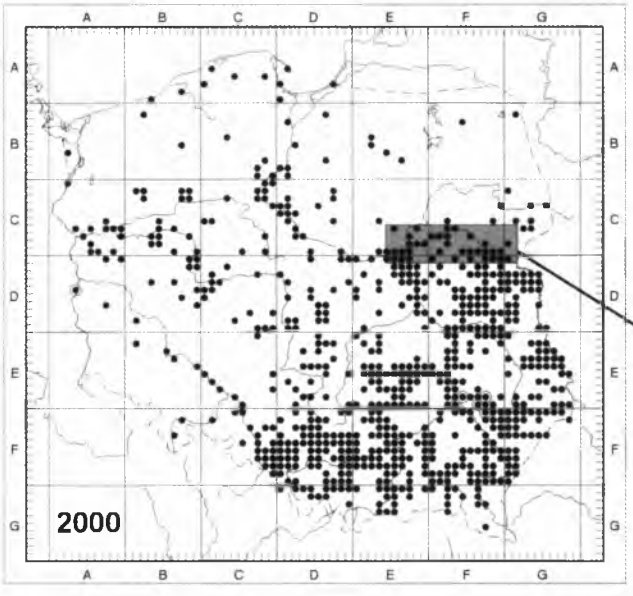
Introduction and start of spread:
19th/20th century - introduction of the species into cultivation

first recorded localities of occurrence: Gubin AD43 in West Poland (LADEMANN 1937), Kraków DF69 and a couple of villages in the vicinity of Lublin (localities in FE & FF cartogramme units)

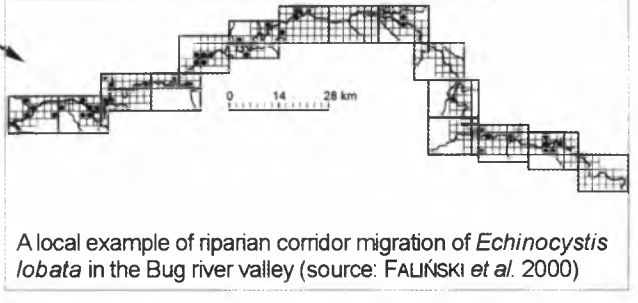
main direction of arrival of this plant from the territories of Germany and Ukraine

spontaneous spread near cultivation and naturalisation sites

riparian corridor migration routes



Subsequent phase of spread:
rapid range increase (invasion), especially in the south-eastern part of the country where this plant is also more often cultivated; a distinct link may also be seen between the migration and river valleys



A local example of riparian corridor migration of *Echinocystis lobata* in the Bug river valley (source: FALIŃSKI *et al.* 2000)

Fig. 48. Recorded history of the spread of *Echinocystis lobata* (F. Michx.) Torr. & A. Gray in Poland – an example of an introduced ornamental plant with invasive properties, or how an introduced plant becomes an invader

"wild" state were recorded for the first time in 1904 (MEUSEL *et al.* 1992; BALOGH 2001); numerous stations were found in Austria and Hungary as early as in the first half of the 20th century (HEINE & TSCHOPP 1953; PRISZTER 1958). In the territories of Poland's neighbours, the species was found to be self-dispersing in 1906 in the former Czechoslovakia (LOHMEYER & SUKOPP 1992), and in 1929 it was found in the Ukraine, where its invasion was observed by Dr M. Shevera (*pers. comm.*). In Slovakia, on the Dubai, it is considered a potentially invasive species (UHERČIKOVÁ 2001). In Lithuania, it started to spread intensively in the 1990s (GUDŽINSKAS 1999a).

Poland: it was probably brought into Poland from two directions: from Germany where it has been recorded since 1922 (MEUSEL *et al.* 1992) and from the Ukraine (Fig. 48). Initially, a dozen or so stations were recorded: Kraków–Bronowice and several localities in the Lubelskie province. At the same time, especially in the last half-century it was cultivated in many regions, from whence it spread into the "wild" (for example in Wrocław it was often recorded on the fences of garden allotments in the 1960s) (Prof. K. ROSTAŃSKI, *pers. comm.*).

Habitats: willow and willow-poplar carrs on riverine and lacustrine banks as well as ruderal sites: fences, refuse heaps, around cottages, abandoned gardens, municipal refuse tips.

Dynamics: the number of its stations began to increase only in the second half of the 20th century, rising from seven sites recorded in the first half of the 20th century to 2047 in 708 ATPOL squares (cf. Appendix A). Currently, the species is widespread in the southern and south-eastern parts of Poland, particularly in riparian habitats (e.g. upon the San, the Vistula rivers, and –

increasingly often – along the Oder river; it is however rarer in northern parts (Fig. 48) and is also found in the lower zones of mountains, most often in the valleys of the Nysa Kłodzka and Biała Lądecka rivers (SZELĄG 2000); in the Western Carpathians along the Wisłoka, Ropa and Biała rivers (KORNAŚ *et al.* 1996) (Fig. 48). Still colonising new sites. Its spread is of an invasive type.

Rudbeckia laciniata L.

Tall Coneflower, Golden Glow
Asteraceae

Biology: conspicuous perennial plant dispersing its seeds through anomochory, exochory and myrmecochory.
Native range: moderate climatic zone of eastern and central North America.
Secondary range: Europe: in the north extending to Sweden, in the south to Corsica and reaching central Russia in eastern Europe. Outside Europe, the secondary range includes also eastern China, New Zealand and Japan (CRONK & FULLER 2001).

History of spread:
Europe: one of the oldest decorative perennial plants brought into Europe in the early 17th century or even earlier (cf. Appendix A). Its occurrence in Paris was recorded in 1615 (JALAS 1993; FRANCÍRKOVÁ 2001). Its frequent cultivation in Europe contributed to its dispersion. The first stations of plants which "moved into the wild state" were recorded in 1787 in an area which currently lies within Poland (JALAS 1993; FRANCÍRKOVÁ 2001). Currently, it is frequently found in a number of areas in Germany, Austria, the Czech Republic and Slovakia. For the last two countries it has been considered an invasive species (cf. Appendix A).
Poland: this species was brought to Poland in the 18th/19th century (KORNAŚ 1968b). The first station in the Sudety Mts. (1787, cf. Fig. 49) was published by FIEK (1881 after Krocker). Subsequent stations recorded in the next half century were also located in this region. In eastern Poland it was recorded by DRYMMER (1897) in the Lubelskie province and the Opoczno, Turek and Sieradz areas. It was SZAFER *et al.* (1924) who observed the Golden Glow moving readily in the "wild" and noted that it could be found within scrub on river banks. In subsequent periods this species was recorded more frequently, especially in south-western Poland. TRZCIŃSKA-TACIK (1971b) characterises this species as common all over Poland, dispersing without assistance, and as also present in semi-natural habitats.
Habitats: banks of rivers, streams and ditches; also enters riparian osier beds and carrs, additionally also grows in ruderal habitats and in gardens.

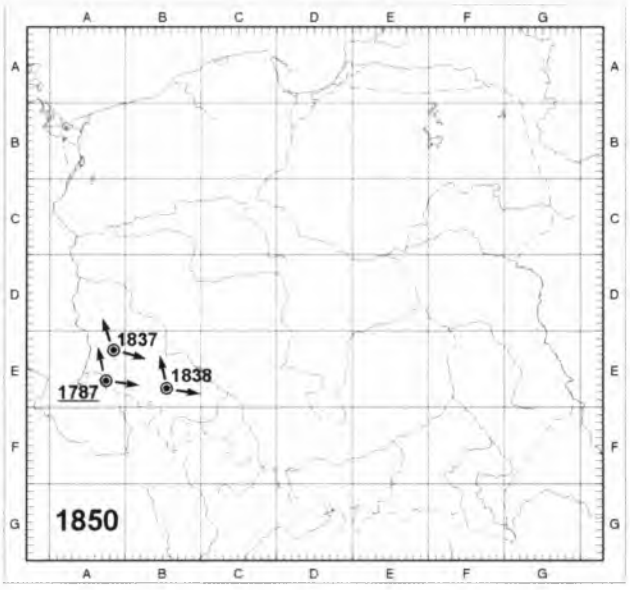
A species characteristic for the *Rudbeckio-Solidaginetum* association (MATUSZKIEWICZ 2001).
Dynamics: as early as at the beginning of the 20th century, the species was recorded in 78 stations, while in the 1950s there were 187 stations. Within recent times, information about as many as 2251 stations was noted in 903 ATPOL squares (cf. Appendix A). It is found throughout the territory of Poland, although more rarely in some regions of central and northern Poland. The regions it most frequently occurs in include the Sudety Mts. and Sudety Foreland, the Wielkopolska–Silesian Lowlands, the Silesian–Cracow Upland, the Małopolska Upland, the Carpathian Basins and the Carpathians (Fig. 49). In the Carpathians it reaches the elevations where the major settlements are: in Babia Góra Mt. – 750 m a.s.l., Gorce – 515 m a.s.l., Bieszczady Zachodnie – 720 m a.s.l. (TRZCIŃSKA-TACIK 1971b).

Mimulus guttatus DC.

Monkeyflower
Scrophulariaceae

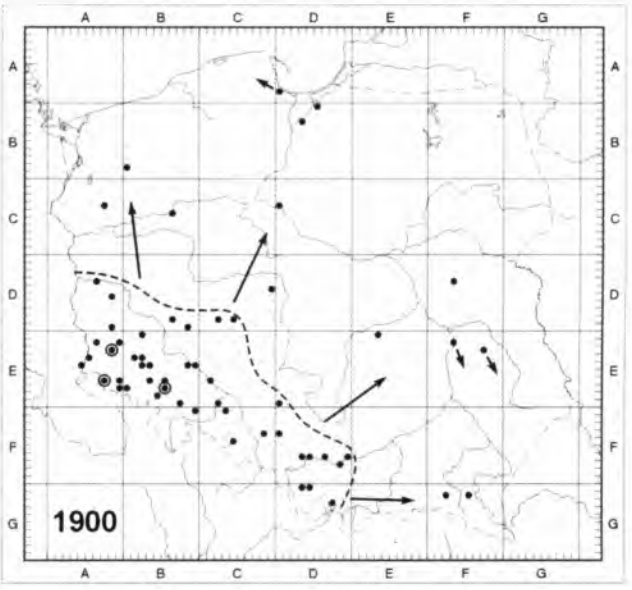
Biology: a perennial plant expanding generatively by minute seeds dispersed by wind and water and also by vegetative processes.
Native range: western part of North America from Alaska to northern Mexico.
Secondary range: western and central Europe: mainly the British Isles, northern France, the Netherlands, Germany, Switzerland, Poland and some areas of northern and eastern Europe: Scandinavia, Lithuania and the European part of Russia.

History of spread:
Europe: in Europe, especially in the western part, a number of species from the *Mimulus* genus were grown, including *M. guttatus*. It is prone to straying into the "wild"; in some areas of Europe it has become naturalised and forms a part of natural communities (PIĘKOŚ 1972; STACE 1997). The first "wild" stations in central Europe were recorded in 1824 (LOHMEYER & SUKOPP 1992), 1847 (BALOGH *et al.* 2001) and in 1853 (PYŠEK *et al.* 2002). In recent years its first stations have been recorded on the Raba River and Dubai in the western part of Hungary (BALOGH *et al.* 2001).
Poland: this species is also grown in some Polish regions (especially in the west) and it strayed from there into the "wild". The oldest occurrence was recorded from the Sudety Mts. (Fig. 50). This is at the same time the oldest registered date of the occurrence of this species in Europe (although it was dispersed in cultivation at that time in other parts of Europe, e.g. in the British Isles). In the Sudety Mts. it started its occupation of new



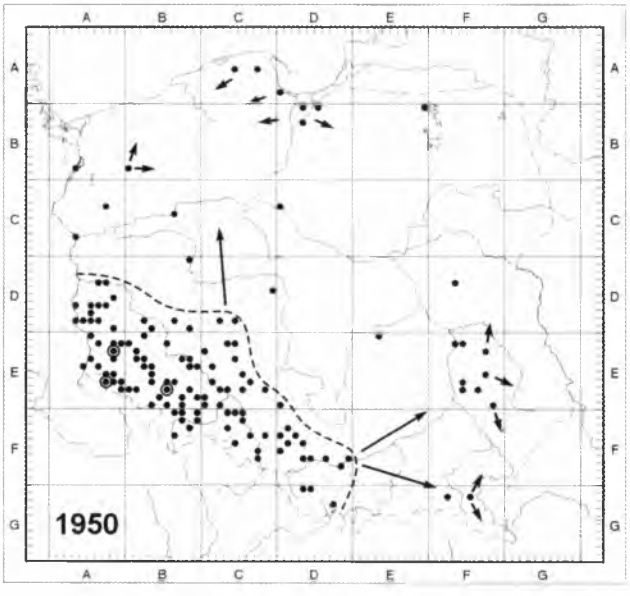
Introduction and start of spread:

- first records: Świeradów AE67 in the Sudety Mountains (FIEK 1881 after Krocker); near Lubań AE67 (after JALAS 1993); subsequent records: Bolesławiec AE28 (SCHNEIDER 1837) and Bystrzyca BE75 (FIEK 1881 after Krocker)
- spontaneous spread near cultivation sites

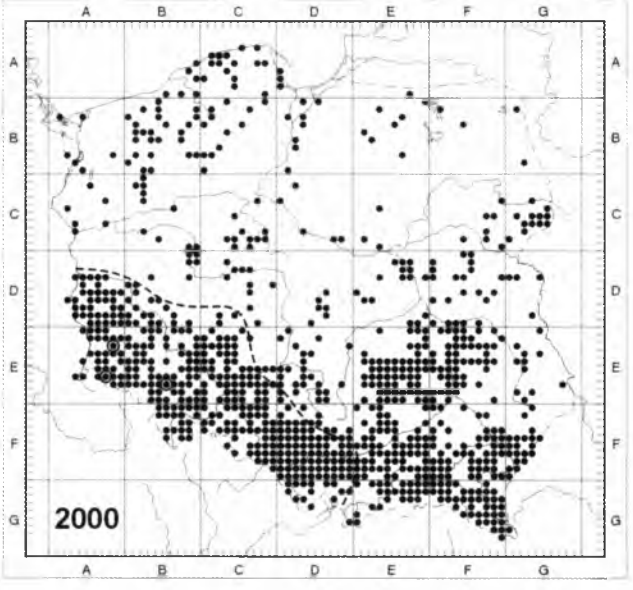


Initial phase of spread:

- increase in the density of localities within the occupied territory
- simultaneous occupation of new localities in other regions of the country due to popularisation of cultivation and the concurrent naturalisation of this plant as well as probable accidental importation of its seeds
- directions of further spread



Subsequent phases of spread:
further increase in the density of localities; spread south-east and north



The current distribution of this species is linked to the history of its cultivation and escapes from gardens

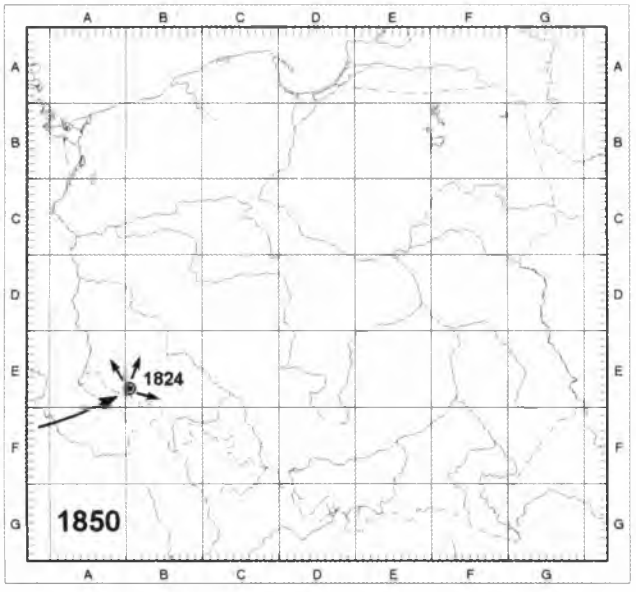
(the map after ZAJĄC A. & ZAJĄC M. (eds.) 2001 – slightly supplemented and modified)

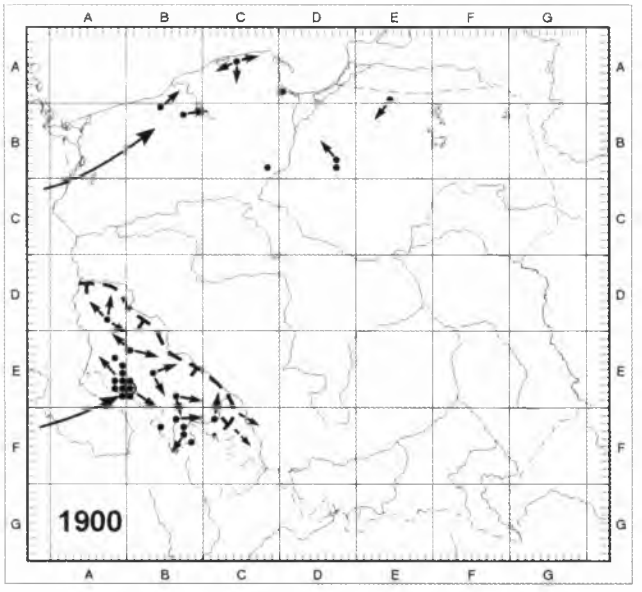
Fig. 49. Recorded history of the spread of *Rudbeckia laciniata* L. in Poland – an example of a popular ornamental plant where naturalisation is due to long and widespread cultivation

stations in the second part of the 19th century; at the same period it was recorded in Pomerania and Masovia where it was probably introduced accidentally (or, initially on purpose) from Germany (in neighbouring Lithuania it has been recorded since 1931; it is currently spread along the Neris and Niemen Rivers (GUDŽINSKAS 1998a)). The history of the dispersion of this species was investigated by PIĘKOŚ (1972) who recorded the occurrence of this species at 112 stations.

Habitats: banks of streams, rivers and lakes, as well as along ditches, rare in ruderal habitats.

A characteristic species of the association *Sparganio-Glycerietum fluitantis* (MATUSZKIEWICZ 2001). KWIATKOWSKI (2003) describes for the first time for Poland the association *Veronico*



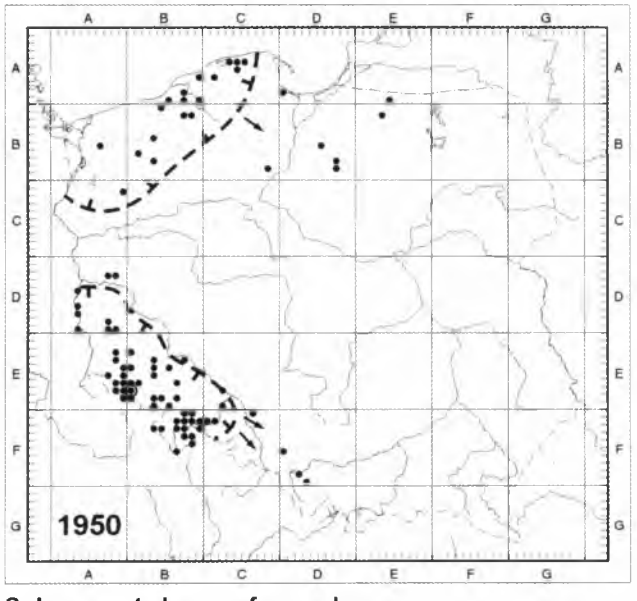


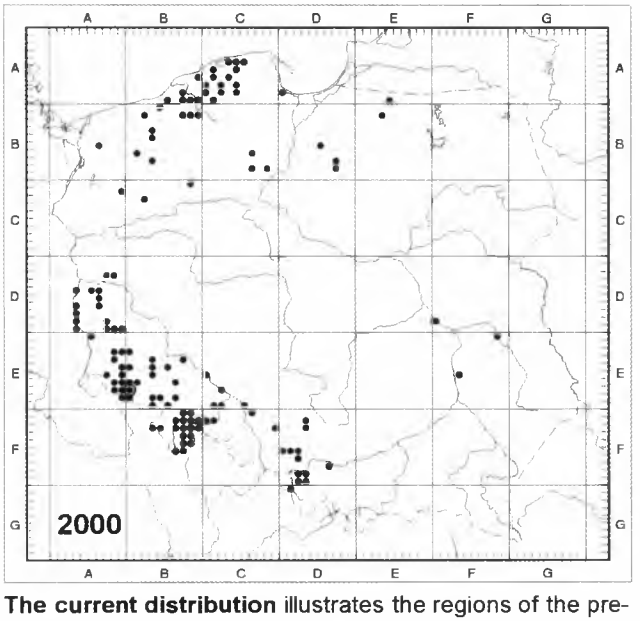
Start of spread:

- first record: Kowary BE80 in Sudety Mts (FIEK 1881; ?? *herb.* WRSL)
- spread in the region of the first record
- probable direction of arrival of this species in Sudety Mts

Initial phase of spread:

- increase in the density of localities within the occupied territory
- simultaneous occupation of new localities in the north of the country
- probable directions of arrival of this species to Poland





Subsequent phases of spread:

- further increase in the density of localities and creation a range encompassing areas in south-western and north-western Poland
- directions of further spread

The current distribution illustrates the regions of the previously occupied localities

Fig. 50. Recorded history of the spread of *Mimulus guttatus* DC. in Poland – an example of a species currently having a characteristic range type in Poland

beccabungae-Mimuletum guttati as a member of the alliance *Sparganio-Glycerion fluitantis*. Sometimes the species occurs in phytocoenoses of other communities of the classes *Phragmitetea* and *Isoëto-Nanojuncetea* (KUCHARSKI 1992).

Dynamics: at present it occurs most often in Lower Silesia and Pomerania. To date it has been recorded in 326 stations in 128 ATPOL squares (cf. Appendix A). The species is gradually increasing the number of its stations, mostly in regions of previous concentrations (Fig. 50). Rapid expansion of this species has been noted particularly in the Karkonosze Mts. (FABISZEWSKI 1985; FABISZEWSKI & KWIATKOWSKI 2001; KWIATKOWSKI 2003).

7.3. The spread of accidentally introduced plants: how an ephemerophyte turns into a kenophyte

7.3.1. Plants introduced accidentally from various regions of Europe

Anthoxanthum aristatum Boiss. [syn.: *A. puelii* Lecoq & Lamotte]

Annual Vernal-grass

Poaceae

Biology: annual plant, disperses through anemochory, also in agricultural/horticultural seed mixtures (KUŹNIEWSKI 1996).

Native range: Western Europe (Atlantic region) and northern part of central Europe: to the east it reaches Germany, to the south it reaches southern France via Corsica and Sardinia (MEUSEL *et al.* 1965).

Secondary range: central and eastern Europe; currently a rare ephemerophyte in the British Isles, but in the past naturalised in sandy and infertile soils in Surrey and East Suffolk; not seen there since the 1970s (STACE 1997).

History of spread:

Europe: it spread out of its original range in Napoleonic times (1805–1813). Since then it has dispersed in various directions, where it grew exclusively in ruderal and segetal habitats (KUŹNIEWSKI 1996; KORNIAK 2002).

Poland: introduced in the 19th century, initially to Pomerania and Silesia (Fig. 51). According to WARCHOLIŃSKA and SICIŃSKI (1976), the species had not been reported in central Poland until 1960. Since 1960 there have been more and more reports of its occurrence in various regions of the country (WARCHOLIŃSKA & SICIŃSKI 1996). In Warsaw, it had been recorded only once (ZANOWA 1964) up until the 1970s, but in the following decade it was found by SUDNIK-WÓJCIKOWSKA (1987a) in several stations, mainly in cereal fields and non-arable land. In 1975, *A. aristatum* was recorded in 118 stations in central Poland. In subsequent years 437 new stations were recorded in the region (WARCHOLIŃSKA & SICIŃSKI 1996). KUŹNIEWSKI (1996) suggests two distinct routes of migration of Annual Vernal-grass in Poland: a northern route from southern areas of the Szczecin province and a southern one – from Lubuskie Lakeland to the Central and Eastern Polish Lowlands.

Although the first recorded dates of occurrence of *Anthoxanthum aristatum* go back to the second half of the 19th century, it was originally witnessed there a half-century earlier, probably by the French army stationed after the 1806 Prussian war in Pomerania and Wielkopolska province. The reconstruction of the expansion stages in specific periods of the 19th and 20th centuries indicates that the belt of the Central Polish Lowlands was the main migration route and the species migrated to this area from German Łużyce.

Habitats: cereal fields, more rare in root crops, stubble fields, sandy areas left out of cultivation, also noted in railway tracks and embankments, as well as on industrial waste heaps. A characteristic species for associations within the alliance *Arnoserido-Scleranthetum* (BALCERKIEWICZ *et al.* 1999).

Dynamics: the number of stations has increased markedly in the last 30 years, particularly in the central part of Poland. A total of 1031 stations have been recorded in 577 ATPOL squares to date (Fig. 51, cf. Appendix A). The area of its expansion includes primarily agrocoenoses appearing in the poorest habitats colonised by *Teesdaleo-Arnoseridetum minimae* (WARCHOLIŃSKA & SICIŃSKI 1976). In accordance with the same authors (1996), the expansion of this species is facilitated mostly by favourable edaphic and climatic conditions, as well as methods and patterns of land use ways; they also stated that occurrences of *A. aristatum* have a "destructive impact on agrocoenoses as this species eliminates other species".

Artemisia austriaca Jacq.

Austrian Sagewort

Asteraceae

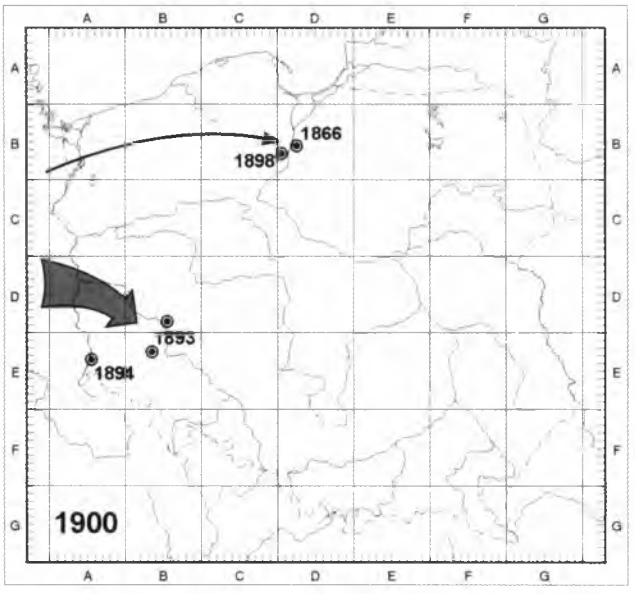
Biology: a perennial plant which disperses in Poland principally through vegetative processes. ŻUKOWSKI and PIASZCZYK (1971) suggest that seed development stops short of maturity or that seeds mature only in some years, and that the plant initially colonises sites solely through vegetative processes.

Native range: eastern and south-eastern Europe (widespread in Podolia, Volhynia and Kiev regions), in western and central Asia, Siberia where it occurs on steppes, steep slopes and ruderal areas (KORNAŚ 1968b; ŻUKOWSKI & PIASZCZYK 1971).

Secondary range: central and western Europe.

History of spread:

Europe: it dispersed from the Podolia and Kiev regions northwards and westwards (ŻUKOWSKI & PIASZCZYK 1971). In Poland it is gradually reaching westward to other European countries thereby extending its range. TRZEBIŃSKI (1930) had already mentioned that this species was introduced accidentally to Germany and France in a few cases. HARDTKE & IHL (2000) present information on a single station of this species in Saxony in 1946.

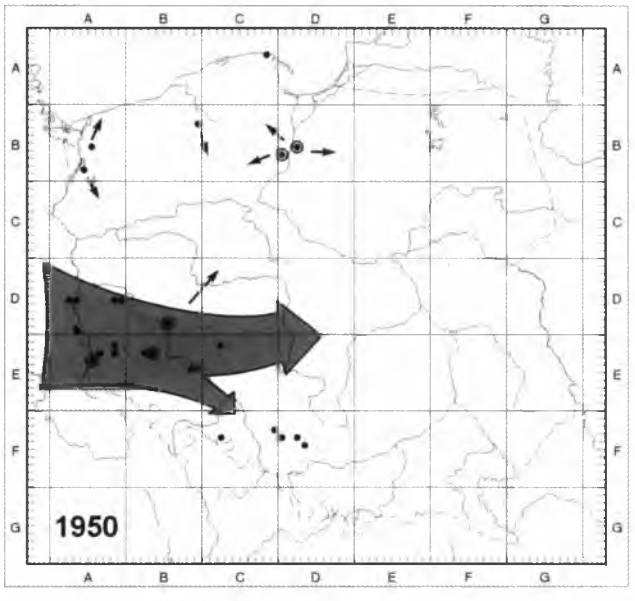


First recorded localities of occurrence:
early 19th century: probably first undocumented accidental importation in the region of North Poland and Central Poland

◉ first records: Western Pomorze: Kwidzyń DB52 (KLINGGRAEFF 1866) and Milewo DB60 (ABROMEIT *et al.* 1898); south-western Poland: environs of Ryczeń BD85 (FIGERT *herb.* W) and between Rzeszotary and Sześcina BE23 (FIGERT *herb.* MGS), as well as in Zgorzelec AE35 (HARDTKE & IHL 2000)

→ probable direction of arrival of this species in Pomerania

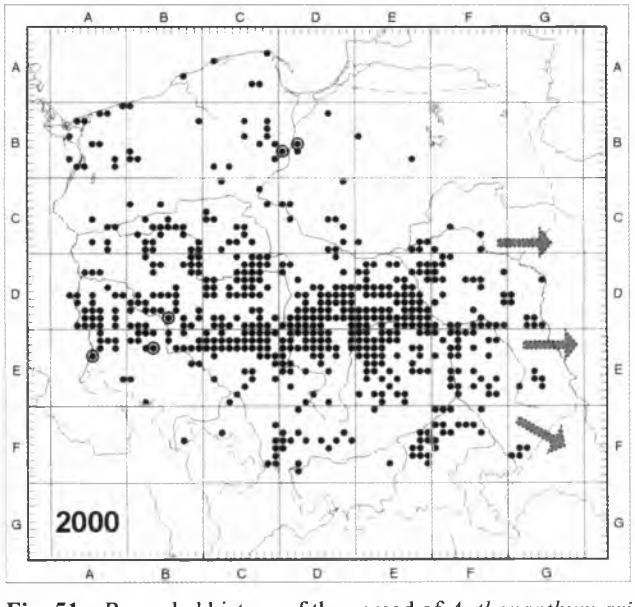
main direction of arrival of this species to Poland



Initial phase of spread:
simultaneous occupation of new localities in the north and in the western part of the country as well as gradual migration of the species to the east

spread near formerly occupied localities

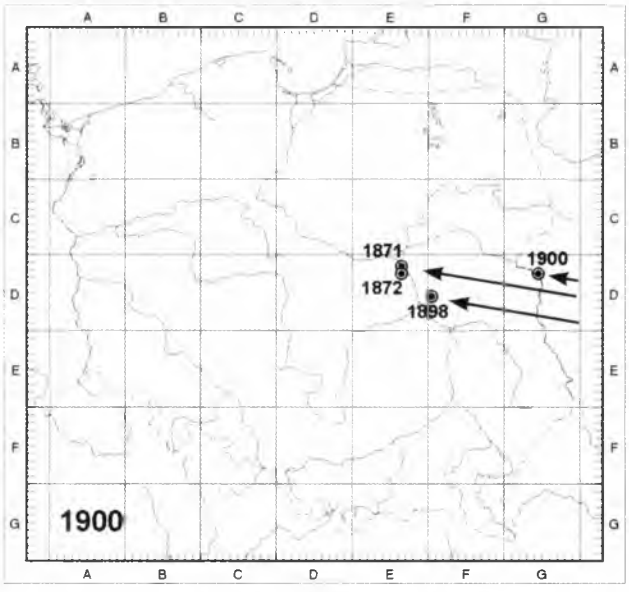
the main migration front



Subsequent phases of spread:
further increase in the density of localities, mainly in Central Poland, and further migration to the east

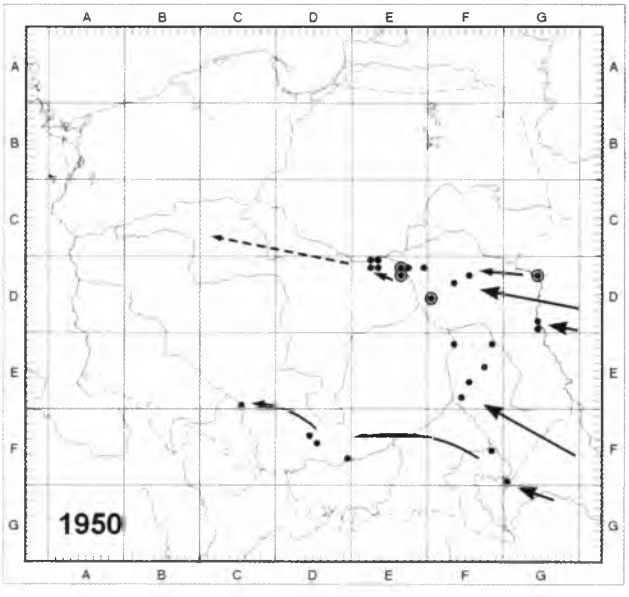
probable direction of further spread

Fig. 51. Recorded history of the spread of *Anthoxanthum aristatum* Boiss. in Poland – an example of a species which increases its range in an easterly direction



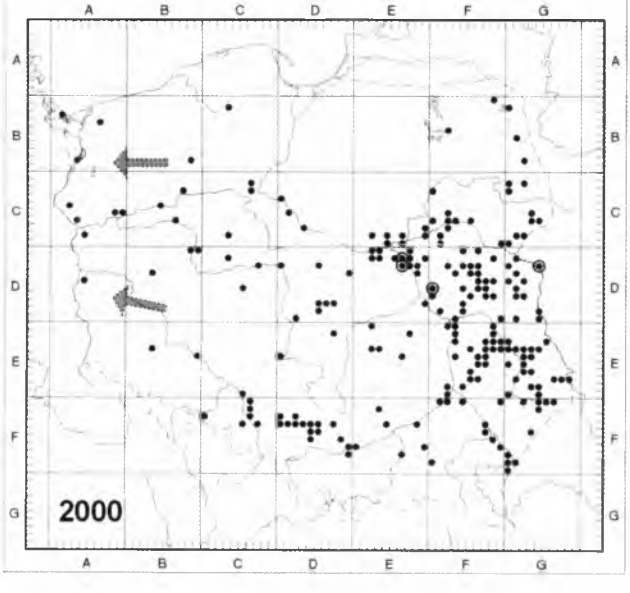
Start of spread:
second half of the 19th century:

- first ephemeral accidental introductions near Warszawa (ROSTAFIŃSKI 1872); subsequent records: Warszawa ED16, ED26 (CYBULSKI 1895), environs of Piława FD50 (TRZEBIŃSKI 1930) and Brześć GD14 (PACZOSKI 1900)
- directions of arrival of this species to Poland with railway transport



Initial phase of spread:
appearance of new localities in the eastern part of the country as well as migration of the species to the west as a result of accidental introductions with railway transport:

- subsequent "jumps" are linked to the main railway lines (see also the text)
- direction of further migration



Subsequent phases of spread:
further increase in the density of localities, mainly in the eastern part of Poland, and further migration to the west

- probable direction of further spread

Fig. 52. Recorded history of the spread of *Artemisia austriaca* Jacq. in Poland – an example of a species which is enlarging its range in a westerly direction, mainly along railway thoroughfares

Poland: the oldest reports mention Warsaw (Rostafiński 1872) (Fig. 52). These stations seem to have an casual nature, since Łapczyński (1882) did not confirm the occurrence of this species and reports it as extinct. It was probably introduced accidentally after the commissioning of the railway line: the first railway station was launched in Warsaw in 1845; the Petersburski Railway Station was open in 1862, while the Terespolski Station followed four years later (Kwiatek & Lijewski 1998). Cybulski (1895) reported another accidental introduction in Warsaw. Trzebiński (1930) describes subsequent sites: in 1898 from the Pilawa town; 1910 in Siedlce and in 1922 in Puławy. The plant disperses mainly along railway lines. The "jump" by this species from these sites to Silesia can be also attributed to railway transport and economic links between what was then Poland and Russia. Kornaś *et al.* (1959) classify this species as part of the group of the so-called "railway specialist". Information on the occurrence of this species in railway stations is also reported by other authors, e.g. Urbański 1958; Rostański K. 1960; Nowak 1997.

Habitats: dry ruderal sites, railway tracks and embankments, roadsides, grass swards.

Dynamics: the species is gradually extending its range towards the west. It survives in many old stations and emerges also in new ones (the number of the latter increased particularly in the 1960s and 1970s). However, the intensity of the expansion is fairly low, probably because of features of the biology of its development (Sudnik-Wójcikowska 1987a). Currently, the overall number of stations exceeds 370 (in 217 ATPOL squares) (cf. Appendix A) (Fig. 52).

Bunias orientalis L.

Warty-cabbage

Brassicaceae

Biology: a perennial plant producing great numbers of seeds dispersed through anemochory, exozoochory (birds, horses), autochory or anthropochory.

Native range: eastern Europe and western Asia. It probably originated from Armenia where it grows at an altitude from between 1000–2500 m a.s.l. up to the sub-alpine vertical zone. From there the species dispersed in the European part of the former Soviet Union, as far as the southern boundaries of western Siberia. It grows in forest and forest-steppe formations, less often in steppes, in the boundaries of fields, in unusable areas and ruderal places (Jehlík 1998; Fedorov 2001).

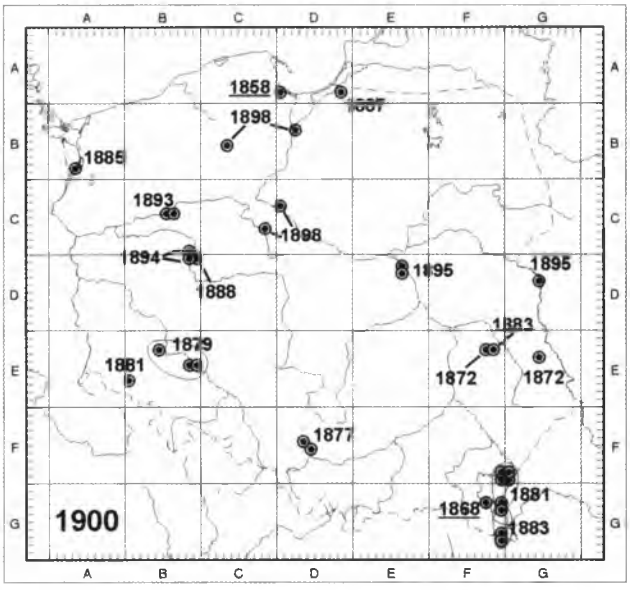
Secondary range: occurs mostly in central and western European countries. It is known to appear in Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Great Britain, Hungary, the Netherlands, Norway, Poland, Romania, Slovakia, Switzerland, Sweden, and the former Yugoslavia. It is also reported as an epecophyte (for terminology see Fig. 2 in Chapter 3) growing in Estonia (Brandes 1992a) and the Ukraine (Burda 1997; Protopopova & Shevera 2002). Outside Europe, it has been introduced accidentally into North America (Jehlík 1998).

History of spread:

Europe: this species was recorded in central Europe as early as in the beginning of the 19th century (Hegi 1935–1961; cf. also Appendix A). Meusel *et al.* (1965) published the map of the general range in Europe, giving the earliest dates within the secondary range: western Russia: years 1720, 1790; southern Scandinavia: 1780; Denmark: 1790; western Europe: 1814, 1862; England: 1880; and Poland 1888 (date reported for Poznań, by Pful after Krawiecowa 1951). Probably introduced accidentally by the Russian Army into France (Paris area, around 1814), Denmark and Germany (Krawiecowa 1951). In Saxony, it was recorded in 1867 (Hardtke & Ihl 2000 after Wünsche 1875). In the eastern part of Central Europe its occurrence is concentrated in river valleys, e.g. Main, Tauber, Rhine, and Meuse. There, it is one of the species extending its range using roads, rivers and canals channels for migration (Brandes 1991) (cf. Chapter 9.2).

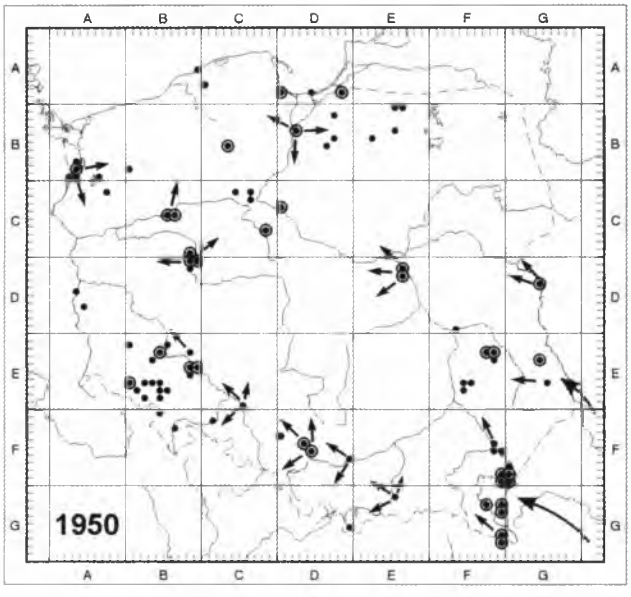
In some European countries (e.g. in the Czech Republic and Slovakia) it qualified as expansive "quarantine weed" spreading on meadows and pastoral land (Jehlík 1998).

Poland: the first stations registered in Poland go back to the second half of the 19th century from Pomerania, Lublin Upland, Eastern Carpathians and Lower and Upper Silesia. The localities for the first reported stations suggest two dispersion routes for this species in the eastern part of Poland: it is a species expanding its range from east to west (anthropogenic stations prevailing) and via long-range transport, both by land and sea. Krawiecowa (1951) states that seeds were mostly transferred with fodder and other seed transport. It was also sporadically grown as a fodder plant. Perhaps this species had been previously introduced into Poland, a theory which is supported by the existence of relatively numerous stations spread all over Poland dated from the second half of the 19th century (Fig. 53). The seedlings of this species have been tentatively described from Tuma near Łęczyca and in fossil layers from the early Middle Ages (Sychowa 1985); in addition several pieces of information are provided by archebotanical data from Gdańsk.



Start of spread:
second half of the 19th century or earlier (suggested by a relatively large number of localities spread out over the whole territory of the country)

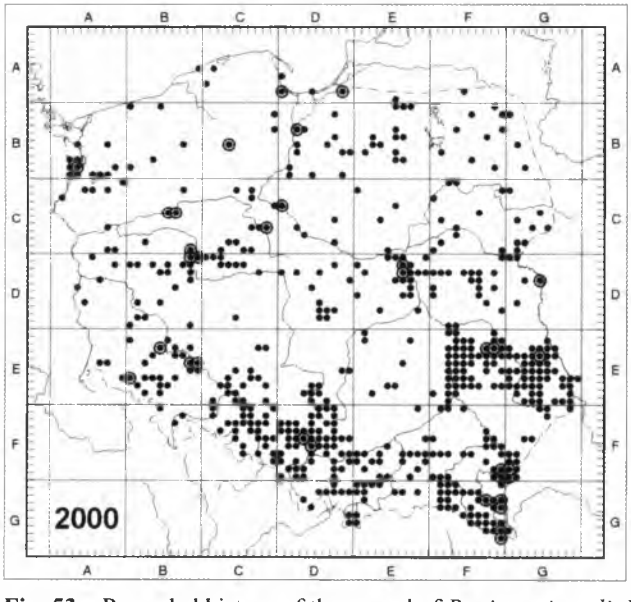
- earliest registered record: Gdańsk DA80 (KLINSMANN *herb.* TRN); subsequent records: Olszanica FG27 (KNAPP 1869), Lublin FE27 and Chełm GE34 (ROSTAFIŃSKI 1872), Mysłowice DF43 (UECHTRITZ 1877) as well as localities in Lower Silesia e.g.: Wrocław BE49 and Wielowieś near Wołów BE24 (UECHTRITZ 1879)



Initial phase of spread:
appearance of new localities in regions from which the species had been previously recorded as the result of accidental introductions of the species (from various directions, especially from Germany) as well as its migration from the east

spread near formerly occupied localities

direction of arrival of this species to Poland



Subsequent phases of spread:
further spread from previously occupied localities (in the recent period mainly along railway lines and automobile roadways) as well as gradual range increase in the western direction

Fig. 53. Recorded history of the spread of *Bunias orientalis* L. in Poland – an example of a species using two modes of spread during the increase in its range: gradual migration and long-range transport

Habitats: roadsides, wastelands, surrounds of cottages, rubble heaps, railway tracks and embankments, also fields, boundary strips and fallow lands; also found in meadows. A species characteristic regionally for the alliance of *Onopordion* associations (Sychowa 1985). Matuszkiewicz (2001) indicates it as a species which distinguishes the communities *Falcario vulgaris-Agropyretum repentis* from the class *Agropyretea intermedio-repentis*. In Central Europe it is classified as a species associated with the *Artemisietea* and *Molinio-Arrhenatheretea* classes of associations (Brandes 1991).
Dynamics: Up until the mid 20th century the number of recorded stations gradually increased (cf. Appendix A). An evident increase was noted in the last half-century where the species increased from 120 to 1353 stations situated in 567 ATPOL squares. Currently, it is distributed throughout Poland, including lowland sites in the Carpathians, e.g. it occurs in massive numbers in the Zakopane Basin (Piękoś-Mirkowa & Mirek 1978), and fairly often in the Bieszczady Mts. (630–740 m a.s.l.), where it has also moved into natural habitats (Zemanek & Winnicki 1999). It is found rarely in the Ciężkowice Foothills (Kornaś *et al.* 1996) and Beskid Żywiecki Mts. where it reaches elevations up to 560 m a.s.l. (Białecka 1982). The species is still expanding and is commonly and frequently found in some regions of southern and south-eastern Poland (Fig. 53).

Eragrostis minor Host [syn.: *E. poaeoides* P. B.]

Small Love-grass
Poaceae

Biology: annual plant, its small grain seeds are dispersed by wind and animals.
Native range: south-eastern Europe and western Asia.
Secondary range: central and western Europe (also Great Britain).

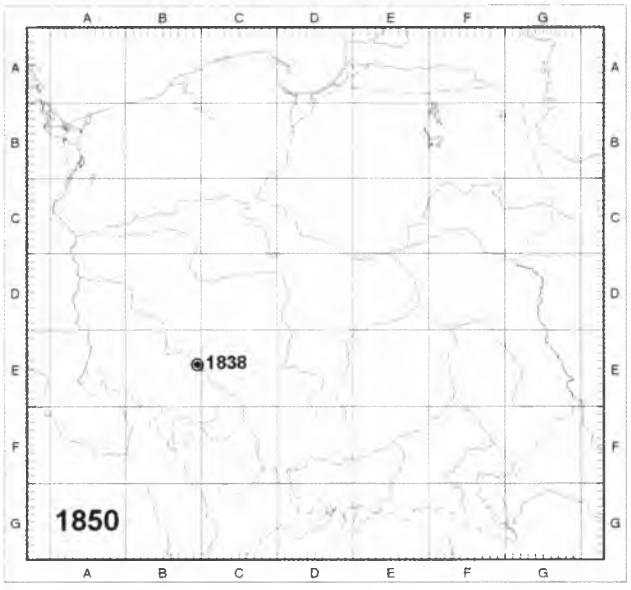
History of spread:
Europe: it appeared in the central part of Europe probably in the early 19th century and at that time it also arrived in Poland (Kornaś 1968b). It was transported with wool, grains, fodder and hay. To-day, it occurs in a number of regions, but mainly in urbanized and railway areas. Landolt (2000) describes the rapid expansion of this species in Zürich, where it was recorded for the first time in the old part of the city in 1873, but it had not dispersed in a visible way until 1980. By 1989, it had occupied of the 68 squares under study, and in the following 10 years it occurred at as many as 106 stations. Lohmeyer & Sukopp (1992) report this species as a newcomer (neophyte) spreading along the Rhine.
Poland: Its first station in Poland was recorded by Grabowski (1843) and Wimmer (1868) in 1838 and it was then reported by Fiek (1881). In the second part of the 19th century this species was known to grow in 7 stations dispersed in localities located on the Oder river: in Nowa Wieś Wrocławska (Wimmer 1868; Fiek 1881) and Pruszków (Fiek 1881); it was also reported in Kraków, on the Vistula river (Knapp 1872), in Puławy (Rostafiński 1872), Warszawa (Cybulski 1894) and in Bydgoszcz (Bock 1908) (Fig. 54). Rostafiński (1872) still considered it a very rare species. At the beginning of the 20th century, Szafer (1919) stated that this species is naturalised in Silesia.
Habitats: wastelands, roadsides, poorly-managed sites, cracks between flagstones, sport stadiums, railway platforms, storage sites covered with slag, railway tracks.

A characteristic species for associations of the *Eragrostion* and *Panico-Eragrostietum* alliances (Balcerkiewicz *et al.* 1999; Matuszkiewicz 2001).
Dynamics: an evident increase in the number of stations occurred as early as in the first half of the 20th century (Fig. 54). In recent times it has been recorded in 1041 stations in 581 ATPOL squares (Tokarska-Guzik 2001a; cf. also Appendix A). Distributed throughout the national territory, it occurs more frequently in some regions. It is still colonising new sites, expanding particularly in towns (probably introduced with sand during pavement renovations).

Rumex confertus Willd.

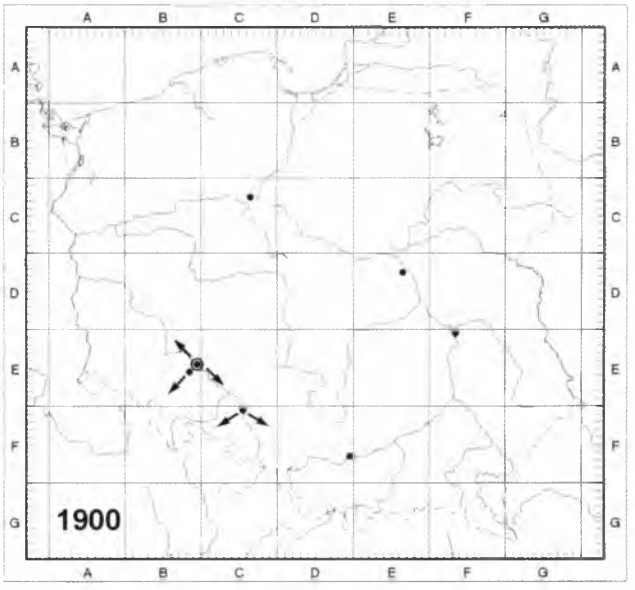
Russian Dock
Polygonaceae

Biology: perennial, dispersing throughout wind and animals (by exochory) and by water.
Native range: eastern Europe and central Asia; probably already native in areas along the Dniester; it reaches the Tomsk areas in the east (Tacik 1992).
Secondary range: Central Europe, towards the western part; also recorded in British Isles in Kent (Stace 1997). In northern-eastern Europe it has spread to Lithuania where it is considered an invasive species (Gudžinskas 1999b).
History of spread:
Europe: It was Eichler and Łapczyński (1892) who noticed that this species was migrating from the east to the west and north-west. The history of the expansion in central and western Europe is connected with the history of this species in Poland (Fig. 55). In addition to the gradual mi-



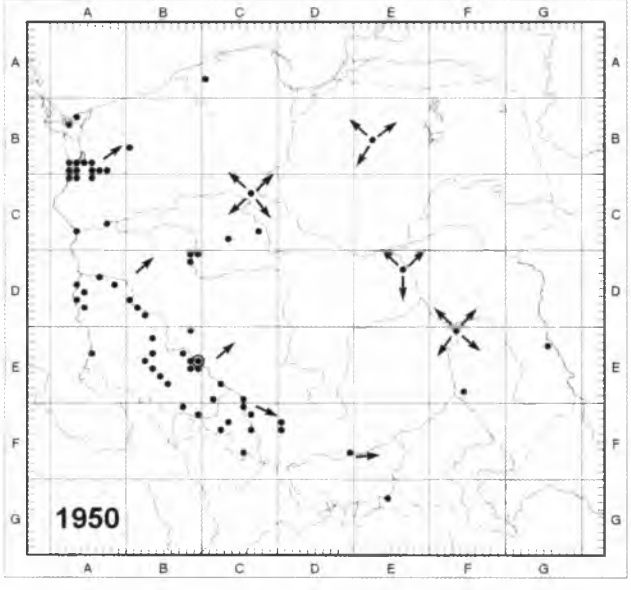
First record in a large city:

◉ Wrocław-Gajowice BE49 (WIMMER 1868; FIEK 1881)



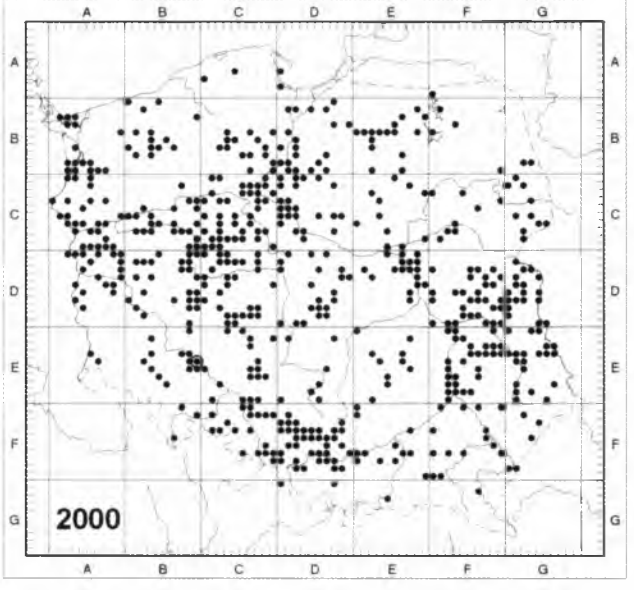
Start of spread:
accidental introductions in cities in various regions of the country (see the text); the location of sites of occurrence along main Polish rivers suggests that in the initial phases of spread, water transport may have played an important role

spread near formerly occupied localities



Initial phase of spread:
appearance of new localities in regions from which the species was previously recorded as well as new accidental introductions in remote sites (the spatial pattern of spread of the species correlates with the location of urban areas and the pattern of communication thoroughfares)

directions of spread

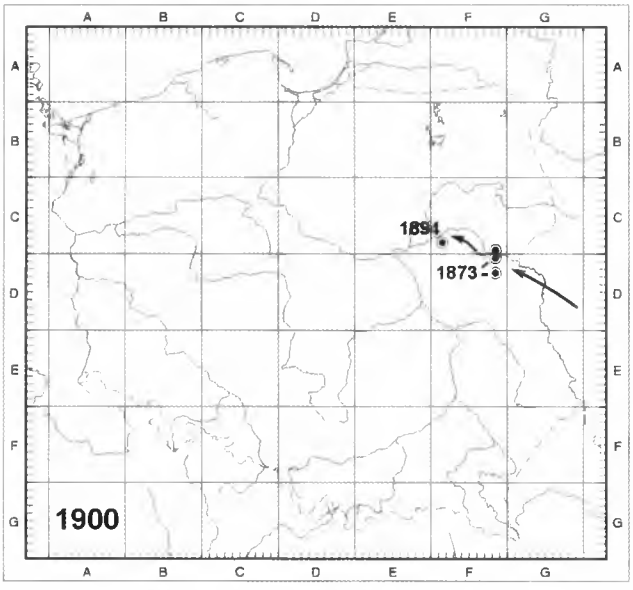


Subsequent phases of spread:
stabilisation and filling in of the range: mainly in specific habitats (cracks in pavements and cobblestone-paved town squares, gravel- or slag-lined sport grounds) in towns and in railway areas (paved or slag-lined rail platforms and storage sites)

Fig. 54. Recorded history of the spread of *Eragrostis minor* Host in Poland – an example of a species associated with urban areas within the limits of its secondary range

gration towards the west, it is also making use of long distance transport.

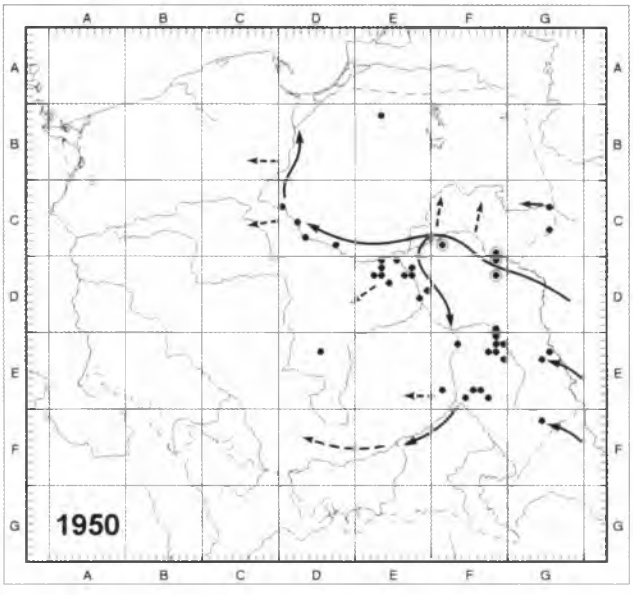
Poland: the first stations of this species were recorded on the Bug river in the second part of the 19th century (Fig. 55). The first stage of internal migration in Polish territory was along rivers (TRZCIŃSKA-TACIK 1963 – the author of the first distribution map of this species in Poland). The current distribution of this species is the result of the migration via river valleys and railways (among other things, the first reports on the occurrence were from Cracow – KORNAŚ (1954) and Wrocław – ROSTAŃSKI K. (1960), where the stations were found in railway areas) and macadam roads. Currently, this species is penetrating settlements, abandoned fields and pastoral land (FALIŃSKI 2000b).



