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HISTORY OF THE SYNANTHROPIC CHANGES OF FLORA AND VEGETATION OF POLAND

ABSTRACT

On the basis of plants found in archaeological excavations in Poland, natural and semi-natural plant communities most often exploited by man in prehistoric times are described. The development of synanthropic flora and vegetation from Neolithic to the Late Middle Ages is discussed. The changes in the synanthropic flora of Cracow during the 19th and 20th centuries are analysed on the basis of herbarium material and published floras. Modern and prehistoric synanthropic floras of Cracow are compared. The opinion is expressed that the present-day synanthropic flora and vegetation reflect local habitat conditions and past and present economic activity of man.

INTRODUCTION

The aim of this article is 1. to discuss the possible ways of formation of the synanthropic flora and vegetation in pre- and early historic times in the whole Poland and 2. to analyse changes in the modern synanthropic flora of a selected area in comparison with subfossil flora of the same area, on the example of Cracow. The data used include subfossil remains of wild plants from archaeological excavations in the whole country [3] and herbarium materials, as well as published floras concerning the synanthropic flora of Cracow in the 19th and 20th centuries [9].

In Poland, 452 species of wild plants were described from 285 archaeological sites covering the time of about 6 thousands years, since the Neolithic to the end of the Late Middle Ages. It is a fairly large number of taxa equalling about one fifth of the present-day Polish flora. They represent only a part of the flora known from the corresponding period of the Holocene because plants found in peats and sediments undisturbed by man were not included in these considerations. The confinement to plants discovered in culture layers allows us to assume that many of them spread in

anthropogenic habitats already in the prehistoric time. Main shortcomings of the material are: different duration of the periods compared (Neolithic Age about 3 thousands years, periods of the Iron Age about 250—400 years each), unequal degree of their investigation (66 species known from the Neolithic and 369 from the younger phase of Early Middle Ages), and the gaps in the record for which no or almost no data about wild plants exist (Bronze Age 1800—700 B.C., La Tène period 400 B.C.—O, Migration period 375—570 A.D.).

Before passing on to the discussion of this material it may be useful to remind the ways of dispersal of diaspores (or other plant fragments). With increasing distance from the parent plant the number of seeds per unit area declines rapidly (Fig. 1). It happens, however, that a dispersal agent (wind, water, animal, man) carries diaspores over longer distances. When we think now of a fossil sample as representing certain place of a prehistoric site we may assume that diaspores were brought to this place by natural means or by man from on area exploited by the inhabitants of this site. Diaspores of plants growing nearest to the site had best chances to get there as well as cultivated and gathered plants. The application of this assumption to the fossil material is justified by the observation that species of a limited geographical range were found as fossils only within or near their present-day range, e.g. *Myrica gale* in Gdańsk, *Thalictrum aquilegifolium* and *Lysimachia nemorum* in Cracow. Therefore, for each identified taxon a habitat and a community[1] (or communities) were indicated where this taxon could have occurred nearest to human settlements. In addition, possible natural communities were mentioned for species growing in anthropogenic habitats. Cultivated plants were not taken into account.

We are aware of the fact that plant communities have changed in the course of time and the more distant period is studied the greater difference may be found compared to the present-day conditions. Some forest communities, for instance, must have had different floristic composition in the older Neolithic than in younger times due to the late spread of *Carpinus* and *Fagus*. We think, however, that — provided unaltered ecological requirements of the majority of plant species — the groups of taxa accepted here give general information about the type of plant communities and of habitats which existed within the range of economic activity of pre- and early historic man. Broad representation of various communities and of various ways of penetration of plants in the habitats changed by man are ensured by the heterogeneity of the subfossil material with respect to its state of preservation (charred and uncharred) and origin (contents of pits, impressions, fossils scattered in culture layers).

[1] Phytosociological units after „Szata roślinna Polski" (A. Medwecka-Kornaś et al. 1972).

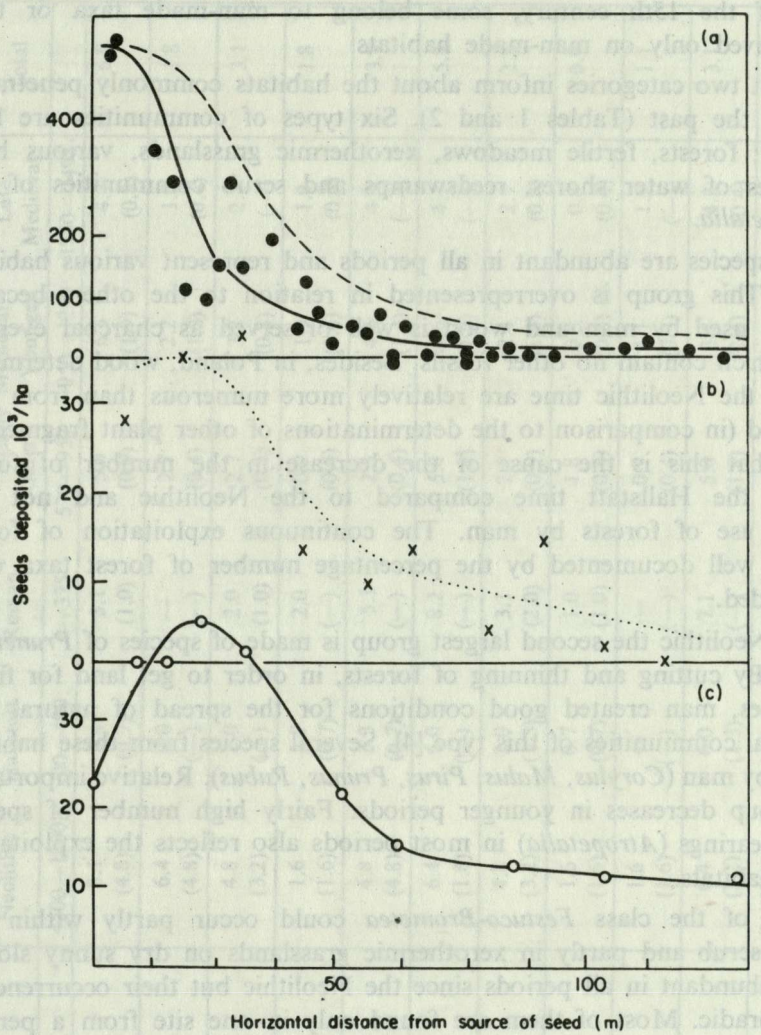

Fig. 1. The distribution of seeds of *Eucalyptus regnans*, from trees ca 75 m high
a) From the edge of a dense forest; b) From the edge of a sparse forest; c) From an isolated tree (after J. L. Harper 1977).

PLANTS OF NATURAL AND SEMI-NATURAL COMMUNITIES IN PREHISTORIC TIMES

Subfossil plants may be grouped in three categories: 1. native species growing exclusively, or almost exclusively, in natural and semi-natural communities, 2. apophytes — species which occur in natural and semi--natural communities, but frequently and abundantly grow in anthropogenic habitats, 3. archaeophytes — species unknown by us from natural habitats; most of them are alien plants introduced with human husbandry before

the end of the 15th century, some belong to man-made taxa or taxa which survived only on man-made habitats.

