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Cultivated plants in medieval Kraków (Poland), with special reference to amaranth (*Amaranthus lividus* L. cf. var *lividus*) and ruderal communities

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ABSTRACT. This paper summarises archaeobotanical studies of plant macroremains derived from medieval town deposits of Kraków, focusing on cultivated plants. Correspondence analysis was used in interpreting the botanical data and their archaeological context. Changes in cultivated plant composition were connected mainly with the chartering of the town under Magdeburg law in 1257, and are discussed in terms of their temporal relation to the chartering of Kraków and possible changes in the food preferences and wealth of the residents. Millet and wheat remains are rarer in specimens from after the establishment of the town; this seems connected mainly with the relocation of the mills outside the city walls. The number of cultivated plants generally increased in the late medieval samples, but hop and mallow were more frequent in the tribal period than later. Problems in the definition of cultivated plants are discussed. The probable escape of cultivated amaranth (*Amaranthus lividus* L. var. *lividus*) from gardens to ruderal communities is indicated in the samples. A comparison of archaeobotanical data from written sources shows the incompleteness of both types of source, including the clear underrepresentation of some cultivated plants in the archaeological deposits of the town (especially peas, *Pisum sativum*), a deficiency which should be considered in other archaeobotanical and palaeodietary studies.

KEYWORDS: cultivated plants, ruderal plants, amaranth, archaeobotany, medieval town, Central Europe

INTRODUCTION

In the area of Kraków an early medieval settlement developed on Wawel Hill from the 7th or the beginning of the 8th century AD. From the end of the 9th century, a prince's gord (stronghold) and a fortified suburb developed on Wawel Hill. The suburb, called Okół ('vicinity'), was at the foot of the northern slopes of the hill. Nearby there were also small unfortified settlements which supplied and served the hill settlement (Zaitz 2012). In the first half of the 10th century, Kraków was part of the Czech State and probably was dependent on the Přemyslid dynasty (in Czech: Přemyslovci) to the end of that century. At the end of the 10th century, Kraków and surrounding lands were incorporated into the Polish State (Radwański 1975, 1991). Major changes in the settlement network occurred with the translocation of the chief prince and the centre of royal power to Wawel Hill, and the location of the diocese there, as manifested by the presence of official secular and ecclesiastical buildings made of stone (and brick from the first half of the 13th century). The residential, agricultural or craft buildings in all the settlements were constructed mostly of wood. Many buildings located outside the castle

and suburb fortifications burnt down during the Tatar invasion in 1241 AD. In the destroyed area north of the Okół suburb, Prince Boleslaw the Chaste (in Polish: Bolesław V Wstydliwy) founded a new town in 1257 under Magdeburg law. International trade developed from that time, making Kraków one of the main Hanseatic cities (Kutrzeba 1902, Wyrozumski 1992: 385, Zaitz 2012).

This paper describes the temporal and spatial setting of cultivated food plants found in medieval layers on the territory of Kraków, and addresses the question of how the plant remains reflect past activities. There are problems in interpreting accumulations of wild-growing plant remains as remnants of gathering activity. In samples from medieval town layers the picture is not clear, especially for ruderal plants. Several ruderal plants, above all those of the families Chenopodiaceae and Polygonaceae, have edible diaspores (fruits/seeds) and are commonly found growing in human settlements. These plants usually produce large numbers of diaspores in one season. Their diaspores are relatively hard and have thick testae or fruit walls, are resistant to taphonomic processes, and are likely to be overrepresented (particularly those of *Chenopodium album* type) in archaeobotanical assemblages. The organic remains in waterlogged medieval deposits can be of various origin; the local origin of several synanthropic, mostly ruderal plants, can be inferred (Mueller-Bieniek & Walanus 2012).

Another problem is the status of a plant, which changes over time (e.g. Maurizio 1926). It is known that several synanthropic plants of alien origin were cultivated previously, and the recently observed phenomenon of escape from cultivation to disturbed habitats may have happened in the past as well (Kornaś & Medwecka-Kornaś 2002: 539). The instability of synanthropic communities and the multiple origin of plant remains in medieval waterlogged layers make it difficult to interpret those remains.