Start of spread:
second half of the 19th century

first recorded localities in the Bug river valley: Zajęczniki FC98 and Łosice FD18 (KARO, *herb.* KRA)

direction of arrival of this species to Poland

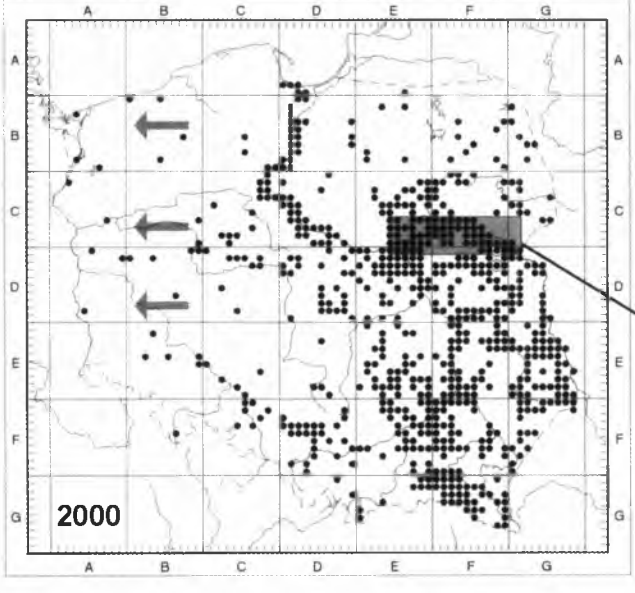


Initial phase of spread:

migration of the species along the Vistula and Bug river valleys

colonisation of ruderal habitats adjacent to (or between) river valleys

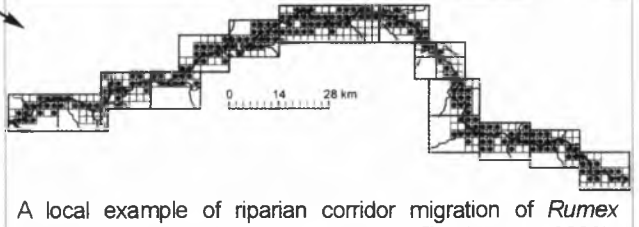
new accidental introductions of the species both in river valleys and on railway territory



Subsequent phases of spread:
further migration along river valleys and communication thoroughfares; transfer of the species to new types of habitats: post-agricultural wasteland, meadows and pasture land

gradual range increase in a westerly direction

(the map after ZAJĄC A. & ZAJĄC M. (eds.) 2001 – slightly supplemented and modified)



A local example of riparian corridor migration of *Rumex confertus* in the Bug river valley (source: FALIŃSKI *et al.* 2000)

Fig. 55. Recorded history of the spread of *Rumex confertus* Willd. in Poland – an example of a species which has increased its range in a westerly direction using river valleys and later also transport thoroughfares

Habitats: semi-natural habitats: meadows, riparian scrub and ruderal sites: roadsides, railway tracks and embankments, also in rubble heaps and around cottages.
Dynamics: in the last 180 years, this species has established itself in south-eastern and central parts of Poland: it is still scattered in the north and west (in these regions it might still be an ephemerophyte). In the Carpathians it occurs frequently in the Beskid Niski Mts. and Western Bieszczady Mts., where it reaches elevations of 690 m a.s.l. (TACIK 1992; ZEMANEK & WINNICKI 1999). The species is expanding its distribution area throughout Poland. In the last half-century, the number of recorded stations increased from 47 (in 37 ATPOL squares) to 1731 (in 673 ATPOL squares) (Fig. 55; cf. Appendix A).

Salsola kali L. subsp. *ruthenica* (Iljin) Soó

Spiny Saltwort, Prickly Saltwort
Chenopodiaceae

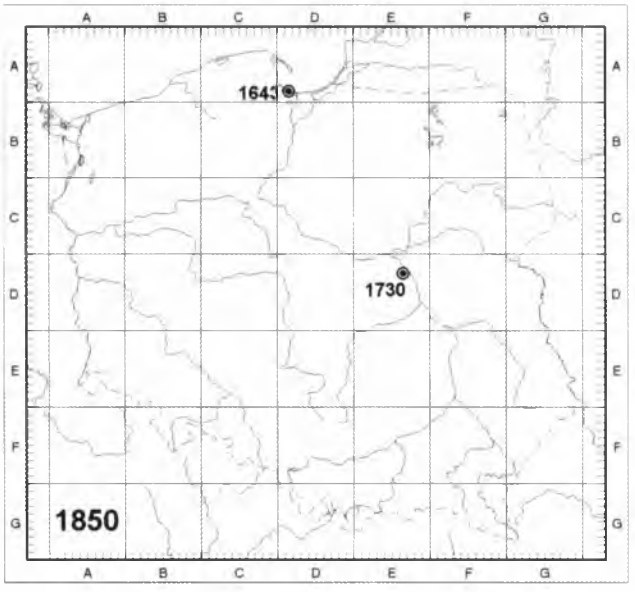
Biology: annual plants dispersing by fine, wind-dispersed seeds.
Native range: southern part of Russia, Caucasus, Siberia and central Asia. In its native country it grows on sand, steppes and riverine cliffs (KOMAROW 1943–1964).
Secondary range: central and western Europe.

History of spread:
Europe: According to HEGI (1963–1983) it was introduced accidentally to central and western Europe, probably with wool and other raw materials at the beginning of the 19th century. HARDTKE & IHL (2000) found an earlier date of the occurrence of this species in Germany, namely 1775.
Poland: BARADZIEJ (1972) reports the oldest Polish stations as existing in the second half of the 19th century. She was the author of the first map of the distribution of this species in Poland. She states that the species migrated to Poland by gradually moving further and further westwards. BARADZIEJ (1972) also noticed that the stations of *Salsola kali* subsp. *ruthenica* clearly occurred along the valleys of large rivers and on railway lines.

An analysis of the distribution of the stations from the earliest periods of the dispersion of this species in Poland shows the primary link with the Vistula river valley (Fig. 56). It can be supposed that the Spiny Saltwort was introduced accidentally into the valley even earlier: maybe in the period of trade in grains. The commercial route on the Vistula river was established as early as in the mid-15th century, when the whole river basin belonged to a united Poland and Lithuania, which were at that time under the same political rule (DAVIES 2001). For some two centuries the trade in grain significantly boosted the whole economy of the Polish Republic (*Rzeczpospolita*). Early stations for this species were located along the Vistula river and its tributaries: the Bug and San, which supports the hypothesis that the first cases of the dispersion of this species in Poland took place along the Vistula trade route. The oldest date refers to Gdańsk, a city located strategically at the end of the Vistula trade route, which was used for grain exports even in the 17th century. At the same time, Gdańsk was connected by a complicated river network with inland areas. All the main tributaries of the Vistula: the Narew, Pilica, Bug, Wieprz, Wisłoka, Dunajec and San were suitable for water transport. All the tributaries had their own ports with storehouses and shipyards. In the 18th century, the Vistula area was connected with the Warta and Oder via the Bydgoski Channel (1771), with Prypeć and Dniepr by the Królewski Channel (1775–1784), and with Szczara and Niemen by the Ogiński Channel (1765–1784) (DAVIES 2001). These connections made possible the subsequent stages of the migration of the species which, when the railway developed, started migrating along new routes. The first stations where this species was introduced accidentally via the railway transport were Szczakowa, Lublin and Wrocław (Fig. 56). At that time, Szczakowa (the current district of Jaworzno town) was a railway junction station and, at the same time, an Austrian boundary station serving both directions: to Prussia and Russia[34]. In addition, such a pattern of expansion is confirmed by early, frequent reports on the occurrence of this species on the Vistula river, and less frequently on railway areas as previously noted by SUDNIK-WÓJCIKOWSKA (1987a). The earlier accidental introduction can be also contributed by the then trade in salt which was developed by the Cistercian monks.
Habitats: inland sands and sand dunes in the interior part of Poland, fields, ruderal sites, roadsides, wastelands, heaps on industrial properties, and railway tracks and embankments.

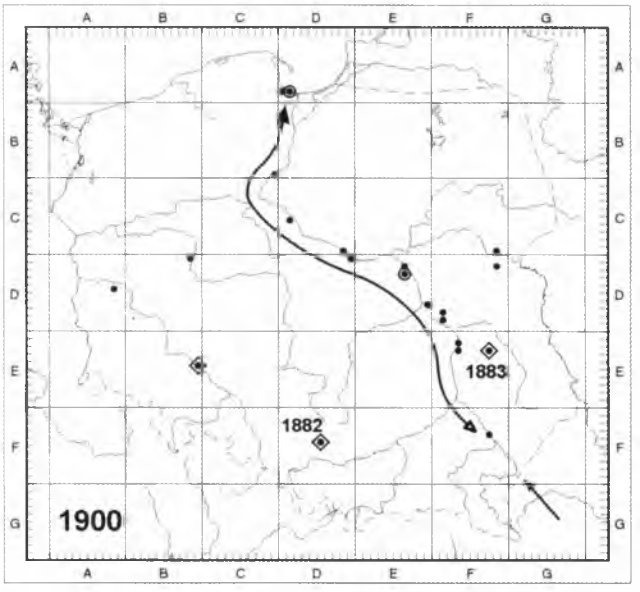
A characteristic species of the *Salsoletum ruthenicae* association and a distinguishing species for the *Corispermo-Brometum* association (MATUSZKIEWICZ 2001).

[34] In 1847, the Katowice–Kraków (Cracow) railway line was built across Szczakowa, and in 1848 it was linked with Warsaw–Vienna route. In Lublin, the first railway line was opened in 1877 (KWIATEK & LIJEWSKI 1998).



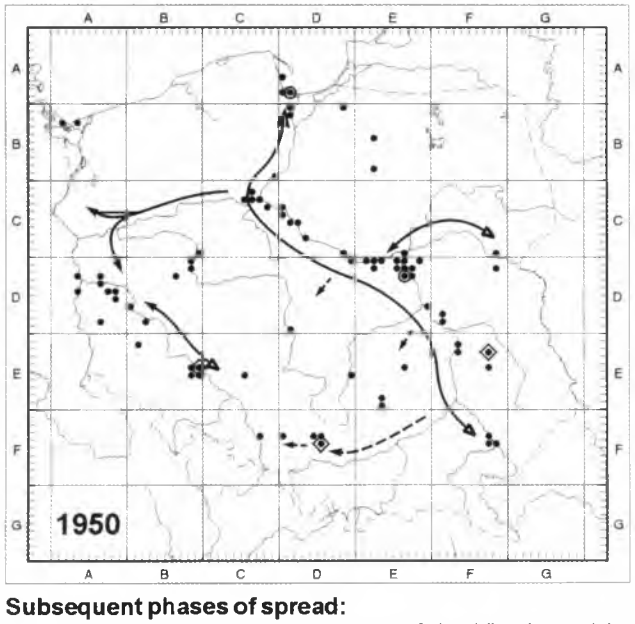
Start of spread:
first half of the 17th century or earlier (see also Chapter 5.2)

- first recorded localities: Gdańsk DA81 (SCHWARZ 1967 after Oelhaf); Warszawa ED26 (SUDNIK-WÓJCIKOWSKA 1987a after Erndtel)



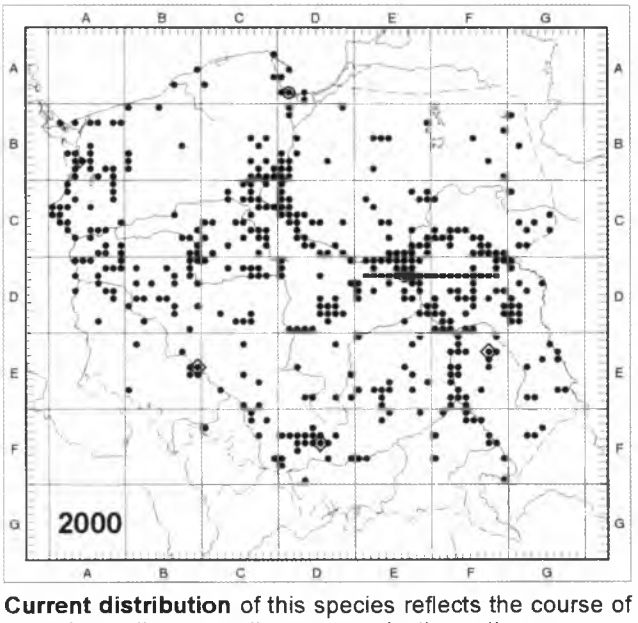
Initial phase of spread:

- migration of the species along the Vistula river valley
- first localities in which this species appeared probably accidentally introduced with railway transport are Wrocław BE49, Szczakowa DF45 and Lublin FE27
- probable directions of arrival of this species to Poland



Subsequent phases of spread:
further migration along river valleys of the Vistula and its tributaries

- simultaneous spread along communication pathways (especially migration along railway lines)



Current distribution of this species reflects the course of main river valleys as well as communication pathways

Fig. 56. Recorded history of the spread of *Salsola kali* L. subsp. *ruthenica* (Iljin) Soó in Poland – an example of a species which used the Vistula pathway as a "conveyor belt" for further spread

Dynamics: the species has gradually invaded new sites (Fig. 56). In the last 50 years the number has increased from 114 to 901 sites recorded in 467 ATPOL squares (cf. Appendix A). Currently, the species constitutes a permanent element of the Polish flora and its distribution closely reflects the pattern of river valleys (principally those of the Vistula and its major tributaries, and of the Lower Oder river), as well as the outlines of the railway network.

7.3.2. Plants brought accidentally from Asia

Sisymbrium altissimum L. [syn.: *S. sinapistrum* Crantz]

Tall Rocket
Brassicaceae

Biology: annual plant, perennial in rarer cases, producing many siliquas. Diaspores (seeds, fruits or even whole plants – so-called "tumbleweed" plants) disperse autochorically and hydrochorically.
Native range: Asia and south-eastern Europe.
Secondary range: remaining part of Europe and North America (SYCHOWA 1985).

History of spread:
Europe: its presence in central and northern Europe was recorded in the second half of the 18th century (MEUSEL *et al.* 1965), where it was probably introduced accidentally with the ballast from ships.
Poland: KORNAŚ (1968b) supposed that the species arrived in Poland before the end of the 18th century. It is confirmed by the oldest dates for finding this species (Fig. 57). This Iran-Turanian species was probably introduced to Gdańsk via ballast and grain (PREUSS 1928). Its oldest stations go back to the first half of the 19th century and they were located in the northern part of Poland: in Gdańsk and Toruń. Subsequent stations dating from the second half of the 19th century were also located in the northern part of Poland: in the Malbork area (KLINGGRAEFF 1854), in Chełmno (ABROMEIT *et. al.* 1898 after Wacker 1861), Braniewo, Bydgoszcz and Kwidzyń (KLINGGRAEFF 1866) and in Czarna Grobla near Braniewo (1868). This species was introduced accidentally into the interior of Poland by railway transport, to Poznań, Szczakowa (REHMAN 1879) and to the Warsaw area (SUDNIK-WÓJCIKOWSKA 1987a, on the basis of herbarium of Cybulski).
Habitats: ruderal weed, found in railroad tracks and embankments, industrial sites, wasteland, rubble, roadsides, and lawns. Regionally reported as a characteristic species of the *Onopordetalia acanthii* order (SYCHOWA 1985). In the classification published by MATUSZKIEWICZ (2001), it is a characteristic species of the *Sisymbrietum loeseli* association. It also occurs sporadically in semi-natural communities, e.g. at the edges of pine-oak stands, and – more often – in xerothermic grasslands.
Dynamics: Up until the year 1950 it had 59 stations. Their number has begun to grow in the 1960s, with a remarkable increase noted in the last 30 years. SYCHOWA (1985) originally classified this species as rare, occurring in the northern, central and southern parts of Poland, except for the mountains. Currently, it occurs frequently throughout most of Poland, again except for the mountains, and has become common in some regions (Fig. 57). In the last half-century the number of stations recorded increased to 1770 in 812 ATPOL squares (cf. Appendix A). Gradually invades new sites.

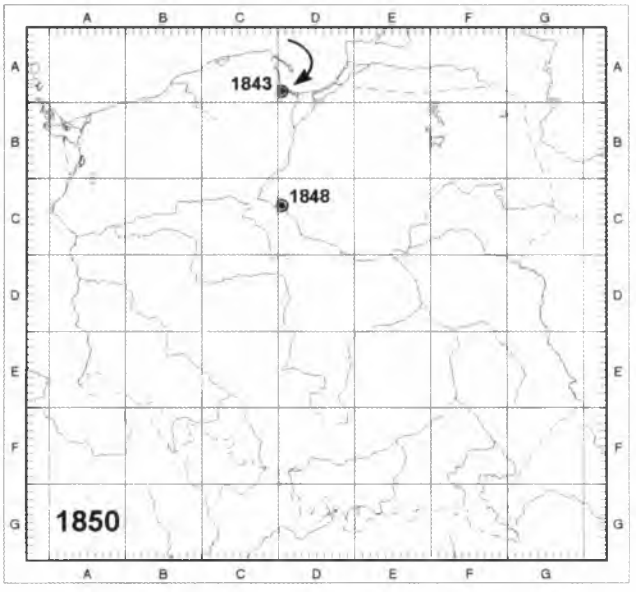
Veronica persica Poir. [syn.: *V. Tournefortii* Gmel.]

Common Field-speedwell
Scrophulariaceae

Biology: annual plant producing great numbers of seed dispersed through wind, water or ants.
Native range: mountains of Asia Minor, northern Iran and western part of the Himalayas (MEUSEL *et al.* 1978).
Secondary range: Central Europe (in the Alps up to an altitude of 1600 m a.s.l.), central Asia, North and South America, southern Australia, New Zealand and New Guinea.

History of spread:
Europe: 1885 – this, the oldest date for central Europe reported by MEUSEL *et al.* (1978), was recorded in the Karlsruhe botanical garden. A subsequent date – 1809 – is reported by PYŠEK *et al.* (2002). In the British Isles it was recorded for the first time in 1825 (STACE 1997). On one hand, the species migrated from east to west, and on the other, it was introduced accidentally into various parts of the continent.
Poland: in the second half of the 19th century it was known to have numerous stations (Fig. 58), which is why it can be supposed that it had been introduced accidentally before this time, which is also suggested by data from various European regions. The oldest stations are dispersed towards the north and south-east, so allowing the presumption that this species was introduced accidentally from various directions: from east and north, via marine transport. In the subsequent half-century it dispersed around previously occupied stations, and in following 50 years it occupied the remaining parts of Poland.
Habitats: cultivated fields, former farmlands, garden allotments, ruderal sites (particularly in moist, shadowed sites).

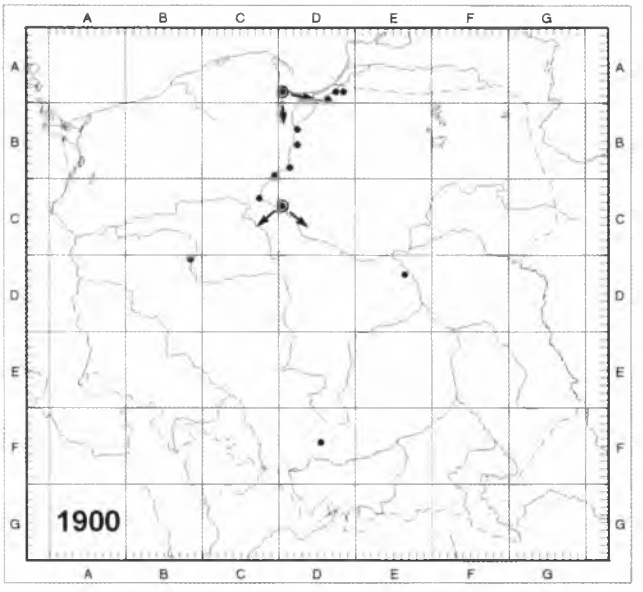
A characteristic species for the *Polygono-Chenopodion* alliance of associations (MATUSZKIEWICZ 2001). Associated with soils of high or medium level of soil fertility. Often, it appears particularly as a weed in cultivated fields in several cultivar systems on several types of soils suitable for cereals and fodder crops. It occurs, among others,



Start of spread:
first half of the 18th century or earlier (see also Chapter 5.2)

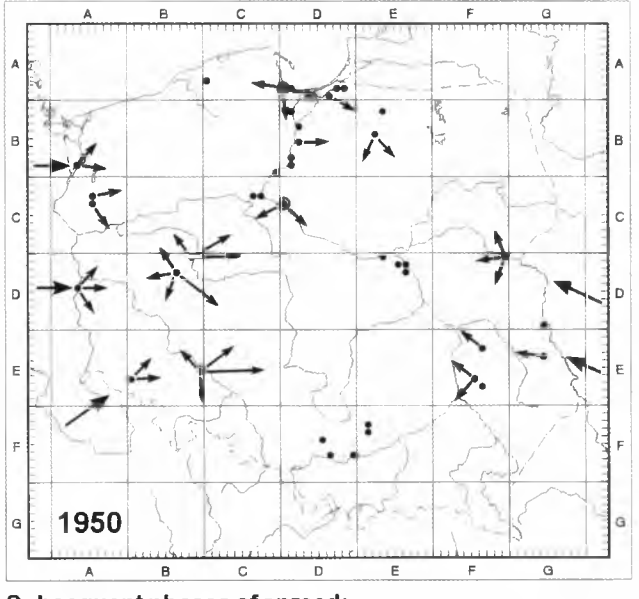
- first recorded localities: Gdańsk DA80 (KLINSMANN 1843) and Toruń DC30 (KLINGGRAEFF 1848)

probable directions of arrival of this species to Poland with marine transport



Initial phase of spread:

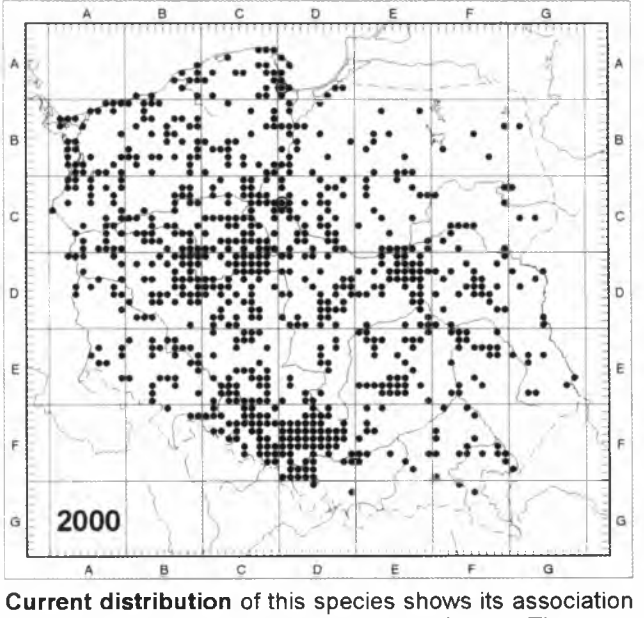
spread of the species in the vicinity of sites of initial accidental introduction (most probably together with long-range transport of goods)



Subsequent phases of spread:

further spread from occupied localities

consecutive accidental introductions of the species with transport of goods (mainly from the area of Germany); simultaneous migration of the species from the south-east

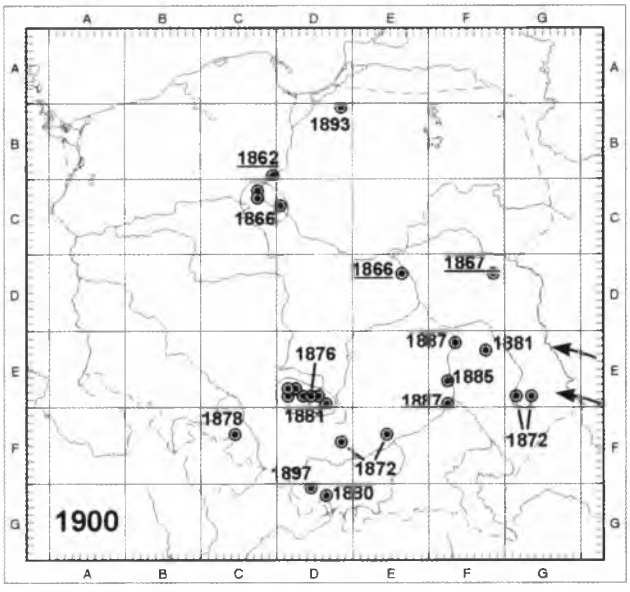


Current distribution of this species shows its association with urban areas and communication pathways. The more common occurrence of the species in the western and central parts of the country can also confirm the hypothesis that the main migration front went from west to east (the map after ZAJĄC A. & ZAJĄC M. (eds.) 2001 – slightly supplemented)

Fig. 57. Recorded history of the spread of *Sisymbrium altissimum* L. in Poland – an illustration of a dominant role of humans in increasing the range of a species

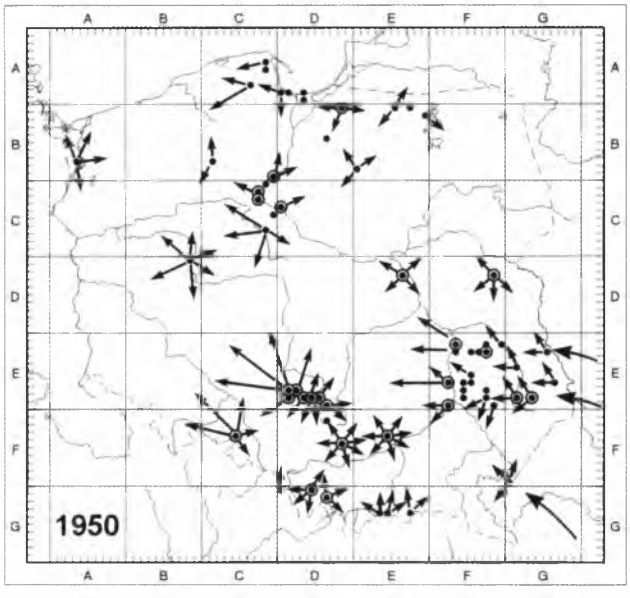
in the *Vicietum tetraspermae* communities, accompanying winter cereal crops and rape fields (WARCHOLIŃSKA 1999).

Dynamics: massive expansion of this species was recorded in the last half-century when the number of stations increased from 84 to over 7800, recorded in 2204 ATPOL squares (cf. Appendix A) (Fig. 58). The species is still expanding although the invasion is limited to segetal and ruderal habitats.



Start of spread:
second half of the 19th century or earlier (see also Chapter 5.2)

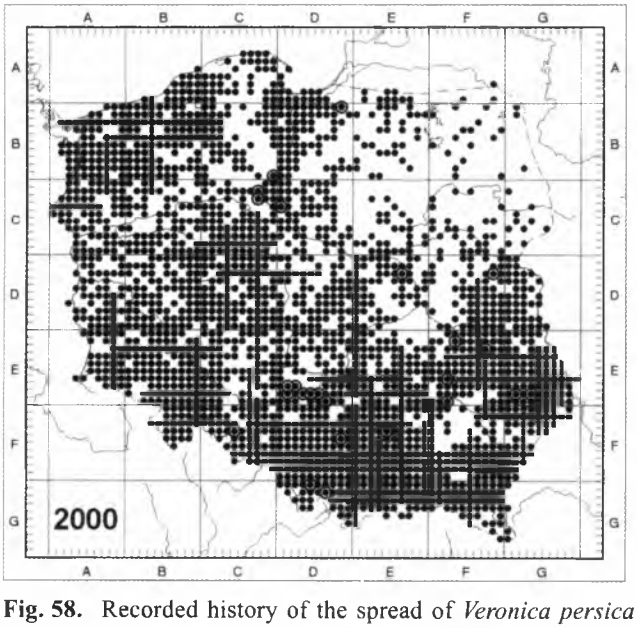
⊙ first recorded localities: Western Pomerania: Chełmno and Świecie CB99 (ABROMEIT *et al.* 1898 after WACKER 1862); Bydgoszcz CC26 (KLINGGRAEFF 1866); Strzelce near Bydgoszcz (KÜHLING 1866); Mazovia–Podlasie Lowland: Warszawa ED16 (ŁAPCZYŃSKI *herb.* UW); Polinów near Łosice FD28 (KARO 1867); probable directions of arrival of this species to Poland



Initial phase of spread:

spread of the species in the vicinity of sites of initial accidental introduction

arrival to a new locality most probably together with long-range transport of goods



Subsequent phases of spread:
sudden and massive occupation of new localities (mainly in anthropogenic habitats); simultaneous migration of the species from the south-east

(the map after ZAJĄC A. & ZAJĄC M. (eds.) 2001 – slightly supplemented and modified)

Fig. 58. Recorded history of the spread of *Veronica persica* Poir. in Poland – an example of invasion by putative repeated accidental importation and simultaneous range expansion

7.3.3. Plants brought accidentally from America

Bidens frondosa L. [syn.: *B. melanocarpus* Wiegand]

Beggarticks
Asteraceae

Biology: annual plant reproducing generatively. Seeds are dispersed in water and by animal and human agents. The warty surface of the fruits with a crown of awns is covered with downward-pointing hooks facilitating their dispersal.
Native range: North America between the Atlantic and Pacific, from New Foundland and southern Saskatchewan to the north, to Colorado, California and Mexico in the south (TRZCIŃSKA 1961).
Secondary range: Europe and eastern Asia.

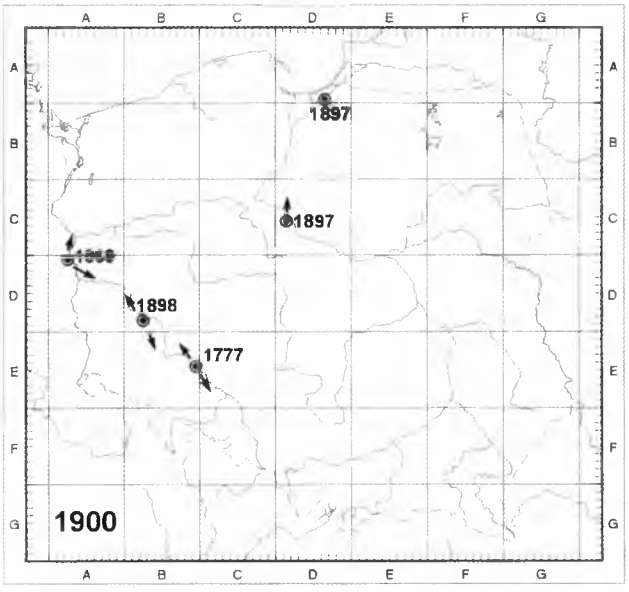
History of spread:
Europe: it appeared in the 18th century in various parts of the continent: France (Botanical Garden in Montpellier) 1762; Italy 1834, 1849, 1861; Portugal 1877; and Germany 1894 (KORNAŚ *et al.* 1959; TRZCIŃSKA 1961); information on its occurrence along the Oder river was reported in 1777 (KROCKER 1790; GRUBEROVÁ *et al.* 2001). LOHMEYER & SUKOPP (1992) report the earliest date of occurrence of this species in central Europe, i.e. 1736. Currently, it is widespread throughout the continent. UHERČIKOVÁ (2001) reports it as an invasive species on the Danube in Slovakia.
Poland: probably migrated from Germany to southern Poland (it spread in Silesia, where it dispersed along the Oder) and northern Poland (it was known in Pomerania since 1897) (Fig. 59). In Poland it was reported for the first time in Wrocław, by the Oder (KROCKER 1790). As late as in 1869 it was found again by Brand, by the Oder, downstream of the river at Słubice (SCHUMACHER 1942). Since then the occurrence of this species was reported by GRAEBNER (1897), who reported its occurrence in Łęcze near Elbląg and by ASCHERSON (1898), recording it by the Vistula river in Ciechocinek. Fiek found this species on the bank of the Oder, near Głogów (SCHUMACHER 1942). Beggarticks migrates via two routes: along watercourses where it disperses by hydrochory and epizoochory and as an antropochorous plant along railway tracks (KORNAŚ *et al.* 1959). The description of this migration in the earliest part of the invasion was given by TRZCIŃSKA (1961), who developed a distribution map on the basis of 101 reported stations. By then it was already a species well established along the Oder river and the Vistula basin: downstream in the Toruń and Bydgoszcz areas and upstream in the Kraków area. The stations in Upper Silesia and detached from Brześć belong to the group of locatities associated with migration of *Bidens frondosa* along railway tracks. At that time it was dispersing southwards and eastwards. In Brześć on the Bug, it was discovered in 1955, while SOKOŁOWSKI (1967) recorded it in the Białowieża Forest in 1965. Since 1970, it has been reported in the Ukraine (Dr M. SHEVERA, *pers. comm.*) where it occurs in urbanized areas (BURDA 1997; PROTOPOPOVA & SHEVERA 2002).
Habitats: banks of inland waters: carrs and riparian alluvia, drying-up margins of lakes and ponds, cultivated fields and moist ruderal habitats: roadside ditches, railway tracks and stations, also rubble heaps. It is a component of the therophytic communities of the class *Bidentetea* and of forest, coastal scrub and reed communities (*Salicion*, *Phragmition*, *Glycerio-Sparganion*). A characteristic species of the communities of the alliance *Chenopodion fluviatile* (MATUSZKIEWICZ 2001).
Dynamics: to date it has been recorded in 3142 stations in 1068 ATPOL squares (cf. Appendix A). Distributed throughout Poland, common in the Oder and Vistula river valleys as well as along their tributaries (Fig. 59). In the mountains it occurs at lower sites (BIAŁECKA 1982; KORNAŚ *et al.* 1996; SZELĄG 2000), e.g. in the Beskid Żywiecki Mts. it occurs up to 455 m a.s.l. (BIAŁECKA 1982). Still expanding.

Chamomilla suaveolens (Pursh) Rydb. [syn.: *Matricaria discoidea* DC.; *M. matricarioides* (Less.) Porter]

Pineappleweed
Asteraceae

Biology: Annual plant dispersing anemochorically, zoochorically (by endo- and exozoochory) and anthropochorically (accidentally introduced via transportation over land and water).
Native range: north-west America and eastern Asia where it grows on the river banks and valleys and on the coast in humid and sandy places (SUDNIK-WÓJCIKOWSKA 1987a).
Secondary range: Europe.

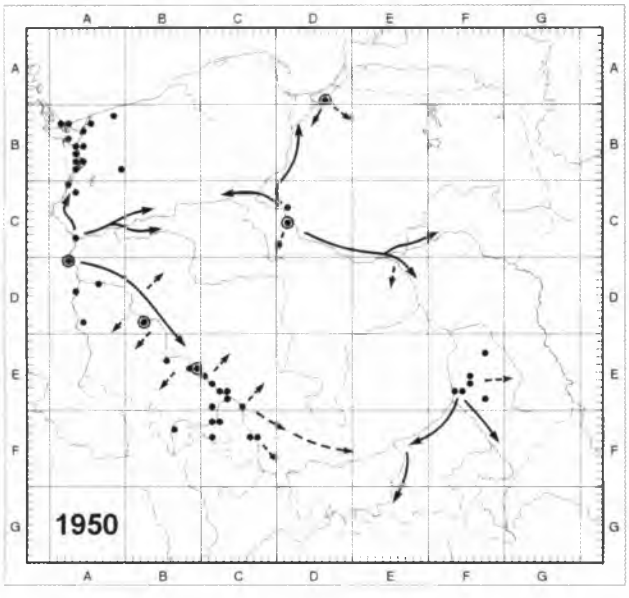
History of spread:
Europe: many authors state that this species appeared in the early 19th century. The oldest recorded date – 1850 – was published by MEUSEL *et al.* (1992) for Scandinavia. A subsequent station in the former Czechoslovakia was reported by PYŠEK *et al.* (2002). In 1852, it was found by Braun in the Berlin area: this author considered it a refugee from the botanical garden (KAMIEŃSKI 1884a). Another station was found in southern Scandinavia in the same year. Every few years new stations of this species are reported in other parts of Europe. The first report on the occurrence of this species in Britain goes back to 1871 (STACE 1997).



Start of spread:
second half of the 19th century or earlier (see also Chapter 5.2)

- first recorded localities: Wrocław BE49 (KROCKER 1790); Słubice AD02 (SCHUMACHER 1942); Łęcze near Elbląg DA96 (GRAEBNER 1897); Ciechocinek DC51 (ASCHERSON 1898); Rapocin near Głogów BD82 (FIEK & SCHUBE 1898)

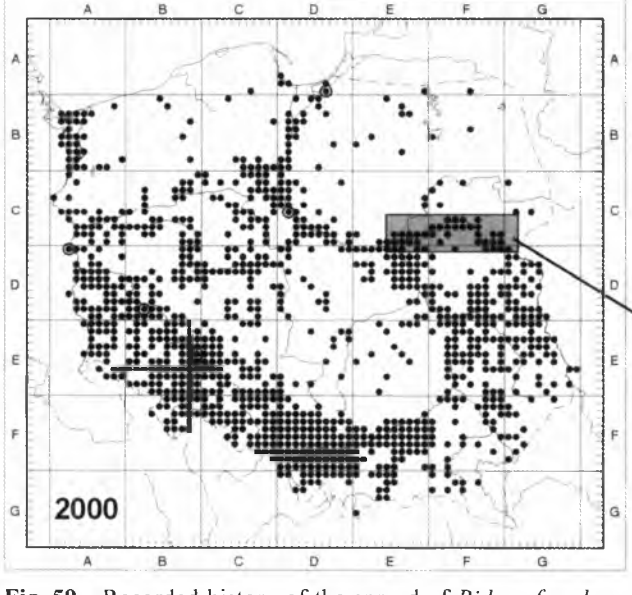
spread of the species near the sites of initial accidental introduction



Initial phase of spread:

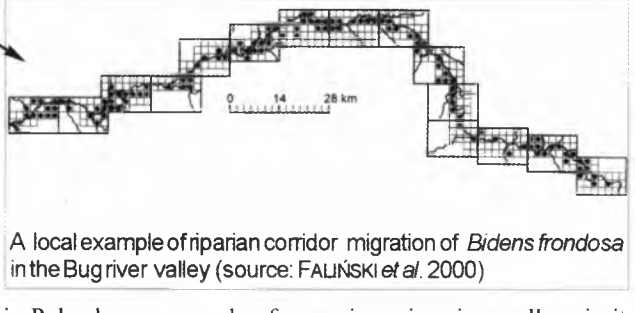
migration along river valleys, especially along the Odra river

first transitions of the species to ruderal habitats outside river valleys



Subsequent phases of spread:
rapid occupation of new localities: migration along and across river valleys (transition from riverside habitats to ruderal habitats). The current distribution reflects the course of major river valleys.

(the map after ZAJĄC A. & ZAJĄC M. (eds.) 2001 – slightly supplemented and modified)



A local example of riparian corridor migration of *Bidens frondosa* in the Bug river valley (source: FALIŃSKI *et al.* 2000)

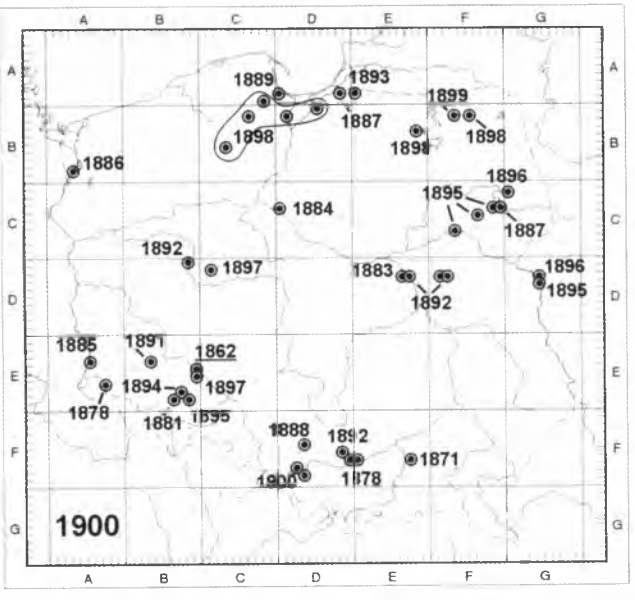
Fig. 59. Recorded history of the spread of *Bidens frondosa* L. in Poland – an example of a species using river valleys in its migrations (migration along and across valleys)

However, the oldest studies by GUDŽINSKAS (1997d) indicate that this species arrived in Europe earlier, since its occurrence was reported by Gilbert in Grodno (Bielarous) in a paper from 1782 and in addition it was also mentioned by JUNDZIŁŁ (1791, 1811) and GÓRSKI (1830).

Poland: recorded for the first time in the 19th century, initially in Lower Silesia (1862), and next in Tarnów (1871) and the Kraków area (1878) (Fig. 60). KAMIEŃSKI (1884a) in his description of this species based on the occurrence in Warszawa, stated that "it is likely that this newcomer to our flora will disperse very quickly and it soon will grow outside Warszawa". The species dispersed at a fast pace. When RACIBORSKI (1885) reported it for the first time (in 1878), this species was present and abundant at several stations in Kraków. PACZOSKI (1895) reports that this plant had been known to the east of Warszawa (e.g. from Kiev) in 1869; the same author also found this species in Białystok and Brześć, and outside Polish borders in the Mińsk area in Wołyń (where this species had occurred before the date reported by GUDŽINSKAS (1997d)). PACZOSKI (1900), in a subsequent publication describes this species as a common species in Polesye, in railway facilities and built-up areas. Due to the fact that the plant was usually found near railway stations the author attributed its occurrence to the development of the railway lines. The invasion by this species commenced in Poland at the end of the 19th and beginning of the 20th centuries.

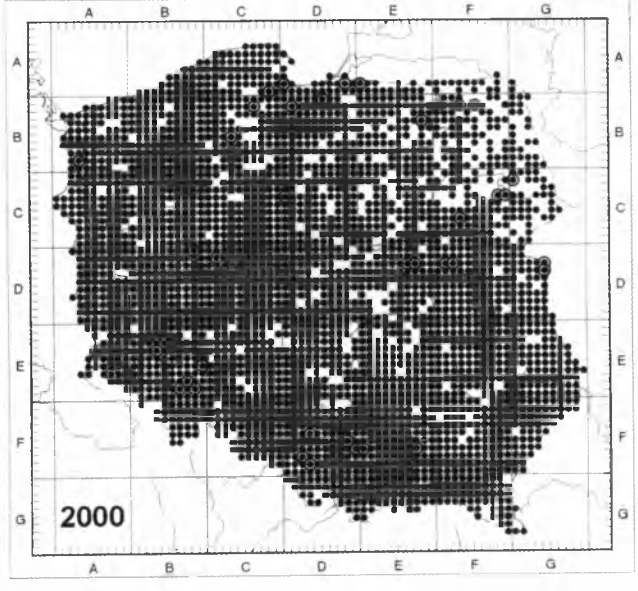
Habitats: distributed in wastelands, along transport routes and in cultivated fields. Associated particularly with trampled sites and the initial stages of ruderal communities.

Dynamics: even though it is not one of the group of the oldest kenophytes, it has colonised



Start of spread:
second half of the 19th century or earlier (see also Chapter 5.2); plant introduced accidentally to many regions simultaneously (most often in cities); maybe initially planted in botanical gardens

⊙ first recorded localities: Wrocław BE49 (UECHTRITZ *herb.* WRSL; KNEBEL *herb.* WU); Tarnów EF67 (HEGER 1871); Kraków DF69 (RACIBORSKI 1885)



Subsequent phases of spread:
rapid and massive colonisation of anthropogenic habitats in the whole area of the country
(the map after ZAJĄC A. & ZAJĄC M. (eds.) 2001 – slightly supplemented and modified)

Fig. 60. Recorded history of the spread of *Chamomilla suaveolens* (Pursh) Rydb. in Poland – an example of a species which became the most common kenophyte in the Polish flora as a result of invasion

the entire national territory of Poland in the last 150 years (Fig. 60). It is distributed throughout lowlands, also in mountain areas as far as the foothills. The species has also spread rapidly across the Carpathians, being reported from Nowy Sącz (Pawłowski 1919 *herb.* KRAM) and other localities in the region (Pawłowski 1925). In the Pieniny Mts. from where it was first reported by Kulczyński (1928), it occurs frequently in villages and along roads, in the periphery of this mountain range (Guzikowa 1972). In the Tatra Mts. it was found at an elevation of 1500 m a.s.l. near the Murowaniec mountain shelter (Piękoś & Mirek 1974), and on the Slovak side of the Tatra Mts. even as high as at 1770 m a.s.l. (Radwańska-Paryska 1963), and later at 1815–1830 m a.s.l. near the mountain shelter and cable car station in the surroundings of the Skrajne Solisko site (Piękoś-Mirkowa & Mirek 1978). In the Karkonosze National Park, the species reached 1540 m a.s.l. occurring along the road leading to the Śnieżka Mt. (Rostański K. 1977). In the massif of the Śnieżnik Mt. and in the Bialskie Mts. it is frequently found at lower mountain sites (Szeląg 2000). In the Bieszczady Mts. it is found only occasionally within ruderal habitats at elevations of 640–750 m a.s.l. (Zemanek & Winnicki 1999). In the Mt. Pilsko massif (Beskid Żywiecki Mts.) it was not very frequent in the early 1980s, being recorded from sites not exceeding 520 m a.s.l. (Białecka 1982). In the last two decades, it spread across the Carpathian Foothills and lower sites in the Carpathians, e.g. in the Ciężkowice Foothills where it occurs frequently as a component of the regional flora (Kornaś *et al.* 1996).

The species continues to colonise new sites. It is one of the most common kenophytes occurring in Poland, for which data have been obtained from 13125 stations in 2965 ATPOL squares (cf. Appendix A and Chapter 5.2) (Fig. 60).

Elodea canadensis Michx. [syn.: *Anacharis canadensis* Planch, *E. canadensis* Rich.; *Helodea*; *Philotria canadensis* Britton.]

Canadian Waterweed

Hydrocharitaceae

Biology: spreads only through vegetative processes owing to the fact that only female individuals were introduced into Europe. The fragments of shoots are transported by water, birds and humans.

Native range: North America

Secondary range: Europe (including northern Scandinavia), New Zealand, Australia (new south Wales, Victoria), Africa (Fedorov 2001).

History of spread:

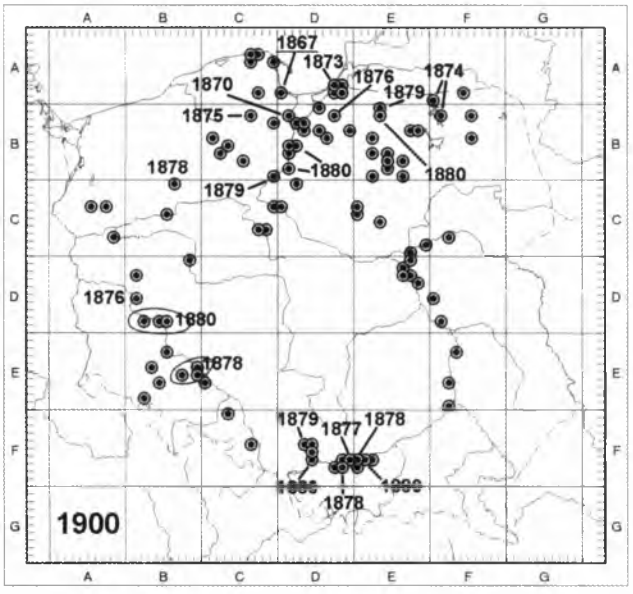
Europe: the naturalisation of Canadian Waterweed in Europe started in the first half of the 19th century. The first record in 1836 comes from Ireland (Kamieński 1879, 1884a & b; Dyakowski 1899; Stace 1997). Next, its occurrence was recorded in the United Kingdom: in 1842 in Scotland and in 1847 in central England. In 1840 it was brought to the Berlin botanical garden, where due to its excessive growth some was thrown away into the river (Kucharski 1992). The peak of its rapid expansion in the central Europe occurred in the period 1859–1935 (Lohmeyer & Sukopp 1992). In the British Isles, after the mass invasion in the 19th century and the first half of the 20th century it withdrew, superseded by *E. nuttallii*, also a North American species.

Poland: the first report from Poland (Gdańsk) dates from 1867 (Abromeit *et al.* 1898). The plant was found for the first time in the Vistula River in 1876 (Dyakowski 1899). 30 stations of this plant were recorded in then Polish (Congress) Kindom in the period 1878–1897, while in Grand Duchy of Poznań it was recorded in all counties (Błoński 1899). Łapczyński (1882) describes this species and presents a drawing of a specimen collected in Warsaw, and in 1887 reports its occurrence in ditches in Sandomierz. A number of occurrences of this species in many Polish regions was published in the following years: Pomerania and Masuria (Abromeit *et al.* 1898 after Scharlok 1884), in western and southern parts of Poland (Uechtritz 1876, 1880; Krupa 1882; Raciborski 1884) and in Masuria (Rosenbohm 1879; Kamieński 1879; Łapczyński 1882) (Fig. 61).

Habitats: lakes, old river beds, rivers and stream with slow current(s), ponds, clay pits, channels, drainage ditches.

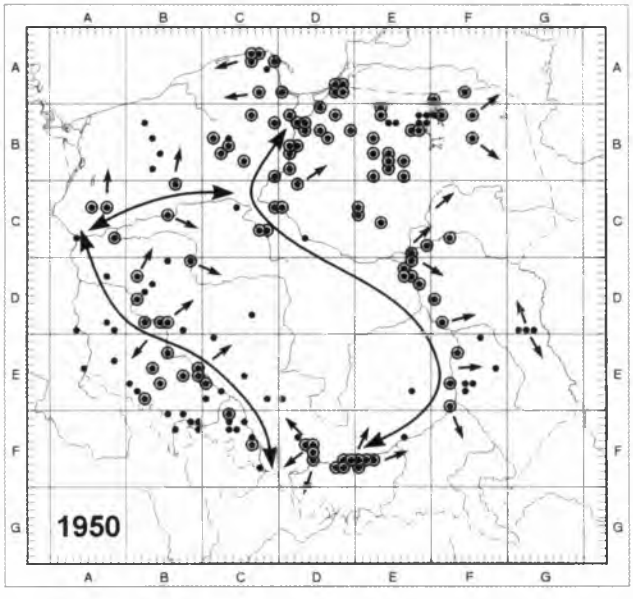
It occurs in water communities from the class *Potametea* and less frequently in communities from the alliance *Phragmition* (Kucharski 1992 and literature cited). In eutrophic water this successful invader builds its own community *Elodeetum canadensis* (Matuszkiewicz 2001).

Dynamics: the contemporary distribution map shows that Canadian Waterweed is abundant on most of the national territory of Poland (except for mountain regions), although it no longer shows any evident invasion. To date it has been recorded in 3681 stations in 1847 ATPOL squares (cf. Appendix A).



Start and initial phase of spread:
mid-19th century or earlier (see also Chapter 5.2);
by the turn of the 19th century, this species already had 140 localities in the waters of the Vistula, Odra and Warta rivers as well as in the lakes of the Lake Districts

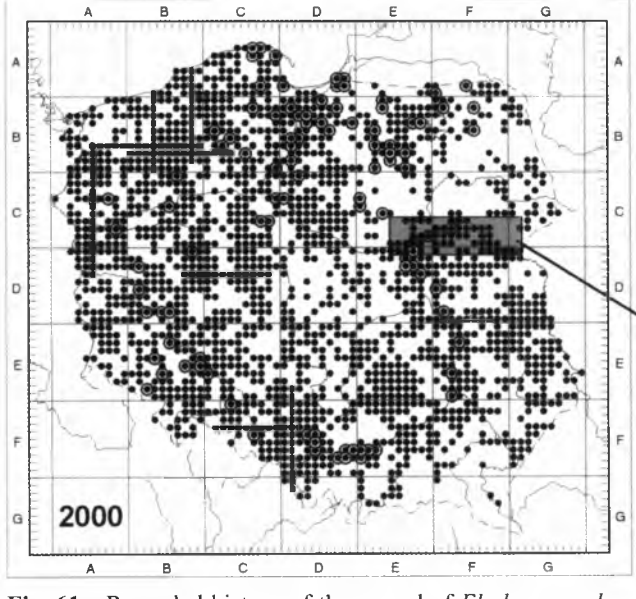
◉ the first recorded locality: Gdańsk DA80, dates from 1867 (ABROMEIT *et al.* 1898).
Note that the map describes localities recorded up to 1880.



Subsequent phases of spread:
rapid occupation of new localities:

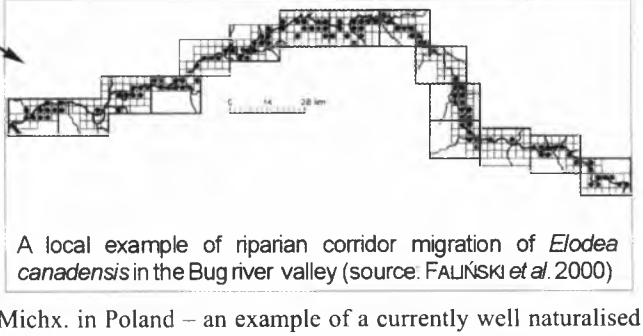
migration along

and across river valleys (including by means of smaller watercourses, old river beds and water reservoirs)



The current distribution reflects mainly the presence of water habitats

(the map after ZAJĄC A. & ZAJĄC M. (eds.) 2001 – slightly supplemented and modified)



A local example of riparian corridor migration of *Elodea canadensis* in the Bug river valley (source: FALIŃSKI *et al.* 2000)

Fig. 61. Recorded history of the spread of *Elodea canadensis* Michx. in Poland – an example of a currently well naturalised species common throughout Poland which owes its wide distribution to water and birds

PART FOUR

Discussion

8. The proportion and role of alien species in the flora: do kenophytes determine the recent shape of the flora of Poland?

In the voluminous body of literature devoted to alien species of plants, some figures can be found illustrating the scale of the phenomenon of their presence in respective floras. These figures are however usually estimates and hardly comparable because of differences in the terminology used, as well as in the intensity and uniformity of the research undertaken (PYŠEK *et al.* 2002; TOKARSKA-GUZIK 2003a & b; PYŠEK *et al.* 2004). For example, for the United States of America, MORSE *et al.* (1995) report 5000 species of alien origin established within the entire flora of some 17 000 species; SCOTT (1997) lists more than 1850 alien species for New Zealand, while ENOMOTO (1997) reports 1196 established species in Japan. In the Hawaiian flora, the initial estimate was 900 native plant species and 4000 introduced species, out of which 870 had established themselves permanently and 91 were accorded the status of invasive species (VITOUSEK *et al.* 1987). According to the so-called "Tens rule" of WILLIAMSON (1993), it is estimated that roughly 10% of the total number of alien species is capable of permanent establishment in the new homeland, and from among these again only 10% can establish themselves not only in anthropogenic habitats but also enter natural communities.

On the basis of *Flora Europaea*, WEBER (1997a) compiled the estimated data for the continent of Europe. The list contains 1568 species which have either expanded beyond their previous ranges (and these account for 63%) or are species originating from outside Europe (the remaining 37% which Weber classified as "exotic species"). Individual countries of Europe differ in the numbers of species of alien origin, from 42 species reported for the European part of Turkey to 479 reported for France (WEBER 1997a). However, this data so recently provided for various European countries is now out of date. The comparison made for the Czech flora by PYŠEK *et al.* (2004) indicates that Weber's figures were an underestimate. For the Polish flora, WEBER (1997a) reported, from analysing *Flora Europaea*, 184 alien species established, including 81 species originating from outside Europe. Weber's totals for Poland, when compared with the figures obtained in the present monograph, is as for the Czech Republic clearly an underestimate.

Detailed lists, compiled for Germany by KOWARIK (1999), show that from among *ca.* 12 000 species introduced in this area, 417 permanently established species now constitute a part of the overall inventory of the German flora (of 3001 species in all). In Germany, most of the species of alien origin colonise disturbed habitats, whereas 228 have been also recorded in natural communities and among the latter, 30 species are regarded as a nuisance and requiring control measures.

The process of exchanging species between various regions of the world has been analysed by JÄGER (1988). His results point to a particularly dynamic exchange between Eurasia and North America. The estimated figures show an evidently higher proportion of alien species in the North American flora (26%), compared with Europe (*ca.* 9%) (FORMAN 2003)[35].

[35] Following other authors FORMAN (2003) points out that species introduced in mid 19th century from Europe into America appeared to be more successful at naturalising than American species introduced to Europe. There are three main hypotheses suggested by author for explaining the phenomenon: 1) European weeds are better competitors than their American counterparts; 2) European plant species evolved among greater disturbance than American ones, making it easier for them to establish in a newly colonised America; 3) the flow of species has been greater into America than to Europe.

Again, it seems clear that the figures showing the proportions of alien species in floras will have to be periodically updated.

The list of alien species compiled by Polish researchers for the Polish flora includes more than 1000 species (Mirek *et al.* 2002; cf. also Chapter 5.1; Table 3). The list of archaeophytes contains 160 species. The first list of kenophytes published in the 1960s included 117 species (Kornaś 1968b). The list of more recent, but firmly established arrivals, was checked 30 years later, and has grown to as many as 251 species (Zając A. *et al.* 1998). This amounts to *ca.* 10% of the flora of Poland. It can thus be presumed that this flora contains a total of over 400 species of permanently established species (which represents *ca.* 15% of the overall flora) (Tokarska-Guzik 2003a).

The comparison of the floras of Poland, the Czech Republic (Pyšek *et al.* 2002) and Germany (Kühn & Klotz 2003) with respect to the proportions of individual groups of species of alien origin is made difficult because of differences in the classification criteria. Moreover, the figures should be also related to geographical location and the natural conditions prevailing in these countries.

Generally, the proportions of alien species in the three countries concerned are similar (Fig. 62). In the Czech flora, the combined number of alien species (1378) is higher compared with Poland (1017 species), whereas for Germany this figure is lower still (913)[36]. The proportions of established newcomers in the floras of the three countries concerned differ from one another, but these differences stem mainly from discrepancies in the classification applied, as well as from the methodological premises made by the authors.