The first two categories inform about the habitats commonly penetrated by man in the past (Tables 1 and 2). Six types of communities are best represented: forests, fertile meadows, xerothermic grasslands, various herb communities of water shores, reedswamps and scrub communities of the order *Prunetalia*.

Forest species are abundant in all periods and represent various habitats (Table 1). This group is overrepresented in relation to the others because timber was used by man and wood is well preserved as charcoal even in dry sites which contain no other fossils. Besides, in Poland, wood determinations from the Neolithic time are relatively more numerous than from any other period (in comparison to the determinations of other plant fragments). It seems that this is the cause of the decrease in the number of forest species in the Hallstatt time compared to the Neolithic and not the decreasing use of forests by man. The continuous exploitation of forest habitats is well documented by the percentage number of forest taxa with trees excluded.

In the Neolithic the second largest group is made of species of *Prunetalia* (Table 2). By cutting and thinning of forests, in order to get land for fields and pastures, man created good conditions for the spread of natural and semi-natural communities of this type [4]. Several species from these habitats were used by man (*Corylus, Malus, Pirus, Prunus, Rubus*). Relative importance of this group decreases in younger periods. Fairly high number of species of forest clearings (*Atropetalia*) in most periods also reflects the exploitation of forest habitats.

Species of the class *Festuco-Brometea* could occur partly within the *Prunetalia* scrub and partly in xerothermic grasslands on dry sunny slopes. They are abundant in all periods since the Neolithic but their occurrence is always sporadic. Most of them are found only in one site from a period.

At all times an important role was played by species of different herb communities growing on water shores (*Bidentetalia, Isoëto-Nanojuncetea, Agropyro-Rumicion crispi*, species of riverside landslides and gravels). This group includes the largest number of frequent species, i.e. described from at least 3 localities in a period. Here we have also 6 species which belong to the most common taxa of wild herbs in prehistoric times: *Chenopodium album* (47 localities), *Polygonum persicaria* (45), *P. lapathifolium* s.l. (34), *P. aviculare* (32), *Rumex crispus* (21), and *Polygonum hydropiper* (19).

Two species which occur today chiefly in meadows, were found already in the Neolithic time, namely *Plantago lanceolata* and *Rumex acetosa*. At that time they grew probably at the edge of riverside brushwoods or in grazed forests. The number of meadow species increases distinctly in the Hallstatt time and remains at more or less the same level through

Table 1. Number of forest species from archaeological excavations in Poland as % of the total of wild plants (in brackets numbers of species known at least from 3 sites). For other explanations see Table 2

Period	Neolithic	Hallstatt	Roman	Early Medieval Older	Early Medieval Younger	Late Medieval	Total
Age BC/AD	4500—1800	700—400	0—375	570—950	950—1250	1250—1492	
Deciduous forests *Querco-Fagetea*	8.1 (4.8)	5.4 (0.7)	3.1 (1.0)	5.0 (0.9)	6.5 (1.9)	4.7 (0.8)	6.0
Shady deciduous forests *Fagetalia*	6.4 (4.8)	2.0 (—)	— (—)	2.7 (0.4)	2.2 (1.3)	1.5 (0.4)	1.8
Oak-hornbeam forests *Tilio-Carpinetum*	4.8 (3.2)	2.0 (—)	2.0 (1.0)	2.7 (0.4)	3.2 (0.8)	2.3 (—)	3.1
Swamp forests *Alnetalia*	1.6 (1.6)	2.7 (0.7)	2.0 (—)	0.9 (0.4)	1.9 (0.4)	1.9 (0.5)	1.8
Carr with ash, alder and elm *Alno-Padion*	4.8 (4.8)	3.3 (0.7)	5.1 (—)	2.3 (0.4)	4.6 (1.3)	4.7 (—)	3.9
Poplar-willow riverside carr *Populetalia*	6.4 (1.6)	6.0 (—)	8.2 (—)	5.0 (1.8)	4.6 (1.9)	4.3 (—)	5.3
Mixed pine-oak forests *Pino-Quercion*	4.8 (3.2)	2.0 (1.3)	3.1 (2.0)	2.7 (0.9)	2.4 (1.3)	2.7 (0.8)	2.2
Pine forests *Dicrano-Pinion*	1.6 (1.6)	0.7 (0.7)	1.0 (1.0)	1.8 (0.4)	0.8 (0.5)	0.8 (0.4)	0.9
Coniferous forests *Vaccinio-Piceetea*	1.6 (1.6)	— (—)	— (—)	0.9 (0.4)	1.1 (0.3)	1.5 (—)	1.1
Forest clearings and windfalls *Atropetalia*	6.4 (3.2)	6.0 (1.3)	7.1 (—)	5.0 (1.8)	3.5 (2.4)	4.3 (0.4)	3.1
Σ of forest species Σ of forest excl. trees	29.0 10.0	24.2 18.2	26.5 17.5	21.3 14.5	24.1 17.9	23.3 16.7	22.8
Σ of all wild taxa (100%)	62	149	98	221	369	257	452
Number of sites	77	60	19	29	62	12	285

Table 2. Number of species of various plant communities found in archaeological excavations from Poland as % of the total of wild plants (in brackets number of species known at least from 3 sites)

Period	Neolithic	Hallstatt	Roman	Early Medieval Older	Early Medieval Younger	Late Medieval	Total
Age BC/AD	4500—1800	700—400	0—375	570—950	950—1250	1250—1492	
Σ of forest species	29.0	24.2	26.5	21.3	24.1	23.3	22.8
Σ of forest excl. trees	10.0	18.2	17.5	14.5	17.9	16.7	
Xerothermic scrub and woodlands	3.2	1.3	1.0	2.3	1.9	2.7	2.2
Quercetalia pubescentis	(1.6)	(0.7)	(—)	(0.4)	(1.1)	(0.4)	
Scrubs of forest edges	17.7	6.7	5.1	7.2	6.7	8.6	7.3
Prunetalia	(3.2)	(—)	(—)	(1.3)	(2.7)	(0.4)	
Xerothermic grasslands	8.1	8.7	3.1	6.3	9.7	8.9	9.7
Festuco-Brometea	(—)	(—)	(—)	(—)	(1.6)	(—)	
Hay–meadows	3.2	8.7	8.2	5.9	5.1	6.2	4.6
*Molinio-Arrhenatheretea**	(—)	(—)	(—)	(2.3)	(2.4)	(—)	
Fresh hay–meadows	—	2.0	1.0	5.0	4.1	3.5	4.9
Arrhenatheretalia	(—)	(—)	(—)	(—)	(0.8)	(—)	
Periodically wet hay meadows	—	7.4	6.1	6.8	5.7	7.8	6.0
Molinietalia	(—)	(—)	(—)	(—)	(1.6)	(—)	
Inland sand associations	—	4.7	3.1	3.2	2.7	2.3	2.9
Sedo-Scleranthetea	(—)	(—)	(—)	(0.4)	(0.5)	(—)	
Heathlands and infertile meadows	—	1.3	1.0	1.3	1.1	1.5	0.9
Nardo–Callunetea	(—)	(—)	(—)	(0.4)	(0.3)	(—)	
Dump meadows, bogs	1.6	4.7	5.1	4.1	4.1	4.7	4.2
Scheuchzerio–Caricetea	(—)	(—)	(—)	(—)	(0.5)	(—)	
Water shores**	11.3	10.1	12.2	11.3	9.5	9.3	8.6
	(4.8)	(2.7)	(4.1)	(2.7)	(2.4)	(0.8)	
Reedswamps**	4.8	8.0	13.3	7.2	8.7	7.8	8.2
	(—)	(—)	(—)	(0.4)	(2.4)	(—)	
Aquatics	3.2	4.0	1.0	0.9	2.4	1.2	2.6
	(—)	(—)	(—)	(—)	(0.3)	(—)	

Plant species occurring frequently in different present–day communities were included in several syntaxonomic groups.