The boundary between cultivation and gathering, and between wildness and domestication, can be blurred. Some wild medicinal plants were cultivated in the past at least periodically; examples are wild marjoram (*Origanum vulgare* L.), henbane (*Hyoscyamus niger* L.), common vervain (*Verbena officinalis* L.) meadowsweet (*Filipendula ulmaria* (L.) Maxim.), dropwort (*F. vulgaris* Moench), hemlock (*Conium maculatum* L.), and trifid bur-marigold (*Bidens tripartita* L.) (Motyka & Panycz 1936, Mamczur & Gładun 1988, Celka 1999). Cultivation of some plants has ceased or has survived only in some regions (Hanelt 2001). In the second half of the 20th century, to protect some common plants that were intensively gathered for medicinal purposes (e.g. *Hypericum perforatum*) it was recommended to cultivate them, either by standard methods or by sowing seeds at the plants' natural sites (Brunarska et al. 1984). The latter type of cultivation (or rather paracultivation) does not disturb the natural plant cover, does not promote the development of weed communities, and does not alter the maintained plant. When morphological features of domestication are not evident in the fruits and seeds, in many cases it can be hard to interpret an accumulation of plant macroremains in archaeological deposits, that is, to decide whether to attribute the remains to cultivation, gathering, cleaning (rubbish disposal) or natural occurrence. This is a problem especially when dealing with organic layers of medieval towns.

The type of fossilisation is another important factor affecting the interpretation of archaeobotanical data. In medieval town layers most plant remains are preserved by waterlogging, but charred and mineralised remains are also present in much smaller amounts. Charred plant assemblages represent a small part of the plant remains originally present and discarded at any one site (Jacomet et al. 1989: 54–84, van der Veen 2007: 977), while waterlogged remains better represent the real past plant cover and uses.

Medieval layers from Kraków have been studied archaeobotanically since the beginning of the 20th century (Wasylikowa et al. 2009, Mueller-Bieniek 2012). The samples date to three chronological periods: tribal (MA1 – from the beginning of medieval times to the end of the 10th century), early medieval (MA2 – from the beginning of the 11th century to the chartering of the town in 1257), and late medieval (MA3 – from chartering to the end of the 15th century).

MATERIAL AND METHODS

We compared archaeobotanical data from 265 samples collected from 28 localities (profiles or trenches) in Kraków (Tab. 1, Fig. 1). The samples were studied in the W. Szafer Institute of Botany (Polish Academy of

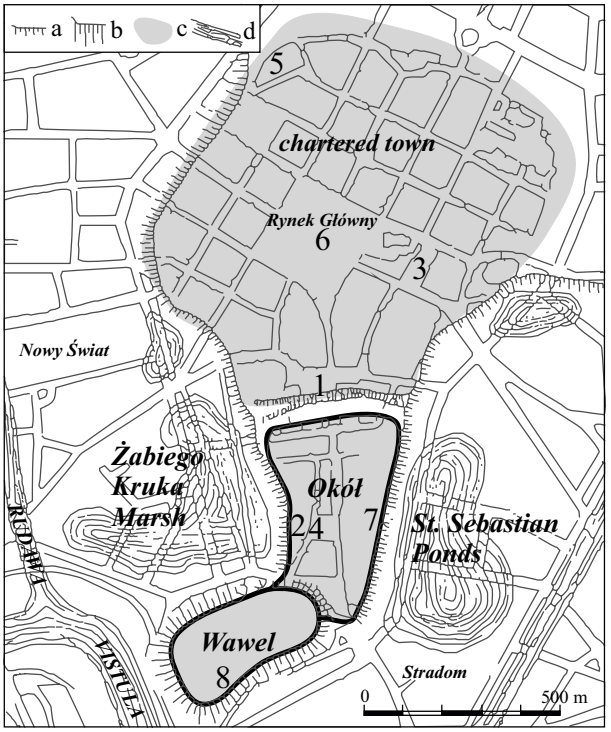

Fig. 1. Location of analysed sites on map of the medieval settlement of Kraków (after Radwański 1991, Wasylikowa et al. 2009, Zaitz 2012). **a** – middle terrace, **b** – hills, slopes, **c** – settlements, **d** – rivers, ponds, **1** – Grodzka St. 19, **2** – Kanonicza St. 17, **3** – Little Square (Mały Rynek), **4** – Wit Stwosz plaza (plac Wita Stwosza), **5** – Reformacka St. 4, **6** – Main Square (Rynek Główny), **7** – Skarpa, **8** – Wawel Hill

Sciences, Kraków). The data were obtained from uniform laboratory analyses, using 0.5 mm-mesh sieves and consistent identification criteria. The analyses are based on published and unpublished data (Tab. 1, more details in Mueller-Bieniek 2012). The archaeobotanical data are from 17 samples dating to the tribal, 122 dating to the early medieval, and 126 to the late medieval periods. Early medieval samples dominate those from Wawel Hill, and late medieval those from the Main Square (Polish: Rynek Główny) (Tab. 1). We combined the counts for specimens identified as "similar to" (cf.) and those identified precisely, and used the *ArboDat* archaeobotanical database (Kreuz & Schäfer 2002) in preparing the data.