The researchers who study the species of alien origin in various floras report problems connected with the appearance of hybrids. These are both hybrids produced by "crossing" between two alien species, often while already in the new homeland, and the hybrids developing between alien and native species.

Among the kenophytes occurring in Poland, only 25 hybrids have been found (these being mostly hybrids produced by crossing between an alien

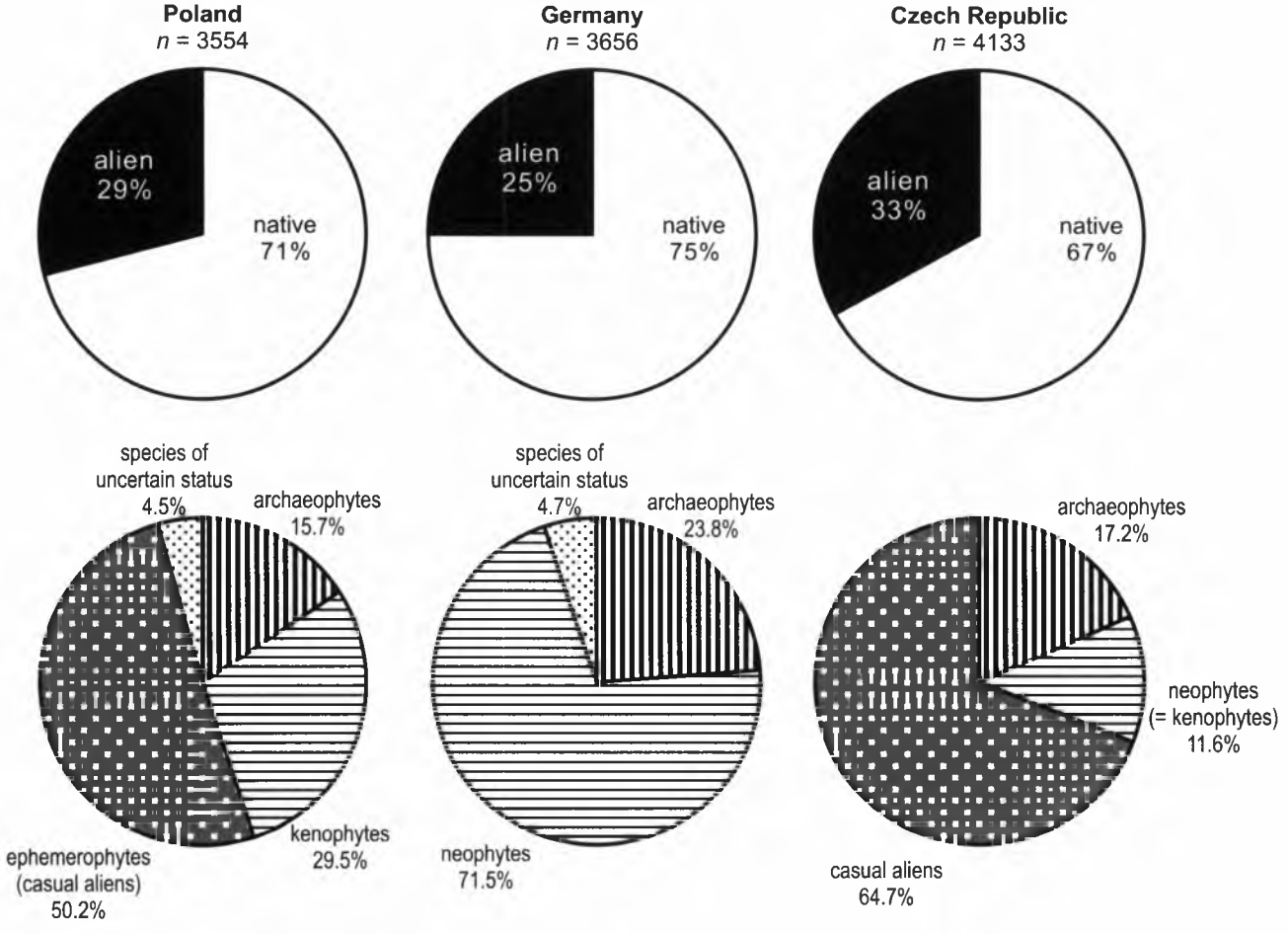


Fig. 62. Comparison of the structure of the flora of Poland, Germany and Czech Republic (for more explanation see the text)

[36] In their analyses the authors considered only 207 species regarded to be the most frequent ephemeral newcomers into Germany (casual alien plants that are very common in Germany); including the rare casuals would increase the number of alien species greatly (Kühn & Klotz 2003).

species and an indigenous one) (cf. Chapter 5.1 and Appendices A and B). Nevertheless, both the available guides for the identification of species as well as the *Flora of Poland* [*Flora Polski*], provide ample information on possible hybridisation between alien newcomers and native species[37].

The hybridisation of an alien species with a native species can result in the production of a fertile hybrid which is capable of spreading faster than its parents[38]. This happened in the case of *Reynoutria* x *bohemica*[39] (BAILEY *et al.* 1996; FOJCIK & TOKARSKA-GUZIK 2000; MANDÁK *et al.* 2004), which is found fairly frequently in some regions of Poland. The emergence of species of hybrid origin[40] results in various problems of taxonomic nature, but above all ecological ones (cf. Chapter 12). The invasive characteristics of *Reynoutria* x *bohemica* present an example of the so-called "invasion by hybridisation"[41] (WEBER *et al.* 1998). The erosion of the genotype of native plants (via backcrossing and introgression) could be yet another effect of hybridisation[42].

The most species rich families in the Polish flora, which also contain species of foreign origin (including many kenophytes), are: Asteraceae (46 species), Rosaceae (37), Onagraceae (23), Brassicaceae (19), Fabaceae (14) and Poaceae (14)[43] (cf. Chapter 5.1.4). Similar proportions were reported for the Czech flora by PYŠEK *et al.* (2002), although in a different order, resulting from also adding the most recently arriving casual (ephemeral) species.

The comparisons made in this study for various systematic groups corroborate with the reports of other authors, who have pointed out that the properties enhancing invasiveness are particularly concentrated in some families, namely Asteraceae, Poaceae, Brassicaceae and Chenopodiaceae, whereas some other families such as Cyperaceae or Orchidaceae lack them completely[44] (e.g. REJMÁNEK *et al.* 1991; KORNAŚ 1996; PYŠEK *et al.* 2002).

The most species rich family of angiosperms, i.e. Asteraceae (ca. 1250–1300 genera with 20 000 – 25 000 species) is represented in floras worldwide, particularly in regions of moderate or subtropical climates (TAKHTADŽJAN 1987). This family provides most of the species of alien origin within the floras of various regions of the world.

Poaceae is the second most numerous family among the flowering plants, predominating from the ecological perspective and being particularly important to the human economy. Moreover, this group represents a major proportion of the floras of most regions worldwide (KORNAŚ & MEDWECKA-KORNAŚ 2002; FORMAN 2003). In Poland, grasses constitute 7.3% of the whole flora, and are one of the three most species rich families, along with Asteraceae – 12.1% and Rosaceae – 7.3% (KORNAŚ & MEDWECKA-KORNAŚ 2002; PIĘKOŚ-MIRKOWA & MIREK 2002). In all, 298 species of grasses have been recorded in Poland (FREY & RUTKOWSKI 2002), including *ca.* 155–165

[37] Among others, hybridisation occurs between species of the genus *Amaranthus*; *Centaurea diffussa* crosses with *C. stoebe*, *C. rhenana* and *C. jacea*; *Digitalis purpurea* produces hybrids with *D. grandiflora*; hybridisation takes place also between *Diplotaxis tenuifolia* and *D. muralis*; *Echinops exaltatus* produces a hybrid with *E. sphaerocephalus* (= *E.* x *pallenzianus* – STACE 1997); *Epilobium ciliatum* hybridises with several other species of the genus (some of them have been reported as common, for example, from the British Isles – STACE 1997); *Galinsoga ciliata* produces a hybrid with *G. parviflora* (*G.* x *mixta* J. Murr.); in Great Britain, hybridisation has been reported between *Heracleum mantegazzianum* and a native species *H. sphondylium* (STEWART & GRACE 1984); *Trifolium patens* produces hybrids with *T. campestre*, and *Xanthium albinum* with *X. strumarium*.

[38] An example of a hybrid which, in some parts of Europe, and in Poland, might be more frequent compared with its parent species, is provided by a swarm of hybrids described as *Medicago* x *varia*, which resulted from the introgressive crossing of *Medicago sativa* with the native *M. falcata*. REBELE (1988) reported this hybrid from industrial sites in West Berlin with a markedly higher frequency (in 39.2% of the areas studied) while the parental species were found less frequently (*M. sativa* in 13.7% and *M. falcata* in 11.8% of sites).

[39] The introduction of taxa of the genus *Reynoutria* (*Fallopia*) into Europe has led to the emergence of a hybrid, *Fallopia x conollyana* J.P. Bailey, which resulted from the hybridisation of *Reynoutria* (*Fallopia*) *japonica* and *Fallopia baldschuanica* (Regel) Holub. Initially it was found in the form of seeds, while from Great Britain it has been reported in the wild state since 1986 (BAILEY & CONOLLY 1984; BAILEY 1988, 2001).

[40] A species of hybrid origin is a much more significant phenomenon than a hybrid. The implication is that there has been a recovery of fertility and that the new species will form a self-contained cross-breeding genetic population capable of evolution and adaptation.

[41] WEBER *et al.* (1998) described a hybrid which resulted from a cross between an invasive species introduced to California from South America, *Carpobrotus edulis*, with the native *C. chiliensis*. This hybrid is fully fertile, and the authors even foresee a high probability that a genotype capable of expansion will emerge.

[42] Backcrossing has produced hybrid swarms, e.g. *Calystegia sepium* x *C. sylvatica*, and in the case of *Centaurea jacea* x *C. nigra*, an alteration in the genetic make-up of the native species, even though the alien species had died out (CLEMENT & FOSTER 1994).

[43] These are families which also show the highest number of natural hybrids (according to STACE 1975). The author also lists families such as: Cyperaceae, Salicaceae, Scrophulariaceae and others.

[44] The newest findings have modified this opinion, indicating for example that such families as Amarantaceae and Cyperaceae are "weedier" than expected (FORMAN 2003). In Polish native flora *Carex brizoides* it certainly appears to be invasive (expanding natives) (SIERKA & CHMURA 2004).

species occurring in the wild or established, plus almost a hundred of those which are often cultivated and transitionally move into the wild within the lowland regions of Poland (RUTKOWSKI 2002).

The relationships presented above indicate that grasses of alien origin constitute a considerable percentage of the Polish flora, and it also appears that the proportion has been increasing over the last few decades. Among 251 species of newer arrivals recorded in the flora of Poland there are 13 species of grasses (ZAJĄC A. *et al.* 1998), while the first, provisional list of kenophytes (KORNAŚ 1968b) only includes 4 species. The list of ephemerophytes published in the late 1980s included 662 species in all, with 92 species of grasses (ROSTAŃSKI & SOWA 1986–1987). At that time, this number covered 5 species which are now regarded as either fully (*Bromus carinatus*, *Eragrostis albensis*) or locally established (*Bromus japonicus*, *B. squarrosus*, *Hordeum jubatum*). Twenty years ago, the first two were regarded as being only temporarily and accidentally brought in; however, they are now extending their secondary range (TOKARSKA-GUZIK 2003b).

In other regions of the world, the participation of grasses in invasions is also considerable. ENOMOTO (1997) lists 29 grass species among 285 species of alien origin commonly occurring in Japan. In the flora of Italy (5811 species), 214 species are regarded as being alien invasive plants, and this number includes 15 species of grasses (VIEGI 2001). In the Lithuanian flora, the grasses contain the third highest number of alien species after Asteraceae and Brassicaceae (GUDŽINSKAS 1997b). Poaceae (151 species) and Asteraceae (142) are represented by much higher numbers of introduced species than any other families in California (REJMÁNEK *et al.* 1991). As the authors pointed out about Poaceae, "this is certainly an extremely successful family in California". Among the introduced grass species 95 are from Eurasia.

Referring again to the Polish conditions, it is noteworthy to stress that most of the species of Asteraceae have been introduced as decorative plants, while most species of the family Poaceae have been introduced accidentally.

Because of favourable conditions for the transport of diaspores and the absence of significant barriers preventing expansion, among Polish kenophytes the groups originating from various parts of Europe predominate (ZAJĄC A. *et al.* 1998).

The detailed analysis of species of European origin broken down by the European region where they came from, shows an evident predominance of species whose homelands are the southern and south-eastern parts of Europe (species of Mediterranean and Sub-Mediterranean origin) (cf. Chapter 5.1.2). It seems that this fact could be concerned with the more general rule once pointed out by ZAJĄC A. (1979) with respect to archaeophytes, a group again dominated by the species from the same area, namely, that that predominance is associated with specific waves of human migrations. The "oldest" kenophytes (recorded in Poland as early as in 16th century) include mostly species originating from these regions; for some of them even some objections as to their non-native status can be raised (cf. Chapter 5.2.2, Table 7).

Also represented in the flora of Polish kenophytes are species with natural ranges limited to the central regions of Europe, particularly species from the Alps (ZAJĄC A. *et al.* 1998). These are mostly species introduced as useful plants or those which were established in Poland as "relics" of certain experiments in pastoral management carried out at the turn of the 20th century (MIREK 1995).

The discovery of the Americas and the consequent breaching of the geographical barrier represented by the Atlantic Ocean, has had an important role in the process of flora exchange. During the last five hundred years, the flora of Poland has been enriched by 112 alien species of American origin, which are currently recognised as naturalised. This group is represented by 36 families, of which Asteraceae (28 species), Rosaceae (13) and Onagraceae (12) are the most important. The American flora established in Poland is characterised by the preponderance of long-lived perennial herbs (40), woody plants (41) and annuals (28). Among 61 species for which the first records for Poland are available, the majority arrived in Poland in the second half of the 19th and first half of the 20th centuries. Only six species (*Chamomilla suaveolens*, *Conyza canadensis*, *Galinsoga parviflora*, *Amaranthus retroflexus*, *Oxalis stricta* and *G. ciliata*) are common (occurring in 60–90% of 10 x 10 km squares; the total number of squares for Poland is 3646). Eleven species are abundant (occurring in 20–60% of 10 x 10 km squares), others are locally abundant (26 species occurring in 3–20% of 10 x 10 km squares) or rare. The common American species in Poland grow mainly in disturbed habitats. Over 50 species belong to a group that is very successful in migrating into natural and seminatural communities. *Robinia pseudoacacia*, *Elodea canadensis*, *Solidago gigantea*, *Juncus tenuis*, *Lupinus polyphyllus*, *Acer negundo*, *Solidago canadensis*, *Padus serotina*, *Bidens frondosa*, *Rudbeckia laciniata*, *Helianthus tuberosus*, *Echinocystis lobata* and *Quercus*

rubra are widely distributed species which also colonise natural habitats. Most of the above-mentioned species have been classified as invasive plants in Poland (cf. Chapter 12.5).

In the context of migration, the active movements of plants are of minor importance in their overall behaviour, even though they have developed a variety of morphological and biological adaptations for this purpose (Faliński 2000b).

Many authors have discussed those morphological features of plants which could have predisposed them to become effective colonisers of new habitats, often outside their prime range of distribution (e.g. Baker 1974, 1986; Newsome & Noble 1986; Kornaś 1990; Pyšek *et al.* 1995; Starfinger 1997; Jackowiak 1999; Faliński 2004)[45]. As a rule, however, none of the species possesses a full set of the features which might be considered as enhancing invasiveness.

The features of a species and its life strategy, acting in combination with the conditions (most often favourable ones) found in the new environment (disturbed, changed habitats, lack of competition from native species, repeated accidental introduction of diaspores by humans or long-term cultivation ensuring a continuous supply of great quantities of genetically diverse diaspores, and sometimes even the introduction of a species into a habitat which was a "target habitat"[46]) enhances the chances of establishment and further expansion. The success of the colonisation can also be ensured by the plant's method of reproduction; in many cases it will be a vegetative mechanism, and in the case of generative reproduction it will perhaps be dioecism, or – as seems to be the case – the increasing importance of apomixis and self-fertilisation.

Also of importance are, for example, the production of huge quantities of seeds and capacity to disperse them over great distances[47]. For most plants, wind is an essential factor facilitating long-range transportation of seeds and fruits. It is the same among the kenophytes (cf. Fig. 13 in Chapter 5.1.6). This group has a great variability of adaptations to wind dispersal: special devices which help blow seeds away: wings (*Acer negundo*, *Ailanthus altissima*), pappus (*Conyza canadensis*) etc. Also of significance is the weight of seeds and fruits: fine, light seeds are easily transported over considerable distances (*Digitalis purpurea*, *Eragrostis minor*). Another large group among kenophytes includes plants which rely on animals for dispersing diaspores, either in the digestive tract (endozoochory) or attached to the surface of animals' bodies (exozoochory). The former method is used by such species as *Sisymbrium loeselii*, *Padus serotina* or *Amelanchier spicata*. The examples of species using the latter method are, for example, species of the genera *Bidens* and *Xanthium* (with special protrusions or appendages on the surface of seeds), and *Chamomilla suaveolens* (sticky seeds). The plants whose seeds, fruits, leaves or stems can cling on to suitable surfaces, are transported by animals and humans alike (e.g. *Amaranthus albus*, *Bidens frondosa*, *Salsola kali* subsp. *ruthenica*, and species of the genus *Xanthium*). Among the zoochores, there is a separate group of myrmecochores, i.e. the plants whose seeds are transported and dispersed by ants. Their seeds have elaiosomes, which are appendages containing sugar, vitamins and other compounds used by ants as food. Among kenophytes, this manner of seed dispersion is utilised e.g. by *Corydalis lutea*, *Portulaca oleracea*, and species of the genus *Euphorbia*. Then there are the autochores, the self-dispersing plants which have special devices to throw their seeds over a certain distance (sometimes even up to 1 m). The species of the genera *Impatiens* and *Oxalis* could be given as examples of this group. Another group of kenophytes

[45] In the opinions of Kornaś (1990) and Jackowiak (1999) the characteristics of plants which proved essential for synanthropic species in the process of their spread are as follows: short life cycle, broad spectrum of tolerance towards living conditions, indifference towards photoperiod, lack of special habitat requirements during germination, germination spread over the season and prolonged viability of seeds, rapid growth of seedlings and short juvenile stage, early reproductive maturity and utilisation of major resources for reproduction, self-fertilisation, self-pollination or specialised mechanism for cross-pollination, huge and uninterrupted (during the growing season) production of seeds, an ability to disperse seeds over great distances, great potential for vegetative reproduction coupled with competitiveness, an ability to develop ecotypes, polyploids and hybrids, and, finally, great variability in life strategies.

[46] Purposeful introduction of such species as *Padus serotina*, *Quercus rubra*, *Lupinus polyphyllus* to forests provides good examples to illustrate this.

[47] Most abundant alien newcomers produce large quantities of seeds, e.g. a single plant of *Conyza canadensis* generates *ca.* 115 000 achenes (Kostecka-Mądalska 1965), a large individual of *Bidens frondosa* can produce over 500 capitulae with over 10 000 seeds (Lhotská 1968); this has been corroborated by newer studies which found that it produces the highest number of capitulae compared with the species native to Europe, even as many as 17 700 seeds per plant (Gruberová *et al.* 2001). Pyšek *et al.* (1995) report that a single individual of *Heracleum mantegazzianum* produces up to 16 000 seeds, while Tiley & Philip (1997) suggest an even higher number of up to 107 000. *Rudbeckia laciniata* produces *ca.* 1 600 seeds per plant (Francírková 2001) and *Oenothera paradoxa ca.* 8 000 seeds per plant (Tokarska-Guzik 1982). Many other examples are given by Podbielkowski (1995).

includes anthropochores dispersed either intentionally or unintentionally by humans. There are several special cases of anthropochory, such as speirochory, i.e. dispersal of weeds with the seeding material of cultivated plants (among other kenophytes, this mechanism is utilised by *Veronica persica*), ergasiochory, when diaspores are dispersed during tillage (e.g. species of the genera *Vicia*, *Oxalis*, and *Galinsoga*) and agestochory, when diaspores are carried by various means of transport.

As a rule, most of the kenophytes, however, belong to the polychoric group, i.e. the plants which rely on several different mechanisms to disperse their seeds (cf. Chapter 5.1.6 and Appendices A and B).

The processes of plants' seed dispersal depend not only on the morphological and biological features of a given species, but also on the communities where the species finds its niche. In his analysis of dispersal of weeds in cultivated field communities in the Gorce Mts., KORNAŚ (1972) stated that "(...) they use extensively two utterly different ways to disperse: namely: spontaneous seeding brought about by natural factors, and the transport of diaspores by humans (anthropochory). The ultimate composition of communities results from the combined effect of these two means of dispersal".

Apart from confirming the predominant role of generative reproduction, anemochory and autochory, the attempt of this kind of analysis in the group of kenophytes also indicates the existence of some specific features revealing themselves in the context of the types of habitats actually colonised (Fig. 63). In the habitats occupied by stable communities of a semi-natural (meadows and grasslands), or natural (forests and scrub) character, the proportion of vegetative methods of reproduction increases. This is particularly so in aquatic and riparian communities because their specific nature is conducive to this manner of reproduction. On the other hand, in disturbed habitats or those subject to permanent or temporary pressure from humans, the proportion of kenophytes following the vegetative process of reproduction evidently declines. The great majority of kenophytes disseminate their diaspores via anemochory and autochory, that is by methods characteristic of pioneer communities. However, in more evolved communities which usually have a very complex structure, the role of other methods of dissemination increases. They will involve endozoochory in forest and scrub communities and epizoochory in meadow and grassland, as well as aquatic communities. Also in other types of open communities in ruderal habitats, the proportion of the species with diaspores clinging or sticking with mucilage is relatively high.

Generally, it can be stated that heavy-seed species (a category which includes barochores and some zoochores) predominate in more mature communities. Their seedlings, provided with more reserve material, stand better chances of survival under the enhanced competition prevailing in dense and multi-storey patches of vegetation. The group of species with low-motility diaspores, "inclined" to stay on the same site, which include barochores, autochores and the heaviest anemochores must "depend on" humans to ensure the transport of diaspores over greater distances (KORNAŚ 1972).

In order to illustrate the degree of flora transformation in a given area, investigators have used the proportions of species of alien origin and their dynamics, presented in their various historical and spatial aspects, e.g. FALIŃSKI 1971; SUDNIK-WÓJCIKOWSKA 1987a, 1998a; JACKOWIAK 1990, 1998a; CHOJNACKI & SUDNIK-WÓJCIKOWSKA 1994. In connection with progressive synanthropisation, the composition and structure of the flora changes: the number of archaeophytes remains almost unchanged, but the proportion of established more recent newcomers increases[48] (FALIŃSKI 1971; KORNAŚ 1977a; MISIEWICZ 1981).

Kenophytes, as a group distinguished in the geographical/historical classification, are treated as indicators illustrating the intensity of the process[49]. The proportion of this group of species in the flora, particularly in urban areas, helps in demarcating the zones of human impact (called also anthropopressure zones) and has been used by many authors[50].

SUDNIK-WÓJCIKOWSKA (1992) suggested that particularly useful in demarcating the zones of human impact in urban areas will be those indi-

[48] This correlation is illustrated by the so-called coefficient of flora modernisation: M = epecophytes + agriophytes/archaeophytes.

[49] The number of kenophytes in a local flora is also used when indices of flora synanthropisation (including so-called "complex indices of flora synanthropization") are calculated (JACKOWIAK 1990; SUDNIK-WÓJCIKOWSKA 1991, 1992 and references cited there; URBISZ 1991; SUDNIK-WÓJCIKOWSKA & MORACZEWSKI 1993, 1998; MORACZEWSKI & SUDNIK-WÓJCIKOWSKA 1994).

[50] SUDNIK-WÓJCIKOWSKA (1986, 1998a) in characterising the flora of a major town, delineated zones on the basis of the percentage proportion of kenophytes in the 1 km^2 squares of the study area; the spatial diversification of the flora of urban areas has been also illustrated, again in terms of the proportions of kenophytes, by other authors (e.g. TOKARSKA-GUZIK 2000; KUCHARCZYK 2003a; MACIEJCZAK 2003; WOŁKOWYCKI 2003; ZAJĄC M. & ZAJĄC A. 2003).

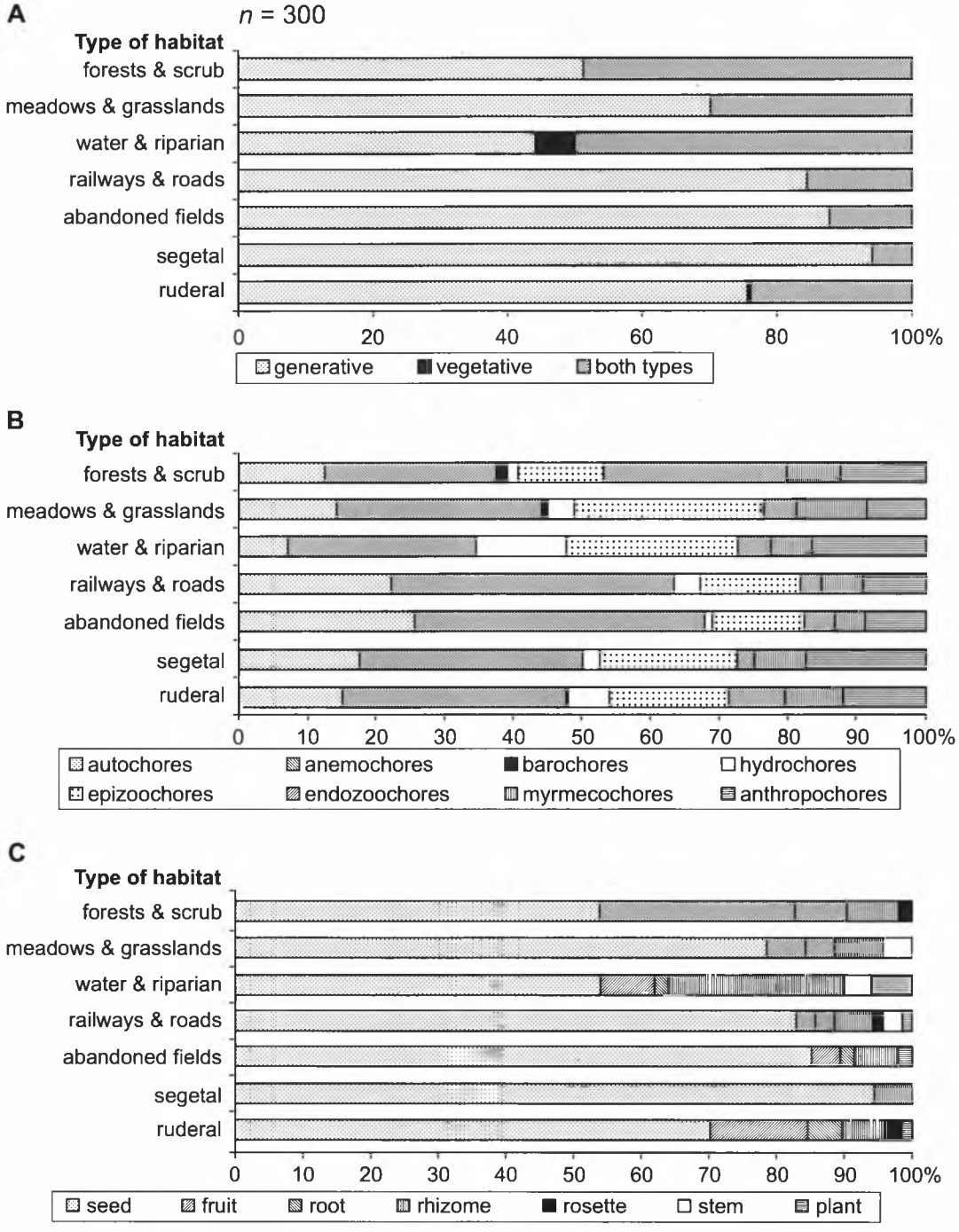


Fig. 63. Reproduction properties of kenophytes from different habitats:
A – manner of reproduction, **B** – dispersal spectra, **C** – propagule used

ces which describe the proportions of such geographical/historical groups as synanthropic newcomers (P4, P5, P9), and permanently established alien species (P1)[51].

At the same time (as suggested by the aforementioned author), using these groups of species as a tool also allows one to evaluate changes in a flora from a historical perspective (with one

[51] P4 = Ep + Ag + Ef + Eg / G x 100% – the percentage of recent anthropophytes in the flora (i.e. within the approach adopted in this paper, it is a combined proportion of kenophytes and diaphytes in the flora; in the approach used by Anglo-Saxon authors it is the proportion of neophytes)

P5 = Tn/G x 100% – the percentage of therophytes-newcomers in the flora

P9 = Ep + Ag/G x 100% – the percentage of kenophytes in the flora

P1 = Ar + Ep + Ag/Ap – the ratio of the total number of permanently established anthropophytes to the number of euapophytes where: G – the total number of species; Ap – the number of euapophytes; Ar – the number of archaeophytes, arrivals established permanently before 15th century; Ep – the number of epecophytes, new arrivals established permanently in anthropogenic habitats after the 15th century; Ag – the number of agriophytes, new arrivals which had established permanently (after the 15th century) in natural and semi-natural communities and usually also in anthropogenic habitats; kenophytes – epecophytes along with agriophytes; Ef – the number of ephemerophytes; Eg – the number of ergasiophygophytes; Tn – the number of therophyte-newcomers, i.e. therophytes that are also epecophytes, agriophytes, ephemerophytes or ergasiophygophytes.

reservation: the applied floristic parameters are only (or may be only) indicators of habitat conditions at a defined point in time).

The issue of the establishment of kenophytes in various types of habitats is a fairly popular subject of research in Poland (TOKARSKA-GUZIK 2003c and references cited there). The majority of kenophytes show an ability to adopt to a relatively wide range of habitats, e.g. *Conyza canadensis* and *Acer negundo*. Only a few species can be named as faithful to a particular type of habitat: *Corydalis lutea* and *Cymbalaria muralis* grow only in crevices in remnants of old walls; *Eragrostis minor* is recorded on railways, store yards and in the centres of towns between flagstones; *Elodea canadensis* and *Lemna turionifera*, as a hydrophyte, only in water (TOKARSKA-GUZIK 2003c).

Among 300 species of kenophytes which are covered in this monograph, 160 species are associated with anthropogenic habitats (so-called epecophytes), whereas 140 species are also established in habitats of a natural or semi-natural type (agriophytes).

The habitats colonised most often are urban areas, railways and riparian habitats[52] (TOKARSKA-GUZIK 2003c).

Most of the kenophytes were once, at least in their respective initial stage of naturalisation in Poland, associated with towns (cf. also Chapter 9.3). The particular conditions shaped in towns by humans (diversity of habitats, little, or a complete absence of, competition from native species, higher temperature prevailing in towns compared with the adjacent areas) provided a chance to negotiate the first barrier: the geographical barrier. After the first stage of expansion, many species embarked on the next stage using the diverse connections between the urban areas and their environs (rivers, roads, railway lines). This stage manifested itself through the colonisation of new areas, outside the urban sites, often coupled with the occupation of new types of habitats.

Some of the kenophyte species show an evident association with urban areas; these, according to WITTIG *et al.* (1985) and JACKOWIAK (1998a, b & c) could be classified as so-called urbanophiles (cf. Chapter 9.3). In the Polish scientific research, well-anchored in the issues of urban ecology, a model for this group of species was suggested by JACKOWIAK (2000). This author pointed to the very high proportion (up to 90%) of alien species among these urbanophiles, predominantly kenophytes (60% of all such species). The author emphasizes that "(...) it is a key moment for understanding the differences between urbanophilous kenophytes and urbanoneutral kenophytes that are widespread in cities".

The botanists involved in studies of the changes occurring in the structure of urban floras, highlight the development of floras specific to such urban habitats as old city centres, defence perimeter walls, railway stations, tram line tracks, or playgrounds, where kenophytes are significantly represented (e.g. KUNICK 1982, 1990; BRANDES 1992b, 1995; ŚWIERKOSZ 1993; KOWARIK 1995b; JACKOWIAK 1998a & c; PYŠEK 1998; SUDNIK-WÓJCIKOWSKA 1998a; GALERA & SUDNIK-WÓJCIKOWSKA 2000a & b; SHEVERA 2003; TOKARSKA-GUZIK 2000, 2003c; ZAJĄC M. & ZAJĄC A. 2003). The role of towns and cities in the establishment of species of alien origin and in overcoming the difficulties of the first stages of expansion is still significant (JACKOWIAK 2003; cf. also Chapter 9.3). The comparison of the share of kenophytes in the 19th century and contemporary floras of selected Polish towns, indicates a remarkable increase in the number of species in the latter period (SUDNIK-WÓJCIKOWSKA 1998a). The cities are the principal places where new species emerge (cf. Chapter 9.3). PYŠEK *et al.* (1998) are of the opinion that in the last century, the role of towns in the invasion and expansion of alien plant species although still very important, has somewhat diminished in favour of rail/road related areas.

The flora of the latter sites (particularly railway stations, tracks and embankments), which have focused the interest of many authors (in Poland, e.g. KORNAŚ *et al.* 1959; ĆWIKLIŃSKI 1968, 1972a, 1974, 1990; SENDEK 1973; LATOWSKI 1977; NOWAK 1997; outside Poland – e.g. RADKOWITSCH 2003), show a high proportion of species of alien origin, including kenophytes (cf. Chapter 9.6.2). For many species, migrating along railway lines is the first stage by which they extend their range (e.g. *Artemisia austriaca*, cf. Chapter 7); for others it is one of the subsequent stages, allowing them to colonise other types of habitats and to capture larger areas (e.g. *Rumex confertus*, cf. Chapter 7).

River valleys are of particular importance both in the migration of kenophytes and in their penetration into the less artificial communities (FALIŃSKI 2000b; cf. also Chapter 9.6.1). These relationships have been identified and illustrated by many authors (in Poland, e.g. FABISZEWSKI 1985; DAJDOK *et al.* 1998, 2003; DAJDOK & KĄCKI 2003; KRASICKA-KORCZYŃSKA *et al.* 2003; KUCHARCZYK 2003a & b; ZAJĄC M. & ZAJĄC A. 2003; in other regions of Europe, e.g. LHOTSKÁ & KOPECKÝ 1966; THEBAUD & DEBUSSCHE 1991; PYŠEK & PRACH 1993).

[52] Similar proportions are reported by PYŠEK *et al.* (1998) for the Czech flora.

From the viewpoint of protecting indigenous nature, it is important to consider the group of plants which shows an ability to penetrate into the plant communities found in an area and/or to form new types of communities (FALIŃSKI 1968b, 1969, 1998a & c). The subsequent phases of such penetration and establishment of an alien species into natural but disturbed plant communities in a new homeland (called the neophytism phases), were described by FALIŃSKI (1968a & b, 1998a & c). Detailed studies illustrating this process have been carried out in Poland by, for example, FALIŃSKI (1968c); KORNAŚ & MEDWECKA-KORNAŚ (1968); KUJAWA-PAWLACZYK (1991); ADAMOWSKI *et al.* (1998).

The formation of the new types of communities as secondary, repeatable compositions of species, developing as a result of associating native and alien species, has been found in extensive and well-documented phytosociological studies, both in European as well as in many Asian countries (FALIŃSKI 2000a)[53].

Also in Poland, many authors describe communities in which alien species, including kenophytes, participate or predominate (e.g. FIJAŁKOWSKI 1967; ROSTAŃSKI K. & GÜTTE 1971; ZAJĄC E. U. 1974; KUCHARCZYK & KUCHARCZYK 1983; SOWA 1989 and the references cited there; KOMPAŁA & WOŹNIAK 2003 and the references cited there; KORNIAK & ŚRODA 2003; KWIATKOWSKI 2003; SAWILSKA *et al.* 2003).

In the opinion of MATUSZKIEWICZ (2001) kenophytes (=neophytes) show a tendency to form single species aggregations, often very conspicuous due to their specific appearance, but actually only in very rare cases do they form separate types of communities, which would justify being classified as separate associations. Among the kenophytes, 32 species are regarded as characteristic species which form separate associations (MATUSZKIEWICZ 2001).

9. Historical aspects of the development of the kenophyte flora of Poland

9.1. General remarks

The reconstruction of the changes in the vascular flora of Poland pertaining to the more recent newcomers, allows a certain clarification of the relationship between the synanthropisation of the flora and the vegetation cover on the one hand, and the relationship with historical events and economic development, on the other hand. As a result, it will also allow the forecast of future changes.

Not without importance in these considerations is the geographical location of Poland, both in historical and geographical aspects. The central position of Poland within the North European Lowland, which, lacking any major natural barrier, presents, according to DAVIES (2001) – "(...) no obstacles to the movement of peoples or to the progress of armies. It makes for constant insecurity. It encourages raids, invasions, and annexations". The question may be raised, whether this statement could be applied to plant geography, and particularly to issues related to mechanisms of plant migration?

9.2. The effect of historical and economic developments on the enrichment of Polish flora by newcomers

Since the 14th century, the history of Poland, stormy and eventful throughout, has been marked by political changes, from the existence of the Commonwealth of Poland and Lithuania over a vast territory (1569–1795) to its entire disappearance from the political map of Europe in the period of the partitions (1795–1807) (cf. Fig. 21 in Chapter 5.2). The political situation affected the economy which followed a period of growth with one of recession(s).

Political events, particularly numerous wars[54] with neighbours, were associated with the march of armies, the destruction of existing infrastructure, and population fluctuations in some regions. These phenomena were conducive to accidental introductions of plant diasporas directly by the hostile armies, as well as with their provisions (food for soldiers, fodder for horses) while warfare and looting created favourable conditions for the settlement of new plant species (although the latter is difficult to prove at present).

[53] Among many examples are also studies devoted to the formation of anthropogenic forests in which more recent newcomers participated (e.g. JURKO & KONTRIS 1982; KOWARIK 1995b; ZERBE 2003) and of ruderal communities (e.g. GÜTTE 1972).

[54] Within the last four centuries, Poland fought wars with Sweden in 1600–1629, and 1655–1660; with Turkey: 1620–1621, and 1672; with Russia: 1654–1667. The Great Northern War took place in the period 1700–1721. Throughout Poland's partition there were numerous civil wars and risings, and foreign armies (French and Russian) marched through Poland during the Napoleonic wars. The first half of the 20th century was the time of the two World Wars.

These events took place against the background of the overall changes which were occurring in the natural environment of the whole continent of Europe. The period of the last 500 years has been marked, both in Poland and throughout Europe, by a constant decrease in the forested area[55] and its continuous fragmentation (MACIEJOWSKI & ULISZAK 2000; MANNION 2001) and by the draining of wetlands and their conversion into new farming lands. In terms of plant geography these changes can be seen as the elimination of the natural barriers limiting the spread of alien species.

The political and economic transformation which has taken place in Europe, especially since the turn of the 18th century, implies a large-scale transformation of the environment[56], and added an integral element to the process of introducing alien plant species either intentionally or accidently.

These changes pertained also to Polish lands though with a certain shift in time and with variable dynamics. The different rates of economic development of areas within the present national territory of Poland (such as the territories which once belonged to the different countries which partitioned Poland) are reflected in the specific patterns of settlements, and the density of the road network (first roads, then railway lines) which are still preserved in the landscape. The improved living standards of residents translated into more opportunities for international contacts and travel, as well as more people pursuing their interest in collecting or growing exotic plant species (people in areas where the living standards are higher are all the more "vulnerable" to "foreign fashions and novelties").

[55] Beginning from the 12th century, forests have been the main source of energy for the textile industry developing in many places in Europe, and later (from the 15th and 16th centuries) also the metallurgical industry (MANNION 2001).

[56] In the period 1400–1750, agriculture was transformed throughout Europe. This was precipitated by climatic changes involving the cooling of the climate, temperatures dropping below average and leading to a major shortening of the growing season (known as the "Little Ice-Age"). Further, quite revolutionary changes in agriculture occurred in the period 1750–1850. Many innovations were introduced such as three- or four-fields crop rotation systems, introducing new cultivated plants, modernising animal husbandry. The 17th and 18th centuries were marked by dynamic industrial development accompanied by infrastructure development, as well as the progressive development of urban areas (initially occurring chiefly in Western Europe) (MANNION 2001).

9.3. Cities as "footholds" for further expansion by fresh newcomers

Cities provide particularly good examples of the role played by humans in shaping floras and plant communities. The analysis of long-term changes in the flora and vegetation of an area undergoing urbanisation was presented by BRANDE *et al.* (1990), and by LANDOLT (1991), using Berlin and Zürich as examples respectively. The earliest stages of flora transformation processes in the areas now occupied by urban agglomerations have been summarised, on the basis of available sources, by SUDNIK-WÓJCIKOWSKA (1998a). This author quotes other researchers who presume that the qualitative composition of the flora in Mediaeval cities was more like that of the flora of a present-day village, and was essentially different from the flora of a contemporary city. The reasons for this can be surmised both in the geographical isolation of Mediaeval Europe and in the spatial structure of the cities at that time. In the Mediaeval tradition, the city (*civitas* in Latin) was more a legal concept than a geographical phenomenon (DAVIES 2001). Modern historians regard this name as having little in common with what we now call the "urban area". Most of the land within a city's limits was used for cultivation. The cities were actually defined in terms of legal privileges irrespectively of the land-use within their limits (DAVIES 2001).

DAVIES (2001) estimates that of 700 cities founded in Poland in the late 16th century only a dozen or so (i.e. Kraków, Gdańsk, Elbląg, Toruń, Bydgoszcz, Warszawa, Poznań, Lublin, Sandomierz, Lwów, and Kamieniec) had 10 000 or more residents.

Warszawa (Warsaw), was already a city with a marketplace in the early 1300s, had been overshadowed by other cities. In 1600, Gdańsk had a population of 50 000, five times more than Warszawa and more than three times that of Kraków and Poznań, and the citizens of Gdańsk dwelled in houses built in the Flemish style, and travelled abroad. The structure of trade in Gdańsk was fairly complex. Apart from grain, the ships leaving the Gdańsk harbour also took wool, flax, leather, wood and metals. On their way back they brought manufactured products, colonial goods, fish, alcohol, salt and coal (DAVIES 2001). The city maintained links with all the then active trade markets overseas. As far as overland routes are concerned, Gdańsk had links with Germany (particularly with Silesia), Kraków (and, through it, with the Danube ba-

sin) and with the eastern city of Łuków, which was then a centre of trading in cattle and hides, and also with the Ukraine and, indirectly, with Moscow.

With the passage of time, the role of Warszawa as an urban centre has grown. Because of its strategic position on the middle part of the Vistula river course, the city had convenient links with Gdańsk in the north and Kraków in the south but, most importantly, with the main stream of trade flow (a crossing of the main inland waterway with major overland routes). The 16th and 17th centuries[57] witnessed the enormous development of the city and its transformation from a wooden structure to one of stone and marble.

One of the oldest cities within the present limits of Poland is Wrocław (called Wratislavia in the Mediaeval times; Vratislav in Czech; Breslau in German) – the historic capital of Silesia. The continuity of human settlements in the area reaches back to the Bronze Age, and the Lusatian culture. As early as in the 5th century B.C., on the right bank of the Oder, at the site now occupied by the location of Osobowice, there was a stronghold guarding the crossing of the river. At the beginning of the 15th century, Wrocław was the single largest city within the Polish lands (Kwiatek & Lijewski 1998). This city also had economic links with the great trade centres of that time: Prague, Nuremberg, Magdeburg, Frankfurt am Main, and – through Gdańsk – with the Baltic states. Wrocław even had links with Venice.

Equally old is Kraków (Cracow) – the old capital, and now the third largest city in Poland[58]. In the Mediaeval times, Kraków was already significant for its location on an important trade route from Germany and Bohemia to Ruthenia.

Common elements for the aforementioned cities, such as the long history and strategic position on major trade routes were the chief factors supporting both processes of alien plant

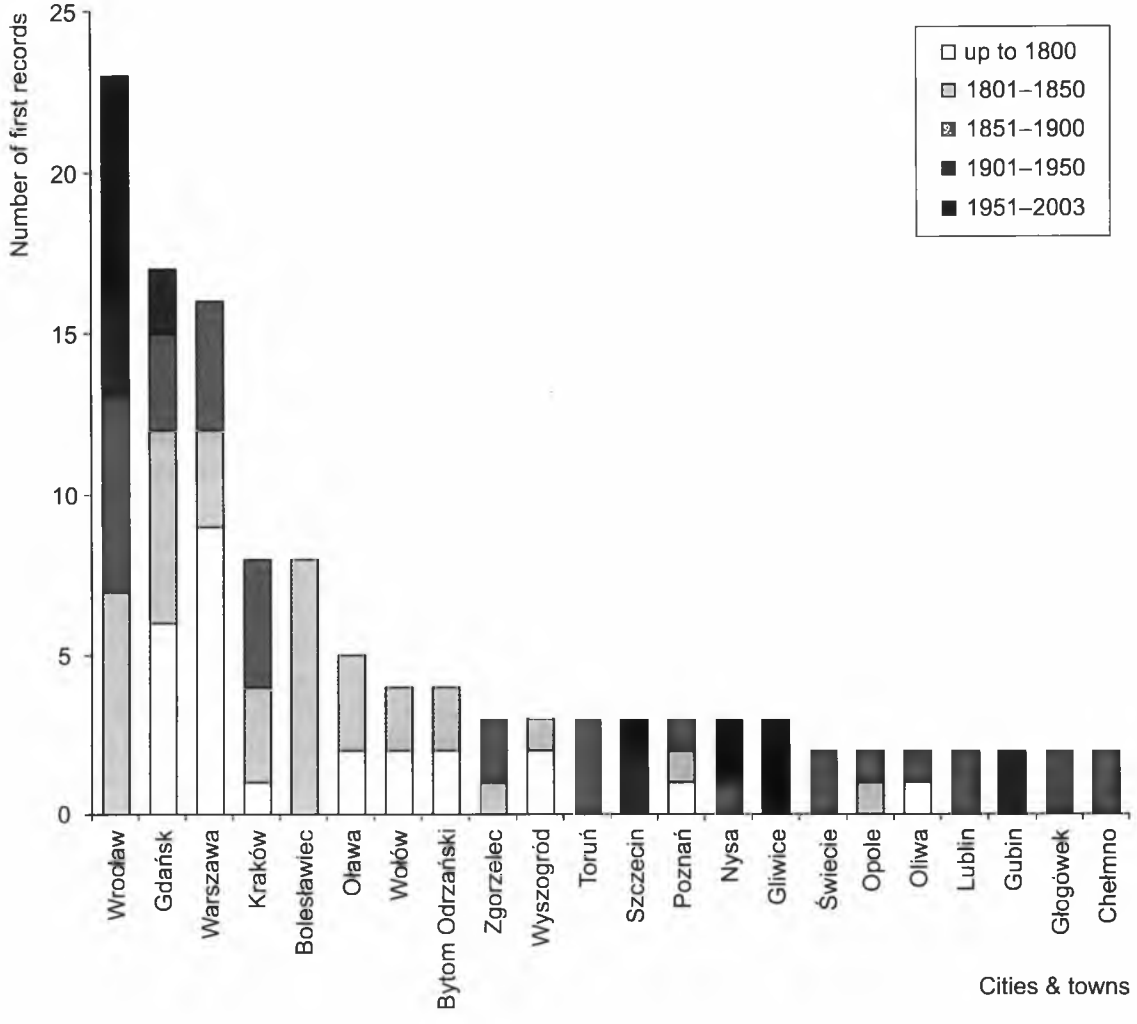


Fig. 64. Role of cities and towns in establishing of kenophytes in the flora of Poland (on the basis of the number of the first records)

[57] In the 17th century, the development of Warszawa was disturbed by Swedish invasions (the "Swedish deluge") when the city suffered much damage.

[58] At present, Warszawa and Łódź are the largest cities in Poland. Until the 1930s, Wrocław was second only to Warszawa in the territory within the present Polish borders.

species introduction by humans, accidental and intentional. It was in just these cities where the greatest numbers of "first floristic records" for kenophytes are located (Fig. 64). Through to the beginning of the 19th century, the greatest role in establishing newcomers was played by Warszawa and Gdańsk, cities situated on the main commercial route in Poland running along the course of the Vistula, but also by some smaller cities, such as Wyszogród[59] – again situated on the Vistula route, and Silesian cities: Wołów[60], Oława[61], and Bytom Odrzański[62]. In the first half of the 19th century the role of the city of Wrocław[63] grew as the site for the first records of kenophytes, as well as the significance of other Silesian cities which were then within the borders of Germany. The political and economic situation at that time evidently favoured the settling of new plant species into local floras. The most recent 150–200 years constituted the period of the industrial revolution which occurred with variable speed in various cities of Central Europe. The development of industry was coupled throughout by the parallel extension of transport networks. The inbound migration of the population into cities accelerated causing them to significantly expand their territories. As a result, dramatic changes occurred in the habitats and the overall environment (Sudnik-Wójcikowska 1998a).

At that point in time, the Polish lands were situated on the main divide of the industrial map of Europe, separating the highly industrialised German lands from backward areas of Russia and Austria–Hungary (Davies 2001). The analysis of quantitative changes in the kenophyte flora within Poland sets out the areas where migration of alien species was faster and more intensive than elsewhere[64] (Fig. 65). These are areas which had been urbanised earlier, thus having denser transport networks connections.

When considering the role of cities as a "foothold" which enables the species, whether accidentally brought in or introduced, to expand further into adjacent areas, it is worth noting that the cities had a similar effect on these two groups of plant species. Gdańsk and Kraków stand out among the four oldest and largest cities in Poland, showing opposite tendencies in terms of the means by which plant species were introduced there (Fig. 66). Gdańsk, being a seaport of particular history and tradition, is above all the place of the first records of species brought accidentally, whereas Kraków, an academic and cultural centre, perhaps "created" better chances for intentional introduction.

A similar mechanism is still operating. In many cases the territory of a city is the destination of the first stage of migration by a foreign newcomer (in Poland, these types of circumstances are exemplified e.g. by *Ailanthus altissima* – cf. Chapter 7.1, *Parietaria pensylvanica* (Sawilska & Misiewicz 1998; Guzik 2002)).

The cities have performed multiple functions, being at the same time marketplaces (for farm produce, horses and cattle), industrial centres of cloth manufacturing (e.g. Gorzów Wlk., Toruń), railway hubs, and sometimes river ports (Bydgoszcz, Gliwice), thus becoming "open to invasions of alien species, their number unforeseeable" (Trepl 1994).

One should also note the coincidence of dates of these first records with the dates of commissioning new railway connections (cf. Fig. 64 and Appendix A). The railway reached Bolesławiec[65] as early as in the first half of the 19th century (in 1845 the city was linked by railway line with Wrocław, then it was extended to Gubin and Zgorzelec). Wołów is situated on the

[59] Wyszogród is one of the oldest defensive strongholds of Mazovia, located on a high bank of the Vistula (its name derives from this situation). The city overlooked the crossing of the Vistula and thus developed as a trade centre and river port. In the 16th century Wyszogród was the single largest centre in Mazovia (Kwiatek & Lijewski 1998).

[60] Wołów – a city founded in the 13th century on the site of a former stronghold; in the 16th century it became a centre of cloth manufacturing and crafts (Kwiatek & Lijewski 1998).

[61] Oława – even in the early Mediaeval times, it was a stronghold and marketplace settlement developing on the trade route from Wrocław to Kraków. In the 16th century, Oława had breweries, a paper mill, and the prince's mint (Kwiatek & Lijewski 1998).

[62] Bytom Odrzański – an old stronghold situated at the crossing of the Oder river. It recorded a period of dynamic growth at the turn of the 17th century when the city developed as a centre of trade and crafts upon the Oder river route (Kwiatek & Lijewski 1998).

[63] Wrocław – at the end of the 18th century the city experienced a major boost in its economy: cloth and metal industries developed and the Oder inland waterway acquired major importance as a link with Prussian provinces. In the mid 1900s, the city became connected by railway links with Berlin, Dresden and Upper Silesia (Kwiatek & Lijewski 1998).

[64] The picture of quantitative changes in the kenophyte flora of various regions of Poland depends much on the level of details known about floras of particular regions, and this in turn is linked with an overall level of economic and cultural development (expressed by the number of academic centres and various schools where such studies were initiated).

[65] At the same time, these were old Mediaeval cities or settlements usually located upon rivers or on trade routes – in the 15th and 16th centuries. Bolesławiec, upon the Bóbr river, was a centre of cloth manufacturing and the single largest salt market in Silesia, as well as a market for horses and cattle (Kwiatek & Lijewski 1998).

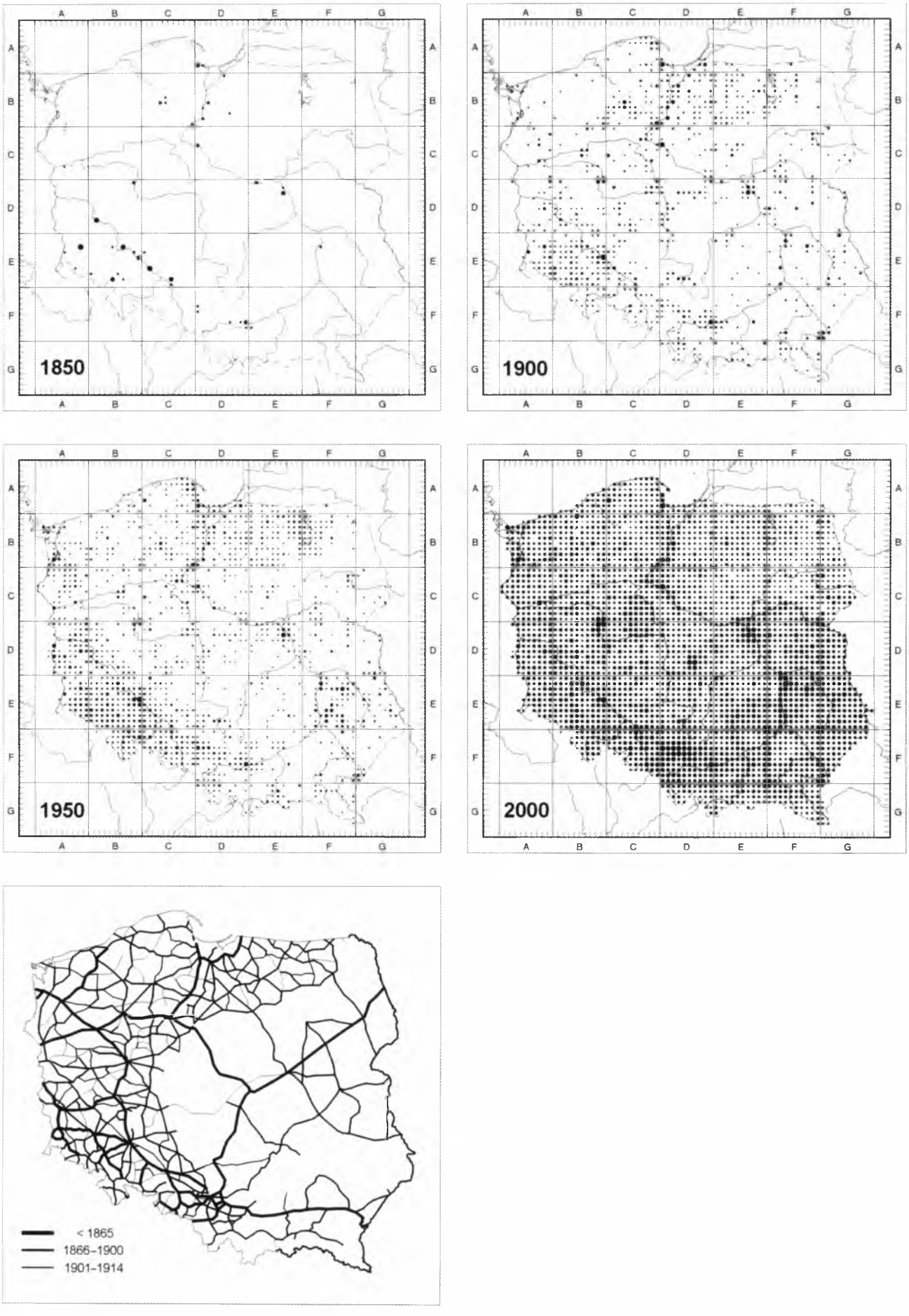


Fig. 65. Concentration of 174 species of kenophytes and the expansion of the railway network in Poland (CZAPLIŃSKI & ŁADOGÓRSKI 1998) in the historical sequence 1501 – XX century

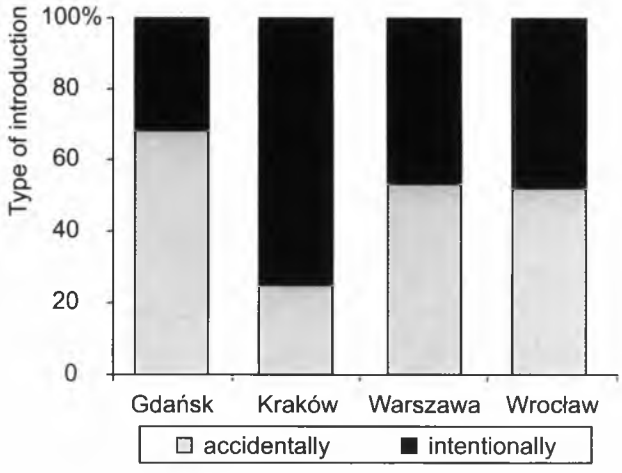


Fig. 66. Role of the Polish greatest cities in the first stages of spread of kenophytes with respect to the presumed type of introduction into the country

Wrocław – Zielona Góra – Szczecin railway line, and this section opened in 1874, whereas Bytom Odrzański – on the Głogów – Zielona Góra railway line, opened in 1871. The railway line linking Oława with Wrocław is the oldest railway line in Poland, which has been in operation since 1842.