* Does not include species counted in *Arrhenatheretalia* and *Molinietalia*.

** *Bidentetalia, Agropyro–Rumicion crispi, Isoëto-Nanajunalea*, plants of landslides and gravels.

*** *Phragmitetea, Calthion, Filipendulo-Petasition*.

all the younger periods. By meadow species we understand plants which have their ecological optimum and most common occurrence in the present-day meadows. Many of them originally were forest plants. Meadows of fertile habitats (*Molinio-Arrhenatheretea*) are best represented, and particularly abundant are species of communities growing in wet habitats (*Molinietalia*). Species of fresh soils (*Arrhenatheretalia*) increase in number since the older phase of the Early Medieval time. The presence of species of the classes *Sedo-Scleranthetea* and *Scheuchzerio-Caricetea* indicates that grasslands on poor soils were also used as early as the Hallstatt time. Three species of meadows and one of sandy grasslands were frequently found in archaeological excavations: *Rumex acetosa* (24 localities), *Melandrium album* (23), *Plantago lanceolata* (14), and *Rumex acetosella* s.l. (24).

Table 3. Number of syntaxonomic units (alliances or classes) growing in the area penetrated by man in prehistoric and historic periods

Period	Neolithic 4500—1800	Hallstatt 700—400	Roman 0—375	Early Medieval		Late Medieval 1250—1492	20th century
				Older 570—950	Younger 950—1250		
Natural communities	17	19	20	23	24	25	29*
Semi-natural communities (hay-meadows)	1	5	3	5	5	5	5
Synanthropic communities including:	5	8	6	9	9	9	9
field communities	4	4	4	5	5	5	5
ruderal communities	1	4	2	4	4	4	4

* Excluding communities of special habitats: sea-shores (*Ammophiletea*), mountains (*Elyno-Seslerietea, Caricetea curvulae, Salicetea herbaceae, Asplenietea rupestris, Pinion mughi*), saline places (*Thero-Salicornietea, Juncetea maritimi*), springs (*Montio Cardaminetae*) and oligotrophic lakes (*Littorelletea*): phytosociological units after „Szata roślinna Polski" A. Medwecka-Kornaś et al. 1972).

An interesting feature is seen from the comparison of the number of communities penetrated and exploited by man throughout the ages (Table 3). Number of native communities increases gradually till modern times while the number of synanthropic, segetal and ruderal, communities is established relatively early. This may mean that human activities had strong influence on the flora at least since the Neolithic time and the spread of native plants on man-made habitats was a rather quick process. Large number of apophytes in the Neolithic suggests that some of them (particularly those of the water shores) could have occurred on places disturbed by man even before the introduction of agriculture, in the Mesolithic Age.

SYNANTHROPIC FLORA OF POLAND IN PREHISTORIC TIMES

Plants which could occur as apophytes in prehistoric time make 23% of the total number of wild species (105 species: Appendix 1, Table 4). Number of ruderals is more or less equal to the number of segetal species with the exception of the Neolithic and Roman times which are characterized by the predominance of segetal weeds. This may be explained partly by the type of material — from both these periods mostly samples of charred cereals were studied. However, it is possible that the smaller number of ruderal species in the Neolithic Age reflects also lesser stability of settlements and their shorter historical background, compared to the well developed permanent settlements of the Hallstatt time.

Table 4. Apophytes from archaeological excavations in Poland

Period Age BC/AD	Neolithic 4500—1800		Hallstatt 700—400		Roman 0—375		Early Medieval				Late Medieval 1250—1492		Total	
							Older 570—950		Younger 950—1250					
	Σ	%	Σ	%	Σ	%	Σ	%	Σ	%	Σ	%	Σ	%
Total of apophytes	17	27.4	47	31.5	26	26.5	68	30.8	91	24.7	66	25.7	105	23.2
ruderals	6	9.7	22	14.8	9	9.2	29	13.1	43	11.6	28	10.9	47	10.4
ruderals/weeds	2	3.2	5	3.3	6	6.1	10	4.5	11	3.0	8	3.1	12	2.6
fields weeds	9	14.5	20	13.4	11	11.2	29	13.1	37	10.0	30	11.7	46	10.2
Apophytes of:														
water shores	7	11.3	13	8.7	11	11.2	24	10.8	30	8.1	22	8.6	34	7.5
forests	4	6.4	12	8.0	6	6.1	17	7.7	26	7.0	16	6.2	27	6.0
meadows	2	3.2	13	8.7	7	7.1	16	7.2	19	5.1	18	7.0	25	5.5
xerothermic habitats	4	6.4	6	4.0	—	—	6	2.7	11	3.0	6	2.3	12	2.6
sandy habitats	—	—	3	2.0	2	2.0	4	1.8	5	1.3	4	1.5	6	1.3
others	—	—	—	—			1	0.4	—	—	—	—	1	0.2
Total of wild plants 100%	62		149		98		221		369		257		452	

Among apophytes the predominating group is made of species coming from different habitats connected with shores of water bodies (Table 4). This group includes almost the same number of segetal and ruderal species (see Appendix 1). Next in numbers are the apophytes of forests and fertile meadows. Forest species play an important role since the Neolithic, most of them belong to ruderals. Meadow apophytes increase in number in the Hallstatt period and ever since form an important group comprising more species growing in fields than in ruderal habitats. Apophytes of xerothermic and sandy habitats are less numerous, the latter are represented almost exclusively by field weeds.

The comparison of the five largest groups of plants with respect to the ratio of apophytes to non-apophytes indicates that almost all plants of water

shores belong to apophytes (Table 5). This results from their ability to spread on disturbed habitats and their high demands concerning the nitrogen content in the soil. Among the forest and meadow species apophytes make only about on third and among the xerothermic species one sixth of the total number of taxa in these groups.