We identified 370 species of embryophytes and ergot (*Claviceps purpurea*), excluding identifications to genus or family level, of which ca 40 were cultivated or probably-cultivated plants (Mueller-Bieniek 2012). The data were analysed in two ways: by simple comparison of the data (frequency and numbers), and by correspondence analysis (CA) for cultivated/probably-cultivated plants, using STATISTICA 10 software.

For the correspondence analysis, row numbers (n) were square-root-transformed ($n^{1/2}$) to lower the asymmetry of their distribution. Distribution asymmetry was due to having very many counts for a few taxa and low counts for many taxa that are no less important. For similar reasons, samples with less than 25 counts of any taxon were censored. The cutoff of 25 counts (in fact, 5 after transforming $25^{1/2}$) was a subjective choice made after considering many results.

The analysis was done for all the remains (waterlogged, carbonised, mineralised) and separately for waterlogged specimens only. It was not possible to analyse charred or mineralised remains separately, due to the paucity of data and also predepositional processes affecting the charring or mineralisation of the remains. In the first analysis the number of plant taxa was reduced to 16 (out of 40 cultivated and probably-cultivated) and the number of samples to 95 (out of 265); in the second analysis the number of taxa was reduced to 12 and the number of samples to 69. The same analysis was also done for cultivated/probably-cultivated species occurring in at least 11 samples. In earlier work we analysed frequently occurring plants and plants clustered into broad ecological groups (Mueller-Bieniek & Walanus 2012), and those results are used here.

RESULTS AND DISCUSSION

Overall, the samples are dominated by millet (*Panicum miliaceum* L.) (Fig. 2A); this can be explained by overrepresentation of this crop due to food preparation methods. Millet was stored husked (grain enclosed by lemma and palea), reputedly for up to 20 years (Lundstrom-Baudais & Bailly 1995: 190). Preparation for consumption involved dehusking, and such bare grains had to be eaten in two days; otherwise the millet developed a bitter taste (Lundstrom-Baudais & Bailly 1995: 180–181, Strzelczyk 2003: 18). Frequent dehusking and winnowing scattered a lot of chaff in the settlement, composed mainly of lemmas and paleas, which are also resistant to taphonomic and digestive processes and easy for a botanist to identify. Millet was also used as poultry feed (Lundstrom-Baudais & Bailly 1995), another cause of its overrepresentation in the remains.

Large-grained crops like rye (*Secale cereale* L.), barley (*Hordeum vulgare* L.), wheat (*Triticum aestivum* L. type and *Triticum* sp.), and oat (*Avena sativa* L., and *Avena* sp.) are also very abundant. The remains of large-grained crops were preserved mainly by charring, and ca 500 dehusked grains of millet were also preserved in this way (ca 1/6 of all millet remains), while amaranth seeds were preserved only by waterlogging (Tab. 2, Fig. 2D). Other cultivated and probably-cultivated plants were also represented mainly by waterlogged remains (Tab. 2), like most of the other plant macroremains from medieval Kraków (Mueller-Bieniek 2012).

Looking at the presence of remains in chronological periods (Figs 2 B, C, Tab. 2) over time we see a decrease of millet, rye, and wheat

Table 1. List of sites and number of samples included in the study. **MA1** – tribal period, **MA2** – early medieval period, **MA3** – late medieval period. Unpublished results of botanical studies are in the archives of the Department of Palaeobotany (W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków) and in the ArboDat archaeobotanical database (Kreuz & Schäfer 2002).