Although the impact of humans within the limits of the European cities has a history spanning over many centuries, geographical location remains the factor of prime importance in terms of affecting flora composition. The flora of urban areas has derived primarily from the native species from the nearest environs of the city. The proportion of species of alien origin, including the more recent newcomers, which usually prevail over older immigrants, fluctuates from *ca.* 12–25% in the cities located in the south of the continent, to 40–50% in Central European cities (Faliński 1971; Pyšek 1989; Kowarik 1995b; Celesti Grapow & Blasi 1998; cf. also Chapter 8). Apart from the differences associated with variable methodologies and different time horizons, the overall differences may stem both from the higher proportion of species arriving from North America (similar climate) and southern Europe which can utilise "urban heat islands"[66] offered by the cities situated more to the north, a much less important factor in the cities of southern Europe (Celesti Grapow & Blasi 1998).

Some species have been virtually regarded as being specifically associated with cities and other human settlements. The term "plantae urbanae" was first introduced by Schouw in 1823 (Sukopp 2002), giving *Xanthium strumarium*[67] as one of the examples. Later, the concept of the formation of local distribution ranges in urban conditions has been further developed e.g. by Wittig *et al.* (1985) and Jackowiak (1990, 1998a, b & c). One of the specific features of cities is the "urban climate", characterised, among other phenomena, by the presence of the "thermal island"[68], the over-dryness and pollution of air (Sukopp & Werner 1983; Jackowiak 1998a, b & c; Sudnik-Wójcikowska 1998a & b, 2000; Sukopp & Wurzel 2000).

The following species are listed as associated with Central European cities: *Ailanthus altissima*, *Buddleja davidii*, *Chenopodium botrys*, *Diplotaxis muralis*, and *Eragrostis minor* (Table 9). *Ailanthus altissima*, *Diplotaxis muralis*, and *Eragrostis minor* are specifically associated with the central parts of cities, and are termed "thermal bioindicators" (Sudnik-Wójcikowska 1998a & b). Despite sharing some floristic characteristics, the proportions of individual species of kenophytes in European cities are differentiated by the climatic conditions resulting from the geographical position of a given city (Table 9). This specificity has already been noted by Kunick (1982) when he listed alien species typical of cities situated in Eastern Europe, e.g. *Amaranthus albus*, *Atriplex tatarica* and *Iva xanthiifolia*. On the other hand, in cities situated in the western part of the continent, the following species are recorded more often: *Ailanthus altissima*[69] (in Poland, this particular species is at the initial stages of dispersion – cf. Chapter 7), *Buddleja davidii* (a shrub, established locally in Poland, susceptible to freezing in winter) and *Chenopodium botrys* (in Poland it is found primarily in industrial wastelands, such as spoil heaps or settlement ponds, and is much rarer in the actual cities).

[66] The built-up areas, because of their specific climate and the type of habitats, provide favourable conditions for the expansion of plants and animals from the warmer climatic zones. In Berlin, for example, some 60% of alien plant and animal species (archaeophytes and neophytes) come from warmer regions (Sukopp 2002).

[67] "In most cases foreign origin is the cause why these plants are located only near cities and villages" (Sukopp 2002 after Schouw).

[68] In the Central European cities this phenomenon has been observed for over four decades. Urban ecologists have long indicated the importance of flora as a bioindicator of the thermal conditions prevailing in a given city (Sudnik-Wójcikowska 2000 and references cited there).

[69] *Ailanthus altissima* is also a permanent and frequent component of cities situated in the southern parts of Europe, e.g. in Rome (Celesti Grapow 1995), or Ljubljana (Tokarska-Guzik, *pers. observ.*).

Table 9. Species indicated as associated with Central European cities

Species	Locality and author			
	examples from Poland		examples from other European towns	
Acer negundo	Warszawa	Galera & Sudnik-Wójcikowska 2000a, b	Donetsk, Lugansk, Slavyansk, Mariupol	Burda 1997
Ailanthus altissima	Łódź Warszawa Katowice, Kraków, Wrocław	Witosławski 1993 Sudnik-Wójcikowska & Guzik 1998 Tokarska-Guzik, *pers. observ.*	Berlin Münster, Essen, Düsseldorf Halle, Leipzig Berlin, Karlsruhe, Köln, Stuttgart, Würzburg Zürych Leipzig Roma	Kunick 1982; Böcker & Kowarik 1982; Kowarik & Böcker 1984 Wittig *et al.* 1985 Gutte *et al.* 1987 Kunick 1990 Landolt 1991 Gütte 1992 Celesti Grapow 1995
Amaranthus albus			Donetsk, Lugansk, Slavyansk, Mariupol	Burda 1997
Amaranthus blitoides	Łódź Poznań	Sowa 1960 Jackowiak 1993	Donetsk, Lugansk, Slavyansk, Mariupol	Burda 1997
Atriplex tatarica	Poznań Warszawa, Lublin	Jackowiak 1993 Sudnik-Wójcikowska 1998a	Donetsk, Lugansk, Slavyansk, Mariupol	Burda 1997
Buddleja davidii			Berlin Münster, Essen, Düsseldorf Halle, Leipzig Berlin, Cologne, Düsseldorf, Essen, Freiburg, Stuttgart	Kunick 1982 Wittig *et al.* 1985 Frank & Klotz 1990 Kunick 1990
Chenopodium botrys	Wrocław	Rostański 1960	Leipzig Berlin Halle, Leipzig Mariupol	Gütte 1971 Sukopp 1971; Kunick 1982 Frank & Klotz 1990 Burda 1997
Diplotaxis muralis	Poznań Łódź Warszawa	Jackowiak 1993 Witosławski 1993 Chojnacki & Sudnik-Wójcikowska 1994; Sudnik-Wójcikowska 1998a	Donetsk, Lugansk, Slavyansk, Mariupol	Burda 1997
Eragrostis minor	Poznań Łódź Warszawa Katowice	Jackowiak 1993 Witosławski 1991 Sudnik-Wójcikowska 1998a; Galera & Sudnik-Wójcikowska 2000a, b Tokarska-Guzik, *pers. obser.*	Leipzig Berlin Braunschweig Münster, Essen, Düsseldorf Halle, Leipzig Zürych Donetsk, Lugansk, Slavyansk, Mariupol Vienna	Gütte 1971, 1992 Darius & Drepper 1984 Brandes 1987 Wittig *et al.* 1985 Frank & Klotz 1990 Landolt 1991 Burda 1997 Jackowiak 1998c
Iva xanthiifolia	Poznań Warszawa Lublin	Urbański 1955 Sudnik-Wójcikowska 1987b Święs 1993		
Parietaria pensylvanica	Bydgoszcz Warszawa	Sawilska & Misiewicz 1998; Sawilska *et al.* 2003 Guzik 2002	Berlin	Sukopp & Scholz 1964

9.4. Historical gardens, botanic gardens, cloister and convent gardens as places of "domesticating" exotic species prior to their spontaneous establishment

Human settlements in the latter stages of their development have always been accompanied by plants closely connected with humans and with their ever-improving forms of economic activities. These plants include cultivated plants, weeds and ruderal plants. Humans gradually introduced increasingly more plant species into cultivation, first those used to obtain food and medicines, then industrial and decorative plants.

The second half of the 18th century was thus characterised by KLUK (1786): "[...] This time is so good in housekeeping and thence it looks to naturalising much of its native and alien resources in order to need only a little from abroad" ["Wiek teraźniejszy bardzo gospodarny, szuka iak naywięcey w kraju swoim oswoić, aby mniey potrzebować z cudzego"]. This author thus provided not only the lists of native and alien species accidentally introduced into Poland and cultivated during those times (cf. Table 6 in Chapter 5.2), but also the plants cultivated in the neighbouring countries which he deemed worthy of acclimatising in Poland (e.g. *Asclepias syriaca*).

The list of plants cultivated in various historical periods documents the history of the cultivars, the changing needs of humans, as well as trends prevailing in the art of gardening. Each garden, being a defined spatial system, is shaped in terms of functions under certain environmental conditions, but taking into account also the time, needs and place of its establishment is additionally affected by prevailing tendencies in arts, opinions, customs and beliefs (MAJDECKI 1993). The historical gardens have preserved till our times ample sources of information about history, fine arts, the use of plant resources and nature in general.

Trends in the way gardening art has shaped gardens have depended on many historical, cultural and biological factors, but the selection of plant species has also been a significant factor. The basic species structure (plant cover) of any park is usually provided by indigenous elements, matching the habitat conditions of the original area where the park was designed. With time, however, plant material resources became richer owing to achievements in plant breeding. The supplement to the indigenous plants came in the form of alien species, which were to augment both the biological and spatial structure of a garden.

In 18th century England, when regular gardens were radically replaced by landscape-type ones, species of alien origin, called "exotic", were introduced on a massive, never before seen, scale (SIEWNIAK 1989). The peak of this so-called "exotica madness" occurred in the 1840s. It was associated with expeditions of discovery by arboriculturalists, e.g. those of D. Douglas along the north-eastern coast of North America, and of R. Fortune across East Asia. The example of England was followed by massive imports of "exotics" into the Netherlands and France. After a certain time delay, these species reached Central Europe. In Poland, these alien species appeared relatively early in gardens because of wealthy landowners (WODZICKI 1824–1828; SIEWNIAK 1989).

The state of our knowledge about the proportions of alien trees and shrubs in historical parks is still far from exhausted. A majority of recorded and published data pertains to the first instance of introducing species into botanic gardens or the more significant parks (MAJDECKI 1993). Relevant materials, if available, are usually scattered or included in sources reaching back merely to the 19th century, and difficult to access (HEREŹNIAK 1992). Also lacking is sufficient information on nurseries breeding decorative plants and directly involved in spreading trees and shrubs. MAJDECKI (1993) presents selected examples of the most frequently encountered trees and shrubs of alien origin in Polish historical parks. The list also includes trees and shrubs established in Poland only recently (Table 10). Despite having been cultivated for 100–200 years, some of the species listed in the table have been deemed to be established only in the most recent decades (and some only locally – cf. Appendix B).

Among the attractive avenue-forming trees used in the Baroque period were the Horse Chestnut *Aesculus hippocastanum*, and the still occasionally-used Locust *Robinia pseudoacacia*; which have been known in Europe since the 17th century; in gardens of that period shrubs were also planted, such as lilac and spirea. Other species listed in Table 10 include species now commonly occurring in Poland and still expanding, such as *Acer negundo*, *Quercus rubra*, *Robinia pseudoacacia*, *Fraxinus pennsylvanica* and *Padus serotina*.

The successful process of establishing many tree species was not solely an outcome of their

introduction to historical parks[70]. For example, the Black Poplar called *Italica* (*Populus nigra* 'Italica'), was initially a hallmark of the parks established in the first half of the 19th century and only later did it go into widespread use as a tree planted in cemeteries and also to create avenues.

Another essential role of gardens was that of "domesticating" perennial plants imported in order to add decorative and artistic merit.

The assortment of decorative plants used in the herbaceous layer of gardening arrangements included the Dame's-violet *Hesperis matronalis*, and flower beds were made of Common Foxglove *Digitalis purpurea*, Sweet William *Dianthus barbatus*, Elecampane *Inula helenium*, and Garden Lupin *Lupinus polyphyllus*, while the borders of flower beds used Hyssop *Hyssopus officinalis* among other species (Majdecki 1993).

Table 10. Trees and shrubs of alien origin the most frequently encountered in Polish historical parks, contemporarily naturalised in Poland

Taxon	Origin	Hab.	Status in Poland	Described as invasive elsewhere
XVII–XVIII				
Acer negundo	Am N	NSH	invasive [rip. agr. urb.]	Eur C [rip. agr. & urb.]
Acer saccharinum	Am N	H	casual / locally naturalised	
Aesculus hippocastanum	Eur SE	SH	naturalised	
Elaeagnus angustifolia	Eur S, Asia W & C	H	casual / locally naturalised	Hungary; Am N [rip.]
Pinus strobus	Am N	N	locally naturalised	Czech Rep.
Populus nigra "Italica"	Anthropog.	H	locally naturalised	
Quercus rubra	Am N	N	naturalised / invasive	Czech Rep.
Robinia pseudoacacia	Am N	NSH	invasive [rip. agr. urb.]	some regions of Eur C & S
Syringa vulgaris	Eur SE	NSH	naturalised / relic	Czech Rep.
1/2 XIX				
Ailanthus altissima	Asia E	H	naturalised /pot. invasive [urb.]	Eur C & S [urb. & rip.]; Am N
Amorpha fruticosa	Am N	H	casual / locally naturalised	some regions of Eur C
Fraxinus pennsylvanica	Am N	SH	naturalised /invasive	Czech Rep. & Hungary
Lonicera tatarica	Eur SE & Asia C	SH	locally naturalised	
Pseudotsuga menziesii	Am N	N	locally naturalised	
Ptelea trifoliata	AmN	H	locally naturalised	
Rhus typhina	Am N	H	locally naturalised	
Symphoricarpos albus	Am N	NSH	naturalised	Czech Rep.
Tsuga canadensis	Am N	N	casual / locally naturalised	
2/2 XIX				
Cotoneaster lucidus	Asia C	NH	locally naturalised	
Mahonia aquifolium	Am N	H	locally naturalised	Czech Republic, Germany
Populus berolinensis	Anthropog.	H	locally naturalised	
Padus serotina	Am N & Am S	NS	invasive [rip. agr. urb.]	Eur C [forests]
Pterocarya fraxinifolia	Asia SW	N	casual / locally naturalised	
Rosa multiflora	Asia E	NSH	locally naturalised	
Rosa rugosa	Asia E	NSH	naturalised /relic	
Thuja plicata	Am N	NH	casual / locally naturalised	

[70] European forestry has played an important role in the introduction of exotic species (Siewniak 1989). This author is of the opinion that foresters had the following goals: to produce more technically valuable wood, to decrease the vulnerability of forests to pathogens (lack of natural pests) and to widen tolerance to habitat conditions.

[71] *Artemisia dracunculus* was used for salads and as a spice, the leaves of *Atriplex hortensis* were used as spinach; *Hyssopus officinalis* was cultivated as a spice or medicinal plant: strewn in baths and also taken internally "to strengthen nerves", *Marrubium vulgare* was applied in the same capacity.

Botanic gardens, small gardens at monasteries and convents, as well as some home gardens also became types of "seedling nurseries" for plants imported for use in medical treatments or cooking[71] (e.g. *Artemisia dracunculus*, *Atriplex hortensis*, *Hyssopus officinalis*, *Marrubium vulgare*). Some other species were casually brought in with imported seed or seedlings, and passed through gardens in the first stages of their establishment (e.g. *Amaranthus albus*, *Eragrostis multicaulis*, *Euphorbia humifusa*).

There has long since been a worldwide interest in the history of introducing exotic plant species into parks and gardens. The effects of their "escape" and establishment outside garden and park sites places has been frequently documented (e.g. UDVARY & FACSAR 1997; SUKOPP 2002 and references cited therein). Archaeological and ethnobotanical studies permit the reconstruction of the history of growing fruit trees, vegetables and other plants used by humans from as long ago as the early Neolithic Period. The results of these studies can even indicate the differences in preferences shown towards cultivated species in urban and rural areas (ZEIST *et al.* 1991).

9.5. Immigration periods (peak inflows of kenophytes)

The reconstruction of the immigration periods of individual kenophytes and groups (e.g. species with common origin) calls for specific information: when the species was accidentally brought in, or introduced into cultivation, and when it was initially recorded as spreading spontaneously (the "first" record!). Also essential is information on the rate of spread from the first record until recent times (expressed in the numbers of stations in subsequent periods).

Differences in the method of gathering data and the changes which occurred to the national territory of Poland throughout the last four centuries, allow only estimated reconstructions of the periods of "influx" of newcomers into Poland and their course of expansion.

In most cases, the first known record of a kenophyte in Poland does not reflect the actual timing of its appearance. Unless there were spectacular, sudden and massive occurrences of a newcomer (as was e.g. the case of Canadian Waterweed *Elodea canadensis*), a species was usually noted after a certain delay.

For example, in the case of the species *Acorus calamus*, described in the 17th and 18th centuries (SYREŃSKI 1613; KLUK 1787) as a common plant, growing in inland water courses, lakes and ponds throughout Poland, the earliest record identifying a specific place dates back only to 1824 (the only earlier record, which pertains to an urban site in Warsaw dates back to 1652; after SUDNIK-WÓJCIKOWSKA 1987a; cf. Appendix A).

It is thus highly likely that many species were accidentally brought in earlier and that the first available records do not correspond with the initial phase of the expansion of the new species (cf. Chapter 5.2) in the new range colonised by it. Such a conclusion is legitimate if there is a great number of records for a particular species within a short time of its first record (e.g. *Echinops sphaerocephalus*, *Lycium halimifolium*, *Reseda luteola*, *Hesperis matronalis* or *Sisymbrium loeselii*)[72].

The second group consists of species intentionally introduced into cultivation by humans which subsequently become wild. In such cases, the date of introduction into cultivation is typically more precise compared with the date when the plant becomes wild, which is usually known only as a rough estimate. Apart from a list of species, the oldest floras usually provided only descriptions of the plants and their uses. Information on the course by which they entered the flora in a given area was most often referred to only in general terms. The first "full" records, carrying information suitable for entering into databases and drawing maps most often pertain to later periods compared with the mostly unnoticed period of "going into the wild state".

Difficulties in a thorough and accurate reconstruction of the course of expansion, using a uniform method for the entire group of kenophytes, do not alter the fact that Poland's flora was enriched by newcomers in a whole series of historical periods. In this process of influx of alien species one can even speak of peaks ("migration waves") the highest of which occurred in the second half of the 19th century (cf. Chapter 5.2). Changes in both the number and proportions of kenophytes of different origins in the series of "immigration waves" can be linked to the economic situation of Poland in the periods identified.

In contrast to Western Europe, the industrialisation of the eastern part of the continent started after a significant delay and progressed not without perturbations (DAVIES 2001). In the Polish lands, the first rather less advanced industrial manufactories appeared in the first half of the 18th century. During the industrialisation of Poland, modern accounts distinguish three stages: the first, from the 1740s until 1815 (characterised by no major changes in economy but significant progress in science and technology and the development of trade); the second – from 1815 until the outbreak of World War II (called "the first industrialisation"), and the third – post 1945 (called "the second industrialisation stage"), which continues through to today (DAVIES 2001).

[72] In the case of some of the "oldest" arrivals among the kenophytes, some doubts exist as to their true status in Poland. For example, in KORNAŚ's (1968b) opinion, *Lycium halimifolium* and *Reseda luteola* should be grouped with the oldest arrivals (archaeophytes).

Subsequent peaks in the influx of kenophytes can be coupled with the stages of industrialisation cited above. The gradual rise in the number of species up to the end of the 18th century, with an evident predominance of species of European and Asian origin, can be explained by trade links, as well as by wars fought by Poland at that time. An evident rise in the number of newcomers continued throughout the subsequent periods of the 19th century, in the stage of "the first industrialisation", with an added tendency towards an increased proportion of alien species from the Americas (particularly North America). The most dynamic period of "the first industrialisation" fell in the years 1864–1918, when Polish industry was drawn into a wider European market of goods, labour, and capital (DAVIES 2001). The railway network expanded, new industrial regions developed and stimulated urban growth in adjacent areas (cf. Fig. 65). The density of the proportion (i.e. the concentrations) of kenophytes in the floras of individual regions of Poland over this period reflects the distribution of major cities, industrial centres and the links between them.

The evidently higher density of kenophytes in the south-western, western and northern parts of Poland arose not only from a higher degree of industrialisation and urbanisation compared with other regions of Poland, but also from many centuries of traditional links between these areas and Western Europe. The rate of industrialisation and urbanisation was definitely higher in those areas than remaining German. The industrial revolution reached Prussia relatively early. The first iron smelter was opened in the Ruhr basin in the 1780s, and the first in Silesia was commissioned in 1794. In 1847, the first railway line went to use in Prussia. The most important region of modern Poland was established, developed and brought to "economic maturity upon the initiative of Germany within the economic system of Prussia. Throughout the industrial revolution its links were not oriented towards Poland but towards other parts of Germany" (DAVIES 2001).

Adopting the expression once used by DAVIES (2001) who suggested that "it is the geography of Poland which stands guilty of determining her past" we might condition (to a certain extent) the results of the reconstruction of past Polish floras of kenophytes both on the geography and history of the Polish Republic.

9.6. Migration routes

The overall tendency to spread, common to all plants, depends on many factors. Most migrations are short-distance and are carried out step by step. But plants also "attempt" long "leaps" of distances measured in hundreds or even thousands of kilometres (KORNAŚ & MEDWECKA-KORNAŚ 2002). The effect of these migrations depends on the biological properties of the plant and, above all, on the mode of production of offspring and the methods of dissemination of diaspores, as well as other natural factors. In many cases, anthropogenic factors are also of significance.

The enormous potential of plants to migrate has been demonstrated throughout the course of the development of natural vegetation cover, and was particularly evident in the Quaternary, i.e. following the end of the last glaciation. In the Holocene, at least since the Neolithic Period, human beings have become a prime factor in plant migrations (JACKOWIAK 1999; ZAJĄC A. 1979). The discovery of America by Columbus[73], which initiated ever-intensifying contacts between the continents, contributed to the commencement of a "global experiment" in which elements of floras are exchanged between regions separated by natural geographical barriers (KORNAŚ 1990; JACKOWIAK 1999).

As regards the group of newer arrivals, these are migrations in the geographical meaning of the word. They lead to a widening of the initial range (this phenomenon pertains to some European species – cf. Chapters 6 and 7) or mostly result in the appearance and development of a new, secondary range (FALIŃSKI 2004).

Plants showing only a limited potential for active migration, apart from developing some adaptations facilitating dispersion, utilise the natural conditions of the colonised regions or make use of the means of transport provided by other species, i.e. animals and humans (cf. Chapter 8).

9.6.1. Rivers as migration corridors aiding the spread of kenophytes

River beds and valleys are migration routes used by plants that are often rather easy to document (KORNAŚ 1990; SUKOPP & TREPL 1987). These river-related plant migrations, their essence and importance in ecological and geographical expansions, based on many examples, were reviewed in detail by FALIŃSKI (2000b).

[73] The latest research completed in Europe and America shows that Vikings should be regarded as the precursors of sailing across the Atlantic Ocean to the New World. Eric the Red of Iceland, who was banished from the island and thus went on to Greenland where he established two settlements, is considered to be a pioneer of discoveries in America (DŁUGOSZ 2001).

Among the newer arrivals, many authors present examples of species which use river valleys during certain stages of their expansion. For example, LHOTSKÁ & KOPECKÝ (1966) refer to the expansion of *Impatiens glandulifera* in the Upper Oder river basin as well as in the basins of Vratka and Svitava rivers in the present territory of the Czech Republic. Within the borders of Poland, the highest number of stations of this species are concentrated in the upper and middle course of the Oder (from the border with the Czech Republic down to Wrocław) (cf. also Chapter 7), which is perhaps related to soil type (rich brown soils) and the forms of human impact on the environment in this part of the valley (DAJDOK *et al.* 2003). Also DRESCHER & PROTS (2003) highlighted the connection between the dispersion of *I. glandulifera* and migrations along river valleys, pointing out that the "dispersion and establishment of the species along watercourses will depend strictly on the geomorphology of the river and the bank, the duration of flood, the speed of water flow and the type of sediment material".

Another species spreading along rivers is the *Bidens frondosa*, which expands its ranges in Europe along the Rhein and Elbe in Germany, by canals in the English midlands (PRESTON *et al.* 2002 after Cadbury 1971), and the Loire in France (KEIL 1997 and references cited there). In Poland also, the first stages of occupying new sites are specifically associated with river valleys (cf. also Chapters 6 and 7). Further east, *Bidens frondosa* is currently expanding along the Neman (Lithuanian: Nemunas) (GUDŽINSKAS 1997d).

In characterising the distribution of *Eragrostis albensis* (earlier described as *E. pilosa*) in the Vistula river valley, SUDNIK-WÓJCIKOWSKA & GUZIK (1996) emphasise the important role played by the natural conditions still prevailing along this, the largest river of Poland[74]. In the spreading of this species the fine and light-weight seeds are transported by water, thus floods and surges of waters also play a certain role in the process.

SUKOPP (1998) points to the proportion and already permanent presence of some alien species in the summer therophyte communities developing on the draw-down zone of water courses[75]. This statement pertains to the *Bidens frondosa* and *Xanthium albinum* along the Elbe river. The distribution of the latter species and the association of its migrations with river valleys have been also illustrated by GUDŽINSKAS (1997d) in Lithuania where *Xanthum albinum* is common along the Neris and Neman rivers and in Poland by DAJDOK & KĄCKI (2003) and KUCHARCZYK (2003b) along the Lower Odra and in the middle course of the Vistula, respectively (cf. also Chapter 6). In Poland *Rumex confertus*, a species associated with the valleys of the Vistula and Bug rivers, has become a model species in this respect (cf. Chapters 6 and 7 and references cited there; also KRASICKA-KORCZYŃSKA *et al.* 2003).

BRANDES (1991) regards *Bunias orientalis* as a species occurring chiefly along rivers (in Western Europe its stations concentrate in river valleys, e.g. the Main, Tauber, Rhine, Meuse), although some other corridors are also listed, such as roads, canals where it grows on banks of fertile soils, principally on limestone substrate (mostly chalky). In Poland, this species has expanded above all along roads and the role of river valleys is only secondary. However, in Poland, similarly to its expansion in Western Europe, the species seems "attached" to calcium-rich soils and generally to warmer regions of the country (cf. Chapter 6).

Other species often referred to in conjunction with rivers are: the *Echinocystis lobata*, which originally occurs in riverine forests of North America but is now going into the wild state in many European regions and spreading along major or middle-sized rivers (GUDŽINSKAS 1999a; DAJDOK & KĄCKI 2003; cf. also Chapters 6 and 7), and *Mimulus guttatus*, which is associated with the Neris and Neman rivers in Lithuania (GUDŽINSKAS 1998a), whereas in Poland it spreads along brooks in the Sudety Mts. (FABISZEWSKI 1985; FALIŃSKI 2000b; KWIATKOWSKI 2003), as well as along some rivers in the Beskidy Mts. and in northern Poland (e.g. upon the Łupawa river, *pers. observ.*).

9.6.2. The role of humans in the migrations of kenophytes

"Long-range transport"

One cannot overestimate the role of humans in creating opportunities for species to reach new territories. Although an "enormous number of alien newcomers travelled over Atlantic without any prior intention or knowledge of Man" (KORNAŚ 1996), an equally large group

[74] "In the middle course of the Vistula, where its flow and course are unconstrained, natural habitats still predominate. The river has a slow current here and the width of the valley ranges from 1 to 14 km. The Vistula forms river arms, the current often changing direction among numerous sandy banks and holms within the river channel" (SUDNIK-WÓJCIKOWSKA & GUZIK 1996).

[75] "It has become clear that agriophytes play a major role in the floristic structure of therophyte communities, which develop every summer on initially bare riversides as the water level falls" (SUKOPP 1998).

was imported by humans on purpose (cf. Chapters 5 and 9.4, App. A and B). Unintentionally aided species have utilised enormously diverse means of transport: with seeding material, animal fodders, wool, packing stuffs, wood and, above all, with ballast earth, bringing with them an entire "bank" of seeds, spores and all other kinds of plants (KORNAŚ 1996) (cf. also Appendix A).

Accidental introduction has been also facilitated by human migrations during past wars and post-war periods and by armies marching through[76], while in modern times the process is chiefly facilitated through the exchange of goods now effected on a global scale, as well as by dynamically growing tourism.

Once introduced somewhere, the migration of plants has tended to follow suitable natural conditions (such as the aforementioned river valleys) as well as making use of the opportunities provided by humans (through economic development[77], the cutting down of forests, settlement development, trade, the construction of roads and railways, sea and river ports etc.).

Transport routes

The possibility of accidental introduction along railway lines was pointed out early by PACZOSKI (1900)[78]: "Railways are extremely conducive to the accidental introduction of plants which has to be attributed not only to transport and dissipation of seeds, but is also to the fact that the tracks are laid on sandy embankments where competition from other species is non-existent". This author enumerated such species as: *Anthemis ruthenica*, *Chamomilla suaveolens*, *Artemisia austriaca*. The issue was then re-addressed by KORNAŚ *et al.* (1959), emphasising that "the massive transport of goods over long distances provides convenient conditions for the transfers of seeds, fruits and other diaspores".

This manner of spread is utilised by such plants as *Acer negundo*, *Artemisia austriaca*, *Cardaria draba*, *Centaurea diffusa*, *Diplotaxis muralis*, *Eragrostis minor*, *Impatiens parviflora*, *Linaria repens*, *Potentilla intermedia*, *Sisymbrium altissimum*, *Solidago canadensis*, species of the genus *Oenothera*, and in recent decades also by *Rumex confertus* (cf. Chapter 7) (data obtained from author's own research and that of other authors, e.g. URBAŃSKI 1958; ROSTAŃSKI K. 1960; ĆWIKLIŃSKI 1968, 1972a, 1990; SENDEK 1971; MICHALAK & SENDEK 1974–1975; SZMAJDA 1974; LATOWSKI 1977; ROSTAŃSKI K. *et al.* 1989; NOWAK 1997; WĄSOWICZ 2003).

Some species have even been deemed to be types of "railway specialists" (KRAWIECOWA 1951; KORNAŚ *et al.* 1959; SENDEK 1971; JEHLÍK 1981). Railway type of habitats provides them with conditions similar to those they select in their respective homelands (ZAJĄC E.U. & ZAJĄC A. 1969)[79], and further equivalent habitats can be found in heaps, rubble dumps, roadsides. Both railways and roads facilitate penetration by adventitious species into communities of indigenous plants or increase their vertical ranges in mountains.

"Even small countries typically contain
many different habitats
as well as biogeographically distinct subregions,
each of which may have a unique invasion history
and be differently susceptible to invasion".
SUKOPP 1998

10. Recent distribution ranges of kenophytes and principles affecting the distribution pattern

When considering plants of alien origin, it is as difficult to reconstruct the history of their expansion as it is to analyse their contemporary distribution ranges. The pattern of the distribu-

[76] SEMPOŁOWSKI (1880–1881) provided such description of the routes and manners of the accidental introduction of *Xanthium spinosum* to Central Europe: "[...] it is said that the Russian armies marching through Vallachia brought it there; according to eye witnesses many characteristic spiny fruit of this plant could be seen entangled in manes and tails, particularly of Cossack horses". Further expansion has been facilitated chiefly by pigs, sheep and the wool of the latter: "Spiny fruit of the cocklebur cling easily to the bristles of pigs, particularly Serbian and Hungarian [pigs], which have long and curly bristles and the pigs transfer the fruit sometimes to very remote locations. This fact is easily noted because this weed appears in large numbers along the tracks where pig herds have been driven either to Hungary or across it, especially at the sites of longer rests. Since the time when railways were used to transport pigs to northern Germany (e.g. to Hamburg), the cocklebur has been seen along the relevant railway routes. The species reached Vienna and some regions of Germany with contaminated wool". Initially it was found around wool warehouses and cloth factories. In Bukovina it was noted in 1830 and because its discovery coincided with a cholera epidemic there, thus the local peasants gave it the vernacular name of "cholera thistle".

[77] In some periods, the accidental introductions of alien plant species were helped to a large extent by the cloth manufacturing and food processing industry (grain elevators, mills).

[78] THELLUNG (1918–1919) noted the same.

[79] Habitat conditions prevailing at railways sites are specific. Among the essential ones are the predominance of skeletal structures in the substrate, excessive dryness and insolation.

tion range of synanthropic species is affected by many factors, both historical (time, manner and routes of introduction), as well as those related to the biological properties of a given species (e.g. life strategies, means and rate of dispersion of diaspores) and by the specific conditions a species encounters in the new homeland.

Among the factors operating on a large (global) scale, climatic factors are all-important[80] (either as limiting or advantageous factors depending on the climatic zone from which a newcomer originates, i.e. on the conditions in which it grew in its homeland). Other factors of paramount importance are potential natural barriers (oceans, seas, mountain ranges, vast forest complexes, deserts). The specific habitat conditions found in the new site (land relief, soil types, presence of water courses, land use etc.) are only of secondary importance.

In the conditions prevailing in Poland, many kenophytes find an evident climatic barrier limiting their occurrence in the mountains (particularly noticeable in the Carpathians) and in north-eastern Poland[81], as well as in some locally cooler regions (cf. Chapter 7). In the mountains, particularly at higher elevations, there are no kenophytes of Irano-Turanian or Mediterranean origin (they may occur only locally in larger cities or along railway tracks and embankments, e.g. *Sisymbrum altissimum* and *S. loeselii*, *Lycium halimifolium,* and *Datura stramonium*).

Of the overall number of 123 species of kenophytes recorded in the Carpathians, 42 species have fairly numerous stations in the region, whereas 81 species have only isolated stations (Zając M. & Zając A. 2001). According to the data provided by these authors, among the kenophyte species which are often found in the Carpathians, 14 kenophytes are plants associated with anthropogenic habitats (epecophytes), whereas 23 species (agriophytes) penetrate into natural communities. Among the kenophytes found more rarely there, 27 species are epecophytes, while 33 are agriophytes.

The number of kenophytes falls in line with the rise in elevation above sea level. Kenophytes tend to concentrate in the lower mountain sites (up to 500 m a.s.l.) which in the Polish Carpathians means a zone in transition between the foothills and the lower montane zones. The species associated with some extra-zonal habitats such as *Juncus tenuis* (paths, roads) and *Solidago gigantea* (river and stream banks) can reach the highest elevations attained by kenophytes. The upper limit of cultivated fields (*ca.* 700 m a.s.l.) is reached by kenophytes constituting field weeds: *Conyza canadensis*, *Oxalis fontana*, *Veronica persica*, *Galinsoga parviflora* and *G. ciliata*.

Similar relationships were found in the Sudety Mts., the Śnieżnik massif and Bialskie Mts. (Szeląg 2000), where rare and very rare species, with occurrence limited to the lowest elevations, predominate among some 60 species of kenophytes recorded. The list of kenophytes which are found frequently and also recorded in sites with elevations of *ca.* 700 m a.s.l., and sometimes even 900 m a.s.l. includes: *Chamomilla suaveolens*, *Galinsoga ciliata*, *G. parviflora*, *Tanacetum parthenium* and *Veronica persica* – associated with anthropogenic habitats, and *Impatiens parviflora*, *Juncus tenuis* and *Rudbeckia laciniata* – which are also established in natural and semi-natural habitats.

On the other hand, one can identify some specific features of the floras in the mountain regions of Poland resulting from the presence of kenophytes. In the Bieszczady Mts. these will be newer arrivals penetrating natural communities: *Bunias orientalis*, found on roadsides, alluvia, anthropogenic habitats and moving on to natural communities (up to 630–740 m a.s.l.); *Juncus tenuis* spreading along paths, up to 630–900 m a.s.l.), *Rudbeckia laciniata*, a plant which occurs, sometimes in massive numbers, on the edges of riverine woods and scrub (up to 630–750 m a.s.l.) and *Veronica filiformis*, not very common but locally abundant (up to 650–800 m a.s.l.) (Zemanek & Winnicki 1999).

In many regions of the western Beskidy Mts., particularly in lower sites, the species *Digitalis purpurea*, *Heracleum mantegazzianum*, *Impatiens glandulifera* and *Reynoutria japonica*, and

[80] The climate may be considered a complex of factors setting the broad limits for plant distribution, while other factors, such as geology, soils and competition, will determine the presence or absence of a species in a particular area and on a finer regional or local scale (Welk *et al.* 2002). For example *Reynoutria* (*Fallopia*) *japonica* was found to be controlled by two climatic variables – the length of the growing season, measured in day-degrees, and the minimum temperature – while for *Impatiens glandulifera* only the length of the growing season was critical (Beerling 1993; Beerling *et al.* 1995).

[81] The kenophytes which have also successfully established themselves in the ruderal floras of the Northern Podlasie Lowland include the very common species *Chamomilla suaveolens*, *Amaranthus retroflexus*, *Galinsoga parviflora* and the rare *Datura stramonium* (Wołkowycki 1997). *Elsholtzia ciliata*, a species absent from central and northern Poland and even recently withdrawing from earlier stations (cf. Chapter 7) constitutes, along with some species belonging to other geographical/historical groups, a specific feature of the ruderal floras in villages and small towns in that region of Poland.

in the Sudety Mts.: *Mimulus guttatus*, *Impatiens glandulifera* and *Reynoutria japonica* (Fabiszewski & Kwiatkowski 2001; Kwiatkowski 2003) undoubtedly belong to this characteristic group of species.

There is a lack of detailed studies devoted to the autecology of individual species which could elucidate the nature of the above phenomenon (Zając M. & Zając A. 2001). One pioneering, and so far the only Polish study on this topic, is a monograph by Kornaś (1972) devoted to the dissemination of weeds in the Gorce Mts., where the author proved, *inter alia*, that the proportion of anthropophytes fell and the proportion of apophytes increased in line with the elevation above sea level (cf. also Chapter 8). For several species of kenophytes spreading in the Gorce Mts. as weeds in cultivated fields, maximum elevations were given: *Vicia dasycarpa*: 560 m a.s.l. (average: 499), *Galinsoga ciliata*: 655 m a.s.l. (average: 636), *Oxalis stricta*: 705 m a.s.l. (average: 668), *Galinsoga parviflora*: 730 m a.s.l. (average: 654), *Veronica persica*: 965 m a.s.l. (average: 910).

Specific ecological conditions (type of substrate or soil) may locally limit the range of a species despite general climatic conditions being potentially favourable for its occurrence (Welk *et al.* 2002). In Poland such a relationship is, for example, manifested by *Anthoxanthum aristatum*, a species whose distribution in Poland is determined by soil conditions[82] (cf. also Chapter 7).

In the regions potentially less favourable to dissemination, there might be suitable conditions prevailing locally, e.g. in the form of extra-zonal habitats in a generally dry climate. These might be: river valleys, wet or shaded sites, northern slopes and mountain habitats, as well as some ruderal habitats in cities.

The majority of kenophytes occurring in Poland, however, do not form characteristic distribution ranges over the entire national territory nor locally. They are mostly ubiquitous species whose history of establishment has nevertheless one common feature. These species were accidentally brought (often repeatedly) or they were (or are) cultivated in many places in Poland, and have succeeded in spreading from these places in many directions (e.g. *Chamomilla suaveolens*, *Conyza canadensis*, cf. Chapters 6 and 7).

Although in the case of this large group of species no specific patterns of distribution can be detected, nevertheless for one particular subgroup (of 14 species) some centres of concentration of stations can be demonstrated, e.g. within the Silesian Upland (and particularly the Upper Silesian Industrial Region – GOP[83]) and within large cities (cf. Chapter 6). The pattern of distribution for these 14 species which at present show certain relationships with urban areas, railway lines and roads coincides mostly with the "heat islands", or "zones of influence" of urban centres (Jackowiak 2003 after Różański 1979) (Fig. 67).

Some species show certain patterns of distribution associated with local habitat conditions (e.g. the local distribution of *Acorus calamus* or *Elodea canadensis* is determined by the presence of suitable habitats, thus these species will be found on rarer occasions in those regions where a hydrographical network is less developed, such as the Kraków–Wieluń Upland).

There is also a small group of species which currently form compact ranges limited to a specific region of Poland. The group includes, for example: *Erechtites hieracifolia* (the majority of its localities is concentrated in south-western Poland), *Solidago graminifolia* (Silesian Lowland), *Trifolium patens* (Carpathian Foothills, Rzeszów Foreland and Małopolska Upland), and *Veronica filiformis* (south-eastern Poland). The current patterns of their distribution are not simple reflections of climatic conditions, but also bear the marks of the history of their respective arrivals into Poland. These species were accidentally brought into a single region (or no more than a few regions) of Poland and then spread out gradually (Pietras 1970; Loster 1972; Górski *et al.* 2003; Tokarska-Guzik & Dajdok 2004).

Only a small number of kenophytes can be considered as has recently been reaching any limit of their ranges in Poland (cf. Chapter 6). These species (apart from a few exceptions – cf. Chapter 11) still have not completed their migrations and one may suppose that the area of Poland, generally devoid of major barriers, is

[82] Warcholińska & Siciński (1996) suggest that *Anthoxanthum aristatum* finds optimum conditions for development on the sandy "bielitza" soils of the weak rye soil or rye-lupine soil complex; another important factor favouring the concentration of stations in central Poland is the impact of the oceanic climate.

[83] The Silesian Upland and the Upper Silesian Industrial Area (abbreviated as GOP) are the two most disturbed regions in Poland (Tokarska-Guzik & Rostański 2001); in terms of the effects on climate, the GOP should be treated as a single urban-industrial complex constituting a "thermal island" in the atmosphere (Kruczała 1972). The region's population amounts to 2.178.400, its population density (1.720 residents/km^2 is the highest in Poland, where the average is 124 residents/km^2) and in the European Union (116 persons/km^2).

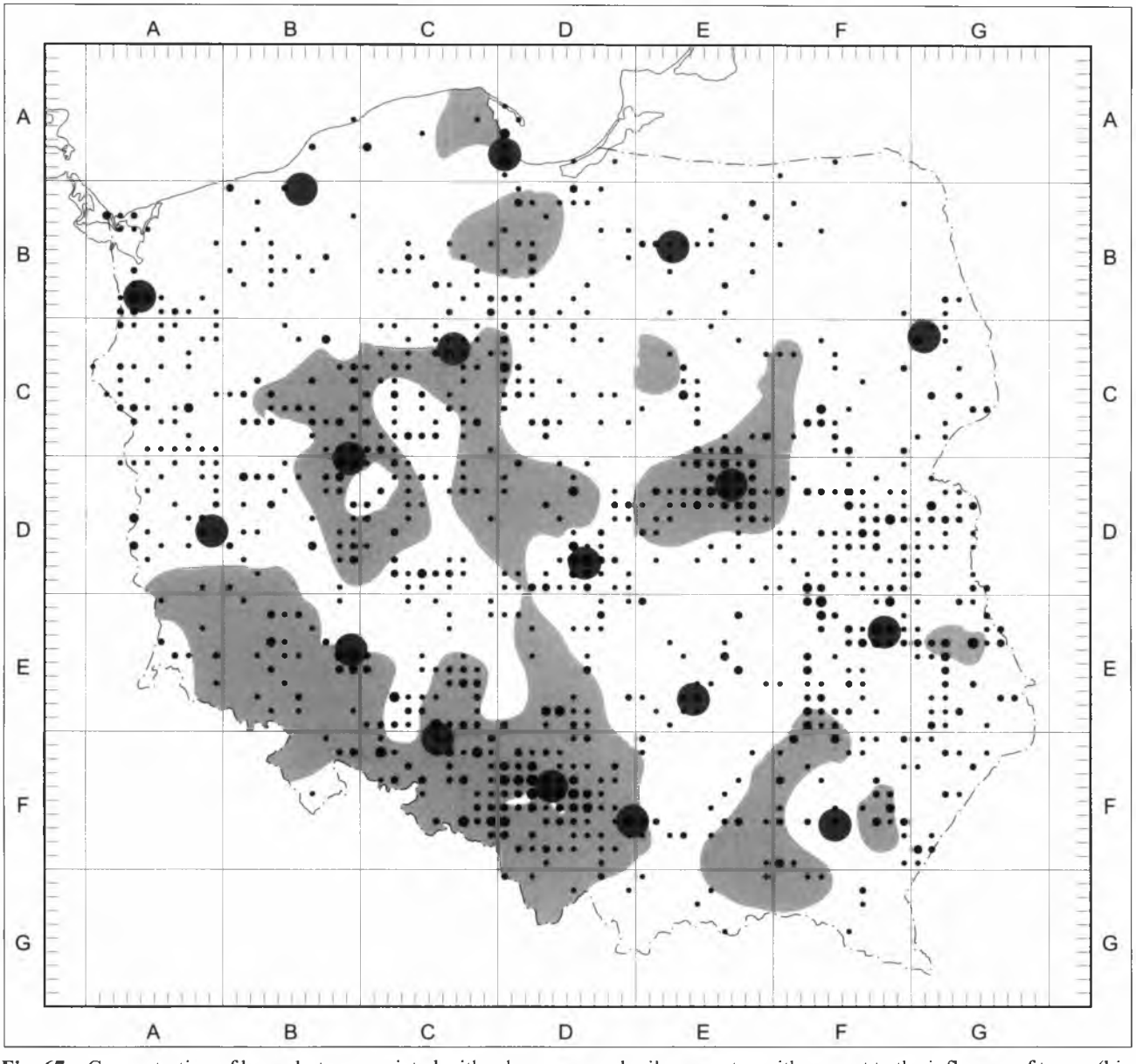


Fig. 67. Concentration of kenophytes associated with urban areas and railway routes with respect to the influence of towns (big dark gray circles) on the thermal conditions in the region on the example of the relation of artificial heat emission (gray spots) to the solar radiation in Poland (source: JACKOWIAK 2003, significantly changed)

not going to be any great obstacle in their further expansion.

As mentioned earlier, some of the species are currently expanding their ranges in the same continent (this pertains to species of European origin), while others developing disjunctive, secondary ranges. The species which have expanded their ranges in Europe in recent centuries include, *inter alia*, *Anthoxanthum aristatum* (Fig. 68) (cf. also Fig. 51 in Chapter 7), *Artemisia austriaca* (Fig. 52 in Chapter 7), *Clematis vitalba* (Fig. 40 in Chapter 7) and *Rumex confertus* (Fig. 55 in Chapter 7).

PYŠEK (2001) states that forecasts and estimates pertaining to the distribution of other species have been formulated very recently, thus there has been too little time allowed to pass any judgement as to their merits. The conclusions found in published studies on this topic are based on presumptions (or even speculations)[84]. Equally rare are efforts to forecast the limit of the synanthropic range based on bioclimatological data. An attempt at such a forecast, based on GIS methodology, was made by WELK *et al.* (2002)[85].

[84] These conclusions take into account the origin of diaspores which might be locally adapted to specific conditions. Also considered is the fact that it is sometimes only random samples of the genetic diversity of the species which are brought accidentally from their natural ranges. Finally, whether a species can change its life strategy in certain circumstances is also discussed.

[85] In that study the authors presented the analysis of the relationship between the distribution within the natural range and the spatial interpolation of the average monthly temperature and precipitation conducted for *Alliaria petiolata* (Garlic Mustard), a species native to Europe while being regarded as invasive in North America.

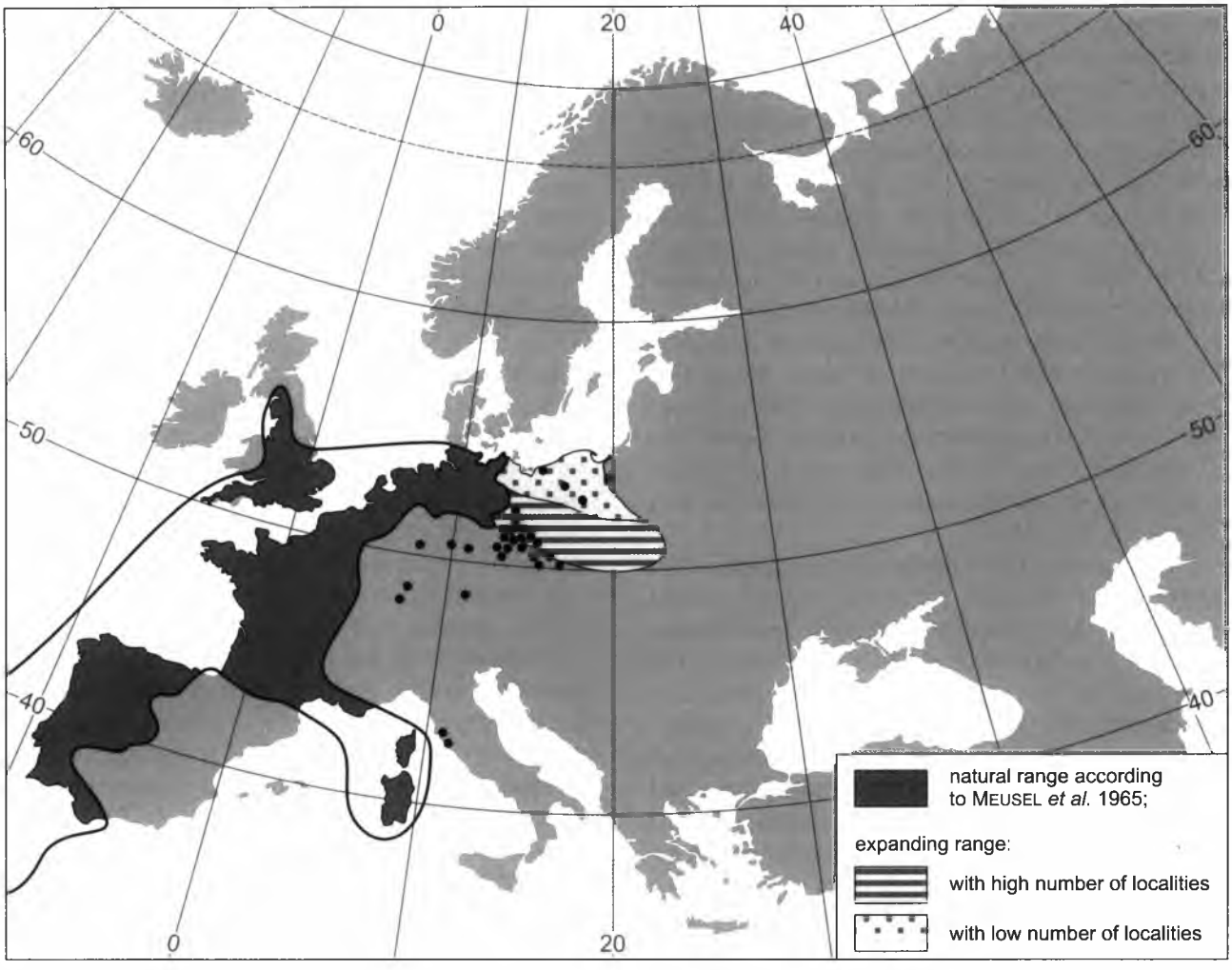


Fig. 68. Changes in distribution range of *Anthoxanthum aristatum* Boiss. in Europe

11. Dynamic tendencies in the process of kenophyte expansion in Poland

As mentioned earlier, the initial stages of anthropophyte species migrations are linked to the introduction of agriculture (earlier periods are currently impossible to reconstruct; some hope in this respect may be linked with the results of archeobotanical studies). Since that period, the process has continued with varying intensity up to the present time.

The dramatic velocity of these migrations is often stupefying; it usually takes between several dozen years to two hundred years for a newly arrived species to fill totally the potential area of its occurrence in its new homeland (KORNAŚ 1996) (see also Chapter 7).

The rate of spread in Poland has been reconstructed for 174 kenophyte species (see also Chapter 4 and Appendix A), for which detailed information about the number of localities of occurrence (historical as well as current) has been gathered. In successive 50-year periods, the number of new arrivals recorded for the flora of Poland grew steadily (in the 50 years to 1850 – 49 species; to 1900 – 117 species; to 1950 – 143 species and to 2000 – 174 species, respectively). The same tendency was apparent for the total number of recorded localities (in the 50 years to 1850 – 151 localities; to 1900 – 3 675; to 1950 – 9 273 and to 2000 – 196 441 localities, respectively) (cf. Chapter 5.2)[86].

The number of localities shows an especially rapid growth. Nearly 94% of the total number of localities for the above-mentioned 174 species have been recorded during the last half-century. This fact must be linked mainly to the increase in

[86] It should be taken into account that the presented listings refer to data accumulated in the ATPOL database on the basis of available sources. The density of kenophyte occurrence presented on maps for consecutive half-century periods during the last two centuries should be regarded only as an approximation when interpreting in terms of the dynamic tendencies of this group of anthropophytes spreading in Poland. The maps which illustrate the earliest reconstructed periods do not show the presence of some species due to the process of data acquisition and presentation peculiar for that period of scientific research (lack of precise data on locality, see also Chapter 4), whereas the maps from subsequent periods are also affected by differences in the degree of thoroughness of research conducted in each region of the country.

the intensity of studies of the synanthropic flora in the post-war period (we can thus refer to it as a partly "spurious" increase in the number of localities). In many cases, however, we have data proving that an actual increase in the invasion rate took place for many species. An example for this type of case is *Echinocystis lobata* – the history of its arrival and the consecutive phases of occupation of new localities by this species have been recorded rather precisely. The history of spread of this species in the territory of Poland encompasses the whole of the last century when the acquisition of floristic data had proceeded relatively systematically (with an interruption during World War II), although the intensity of research was variable from one region of the country to another (see also Chapter 7; Fig. 48).

The migration rate mainly depended not on the mode of translocation from one site to another (the spreading of seeds), but rather on the resistance of the environment to colonisation. An important factor was the way in which the immigrant species had been introduced. Those species which spread in anthropogenic habitats (at least in the initial phases of their migrations) and which had been introduced simultaneously into multiple regions in Poland were characterised by a high invasion rate. This pattern applies *inter alia* to the following species: *Amaranthus retroflexus*, *Chamomilla suaevolens*, *Conyza canadensis*, *Galinsoga parviflora* and *Veronica persica* (see also Chapters 5.2 and 7).

Auld & Tisdell (1986) have shown that the increase of total area occupied by an expanding species is faster when several small independent populations take part in the expansion, than when there is one large spreading population. The time and mode of introduction are also of importance. Subsequently, natural and anthropogenic factors decide whether a species will spread quickly or slowly and what type of range it will adopt.

This hypothesis is proven in the Polish circumstances by the following species (in addition to the ones listed earlier): *Trifolium patens*, *Veronica filiformis* and *Mimulus guttatus* (see also Chapter 7), which after having been introduced into a single region subsequently spread gradually in that specific part of the country (the principal factor that was decisive for the possibility of efficient naturalisation of a species in a given region of the country was obviously the climate; see also Chapter 10). It took another introduction event or the appearance of the species in another region for the species to be able to spread its range further, on conditions that the other region also had favourable conditions for the naturalisation of this species (see *Mimulus guttatus* – Chapter 7, Fig. 50).

The biological properties of a species are also highly relevant, especially the modes of reproduction and seed dispersal. Species which show a better strategy in this respect with regard to the conditions found in the new territory of occurrence are usually characterised by a faster rate of migration.

Among 174 kenophyte species for which dynamic tendencies have been identified, species with a relatively high number of localities predominate, but their distribution is usually limited to a specific part of the country (Fig. 69; cf. also Fig 15A & B in Chapter 5 and Chapter 6). They are also at the same time those species which gradually occupy new sites. The least numerous group is formed by common and broadly distributed species (with a very high number of localities). They also predominantly include the species which are still spreading: they occupy new sites and at the same time in many cases they increase the number of individuals in the populations at all localities (the so-called invasive species – see Chapter 12).

Weber (1998) has reconstructed the pattern of spread shown by 3 species from the genus *Solidago* in Europe. These species, originally from North America, were introduced into Europe as ornamental plants and as nectar sources for honey production: *S. canadensis* (*altissima*)[87] in *ca.* 1735 (vicinity of London) and the remaining two species probably around 1758 (see Appendix A), respectively. The first wild localities were recorded in the mid-19th century. *S. canadensis* and *S. gigantea* are currently common in many regions of Europe and are considered to be "aggressive" invaders on abandoned fields and river banks, also in protected areas (Sukopp 1966; Guzikowa & Maycock 1986; Weber 1998; Balogh 2001). The comparison of data regarding the number of localities, starting with 1850s, shows in the case of all species a continuous tendency to spread, albeit with a varying rate. *Solidago gigantea* is characterised by the fastest expansion rate, while the slowest one was recorded for *Solidago graminifolia.* As noticed by Weber (1998 after Hengeveld 1989), the spread of these species is not reflected in the occurrence of a conspicuous range front, but is effectuated according to the model of hierarchic diffusion. The spread by large jumps with subsequent local spread in all directions is defined as the hierarchic diffusion model (Hengeveld 1989) and might be the most applicable spread mode for invaders introduced as ornamentals (Weber 1998).

A similar expansion rate has been shown by these species in the area of Poland (Guzikowa &

[87] The taxonomic status of this species in Europe is unclear; *S. altissima* and *S. canadensis* are often not distinguished in the literature. On the basis of morphological characteristics it may be inferred that the species occurring in Europe is *S. altissima.* However, due to the mentioned doubts they are both still treated as a single species (Weber 1997b & c, 1998).