Table 5. Percentage number of plant species from archaeological excavations in Poland in five largest ecological groups

Period Age BC/AD	Neolithic 4500—1800	Hallstatt 700—400	Roman 0—375	Early Medieval		Late Medieval 1250—1492	Total
				Older 570—950	Younger 950—1250		
Total of wild plants 100%	62	149	98	221	369	257	452
Total of apophytes	17	47	26	68	91	66	105
Forest plants	29.0	24.2	26.5	21.3	24.1	23.3	22.8
apophytes	6.4	8.0	6.1	7.7	7.0	6.2	6.0
others	22.6	16.2	20.4	13.6	17.1	17.1	16.6
Water-shore plants	11.3	10.1	12.2	11.3	9.5	9.3	8.6
apophytes	11.3	8.7	11.2	10.8	8.1	8.6	7.5
others	—	1.4	1.0	0.5	1.4	0.7	1.1
Meadow plants	3.2	18.1	15.3	17.7	14.9	17.5	15.5
apophytes	3.2	8.7	7.1	7.2	5.1	7.0	5.5
others	—	9.4	8.2	10.5	9.8	10.5	10.0
Xerothermic plants	19.3	14.1	6.1	9.9	13.3	13.2	15.9
apophytes	6.4	4.0	—	2.7	3.0	2.3	2.6
others	12.9	10.1	6.1	7.2	10.3	10.9	13.3
Plants of sandy soils	—	4.7	3.1	3.2	2.7	2.3	2.9
apophytes	—	2.0	2.0	1.8	1.3	1.5	1.3
others	—	2.7	1.1	1.4	1.4	1.8	1.6

Archaeophytes are represented by 88 species, i.e. 19% of the total number of wild plants from archaeological localities (Appendix 2, Table 6). Thirteen species, it means 15% of all archaeophytes, occur already in the Neolithic. They belong mostly to the field weeds. New species of archaeophytes arrive in each successive period (Table 6). Strong influence of permanent settlement may be seen in the increasing number of ruderal species first in the Hallstatt time and then in the older phase of the Early Medieval time. Particularly large number of new archaeophytes appear in the latter time (6—10th centuries A.D.), when 30 new species arrive, i.e. 34% of the total of archaeophytes. Probably this was the time of the more intensive synanthropization of the flora connected with the development of settlement following the Migration period.

Table 6. Synanthropic plants from archaeological excavations in Poland

Period / Age BC/AD			Neolithic 4500—1800		Hallstatt 700—400		Roman 0—375		Early Medieval: Older 570—950		Early Medieval: Younger 950—1250		Late Medieval 1250—1492		Total	
			Σ	%	Σ	%	Σ	%	Σ	%	Σ	%	Σ	%	Σ	%
Archaeophytes	Total		13	21	25	17	23	23	58	26	74	20	58	23	88	19.5
	ruderals		2	3.2	9	6	4	4.1	20	9.0	31	8.4	16	6.2	34	7.5
	ruderals/weeds		1	1.6	1	0.7	2	2.0	5	2.3	4	1.1	5	1.9	6	1.3
	field weeds		10	16.1	15	10.1	17	17.3	33	14.9	39	10.6	37	14.4	48	10.6
Number of new species in each period	Total		13		15		10		30		14		6			
	ruderals		2		8		2		13		19		1			
	ruderals/weeds		1		—		1		2		—		1			
	field weeds		10		7		7		15		5		4			
Archaeophytes + apophytes	ruderals		30	48.4	72	48.4	49	50.0	126	57.0	165	43.5	124	48.0	193	47.0
	ruderals/weeds		8	12.9	31	21.0	13	13.2	49	22.2	74	19.6	44	17.1	81	19.0
	field weeds		3	4.8	6	4.3	8	8.2	15	6.8	15	3.9	13	5.1	18	4.0
			19	30.5	35	23.5	28	28.5	62	28.0	76	20.0	67	26.0	94	21.0
Total of wild plants (100%)			62		149		98		221		369		257		452	

As far as the origin of archaeophytes is concerned [10] we can see that the majority of species known from the Neolithic and Hallstatt times come from the south-east (e.g. *Setaria glauca* from south-east Asia, *Thlaspi arvense* and *Avena fatua* from central Asia, *Chenopodium ficifolium* and *Hyoscyamus niger* from Irano-Anatolian area, *Agrostemma githago* and *Sonchus asper* from East-Mediterranean area). Similarly, the species which immigrate in the older phase of the Early Medieval time include many newcomers from the Irano-Turanian area (*Nepeta cataria, Lamium album*), from the other Asiatic centres (*Descurainia sophia, Lepidium ruderale*) and from the Pontic area (*Consolida regalis, Melandrium noctiflorum*). Species of the West-Mediterranean origin arrive in the Roman time (*Scleranthus annuus, Spergula arvensis*) and in the younger phase of Early Medieval time (*Geranium dissectum*). In this phase also the Atlantic-Mediterranean species appear (*Aphanes arvensis, Sonchus oleraceus*). The appearance of archaeophytes of different origin in different periods indicates that species expanded in groups at various times and we may speak about the waves of migration from the south-east and the south-west.

SYNANTHROPIC FLORA OF CRACOW IN MODERN TIMES

In the 19th century, archaeophytes became large and widespread group (about 150 species in Poland and 128 only in Cracow). Their expansion was connected with the maximum spread of cultivated land due to the bringing into cultivation also poor lands (too dry, too wet, stony) and with poor sanitary conditions of settlements, increasing in size and population density. Highly differentiated anthropogenic habitats covered large areas and were not yet subjected to radical changes. In the latter part of the 20th century (after 1950), on the other hand, the regress of the archaeophytes can be observed. Twenty six species disappeared from Cracow; this number includes 20 species noted for the last time in 1907—1920 and 6 about 1950. Altogether 20 species of segetal weeds and 6 species of ruderal plants retreated from the town area. In most cases they can be found in the terrains distant from towns and industrial centres. Few archaeophytes became rare plants, for instance *Adonis aestivalis* was known from 13 localities in Cracow, but only once it was recorded after 1950. *Chenopodium bonus-henricus* and *Polygonum lapathifolium* ssp. *pallidum* are other examples of the regression of archaeophytes as urbanization of the studied area increased (Fig. 2).

Kenophytes[2] — species introduced since the end of the 15th century and established in our flora — immigrated gradually. The oldest published floras of Cracow [1, 2] mention 16 kenophytes, including 15 epoecophytes

[2] Kenophytes, holoagriphytes, hemiagriophytes sensu J. Kornaś (1968).