Site	Sample code	Number of samples			Other
		MA1	MA2	MA3	
Grodzka St. 19	G19_		2	13	det. K. Wasylikowa, arch. L. Dębowska, moat
Kanonicza St. 17					
trench XXIX	K29_	3	5	1	det. A. Bieniek, Z. Tomczyńska, K. Wasylikowa, arch. E. Zaitz (Bieniek et al. 2004)
trench XXXIV	K34_	3	11	3	det. Z. Tomczyńska, arch. E. Zaitz (Zaitz 2005 unpubl.)
trench XXXVIIN	K37_			17	det. A. Bieniek, arch. E. Zaitz (Zaitz 2005 npubl.)
Mały Rynek	MR		5	19	Mueller-Bieniek & Skawińska-Wieser 2009, arch. E. Zaitz (Zaitz 2009)
Plac W. Stwosza	WS_		8	6	Jedliczka 1965, arch. K. Radwański (Lenkiewicz 1959; Radwański 1975)
Reformacka St. 4	Ref_		4		det. K. Wasylikowa, arch. E. Zaitz (Zaitz 2004 npubl.)
Rynek Główny					
profile 11	RG11_		4	6	Wieserowa 1979, arch. K. Radwański (Lenkiewicz 1964, Radwański 1975)
point 12	RG12_		1		det. A. Wieserowa, K. Wasylikowa, arch. K. Radwański (Lenkiewicz 1964, Radwański 1975)
point 13	RG13_		1		det. A. Wieserowa, K. Wasylikowa, arch. K. Radwański (Lenkiewicz 1964, Radwański 1975)
point 14	RG14_			5	det. H. Ranheden, arch. A. Wałowy (Lenkiewicz 1964, Radwański 1975)
point 15	RG15_			5	det. K. Wasylikowa, arch. K. Radwański (Lenkiewicz 1964, Radwański 1971, 1975)
R/47	RG_47			1	Wasylikowa 1965 and later unpubl., arch. K. Radwański, town hall
profile 4	RG4_		10	8	Wieserowa 1979, bad. arch. K. Radwański (Lenkiewicz 1964, Radwański 1975)
point 9	RG9_		5	3	det. H. Ranheden, bad. arch. K. Radwański (Lenkiewicz 1964, Radwański 1975)
profil CW	RGCW_		6	6	det. A. Bieniek, arch. C. Buśko
pit E1	RGE1_		8	1	det. A. Bieniek, arch. C. Buśko
NW (wooden stalls)	RG6gS_, RGXIII_, RGXIV_, RG10a_		1	28	det. Bieniek i in. 2006 and later A. Bieniek and K Wasylikowa unpubl., arch. E. Zaitz (Zaitz 2006)
Skarpa	SK_		4		det. K. Wasylikowa, arch. E. Zaitz 1977 (Zaitz 1976, Zaitz 1977)
Wawel Hill					Wasylikowa 1978, arch. A. Żaki (Żaki 1956)
area X	WX_	10	34	2	
area VIB	WVIB_			2	
area VB	WVB_			2	
area XII	WXII_	1	3		
area IX	WIX_		1		

(mostly bread wheat), and a general increase in the number and frequency of other cultivated and probably-cultivated plants. Some of them appear already in late medieval samples, usually sporadically (e.g. onion *Allium cepa* L., dill *Anethum graveolens* L., cabbage *Brassica oleracea* L., gold-of-pleasure *Camelina sativa* (L.) Crantz, fennel *Foeniculum vulgare* Mill., walnut *Juglans regia* L.). Amaranth is exceptional in appearing in early medieval samples in large numbers and decreasing rapidly in late medieval times.

Apart from the cereals and amaranth, cultivated oil plants such as hemp (*Cannabis sativa* L.), flax (*Linum usitatissimum* L.), poppy (*Papaver somniferum* L.), and *Brassica napus/rapa* occurred in significant amounts (Tab. 2). Fruits and seeds of vegetables were not numerous and were usually of doubtful interpretation (Karg & Robinson 2002, Latałowa et al. 2007, Mueller-Bieniek 2010). The occurrence of fig (*Ficus carica* L.) diaspores was similar to that of poppy seeds (Tab. 2), becoming more numerous in the late medieval samples. Among