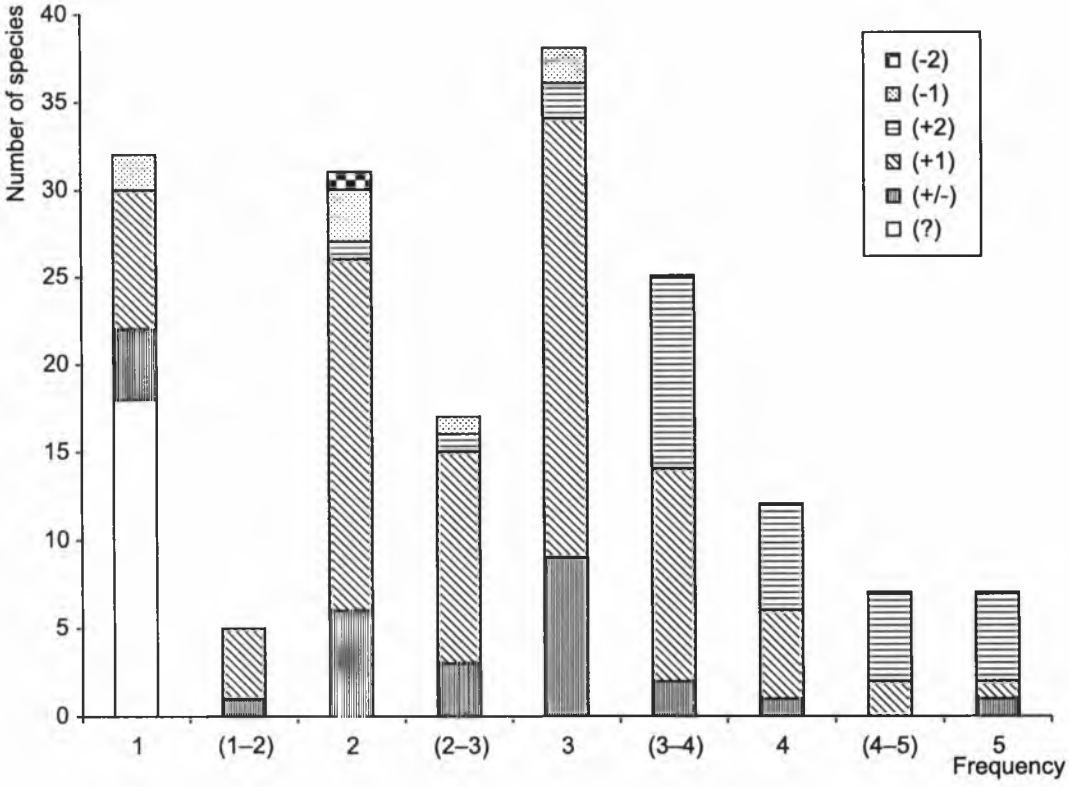


Fig. 69. Dynamic tendencies of 174 species of kenophytes occurring in Poland (according to ZARZYCKI *et al.* 2002; for more explanation see also Chapter 4)

Frequency in the wild at the territory of the country in relation to the number of localities: **1** – very low number of localities (1–20), **2** – low number of localities (up to 100), **3** – high number of localities, but with narrower distribution (in one or two regions of the country), **4** – high number of localities in many regions, **5** – common (abundant) in the whole territory.

Dynamic tendency: **(-2)** – high decrease of(in) number of localities, **(-1)** – decrease in number of(in) localities or decrease in abundancy over existing localities, **(+1)** – increase of(in) number of localities, increase in abundance over existing localities, **(+2)** – high increase of localities (colonizing new localities), **(-/+)** – disappearing of some localities and appearing of new localities, **(?)** – undefined dynamic tendencies

MAYCOCK 1986) (Fig. 70 & Fig. 71). One might accept the prognosis of WEBER (1998) which suggests that these species will continue to spread by increasing both the number of occupied localities and the number of individuals at each locality. Only *Solidago graminifolia* is characterised by a slower rate of expansion. In Poland, this species was recorded for the first time in Lower Silesia near Niemodlin in 1888 (see Appendix A). Currently, its occurrence is limited to south-western Poland with individual dispersed localities in the centre of the country (Fig. 70). Nevertheless, during recent years a significant increase can be observed both in the number of sites of occurrence and in the size of the populations of this species in regions linked with its longest-lasting presence (Lower Silesia) where it colonises mainly wet meadows and disused quarries (TOKARSKA-GUZIK & DAJDOK 2004).

The comparison of rates of spread for selected kenophytes (neophytes according to the cited authors) in the area between the Oder and the Elbe (HARDTKE *et al.* 1981) and in the territory of Poland has led to similar results (Fig. 72). A faster rate of spread is characteristic for two species: *Sisymbrium loeselii* and *Rudbeckia laciniata*, while *Cardaria draba* and *Salsola kali* subsp. *ruthenica* spread significantly more slowly. It seems that in the case of these species also, the decisive influence on the rate of spread was the nature of the wilful or accidental introduction (at at least several dispersed points), and of secondary impact were the types of habitats occupied by these species as well as their biological properties.

The influence of elements such as the time of introduction and the biological characteristics of a species on the variable rate of spread may be illustrated from the example of two closely related species from the genus *Galinsoga* which are currently common and frequent kenophytes in nearly the whole area of Poland (Fig. 73). *Galinsoga ciliata* occupied new localities at a slower pace than *Galinsoga parviflora*, presumably because the former species had been introduced later (see Appendix A) and is able to spread its seeds for shorter distances due to their higher weight. These conjectures are supported by typical information found in many local floristic studies (dating back even to the 1970s) where their authors characterise *G. ciliata* as: "a rare weed in the initial phase of spreading" (BŁASZCZYK 1959); "rare, only several specimens found" (MAZUR *et al.* 1978); or "with a distinctly

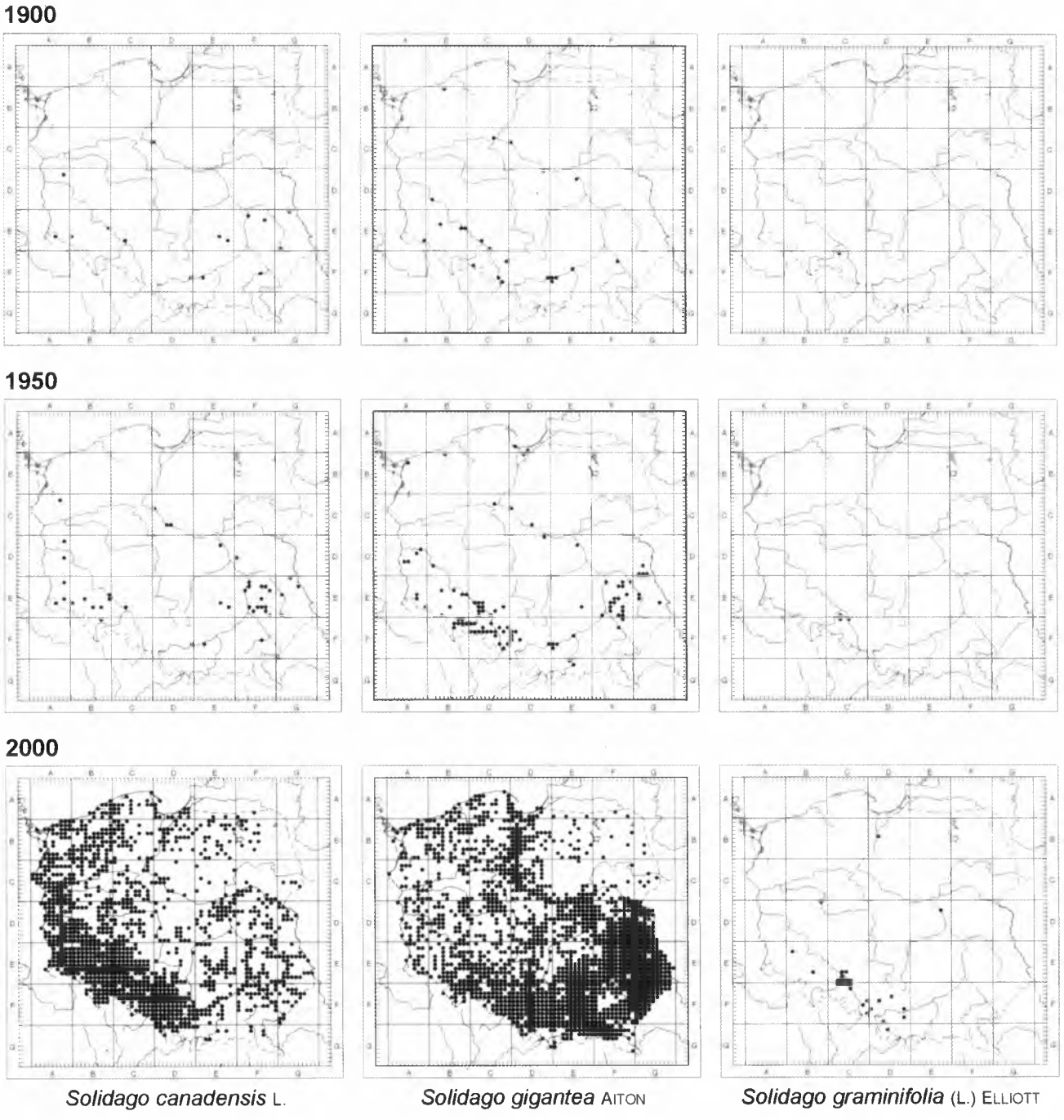


Fig. 70. Recorded history of expansion of three species of *Solidago* in Poland (after TOKARSKA-GUZIK 2001b; ZAJĄC A. & ZAJĄC M. 2001)

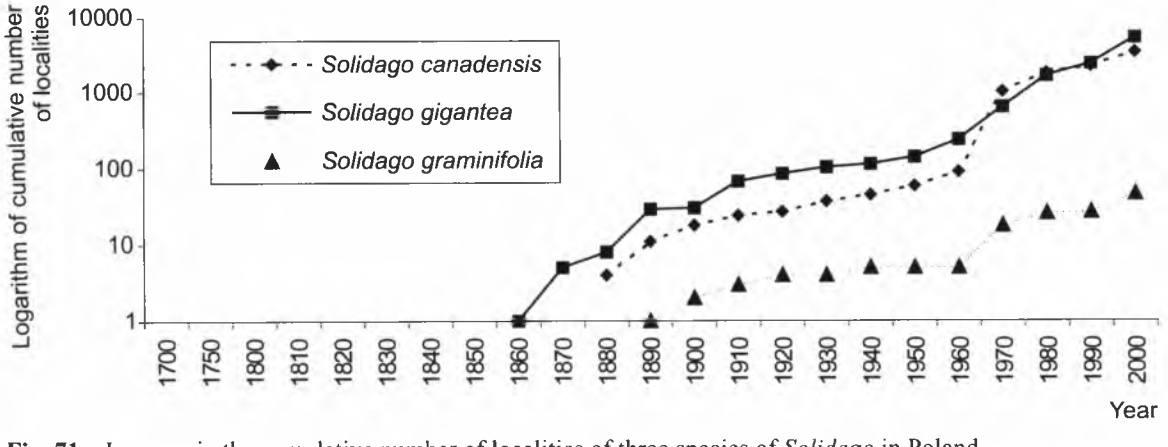


Fig. 71. Increase in the cumulative number of localities of three species of *Solidago* in Poland

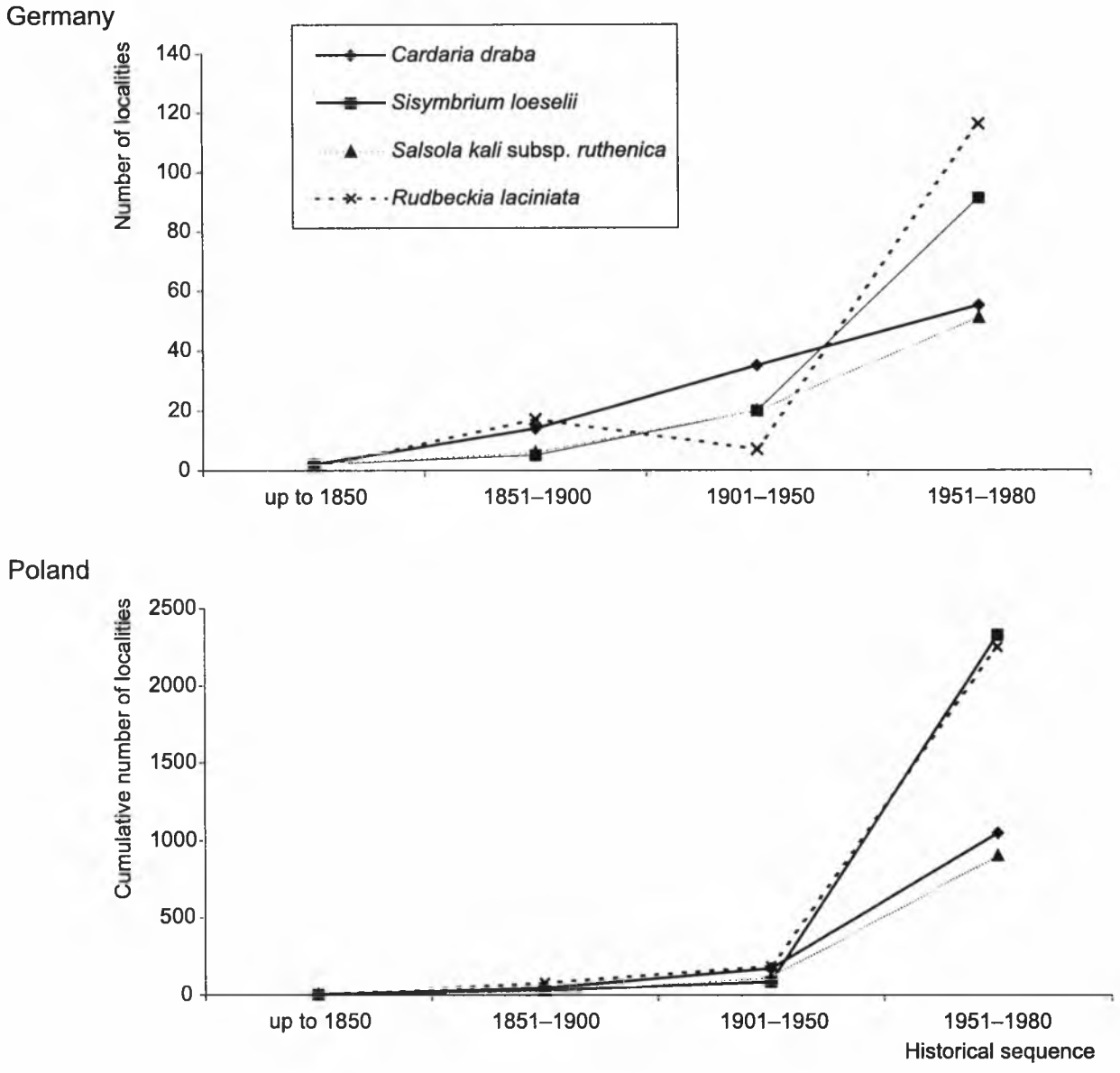


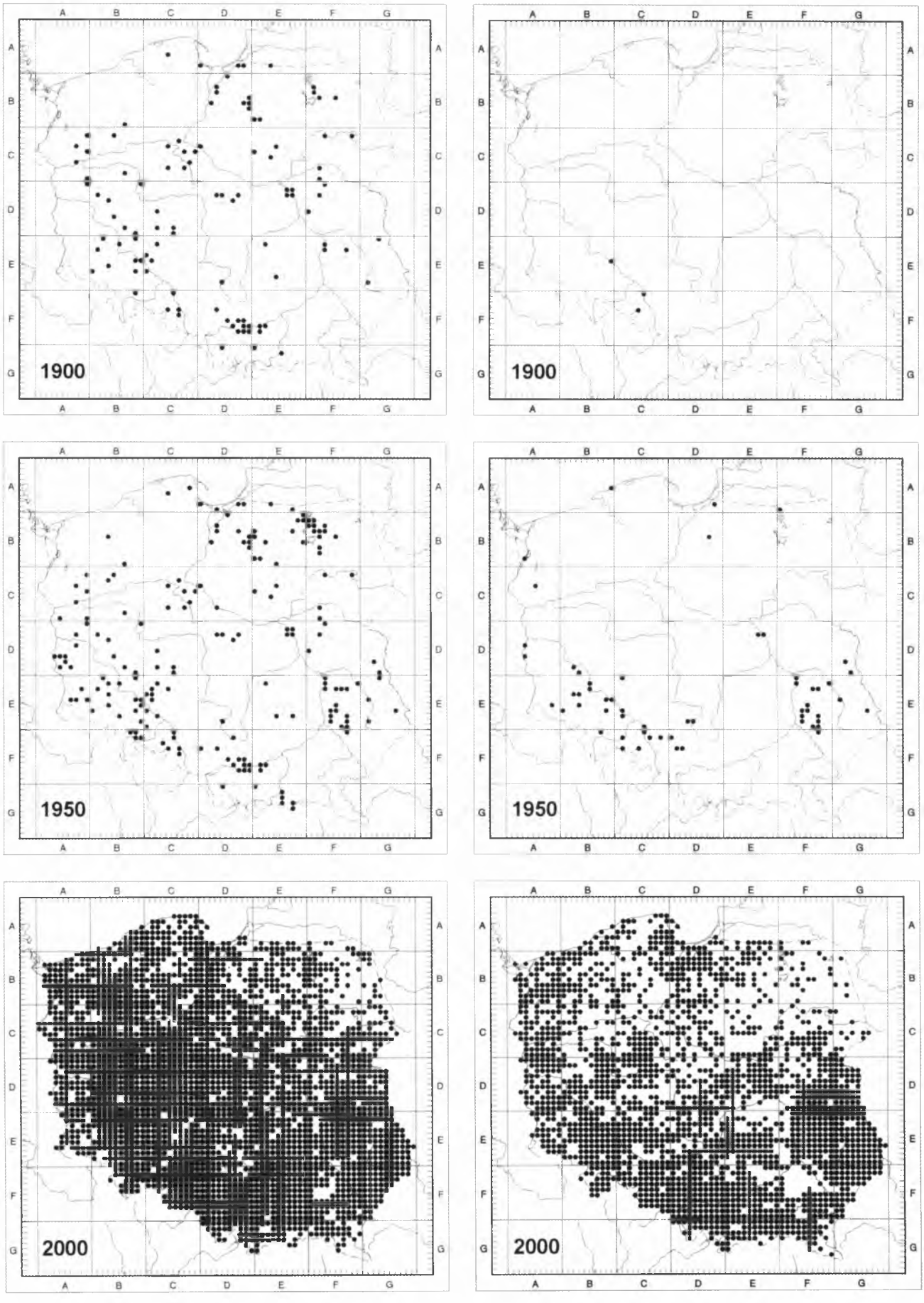
Fig. 72. Comparison of the rate of spread of four alien plant species in Germany (HARDTKE *et al.* 1981) and in Poland

lower number of localities" (e.g. SZMAJDA 1974; MACIEJCZAK 1988; CHMIEL 1993).

On the other hand, in Lithuania, according to GUDŽINSKAS (1997d), *Galinsoga ciliata* is characterised by a different rate of spread than the one reconstructed for Poland. There, this species is much more "aggressive" than *G. parviflora*, although it again started to spread at a later date. Also apparently in UK, where *G. parviflora* was introduced into Kew Gardens in 1796, and was first recorded in the wild in 1860 (and was known as "the Kew weed") and has spread steadily since. *G. ciliata* was first recorded in the wild in 1909 and has spread more rapidly and now has a similar range to *G. parviflora* (PRESTON *et al.* 2002). The original introductions seem to have been supplemented with later ones from nurseries and in wool waste used as an agricultural fertiliser (a very important source of adventives in UK; Prof. I.C. Trueman, *pers. comm.*). The differences between these two species noted in Poland and other countries can be connected with climate factors and history of introductions of the species but also can be caused by erroneous identification of the two species (particularly at the beginning of their spread in Poland).

Locally, however, species which one would expect to realise a similar spreading strategy due to their close relationship[88] may often increase their

[88] Often related species are characterised by similar geographical origin (e.g. *I. glandulifera* and *I. balfouri* which also occurs in some regions of Europe are both originally from the Himalaya mountains) as well as seed dispersal mechanisms (WADE 1997 and the literature cited therein), but their mode and rate of spread may be different in many regions of their secondary range. The above-mentioned *I. balfouri*, even though it was recorded in 1979 on the Thames in London, has not managed to become naturalised in the British Isles, while it is already a naturalised species in riverside and ruderal habitats in other regions of Europe (e.g. in Croatia, *pers. observ.*).



Galinsoga parviflora CAV. *Galinsoga ciliata* (RAF.) S.F. BLAKE

Fig. 73. Recorded history of expansion of two species of *Galinsoga* in Poland (after ZAJĄC A. & ZAJĄC M. 2001, supplemented)

secondary ranges at a different rate. PERRINS *et al.* (1993) have estimated the rate of invasion for 3 species from the genus *Impatiens*: for *I. glandulifera* 38 km/year, for *I. parviflora* 24 km/year and 13 km/year for *I. capensis*. As a result, these species which occur currently in the British Isles are characterised by different status and distribution patterns. The 3 species mentioned also occur in Poland, but in the circumstances of our country their distribution and status are divergent from the respective characteristics in Britain (Table 11).

Table 11. Comparison of invasive status of three species of the genus *Impatiens* from Great Britain (PERRINS *et al.* 1993) and Poland

Species	Frequency and status	
	Great Britain	Poland
Impatiens glandulifera	invasive, common	invasive in S
Impatiens parviflora	invasive, local	invasive, common
Impatiens capensis	invasive in S & E	not invasive, limited distribution

A very small group among kenophytes is formed by species which are decreasing their area of occurrence (withdrawing species) or the ones which are not currently spreading (they usually persist on the previously occupied localities) in the territory of Poland. This group includes e.g.: *Ambrosia artemisiifolia*, *Corydalis lutea*, *Cymbalaria muralis*, *Helleborus viridis*, *Hyssopus officinalis*, *Lathyrus nissolia*, *Marrubium vulgare*, *Mercurialis annua* and *Oenothera cruciata* – species which were never frequent in Poland, even in the periods of the recorded increase in the number of new localities. The progressive decrease of their occurrence may be explained by the elimination of specific habitats which they were linked with, as in the case of *Corydalis lutea* and *Cymbalaria muralis* (see also Chapter 7), as well as the ever-diminishing frequency of their cultivation in modern times.

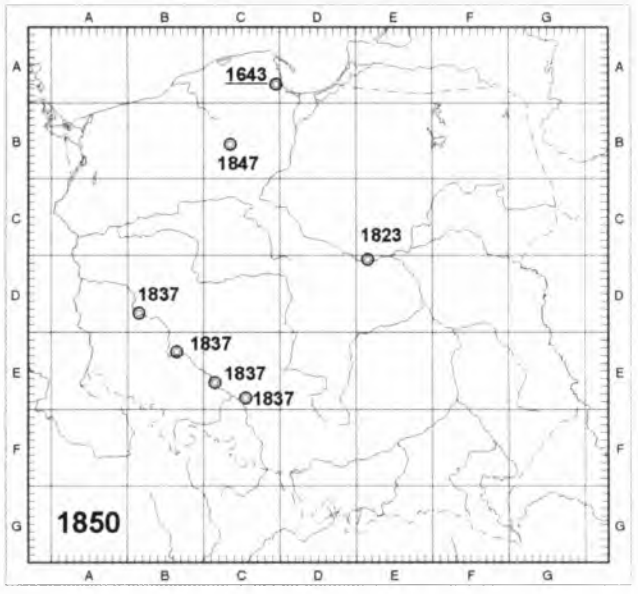
Common Hyssop *Hyssopus officinale*, originating from southern and eastern Europe and from south-western Asia, was introduced into garden cultivation in Poland in the 17th century (see Appendix A and Chapter 5.2) or even earlier in monastery gardens. It is a plant which has been cultivated in many countries for a very long time, it is used in the cosmetic industry, it is also a melliferous and medicinal plant. It may be presumed that the localities reported during the initial stage if naturalisation of this species in Poland are sites of its escape into the wild near localities of its cultivation. Currently, it occurs at dispersed localities in the whole country.

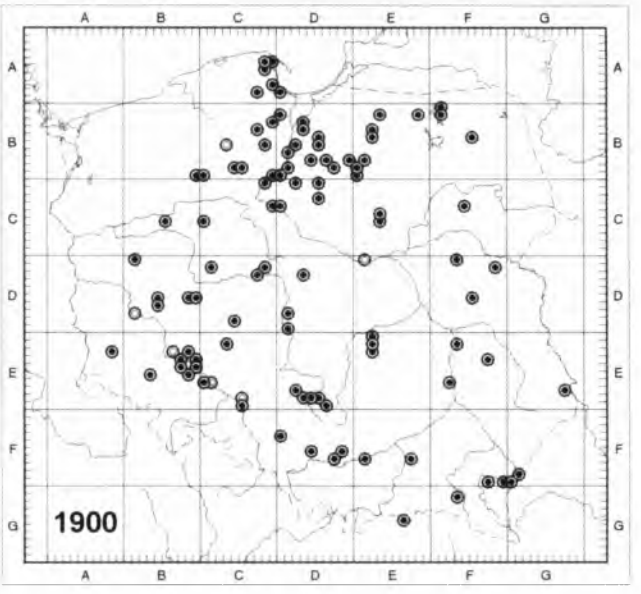
White Horehound *Marrubium vulgare*, originally native to the Mediterranean region, has been cultivated in Poland probably as early as the 16th century. The first locality was recorded from Gdańsk in 1643, the next one – after nearly two centuries – was reported from Wyszogród. It is a medicinal plant with a relatively wide application and most probably was more often cultivated earlier than can be inferred from the number of historical localities of occurrence of this plant. In the late 19th and early 20th century it was probably much more frequent than it is today (Fig. 74). The history of naturalisation of *Marrubium vulgare* in Poland dates maybe all the way back to the Middle Ages. The status of this species is uncertain, some authors consider it to be an older arrival, one of the so-called archaeophytes (SUDNIK-WÓJCIKOWSKA 1987a; JACKOWIAK 1992; RUTKOWSKI 1998). It occurs currently over the whole area of the country, although it is not everywhere frequent (it has not been recorded from some regions, e.g. in the mountains it is rare and occurs only at lower elevations).

The habit of occurrence of both species: dispersed localities, usually near sites of old cultivation, as well as the type of occupied habitats, such as roadsides, old lawn plots, old walls, vicinities of allotment gardens, points to a still conspicuous link with human activity. Both species were probably much more common at the turn of the 19th century (Fig. 75). These species do not show a tendency to spread, which is probably a result of the fact that they are no longer commonly cultivated. It may, however, be presumed that the recurring increase of interest in the cultivation of medicinal plants (herbs), observed currently also in small gardens, will assure such species as the horehound and the hyssop a permanent presence in the flora of Poland.

The data of other botanists also tend to confirm the decrease in occurrence of the kenophyte species cited here. Similarly, *Mercurialis annua* has been reported as being widespread from the territory of Poland by BESSER (1809) and BERDAU (1859), but, starting from the end of the 19th century, it has been found more and more rarely (RACIBORSKI 1884; TRZCIŃSKA-TACIK 1971a). GUDŽINSKAS (1999a) reports that this species has become more and more scarce in the Baltic countries during the last ten years; it still persists in Klaipeda.

A tendency to decrease their ranges and even to withdraw from the localities which were occupied years ago is being shown also by species which were at some point in time considered to



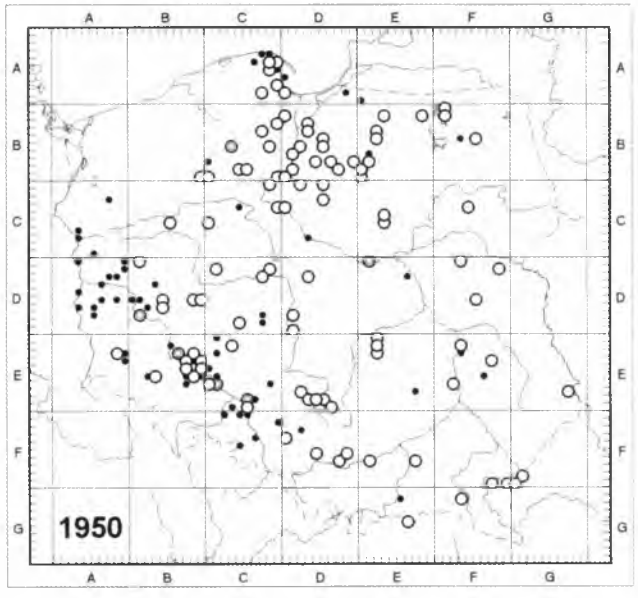


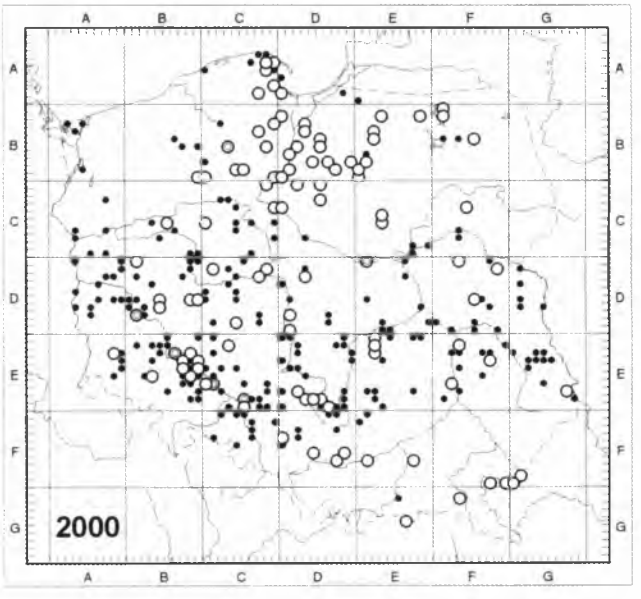
Introduction as cultivated plant

○ dubious records: most probably the records refer to the localities from cultivation

Naturalisation and spread close to sites of cultivation

◉ oldest recorded localities of occurrence in many regions; some of them probably refer to sites of its cultivation





Subsequent phases of spread

○ records dated back to the previous periods of 1851–1900 and 1901–1950

Fig. 74. Recorded history of cultivation and spread of *Marrubium vulgare* L. in Poland – an example of a species decreasing its area of occurrence

be frequent, at least locally. These species include e.g. *Elsholtzia ciliata* listed in many old floras (e.g. Rostafiński 1872; Cybulski 1894; Czyrsznicówna 1929; Kobendza 1930; Grochowski 1931). This species was still spreading westward in the early post-war period (see Chapter 7). During the last 20 years, its occurrence has not been confirmed at many of its earlier localities or the population size has been found to be very limited (own data). This conjecture is also confirmed by data found in some local floras dating from recent years (e.g. Chmiel 1993).

A similar situation concerns *Amaranthus ascendens*. The urbanisation of villages and small towns leads to the dwindling of areas which are occupied by habitats of the *Urtico-Malvetum* association which leads to a decrease in the number of sites of occurrence of this species which is tightly linked with this association (Frey 1974) not only in Poland, but also in other countries in Europe.

There has been rather little study of the variation in rates of spread of alien plant species (Williamson *et al.* 2003). The authors concluded that the rates of spread of species in the same genus are both very similar and very different and that explanation of variations in rate of spread are likely to remain case by case. Recently, some

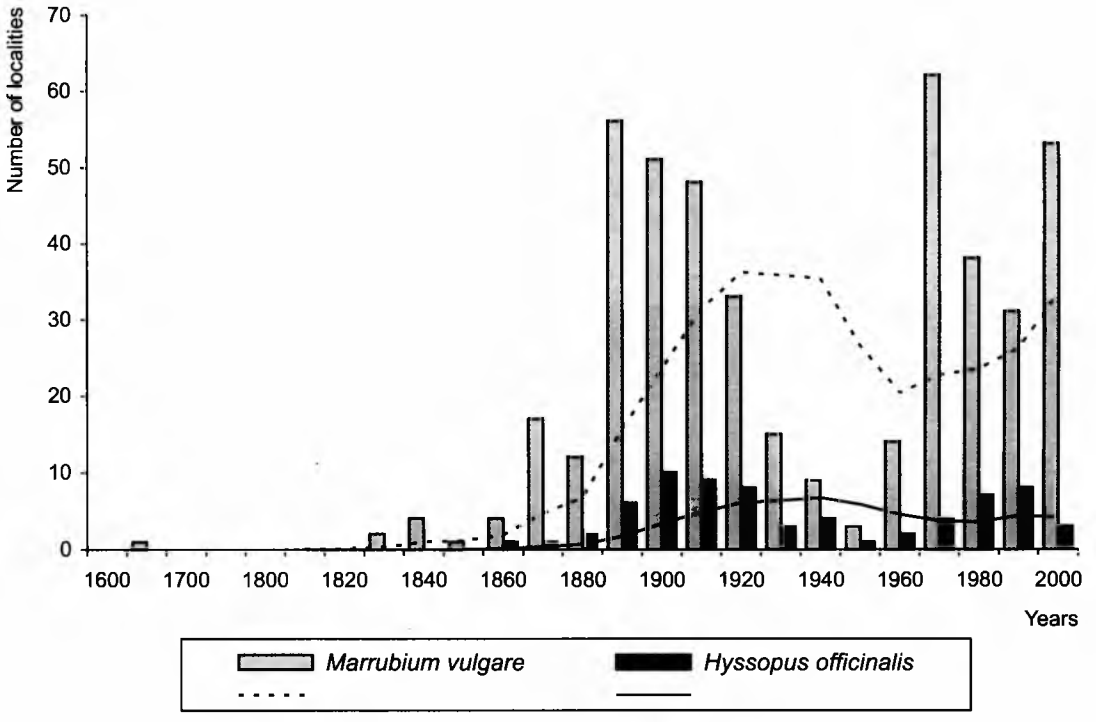


Fig. 75. Comparison of the rate of spread of *Hyssopus officinalis* and *Marubium vulgare* in Poland

long-term studies have been undertaken which make it possible to trace the rate of spread for alien species on a varying time scale.

> "The species *Homo sapiens* itself is without question the super invader of all time"
>
> WAGNER 1993
>
> "Human activities do not only destroy habitats, but they lead – together with climate change – to the spread of species beyond their natural ranges. Alien species may threaten the indigenous flora, completely change the character of the place they invade, cause diseases and be pest organisms".
>
> "The problem of biological invasions is growing in severity as global trade and travel accelerate".
>
> "Habitat disturbances and biological invasions create contact zones between con- and heterospecific populations which were isolated by distance and/or by the environment".
>
> DEN NIJSS *et al.* 1999

12. Plant invasions: the substance of the phenomenon and kenophytes as invasive plants

12.1. More remarks on terminology

In Polish phytogeographical literature, despite the defined etymology and meaning of terms "migration", "expansion", "invasion" and the derived terms "expansive", "invasive" (species), there is still a tendency to a rather free interpretation of these words, additionally compounded by their use in applicational publications (legal texts, official decrees etc.) (TOKARSKA-GUZIK 2003a & b). These terms are often applied interchangeably, e.g. by TROJAN (1975): "Invasion or expansion denotes settlement of individuals in new territory which has hitherto not been occupied by any population of this species".

The authors of the principal Polish academic handbook of plant geography consider invasion to be "a spectacular form of massive expansion of a recently arrived alien species which appears suddenly and so abundantly that it can cause significant ecological disturbances and severe economic losses" (KORNAŚ & MEDWECKA-KORNAŚ 2002)[89]. According to these authors and to other Polish researchers (FALIŃSKI 1998a & c; JACKOWIAK 1999), plants which increase their abundance and area of occurrence due to human activity (so-called hemerophilous species) include both native species derived from local natural communities and alien species[90].

[89] Already in the earliest Polish phytogeographical publications attention has been directed towards the specific phenomena which accompany plant migrations. PACZOSKI (1900) has indicated the problem of migration rate and the time required by plants to colonise new sites: "some species spread with a speed nearly as quick as lightning, others obviously advance at a turtle's pace and require a very long time to occupy a very small space" (cf. also Chapters 2 and 11).

[90] Both these groups are encompassed by the common term "synanthropic plants" (KORNAŚ & MEDWECKA-KORNAŚ 2002; see also Chapter 3 – Terminology). Also in foreign literature some authors tend to accept a similar inclusive concept, e.g. WADE (1997) mentions that invasions may concern also native species which can also become weeds, e.g. *Urtica dioica* and *Typha latifolia*.

Jackowiak (1999) has suggested more specific definitions of biological expansion, designating the spreading of a species into anthropogenous habitats within its natural range as "ecological expansion", while he called the spread of a species outside its natural geographical range "chorological (or territorial) expansion" (Fig. 76). Plant

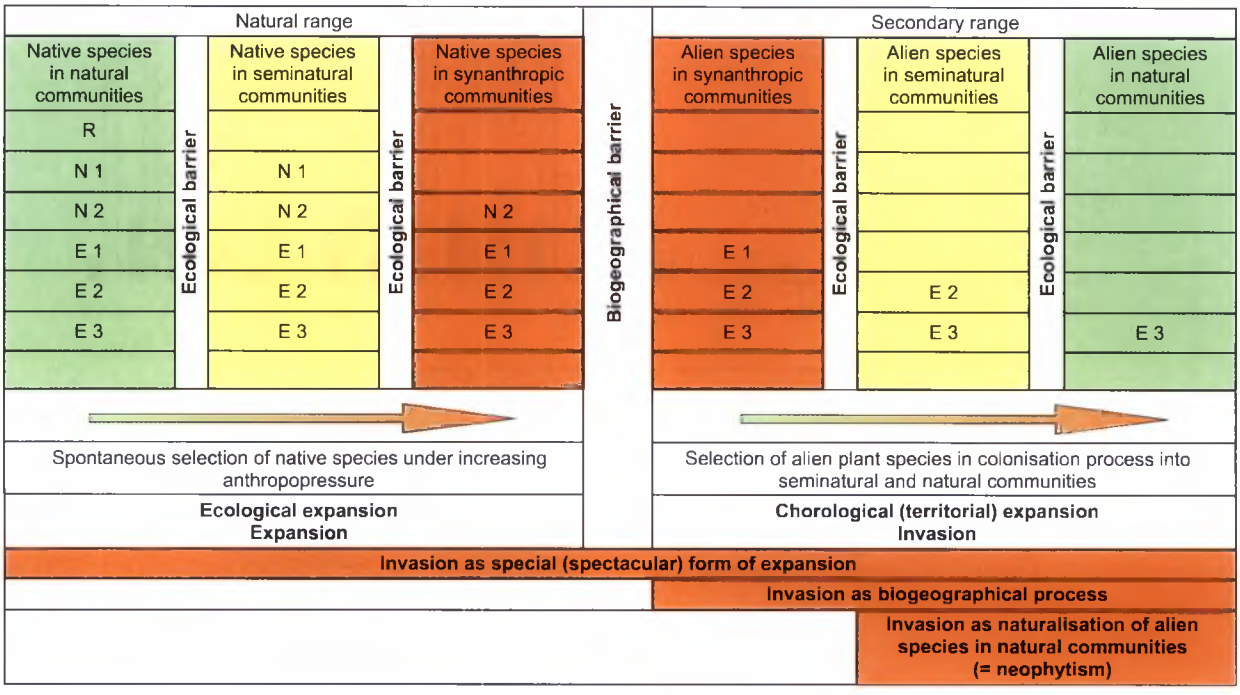


Fig. 76. Model of ecological and chorological (territorial) expansion of synanthropic plants (according to Jackowiak 1999) together with "wide" and "narrow" understanding of invasion process:
R, N, E – species with different abilities to cross the ecological and biogeographical barriers

migrations expressed as changes in their geographical range and new biological and ecological phenomena caused by them have been illustrated by Faliński (1968a, 1998a & c, 2000a & b, 2004).

Invasion (from the Latin word *invasio* = irruption, inroad) can be confronted with encyclopaedic definitions:

- armed intrusion into a foreign territory; attack, inroad (*Dictionary of the Polish Language*, PWN);
- spontaneous change of the range of a species linked to the initiation of a migration over a relatively long distance simultaneously by a significant number of individuals and to the occupation by the species of areas not previously inhabited by its representatives (Szweykowska & Szweykowski 1993, *Botanical Dictionary*).

This understanding of the term "invasion" is akin to the term "ecological explosion", or "territorial expansion accompanied by a tremendous increase in the number of individuals of a species in the newly occupied territory", introduced by Elton (1958) who is regarded as a key researcher in this field.

In discussions by phytogeographers who study the topic of invasions, terminological questions are regularly addressed, not only for purely semantic reasons, but also for practical purposes in order to make a comparative approach possible (Pyšek 1995; Richardson *et al.* 2000; Tokarska-Guzik 2001b, 2003b; Chmura & Sierka 2004; Pyšek *et al.* 2004)[91].

In the English language literature most studies adopt the biogeographical concept of "invasion" which assumes that this process is a consequence of intentional or non-intentional human activity and as such includes only alien species (Pyšek 1995; Pyšek *et al.* 2004 and the literature cited therein)[92]. In the Polish literature, this view is represented by Chmura & Sierka (2004).

In some publications, examples of an even narrower understanding of "invasion" may be found, the term being explained as the process of naturalisation of an alien species in natural communities (Fig. 76). In this sense, the definition of invasion would correspond partially to the definition of neophytism suggested by Faliński (1998a & c).

These terminological arguments are a result of different approaches to the problem adopted by various biological disciplines (Rejmánek 1995; Pyšek *et al.* 2004 after Rejmánek 1995); there is

[91] Precisely defined terms provide the basis for comparative studies; they are also of a practical importance (preparation of lists of invasive species; conservation of diversity, combating the threat). It should be stressed here that the value of any study depends especially on the correct collection of information on the flora of a given area (taxonomy, locality, habitat) and its correct appraisal (status of a species in a locality, its origin, time and way of arrival).

[92] e.g. Celesti Grapow *et al.* 2001: invasive alien species and expanding natives (apophytes).

also a significant impact of the usually anthropocentric viewpoint of researchers[93].

Analogously, in many studies the terms "naturalised"[94] and "invasive" are applied interchangeably, whereas they are actually represented by two different phases of one continuous process. According to some authors, the process of invasion consists of 3 stages:
- introduction,
- colonisation,
- naturalisation (e.g. COUSENS & MORTIMER 1995).

According to others (e.g. WEBER 1998), the spread of an invasive non-native species in an area where it has never occurred before involves four steps:
- the arrival of the species and the local introduction of individuals in a habitat,
- the formation of a persistent founder population by growth and reproduction,
- deriving of new populations by transport of diaspores to safe sites,
- range expansion by increases in the number and size of populations.

Each of these steps is tightly linked not only to the character and autecological properties of a species, but also depends on various facets of human influence.

A commonly accepted mechanism of such invasions is the so-called "enemy release hypothesis" (ERH) (KEANE & CRAWLEY 2002). A plant devoid of the burden of natural enemies in the new homeland may spread very quickly[95]. An important factor favouring invasion is also the competition from native species which may be weakened due to the fact that native species still remain in conflict with their own "enemies" (specialised monophages which are usually non-existent for the potential invasive species in its new homeland).

SHEA & CHESSON (2002) use population ecology theory to explain mechanisms of invasion; specifically, they take advantage of the notion of ecological niche to introduce the concept of "niche opportunity" which defines conditions favourable to invasion with regard to resources, natural enemies, abiotic conditions and interactions between the listed factors in relation to changes occurring in time and space. Invasion according to these authors consists of the following basic phases:
- transport of an organism onto its new locality of occurrence;
- naturalisation and increase of population size at the invaded locality;
- regional spread from initial successful populations.

Invasion ecology from the population viewpoint provides possibilities to explain invasion success and the influence of the invasive species on the existing components of the ecosystem.

Some authors distinguish species which become naturalised but pose no practical problems (KORNAŚ 1990; WADE 1997). The latter author distinguishes (as was done similarly subsequently by RICHARDSON *et al.* 2000) the following categories of plant species: alien – established – invasive (pest). The term "invasive" is used for an alien whose distribution and/or abundance in a region is increasing, i.e. can be considered as a successful alien.

Following the above-mentioned terminology PYŠEK *et al.* (2004) suggest definitions of terms associated with plant invasion and place these in the context of floras. The hierarchical scheme for the suggested classification of alien plants consists of after PYŠEK *et al.* (2004):

1. cultivated plants
2. plants outside cultivation
   - 2.1. casual (not established/naturalised)
   - 2.2. naturalised
     - 2.2.1. non-invasive
     - 2.2.2. **invasive**[96]
       - 2.2.2.1. not harmful
       - 2.2.2.2. transformers[97]
       - 2.2.2.3. weeds[98]

The recent *European strategy on invasive alien plants* uses the definitions agreed by the Conference of the Parties to the Convention on Biological Diversity for the purposes of the CBD

[93] Invasion ecology has perhaps suffered more than other fields, since the notion of "invasion" frequently evokes anthropocentric concepts (aggression, assault, attack, encroachment, incursion, infringement, intrusion, onslaught, raid, etc.) (RICHARDSON *et al.* 2000).

[94] RICHARDSON *et al.* 2000 have compiled a review of dictionaries, encyclopaedias and naturalist articles in order to compare the definitions adopted for the term "naturalised".

[95] It may be significant for some species; for others disturbances in the environment are the most important catalysts.

[96] Definition: Invasive plants are a subset of naturalised plants that produce reproductive offspring, often in very large numbers, at considerable distances from the parent plant, and thus have potential to spread over a large area.

[97] Definition: Transformers – A subset of invasive plants (not necessarily alien) that change the character, condition, form or nature of ecosystems over substantial area. (Substantial means relative to the extent of that ecosystem.) Transformers are essentially equivalent with "edificators" (i.e. edifice builders), a term used in European, especially Russian literature. Edificators are defined as "environment forming plants" (PYŠEK *et al.* 2004). In Polish literature the term could be compared with neophytes *sensu* FALIŃSKI (1998a & c) as already mentioned in this chapter.

[98] Definition: Weeds – plants (not necessarily alien) that grow in sities where they are not wanted and which have detectable economic or environmental impact or both.

Guiding Principles and understand "invasive alien species" as an alien species whose introduction and/or spread threaten biological diversity (GENOVESI & SHINE 2004).

For practical purposes (taken into account during the creation of national, regional and local lists of invasive species), apart from scientific categories, "extrascientific" criteria of plant appraisal[99] are often used (species that lead to specific economic losses, harmful to human and/or animal health, etc.).

As observed by ESTER (1998), the vocabulary introduced into the ecological nomenclature is often without scientific meaning; it contains a high dose of the emotional attitude of the author towards the phenomenon and the introduction of an aspect of evaluation into the common meaning of the word[100]. The author quotes also the encyclopaedic definition of the term "invasive" from Webster's *New Encyclopedic Dictionary* of 1993:

Invasion means: "1. (...) entrance of an army into a country for conquest; 2. (...) the entrance or spread of some usually harmful thing"; it means that the process has to do with aggression and destruction.

Invasiveness has been predicted on the basis of the biological properties of a species, its ecological habitat conditions, its general distribution and information on whether the species "behaves" as an invasive species in any region of the globe.

STARFINGER (1998) and subsequently also FORMAN (2003) state that a possible indicator of later success as an invasive species may be its apophytism within its natural range (which is also consistent with the chorological expansion model of JACKOWIAK 1999; see Fig. 76) (Table 12).

[99] For example such categories of invasive species are given by CalEPPC (the governmental organisation in California responsible for monitoring and controlling invasive species): 1. most invasive wildland plants; 2. wildland pests of lesser invasiveness; 3. red alert plants (species with potential to spread explosively); 4. species for which more information is needed; 5. species being considered but not listed (CALIFORNIA EXOTIC PEST PLANT COUNCIL 1999).

[100] To underline the scale of the phenomenon of invasion many authors use sentences like this: "*Arundo donax* dramatically alters the ecological/successional processes in riparian systems (...)" (BELL 1997); "*Lepidium latifolium* has rapidly spread (...) is an extremely competitive weed" (YOUNG *et al.* 1997); "*Lepidium latifolium* (...) aggressively invading wetlands and riparian habitats" (BLANK & YOUNG 1997); "*Tamarix ramosissima* is aggressive competitor (...) growing in monoculture stands (...) destroying wetlands and wildlife habitats" (DUNCAN 1997). The examples mentioned have been derived from a single volume devoted to biological invasion (BROCK *et al.* 1997).

12.2. Consequences of invasions by alien species, legal regulations and methods of combating the threat

The consequences of the migrations of some synanthropic plants have proven to be very serious indeed, since the new arrivals have turned out to be extremely expansive and now dominate over large areas occupied at the expense of native species (KORNAŚ 1996). The outcome of these processes may be considered in relation to the following aspects (TOKARSKA-GUZIK 2002, 2003b):

- **Natural**
  - impact on the biological diversity of the flora and fauna at all levels of organisation[101] (e.g. BROCK & FARKAS 1997; IUCN 2000; MACK *et al.* 2000; SCHERER-LORENZEN *et al.* 2000; CRONK & FULLER 2001; MCNEELY *et al.* 2001; BALOGH 2003; FORMAN 2003; GENOVESI & SHINE 2004);
  - threat to protected areas (e.g. BALOGH 1996; ADAMOWSKI & KECZYŃSKI 1998; ADAMOWSKI *et al.* 1998);
  - changes in the landscape and land use (e.g. D'ANTONIO & VITOUSEK 1992; D'ANTONIO 2000; HOBBS 2000 and literature cited therein)
- **Social**
  - detriment to public health (allergenic plants, stinging plants etc.) (e.g. CAMM *et al.* 1976; WADE *et al.* 1997);
  - creating difficulties or limitations for leisure;
  - lowering aesthetic values
- **Economic**
  - need for preparation of plans to combat the threat (e.g. CHILD *et al.* 1992, 2001; LUKEN & THIERET 1997; CHILD & WADE 1999, 2000; BIMOVÁ *et al.* 2001;
  - costs of eradication/prevention (e.g. CHILD *et al.* 1998; CHILD & WADE 2000; PIMENTAL 2002 and literature cited therein).

For Poland, examples of species which pose a threat with regard to the aspects listed have been given later in the present chapter.

In comparison to other threats to biological diversity, in most European countries including Poland invasive alien species have been given relatively little attention. The reason for this situation is the fact that few countries in Europe have

[101] The most significant biological threats include: the replacement of floristically diversified indigenous communities by monospecific phytocoenoses formed by populations of the alien species, the direct threat to the native flora and fauna leading to elimination of native species, changes in the habitat, modifications of geomorphological processes, as well as generation of a fire hazard.

Table 12. Apophytism of sample species described as invasive outside Poland (Europe)

Species	Hemeroby	Described as invasive	Source
Acer pseudoplatanus	oemp	Australia, New Zealand, Oceanic Islands, America S	Cronk & Fuller 2001
*Agropyron repens** (= *Elymus repens*)	.mep	America N	Luken & Thieret 1997
*Alliaria petiolata**	ome.	America N	Luken & Thieret 1997
Ammophila arenaria	ome.	Australia, New Zealand, some regions of America N (California)	Luken & Thieret 1997; Cronk & Fuller 2001
*Anthoxanthum odoratum**	.mep	Chile, Hawaii	Cronk & Fuller 2001
*Bromus inermis**	.mep	America N	Luken & Thieret 1997
Bromus tectorum	.mep	America N, Asia E (Japan), Oceanic Islands (Tenerife)	Mack 1981; Luken & Thieret 1997; Cronk & Fuller 2001
Calluna vulgaris	o...	New Zealand	Cronk & Fuller 2001
Carduus nutans	.me.	Canada, New Zealand	Cronk & Fuller 2001
*Cirsium arvense**	.mep	America N	California Exotic Pest Plant Council. 1999
Crataegus monogyna	omep	Australia, New Zealand, America N	Cronk & Fuller 2001; California Exotic Pest Plant Council. 1999
Cytisus scoparius	.me.	Australia, New Zealand, Africa S, Asia (India)	Cronk & Fuller 2001
*Dactylis glomerata**	.mep	Hawaii	Cronk & Fuller 2001
Euphorbia esula	.mep	America N	Luken & Thieret 1997
Hieracium pilosella	.mep	Australia, New Zealand	Scott *et al.* 1990; Cronk & Fuller 2001
*Holcus lanatus**	.me.	Hawaii, New Zealand, America N	Cronk & Fuller 2001; California Exotic Pest Plant Council. 1999
*Hypericum perfoliatum**	.me.	America N	California Exotic Pest Plant Council. 1999
*Linaria vulgaris**	.mep	America N	Luken & Thieret 1997
*Lythrum salicaria**	ome.	America N	Malecki *et al.* 1993; Luken & Thieret 1997; Cronk & Fuller 2001
Myriophyllum spicatum	om..	USA	Cronk & Fuller 2001
Ranunculus ficaria	omep	America N	Luken & Thieret 1997
Rhamnus cathartica	om..	America N	Luken & Thieret 1997
Salix fragilis	omep	New Zealand	Cronk & Fuller 2001

Degree of hemeroby: **a** – ahemerobic, **o** – oligohemerobic, **m** – mezohemerobic, **e** – euhemerobic, **p** – polyhemerobic, **meta** – metahemerobic
Scale of hemeroby for Poznań city after Jackowiak 1993, 1998a & c
* species listed as apophytes appearing in Poland in ruderal and segetal communities (Zając M. & Zając A. 1992).

had negative experiences with alien species on a scale comparable with Australia or USA. Social consciousness of the problems posed by alien species is surprisingly low in Europe (Solarz 2001). Only in recent years have these problems been addressed with regard to the whole continent (research programmes, seminars and scientific conferences; see Chapter 2), and last year has seen the publication of the *European strategy on invasive alien species* (Genovesi & Shine 2004).

Legal platforms concerning protection against introduction, control and/or combating already-introduced alien species have hitherto been prepared mainly in those parts of the world where the various threats posed by these species were most conspicuous, i.e. for example in USA, Canada, Australia and New Zealand (Tokarska-Guzik 2002, 2003b). The legislation on invasive alien species in European countries is insufficient for the efficient solution of problems posed by these species. There is a lack of dedicated laws with a complex approach to the problem, encompassing all habitats (terrestrial ecosystems, fresh waters and marine waters), all organisms (plants, game animals, fish, microorganisms, GMO) and all branches of the economy (agriculture, marine and inland fisheries, game hunting, nature protection). In some countries, no full lists of species considered to be alien are available[102]. Also

[102] In recent years, actions have been taken for this purpose, ending with the preparation and publication of lists of alien species, including invasive species, e.g. Essl & Rabitsch 2002; Botond & Botta-Dukát 2004; also in Poland, a research project entitled *Alien invasive species in the flora and fauna of Poland in the context of conservation of biological diversity* is in the completion stage by group of botanists and zoologists and its results should be the publication of the *Invasive species data book*.

regulations are lacking concerning the population control and elimination of alien species which threaten biodiversity (Solarz 2001). Legal regulations may play a significant role at various stages of the process of invasion for a given species by preventing or limiting its introduction and later on by controlling its spread.

Invasions of alien plants are considered to be one of the major threats to biological diversity on a global scale, next to the fragmentation and degradation of natural habitats[103]. In the International Convention on Biological Diversity signed in 1992 in Rio de Janeiro, a special stipulation was included exhorting signatory countries to combat alien invasive species which are a threat to native habitats, communities or species (Art. 8 pt. h). Methods of combating invasive species employed in many regions of the world (in Europe mainly in Great Britain) include the following means:
- mechanical – manual removal, cutting, mowing, rooting out with the use of various equipment, burning out, usage of screens;
- chemical – spraying, use of applicator probes;
- biological – grazing, herbivores, pathogens;
- mixed.

The accumulated experience related to the preparation and validation of individual procedures, determining the relative effectiveness of separate methods as well as their costs, has been presented in numerous publications (e.g. Room 1981; Scott *et al.* 1990; Holden *et al.* 1992; Malecki *et al.* 1993; Luken & Thieret 1997 and the literature cited threin; Child *et al.* 1998; Child & Wade, 2000; Cronk & Fuller 2001; Bímová *et al.* 2001; Child *et al.* 2001).

12.3. Invasive kenophytes in Poland

A significant contribution to our knowledge on invasions is brought by lists of alien species and synthetic studies regarding individual regions, which may form a basis for practical action. Therefore, lists of invasive species have been compiled for many countries and regions. The tentative list of invasive kenophytes occurring in Poland has been prepared on the basis of the following criteria:
- the dynamic tendencies of analysed species in sequential time periods (50 years) (i.e. abundance, dominance and expansion rate, also ability to establish in different types of communities) – the objective criterion;
- effects caused in the natural environment, economy and public health – the subjective criterion.

Analysis was performed on 300 species considered by the author to be recent synanthropic arrivals naturalised in Poland (or merely kenophytes). Eventually, a final list of 54 invasive species has been selected (including 4 potentially invasive and 2 post-invasive species). In this group, 14 species are limited in their occurrence to anthropogenous habitats, while others also enter semi-natural and natural habitats (Table 13).

The invasive species listed for Poland belong to 22 families (including 13 families represented by a single species), with the most amply represented families being: Asteraceae (17 species), Fabaceae, Polygonaceae and Scrophulariaceae (4 species each), Brassicaceae and Poaceae (3 each) as well as Balsaminaceae, Cucurbitaceae and Apiaceae (2).

The species belonging to this group represent various life forms, with the same share of perennial and annual species (20 and 17 species respectively); trees and geophytes are also represented by the similar number of species (8 and 9 each); *Elodea canadensis* is the only hydrophyte.

The majority of species reproduce generatively (31), while the remaining ones usually take advantage of both manners of reproduction (17) and only very few reproduce only vegetatively (1) or with a predominance of this manner of reproduction (6).

The plants listed spread their seeds mainly using wind and animals (with a predominance of exochory) with a significant role played by myrmecochory and autochory; they also use water as a mode of dispersal and they often take advantage of human assistance.

A definite majority of this group are effective competitor plants (*C* type strategy – 23 species); a relatively large group is formed also by species with a mixed strategy of the *CR* type (11 species) and of the *CRS* type (3 species). The only species from among 5 species with an *R* type strategy which has had a spectacular success in the course of its invasion is *Chamomilla suaevolens*, while two others: *Anthoxanthum aristatum* and *Eragrostis minor* limit the scope of their invasion to very specific habitats

[103] After the problem of invasions had been noticed, methods and directives concerning the elimination of invasive plants followed. Already at the end of the 19th century one could learn from the work of Sempołowski (1880–1881) on *Xanthium spinosum* that: "It is recommended to think in due time about its eradication, before it makes itself excessively at home in our fields. A radical mode of action is plucking or mowing the plant before it is able to produce seeds. An incentive for the extermination of this weed for every landowner should be provided by the deterrent example showing the extraordinary spread of some weeds and parasites such as e.g. the Spring Groundsel (*Senecio vernalis* W. et K.) or the dodders (*Cuscuta*), against which in some countries the government was forced to start a struggle with police decrees about the obligatory eradication of these weeds".