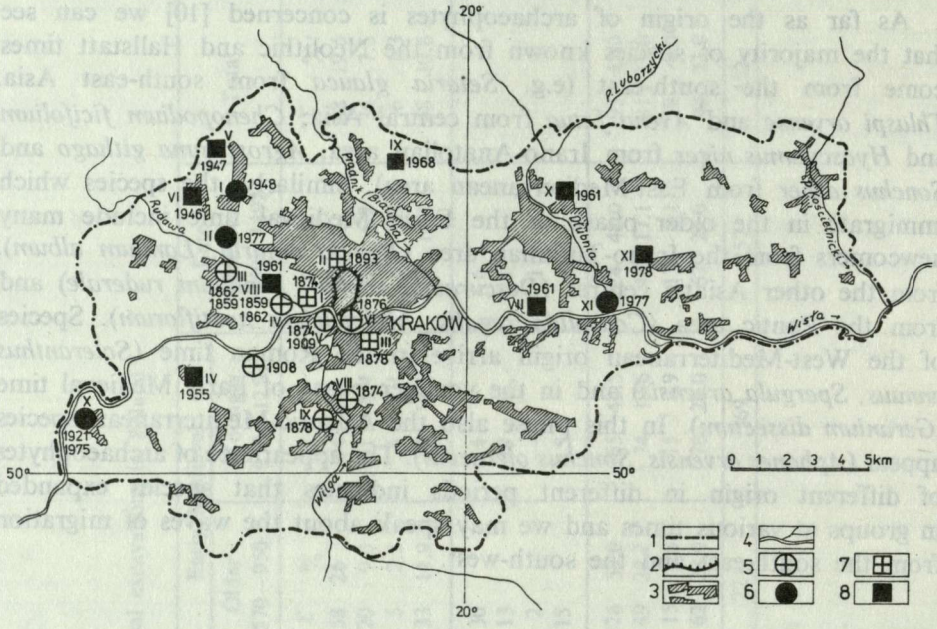

Fig. 2. Examples of regression of archaeophytes from the Cracow area
1 — present-day city limit; 2 — the limit of the Old Town; 3 — buildings; 4 — rivers; *Chenopodium bonus-henricus*: 5 — localities known from before 1920 A.D.; 6 — localities known after 1920 A.D.; *Polygonum lapathifolium* ssp. *pallidum*: 7 — localities known from before 1920 A. D.; 8 — localities known after 1920 A. D. (after H. Trzcińska-Tacik, 1979).

and one holoagriophyte. After the railway line was built in Cracow (1844 and 1851) a new wave of kenophytes immigrated in the years 1860—1920: 11 epoecophytes, 6 hemiagriophytes and one holoagriophyte. During the years 1921—1979 the flora of Cracow was enriched in one holoagriophyte (previousely known as epoecophyte), 7 hemiagriophytes and 21 epoecophytes; 16 species of the last group appeared around 1950.

After the year 1960 new species arrive but only few of them show the tendency to spread and become established. Most of them belong to the species already known from other places in Poland, for instance *Epilobium adenocaulon* and *Oenothera depressa*. At the same time, older immigrants expand on new habitats, e.g. *Impatiens parviflora* penetrates to forests, *Vicia sordida* to xerothermic grasslands and meadows.

Certain species of epoecophytes and agriophytes, which expanded in the 19th century, at present tend to diminish the number of their localities. *Datura stramonium* and *Elodea canadensis* are good examples. *Elodea*, noticed for the first time in Cracow in 1877, had 9 localities in 1885 and only 3 in 1979.

Thus, we can observe the arrival of new species, their expansion and regression, according to changes in the economic activity of man which makes an important element of plant habitats.

Proper apophytes must have been fairly common in the town floras of the 19th century, though often the occurrence of native species in anthropogenic habitats was not noticed. Native species of some extreme habitats became apophytes when agricultural exploitation of land spread on these habitats. When the use of these habitats was given up, several species disappeared (e.g. in Cracow after 1950 — *Filago minima, F. arvensis, Arnoseris minima, Illecebrum verticillatum, Myosurus minimus*) or became very rare (e.g. *Radiola linoides, Veronica verna*).

The expansion of apophytes in modern times may be traced only with respect to rare species, which were recorded by former botanists, for instance *Puccinellia distans*. No method exists which would enable us the study of changes in the distribution of more common plants which have expanded recently, but which were omitted in the floristic records from the 19th century.

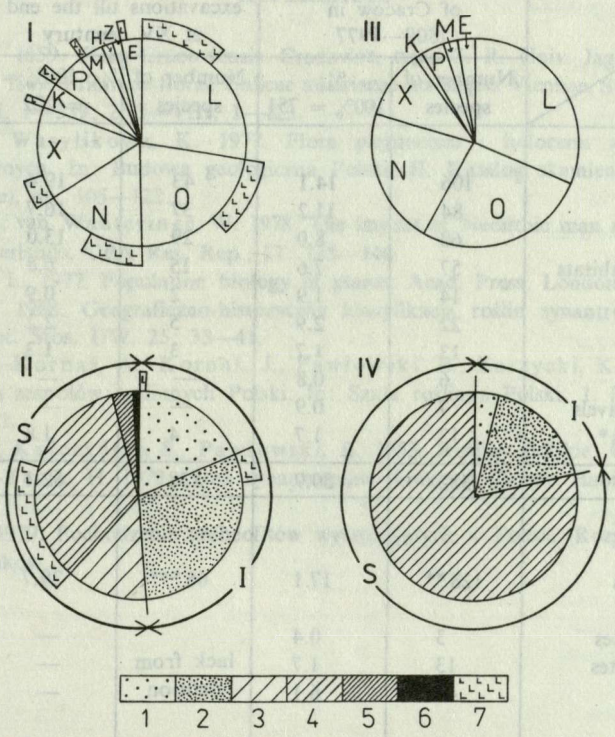

Fig. 3. The comparison of the present-day synanthropic flora of Cracow (1809—1977; I — apophytes; II — anthropophytes) with archaeobotanical data from the same area (III — apophytes, IV — anthropophytes).

I, III — apophytes of: L — forests, O — meadows, N — water shores, X — xerothermic habitats, K — rocks, P — sands, M — wet sands, H — saline habitats, Z — Carpathian gravels, E — other habitats; II, IV — anthropophytes: 1 — ephemerophytes, 2 — ergasiophygophytes, 3 — epoecophytes, 4 — archaeophytes, 5 — hemiagriophytes, 6 — holoagriophytes, 7 — number of species of corresponding group in archaeobotanical data; S — metaphytes, I — diaphytes (after H. Trzcińska-Tacik, 1979).

Among the proper apophytes, there is a large number of species of water shore habitats and of forest clearings, similarily as in prehistoric and early historic periods (Table 7, Fig. 3).

A group of special interest is made of species coming from distant areas and occurring only casually (diaphytes). They may disperse spontaneously as ephemerophytes or escape from cultivations as ergasiophygophytes. In the material from archaeological excavations one species may be considered as ephemerophyte, namely *Sideritis montana* found in Przemyśl. The importance of this group increases in the 19th and 20th centuries. This concerns the absolute number of species (in Cracow 72 species in 1809—1920 and 140 species in 1921—1979, altogether 179 species)

Table 7. Comparison of the archaeological data from Cracow with its present-day synanthropic flora