Table 13. Invasive alien species in the flora of Poland: a selection from the recent arrivals (the so-called kenophytes)

Species	Origin	Numbers of loc. up to 2000	Numbers of sq.	Dyn	Habitats	Scale	Category	Invasive elsewhere	Threat						
									biological diversity	protected areas	landscape	economy	leisure	public	health
Acer negundo L.	Am N	3526	1379	4(+2)	NSH [riparian; urban; abandoned fields]	Inter-Regional	T	Eur C; Lithuania	•	•	•	•			
Ailanthus altissima (Mill.) Swingle [= *A. glandulosa* Desf.]	Asia E	31	29	2(+1)	H [urban]	Local	pot. inv.	Eur C & S; Am N			•				
Amaranthus retroflexus L.	Am N & C	7651	2379	5(+2)	H [fields; urban; wasteland]	National	W	Eur C				•			
Ambrosia artemisiifolia L.	Am N	101	61	2–3(+/–)	H [wasteland]	Regional	pot. inv	some regions of Eur; Am N				•		•	
Anthoxanthum aristatum Boiss. [= *A. puelii* Lecoq & Lamotte]	Eur S	1031	577	3–4(+2)	H [fields]	Sub-Regional	W					•			
Aster lanceolatus Willd.	Am N	n.c.d	260*	?	SH [riparian]	Sub-Regional ?	T	Czech Rep. & Hungary	•	•	•				
Aster novi-belgii L.	Am N	n.c.d	353*	?	SH [riparian]	Sub-Regional ?	T	Czech Rep.	•	•	•				
Aster salignus Willd.	Am N	n.c.d	139*	?	SH [riparian]	Sub-Regional ?	T	Czech Rep. & Hungary	•	•	•				
Bidens frondosa L. [= *B. melanocarpus* Wiegand]	Am N	3142	1068	4(+2)	NSH [riparian; wasteland]	Sub-Regional	T	Eur C	•						
Bromus carinatus Hook & Arn.	Am N	1130	404*	3–4(+2)	SH [urban; maedows]	Sub-Regional	T/W					•			
Bryonia alba L.	Eur E & Asia W	1328	728	3–4(+1)	NSH [riparian]	Sub-Regional	pot.inv.	Czech Rep.			•				
Bunias orientalis L.	Eur SE & Asia W	1353	567	3–4(+2)	SH [road banks; grassland]	Sub-Regional	T	Czech Rep. & Slovac Rep.	•		•				
Cardaria draba (L.) Desv. [= *Lepidium draba* L.]	Eur SE & Asia SW	1048	576	3–4(+2)	SH [road banks; grassland]	Sub-Regional	T	Czech Rep.	•		•				
Chamomilla suaveolens (Pursh) Rydb. [= *Matricaria discoidea* DC.]	Am N & Asia E	13125	2965	5(+2)	H [urban; fields]	National	W	Eur C				•			
Conyza canadensis (L.) Cronquist [= *Erigeron canadensis* L.]	Am N	11601	2929	5(+2)	H [urban; grassland; fields]	National	W	Eur C		•	•	•			
Digitalis purpurea L.	Eur W	341	169	3(+1)	NSH [forests]	Regional	T	Czech Rep.	•	•	•				
Echinocystis lobata (F. Michx.) Torr. & A. Gray	Am N	2047	708	3–4(+2)	NSH [riparian; wasteland]	Sub-Regional	T	Czech Rep. & Slovac Rep.; Hungary	•	•	•				

continuated Table 13

Species	Origin	Numbers of loc. up to 2000	Numbers of sq.	Dyn	Habitats	Scale	Category	Invasive elsewhere	Threat						
									biological diversity	protected areas	landscape	economy	leisure	public	health
Elodea canadensis Michx.	Am N	3681	1847	4(+1)	NSH [water]	Sub-Regional	T	Eur C	•	•	•	•	•		
Elsholtzia ciliata (Thunb.) Hyl. [= *E. patrini* (Lepech.) Garcke]	Asia E	1352	814	3–4(+/–)	H [urban]	Sub-Regional	p-inv.								
Epilobium ciliatum Raf. [= *E. adenocaulon* Hausskn.]	Am N	1224	470	3–4(+1)	NSH [forests; wasteland]	Sub-Regional	T	Czech Rep.	•	•					
Eragrostis minor Host	Eur SE & Asia W	1041	581	3–4(+2)	H [urban]	Sub-Regional	NotH	Eur C							
Erechtites hieracifolia (L.) Raf. ex DC.	Am N & S	124	73	2–3(+1)	NSH [forests]	Regional	T	Hungary	•	•					
Erigeron annuus (L.) Pers.	Am N	3557	1133	4(+2)	SH [grassland]	Sub-Regional	T	Hungary	•	•	•				
Fraxinus pennsylvanica Marshall	Am N	n.c.d	179	3(+2)	SH [abandoned fields]	Regional	T	Czech Rep. & Hungary	•		•				
Galinsoga ciliata (Raf.) S. F. Blake [= *G. quadriradiata* Ruiz & Pav.]	Am C [m]	6777	2021	4–5(+2)	H [fields]	National	W	Eur C				•			
Galinsoga parviflora Cav.	Am S & C [m]	10932	2726	5(+2)	H [fields]	National	W	Eur C				•			
Helianthus tuberosus L.	Am N	1416	778	3–4(+2)	NSH [riparian; wasteland]	Sub-Regional	T	some regions of Eur C	•	•	•				
Heracleum mantegazzianum Sommier & Levier	Asia C & E	100	74146*	2–3(+2)	NSH [riparian; road banks; abandoned fields]	Regional	T	Eur W, C & N	•		•	•	•	•	
Heracleum sosnovskyi Manden.	Asia SW [Cauc.]	96	72146*	2(+2)	NSH [riparian; road banks; abandoned fields]	Regional	T	Hungary, Lithuania	•		•	•	•	•	
Impatiens glandulifera Royle [= *I. roylei* Walp.]	Asia C [Himal.]	1574	675	3–4 (+2)	NSH [riparian]	Sub-Regional	T	Eur W & C	•	•	•				
Impatiens parviflora DC.	Asia C & E	6730	1681	4–5(+2)	NSH [forests]	National	T	Eur C	•	•	•				
Iva xanthiifolia Nutt.	Am N	294	150	3(+/–)	H [wasteland]	Regional	pot.inv.	Eur S (warm regions)						•	
Juncus tenuis Willd. [= *J. macer* A. Gray]	Am N	5332	1440	4–5(+1)	SH [meadows]	National	T	Czech Rep.	•	•					
Lupinus polyphyllus Lindl.	Am N	2674	1387	4(+1)	NSH [forests; grassland]	Sub-Regional	T	Czech Rep.; Lithuania	•		•				
Lycium barbarum L. [= *L. halimifolium* Mill.]	Asia E & Eur SE	2634	1224	4(+1)	NSH [scrub]	Sub-Regional	T	Czech Rep.	•		•				

Mimulus guttatus DC.	Am N	326	128	3(+2)	NS [riparian]	Regional	T		•	•	•				
Oxalis fontana Bunge [= *O. stricta* L.]	Am N	8806	2141	5(+1)	H [gardens]	National	W					•			
Padus serotina (Ehrh.) Borkh. [= *Prunus serotina* Ehrh.]	Am N & S	2564	1134	4(+2)	NS [forests]	Sub-Regional	T	Eur C	•	•	•	•			
Parthenocissus inserta (A. Kern.) Fritsch [= *P. vitacea* (Knerr) Hitchc.]	Am N	558	332	3(+2)	NSH [riparian]	Regional	T	some part of Eur C	•		•				
Quercus rubra L.	Am N	n.c.d	554*	3–4(+2)	N [forests]	Sub-Regional	T	Czech Rep.	•	•	•	•			
Reynoutria x bohemica Chrtek & Chrtková [= *R. japonica* Houtt. x *R. sachalinensis* (F. Schmidt) Nakai]	Anthropog.	n.c.d	n.c.d.	?(+2)	NSH [riparian; urban]	Regional ? / Sub-Regional ?	T	Czech Rep.	•	•	•	•	•		
Reynoutria japonica (Houtt.) Ronse Decraene var. ***japonica*** [= *Fallopia japonica* Houtt.]	Asia E	3004	1158*	4(+2)	NSH [riparian; urban]	Sub-Regional	T	Eur W & C; Am N	•	•	•	•	•		
Reynoutria sachalinensis (F. Schmidt) Nakai [= *Fallopia sachalinesis* (F. Schmidt et Maxim) Ronse Decraene]	Asia E	474	282*	3(+1)	NSH [riparian]	Regional	T	Czech Rep.	•	•	•	•	•		
Robinia pseudoacacia L.	Am N	7067	1957	4–5(+2)	NSH [grassland; scrub & forests]	National	T	some regions of Eur C, Lithuania	•	•	•	•			
Rudbeckia laciniata L.	Am N	2251	903	3–4(+2)	NSH [riparian; meadows]	Sub-Regional	T	Czech Rep. & Slovak Rep.	•	•	•				
Rumex confertus Willd.	Eur SE & Asia W	1731	673	3–4(+2)	SH [riparian; railway & road banks]	Sub-Regional	T	Lithuania	•						
Sisymbrium loeselii L.	Eur SE & Asia C	2326	976	3–4(+1)	H [wasteland]	Sub-Regional	NotH	Czech Rep.							
Solidago canadensis L.	Am N	3434	1254	4(+2)	NSH [riparian; abandoned fields]	Sub-Regional	T	some regions of Eur C	•	•	•	•	•		
Solidago gigantea Aiton. [= *S. serotina* Aiton]	Am N	5348	1668	4–5(+2)	NSH [riparian; abandoned fields]	National	T	some regions of Eur C	•	•	•	•	•		
Solidago graminifolia (L.) Elliott	Am N	46	27	2(+1)	NSH [meadows]	Local	T		•	•	•	•	•		
Trifolium patens Schreb.	Eur S	227	54	2–3(+1)	NH [meadows]	Regional	T		•		•				
Veronica filiformis Sm.	Asia SW [Cauc.]	161	69	2–3(+1)	SH [meadows]	Regional	p-inv.	Czech Rep.; USA				•			
Veronica persica *Poir.*	Asia SW [Cauc.]	7887	2204	5(+2)	H [fields]	National	W	Czech Rep.				•			
Vicia grandiflora Scop.	Eur S & Asia SW	1540	506	3–4(+2)	S A [grassland; fields]	Sub-Regional	T/W					•			

Species: Latin name and synonym(s); species are arranged alphabetically; species names nomenclature according to MIREK *et al.* 2002; **Origin**: Eur – Europe, Asia; Am N – North America; Am S – South America; C – central, E – east, N – north, S – south, W – west; **No of loc**: number of localities; **No of sq**: number of ATPOL squares (total number of squares for Poland: 3646); * – indicates that number of squares recorded need to be verified; n.c.d. – not complete data; **Dyn** – frequency and dynamic tendencies according to ZARZYCKI *et al.* 2002: Frequency in the wild at the territory of the country: 1 – very low number of localities (1–20); 2 – low number of localities (up to 100); 3 – high number of localities, but with narrower distribution (in one or two regions of the country); 4 – high number of localities in many regions; 5 – common (abundant) in the whole territory; **Dynamic tendency** (in brackets): (–2) – high decrease of(in) number of localities; (–1) – decrease in number of(in) localities or decrease in abundance over existing localities; (+1) – increase of(in) number of localities, increase in abundance over existing localities; (+2) – high increase of localities (colonizing new localities); (–/+) – disappearing of some localities and appearing of new localities; ? – undefined dynamic tendencies; **Habitats**: type of habitats invaded: N – natural; S – seminatural; H – human-made (anthropogenic); [in brackets] impacted ecotopes; **Category**: according to the classification by PYŠEK *et al.* 2004: T – transformer; W – weed; NotH – not harmful.

and also specific geographical regions in Poland (cf. Chapter 8); the remaining one: *Elsholtzia ciliata* has the status of post-invasive species.

Most of current invasive kenophytes have been introduced to Poland intentionally. They are twice more numerous (36 species) than the casually introduced species. The largest group is formed by species originating from both Americas (with a predominance of North American species – 29), from Asia (9) as well as from southern Europe and western Asia (9), so they are mainly arrivals from geographically remote areas. The greater part of the species is considered invasive also in other regions of Europe or even on the global scale.

12.4. Threatened regions and habitats

Eleven (11) species have been deemed to be invasive on the national scale (Table 13). They are mostly kenophytes linked to anthropogenous habitats included in the category of weeds and thus constituting a threat to agricultural areas[104].

The species which are most often mentioned in this context include *Amaranthus retroflexus* and the two species of genus *Galinsoga* which are considered to be troublesome weeds of root crop fields (Wnuk 1996; Rola & Rola 2002). This group, but considered on a regional scale, also includes *Anthoxanthum aristatum* (Kuźniewski 1996; Warcholińska & Siciński 1996).

A similar scale of distribution in Poland is shown by *Elodea canadensis* and *Impatiens parviflora* (the latter of which, however, is still a rarely encountered species in north-eastern Poland). These species may justly be considered as "dangerous" from the point of view of threat to the native flora and vegetation. While *Impatiens parviflora*[105] is a species which is still able to occupy new habitats (found more and more often in protected areas) and it requires monitoring, in special cases even qualifying for active elimination (Adamowski & Keczyński 1998), *Elodea canadensis* is a kenophyte which may also have entered the existing ecosystems permanently, but which is, however, past the end of its period of rapid spread.

Most invasive kenophytes are species which pose a threat on the regional scale (usually in one or several regions in the country, e.g. *Anthoxanthum aristatum* (cf. also Chapter 7), *Bromus carinatus*, *Echinocystis lobata*, *Fraxinus pennsylvanica*, *Heracleum mantegazzianum*) (Table 13).

Special attention should be paid to those kenophytes which are characterised by high competitive capabilities and which can penetrate into semi-natural and natural communities (Tokarska-Guzik 2003a).

Invasive kenophytes widespread in forests, especially in the southern part of Poland, include the arboreal species *Padus serotina* and *Quercus rubra* as well as the herbaceous species *Lupinus polyphyllus* (the spreading of this species is helped by a continuous supply of diaspores generated by additional sowing) and *Digitalis purpurea* (a species which may be considered invasive on a local scale, especially in some regions of the Carpathian Mountains).

Species which pose a threat to meadows and other grasslands include *Solidago canadensis* and *Solidago serotina* (these species also massively encroach on riverside habitats and on fallow fields), species from the genera *Aster* and *Heracleum*, additionally *Rumex confertus*, *Bunias orientalis*, *Bromus carinatus* and locally *Veronica filiformis* (which is probably receding in recent times).

"Particular habitats such as watersides are the most endangered ones and are most easily invaded by alien invasive plants and then play a role as a transmitter into other habitats such as scrub and woodland" (Tokarska-Guzik 2003c). Invasive kenophytes which seize this kind of habitats, often on a massive scale, include the species already mentioned from the genus *Solidago*, as well as *Reynoutria*, *Impatiens glandulifera*, *Rudbeckia laciniata* and *Heracleum mantegazzianum*.

A separate problem is the proportion of invasive species in protected areas and the consequences brought about by their presence. Analysis of several dozen publications related to national parks, nature reserves and other forms of protection has shown that in many situations of that type, there

[104] The accepted principle states that dangerous weeds are the ones which reach phytosociological constancy levels of IV or V and a high value of the coverage coefficient, while the species which reach constancy level IV or V buthave a smaller coverage coefficient may be potentially dangerous to agriculture (Wnuk *et al.* 1989). The author does not, however, list any kenophytes among "dangerous" species – although they show up in the releves, they do not fulfil the standards. Apophytes and archeophytes predominate in segetal communities – kenophytes have a smaller share.

[105] In favourable conditions this species may obtain an invasive success while not being a very good competitor. Its success is due according to Trepl (1984) to its shallow root system. Contrary to native herbaceous species, the Small Balsam can avoid competition with root systems of trees. Thus, the species has discovered an unexplored niche (in the sense of unused resources) and is able to colonise it.

are no alien species at all[106]. They mostly encompass areas which were designated to protect either multi-specific deciduous forests with a relatively high degree of naturalness or peat-bogs (e.g. Czarnecka 1978; Łuczycka-Popiel 1989; Brzeg *et al.* 1995; Sokołowski 1995b, 1996a & b, 1997a; Obidziński *et al.* 1998). The relatively scarce occurrence of invasive species in protected areas created in mountainous areas (especially in some regions of the Carpathians) is due to climatic factors which limit their spread (see Chapters 6 and 10). In many cases kenophytes are mentioned there as sporadic in occurrence with a low abundance (e.g. Krawiecowa 1972; Celiński & Wika 1978).

Detailed studies devoted to anthropogenous transformations of the flora and vegetation have been carried out in the Ojców National Park (Michalik 1972, 1974). They have shown the presence of *ca.* 35 species of alien origin, casually introduced (e.g. *Conyza canadensis*, *Galinsoga ciliata*, *G. parviflora*, *Impatiens parviflora*, *Bunias orientalis*, *Geranium pyrenaicum* and others) as well as intentionally planted by humans (e.g. *Quercus rubra*, *Helianthus tuberosus*, *Rudbeckia laciniata*, some species from the genus *Aster*).

Similar results were obtained from studies on synanthropisation in the Pieniny National Park (Guzikowa 1972). This area, in the 1960s characterised by a lower share of anthropophytes in comparison with the adjacent territories of Gorce Mts. and Sądecczyzna (Nowy Sącz province), has been "opened" for infiltration by recent arrivals following the building of new communication pathways. Next to common kenophytes linked to ruderal habitats (mainly in villages and towns), which are widespread also in other regions of the country, the author of the study lists also species which enter deep into natural communities (e.g. *Impatiens parviflora* into riverside willow communities on the Dunajec and Krośnica rivers and into forest communities *Alnetum incanae*, *Fagetum carpaticum*, *Phyllitido-Aceretum* and *Carici-Fagetum*, as well as *Juncus tenuis* which spreads along paths over wet ground). Later studies in the same area have confirmed further spreading of the aforementioned species and they have also turned attention to the rapid spread of species which have escaped from cultivation, including: *Heracleum sosnovskii*, *Helianthus tuberosus*, *Reynoutria japonica*, *Solidago canadensis* and *S. gigantea* (Zarzycki 1982, 2000b).

However, in many regions of the country due to an insufficient level of knowledge about synanthropic vegetation (even the total number of alien species in the flora is unknown) it is still not possible to consider the available data as final or to reliably estimate the degree of invasion of alien species (Jutrzenka-Trzebiatowski *et al.* 2002). A general rule applies that in areas with a larger extent and thus with a more complicated mosaic of habitats, the number of alien species is higher.

One of the species most often mentioned is *Impatiens parviflora* (e.g. Ćwikliński 1972b; Michalik 1972; Krawiecowa 1972; Sokołowski 1997b; Adamowski & Keczyński 1998; Piskorz & Klimko 2001). This plant is starting to appear in massive amounts in those regions in Poland where it has hitherto been a rare element of the flora (cf. Chapters 7 and 8), e.g. in mixed forests along the southern edge of Wigry lake (in the Wigry National Park) (Jutrzenka-Trzebiatowski *et al.* 2002).

Plants which threaten protected areas also include species from the genus *Solidago* which infiltrate meadows and grasslands (Ćwikliński 1972b; see also Chapter 11). A major threat to protected areas is the migration of synanthropic species along field tracks (Świerkosz 1995) and tourist trails.

In Polish national parks, the majority of synanthropic changes occur currently under the predominant influence of tourism and to a lesser extent forest management; grazing, pasture and meadow management experiments and activities have also been of historic importance (Piękoś-Mirkowa & Mirek 1978; Mirek & Piękoś-Mirkowa 1987). In this publication, the authors, who have monitored modifications in the nature of the Tatra National Park for many years, express their opinion that the most visible effects are changes in the horizontal and vertical distribution of species. These migrations are made possible by humans who both transport the diaspores and create suitable habitats where these species can spread. Sites of occurrence of synanthropic species in the Tatra mountains include roadsides, roadside ditches, parking lots and their surroundings, tracks and tracksides of railways, clearings cut under tracks of cable cars and chairlifts, tourist trails, forest glades and mountain meadows. The highest number of synanthropic species may be found around mountain shelters, ski-lift stations, chalets and similar sites.

Similar relationships have been found by Rostański (1977, 1978) in the area of the Karkonosze National Park. Fabiszewski (1985) summarised the threats to nature in this Park linked to the influences of industry and mass tourism and identified synanthropic species including alien species

[106] Authors do not however always give a complete flora, while the published phytosociological releves are usually taken on the most typically formed plots. Occasionally, this "ruse" of authors appears to be intentional, with the possible goal to form an argument during legal procedures.

(such as *Lysimachia punctata* and *Mimulus guttatus*), which migrate up to the highest peaks in connection with tourist traffic, urbanisation, wastewater and trash littering.

Despite having a largely preserved natural character, the Białowieża Primaeval Forest is also an area where alien species are recorded. Apart from the already mentioned *Impatiens parviflora*, cases of naturalisation of cultivated species, especially trees, are becoming more and more frequent. Łuczaj & Adamowski (1991) list among the most often recorded species: *Acer negundo*, *Quercus rubra* and *Cotoneaster lucidus*. The latter species in the opinion of the cited authors may in the future become a permanent component of a fringe scrub community from the *Prunetalia* order. The degree of encroachment of alien tree species in forest communities in the Białowieża Primaeval Forest is still however significantly smaller than in analogous communities in the western part of Poland.

12.5. Forecasting invasions: potentially invasive species

A reconstruction of the ways and manners of expansion of a species in the past may help in understanding its invasive success and in forecasting further stages of its migration. Of equal importance in forecasting invasions is autecological research, especially regarding the life strategy, means of reproduction and dispersal and conditions of seed germination of potentially invasive species (Wade 1997).

Moreover, useful data in forecasting invasions include not only ecological factors, such as temperature, habitat conditions and disturbances, but also information as to whether the species is invasive in another part of the globe.

Possibilities and limitations in forecasting further exchanges of species between various regions of the world have been analysed by Jackowiak (1999) (earlier also by Jäger 1988 and Sukopp 1995; see also Chapter 8) on the example of plants from the family Asteraceae. The results of this analysis lead to the conclusion that the exchange of the flora has not yet been completed.

Forman (2003) has published the so-called *Warning list of species* basing upon the previously mentioned relation between the apophytism ("weediness") of a species in its homeland and the probability of its invasion into a newly occupied area (compare also Table 12 in Chapter 12.1). The results of her analyses reveal higher than expected potential invasive characteristics in families Amaranthaceae, Cyperaceae, Poaceae which have hitherto not been considered highly invasive (as opposed to large families, such as: Asteraceae, Rosaceae and Fabaceae). The present study has confirmed these results in part.

When forecasting the further influx of potentially invasive species into Poland, it is necessary to gather information on the behaviour of each species in other regions of Europe. By way of example, in the Czech Republic and Slovakia (as well as in other warm regions of the continent) *Ambrosia artemisiifolia* is an invasive species which spreads massively along roads, railways and in arable fields. Also, *Senecio inaequidens*[107] (already recorded on first sites of occurrence on railway grounds – Guzik J., Pasierbiński A. & Rostański A., *pers. comm.*) and *Dittrichia graveolens* may migrate to Poland from the territory of Germany, as it has happened many times in the past for other plants (Radkowitsch 2003).

Cynodon dactylon is one of the most common apophytes in the cities of southern Europe (Celesti Grapow & Blasi 1998), while it has only an ephemerophyte status in Poland; a similar situation concerns *Eleusine indica* which is naturalised in the Mediterranean basin (Urbisz & Urbisz 2003). Such species as mentioned above can be considered as potentially able to become established or even invasive in the future.

12.6. Final remarks

Although studies of alien species in the flora as well as about the broadly understood process of synanthropisation of the plant cover have been conducted in Poland for a long time (Tokarska-Guzik 2001a), there is still insufficient multi-aspect research on alien invasive species, especially in the context of the threat they pose to the indigenous nature. In order to limit the invasions of undesirable alien species it is important to know in detail their ecology and distribution (Child *et al.* 2001).

Taking into account the huge variability in definitions of plant invasion and in the evaluation of the invasive potential of plant species, Kowarik & Schepker (1998) point to the need for the preparation of specific case documentation detailing the impact of invasions on the local plant cover and the possible threat they may cause, as well as estimations of the social, economic and ecological effects of the invasions.

[107] Starting to appear in the Black Country (Central England), probably introduced with ornamental plants imported from Holland (Prof. I.C. Trueman, *pers. comm.*).

A significant element which may lead to limiting the spread of invasive plants may be the dissemination of relevant information.

"An intensive development of commerce and the concurrent development of communication routes exert a powerful influence on the spread of various plants, often even from very distant places. Of course, not all of these introduced plants remain in the locality to which they were brought. Some of them, however, find favourable conditions and quickly turn into the most common weeds. Some synanthropic plants are so common and we have grown so used to them that we consider them nearly as a part of the local element" (Paczoski 1900). These words have not lost their significance in the age of globalisation of commerce, the dynamic development of tourism, and in Poland also the current intensification of the development of residential building activity.

PART FIVE

Summary, conclusions and the perspectives for studies of plants of alien origin in Poland against the trends prevailing in Europe and the world

13. Summary and conclusions

The objective of this monograph was to summarise the research carried out on the development of the flora of kenophytes within the territory of Poland and to arrive at a synthesis of the relevant knowledge available to date.

The intention of the author was also to describe the history and directions of studies concerning the newest synanthropic newcomers established in Poland, and to provide references to the most important studies and special topics undertaken by Polish botanists, whose work constitutes a permanent contribution to the achievements of biogeographic sciences (Chapter 2; Table 1).

The result of this attempt is a new list of this group of species, considerably broader than that which could be found in earlier works and augmented by the inclusion of the ecological and geographical characteristics of the species (Appendices A and B, and Chapters 5.1 and 8). Researching historical sources ("old" floras, herbarium documentation) has allowed the verification or determination of the first floristic records of particular species of Polish kenophytes (Apendices A and B; also Chapters 5.2, 7 and 9). An attempt was also made to reconstruct the periods where the influx and spread of kenophytes were most intense, relating these to historical and geographical factors (Chapters 5.2 and 9).

For a selected group of 25 species the history of their spread in Poland has been reconstructed in detail (Chapter 7). Detailed data on the distribution of 174 species of kenophytes has been used to represent the typology of their ranges within Poland's borders (Chapter 6), augmented by a discussion on the principal factors influencing the formation of their ranges (Chapter 10). Many distribution maps have been augmented (Chapter 7) and five new maps have been developed (Fig. 39 in Chapter 7, and Appendix C).

Another reconstruction effort had the aim at finding changes in the ranges of kenophytes, with the elucidation of possible migration routes (Chapter 9). The dynamic trends among kenophytes have also been discussed vis-à-vis the factors helping them acquire various types of habitats (Chapter 11). From the list of kenophytes, invasive species have been identified (a list of invasive kenophytes for Poland has been proposed), opening wider discussion on the criteria adopted for their selection, and indicating those regions of Poland threatened by invasion (Chapter 12).

In opinion of the author, the most important conclusions of this study area are as follows:

• In the ever-progressing process of the synanthropisation of vegetation, viewed in the time frame of the last five centuries, the role of newer arrivals (kenophytes) has been growing. The transformation of the composition of the flora occurs at the level of taxonomic, geographical/historical, biological and ecological structures (even the genetic structure) and its course is realised in time and space.

The kenophytes occurring in Poland originate from five continents, with a predominance of species from the various European regions (chiefly from its southern and south-eastern parts) and from North America. Among them, hemicryptophytes and therophytes predominate. The species intentionally introduced by humans show a tendency to colonise natural and semi-natural habitats, whereas those species introduced accidentally,

colonise the anthropogenic habitats before any others (only in the subsequent stages of their expansion, do some of them also colonise natural and semi-natural habitats).

The kenophytes occurring in Poland are mostly insect- and wind-pollinated plants, reproducing by generative means; some of them also implement various methods of vegetative reproduction. Anemochory and zoochory play predominating roles in the expansion of this group of anthropophytes. Among the kenophytes, species of high competitive potential prevail (those with *C*-type life strategy), together with those adapted to circumstances where the effect of stress is low and competition is limited by disturbances (*C-R* type life strategy) and mobile pioneer species (*R* type).

• The reconstruction of the historic floras of kenophytes has permitted the establishment of a list of the "oldest" arrivals among this group of alien species. The Polish flora of the 17th century undoubtedly included such species as: *Acorus calamus*, *Datura stramonium*, *Echinops sphaerocephalus*, *Marrubium vulgare*, *Tanacetum parthenium* and others.

• The historical and economic conditions in Poland exerted a significant impact on the augmentation of local flora by newcomers. The migrations of kenophytes had certain culminations of influx (called "migration waves"). The highest culmination occurred in the second half of the 19th century, coupled with the "first industrialisation stage". The culminations differed from one another by their respective origins. From the beginning of the 16th century through to the first half of the 19th century, species of European and Asian origin had predominated. The last 150 years showed a noticeable predominance of species coming from the Americas. Finally, in the most recent period, the proportion of species of hybrid origin, which owe their appearance to humans, either directly or indirectly, has increased in the Polish flora.

• Kenophyte migrations have covered the whole present territory of Poland, and the maps of their occurrence reveal the areas of their high concentrations, namely the Vistula river valley, the Silesian Upland and major urban centres.

Many kenophytes do not show any definite type of range. This reflects the history of their arrival into Poland, as well as their mechanisms of establishment in the local flora (long-term cultivation or multiple accidental introductions into many regions).

Some of the species of this group can nevertheless be allocated to certain types of definite distribution ranges. Climatic conditions should be regarded as the main factors affecting the pattern of the range while natural conditions and local anthropogenic factors are the second and third most important factors, respectively.

At present, a dozen or so species have their eastern limits of distribution within the Polish lands, while several other species reach their western and northern limits there. Species closely linked to rivers, particularly the groups of kenophytes characteristic of the major rivers of Poland: the Vistula, Odra and Bug (*Eragrostis albensis*, *Oenothera depressa*, *Oenothera* x *hoelscheri*, *Rumex confertus*, *Salsola kali* subsp. *ruthenica* and *Xanthium albinum*) and the kenophytes associated with cities and railway links between them represent a specific and distinctive type of distribution.

• The reconstructed courses of immigration and expansion of individual species have revealed the factors affecting the rate of spread and direction of expansion and, ultimately, the current pattern of their distribution range in Poland. These factors include the manner and nature (frequency) of their introduction. Those species accidentally introduced on many occasions, or those adopted as cultivated plants (maintained as cultivars) in various regions, have spread faster and their ranges are larger. Most of the species concerned, even those which came primarily from very remote geographical regions, spread in Poland as an effect of their previous intentional or casual introduction into Western Europe (historically earlier industrialised and urbanised).

• The rate of expansion shown by kenophytes in their new homeland depends on their biological properties, historical circumstances (timing and manner of introduction), and a set of factors (natural and anthropogenic) collectively referred to as the resistance of the environment. A rapid rate of expansion has been characteristic for these kenophytes repeatedly casually introduced to many regions of Poland, and colonising (at least in the initial phase) anthropogenic habitats. This statement holds for such species as the *Chamomilla suaveolens*, *Conyza canadensis*, *Galinsoga parviflora* and *G. ciliata*.

• Among the major factors facilitating the migrations of alien species, the following factors can be "guaranteed" by humans:
– elimination of barriers (development of transport over great distances, reduction in the size of forested areas and wetlands and their fragmentation);
– introducing species into cultivation and maintaining them in cultivation for a long period of

time, which helps them to escape into the wild (cultivation involves significant numbers of diaspores of great genetic variability being introduced simultaneously, and this process is repeated many times);
– "creating" (often quite unintentionally) completely new habitats in the wild which could be surrogate habitats for alien newcomers (stone fences and walls, railway tracks and embankments, cracks in flagstones, or utterly artificial sites such as heaps, new geomorphological forms or areas completely deprived of vegetation);
– applying alien plants in the arrangement of public green areas, as well as in the reclamation of degraded areas (this latter measure is sometimes implemented on a vast scale);
– developing railway and road transport (creating migration corridors);
– permanent or periodical interference in the habitat conditions and structure of native phytocoenoses (maintaining and extending large-sized disturbed habitats, fallow lands, rivers and streams canalization);
– inappropriate forest management (the direct introduction of alien species into forests).

• Synthetical studies concerning the expansion of species of alien origin will provide a theoretical basis to develop checklists of invasive species which, in turn, will help in planning practical measures (prevention and control).

14. Invasions of alien plant species at the dawn of the 21st century: perspectives for further studies

Those species of alien origin, particularly invasive and potentially invasive species will continue to attract the interest of taxonomists, ecologists, plant geographers, as well as many conservationists.

The effective protection of biodiversity calls for modern taxonomic studies, particularly of critical taxa. In the Polish flora these include the genera *Aster*, *Helianthus*, and *Rubus*[108] and hybrid forms[109] in these and other genera.

Also in need of more modern studies is the biology of individual species and their possible changes (in the methods of pollination, pollinators, disseminating methods of entire communities with participating kenophytes, associations and relationships with other plant species, parasitic and saprophytic fungi, and microorganisms). These studies should also be pursued at the level of the genotype. On the population level, studies on morphological and genetic differentiation are needed along with studies of the evolutionary processes operating in the immigrant populations.

Finally, there is a need to undertake studies on the impact of invasive plants on the functions and structure of ecosystems (also involving long-term studies). To date, such studies have only been rarely undertaken in Poland.

The issue of separating apophytes from anthropophytes (Kornaś 1981) is still open and awaiting solution. The elucidation of the origin and status of individual species can still be helped by involving palaebotanical and archaeobotanical methods.

As stated by Welk *et al.* (2002) "(...) The research on well-known, non-indigenous European species in North America, and vice versa, provides us with opportunities for long-term field tests because many of the species have had enough time to reach even the remote parts of their potential distribution ranges on their 'new' continents. With a review of the results of investigations on a large number of species with different life history strategies, life forms and native range types, our understanding of the different capacities of climatic range models for predicting invasiveness could be improved".

The subject matter of public and scientific debates on the possible evaluation of hazards involving genetically modified plants and their release into the environment should also become topics of future scientific studies. Hazards associated with the gene flow from GM crops to wildlife species (crossing with close wild relations)[110] should also become a topic for more studies; it is necessary to develop proper tools for the assessment of possible hazards (cf. e.g. Abbot 1992; Arnold 1997; Pohl-Orf *et al.* 1998;

[108] Taxonomic studies on this species have already been completed (Zieliński 2004)

[109] Hybridisation has long-since been recognised as playing an important role in the evolution of plants (Stebbins 1950). In the recent decades the role of anthropogenic hybridisation has increased. Hybrids produced this way, being more invasive, can squeeze out or replace the parental species or can produce a genetic mix. At present, such a process is even referred to as the "extinction of species by hybridisation and introgression" or "invasion by hybridisation".

[110] It is also essential to study and chart the distribution of wild relatives and hybrids between cultivated plants and their wild relations. This knowledge would allow the assessment of potential possibilities of hybridisation between GMP and their wild relations; the phenomenon of introgression is particularly important in respect to the Brassicaceae, Solanaceae, Poaceae families and some tree species, e.g. *Populus*, *Salix* and *Picea*. Also needed is more taxonomic knowledge about cultivated species, the regions of their cultivation, as well as of the distribution of their wild relations and potential hybrids.

RIESEBERG & CARNEY 1998; DEN NIJSS *et al.* 1999; ALLENDORF *et al.* 2001).

Despite the multitude of studies undertaken in the currently developing branch of ecology called **ecology of invasion**, many questions are still awaiting answers. An evident and indispensable tendency leads to precisely planned studies (including long-term projects), employing the modern methods and tools of the various disciplines of biology (including molecular biology and cytogenetics). Special attention has already been focused on the genetic aspects and methods of reproduction which support the invasiveness of plants.

An additional activity to be coupled with studies should be data gathering (Global Network on Taxonomy – a network and data exchange systems), the exchange and propagation of information.

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Barbara Tokarska-Guzik

Zadomawianie się i rozprzestrzenianie obcych gatunków roślin (kenofitów) w florze Polski

Streszczenie

Tematyka niniejszej pracy mieści się w problematyce dotyczącej synantropizacji szaty roślinnej. Jednym z przejawów tego ukierunkowanego procesu przemian zachodzących w wyniku różnych form działalności człowieka na kuli ziemskiej są procesy wymierania jednych gatunków i rozprzestrzeniania się innych, nasilające się w ostatnich stuleciach i przyczyniające się do zmian różnorodności biologicznej w skali regionów, krajów i kontynentów.

Celem niniejszej monografii było ukazanie badań nad kształtowaniem się flor nowszych przybyszów synantropijnych zadomowionych na obszarze Polski (kenofitów) oraz synteza dotychczasowej wiedzy w tym zakresie. Moim zamysłem było także ukazanie historii i kierunków badań nad tą grupą roślin obcego pochodzenia, wraz z przytoczeniem najistotniejszych opracowań i zagadnień specjalnych podejmowanych przez polskich botaników, które na trwałe wpisane zostały w dorobek nauk biogeograficznych (rozdz. 2; tab. 1).

Wynikiem podjętych studiów jest opracowanie nowego, uzupełnionego w stosunku do literatury, wykazu dla tej grupy gatunków, poszerzonego o ich charakterystykę ekologiczno-geograficzną (załączniki A i B oraz rozdz. 5.1 i 8). Dotarcie do źródeł historycznych (historyczne/„stare" flory, dokumentacja zielnikowa) umożliwiło zweryfikowanie lub ustalenie pierwszych dat florystycznych (znalezisk) dla poszczególnych gatunków polskich kenofitów (zał. A i B; także rozdz. 5.2, 7 i 9). Podjęto również próbę odtworzenia okresów kulminacji napływu i rozprzestrzeniania się kenofitów, z ukazaniem zależności od czynników historycznych i geograficznych (rozdz. 5.2 i 9).

Dla wyselekcjonowanej grupy 25 gatunków odtworzono dzieje ich rozprzestrzeniania się na obszarze kraju (rozdz. 7). Na podstawie zebranych szczegółowych danych o rozmieszczeniu dla 174 gatunków kenofitów przedstawiono typologię ich zasięgów w granicach Polski (rozdz. 6), a także zweryfikowano hipotezy odnoszące się do głównych czynników wpływających na ich kształtowanie się (rozdz. 10). Mapy rozmieszczenia dla wielu gatunków zostały uzupełnione (rozdz. 7); opracowano ponadto 5 nowych map (rys. 39 w rozdz. 7 oraz zał. C).

Dokonano próby rekonstrukcji historycznych zmian zasięgów kenofitów wraz ze wskazaniem możliwych dróg ich migracji (rozdz. 9). Omówiono ponadto tendencje dynamiczne kenofitów z uwzględnieniem czynników sprzyjających opanowywaniu różnych typów siedlisk (rozdz. 11). Z listy kenofitów wyłoniono tzw. gatunki inwazyjne (propozycja listy inwazyjnych kenofitów dla kraju), jednocześnie inicjując dyskusję nad przyjętymi kryteriami ich selekcji, a także wskazano rejony kraju zagrożone inwazją (rozdz. 12).

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Etablierung und Ausbreitung gebietsfremder Pflanzenarten (Kenophyten) der Flora Polens

Zusammenfassung

Das Thema der vorliegenden Arbeit gehört zur Problematik der Synanthropisierung der Pflanzendecke, d.h. des Auftretens von wilden Pflanzenarten in sekundären Biotopen, in denen die natürliche Urflora von dem Menschen zerstört worden ist. Eins von den Symptomen der gezielten Verwandlungen auf der Erde, die unter der Wirkung von verschiedenartigen Formen der menschlichen Tätigkeit eintreten, ist das Aussterben von einigen und das Ausbreiten von anderen Pflanzenarten, die in den letzten zehn Jahren stark zugenommen haben und die zur Veränderung der biologischen Vielfältigkeit in den Regionen, Ländern und auf den Kontinenten beitragen.

Das Ziel der vorliegenden Monografie war, die Entstehung von der Flora der neueren synanthropischen und auf dem polnischen Gebiet heimisch werdenden Ankömmlingen (Kenophyten) zu untersuchen und die bisherigen Kenntnisse im dem Bereich zusammenzufassen. Die Verfasserin wollte auch die Geschichte und die Richtungen der, über die Pflanzen der fremden Herkunft geführten Forschungen zeigen und die wichtigsten, zu Errungenschaften der biogeographischen Wissenschaften eingezählten Monografien der polnischen Botaniker vorbringen (Kpt. 2; Tab. 1).

In Folge der Forschungen wurde das neue Verzeichnis der Pflanzenarten mit deren ökologisch-geographischer Charakteristik (Beilagen A, B u. Kpt. 5. 1 u. 8) erschafft. Da es sich der Verfasserin gelungen hat, zu historischen Quellen (historische/„alte" Floren, Herbarien) zu gelangen, konnte sie die ersten floristischen Daten (Funde) für einzelne Arten der polnischen Kenophyten (Beilagen A, B; Kpt. 5.2, 7 u. 9) festzulegen. Sie versuchte auch, die Kulminationsperioden für Zustrom und Ausbreitung von Kenophyten wiederzugeben und deren Abhängigkeit von historischen und geographischen Faktoren zu zeigen (Kpt. 5.2 u. 9). Man hat die Geschichte der Ausbreitung auf dem polnischen Gebiet von 25 ausgewählten Pflanzenarten wiedergegeben (Kpt. 7). Anhand der gesammelten genauen Daten über die Anordnung von 174 Kenophytenarten wurde die Typologie ihrer Reichweiten in Polen (Kpt. 6) dargestellt und die Hypothesen über die wichtigsten Faktoren, die für ihre Gestaltung verantwortlich sind erörtert (Kpt. 10). Man hat die Anordnungskarten für viele Pflanzenarten ergänzt (Kpt. 7) und über 5 neue Karten erschafft (Abb. 39, Kpt. 7 u. Beilage C). Man hat sich die Mühe gemacht, historische Veränderungen der Reichweiten von Kenophyten zu rekonstruieren und auf die möglichen Migrationswege hinzuweisen (Kpt. 9). Besprochen wurden auch dynamische Tendenzen von Kenophyten unter Berücksichtigung der Faktoren, die die Besetzung von verschiedenen Biotoptypen begünstigen (Kpt. ll). Man hat von der Liste sog. invasive Pflanzenarten ausgewählt (die Liste von invasiven Kenophyten für das Gebiet Polens) und die mit der Invasion bedrohten Gebiete genannt. Auf diese Weise wurde zur Diskussion über die Auswahlkriterien von Kenophyten der erste Anstoß gegeben.

Appendices

Abbreviations and symbols used in Appendix A & B

Species – Latin name and synonym(s); species are arranged alphabetically; species names nomenclature according to MIREK *et al.* 2002

H – hybrid origin

LF – life form according to RAUNKIAER (1905)
- M – megaphanerophyte
- N – nanophanerophyte
- Ch – chamaephyte
- H – hemicryptophyte
- G – geophyte
- Hy – hydrophyte
- T – therophyte
- li – climber
- p – parasithe

R – reproduction
- G – generative
- V – vegetative

P – pollination mode
- w – wind
- i – insects
- s – self-pollination
- a – apogamic

Disp – dispersal mode
- aut – autochory
- ane – anemochory (wind)
- bar – barochory
- egz – egzochory (epizoochory)
- end – endozoochory
- myr – myrmecochory (dispersal by ants)
- hyd – hydrochory (water)
- anthr – anthropochory (dispersal by humans)

Prop – propagule
- se. – seed
- fr. – fruit
- st. – stem
- ro. – root
- rh. – rhizome
- ros. – rosette
- pl. – whole plant

LS – life strategy (GRIME 1979)
- *C* – competition,
- *S* – stress,
- *R* – ruderal, *CS*, *CSR*, *SR*

Origin – native range
- Eur – Europe
- Asia
- Am N – North America
- Am S – South America
- Afr – Africa
- C – central
- E – east
- N – north
- S – south
- W – west

Way of INT – way of introduction to the country; hybrids escaped from cultivation are considered "intentionally"
- UI – unintentionally → vector of accidential introduction (in brackets):
  - G – grain
  - S – with seeds of other plants
  - BS – bird-seeds
  - SB – soy beans
  - BA – ballast
  - W – wool
  - GA – garden material
  - FD – fodder
  - B – botanical (as weed in botanical gardens)
  - AN – animals
  - RW – railways
  - P – potatoes
- I – intentionally → planting purpose (in brackets):
  - O – ornamental
  - FO – forestry
  - A – agriculture (incl. food)
  - FD – fodder
  - M – medicinal
  - B – botanical (botanical gardens)
  - C – cultivation (e.g. for bees, cosmetic industry, lawns, landscaping, reclamation)
- I/UI – both ways

First record for Europe – year (if available) or period of the first record in the wild; for some taxa (mainly woody plants) also year of deliberate introduction [I];
Ar ? – in some part of Europe considered as archaeophyte ("oldcomer"); in some cases a few known oldest

data were given, Anc – from ancient time in cultivation, [1–50] – source (author & year) of information; listed at the end of the table

First record for Poland – year (if available) or period of the first record in the wild; for some taxa (mainly woody plants) also year of deliberate introduction [I]; in some cases a few known oldest data were given

The oldest locality & source of data for the first record for Poland
Locality: region or(and) town
Source: author & year; for herbarium data abbreviation for particular herbarium was given (in **bold**). Acronyms for herbaria after Mirek *et al.* 1997.
B – Botanisches Museum Berlin–Dahlem; **KOR** – Institute of Dendrology, Polish Academy of Sciences, Kórnik; **KRA** – Institute of Botany, Jagiellonian University; **KTC** – Department of Botany, Institute of Biology, J. Kochanowski Pedagogical University, Kielce; **KTU** – Department of Plant Systematics, University of Silesia; **LBL** – Department of Systematics and Phytogeography, Institute of Botany, Maria Curie-Skłodowska University, Lublin; **MGS** – Upper Silesian Museum; **POZ** – Adam Mickiewicz University in Poznań; **PRC** – Herbarium at the University of Prague; **SZUB** – Department of Botany, Szczecin University; **TRN** – Institute of Biology and Environment Protection, N. Copernicus University in Toruń; **W** – Herbaria in Wien; **WA** – Department of Plant Systematics and Geography, Institute of Botany, Warsaw University; **WRSL** – Museum of Natural History, University of Wrocław

Nrs of loc – number of localities in distinguished periods

Nrs of sq – number of ATPOL squares (total number of squares for Poland: 3646);
* – indicates that number of squares recorded need to be verified
n.c.d. – not complite data

Dyn – frequency and dynamic tendencies according to Zarzycki *et al.* 2002
Frequency in the wild at the territory of the country:
1 – very low number of localities (1–20)
2 – low number of localities (up to 100)
3 – high number of localities, but with narrower distribution (in one or two regions of the country)
4 – high number of localities in many regions
5 – common (abundant) in the whole territory
Dynamic tendency (in brackets):
(–2) – high decrease of(in) number of localities
(–1) – decrease in number of(in) localities or decrease in abundancy over existing localities
(+1) – increase of(in) number of localities, increase in abundancy over existing localities
(+2) – high increase of localities (colonizing new localities)
(–/+) – disappearing of some localities and appearing of new localities
? – undefined dynamic tendencies

Hab – tape of habitats invaded
N – natural
S – semi-natural
H – human-made (anthropogenic)

Inv. elsewhere – described as invasive elsewhere; in brackets type of invaded habitat is given
agr. – agricultural, rip. – riparian, urb. – urban

Maps – published distribution maps (only most important ones) and distribution map for Poland (in italics)
** – indicates that distribution map was compiled exclusively on the herbarium data

Imp stud – important studies for Poland

Sources of the first data for Europe: **1** – Hereźniak 1992; **2** – Lohmeyer & Sukopp 1992; **3** – Hegi 1908–1931; **4** – Lauener 1996; **5** – Pyšek *et al.* 2002; **6** – Frey 1974; **7** – Jehlík 1998; **8** – Stace 1997; **9** – Kuźniewski 1996; **10** – Hardtke & Ihl 2000; **11** – Reichenbach 1842; **12** – Meusel *et al.* 1965; **13** – Sudnik-Wójcikowska 1987a; **14** – Meusel *et al.* 1992; **15** – Hegi 1935–1961; **16** – Meusel *et al.* 1978; **17** – Żukowski & Piaszczyk 1971; **18** – Ascherson & Graebner 1902–1904; **19** – Ascherson & Graebner 1901–1913; **20** – Ascherson & Graebner 1913; **21** – Ascherson & Graebner 1915; **22** – Ascherson & Graebner 1917; **23** – Ascherson & Graebner 1938; **24** – Zając *et al.* 1998; **25** – Kowarik 1995a; **26** – Guzik & Sudnik-Wójcikowska 1994; **27** – Dyakowski 1899; **28** – Perring & Walters 1962; **29** – Kornaś 1968b; **30** – Rostański K. 1998; **31** – Rostański K. & Serwatka 1968; **32** – Gutte & Rostański 1971; **33** – Rostański K. & Kloss 1965; **34** – Hantz 1979; **35** – Starfinger 1997; **36** – Misiewicz *et al.* 1996; **37** – Bailey & Conolly 2000; **38** – Hollingsworth & Bailey 2000; **39** – Zieliński 1991; **40** – Zieliński 2004; **41** – Francírková 2001; **42** – Kucharski 1992; **43** – Balogh 2001; **44** – Drescher & Prots 2003; **45** – Adamowski *et al.* 2002; **46** – Seneta 1994; **47** – Gutte 1997; **48** – Seneta & Dolatowski 1997; **49** – Guzik 2002; **50** – Ascherson 1866; **51** – Rostański K., *personal inf.* (specimen from the Natural History Museum in Budapest); **52** – Krawiecowa 1951; **53** – Lhotská & Kopecký 1966; **54** – Perrins *et al.* 1993; **55** – Rostański K. 1982; **56** – Gudžinskas 1997d; **57** – Gudžinskas 1997c; **58** – Gudžinskas 1998a; **59** – Gudžinskas 1997b; **60** – Weber 1998; **61** – Gudžinskas 2000a; **62** – Gudžinskas 2000b.

Appendix A. List of Polish kenophytes together with their ecological-geographical characteristic and history of distribution throughout the country

Name of species	Family	LF	R	P	Disp	Prop	LS	Origin	Way of INT	First record for Europe*	First record for Poland	The oldest locality in Poland & source of data	Nrs of loc. up to 1850	Nrs of loc. up to 1900	Nrs of loc. up to 1950	Nrs of loc. up to 2000	Nrs of sq.	Dyn	Hab.	Inv. elsewhere	Maps
Acer negundo L.	Aceraceae	M	G/V	i w	ane hyd	se. ro.	*C*	Am N	I [O]	1688 [I][1] 1699[2] see also Chapter 7	1808 [I] 1873 ? 1899	Kraków – botanical garden [I] (Hereźniak 1992); Kraków (Boehm 1873); Wrocław (Baenitz *herb.* **PRC**, **W**, **WRSL**); Puławy (Berdau *herb.* **LBL**)	0	3	30	3526	1379	4(+2)	NSH	Eur C; Lithuania [rip. agr. & urb.]	Little 1971; *Zając A. & Zając M. 2001*
Acorus calamus L.	Araceae	Hy	V	i w	anthr hyd	rh.	*CS*	Asia C & S	I[M, B] →UI	1557 [I][3] XVI[2] 1577[18]	XVI 1613* 1652 1824	* general information (after Syreński 1613); XVIII – Kluk (1786); Warszawa (Sudnik-Wójcikowska 1987a); Mazowsze Lowland: Wyszogród (Zalewski 1892 after Gawarecki 1824); Warszawa (Szubert 1824)	8	88	146	4319	1999	5(–/+)	NS		Hulten 1964; Hulten & Fries 1986; Meusel *et al.* 1965; *Zając A. & Zając M. 2001*
Ailanthus altissima (Mill.) Swingle [= *A. glandulosa* Desf.]	Simaroubaceae	M	G/V	i	ane hyd	se. ro.	*C*	Asia E [China]	I [O, M]	1751 [I][4] 1780 [I][2, 25] 1874[5] 1902[25] see also Chapter 7	1818 [I] 1931	[I] (Hereźniak 1992); Wrocław (Meyer 1931)	0	0	3	31	29	2(+1)	H	Eur C & S [urb. & rip.] Am N	**original:** see Chapter 7, Fig. 39
Amaranthus albus L.	Amaranthaceae	T	G	i w	ane egz	se.	*SR*	Am N [W]	UI [G, B]	1723[6]	1907	Lublin Upland: Rejowiec (Trzebiński 1930)	0	0	60	782	379	3(+/–)	H	Eur C [agr.]	Jalas & Suominen 1980; *Frey 1974*; *Tokarska-Guzik 2001b* (1)
Amaranthus blitoides S. Watson	Amaranthaceae	T	G	i w	ane egz	se.	*CR*	Am N [W]	UI [G]	1893[2]	1911	Wielkopolska Lake District: Krosno Odrzańskie; South Wielkopolska Lowland: Żary (Decker 1911)	0	0	8	283	150	3(+1)	H	Eur C [agr.]	Jalas & Suominen 1980; *Frey 1974*; *Tokarska-Guzik 2001b* (2)
Amaranthus chlorostachys Willd. [= *A. hybridus* L.]	Amaranthaceae	T	G	i w	ane egz	se.	*CR*	Am C & S	UI [W]	1872	1872	Carpathian Foothills: Tarnów (Knapp 1872)	0	2	14	425	260	3(+1)	H	Eur C [agr.]	Jalas & Suominen 1980; *Frey 1974*; *Tokarska-Guzik 2001b* (3)
Amaranthus lividus L. [= *A. ascendens* Loisel.]	Amaranthaceae	T	G	i w	ane egz end myr anthr	se.	*CR*	Eur S & Afr N	I [A] →UI	Ar[2]	1826	Gdańsk (Klinsmann *herb.* **TRN**)	9	77	117	728	453	3(–/+)	H	Eur C [agr.]	Jalas & Suominen 1980; *Frey 1974*; *Tokarska-Guzik 2001b* (4)
Amaranthus retroflexus L.	Amaranthaceae	T	G	i w	ane egz anthr	se.	*CR*	Am N [W] & Am C	I [B] / UI [BA]	1783[6]	1801 1814	Opole, Gdańsk (Thellung 1914)	8	169	291	7651	2379	5(+2)	H	Eur C [agr.]	Meusel *et al.*1965; Hulten 1968, 1971; Jalas & Suominen 1980; Hulten & Fries 1986; *Frey 1974*; *Zając A. & Zając M. 2001*
Ambrosia artemisiifolia L.	Asteraceae	T	G	i w	ane egz anthr	se.	*CR*	Am N [E & SE]	UI [G, SB, BA]	1863[7] Germany 1865[14]	1613* XVIII 1873	* general information: probable ref. this species (after Syreński 1613); XVIII – Kluk (1786); Silesian Lowland: Szczepanowice (Plotel *herb.* **WRSL**)	0	11	25	101	61	2–3 (+/–)	H	some regions of Eur C, S & E; Am N	Meusel *et al.* 1992; *Tokarska-Guzik 2001b* (5)
Ambrosia psilostachya DC. [= *A. coronopifolia* Torr. & A. Gray]	Asteraceae	H	G/V	i w	ane egz anthr	se. rh.	*C*	Am N [SE]	UI [G]	1901 1903[8]	1901	Świnoujście (Ruthe *herb.* **SZUB**)	0	0	9	30	21	2(+/–)	H	Am N	Meusel *et al.* 1992; *Tokarska-Guzik 2001b* (6)
Anthemis ruthenica M. Bieb.	Asteraceae	T	G	i	ane egz anthr	se.	*CR*	Eur SE	UI [G]	1869	1869	Carpathian Foothills: Krządka (Jachno 1869)	0	29	63	408	269	3(+1)	H		Meusel *et al.* 1992; *Zając A. & Zając M. 2001*

Name of species	Family	LF	R	P	Disp	Prop	LS	Origin	Way of INT	First record for Europe*	First record for Poland	The oldest locality in Poland & source of data	Nrs of loc. up to 1850	Nrs of loc. up to 1900	Nrs of loc. up to 1950	Nrs of loc. up to 2000	Nrs of sq.	Dyn	Hab.	Inv. elsewhere	Maps
Anthoxanthum aristatum Boiss. [= *A. puelii* Lecoq & Lamotte]	Poaceae	T	G	w	ane egz anthr	se.	*R*	Eur S	UI [FD]	1805 1813[9] see also Chapter 7	1866	West Pomerania: Kwidzyń (KLINGGRAEFF 1866)	0	6	42	1031	577	3–4 (+2)	H		MEUSEL *et al.* 1965; *TOKARSKA-GUZIK 2001b* (7)
Artemisia annua L.	Asteraceae	T	G	i s	ane egz anthr	se.	*CR*	Eur SE & Asia W	I [C] →UI [G, BS, W]	1871[I] 1881 1899[7]	1871 [I] 1881	Wielkopolska Lake District: Cerekwica (ŻUKOWSKI & PIASZCZYK 1971)	0	11	35	337	154	3(+/–)	H	Czech Rep. [agr.], Slovac Rep. [rip.], Hungary	MEUSEL *et al.* 1992; *ŻUKOWSKI & PIASZCZYK 1971*; *TOKARSKA-GUZIK 2001b* (8)
Artemisia austriaca Jacq.	Asteraceae	Ch	V/G	i s	ane egz anthr	ros. se.	*CS*	Eur SE & Asia W	UI [RW]	1871 1946[10] see also Chapter 7	1871	Warszawa (ROSTAFIŃSKI 1872)	0	8	33	374	217	3(+/–)	H		MEUSEL *et al.* 1992; *ŻUKOWSKI & PIASZCZYK 1971*; *TOKARSKA-GUZIK 2001b* (9)
Artemisia dracunculus L.	Asteraceae	H	G/V	i s	ane egz anthr	se. rh.	*C*	Am N & Asia	I [A, M]	XVI[10] Ar[17]	XVI[I] 1613* XVIII 1850	* general information (after SYREŃSKI 1613); XVIII – KLUK (1786) as cultivated plant; Poznań (Schoenke *herb.* **POZ**)	1	10	28	87	59	2(+/–)	H		MEUSEL *et al.* 1965; *ŻUKOWSKI & PIASZCZYK 1971*; *TOKARSKA-GUZIK 2001b* (10)
Asclepias syriaca L.	Asclepiadaceae	H	V/G	i	ane anthr	rh. se.	*C*	Am N [E]	I [O]	XVIII[10] 1855[43] 1901[5]	XVIII 1872	Kalisz, Lublin (ROSTAFIŃSKI 1872)	0	4	7	62	52	2(+1)	H	some part of Eur C & S	**original:** see App. C
Atriplex oblongifolia Waldst. & Kit. [= *A. oblongifolium* Waldst. & Kit.]	Chenopodiaceae	T	G	s i	ane hyd anthr	se.	*CR*	Eur E, Asia W & Afr	UI [RW]	2/2 XIX[10]	1882	Toruń (ABROMEIT *et al.* 1926)	0	4	18	154	100	3(+1)	H	Czech Rep.	MEUSEL *et al.* 1965; JALAS & SUOMINEN 1980; *TOKARSKA-GUZIK 2001b* (11)
Atriplex tatarica L. [= *A. tataricum* L.]	Chenopodiaceae	T	G	s i	ane hyd anthr	se.	*CR*	Eur S & SE, Asia C	UI [RW]	1820[11] Ar[8]	1847	Warszawa (WAGA 1847)	1	13	36	294	153	3(+1)	H		JALAS & SUOMINEN 1980; HULTEN & FRIES 1986; *TOKARSKA-GUZIK 2001b* (12)
Barbarea intermedia Boreau	Brassicaceae	H	G	i s	ane	se. fr.	*CR*	Eur S & W	UI		1908	West Pomerania: Połczyn (ROMER 1908)	0	0	1	11	9	1(?)	H		*MIREK 1984, 1997*; *ZAJĄC A. & ZAJĄC M. 2001*
Beckmannia eruciformis Host.	Poaceae	H	G/V	w	ane egz anthr	se. rh.	–	Eur E & S, Asia W	I [FD] →UI	1837	1837	south-western Poland: Wrocław & Bolesławiec (SCHNEIDER 1837)	2	4	9	64	57	2(+1)	SH		HULTEN 1964; HULTEN & FRIES 1986; *FREY & PASZKO 2000*; *ZAJĄC A. & ZAJĄC M. 2001*
Bidens connata H. L. Mühl. [= *B. connatus* H. L. Mühl.]	Asteraceae	T	G	i s	egz hyd	se.	*CR*	Am N [E]	I [B] / UI [W, S]	1865[2, 14]	*ca.*1874 1895	Bydgoszcz (TRZCIŃSKA-TACIK 1971a)	0	8	22	148	114	3(+1)	NH		MEUSEL *et al.* 1992; *TOKARSKA-GUZIK 2001b* (13)
Bidens frondosa L. [= *B. melanocarpus* Wiegand]	Asteraceae	T	G	i s	egz hyd	se.	*CR*	Am N [N]	UI [W, S] / I [B]	1736[2] see also Chapter 7	1777 1869	Wrocław (KROCKER 1790); Wielkopolska Lake District: Słubice (Brand after SCHUMACHER 1942)	0	4	60	3142	1068	4(+2)	NSH	Eur C [rip.]	MEUSEL *et al.* 1992; WALTER & STRAKA 1970; *TRZCIŃSKA 1961*; *ZAJĄC A. & ZAJĄC M. 2001*
Bromus carinatus Hook & Arn.	Poaceae	T H	G	w	ane egz anthr	se.	–	Am N	I [C, A]	1912 1934[5]	1911	Wielkopolska Lake District: Torzym (DECKER 1911)	0	0	3	1130	404*	3–4 (+2)	NH		*ZAJĄC A. & ZAJĄC M. 2001*
Bryonia alba L.	Cucurbitaceae	H li	G/V	i	end hyd anthr	fr. st.	*C*	Eur E & Asia W	I [O, M]	Ar[5, 10]	XVII [I] 1824	XVIII – KLUK (1786) – only as cultivated plant; Mazowsze Lowland: Wyszogród (ZALEWSKI 1892 after Gawarecki 1824)	8	115	169	1328	728	3–4 (+1)	NSH	Czech Rep.	MEUSEL *et al.* 1992; *ZAJĄC A. & ZAJĄC M. 2001*
Bryonia dioica Jacq. [= *B. cretica* L. subsp. *dioica* (Jacq.) Tutin]	Cucurbitaceae	H li	G/V	i	end hyd anthr	fr. st.	*C*	Eur S & W	I [B, O]	1820[10] Ar[5]	1847	West Pomerania: Pomoc near Chojnice (HAUB 1847 ATPOL sources)	1	4	13	116	77	2–3 (+/–)	H		MEUSEL *et al.* 1992; *TOKARSKA-GUZIK 2001*b (14)
Bunias orientalis L.	Brassicaceae	H	G/V	i s	ane egz aut anthr	se. ro.	*C*	Eur SE & Asia W	UI [FD, G]	1720[12] Russia W; 1814[52] 1856[5, 7] 1867[10] see also Chapter 7	1858	Gdańsk (Klinsmann *herb.* **TRN**)	0	49	120	1353	567	3–4 (+2)	SH	Czech Rep. & Slovac Rep.	MEUSEL *et al.* 1965; HULTEN & FRIES 1986; *TOKARSKA-GUZIK 2001b* (15)

Name of species	Family	LF	R	P	Disp	Prop	LS	Origin	Way of INT	First record for Europe+	First record for Poland	The oldest locality in Poland & source of data	Nrs of loc. up to 1850	Nrs of loc. up to 1900	Nrs of loc. up to 1950	Nrs of loc. up to 2000	Nrs of sq.	Dyn	Hab.	Inv. elsewhere	Maps
Cardaria draba (L.) Desv. [= *Lepidium draba* L.]	Brassicaceae	G H	G/V	i s	aut ane egz anthr	se. ro.	*CSR*	Eur SE & Asia SW	UI [G, FD]/ I [O]	1652 ?[13] 1675[23] 1728[12, 23] 1829[8] Ar[5]	1837	Sudety Mts.: Bolesławiec (SCHNEIDER 1837)	2	44	174	1048	576	3–4 (+2)	SH	Czech Rep.	MEUSEL *et al.* 1965; HULTEN & FRIES 1986; *TOKARSKA-GUZIK 2001b* (16)
Centaurea diffusa Lam.	Asteraceae	T H	G	i s	ane egz anthr	se.	*CSR*	Eur SE & Asia SW	UI [BA, G]	1876[2]	1878	Silesian Upland: Szczakowa (Unverricht *herb.* **KRA**)	0	3	12	178	89	2–3 (+1)	SH		MEUSEL *et al.* 1992; *TOKARSKA-GUZIK 2001b* (17)
Chaerophyllum aureum L.	Apiaceae	H	G/V	i	egz	se.	*C*	Eur C & S	UI [RW]		1809 ? 1994	Dukla (Besser ?); Beskidy Mts.: Szczawne (OKLEJEWICZ 1999)	0	0	0	12	6	1(+1)	NH		*OKLEJEWICZ 1999, 2001*
Chamomilla suaveolens (Pursh) Rydb. [= *Matricaria discoidea* DC.]	Asteraceae	T	G	i s	ane egz end anthr	se.	*R*	Am N & Asia E	UI	1782[56] 1850[14] 1851[5] 1852[10] see also Chapter 7	XVII ? 1862	Wrocław (Uechtritz *herb.* **WRSL**; Knebel *herb.* **WU**)	0	72	254	13125	2965	5(+2)	H	Eur C	HULTEN 1971; MEUSEL *et al.* 1992; *ZAJĄC A. & ZAJĄC M. 2001*
Chenopodium aristatum L.	Chenopodiaceae	T	G	w	ane	se.	–	Eur E, Asia C & E	UI [S]		1941	Szczecin (TRZCIŃSKA-TACIK 1992)	0	0	1	3	3	1(?)	H	Hungary	*GŁAZEK, MIREK & POŁOŃSKA 1985*; *ZAJĄC A. & ZAJĄC M. 2001*
Chenopodium botrys L.	Chenopodiaceae	T	G	w	ane hyd	se.	*R*	Asia C	I / UI	Ar[5]	1613* 1829 1837	* – general information (after SYREŃSKI 1613); Lublin Upland: Horodło (WAGA 1847)	4	26	34	70	49	2(+/–)	H		HULTEN 1971; JALAS & SUOMINEN 1980; HULTEN & FRIES 1986; *TOKARSKA-GUZIK 2001b* (18)
Chenopodium strictum Roth [= *Ch. album* L. subsp. *striatum* (Krašan) Murr]	Chenopodiaceae	T	G	w	ane hyd	se.	*CR*	Asia C	UI	XIX[24] 1939[10]	1891	Toruń (ABROMEIT *et al.* 1926)	0	1	1	896	256	3(+/–)	H	Hungary	*PAŚNIK 2001***
Chenopodium suecicum Murr	Chenopodiaceae	T	G	w	ane hyd	se.	*CR*	Am N, Eur N, Asia N	UI		1827	Mazury Lake District: Dobre Miasto (ATPOL sources: SEYDLER 1827)					96	2–3 (+/–)	H		JALAS & SUOMINEN 1980; HULTEN & FRIES 1986; *PAŚNIK 2001***
Clematis vitalba L.	Ranunculaceae	N li	G	i	ane egz anthr	se.	*C*	Eur C [m], Asia W & Afr NW	I [O]	1663 [I][25] 1883[25] see also Chapter 7	1613* XVIII 1847	* – general information (after SYREŃSKI 1613); XVIII – KLUK (1786) – as cultivated plant; Lublin Upland: Kazimierz (WAGA 1847)	1	20	43	354	216	3(+I)	NH	New Zealand	MEUSEL *et al.* 1965; HEGI 1974; JALAS & SUOMINEN 1989; *TOKARSKA-GUZIK 2001b* (19)
Conyza canadensis (L.) Cronquist [= *Erigeron canadensis* L.]	Asteraceae	T H	G	i s	ane egz	se.	*CR*	Am N [N]	UI [S]	1646[2, 14]	1730 1825 1837	Warszawa (SUDNIK-WÓJCIKOWSKA 1987a after Erndtel 1730); around Gdańsk (REYGER 1825); south-western Poland: Bytom Odrzański, Oława, Wołów (SCHNEIDER 1837)	8	108	196	11601	2929	5(+2)	H	Eur C [urb. & agr.]	HULTÉN 1971; HULTÉN & FRIES 1986; MEUSEL *et al.* 1992; *ZAJĄC A. & ZAJĄC M. 2001*
Corydalis lutea (L.) DC. [= *Pseudofumaria lutea* (L.) Borkh.]	Fumariaceae	H	G	i	myr	se.	*CSR*	Eur C [Alps]	I [B, O]	*ca.*2/2 XVIII[10] 1884 1886[5]	1884	Sudety Mts.: Bożejów (SCHUBE 1903b)	0	1	5	29	26	2(–1)	H		MEUSEL 1943; JALAS & SUOMINEN 1991; *TOKARSKA-GUZIK 2001b* (20)
Crepis aurea (L.) Cass.	Asteraceae	H	G	i s	ane egz myr	se.	–	Eur C [Alps]	UI [AN]		XIX / XX 1995	West Tatra Mts.: Stoły Clearing (MIREK 1995)	0	0	0	1	1	1(?)	N		*ZAJĄC A. & ZAJĄC M. 2001*
Cymbalaria muralis P. Gaertn., B. Mey. & Scherb. [= *Linaria cymbalaria* (L.) Mill.	Scrophulariaceae	Ch H	G/V	i	aut ane anthr	se. fr.	*CSR*	Eur S	I [O] →UI	1640[8] Ar ? see also Chapter 7	1837	Sudety Mts.: Zgorzelec, Bolesławiec (SCHNEIDER 1837	3	62	181	350	165	3(–1)	H		MEUSEL *et al.* 1978; *ZAJĄC E. U. & ZAJĄC A. 1973*; *ZAJĄC A. & ZAJĄC M. 2001*
Datura stramonium L.	Solanaceae	T	G	i s	ane egz anthr	se. fr.	*CR*	Am N [SE] Asia ?	I [C] →UI [W, BS, SB]	1584[2]	1613* 1652 1825 1837	* – general information (after SYREŃSKI 1613); Warszawa (SUDNIK-WÓJCIKOWSKA 1987a); XVIII – KLUK (1786); Oliwa (REYGER 1825); Silesian Lowland: Oława, Wołów & Bytom Odrzański (SCHNEIDER 1837)	6	128	205	1881	1044	4(+/–)	H	some part of Eur C & S	HULTEN 1971; HULTÉN & FRIES 1986; MEUSEL *et al.* 1978; *ZAJĄC A. & ZAJĄC M. 2001*

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Digitalis purpurea L.	Scrophulariaceae	H T	G	i s	ane anthr	se. ros.	*CR*	Eur W	I [O, M] →UI [S]	1790[5] see also Chapter 7	1809 ? 1862	around Kraków (Besser 1809); Beskidy Mts.: Klimczok (Kolbenheyer 1862)	5	24	59	341	169	3(+1)	NSH	Czech Rep.	Meusel *et al.* 1978; Hulten & Fries 1986; *Cynuel 1965*; *Hantz 1993*; *Zając A. & Zając M. 1997, 2001*
Diplotaxis muralis (L.) DC.	Brassicaceae	T H	G	i s	ane	se.	*CSR*	Eur S & W [Afr.]	UI [BA, G]	XVIII[15] 1827[57] 1842 Ar[5]	1851	Poznań (Ritschl 1851)	0	31	133	2049	991	4(+1)	H		Hulten & Fries 1986; *Tokarska-Guzik 2001b* (21)
Diplotaxis tenuifolia (L.) DC.	Brassicaceae	Ch H	G	i s	ane	se.	*CR*	Eur S & W [Asia, Afr.]	UI [BA, G]	1597[12] England 1768[2] Eur C Ar[5]	1652 1836	Warszawa (Sudnik-Wójcikowska 1987a); Gdańsk (Klinsmann 1836)	1	36	70	497	245	3(+1)	SH		Meusel *et al.* 1965; Hulten & Fries 1986; *Tokarska-Guzik 2001b* (22)
Echinocystis lobata (F. Michx.) Torr. & A. Gray	Cucurbitaceae	T li	G	i	end	se. fr. pl.	*CR*	Am N [E]	I [O]	1904[14, 43] see also Chapter 7	1937	Wielkopolska Lake District: Gubin (Lademann 1937)	0	0	7	2047	708	3–4 (+2)	NSH	Czech Rep. & Slovac Rep. [rip.], Hungary	Meusel *et al.* 1992; *Tokarska-Guzik 2001b* (23)
Echinops exaltatus Schrad. [= *E. commutatus* Jur.]	Asteraceae	H	G	i s	egz ane	se.		Eur E & Asia W	I [C, O]	1897 1995[10]	1897	Chrośle near Nowe Miasto Lubawskie (Karslen *herb.* **TRN**)	0	1	1	9	9	1(?)	SH		Meusel *et al.* 1992; *Zając A. & Zając M. 2001*
Echinops sphaerocephalus L.	Asteraceae	H	G	i s	egz ane myr anthr	se.	*C*	Eur E & Asia W	I [C, O]	1613 1652 1809 Ar[2] see also Chapter 7	XVI 1613* 1652 1809	* – general information (after Syreński 1613); Warszawa (Sudnik-Wójcikowska 1987a); Kraków (Besser 1809)	1	25	99	910	489	3(+1)	SH	Czech Rep.	Meusel *et al.* 1992; *Zając A. & Zając M. 2001*
Elodea canadensis Michx.	Hydrocharitaceae	Hy	V		aut hyd egz anthr	pl.		Am N	UI [BA] / I [B, O]	1836[8, 27] see also Chapter 7	1867	Gdańsk (Abromeit *et al.* 1898)	0	140	226	3681	1847	4(+1)	NSH	Eur C [water]	Hulten 1964; Hulten & Fries 1986; *Zając A. & Zając M. 1992, 2001*
Elsholtzia ciliata (Thunb.) Hyl. [= *E. patrini* (Lepech.) Garcke]	Lamiaceae	T	G	i	ane end myr anthr	se.	*R*	Asia E	I [M] →UI	1830[58] 1847 1853[5] see also Chapter 7	1829 ? 1847	Warszawa (Sudnik-Wójcikowska 1987a; Waga 1847)	1	79	147	1352	814	3–4 (+/–)	H		*Świeboda 1963*; *Tokarska-Guzik 2001b* (24)
Epilobium ciliatum Raf. [= *E. adenocaulon* Hausskn.]	Onagraceae	H	G	is	ane	se.	*C*	Am N [N]	UI [S]	1891[2, 16]	1917	Białowieża Forest (Rubner 1917)	0	0	1	1224	470	3–4 (+1)	NSH	Czech Rep.	Meusel *et al.* 1978; Hulten & Fries 1986; *Zając A. & Zając M. 2001*
Eragrostis albensis H. Scholz	Poaceae	T	G	w	ane egz hyd	se.		unclear	UI				0	0	3	301	50	2–3 (+1)	NH		*Sudnik-Wójcikowska & Guzik 1996*; *Zając A. & Zając M. 2001*
Eragrostis minor Host	Poaceae	T	G	w	ane egz	se.	*R*	Eur SE & Asia W	UI [W, FD, BS]	1819[10] Ar[8] see also Chapter 7	1838	Wrocław Gajowice (Wimmer 1868; Fiek 1881)	1	13	96	1041	581	3–4 (+2)	H	Eur C [urb.]	*Tokarska-Guzik 2001b* (25)
Eragrostis multicaulis Steud.	Poaceae	T	G	w	ane egz	se.		Asia E & SE	UI [B]	1824[26]	1879	Wrocław (Knebel 1879)	0	1	1	4	4	1(?)	H		*Guzik & Sudnik-Wójcikowska 1994*; *Zając A. & Zając M. 2001*
Erechtites hieracifolia (L.) Raf. ex DC.	Asteraceae	H	G	i	ane	se.		Am N & S [N]	UI [S]	1700[2]	1902	Silesian Lowland: Prószków (Schube 1902)	0	0	32	124	73	2–3 (+1)	NSH	Hungary	Croizat 1952; Meusel *et al.* 1992; *Czarna, Górski & Tokarska-Guzik 2001*; *Górski, Czarna & Tokarska-Guzik 2003*
Erigeron annuus (L.) Pers.	Asteraceae	H T	G	i s	ane egz myr	se.	*C*	Am N [N]	I [O, B] →UI	1700[2, 14]	1830	Silesian Lowland: Nowa Karczma upon Odra river (Fiek 1881)	2	65	149	3557	1133	4(+2)	SH	Hungary	Meusel *et al.* 1992; *Zając A. & Zając M. 2001*

Name of species	Family	LF	R	P	Disp	Prop	LS	Origin	Way of INT	First record for Europe*	First record for Poland	The oldest locality in Poland & source of data	Nrs of loc. up to 1850	Nrs of loc. up to 1900	Nrs of loc. up to 1950	Nrs of loc. up to 2000	Nrs of sq.	Dyn	Hab.	Inv. elsewhere	Maps
Erigeron ramosus (Walters) Britton, Sterns & Poggenb. [= *E. annuus* (L.) Pers. subsp. *strigosus* (Muhl. ex Willd.) Wagenitz]	Asteraceae	H T	G	i s	ane egz myr	se.		Am N [N]	I [O] →UI	XVIII / XIX[24]	1888	Silesian Lowland: Opole (Schube *herb.* **WRSL**)	0	1	28	849	408	3(+1)	SH	Hungary	*Zając A. & Zając M. 2001*
Erysimum wahlenbergii (Asch. & Engl.) Borbás	Brassicaceae	H	G	i s	aut ane	se.		Eur C [Carp.]	UI		1974	Tatry Mts.: near Murowaniec shelter (Piękoś & Mirek 1974)	0	0	0	1	1	1(?)	S		*Zając A. & Zając M. 2001*
Euphorbia humifusa Willd.	Euphorbiaceae	T	G	i	aut myr	se.	*R*	Asia E	UI [B]	1813[22]	1846	Kraków (Rostański 1992)	1	7	13	18	8*	1(+/–)	H		Meusel *et al.* 1978
Galinsoga ciliata (Raf.) S.F. Blake [= *G. quadriradiata* Ruiz & Pav.]	Asteraceae	T	G	i s	ane egz myr anthr	se.	*CR*	Am C [m] Am S ?	I [B] / UI [B, G]	1853[14] 1866[2]	1876	Silesian Lowland: Wrocław (Knebel *herb.* **WU**), Głogówek (Richter *herb.* **MGS**)	0	7	97	6777	2021	4–5 (+2)	H	Eur C [agr. & urb.]	Hulten & Fries 1986; Meusel *et al.* 1992; *Zając A. & Zając M. 2001*
Galinsoga parviflora Cav.	Asteraceae	T	G	i s	ane egz myr antr	se.	*CR*	Am S & C [m]	I [B] / UI [B, G]	1798[2]	1807 1863	Budowo near Słupsk (Thellung 1915); Wrocław (Uechtritz *herb.* **WRSL**)	1	135	253	10932	2726	5(+2)	H	Eur C [arg. & urb.]	Hulten & Fries 1986; Meusel *et al.* 1992; *Zając A. & Zając M. 2001*
Genistella sagittalis (L.) Gams in Hegi [= *Genista sagittalis* L., *Chamaespartium sagittale* (L.) P. E. Gibbs]	Fabaceae	Ch	G	i	aut	se.	*CS*	Eur W & S	UI [S?]	1928[5]	1929	Carpathian Foothills: Tryncza near Przeworsk (Nowiński 1929)	0	0	1	11	11	1(?)	NS		Hegi 1924; Meusel *et al.* 1965; *Kaźmierczakowa & Tumidajowicz 1981*; *Tokarska-Guzik 2001b* (26)
Geranium divaricatum Ehrh.	Geraniaceae	T	G	i s	aut egz	se.	*R*	Eur S & Asia W	UI	Ar[10]	1840	Silesian Lowland: near Wrocław (Wimmer 1841)	2	36	55	71	38	2(+/–)	H		*Tokarska-Guzik 2001b* (27)
Geranium pyrenaicum Burm. f.	Geraniaceae	H	G	i s	aut egz	se.	*CSR*	Eur S	UI / I	1762[10, 16]	1837	Sudety Mts.: Bolesławiec (Schneider 1837)	1	46	220	682	396	3(+1)	SH	Czech Rep.	Meusel *et al.* 1978; Hulten & Fries 1986; *Ciaciura et al. 2001a, b*
Geranium sibiricum L.	Geraniaceae	H	G	i s	aut egz	se.	*C*	Eur E, Asia W & E	UI / I	1840	1840	Sudety Foothills: near Dzierżoniów (Fiek 1881)	2	4	7	24	20	2(+1)	H		Meusel *et al.* 1978; *Mirek 1981b*; *Zając A. & Zając M. 2001*
Glyceria striata (Lam.) Hitch.	Poaceae	H	G/V	w	hyd egz	se. rh.		Am N	UI	2/2 XX[24] 1956[59]	1989	Sieraków (Babczyńska-Sendek & Sendek 1989)	0	0	0	3	3	1(+1)	S		*Zając A. & Zając M. 2001*
Helianthus decapetalus L.	Asteraceae	G	V/G	i s	ane egz myr anthr	se. rh.		Am S	I [O]	XX[10] 1910[43]	1956	Szczecin (Scheuermann 1956)	0	0	0	19	18	1(+1)	H		*Tokarska-Guzik 2001b* (28)
Helianthus laetiflorus Pers. [= *H. rigidus* x *tuberosus*]	**H** Asteraceae	G	V/G	i s	ane egz myr anthr	se. rh.	*C*	Anthro-pog.	I [O]	XX[10] 1959[43]	1969	Wrocław (Rostański K. 1969)	0	0	0	26	18	1–2 (+1)	H		*Tokarska-Guzik 2001b* (29)
Helianthus tuberosus L.	Asteraceae	G	V/G	i s	ane egz myr anthr	se. rh.	*C*	Am N	I [O, C, FO, M]	1627[2]	1730 ? 1872	near Warszawa (after Sudnik-Wójcikowska 1987a); XVIII – Kluk (1787) – only as cultivated plant; Wielkopolska Lowland: Kłódno (Rostafiński 1872)	0	7	30	1416	778	3–4 (+2)	NSH	some regions of Eur C	Meusel *et al.* 1992; *Zając A. & Zając M. 2001*
Helleborus viridis L.	Ranunculaceae	H	G	i	myr	se.	*CS*	Eur C & W	I [O]	XVIII[10] 1819[5]	1868	south-western Poland: Głubczyce, Strzelniki, Nowaki near Nysa (Wimmer 1868)	0	17	30	30	26	2(–2)	NH		*Zając A. & Zając M. 2001*
Heracleum mantegazzianum Sommier & Levier[1]	Apiaceae	H	G	i s	ane hyd egz anthr	se.	*C*	Asia C & E	I [O]	1862[5]	1973	Baltic Coast: near Gryfino & Pyrzyce (Ćwikliński 1973)	0	0	0	100	74 146*	2–3 (+2)	NSH	Eur W, C & N [rip. & urb.]	*Tokarska-Guzik 2001b* (30)*
Heracleum sosnowskyi Manden.[1]	Apiaceae	H	G	i s	ane hyd egz anthr	se.		Asia SW [Cauc.]	I [C]	2/2 XX[24]	1980	West Pomerania: Strzelce Dolne near Bydgoszcz (Rutkowski unpubl.)	0	0	0	96	72 146*	2(+2)	NSH	Hungary	*Tokarska-Guzik 2001b* (30)*

Name of species	Family	LF	R	P	Disp	Prop	LS	Origin	Way of INT	First record for Europe+	First record for Poland	The oldest locality in Poland & source of data	Nrs of loc. up to 1850	Nrs of loc. up to 1900	Nrs of loc. up to 1950	Nrs of loc. up to 2000	Nrs of sq.	Dyn	Hab.	Inv. elsewhere	Maps
Hesperis matronalis L.	Brassicaceae	H	G	i s	ane	se.	*CS*	Eur S	I [O]	XVI[2] 1791[57] 1817[5]	XVII [I] 1613* 1837	* – general information (after Syreński 1613); XVIII – Kluk (1787) – as cultivated plant; Sudety Mts.: Bolesławiec & Kup (Schneider 1837)	2	43	69	724	510	3(+1)	NSH		Hulten & Fries 1986; *Zając A. & Zając M. 2001*
Hyssopus officinalis L.	Lamiaceae	Ch	G	i	ane end myr	se. ro.	*CS*	Eur S & SE, Asia SW & C	I [M, C]	(1594)[2] 1819[5] 1829[2]	XVII[I] 1613* 1859	* – general information (after Syreński 1613); XVIII – Kluk (1787) – only as cultivated plant; Carpathian Foothills: Tyniec (Berdau 1859)	0	20	45	69	59	2(–1)	SH		*Tokarska-Guzik 2001b* (31)
Impatiens capensis Meerb.	Balsaminaceae	T	G	i	aut	se.		Am N	UI [BA]	1822[28]	1991	Baltic Coast: Trzebieradz, Trzebież & Police (Pawlaczyk & Adamowski 1991)	0	0	0	3	3	1(?)	N		Meusel *et al.* 1978; Hulten & Fries 1986; *Pawlaczyk & Adamowski 1991*; *Zając A. & Zając M. 2001*
Impatiens glandulifera Royle [= *I. roylei* Walp.]	Balsaminaceae	T	G	i	aut ane end hyd	se.	*C*	Asia C [Himal.]	I [O, M]	1839 [I][53, 44] 1845 [I][2, 44] 1855[54, 44] see also Chapter 7	1890	Sudety Mts.: Siodło, Płóczki Dolne, Stępnica & Płonina (Schube 1903b)	0	9	38	1574	675	3–4 (+2)	NSH	Eur W & C [rip.]	*Zając E. U. & Zając A. 1973*; *Tokarska-Guzik 2001b* (32)
Impatiens parviflora DC.	Balsaminaceae	T	G	i	aut ane end hyd	se.	*SR*	Asia C & E	I [B] →UI	1834[16] Russia 1837[2, 16] see also Chapter 7	1850 1857	near Gdańsk (Meusel *et al.* 1978); near Kraków (Ullepitsch *herb.* **B**)	0	54	136	6730	1681	4–5 (+2)	NSH	Eur C [decidoues forests]	Meusel *et al.* 1978; Hulten & Fries 1986; *Zając A. & Zając M. 2001*
Inula helenium L.	Asteraceae	H	G/V	i s	ane egz myr	se. rh.	*C*	Eur E, Asia W & C	I [O, M]	1819[5]	XVI ? 1613* XVIII 1837	XVI? Zając A. *et al.* 1998; * – general information (after Syreński 1613); XVIII – Kluk (1787); Sudety Mts.: Jedlina Zdrój & Wołów (Schneider 1837)	2	82	168	416	273	3(+1)	NSH		Meusel *et al.* 1992; *Zając A. & Zając M. 2001*
Iva xanthiifolia Nutt.	Asteraceae	T	G	w	ane egz myr	se.	*CR*	Am N	UI [B, G, SB]	1842[14] 1858[7] Germany	1928	Gdańsk (Preuss 1928)	0	0	2	294	150	3(+/–)	H	Eur S (warm regions) [agr.]	Meusel *et al.* 1992; *Guzik & Sudnik-Wójcikowska 1989*; *Zając A. & Zając M. 2001*
Juncus tenuis Willd. [= *J. macer* A. Gray]	Juncaceae	H	G	w	egz	se.	*CSR*	Am N	UI	1795[8]	1862	Sudety Mts.: near Zgorzelec (Uechtritz *herb.* **W**)	0	37	206	5332	1440	4–5 (+1)	SH	Czech Rep.	Hulten 1958; Meusel *et al.* 1965; Hultén & Fries 1986; *Zając A. & Zając M. 2001*
Kochia scoparia (L.) Schrad.	Chenopodiaceae	T	G	w	ane anthr	se.	*CR*	Eur E & Asia W	I [O, C] →UI [G, W, BA]	XVIII[7] 1811[7] 1819[5]	1872	Carpathian Foothills: Sokolniki (Knapp 1872)	0	6	35	422	244	3(+1)	H	Czech Rep. & Slovac Rep. [agr.]	Hulten 1971; *Tokarska-Guzik 2001b* (33)
Lathyrus nissolia L.	Fabaceae	T	G	i	aut	se.	*CR*	Eur S & W	UI	1903 1921[10]	1903	Wrocław and surroundings (Schube 1903b)	0	0	13	18	16	1(–1)	NS		Meusel *et al.* 1965; *Zając A. & Zając M. 2001*
Lemna turionifera Landolt	Lemnaceae	Hy	G/V	i	hyd egz	pl.		Am N	UI [AN, BA]	1983[2]	1994	east & north-east Poland (Wolff & Landolt 1994)	0	0	0	21	21	2(+1)	NS		*Wolff & Landolt 1994*; *Zając A. & Zając M. 2001*
Lepidium densiflorum Schrad.	Brassicaceae	T	G	i s	ane anthr	se.	*R*	Am N	UI [BS, W, G]	1883[10] 1904[5]	1888	Mazury Lake District: between Korpele and Sawica near Szczytno (Abromeit *et al.* 1898)	0	4	67	1259	724	3–4 (+1)	H		Meusel *et al.* 1965; Hulten & Fries 1986; *Tokarska-Guzik 2001b* (34)
Lepidium virginicum L.	Brassicaceae	T	G	i s	ane anthr	se.	*R*	Am N [E]	UI [W, BS, G]	1697[12]	1860	Baltic Coast: Międzyzdroje (Holzfuss 1937)	0	3	20	238	146	3(+/–)	H		Meusel *et al.* 1965; Hulten & Fries 1986; *Tokarska-Guzik 2001b* (35)
Linaria repens (L.) Mill. [= *L. striata* Lam. & DC.]	Scrophulariaceae	G	G	i	ane	se.	*CS*	Eur W	UI / I	1825	1825	Gdańsk Westerplatte (Schwarz 1967 after Klinsmann 1825)	1	3	7	31	26	2(+1)	H		Meusel *et al.* 1978; Hulten & Fries 1986; *Wąsowicz 2001, 2003*

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Lolium multiflorum Lam.	Poaceae	H T	G	w	ane egz	se.	*C*	Eur S & W, Afr N & Asia SW	I [FD, C]	1837 1883[5]	1837	Sudety Mts.: Bolesławiec (SCHNEIDER 1837)	1	11	37	2792	1174	4(+1)	SH		HULTÉN 1964; HULTÉN & FRIES 1986; *ZAJĄC A. & ZAJĄC M. 2001*
Lupinus polyphyllus Lindl.	Fabaceae	H	G	i	aut	se.	*C*	Am N [W]	I [O, FO, C]	1877 1895[5]	1877	Silesian-Cracow Upland: Nieporaz, Carpathian Foothills: Lucjanowice (KRUPA 1877)	0	7	55	2674	1387	4(+1)	NSH	Czech Rep. Lithuania	*ZAJĄC A. & ZAJĄC M. 2001*
Lycium barbarum L. [= *L. halimifolium* Mill.]	Solanaceae	N	G/V	i s	end	se. rh.	*C*	Asia E, Eur SE	I [O]	1769 [I][25] 1839[2] [25] 1870[5]	1847 [I] 1862	[I] as ornamental plant (WAGA 1847); West Pomerania: Świecie; Chełmno and sourrandings (*herb.* TRN WACKER 1862)	0	54	80	2634	1224	4(+1)	NSH	Czech Rep.	MEUSEL *et al.* 1978; *ZAJĄC A. & ZAJĄC M. 2001*
Lysimachia punctata L.	Primulaceae	H	G/V	i s	aut	se. rh.	*C*	Eur SE	I [O]	1819[5]	1870	Grudziądz (ABROMEIT *et al.* 1926)	0	11	36	61	45	2(+1)	SH		*TOKARSKA-GUZIK 2001b* (36)
Malva moschata L.	Malvaceae	H	G	i s	ane egz	se.	*C*	Eur W	I [O] →UI	Ar[10]	XVIII 1885	XVIII – KLUK (1787); Mazowsze – Podlasie Lowlands: Płońsk (PACZOSKI 1895)	0	12	102	286	196	3(+/–)	H		MEUSEL *et al.* 1978; HULTEN & FRIES 1986; *TOKARSKA-GUZIK 2001b* (37)
Marrubium vulgare L.	Lamiaceae	Ch H	G	i s	egz ane	se.	*CSR*	Eur S, Asia SW & Afr N	I [M] →UI	Ar[5, 10]	XVI 1613* 1643 1824	XVI ZAJĄC A. *et al.* 1998; * – general information (after SYREŃSKI 1613); Gdańsk 1643 (SCHWARZ 1967 after Oelhaf); XVIII – KLUK (1787); Mazowsze Lowland: Wyszogród (ZALEWSKI 1892 after Gawarecki 1824)	7	147	255	453	315	3(–1)	SH		MEUSEL *et al.* 1978; HULTÉN & FRIES 1986; *TOKARSKA-GUZIK 2001b* (38)
Medicago sativa L. s. str. [= *M. sativa* L. subsp. *sativa*]	Fabaceae	H	G	i	ane egz anthr	se.	*C*	Asia SW [Cauc.]	I [FD]	XVI[29] 1819[5]	XVI ? 1832 1837	Westerplatte (SCHWARZ 1967 after Klinsmann); south-western Poland: Bytom Odrzański, Oława, Kup & Jedlina Zdrój (SCHNEIDER 1837)	5	23	83	5412	1743	4–5 (+1)	SH		*ZAJĄC A. & ZAJĄC M. 2001*
Medicago varia Martyn **H**	Fabaceae	H	G	i	ane egz anthr	se.	*C*	Anthro-pog.	I [FD] →UI	XIX[15]	1837	Wrocław (SCHNEIDER 1837)	1	60	86	1132	409	3–4 (+1)	SH		**original**: see App. C
Melilotus wolgica Poir. in Lam. [= *M. volgicus* Poir.]	Fabaceae	T H	G	i	aut	se.		Eur E & Asia W	UI [G]	1937	1937	Szczecin Golęcino (HOLZFUSS 1937)	0	0	2	13	10	1(+1)	H		*TOKARSKA-GUZIK 2001b* (39)
Mercurialis annua L.	Euphorbiaceae	T	G	w i	aut myr	se.	*R*	Eur SW	UI [B, BA]	1767[16] Ar[5, 10]	XVI 1825	XVI ZAJĄC A. *et al.* 1998; XVIII – KLUK (1787); Gdańsk (ROSTAŃSKI K. 1992)	2	44	94	143	87	2–3 (–1)	H		MEUSEL *et al.* 1978; HULTEN & FRIES 1986; *TOKARSKA-GUZIK 2001b* (40)
Mimulus guttatus DC.	Scrophulariaceae	H Hy	G/V	i	ane hyd	se. rh.	*CS*	Am N [W]	I [O]	1824[2] 1853[5] see also Chapter 7	1824	Sudety Mts.: Kowary (FIEK 1881; ?? *herb.* **WRSL**)	1	54	173	326	128	3(+2)	NS		MEUSEL *et al.* 1987; HULTÉN & FRIES 1986; *PIĘKOŚ 1972*; *TOKARSKA-GUZIK 2001b* (41)
Mimulus moschatus Douglas ex Lindl.	Scrophulariaceae	H	G/V	i	ane hyd	se. rh.	*CS*	Am N [W]	I [O]	1868[5]	1879	Baltic Coast: Oliwa (Lutzow *herb.* **TRN**)	0	3	10	13	11	1(+1)	NS		*PIĘKOŚ 1972*; *TOKARSKA-GUZIK 2001b* (42)
Myrrhis odorata (L.) Scop.	Apiaceae	H	G	i s	egz ane	se.	*C*	Eur C [Alps]	I [C, M]	XVI [I][10] 1809[5]	1837	Sudety Mts.: Bolesławiec, Jedlina Zdrój, Kup (SCHNEIDER 1837)	3	10	68	119	76	2–3 (+1)	NSH		MEUSEL *et al.* 1978; HULTÉN & FRIES 1986; *ZAJĄC A. & ZAJĄC M. 2001*
Oenothera acerviphila Rostański **H** [probabl.= *Oe. depressa* x *ammophila*]	Onagraceae	H	G	i s	ane aut	se.		Anthro-pog.	UI		1979	Silesia Upland: Brzezinka near Mysłowice town (Rostański *herb.* **KTU**)	0	0	0	2	2	1 (?)	H		*ROSTAŃSKI K. 2001b*
Oenothera canovirens E.S. Steele [= *Oe. renneri* H. Scholz]	Onagraceae	H	G	i s	ane aut	se.	*CR*	Am N		1907[51] 1953[5]	1958	Wrocław (Rostański *herb.* **KTU**)	0	0	0	42	26	2(+1)	H		*ROSTAŃSKI K.& TOKARSKA-GUZIK 1998, 2001*
Oenothera cruciata Nutt. ex G. Don [= *Oe. atrovirens* auct. Europ.]	Onagraceae	H	G	i s	ane aut	se.		Am N [E]	I [B]	1826 [I][30] 1905[31]	1905	West Pomerania: Trzcianka (Bothe *herb.* **B**)	0	0	1	2	2	1(–1)	H		*ROSTAŃSKI K.& TOKARSKA-GUZIK 2001*

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Oenothera depressa Greene [= *Oe. salicifolia* Desf. ex G. Don *Oe. hungarica* Borbás]	Onagraceae	H	G	i s	ane aut	se.		Am N	I [B] →UI	XIX[2] 1835[51] 1936[5]	1894	Warszawa (Cybulski *herb.* **WA**)	0	1	3	643	274	3(+1)	SH		*Rostański K.& Tokarska-Guzik 1998, 2001*
Oenothera fallax Renner em. Rostański **H** [probabl.= *Oe. glazioviana* x *biennis*]	Onagraceae	H	G	i s	ane aut	se.		Anthro-pog.	I [B] →UI	1917[51] 1958 1961[5] 1967[32]	1958	Wrocław (Rostański *herb.* **KTU**)	0	0	0	11	9	1(+/–)	H		*Rostański K.& Tokarska-Guzik 1998, 2001*
Oenothera flaemingina Hudziok **H** [probably a hybrid orginated in Central Germany]	Onagraceae	H	G	i s	ane aut	se.		Anthro-pog.	UI	1968[63]	1994	Silesian Upland: Strzyżowice (Nowak *herb.* **KTU**)	0	0	0	31	31	2(+1)	H		*Rostański K. & Witosławski 2001*
Oenothera glazioviana Micheli in Mart. [= *Oe. erythrosepala* Borbás]	Onagraceae	H	G	i s	ane aut	se.	*CR*	Am N	I [B] →UI	XIX[2] 1864[55] 1866[30] 1890[5]	1879	Silesian Lowland: Sułków (Sintesis *herb.* **WRSL**)	0	1	6	29	23	2(+1)	H		*Rostański K. 2001b*
Oenothera hoelscheri Renner ex Rostański **H** [probabl.= *Oe. biennis* (or) *Oe. rubricaulis* x *depressa*]	Onagraceae	H	G	i s	ane aut	se.		Anthro-pog.	UI	1942 1970[32] 1975[5]	1942	Włocławek upon Vistula river (Renner 1942)	0	0	0	397	171	3(+1)	SH		*Rostański K. & Tokarska-Guzik 1998, 2001*
Oenothera issleri Renner ex Rostański **H** [probabl.=*Oe. biennis* x *oakesiana*]	Onagraceae	H	G	i s	ane aut	se.		Anthro-pog.	UI	1949[5]	1958	Wrocław (Rostański *herb.* **KTU**)	0	0	0	7	5	1(+/–)	H		*Rostański K. & Tokarska-Guzik 1998, 2001*
Oenothera jueterbogensis Hudziok [probabl.= *Oe. biennis* x ?] **H**	Onagraceae	H	G	i s	ane aut	se.		Anthro-pog.	UI	1962[51]	1973	Silesian Upland: Gliwice (Rostański K. & Szotkowski 1973)	0	0	0	6	4	1(+1)	H		*Rostański K. & Tokarska-Guzik 1998, 2001*
Oenothera oakesiana (A. Gray) J.W. Robbins ex S. Watson [= *Oe. syrticola* Bartlett]	Onagraceae	H	G	i s	ane aut	se.		Am N	I [B]	1614 [I][30, 32] 1962[5]	1962	Wrocław (Rostański *herb.* **KTU**); Mazowsze – Podlasie Lowlands: Wygoda near Janów Podlaski (Fijałkowski *herb.* **LBL**)	0	0	0	36	23	2(+1)	H		*Rostański K. & Tokarska-Guzik 1998, 2001*
Oenothera paradoxa Hudziok **H** [probabl. = *Oe. depressa* x *subterminalis*]	Onagraceae	H	G	i s	ane aut	se.		Anthro-pog.	UI	1967[51]	1974	Silesian Upland: Gliwice & Katowice (Celiński *et al.* 1974); Katowice & Siemianowice Śląskie (Michalak & Sendek 1974 –1975)	0	0	0	218	64	2–3 (+1)	H		*Rostański K. & Tokarska-Guzik 1998, 2001*
Oenothera parviflora L.	Onagraceae	H T	G	i s	ane aut	se.	*CR*	Am N	UI	1682 [I][55] 1768 [I][30] 1914[5]	1938	Wałbrzych (Renner 1938)	0	1	2	27	16	1–2 (+1)	H		Meusel *et al.* 1978; *Rostański K. & Tokarska-Guzik 1998, 2001*
Oenothera pseudochicaginensis Rostański **H** [probabl. = *Oe. subterminalis* x *biennis*]	Onagraceae	H	G	i s	ane aut	se.		Anthro-pog.	UI	1959	1959	Wrocław (Rostański *herb.* **KTU**)	0	0	0	7	6	1(+/–)	H		*Rostański K. & Tokarska-Guzik 1998, 2001*
Oenothera punctulata Rostański & Gutte **H** [probabl.= *Oe. pycnocarpa* x *biennis*]	Onagraceae	H	G	i s	ane aut	se.		Anthro-pog.	UI	1969[10] 1972[5]	1973	Silesian Lowland: Nysa, Silesian Upland: Gliwice (Rostański K. & Szotkowski 1973)	0	0	0	9	8	1(+/–)	H		*Rostański K. & Tokarska-Guzik 1998, 2001*
Oenothera pycnocarpa Atk & Bartl. in Bartl. [= *Oe. chicaginensis* De Vries ex Renner]	Onagraceae	T H	G	i s	ane aut	se.		Am N	UI	1958[32] 1960[5]	1963	Baltic Coast: Glinna near Gryfin (Rostański K. & Tokarska-Guzik 1998)	0	0	0	50	35	2(+1)	H		*Rostański K. & Tokarska-Guzik 1998, 2001*
Oenothera royfraseri R.R. Gates [= *Oe. turoviensis* Rostański]	Onagraceae	H	G	i s	ane aut	se.		Am N	UI	1963 1969[10]	1963	Sudety Mts.: Turoszów (Rostański *herb.* **KTU**)	0	0	0	22	14	1–2 (+/–)	H		*Rostański K. & Tokarska-Guzik 1998, 2001*
Oenothera suaveolens Desf. ex Pers.	Onagraceae	H	G	i s	ane aut	se.		Eur S ?	UI	1805[51]	1961	Wrocław, Brzózka Krośnieńska (Rostański *herb.* **KTU**)	0	0	0	6	6	1(?)	H		*Rostański K. 2001b*
Oenothera subterminalis R.R. Gates [= *Oe. silesiaca* Renner]	Onagraceae	H	G	i s	ane aut	se.		Am N	UI	1856[33]	1938	Silesian Lowland: Nowogród Bobrzański (Renner 1938)	0	0	1	220	91	2–3 (+1)	H		Meusel *et al.* 1978; *Rostański K. & Kloss 1965*; *Rostański K. & Tokarska-Guzik 1998, 2001*

Name of species	Family	LF	R	P	Disp	Prop	LS	Origin	Way of INT	First record for Europe	First record for Poland	The oldest locality in Poland & source of data	Nrs of loc. up to 1850	Nrs of loc. up to 1900	Nrs of loc. up to 1950	Nrs of loc. up to 2000	Nrs of sq.	Dyn	Hab.	Inv. elsewhere	Maps
Oenothera victorini R.R. Gates & Catches. in R.R. Gates [= *Oe. nissensis* Rostański]	Onagraceae	H	G	i s	ane aut	se.		Am N	UI	1961 1967[32] 1973[5]	1961	Silesian Lowland: Nysa (Rostański K. 1965)	0	0	0	49	22	2(+/–)	H		*Rostański K. & Tokarska-Guzik 1998, 2001*
Oenothera wienii Renner ex Rostański [probabl.= *Oe. rubricaulis* x *depressa*] **H**	Onagraceae	H	G	i s	ane aut	se.		Anthro-pog.	UI	1937	1937	Gdańsk-Stogi (Renner 1937)	0	0	0	116	74	2–3 (+1)	H		*Rostański K. & Tokarska-Guzik 1998, 2001*
Onobrychis viciifolia Scop. [= *O. viciaefolia* Scop.]	Fabaceae	H	G	i	egz	se.	*C*	Eur S & SE	I [FD]	XVI [I][10] 1837 1852[5]	1837	south-western Poland: Bytom Odrzański, Oława, Wołów (Schneider 1837)	3	140	323	911	452	3(+1)	NSH		*Zając A. & Zając M. 2001*
Ornithogalum boucheanum Asch.	Liliaceae	G	G	i	ane myr	se. ro.	*CSR*	Eur SE	I [O]	*ca.* XVI[I][10]	1880	Silesian Lowland: Głogówek (Richter *herb.* **MGS**)	0	3	24	36	29	2(–1)	SH		*Tokarska-Guzik 2001b* (43)
Oxalis corniculata L.	Oxalidaceae	T H	G/V	i s	aut anthr	se. rh.	*R*	Eur S Asia SW	UI [GA, B]	1576[34] 1852[5]	1863	Sudety Mts.: Zgorzelec (Hantz 1979)	0	25	42	128	84	2–3 (+1)	H	Hungary	Hulten 1971; Meusel *et al.* 1978; Hulten & Fries 1986; *Hantz 1979*; *Tokarska-Guzik 2001b* (44)
Oxalis dillenii Jacq.	Oxalidaceae	T H	G	i s	aut anthr	se.	*R*	Am N [E]	UI [B]	1865[34]	1865	Silesian Lowland: Wrocław (– *herb.* **WRSL** after Hantz 1979)	0	1	2	40	31	2(+1)	H		*Hantz 1979*; *Tokarska-Guzik 2001b* (45)
Oxalis fontana Bunge [= *O. stricta* L.]	Oxalidaceae	G	G/V	i s	aut anthr	se. rh.	*R*	Am N [E], Asia E ?	UI [P, GA, B]	1658[16, 34] 1826[34] 1852[5]	1809	Kraków (Trzcińska-Tacik 1979)	8	111	181	8806	2141	5(+1)	H		Meusel *et al.* 1978; Hulten & Fries 1986; *Hantz 1979*; *Zając A. & Zając M. 2001*
Oxybaphus nyctagineus (Michx.) Sweet	Nyctaginaceae	G	G/V	i	ane	se.		Am N [C]	UI / I	1843[5, 7]	1911	Wielkopolska Lake District: Gubin (Decker 1911)	0	0	1	6	6	1(?)	H	Czech Rep. [agr.], Hungary	*Ceynowa-Giełdon 1988*; *Tokarska-Guzik 2001b* (46)
Padus serotina (Ehrh.) Borkh. [= *Prunus serotina* Ehrh.]	Rosaceae	N M	G	i s	end	fr.	*C*	Am N [E] & Am S [N]	I [O, FO]	1623 [I][35] 1825[25, 35] see also Chapter 7	1813 [I] 1880 ? 1900	Niedźwiedź [I] (Hereźniak 1992); Warszawa (Sudnik-Wójcikowska 1987a); Bydgoszcz (Bock 1908)	0	1	10	2564	1134	4(+2)	NS	Eur C [forests]	*Zając A. & Zając M. 2001*
Parietaria pensylvanica Muhl. ex Willd.	Urticaceae	T	G	w	ane	se.	*CR*	Am N	UI [B, GA]	1810 1820 [I][49] 1861[50] 2000[5]	1991	Bydgoszcz (Misiewicz *et al.* 1996)	0	0	2	2	2	1(+1)	H		*Zając A. & Zając M. 2001*; *Guzik 2002*
Parthenocissus inserta (A. Kern.) Fritsch [= *P. vitacea* (Knerr) Hitchc.]	Vitaceae	N li	G/V	i	end anthr	fr. rh. st.	*C*	Am N [E]	I [O]	1629 [I][1] 1884[2, 25] 1900[5]	1806 [I] 1884	Kraków – botanical garden [I] (Hereźniak 1992); Carpathian Foothills: Tenczyn (Raciborski 1884)	0	1	3	558	332	3(+2)	NSH	some part of Eur C	*Zając A. & Zając M. 2001*
Petrorhagia saxifraga (L.) Link [= *Tunica saxifraga* (L.) Scop.]	Caryophyllaceae	Ch	G	i s	ane egz	se.	*CS*	Eur S & SE	UI / I [O]		1859	Kraków (Berdau 1859)	0	5	9	43	36	2(+1)	N H		Meusel *et al.* 1965; Jalas & Suominen 1986; *Zając A. & Zając M. 2001*
Phleum rhaeticum (Humphries) Rauschert	Poaceae	H	G	w	ane egz	se.		Eur C [Alps]	UI [AN]		XIX / XX 1995	West Tatra Mts.: Stoły Clearing (Mirek 1995)	0	0	0	1	1	1(?)	N		*Zając A. & Zając M. 2001*
Physalis alkekengi L.	Solanaceae	H	G/V	i s	ane end aut	se. fr. rh.	*C*	Eur SE & Asia SW	I [O, M]	1866 1867[10] Ar[5]	1613* 1866	* – general information (after Syreński 1613); Warszawa (Karo *herb.* **WU**)	0	4	19	397	286	3(+1)	NSH		Meusel *et al.* 1978; *Tokarska-Guzik 2001b* (47)
Picris echioides L. [= *Helminthia echioides* (L.) Gaertn.; *Helminthotheca echioides* (L.) Holub]	Asteraceae	T	G	i s	ane egz myr	se.	*CSR*	Eur S & Afr N	UI [BA]	1836 1861[5] 1878[10]	XVIII 1836	XVIII – Kluk (1787); Gdańsk (Schwarz 1967 after Klinsmann *herb.*)	0	1	33	60	37	2(+/–)	NH		Meusel *et al.* 1992; *Tokarska-Guzik 2001b* (48)
Plantago serpentina All.	Plantaginaceae	H	G	i s	ane egz	se.		Eur C [Alps]	UI [AN]		XIX / XX 1995	West Tatra Mts.: Stoły Clearing (Mirek 1995)	0	0	0	1	1	1(?)	N		*Zając A. & Zając M. 2001*

Name of species	Family	LF	R	P	Disp	Prop	LS	Origin	Way of INT	First record for Europe+	First record for Poland	The oldest locality in Poland & source of data	Nrs of loc. up to 1850	Nrs of loc. up to 1900	Nrs of loc. up to 1950	Nrs of loc. up to 2000	Nrs of sq.	Dyn	Hab.	Inv. elsewhere	Maps
Portulaca oleracea L.	Portulacaceae	T	G	s	aut myr	se.	*R*	Asia S & Afr N	I [A]	Ar[2, 5]	1613* XVIII 1837	* – general information (after Syreński 1613); XVIII – Kluk (1787); south-western Poland: Wrocław & Bolesławiec (Schneider 1837)	4	36	94	216	147	3(+1)	H	some part of Eur S	Hulten 1971; Jalas & Suominen 1980; Hulten & Fries 1986; *Tokarska-Guzik 2001b* (49)
Potentilla intermedia L. non Wahlenb	Rosaceae	H	G	i	ane myr end	se.	*CSR*	Eur NE & Asia N	UI [G, A]	1652 ? 1841 1896[10] 1903[5]	1652 ? XVIII / XIX 1841	Warszawa (after Sudnik-Wójcikowska 1987a); XVIII/XIX Kornaś 1968b; Gdańsk (Schwarz 1961)	1	17	41	207	102	3(+1)	H		Hulten & Fries 1986; *Zając A. & Zając M. 2001*
Reseda luteola L.	Resedaceae	H	G	i s	myr ane	se.	*CS*	Eur S, Asia W	I [C] →UI	Ar[2, 5]	XVIII 1825	XVIII – Kluk (1788); Gdańsk (Reyger 1825)	5	62	87	299	182	3(+1)	H		Meusel *et al.* 1965; Jäger 1970; Hulten & Fries 1986; *Tokarska-Guzik 2001b* (50)
Reynoutria japonica (Houtt.) Ronse Decraene var. ***japonica*** [= *Fallopia japonica* Houtt.]	Polygonaceae	G	V/G?	w i s	ane egz myr hyd anthr	rh. st. (se.)	*C*	Asia E	I [B, O, C]	1823–1829[I][37] 1886[38] 1892[5] see also Chapter 7	1882	Wielkopolska Lake District: Gniezno (Cybichowski *herb.* **POZ**)	0	3	63	3004	1158*	4(+2)	NSH	Eur W & C [rip. & urb.]; Am N	Jalas & Suominen 1979; Child & Wade 1999, 2000; *Zając A. & Zając M. 2001*
Reynoutria sachalinensis (F. Schmidt) Nakai [= *Fallopia sachalinensis* (F. Schmidt et Maxim) Ronse Decraene]	Polygonaceae	G	V/G?	w i s	ane egz myr hyd anthr	rh. st. (se.)	*C*	Asia E	I [B, O, C]	before 1864[I][37] 1869[5, 37]	1903	Sudety Mts.: Szklarska Poręba (Schube 1903b)	0	0	16	474	282*	3(+1)	NSH		Jalas & Suominen 1979; *Tokarska-Guzik 2001b* (51)
Robinia pseudoacacia L.	Fabaceae	M	G/V	i	end ane anthr	se. ro.	*C*	Am N [E]	I [O, M, C]	1601 [I][1] 1824[25] 1874[5]	XVIII [I] 1806 [I] 1836 1868	XVIII – Kluk (1788) – only as cultivated plant; Kraków – botanical garden [I] (Hereźniak 1992); Gdańsk-Stogi (Schwarz 1967 after Klinsmann); Mazowsze – Podlasie Lowlands: Tuchowicz near Łuków (Łapczyński *herb.***LBL**)	1	12	39	7067	1957	4–5 (+2)	NSH	some regions of Eur C; Lithuania	*Zając A. & Zając M. 2001*
Rosa rugosa Thunb.	Rosaceae	N	G/V	i s a	end anthr	se. fr. ro.	*C*	Asia E	I [C]	1841 [I][25] 1950[5] 1960[25]	1913 ?	Mazury Lake District: Krzemity (Führer 1913)	0	0	8	1299	701*	3–4 (+1)	NSH		*Zając A. & Zając M. 2001*
Rubus allegheniensis Porter	Rosaceae	N	G/V	i	end	fr.		Am N [E]	I [C]	1890[10]	1899	Wrocław Zalesie (Baenitz *herb.* **LE**)	0	1	1	9	9	1(?)	NSH		*Zieliński 2001, 2004*
Rubus armeniacus Focke	Rosaceae	N	G/V	i	end	fr.		Asia SW [Cauc.?]	I [C]	1860[40]	1843 ? 1902	Skarszyn (source: ATPOL); Szczecin (Holzfuss *herb.* **PR**)	1	1	2	68	58	2(+1)	SH		*Zieliński 1991, 2001, 2004*
Rubus canadensis L.	Rosaceae	N	G/V	i	end	fr.		Am N [E]	I	1727[I][1] 1967[10]	1811 [I] 1967	Krzemieniec – botanical garden [I] (Hereźniak 1992); Parkoszów (Ciaciura *herb.* **SZUB**)	0	0	0	6	6	1(?)	NSH		*Zieliński 2001, 2004*
Rubus laciniatus Willd.	Rosaceae	N	G/V	i	end	fr.		Anthropog.	I [O]	1770 [I][39] 1885[25]	1859 1905	Nysa (source: ATPOL); Wrocław (Baenitz *herb.* **LE**)	0	1	2	16	13	1(+1)	NSH		*Zieliński 1991, 2001, 2004*
Rubus odoratus L.	Rosaceae	N	G/V	i	end	fr.		Am N [E]	I [O]	1635 [I][1] 1880[5] 1890[10]	1806 [I] 1877	Kraków – botanical garden [I] (Hereźniak 1992); Książ (Wacker *herb.* **TRN**)	0	4	8	12	11	1(?)	NSH		*Zieliński 2001, 2004*
Rubus xanthocarpus Bureau & Franch	Rosaceae	H	G	i	end	fr.		Asia E [China]	I [O]	1962[5]	1991	Miedzianka (Bróż *herb.* **KOR** & **KTC**)	0	0	0	1	1	1(?)	H		*Zieliński 2001, 2004*
Rudbeckia laciniata L.	Asteraceae	H G	G/V	a i s	ane egz myr aut	se. ro.	*C*	Am N [E]	I [O]	1615 [I][41] 1787[41] see also Chapter 7	1787	Sudety Mts.: Świeradów (Fiek 1881 after Krocker); Lubań (Jalas 1993)	3	78	187	2251	903	3–4 (+2)	NSH	Czech Rep. & Slovak Rep.	Meusel *et al.* 1992; *Zając A. & Zając M. 2001*
Rumex confertus Willd.	Polygonaceae	H	G	w s	ane egz hyd	se.		Eur SE & Asia W	UI	1873 see also Chapter 7	1873	Mazowsze – Podlasie Lowlands: Zajęczniki & Łosice (Karo *herb.* **KRA**)	0	4	47	1731	673	3–4 (+2)	SH	Lithuania	Jalas & Suominen 1979; *Trzcińska-Tacik 1963; Zając A. & Zając M. 2001*