Kind of data / Groups of plants	Synanthrophic flora of Cracow in 1809—1977		Data from archaeological excavations till the end of XV ceuntury		% of species confirmed by archaebotanical data
	Number of species	%; 100% = 751	Number of species	%; 100% = 222	
Apophytes of:					
forests	106	14.1	43	19.4	40.6
meadows	84	11.2	37	16.7	44.0
water shores	60	8.0	29	13.0	48.3
xerothermic habitats	57	7.6	15	6.8	26.3
rocks	14	1.9	2	0.9	14.3
sands	22	2.9	5	2.2	22.7
wet sands	13	1.7	3	1.3	23.0
saline habitats	6	0.8	—	—	—
Carpathian gravels	7	0.9	—	—	—
others habitats*	13	1.7	4	1.8	30.8
Total	382	50.9	138	62.1	36.1
Anthropophytes:					
Metaphytes:					
Archaeophytes	128**	17.1	66***	29.7	51.6
Kenophytes:					
Holoagriophytes	3	0.4		—	—
Hemiagriophytes	13	1.7	lack from	—	—
Epoecophytes	46	6.1	defition	—	—
Diaphytes:					
Ergasiophygophytes	111	14.8	15	6.8	13.5
Ephemerophytes	68	9.0	3	1.4	4.4
Total	369	49.1	84	37.9	22.8
Total	751	100.0	222****	100.0	29.6

* Apophytes of classes: *Nardo-Callunetea, Scheuchzerio-Caricetea fuscae* and of the order *Prunetalia.*

** including 26 species, which disappeared in the 20th century.

*** including 10 species, which disappeared in the 20th century.

**** number of species determined from the archaeological excavations in Cracow and occuring in today's synanthrophic flora; total number of species known from the archaeological excavations in Cracow is 356.

and their percentage number (30.8% of the total of Cracow synanthropic flora in 1809—1920 and 46.1% in 1921—1979). If we towns of various size we can see that this group of plants is more numerous in larger towns [9].

The most general conclusion of this article is that the synanthropic flora reflects both the local conditions of habitats and the past and present state of economic activities of man. Every change in human intervention in the environment is reflected, though with certain delay, by the changes in the synanthropic flora.

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APPENDIX 1

APOPHYTES DESCRIBED FROM ARCHAEOLOGICAL EXCAVATIONS IN POLAND

r — ruderals, p — field weeds, N — Neolithic Age, H — Hallstatt Period, Rz — Roman Period, PP — older phase of the Early Middle Ages, WP — younger phase of the Early Middle Ages, PS — Late Middle Ages. At the end of each group, percentage numbers of species in relation to the total number of all wild species (not only apophytes) in each period are given. Plant names are according to „Rośliny Polskie" (W. Szafer et. al. 1953)

Apophytes of water shores		Number of localities in each period					
		N	H	Rz	PP	WP	PS
Chenopodium album	r	3	3	2	12	20	2
Polygonum persicaria	r/p	2	3	4	11	16	5
Polygonum lapathifolium	p	3	3	3	7	21	4
Polygonum aviculare	r/p	2	3	4	5	14	2
Polygonum minus	p	1?	—	1	1	2	1
Plantago maior	r	2	1	—	1	1	1
Chenopodium polyspermum	p	1	—	—	2	2	1
Rumex crispus	r		1	—	5	11	1
Polygonum hydropiper	p		1	3	4	10	1
Stachys palustris	p		1	—	1	6	1
Mentha cf. *arvensis*	p		1	1	2	2	1
Agropyron repens	r/p		1	1	2	1	1
Rumex maritimus	r		1	—	1	4	—
Malva alcea	r		1	—	1	2	—
Erysimum cheiranthoides	p		1	—	—	—	—
Potentilla anserina	r			1	1	—	1
Bidens cernuus	r			1	—	—	1
Digitaria ischaemum	r/p			1	—	1	—
Xanthium strumarium	r				1	10	—
Bidens tripartitus	r				1	2	1
Sonchus arvensis	p				1	2	1
Gypsophila muralis	p				1	1	1
Rorippa palustris	r/p				1	1	—
Juncus cf. *bufonius*	p				1	1	—
Potentilla norvegica	r				1	1	—
Potentilla reptans	r				1	1	—
Potentilla supina	r				1	1	—
Chenopodium glaucum	r					2	1
Chenopodium rubrum	r					2	—
Polygonum amphibium	p					1	1
Rorippa silvestris	p					1	1
Plantago pauciflora	p					1	1
Polygonum mite	r					1	—
Sagina procumbens	p						1
Total of species	34	7	13	11	24	30	22
in %		11.3	8.7	11.2	10.8	8.1	8.6
including: ruderals	15	2	5	3	11	13	7
in %		3.2	3.3	3.1	5.0	3.5	2.7
ruderals or weeds	5	2	3	4	4	5	3
in %		3.2	2.0	4.1	1.8	1.3	1.2
weeds	14	3	5	4	9	12	12
in %		4.8	3.3	4.1	4.1	3.2	4.7

Forest apophytes		Number of localities in each period					
		N	H	Rz	PP	WP	PS
Humulus lupulus	r	1	—	—	3	10	2
Galium aparine	p	1	2	—	4	10	2
Lapsana communis	p	1?	—	—	2	4	1
Sambucus ebulus	r	1	2	—	1	4	1
Veronica hederifolia	p		1	1	—	6	1
Galeopsis tetrahit	p		1	1	5	13	2
Sambucus nigra	r		3	1	2	12	1
Galeopsis bifida	p		1	—	1	7	—
Stellaria media	r/p		1	1	2	3	2
Urtica dioica	r		1	1	2	2	1
Solanum dulcamara	r		1	—	—	6	—
Torilis japonica	r		1	—	1	2	1
Polygonum dumetorum	r		1	—	1	3	—
Vicia sepium	r		1	1	—	1	—
Rubus caesius	r/p				3	9	1
Rumex obtusifolius	r				1	2	1
Cirsium arvense	r/p				1?	2	—
Galeopsis pubescens	r				1	1	1
Carex contigua	r				1	1	—
Holcus mollis type	p				1	—	—
Cirsium lanceolatum	r					3	—
Artemisia vulgaris	r					1	1?
Chelidonium maius	r					1	1
Chaerophyllum aromaticum	r					1	1
Geum urbanum	r					1	—
Symphytum officinale	p					1	—
Saponaria officinalis	r					1	—
Total of species	27	4	12	6	17	26	16
in %		6.4	8.0	6.1	7.7	7.0	6.2
including ruderals	17	2	7	3	9	17	10
in %		3.2	4.7	3.1	4.1	4.6	3.9
ruderals or weeds	3	—	1	1	3	3	2
in %			0.7	1.0	1.3	0.8	0.8
weeds	7	2	4	2	5	6	4
in %		3.2	2.7	2.0	2.3	1.6	1.5

Meadow apophytes		Number of localities in each period					
		N	H	Rz	PP	WP	PS
Rumex acetosa	r	2	2	2	4	10	1
Plantago lanceolata	p	1	1	1	3	5	2
Melandrium album	r		2	2	7	12	1
Ranunculus acer	r		1	1	2	8	1
Centaurea jacea	r		1	—	3	6	1
Ranunculus repens	r/p		1	1	2	5	1
Stellaria graminea	p		1	1	2	5	1

Prunella vulgaris	p		1	1	2	3	1
Trifolium pratense	p		1	—	1	2	1
Heracleum sphondylium	r		1	—	1	1	1
Medicago lupulina	r		1	—	—	—	1
Leontodon hispidus	p		1	—	—	—	—
Veronica serpyllifolia	p		1	—	—	—	—
Daucus carota	r/p				1	3	1
Cerastium vulgatum	p				1	1	1
Vicia cracca	p				1	1	—
Trifolium repens	r/p				1	1	—
Festuca pratensis	p				1	1	—
Euphorbia platyphyllos	p				1	—	—
Knautia arvensis	p					2	1
Achillea millefolium	p					1	1
Lysimachia vulgaris	p					1	1
Geranium pratense	r					1	—
Glechoma hederacea	r/p						1
Ranunculus sardous	r						1
Total of species	25	2	13	7	16	19	18
in %		3.2	8.7	7.1	7.2	5.1	7.0
including ruderals	8	1	6	3	5	6	7
in %		1.6	4.0	3.1	2.3	1.6	2.7
ruderals or weeds	4	—	1	1	3	3	3
in %		—	0.7	1.0	1.3	0.8	1.2
weeds	13	1	6	3	8	10	8
in %		1.6	4.0	3.1	3.6	2.7	3.1

Apophytes of xerothermic communities		Number of localities in each period					
		N	H	Rz	PP	WP	PS
Convolvulus arvensis	p	1	2	—	2	3	2
Melampyrum arvense+sp.	p	1	1	—	2	1	1
Plantago media	r	2	1	—	1	1	1
Centaurea scabiosa	p	1	—	—	2	4	1
Linaria vulgaris	r		1	—	1	2	1
Verbascum thapsiforme	r		1	—	—	1	—
Campanula rapunculoides	p		1	—	—	—	—
Salvia verticillata	r				1	1	1
Echium vulgare	r					1	—
Camelina microcarpa ssp. *silvestris*	p					1	—
Coronilla varia	p					1	—
Verbascum cf. *nigrum*	r					1	—
Total of species	12	4	6	—	6	11	6
in %		6.4	4.0	—	2.7	3.0	2.3
including ruderals	6	1	3	—	3	6	3
in %		1.6	2.0	—	1.3	1.6	1.2
ruderals or weeds	—	—	—	—	—	—	—
weeds	6	3	3	—	3	5	3
in %		4.8	2.0	—	1.3	1.3	1.2

Apophytes of sandy places		Number of localities in each period					
		N	H	Rz	PP	WP	PS
Rumex acetosella s.l.	p		2	1	5	10	2
Potentilla argentea	r		1	—	1	4	1
Arenaria serpyllifolia	p		1	—	1	2	1
Polycnemum arvense	p			2	—	—	—
Trifolium arvense	p				1	1	1
Erodium cicutarium	p					1	—
Total of species	6		3	2	4	5	4
in %			2.0	2.0	1.8	1.3	1.5
including ruderals	1		1	—	1	1	1
in %			0.7	—	0.4	0.3	0.4
ruderals or weeds	—		—	—	—	—	—
weeds	5		2	2	3	4	3
in %			1.3	2.0	1.3	1.1	1.2

Other apophytes						
Galeopsis cf. *angustifolia*	p			1	—	—
in %				0.4	—	—

APPENDIX 2

ARCHAEOPHYTES DESCRIBED FROM ARCHAEOLOGICAL EXCAVATIONS IN POLAND

For explanations see appendix[1].

Archaeophytes		Number of localities in each period					
		N	H	Rz	PP	WP	PS
Polygonum convolvulus	p	4	4	5	11	22	5
Bromus secalinus	p	10	6	3	7	14	4
Agrostemma githago	p	4	1	—	9	23	4
Setaria glauca	p	1	1	1	7	17	2
Sinapis arvensis	p	1	—	1	3	11	4
Solanum nigrum	r/p	1	2	1	3	9	1
Centaurea cyanus	p	1	1	—	3	5	4
Chenopodium urbicum	r	1	1	2	4	6	1
Lithospermum arvense	p	1	—	1	2	3	2
Viola arvensis/tricolor	p	1	1	1	1	5	1
Avena fatua	p	1?	1	—	1	1	—
Bromus arvensis	p	1	1	—	—	1	—
Bromus sterilis	r	2	—	—	—	—	—
Galium spurium	p		2	2	5	11	2
Setaria viridis/verticillata	p		1	—	3	10	2
Chenopodium hybridum	r		1	—	1	10	2
Thlaspi arvense	p		1	1	1	9	1
Chenopodium ficifolium	r		1	—	2	7	2
Lolium temulentum	p		3	2	3	4	—

Hyoscyamus niger	r	1	1	1	3	1
Anagallis arvensis+sp.	p	1	1	1	1	1
Malva silvestris	r	1	—	1	2	1
Sonchus asper	p	1	—	1	1	1
Malva neglecta	r	1	—	–	2	—
Carduus acanthoides/crispus	r	1	—	1	1	—
Odontites verna/rubra	p	1	—	—	1	—
Onopordon acanthium	r	1	—	—	1	—
Atriplex patulum	r	1	—	—	3	1
Spergula arvensis+*sativa*	p		2	2	1	1
Galeopsis ladanum	p		1	2	4	1
Echinochloa crus-galli	r/p		1	2	2	1
Stachys annua	p		1	—	1	1
Scleranthus annuus+sp.	p		1	1	1	1
Chenopodium cf. *opulifolium*	r		1	1	1	1
Vicia villosa	p		1?	—	—	1
Avena strigosa?	p		1	—	—	—
Cuscuta epilinum	p		1	—	—	—
Arctium lappa	r		1	1	4	1
Neslia paniculata	p			1	8	2
Euphorbia helioscopia	p			1	5	1
Consolida regalis	p			2	2	1
Urtica urens	r			2	2	1
Galium tricorne	p			1	2	2
Digitaria sanguinalis	p			1	2	1
Melandrium noctiflorum	p			1	2	1
Verbena officinalis	r			1	2	1
Vicia tetrasperma	p			1	2	1

Archaeophytes		Number of localities in each period					
		N	H	Rz	PP	WP	PS
Vicia hirsuta	p				1	1	1
Capsela bursa-pastoris	r/p				1	1	1
Nigella arvensis	p				1	1	1
Ballota nigra	r				1	2	—
Myosotis arvensis, type	p				1	1	1
Lamium album	r				1	2	—
Anthemis cotula	r				1	1	1
Descurainia sophia	r				1	1	1
Nepeta cataria	r				1	1	1
Ranunculus arvensis	p				1	1	1
Bupleurum rotundifolium	p				1	1	1
Spergula arvensis v. *maxima*	p				1	1	—
Atriplex cf. *nitens*	r				1	1	—
Malva crispa	r				1	1	—
Conium maculatum	r				1	1	—
Marrubium vulgare	r				1	1	—
Lepidium ruderale	r				1	—	—
Fumaria officinalis	r/p				1	—	—

Papaver rhoeas type	p	1	—	—
Caucalis daucoides	p	1	—	—
Chenopodium viride	r/p	1	1	1
Cichorium intybus	r		2	1
Anthemis arvensis	p		2	1
Chenopodium vulvaria	r		1	1
Valerianella dentata	p		1	1
Aphanes arvensis	p		1	1
Chenopodium murale	r		1	—
Geranium dissectum	p		1	—
Carduus cf. *nutans*	r		1	—
cf. *Sonchus oleraceus*	r		1	—
Valerianella olitoria	r		1	—
Conringia orientalis	p		1	—
Leonurus cardiaca	r		1	—
Vicia angustifolia?	p			1
Silene gallica	p			1
Aethusa cynapium	p			1
Lamium purpureum	r/p			1
Amaranthus ascendens	r			1
Papaver argemone	p			1

Note: Plants not included among apophytes and archaeophytes are listed in the "Cord index of plant taxa known from the Quaternary of Poland" (unpubl.) in the Department of Paleobotany, Institute of Botany of the Polish Academy of Sciences, Cracow.