Name of species	Family	LF	R	P	Disp	Prop	LS	Origin	Way of INT	First record for Europe*	First record for Poland	The oldest locality in Poland & source of data	Nrs of loc. up to 1850	Nrs of loc. up to 1900	Nrs of loc. up to 1950	Nrs of loc. up to 2000	Nrs of sq.	Dyn	Hab.	Inv. elsewhere	Maps
Salsola kali L. subsp. ***ruthenica*** (Iljin) Soó	Chenopodiaceae	T	G	w i	ane	se.	*SR*	Eur SE & Asia C	UI [W, BA]	1730 1775[10] see also Chapter 7	XVII 1643 1730	XVII Kornaś 1968b; Gdańsk (Schwarz 1967 after Oelhaf); Warszawa (Sudnik-Wójcikowska 1987a after Erndtel)	2	26	114	901	467	3–4 (+1)	H		Meusel *et al.* 1965 *s.l.*; Hulten & Fries 1986; *Baradziej 1972*; *Tokarska-Guzik 2001b* (52)
Sedum album L.	Crassulaceae	Ch	G/V	i s	ane hyd aut myr	se. st. rh.	*S*	Eur S & W, Afr N & Asia W	I [O]		XVII [I] 1868	XVIII – Kluk (1788) – only as cultivated plant; Sudety Mts.: Jordanów Śląski & Mierczyce (Wimmer 1868)	0	5	15	59	47	2(+1)	SH		Meusel *et al.* 1965; Hulten & Fries 1986
Sedum spurium M. Bieb.	Crassulaceae	Ch	G/V	i s	ane hyd aut myr	se. st. rh.	*S*	Asia SW [Cauc.]	I [O]	1879[5]	1880	Silesian Upland: Marcinkowice (Uechtritz 1880)	0	15	62	301	230	3(+1)	H		*Zając A. & Zając M. 2001*
Senecio vernalis Waldst. & Kit.	Asteraceae	T H	G	i s	ane egz myr	se.	*R*	Eur SE & Asia W	UI	1726[14] 1830[57] 1851[14]	1824	Warszawa (Rostafiński 1872)	11	119	219	3932	1948	4–5 (+2)	H		Hultén & Fries 1986; Hegi 1987; Meusel *et al.* 1992; *Zając A. & Zając M. 2001*
Sicyos angulata L.	Cucurbitaceae	T	G	i	end	fr.		Am S	I [O] / UI [SB]	1868 1880[5]	1868	Carpathian Foothills: Krosno (Knapp 1868)	0	13	18	168	101	2–3 (+1)	H		**original:** see App. C
Silene conica L.	Caryophyllaceae	T	G	i s	ane aut	se.	*SR*	Eur S & Asia SW	UI	1879 1892[10]	1879	Wielkopolska Lake District: Czerwieńsk (Uechtritz 1879)	0	23	76	199	104	2–3 (+1)	H		Meusel *et al.* 1965; Jalas & Suominen 1986; Hulten & Fries 1986; *Zając A. & Zając M. 2001*
Silene dichotoma Ehrh.	Caryophyllaceae	H	G	i s	ane aut	se.	*R*	Eur S & SE, Asia SW	UI [BS]	1841[5]	1877	Wrocław (Uechtritz 1877)	0	30	289	496	335	3(+1)	H		Jalas & Suominen 1986; Hultén & Fries 1986; *Zając A. & Zając M. 2001*
Sinapis alba L.	Brassicaceae	T	G	i s	ane	se.	*CR*	Eur S	I [C, M, FD]		XVII [I] 1824	XVIII – Kluk (1788) – only as cultivated plant; Mazowsze Lowland: Wyszogród (Zalewski 1892)	0	18	55	1416	716	3–4 (+1)	H		Hulten & Fries 1986; *Zając A. & Zając M. 2001*
Sisymbrium altissimum L.	Brassicaceae	H T	G	i s	aut hyd	se. pl.	*CR*	Eur SE & Asia C	UI [G, BA]	1780[12] 1815[5] see also Chapter 7	1843	Gdańsk (Klinsmann 1843)	2	24	59	1770	812	3–4 (+1)	H		Meusel *et al.* 1965; Hultén 1971; Hulten & Fries 1986; *Zając A. & Zając M. 2001*
Sisymbrium loeselii L.	Brassicaceae	H T	G	i s	aut ane end	se.	*CR*	Eur SE & Asia C	UI [BA, G]	1654[12, 15] 1819[5]	1654 1824 ? 1847 1856	Gdańsk (Hegi 1935–1961); Warszawa (Sudnik-Wójcikowska 1987a); Gdańsk (Schwarz 1967); Warta river embancment near Poznań (Lechmann *herb.* **POZ**)	2	31	87	2326	976	3–4 (+1)	H	Czech Rep.	Meusel *et al.* 1965; Hulten & Fries 1986; *Zając A. & Zając M. 2001*
Sisymbrium wolgense M. Bieb. ex E. Fourn.	Brassicaceae	H	G/V	i s	aut ane	se. ro.	*C*	Eur SE	UI [RW]	1880[7] Finland	1896	Warszawa (Cybulski *herb.* **WA**)	0	1	2	62	40	2(+1)	H	Czech Rep. [agr.]	*Zając A. & Zając M. 2001*
Sisyrinchium bermudiana L. em. Farw. [= *S. angustifolium* Mill.]	Iridaceae	H	G/V	i	ane	se. ro.	*CSR*	Am N [E]	I [O]	1835[3] 1845 ?[8] 1863[5]	1928	Sudety Mts.: Jelenia Góra & Jeleniec Mały (Schube 1928)	0	0	5	22	17	1–2 (+1)	S		Hultén 1958; **original**: see App. C
Solidago canadensis L.	Asteraceae	G H	G/V	i s	ane egz myr	se. rh.	*C*	Am N [E]	I [O]	1648[14] 1736[2] 1838[5]	1872	Lublin Upland: Lublin (Rostafiński 1872); Rząska near Kraków (Knapp 1872)	0	20	60	3436	1254	4(+2)	NSH	some regions of Eur C	Meusel *et al.* 1992; *Guzikowa & Maycock 1986; Zając A. & Zając M. 2001*
Solidago gigantea Aiton. [= *S. serotina* Aiton]	Asteraceae	G H	G/V	i s	ane egz myr	se. rh.	*C*	Am N	I [O]	1758[14] 1830[14] 1851[5]	1853	Wrocław (Uechtritz *herb.* **WRSL**)	0	40	150	5350	1668	4–5 (+2)	NSH	some regions of Eur C	Meusel *et al.* 1992; *Guzikowa & Maycock 1986; Zając A. & Zając M. 2001*
Solidago graminifolia (L.) Elliott	Asteraceae	G H	G/V	i s	ane egz myr	se. rh.	*C*	Am N [N]	I [O]	1758[60] XIX[2]	1888	Silesian Lowland: Lipno near Niemodlin (Zeidel? *herb.* **WRSL**)	0	2	5	46	27	2(+1)	NSH		*Tokarska-Guzik 2001b* (53)

Name of species	Family	LF	R	P	Disp	Prop	LS	Origin	Way of INT	First record for Europe*	First record for Poland	The oldest locality in Poland & source of data	Nrs of loc. up to 1850	Nrs of loc. up to 1900	Nrs of loc. up to 1950	Nrs of loc. up to 2000	Nrs of sq.	Dyn	Hab.	Inv. elsewhere	Maps
Tanacetum parthenium (L.) Sch. Bip. [= *Chrysanthemum parthenium* (L.) Bernh.]	Asteraceae	H	G	i s	ane egz myr	se.	*CSR*	Eur SE & Asia SW	I [O, M]	1561[2] 1769[14] Ar[5, 10]	XVI ? 1613* 1824	XVI Zając A. *et al.* 1998; * – general information (after Syreński 1613); XVIII – Kluk 1787; Mazowsze Lowland: Wyszogród (Zalewski 1892 after Gawarecki 1824)	1	56	91	1179	734	3–4 (+1)	H		Meusel *et al.* 1992; *Tokarska-Guzik 2001b* (54)
Thladiantha dubia Bunge	Cucurbitaceae	H	V/G	i	end	se. fr. st.		Asia E	I [O]	1917 1939[5]	1917	south-eastern Poland: Turka (Koporska *herb.* **LBL**)	0	0	5	69	46	2(+1)	SH		*Zając A. & Zając M. 2001*
Trifolium patens Schreb.	Fabaceae	H	G	i	ane egz anthr	se.		Eur S	UI [FD]		1933	Carpathian Mts.: Wróblik Szlachecki near Rymanów (Piech 1939)	0	0	1	227	54	2–3 (+1)	N H		Hendrych 1966; *Loster 1972; Tokarska-Guzik 2001b* (55)
Veronica filiformis Sm.	Scrophulariaceae	Ch H	V/G	i s	ane hyd myr aut anthr	st. se.?	*CSR*	Asia SW [Cauc.]	I [B, O]	1780 [I][7] 1838[7] UK 1938[5]	1936 [I]?	Baltic Coast: Sopot (Luttschwager 1936)	0	0	2	161	69	2–3 (+1)	SH	Czech Rep. [maedows] USA	Meusel *et al.* 1978; Hulten & Fries 1986; *Pietras 1970*; *Zając A. & Zając M. 2001*
Veronica peregrina L.	Scrophulariaceae	T	G	i s	ane hyd myr	se.	*R*	Am N	UI [GA]	1760[2] 1809[5]	1854	Kraków Sikornik (– *herb.* **KRA**)	0	2	2	21	16	1–2 (+1)	NSH		Hulten 1971; Meusel *et al.* 1978; Hulten & Fries 1986; *Zając M. & Zając A. 1990; Tokarska-Guzik 2001b* (56)
Veronica persica *Poir.*	Scrophulariaceae	T	G	i s	ane hyd myr anthr	se.	*CR*	Asia SW [Cauc.]	UI [G]	1805[16] 1809[5] see also Chapter 7	1862	West Pomerania: Chełmno; Świecie town sourrandings (Abromeit *et al.* 1898 after Wacker 1862)	0	33	84	7887	2204	5(+2)	H	Czech Rep.	Hulten 1971; Meusel *et al.* 1978; Hulten & Fries 1986; *Zając A. & Zając M. 2001*
Vicia dasycarpa Ten.	Fabaceae	T	G	i	aut anthr	se.	*CR*	Eur S	UI		1898	Toruń (Abromeit *et al.* 1898)	0	1	2	1302	384	3–4 (+1)	H		*Zając A. & Zając M. 2001*
Vicia grandiflora Scop.	Fabaceae	T	G	i	aut anthr	se.	*CR*	Eur S & Asia SW	UI	1877[5]	1907	Silesian Lowland: Kościeżyce & Czepielowice near Brzeg (Schube 1907)	0	0	18	1540	506	3–4 (+2)	SH		Hanelt & Mettin 1970; *Tokarska-Guzik 2001b* (57)
Vicia pannonica Crantz	Fabaceae	T	G	i	aut anthr	se.	*CR*	Eur SE [Pan.]	UI / I	1884 1893[10] Ar[5]	1884	Silesian Lowland: Głuchołazy (Richter *herb.* **MGS**)	0	1	49	91	68	2(+I)	SH		*Tokarska-Guzik 2001b* (58)
Xanthium albinum (Widder) H. Scholz [= *X. riparium* Itzigs. & Hertsch]	Asteraceae	T	G	w s	egz hyd	fr.	*CR*	Am N [S]	UI	1822[42]	1853	Nowa Sól (Fiek 1881 after Franke)	0	40	83	1119	471	3–4 (+1)	SH	some parts of Eur C & S	Meusel *et al.* 1992; *Zając A. & Zając M. 2001*
Xanthium spinosum L.	Asteraceae	T	G	w s	egz hyd	fr.	*CR*	Am S	UI [W, SB]	1681[14] 1872[5]	1849	Wrocław (Uechtritz *herb.* **WRSL**)	1	79	129	294	148	3(+/–)	H	some parts of Eur C & S; different parts of the world	Meusel *et al.* 1992; *Tokarska-Guzik 2001b* (59)
Xanthium strumarium L.	Asteraceae	T	G	w s	egz hyd	fr.	*CR*	Eur / Am N ?	UI [W, SB]	Ar[5, 10]	1613* 1837	* – general information (after Syreński 1613); Silesian Lowland: Oława (Schneider 1837)	3	130	225	1105	712	3–4 (+/–)	H	some parts of Eur C & S; Australia; India; Africa S the Americas	Meusel *et al.* 1992; *Zając A. & Zając M. 2001*

Appendix B. List of Polish kenophytes together with their ecological-geographical characteristic (excluding history of distribution)
This appendix includes 51 species more often cultivated and considered established in some regions of Poland (the species concerned were marked with "?" preceding the species name).

Name of species	Family	LF	R	P	Disp	LS	Origin	Way of INT	First record for Europe	First record for Poland	Source of historical data for Poland	Nrs of sq.	Hab.	Dyn	Described as invasive elsewhere	Maps
? ***Acer saccharinum*** L.	Aceraceae	M	G	i w	ane		Am N [E]	I [O]	1725 [I][1]	1807 [I] XX	Hereźniak 1992	n.c.d.	H	1(+1)		
Achillea crithmifolia Waldst. & Kit.	Asteraceae	H	G	i	ane end	*C/CS ?*	Eur SE	UI	1886[5]	2/2 XX	Zając A. *et al.* 1998	n.c.d.	S	1(?)		
? ***Aesculus flava*** Sol. ex Hope	Hippocastanaceae	M	G	i	bar		Am N [E]	I [O]	1764 [I][1]	1813 [I]	Hereźniak 1992	n.c.d.	N	1(?)		
Aesculus hippocastanum L.	Hippocastanaceae	M	G	i	bar anthr	*C*	Eur SE [m]	I [O, M]	1576 [I][45] 1787[25]	XVII	Adamowski *et al.* 2002; Zając A. *et al.* 1998; XVIII – Kluk (1786) – only as cultivated plant	620*	SH	3(+1)		
Alchemilla rigida Buser	Rosaceae	H	G	a	egz	*CS*	Eur C [Alps]	UI [AN]		XIX	Mirek *et al.* 2002	6	S	1(?)		
Alnus rugosa (Du Roi) Spreng.	Betulaceae	N	G	w	ane	*C*	Am N [E]	I [O,C]	1769[I][1] 1872[5]	1817 [I] 1/2 XX ?	Hereźniak 1992	n.c.d.	N	2(?)		
Amelanchier spicata G.N. Jones	Rosaceae	N	G/V	i	end	*C*	Am N [NE]	I [O]	1783 [I][1]	1820 [I] XIX	Hereźniak 1992; Zając A. *et al.* 1998	n.c.d.	SH	2(+1)		
? ***Amorpha fruticosa*** L.	Fabaceae	N	G	i	egz anthr	*C*	Am N [E & C]	I [O, C]	1724 [I][1] 1907[43] 1932[5]	1807 [I]	Hereźniak 1992	n.c.d.	H	2(+1)	some regions of Eur C	
? ***Anaphalis margaritacea*** (L.) Benth. [= *Gnaphalis margaritacea* L.]	Asteraceae	H	G/V	i	ane egz anthr		Am N	I [O]	1887[5]	XX	Zając A. *et al.* 1998	n.c.d.	SH	1(+1)		
? ***Aronia melanocarpa*** (Michx) Elliot	Rosaceae	N	G	a	end anthr	*C*	Am N [NE]	I [O, F]	*ca.* 1688 [I][1]	1824 [I]	Hereźniak 1992	n.c.d.	NSH	1(?)		
? ***Aronia prunifolia*** (Marshall) Rehder **H** [= *A. arbutifolia* (L.) Pers. x *A. melanocarpa* (Michx.) Elliott]	Rosaceae	N	G	a	end anthr		Am N [NE]	I [O, F]	1800 [I][1]	1833 [I]	Hereźniak 1992	n.c.d.	NSH	2(+1)		
Aster lanceolatus Willd.	Asteraceae	H	G/V	i s	ane egz anthr	*C*	Am N [E]	I [O]	XIX[2]	XIX	Zając A. *et al.* 1998	260*	SH	3(+1)	Czech Rep. & Hungary	Meusel *et al.* 1992
Aster novae-angliae L.	Asteraceae	H	G/V	i s	ane egz anthr	*C*	Am N [E]	I [O]	XIX[2]	XIX/XX	Zając A. *et al.* 1998	155*	SH	3(+1)		
Aster novi-belgii L.	Asteraceae	H	G/V	i s	ane egz anthr	*C*	Am N [E]	I [O]	XVIII[2] 1850[5]	XVIII	Zając A. *et al.* 1998	353*	SH	3(+1)	Czech Rep.	Meusel *et al.* 1992
Aster salignus Willd. **H**	Asteraceae	H	G/V	i s	ane egz anthr	*C*	Am N	I [O]	1787[2]	XIX	Zając A. *et al.* 1998	139*	SH	3(+1)	Czech Rep. & Hungary	Meusel *et al.* 1992
Aster tradescantii L.	Asteraceae	H	G/V	i s	ane egz anthr	*C*	Am N [E]	I [O]	1736[2]	XIX	Zając A. *et al.* 1998	94*	H	2(+1)		Meusel *et al.* 1992
Atriplex hortensis L.	Chenopodiaceae	T	G	s i	ane hyd anthr	*CR*	Asia C, Eur ?	I [O]	1872[5]	XVIII [I] XIX	[I] – Kluk (1786) – only as cultivated plant; Zając A. *et al.* 1998	n.c.d.	H	2(+1)		
Atriplex prostrata Boucher ex DC. subsp. *polonica* (Zapał.) Uotila	Chenopodiaceae	T	G	s i	ane		Eur E	UI		1/2 XX	Zając A. *et al.* 1998	n.c.d.	H	1(?)		
Brachyactis ciliata (Ledeb.) Ledeb.	Asteraceae	T	G	i s	ane egz		Asia	UI	1967	2000	Guzik unpubl.	2	H	1(?)		
Brassica elongata Ehrh. subsp. *integrifolia* (Boiss.) Breistr.	Brassicaceae	C T	G	i s	ane aut		Eur E & Asia W	UI	XIX ? 1960[6]	XIX ?	Zając A. *et al.* 1998	n.c.d.	N	1(?)		*Zając A. & Zając M. 2001*
Brassica nigra (L.) W.D.J. Koch	Brassicaceae	T	G	i s	ane aut anthr	*CR*	Eur SW & W	I [A]→UI	XVI ?[2] Ar[8]	XVI	Zając A. *et al.* 1998	286	SH	3(+1)	Czech Rep.	Meusel *et al.* 1965; Hultén & Fries 1986

Name of species	Family	LF	R	P	Disp	LS	Origin	Way of INT	First record for Europe	First record for Poland	Source of historical data for Poland	Nrs of sq.	Hab.	Dyn	Described as invasive elsewhere	Maps
Brassica rapa L. (L.) W.D.J. Koch subsp. ***rapa***	Brassicaceae	T	G	i s	ane aut anthr		Anthropog.	I [A]	Ar ?	XVI	Zając A. *et al.* 1998	n.c.d.	H	2(?)		
Brassica rapa subsp. ***sylvestris*** (Lam.) Janch.	Brassicaceae	T H	G	i s	ane aut anthr	*CR*	Eur S & Afr N	UI	1964[5]	XIX ?	Zając A. *et al.* 1998	n.c.d.	H	2(?)		
Bromus japonicus Thunb. ex Murr [= *B. patulus* Mert. & W.D.J. Koch]	Poaceae	T	G	w	ane egz anthr	*R*	Eur S & Asia W	UI [BS, W]	1839[11] Ar[5]	1850	Poznań (Krawiecowa 1951 after Ritschl)	54	H	2(+1)		Meusel *et al.* 1965; Hulten 1964; Hulten & Fries 1986
Bromus pseudothominii P.M. Sm. **H** [= *B. hordaceus* L. x *B. lepidus* Holmb.]	Poaceae	T	G	w	ane egz		Anthropog.	UI		XX	Zając A. *et al.* 1998	n.c.d.	H	2(?)		
Bromus squarossus *L.*	Poaceae	T	G	w	ane egz anthr	*CR*	Eur S & Asia SW	UI [BS W]		1911	Schube 1911	n.c.d.	H	2(+1)		Meusel *et al.* 1965
? ***Buddleja davidii*** Franchet	Buddlejaceae	N	G	i	ane anthr	*C*	Asia [China]	I [O]	1890 [I][45] 1952[25]	XX	Adamowski *et al.* 2002	n.c.d.	H	1(+1)	UK; New Zealand	
Calendula arvensis L.	Asteraceae	T	G	i s	ane egz	*R*	Eur S & Asia SW	I	1901[5] Ar[10]	XVIII	Kluk (1786); Zając A. *et al.* 1998	n.c.d.	H	2(+/–)		Hulten & Fries 1986
Calystegia sylvatica (Kit.) Griseb.	Convolvulaceae	G H li	G	i s	ane		Eur S	UI		XIX / XX	Zając A. *et al.* 1998	n.c.d.	H	2(?)		Hulten & Fries 1986
? ***Carya cordiformis*** (Wangerin) K. Koch	Juglandaceae	M	G	w	bar		Am N [C & E]	I [O]	1689 [I][1]	1820 [I]	Hereźniak 1992; Seneta 1994	n.c.d.	N	1(?)		
? ***Carya ovata*** (Mill.) K. Koch.	Juglandaceae	M	G	w	bar		Am N [E & C]	I [O]	1629 [I][1]	1808 [I]	Hereźniak 1992; Seneta 1994	n.c.d.	N	1(?)		
Centaurea micranthos S.G. Gmelin ex Hayek [= *C. biebersteinii* DC.; *C. stoebe* subsp. *micranthos* Hayek]	Asteraceae	H	G	i s	ane egz		Eur SE & EC	UI		2/2 XX	Zając A. *et al.* 1998	n.c.d.	H	1(?)		
Cerasus mahaleb (L.) Mill. [= *Prunus mahaleb* L.]	Rosaceae	N	G	i	end	*C*	Eur S & Asia C	I [O, F]	1785[I][25] 1839[25]	XVIII [I] ? XIX	Zając A. *et al.* 1998	n.c.d.	N	2(+1)		
Cerasus vulgaris Mill. subsp. ***vulgaris*** [= *Prunus cerasus* L.]	Rosaceae	M	G/V	i	end		Eur SE & Asia SW	I [F]	Anc	Anc XIX ?	Adamowski *et al.* 2002; Seneta 1994	n.c.d.	N	1(?)		
Chenopodium schraderanum Schult.	Chenopodiaceae	T	G	w	ane		Afr N [m]	I / UI	1864[5]	1964	Fijałkowski 1964; Kulpa 1964	3	H	1(?)		
? ***Comptonia peregrina*** (L.) Coult.	Myricariaceae	N	G/V	w	ane		Am N [E]	I [O]	1714 [I][1]	1813 [I]	Hereźniak 1992; Seneta 1994	n.c.d.	N	1(?)		
? ***Cornus alba*** L.	Cornaceae	N	G	i s	end	*C*	Eur E, Asia C & E	I [O]	1773 [I][25] 1857[25]	1741 [I] XIX ?	Seneta 1994	n.c.d.	NH	2(+1)		
? ***Cotoneaster horizontalis*** Decne	Rosaceae	N	G/V	i	end	*C*	Asia [China]	I [O]	*ca.* 1870 [I][46] 1962[2]	XX	Seneta 1994	n.c.d.	H	1(+1)		
? ***Cotoneaster lucidus*** Schlecht	Rosaceae	N	G	i	end		Asia C	I [O]	1840 [I][46]	XX	Seneta 1994	n.c.d.	NH	2(+2)		
Crataegus flabellata (Bosc ex Spach) K. Koch	Rosaceae	N	G	i	end		Am N [NE]	I [O]	1830[I][46] 1993[5]	1928 [I] 2/2 XX	Seneta 1994	n.c.d.	H	1(?)		
Crataegus pedicellata Sarg. [= *C. coccinea* Hort.]	Rosaceae	N M	G	i	end		Am N [NE]	I [O]	1683 [I][46]	1810 [I] XX	Seneta 1994	n.c.d.	N	1(+1)		
? ***Crocus vernus*** (L.) Hill	Iridaceae	G	V/G	i	ane		Eur C [m]	I [O]		XIX	Schube 1903; Mirek *et al.* 2002	n.c.d.	SH	1(?)		
Cuscuta campestris Yunck.	Cuscutaceae	Tp	G/V	i s	ane		Am N [W]	UI	1883[2, 5, 7] 1898[2]	1939	Piech 1939	29	H	2(+/–)	some countries in Eur: Hungary & Russia [meadows]	
Cuscuta trifolii Bab. & Gibson	Cuscutaceae	Tp	G/V	i s	ane		Eur S	UI	1843 1850[7]	1866	Klinggraeff 1866	70	H	2(+1)	some countries in Eur: [meadows]	
Dianthus barbatus L.s.s.	Caryophyllaceae	Ch	G/V	i	ane anthr		Eur C & S [m]	I [O]	1874[5]	XVI?	Zając A. *et al.* 1998; XVIII – Kluk (1786)	95*	H	2(+1)		

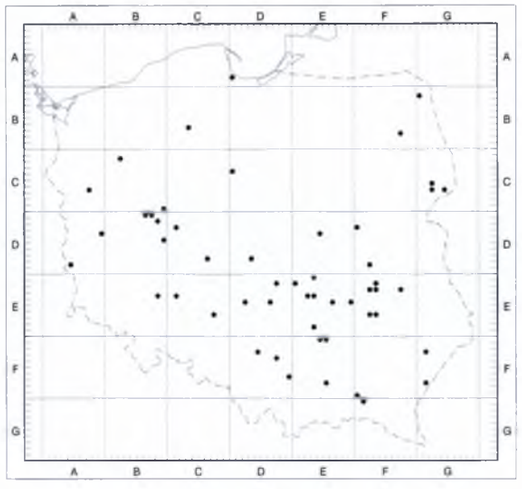
Name of species	Family	LF	R	P	Disp	LS	Origin	Way of INT	First record for Europe	First record for Poland	Source of historical data for Poland	Nrs of sq.	Hab.	Dyn	Described as invasive elsewhere	Maps
? ***Elaeagnus angustifolia*** L.	Elaeagnaceae	N M	G	i	end	*C*	Eur S, Asia W & C	I [O]	1736 [I][25] 1883[25]	1652 [I] XIX ?	Hereźniak 1992	n.c.d.	H	1(?)	Hungary; Am N [rip.]	
? ***Elaeagnus commutata*** Bernh. [= *E. argentea* Pursh]	Elaeagnaceae	N	G/V	i	end		Am N [E]	I [O]	1813 [I][45]	XIX	Zając A. *et al.* 1998	n.c.d.	NH	2(+1)		
Erucastrum gallicum (Willd.) O.E. Schulz	Brassicaceae	T H	G	i	ane	*CR*	Eur S & W	UI [BA, G]	1867[5]	1936	Ascherson & Graebner 1936	31*	H	2(+1)		Hultén & Fries 1986
Erysimum marschallianum Andrz. ex m. Bieb. [= *E. durum* J. Presl & C. Presl]	Brassicaceae	H	G	i s	aut ane		Eur SE & Asia	UI	2/2 XIX	1985	Zając A. *et al.* 1998; Rutkowski unpubl.	11*	SH	1(?)		
Euphorbia maculata L.	Euphorbiaceae	T	G	i	aut myr	*R*	Am N	UI / I	XIX ?	2/2 XIX	Zając A. *et al.* 1998	n.c.d.	H	1(?)	some part of Eur S	
Festuca rupicarpina (Hack.) A. Kern.	Poaceae	H	G	w	ane egz		Eur C [Alps]	UI [AN, S]		1995	Mirek 1995	1	S	1(?)		*Zając A. & Zając M. 2001*
? ***Fraxinus angustifolia*** Vahl subsp. *angustifolia*	Oleaceae	M	G	w	ane		Eur S, Afr N, Asia W	I [O]	XIX ?	1/2 XIX	Zając A. *et al.* 1998	n.c.d.	H	1(?)		
Fraxinus pennsylvanica Marshall	Oleaceae	M	G	w	ane	*C*	Am N [C & E]	I [O]	1783 [I][1]	1817 [I] 1/2 XIX	Zając A. *et al.* 1998	179	SH	3(+2)	Czech Rep. & Hungary	
Geranium bohemicum L.	Geraniaceae	T	G	i s	egz aut	*CR*	Eur C [N]	UI [G ?]	1801[20]	1872	Knapp 1872	4	H	1(+/–) ?	Red List (Benkert *et al.* 1998)	Meusel *et al.* 1978; Hulten & Fries 1986
Gypsophila perfoliata L.	Caryophyllaceae	Ch	G	i	ane	*CS*	Eur SE, Asia W & C	UI		XX	Zając A. *et al.* 1998	n.c.d.	H	1(+1)		
Hordeum jubatum L.	Poaceae	T	G	w	ane egz	*SR*	Am N & Asia E	I [O, G]	1894[10]	XX	Zając A. *et al.* 1998	n.c.d.	H	2(+1)	Am N	Hulten 1964; Hulten & Fries 1986
? ***Juglans regia*** L.	Juglandaceae	M	G	w	bar end		Asia SW, C & E	I [F, M]	Ar[2, 5, 25] 1968[25]	XVIII XIX	Kluk (1787) – only as cultivated plant	n.c.d.	SH	1(+1)		
Lactuca tatarica (L.) C.A. Mey.	Asteraceae	H	G/V	i s	egz ane myr	*CS*	Eur SE & Asia W	UI [G]	1884[7] UK 1900[2]	1/2 XX	Zając A. *et al.* 1998	12	SH	1(+1)		Hultén & Fries 1986; Meusel *et al.* 1992
? ***Larix kaempferi*** (Lamb.) Carrière [= *L. japonica* Carrière; *L. leptolepis* (Siebold & Zucc.) Endl.]	Pinaceae	M	G	w	ane		Asia W [Japan]	I [FO, O]	1861 [I][45]	XIX ?	Seneta & Dolatowski 1997	n.c.d.	N	1(+1)		
Linum austriacum L.	Linaceae	H	G	i s	aut egz		Eur W & C	UI	1860[2]	XIX ?	Mirek *et al.* 2002	n.c.d.	NS	1(?)		Meusel *et al.* 1978 *Zając A. & Zając M. 2001*
Linum perenne L.	Linaceae	H	G	i s	aut egz anthr	*CS*	Eur S & E	UI / I [C]		XX	Zając A. *et al.* 1998	17	SH	1(+1)		Hulten 1971; Hulten & Fries 1986
? ***Lonicera caprifolium*** L.	Caprifoliaceae	N li	G	i	end	*C*	Eur SE	I [O]	1809[5]	1613* XVIII	* – general information (after Syreński 1613); Kluk (1787) – as cultivated plant; probably also in the wild	n.c.d.	NSH	1(?)		
Lonicera tatarica L.	Caprifoliaceae	N	G/V	i	end	*C*	Eur SE & Asia C	I [O]	1752 [I][45] 1864[25]	XVIII ?	Adamowski *et al.* 2002; Zając A. *et al.* 1998	n.c.d.	SH	2(+1)		
Lycopersicon esculentum Mill. [= *Solanum lycopersicum* L.]	Solanaceae	T	G	i s	aut hyd anthr	*CR*	Am S	I [C]	XVIII [I][24] 1880[5]	1613* XVIII [I] 2/2 XX	* – general information (after Syreński 1613); XVIII – Kluk (1788) – only as cultivated plant; Zając A. *et al.* 1998	n.c.d.	H	2(+1)		
? ***Mahonia aquifolium*** (Pursh) Nutt.	Berberidaceae	N	G	i s	end	*CS*	Am N [W]	I [O]	1822 [I][25] 1860[2, 25]	1839 [I] 2/2 XX	Hereźniak 1992	n.c.d.	H	1(+1)	Czech Rep., Germany	
? ***Malus domestica*** Borkh. **H**	Rosaceae	M	G	i	end		Anthropog.	I [F, O]	Anc Ar[2, 5]	Anc		n.c.d.	SH	2(+1)		

Name of species	Family	LF	R	P	Disp	LS	Origin	Way of INT	First record for Europe	First record for Poland	Source of historical data for Poland	Nrs of sq.	Hab.	Dyn	Described as invasive elsewhere	Maps
Mentha citrata Ehrh. subsp. ***pubescens*** (Willd.) Tacik **H** [= *M. spicata* x *aquatica* L.]	Lamiaceae	H	G/V	i	hyd		not definie	UI		XX ?	Mirek *et al.* 2002	n.c.d.	**H**	?		
Mentha niliaca (Juss.) ex Jacq. **H**	Lamiaceae	H	G/V	i	hyd		not definie	I	1976[5]	XIX ?	Zając A. *et al.* 1998	n.c.d.	**H**	?		
Mentha rotundifolia (L.) Huds.	Lamiaceae	H	G/V	i	hyd		Eur S	I	1846[5]	XIX ?	Zając A. *et al.* 1998	n.c.d.	H	?		
Mentha spicata L. emend. L.	Lamiaceae	H	G/V	i	hyd	*C*	Anthropog.	I [C]	1818[5]	XVIII	Zając A. *et al.* 1998	n.c.d.	SH	?		Hultén & Fries 1986
Oenothera perangusta R.R. Gates	Onagraceae	H	G	i s	ane aut		Am N	UI		XX ?	Mirek *et al.* 2002	n.c.d.	H	1(?)		
? ***Oxycoccus macrocarpos*** (Aiton) Pursh	Ericaceae	Ch	G/V	i	ane end anthr		Am N	I [C]		XX	Mirek *et al.* 2002	n.c.d.	SH	1(?)		
? ***Picea glauca*** Voss [= *P. alba* (Aiton) Link; *P. canadensis* (Mill.) Britton]	Pinaceae	M	G	w	ane end		Am N [N & NE]	I [O]	*ca.* 1700 [I][1] 1976[61]	1808 [I]	Hereźniak 1992	n.c.d.	N	1(?)		
? ***Picea sitchensis*** (Bong.) Carrière	Pinaceae	M	G	w	ane end		Am N [W]	I [O]	1831 [I][1]	1876 [I]	Hereźniak 1992	n.c.d.	N	1(?)		
Pinus banksiana Lamb.	Pinaceae	M	G	w	ane		Am N [NE]	I [FO]	1735 [I][1] 1990[61] Lithuania	1822 [I] 1927 ?	Hereźniak 1992: Sudnik-Wójcikowska 1987a	n.c.d.	N H	2(?)		
? ***Pinus nigra*** J.F. Arnold	Pinaceae	M	G	w	ane		Eur S, Afr NW, Asia W**	I [FO, O]	1759 [I][45]	XIX [I]	Adamowski *et al.* 2002	n.c.d.	N	1(?)		
Pinus strobus L.	Pinaceae	M	G	w	ane	*C*	Am N [NE]	I [FO, O]	XVI [I][1] 1800[5]	*ca.* 1798 [I]	Hereźniak 1992	n.c.d.	N	1(?)	Czech Rep.	
Polycneum heuffelii Láng	Chenopodiaceae	T	G	w	ane		Eur E & SE	UI	Ar[5]	1879	Uechtritz 1880	4	H	1(–1)		Jalas & Suominen 1980
Polycneum majus A. Braun	Chenopodiaceae	T H	G	w	ane	*SR*	Eur S & Asia C	UI	Ar[5]	1953	Kornaś 1954	15	H	1–2 (+/–)		Jalas & Suominen 1980
? ***Populus berolinensis*** (K. Koch) Dippel **H** [= *P. laurifolia* Ledeb. x *P. nigra* L. 'Italica']	Salicaceae	M	V	w	ane		Anthropog.	I [O, C]	1870 [I][48] Berlin	2/2 XIX [I]	Seneta & Dolatowski 1997; Mirek *et al.* 2002	n.c.d.	H	?		
Populus canadensis Moench **H** [= *P.* x *euroamericana* (Dode) Guinier; *P. deltoides* Marshall s. l. x *P. nigra* L. s.l.]	Salicaceae	M	V	w	anthr	1952[25]	Anthropog.	I [O, C]	1750 [I][45]	XX	Adamowski *et al.* 2002; Mirek *et al.* 2002	n.c.d.	NH	?(+1)		
? ***Populus candicans*** Aiton	Salicaceae	M	V	w	ane		Am N [E]	I [O]	1755 [I][1]	XIX	Hereźniak 1992; Zając A. *et al.* 1998	n.c.d.	SH	?		
? ***Populus*** 'NE 42' **H**	Salicaceae	M	V	w	ane		Anthropog.	I [O]			Mirek *et al.* 2002	n.c.d.	H	?		
? ***Populus nigra*** L. 'Italica'	Salicaceae	M	V	w	ane		Anthropog.	I [O]	XVII [I][45]	XIX [I]	Mirek *et al.* 2002	n.c.d.	H	?		
? ***Populus trichocarpa*** Torr. & A. Gray ex Hook.	Salicaceae	M	G	w	ane		Am N [NW]	I [O]	1892 [I][1]	XIX ?	Hereźniak 1992; Zając A. *et al.* 1998	n.c.d.	H	?		
Prunus cerasifera Ehrh. [= *P. divaricata* Ledeb.]	Rosaceae	N M	G	i	end		Eur SE, Asia SW & C	I [F, O]	1594[45]	XIX	Adamowski *et al.* 2002; Zając A. *et al.* 1998	n.c.d.	SH	?		
Prunus domestica L. subsp. ***domestica*** **H** [probabl. = *P. cerasifera* Ehrh. x *P. spinosa* L.]	Rosaceae	N M	G/V	i	end		Anthropog.	I [A]	1594 [I][25] 1787[25] Ar[5]	Anc. XVI [I] ? XVIII ?	Adamowski *et al.* 2002	n.c.d.	SH	?		
? ***Pseudotsuga menziesii*** (Mirb.) Franco [= *P. douglasii* (Sabine ex D. Don) Carrière; *P. taxifolia* (Poir.) Britton ex Sudw.]	Pinaceae	M	G	w	ane		Am N [NW]	I [O]	1827 [I][1]	1833 [I]	Hereźniak 1992; Seneta & Dolatowski 1997	n.c.d.	N	?		
? ***Ptelea trifoliata*** L.	Rutaceae	N	G	i w	ane		Am N [E]	I [O]	1704 [I][1, 21, 45]	1806 [I] 1937	Hereźniak 1992	n.c.d.	H	1(+1)		
? ***Pterocarya fraxinifolia*** Spach	Juglandaceae	M	G/V	i w	ane		Asia SW [Cauc.]	I [O]	1872 [I][45]	XIX [I]	Adamowski *et al.* 2002	n.c.d.	N	?		
Pyrus communis L. **H** [= *P. pyraster* (L.) Burgsd. x *P. eleagrifolia* Pall. x *P. nivalis* Jacq.]	Rosaceae	M	G	i	end		Anthropog.	I [A, O]	1594 [I][25] 1787 ?[25] Ar[5]	Anc. XVI [I] ? XVIII ?	Adamowski *et al.* 2002	n.c.d.	NSH	?(+1)		
? ***Quercus cerris*** L.	Fagaceae	M	G	w	bar end	*C*	Eur SE, Asia W	I [O]	1796 [I][25] 1957[25]	XIX [I] XX	Zając A. *et al.* 1998	n.c.d.	NS	?		

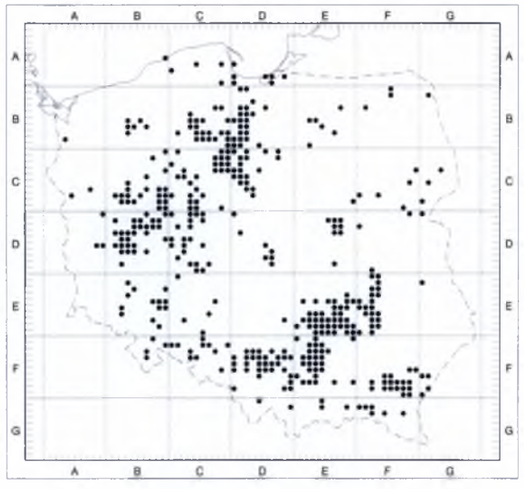
Name of species	Family	LF	R	P	Disp	LS	Origin	Way of INT	First record for Europe	First record for Poland	Source of historical data for Poland	Nrs of sq.	Hab.	Dyn	Described as invasive elsewhere	Maps
Quercus rubra L.	Fagaceae	M	G	w	bar end anthr	*C*	Am N [E]	I [FO, O]	1691 [I][1] 1887[25]	1806 [I] 1924 ? 1937 ?	Hereźniak 1992; Warszawa (Sudnik-Wójcikowska 1987a); Wolny *herb.* **MGS**	554*	N	3–4(+2)	Czech Rep.	
Reynoutria bohemica Chrtek & Chrtková **H** [= *R. japonica* Houtt. var. *japonica* x *R. sachalinensis* (F. Schmidt) Nakai]	Polygonaceae	G	V/G?	w i s	ane egz myr		Anthropog.	I [O, C] →UI	1942[5]	1/2 XX ?	Fojcik & Tokarska-Guzik 2000	n.c.d.	NSH	?(+2)	Czech Rep.	
? ***Rhododendron ferrugineum*** L.	Ericaceae	N	G	i	ane		Eur C [m]	I [O]	XIX	XIX	Zając A. *et al.* 1998	n.c.d.	SH	?		
Rhus typhina L.	Anacardiaceae	N	G/V	i	ane aut	*C*	Am N [C & E]	I [O]	1602 [I][1]	1806 [I] 1937	Hereźniak 1992; Adamowski *et al.* 2002	n.c.d.	H	?		
? ***Ribes rubrum*** L.	Grossulaceae	N	G	i	end		Eur [NW]	I [F, O]	Anc[45] 1809[5]	Anc XIX?	Adamowski *et al.* 2002	n.c.d.	SH	?		
? ***Rosa acicularis*** Lindl.	Rosaceae	N	G	i s a	end		Eur NE, Asia N & NE	I [O]		XX	Zając A. *et al.* 1998	n.c.d.	H	?		
? ***Rosa blanda*** Aiton	Rosaceae	N	G	i s a	end		Am N [E]	I [O]	1773 [I][45]	2/2 XX	Adamowski *et al.* 2002; Zając A. *et al.* 1998	n.c.d.	H	?		
? ***Rosa carolina*** L.	Rosaceae	N	G/V	i s a	end		Am N [E & S]	I [O]		2/2 XX	Zając A. *et al.* 1998	n.c.d.	H	?		
? ***Rosa davurica*** Pall.	Rosaceae	N	G	i s a	end		Asia E	I [O]		1/2 XX	Zając A. *et al.* 1998	n.c.d.	H	?		
Rosa foetida Herrm.	Rosaceae	N	G	i s a	end		Asia SW	I [O]	1814[5]	1/2 XX	Zając A. *et al.* 1998	n.c.d.	H	?		
Rosa glauca Pourr. [= *R. rubrifolia* Vill.]	Rosaceae	N	G/V	i s a	end	*C*	Eur SW [m]	I [O]	1814[45] 1874[5]	1/2 XX	Zając A. *et al.* 1998	n.c.d.	SH	?		Zieliński 1981
Rosa gorenkensis Besser [= *R. glabrifolia* auct. non C.A. Mey.]	Rosaceae	N	G	i s a	end		Eur SE, Asia W	I [O]	?	2/2 XIX	Adamowski *et al.* 2002; Zając A. *et al.* 1998	n.c.d.	NS	?		
Rosa multiflora Thunb.	Rosaceae	N	G	i s a	end		Asia E	I [O]	before 1868[45]	2/2 XX	Adamowski *et al.* 2002; Zając A. *et al.* 1998	n.c.d.	NSH	2(+1)		
Rosa spinosissima *L.* [= *R. pimpinellifolia* L.]	Rosaceae	N Ch	G/V	i s a	end	*C*	Eur S & SE, Asia SW & C	I [C]	XVI[45]	XIX [I] 2/2 XX	Adamowski *et al.* 2002; Zając A. *et al.* 1998	n.c.d.	H	?		Meusel *et al.* 1965; Hulten & Fries 1986
? ***Rosa virginiana*** Herrm.	Rosaceae	N	G/V	i s a	end		Am N [E & N]	I [O]		1/2 XIX	Zając A. *et al.* 1998	n.c.d.	H	?		
Rudbeckia hirta L.	Asteraceae	H	G	i s	ane egz myr anthr	*CR*	Am N	I [O]	1860[2]	2/2 XIX	Mirek *et al.* 2002	n.c.d.	H	1(+/–)		Meusel *et al.* 1965
Rumex longifolius DC.	Polygonaceae	H	G	w s	ane egz hyd		Eur NE	UI	1961[5]	XIX	Zając A. *et al.* 1998	n.c.d.	SH	?	Czech Rep.	
Rumex patientia L.	Polygonaceae	H	G	w s	ane egz hyd	*C*	Eur & Asia	I [C]	1861[5]	XVIII [I] XIX	Kluk (1788) – only as cultivated plant; Zając A. *et al.* 1998	n.c.d.	H	?		Hegi 1958; Jalas & Suominen 1979
Salix acutifolia Willd.	Salicaceae	N	G/V	i	ane	*C*	Eur E & Asia C	I [O, C]		XVIII	Zając A. *et al.* 1998	154	NSH	2(+1)		
? ***Salix cordata*** Michx.	Salicaceae	N	G/V	i	ane		Am N	I [FO]		2/2 XX	Zając A. *et al.* 1998	n.c.d.	N	?		
? ***Salix eriocephala*** Michx.	Salicaceae	N	G/V	i	ane		Am N	I [O]	XIX[10]	2/2 XX	Zając A. *et al.* 1998	n.c.d.	H	?		
Scutellaria altissima L.	Lamiaceae	H	G	i	ane egz aut	*C*	Eur S & SE	I [C]	1901[5]	1/2 XX	Zając A. *et al.* 1998	n.c.d.	SH	?		
Sorbaria sorbifolia (L.) A. Braun	Rosaceae	N	G/V	i	aut anthr	*C*	Asia N & E	I [O]	1750 [I][45] 1890[62] 1904[25]	XIX	Adamowski *et al.* 2002; Zając A. *et al.* 1998	n.c.d.	NSH	?		
? ***Spiraea tomentosa*** L.	Rosaceae	N	G/V	i	ane aut anthr		Am N [E]	I [O]	XIX	XIX	Hereźniak 1992; Dajdok Z., Pender K. & Kącki Z. 2003 unpubl.	n.c.d.	NSH	?	Germany	
? ***Spirea chamaedryfolia*** L. em. Jacq. [= *S. ulmifolia* Scop.]	Rosaceae	N	G/V	i	ane aut anthr		Eur SE, Asia NE & C	I [O]	1789 [I][45] 1826[62] 1900[5]	XIX	Zając A. *et al.* 1998	n.c.d.	NSH	?		

Name of species	Family	LF	R	P	Disp	LS	Origin	Way of INT	First record for Europe	First record for Poland	Source of historical data for Poland	Nrs of sq.	Hab.	Dyn	Described as invasive elsewhere	Maps
? ***Spirea pseudosalicifolia*** Silverside **H** [= *S. salicifolia* L. x *S. douglasii* Hook.]	Rosaceae	N	V/G	i	ane aut anthr		Anthropog.	I [O]		XIX ?	Zając A. *et al.* 1998	n.c.d.	H	?		
? ***Symphoricarpos albus*** (L.) S.F. Blake [= *S. racemosus* Michx.; *S. rivularis* Suksd.]	Caprifoliaceae	N	G/V	i	end anthr	*C*	Am N [NE]	I [O]	1789 [I][1] 1887[25]	1824 [I] XVIII ?	Hereźniak 1992; Zając A. *et al.* 1998	n.c.d.	NSH	?	Czech Rep.	
Syringa vulgaris L.	Oleaceae	N	G/V	i	aut	*C*	Eur SE	I [O]	1554 [I][45] 1787 ?[25]	XVI [I] ? XVIII	Adamowski *et al.* 2002; Zając A. *et al.* 1998; Kluk (1788) – only as cultivated plant;	n.c.d.	NSH	3(+1)	Czech Rep.	
? ***Thuja plicata*** Donn ex D. Don	Cupressaceae	M	G	w	ane end		Am N [W]	I [O]	1853 [I][1]	1826 [I]	Hereźniak 1992	n.c.d.	NH	?		
? ***Tsuga canadensis*** (L.) Carrière	Pinaceae	M	G	w	ane		Am N [E]	I [O]	1736 [I][1]	1813 [I]	Hereźniak 1992	n.c.d.	N	?		
Typha laxmanii Lepech.	Typhaceae	H	G/V	w	ane		Eur & Asia	I [O]	1996[47]	XX	Mirek *et al.* 2002	15	NSH	1(+1)	Hungary	Baryła *et al.* 2005
Ulex europaeus L.	Fabaceae	N	G	i	aut myr	*C*	Afr N & Eur SW	I [O, FO]	1773[10] 1880[5]	XIX	Zając A. *et al.* 1998	n.c.d.	SH	?		Meusel *et al.* 1965; Hultén & Fries 1986
Veronica gentianoides Vahl	Scrophulariaceae	H	G/V	i s	ane myr		Asia SW	I [O]		1968	Mirek *et al.* 2002; Oklejewicz 1997	n.c.d.	S	?		
? ***Vitis vinifera*** L. subsp. ***vinifera*** [= *V. vinifera* L. *s.str.*]	Vitaceae	H li	G/V	i s	end		Eur Asia	I [F, O]	Anc Ar[5]	Anc XX	Kluk (1788) – only as cultivated plant	n.c.d.	SH	?		

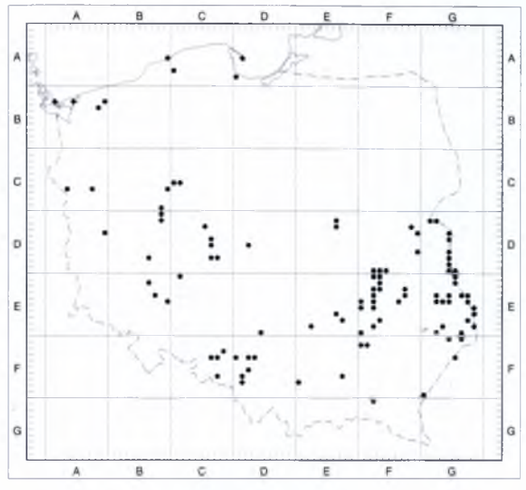
Appendix C. Supplements to the *Distribution Atlas of Vascular Plants in Poland*



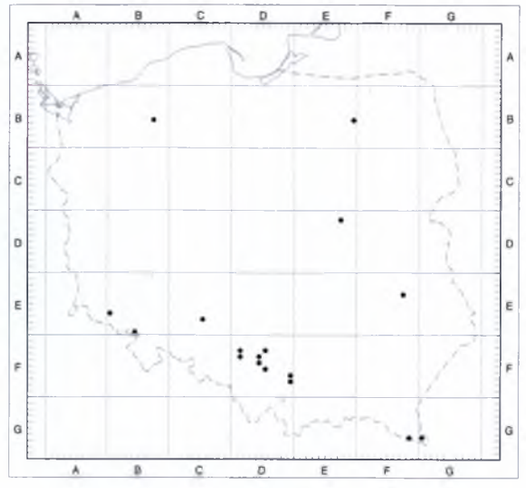
Asclepias syriaca L.



Medicago x varia Martyn



Sicyos angulata L.



Sisyrynchium bermudiana L. emend. Farw.

During the process of gathering data on the distribution of kenophytes in Poland, 5 maps were developed for the species not included in *Distribution Atlas of Vascular Plants in Poland* (Zając A. & Zając M. 2001). These are:

Ailanthus altissima (Mill.) Swingle (the map for this species is included in Chapter 7: Fig. 39);
Asclepias syriaca L.
Medicago x *varia* Martyn
Sicyos angulata L.
Sisyrinchium bermudiana L. em. Farw.

Among the above-listed species, *Medicago* x *varia* occurs relatively often and is a species of hybrid origin resulting from the crossing of an alien species *M. sativa* with the native *M. falcata.* In some regions it might even be found more frequently than the parental species (cf. also Chapter 8). The other three species continue to show increases in the number of stations occupied. It is worth noting that *Asclepias syriaca*, previously noted around cultivated areas or along railway routes (on embankments) has been now recorded in dry meadows and grasslands, where (being a clonal plant) it colonises large areas. *Sisyrinchium bermudiana*, found in meadows and ruderal habitats, probably has more stations but is difficult to find outside the brief flowering period and thus might be overlooked. This species, which originated from the eastern part of North America, occurs also in the Bermudas and in Ireland (Sendek & Wika 1982). It was brought to Europe in the first half of the 19th century as a decorative plant. The first sites where it returned to the "wild" were reported in 1835 from north-western Germany (after Hegi 1909). In Poland, it was first found as recently as in the first half of the 20th century in the Sudety Mts. (Schube 1928). Occurs also in all countries bordering Poland. The number of sites with the plants returning to the "wild state" could increase because the plant is currently offered by gardening shops.

Appendix D. A comparison of the terminologies for the classification of synanthropic plants used in studies on plant invasions in Central Europe, in Poland and that proposed by Richardson *et al.* 2000

Proposed phytogeographical term in Central European studies	Definition	Term used in Polish studies	Definition	Recommended terminology by Richardson *et al.* 2000	Definition
A. Apophytes	native species occurring in man-made habitats	A. Apophytes	native species occurring in man-made habitats		
B. Anthropophytes	species introduced by man	B. Anthropophytes	alien plant species	Alien plants	Plant taxa in a given area whose presence there is due to intentional or accidential introduction as a result of human activity.
I. Hemerophytes	introduced intentionally	I. Diaphytes	not permanently established	Casual alien plants	*Alien plants* that may flourish and even reproduce occasionally in an area, but which do not form self-replacing populations, and which rely on repeated introductions for their persistence.
II. Xenophytes	introduced unintentionally	II. Metaphytes	permanently established /settled	Naturalised plants	*Alien plants* that reproduce consistently and sustain populations over many life cycles without direct intervention by humans (or in spite of human intervention); they often recruit offspring freely, usually close to adult plants, and do not necessarily invade natural, semi-natural or human made ecosystems.
1. Archaeophytes	introduced before 1500	1. Archaeophytes	introduced before 1500	Invasive plants[1]	*Naturalised plants* that produce reproductive offspring, often in very large numbers, at considerable distances from parent plants (approximate scales: > 100 m; < 50 years for taxa spreading by seeds and other propagules; > 6 m/3 years for taxa spreading by roots, rhizomes, stolons, or creeping stems), and thus have the potential to spread over a considerable area.
2. Neophytes	introduced after 1500	**2. Kenophytes**	introduced after 1500		
a. Ephemerophytes	temporary occurrence, only in man-made habitats (not invasive)				
b. Epecophytes	established in man-made habitats	a. Epecophytes	established in man-made habitats		
c. Neoindigenophytes (= agriophytes)	penetrating into natural habitats	b. Agriophytes (= Neophytes *sensu* Faliński)	penetrating into natural habitats	↓ Transformers	A subset of *invasive plants* which change the character, condition, form or nature of ecosystems over a substantial area relative to the extent of that ecosystem.

Source: Kornaś 1981; Pyšek 1995; Tokarska-Guzik 2001a; Richardson *et al.* 2000

1 – The Authors of the cited definition suggest that *invasive* should be used with reference to the 'biogeographic/demographic' status of a species without any connotation of impact;

Richardson *et al.* 2000 also include in their recommended terminology the well-established term for harmful plants – **Weeds** – plants (not necessarily *alien*) that grow in sites where they are not wanted and which usually have detectable economic and environmental effects (see also text in Chapter 12);

yellow cells – indicates the main correspondence in alien plant terminology between different classifications; red cells – indicates kenophytes and their equivalent groups in the other terminologies cited.

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