HISTORIA PRZEMIAN SYNANTROPIJNYCH FLORY I ROŚLINNOŚCI NA TERENIE POLSKI

STRESZCZENIE

Celem artykułu jest pokazanie sposobów powstawania synantropijnej flory i roślinności w czasach prehistorycznych i wczesnohistorycznych oraz porównanie zmian we współczesnej florze synantropijnej wybranego terenu z danymi z wykopalisk archeologicznych z tego samego terenu (na przykładzie Krakowa). Wnioski dotyczące okresu od neolitu do końca XV w.n.e. opierają się na zestawieniu wszystkich gatunków roślin dzikich znalezionych na stanowiskach archeologicznych z terenu całej Polski [3]. Informacje o florze synantropijnej Krakowa w czasach nowożytnych oparte są na materiałach zielnikowych i danych z literatury odnoszących się do tego terenu [9].

Rośliny naturalnych i półnaturalnych zbiorowisk w czasach prehistorycznych

Rośliny z wykopalisk archeologicznych obejmują 1. gatunki rodzime występujące wyłącznie, lub prawie wyłącznie, w zbiorowiskach naturalnych i półnaturalnych, 2. apofity i 3. archeofity. Dwie pierwsze grupy mówią o siedliskach często penetrowanych przez człowieka w przeszłości (tab. 1 i 2). Analiza składu gatunkowego oraz liczby szczątków poszczególnych gatunków pozwala na sformułowanie następujących twierdzeń:

— eksploatacja lasów była prowadzona przez cały badany okres,

— gatunki z rzędu *Prunetalia* były stosunkowo liczne w neolicie, a potem względna rola tej grupy zmalała,

— stosunkowo często, lecz sporadycznie, występują w wykopaliskach gatunki muraw kserotermicznych (podobnie jak we współczesnych florach synantropijnych),

— licznie i obficie we wszystkich okresach występują gatunki siedlisk nadwodnych,

— liczba gatunków łąkowych z *Molinio-Arrhenatheretea* i *Molinietalia* wzrasta wyraźnie od okresu halsztackiego, liczba gatunków z *Arrhenatheretalia* od okresu przedpiastowskiego,

— obecność gatunków z *Sedo-Scleranthetea* i *Scheuchzerio-Caricetea fuscae* wskazuje na wykorzystywanie przez człowieka także uboższych siedlisk,

— liczba zbiorowisk naturalnych penetrowanych przez ludzi wzrasta stopniowo, co wskazuje na zwiększanie zakresu i siły oddziaływania gospodarki człowieka na szatę roślinną.

Flora synantropijna Polski w czasach prehistorycznych

Apofity stanowią 23% ogólnej liczby gatunków znalezionych w wykopaliskach archeologicznych (Appendix 1, tab. 4). Wśród apofitów właściwych najliczniejszą grupę stanowią gatunki pochodzące z siedlisk nadwodnych, stosunkowo liczne są gatunki leśne i łąkowe, natomiast niewiele jest gatunków muraw kserotermicznych i siedlisk piaszczystych (tab. 5).

Archeofity reprezentowane są przez 88 gatunków (19%), z których 13 wystąpiło już w neolicie (Appendix 2, tab. 6). Wyraźny wzrost liczby archeofitów ruderalnych w okresie halsztackim i przedpiastowskim związany jest z rozwojem trwałego osadnictwa. Szczególnie wiele nowych gatunków archeofitów przybyło w okresie przedpiastowskim.

Analizując pochodzenie archeofitów [10] można wskazać okresy charakteryzujące się natężeniem migracji gatunków z pewnych ośrodków. W neolicie, okresie halsztackim i przedpiastowskim pojawiło się wiele gatunków pochodzących z południowego wschodu, natomiast w okresie rzymskim i wczesnopiastowskim zostały po raz pierwszy znalezione niektóre gatunki pochodzące z południowego zachodu.

Flora synantropijna Krakowa w XIX i XX w.

W XIX w. archeofity stanowiły liczną i szeroko rozprzestrzenioną grupę gatunków zarówno w całej Polsce, jak i w Krakowie [9]. Ich regres na terenie Krakowa zaczął się na początku XX w., a nasilił się około 1950 r. W XX w. wyginęło na terenie miasta ogółem 26 gatunków. Ustępowanie gatunków z terenu miasta pod wpływem urbanizacji pokazuje fig. 2.

Kenofity przybywały stopniowo. Najstarsze flory notują 16 gatunków, w okresie 1860—1920 przybywa 18, a w okresie 1921—1979 29 gatunków (z tej ostatniej grupy 16 gatunków zanotowano po raz pierwszy około 1950 r.). Ostatnio niektóre gatunki agrio- i epekofitów zmniejszają liczbę swoich stanowisk. Obserwujemy więc przybycie gatunku, jego rozprzestrzenianie się i ustępowanie, zależnie od zmian gospodarczej działalności człowieka, stanowiącej ważny element siedliska życiowego roślin.

Apofity były prawdopodobnie dość pospolite w XIX w., ponieważ jednak dla gatunków pospolitych brak danych o częstości występowania, o zmianach w tym zakresie możemy mówić tylko w odniesieniu do gatunków rzadszych.

Porównanie udziału poszczególnych grup apofitów i antropofitów w danych z wykopalisk archeologicznych i we współczesnej florze synantropijnej Krakowa pokazują tab. 7 i fig. 3. W czasach nowożytnych wyraźnie wzrosła liczba gatunków przejściowo występujących we florze (diafitów).

Analiza zebranych materiałów pozwala stwierdzić, że flora synantropijna odbija zarówno lokalne warunki siedliskowe jak i przeszłą i obecną działalność człowieka.

ИСТОРИЯ СИНАНТРОПИЧЕСКИХ ПЕРЕМЕН ФЛОРЫ И РАСТИТЕЛЬНОСТИ НА ТЕРРИТОРИИ ПОЛЬШИ

РЕЗЮМЕ

В работе описаны природные и полуприродные растительные сообщества, чаще всего используемые доисторическим человеком, на основании растительных находок обнаруженных при археологических раскопках. Обсуждено развитие синантропической флоры

и растительности от неолита до позднего средневековья и изменения синантропической флоры г. Кракова на протяжении XIX и XX веков, реконструированные на основании гербариев и литературных данных. Проведено сравнение современной и доисторической синантропической флоры Кракова. Содержащиеся в работе данные и их анализ позволяют сделать вывод, что на современной синантропической флоре отражаются как местные условия среды, так и прежняя и современная хозяйственная деятельность человека.