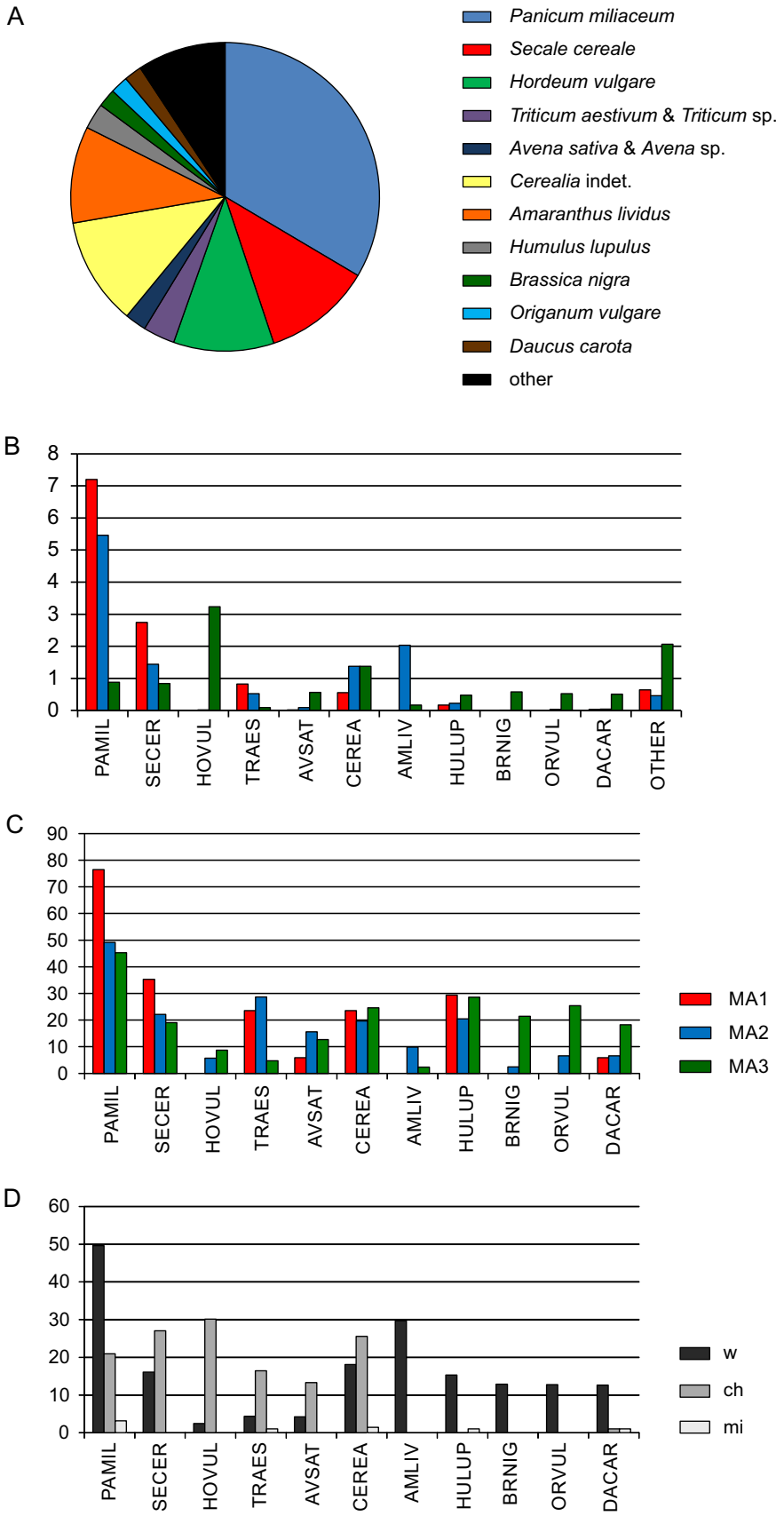

Fig. 2. Main cultivated and probably-cultivated plants found in the studied samples from medieval Kraków. Plant codes as in Table 2. Group 'other' includes plants listed in Table 2. **A** – proportions of the listed plant macroremains in the total material, **B** – share of cultivated plant remains as a percentage of all specimens found in samples dated to the same period. 100% of macroremains for: MA1 – 5944, MA2 – 40,956, MA3 – 28,019, **C** – frequency in samples as percentages of all samples dated to the same period, 100% of samples for: MA1 – 17, MA2 – 122, MA3 – 126, **D** – type of fossilisation, number of specimens (given as square root), **w** – waterlogged, **ch** – charred, **mi** – mineralised

Table 2. List of cultivated and probably-cultivated plants, number of specimens (N), and frequency (F) in three chronological periods. Number of specimens according to fossilisation type is given regardless of their age. **Code** – unique plant code from ArboDat database (Kreuz & Schäfer 2002) used in preparing the data for this study, with some exceptions asterisked (*), **Code2** – taxa clustered in statistical analysis, **MA1**–**MA3** – as in Table 1, **w** – waterlogged, **ch** – charred, **mi** – mineralised

Plant name	Code	Code2	MA1	MA1	MA2	MA2	MA3	MA3	w	ch	mi
			N	F	N	F	N	F	N	N	N
Allium cepa L.	ALCEP		0	0	0	0	1	1	1	0	0
Amaranthus lividus L. var. *lividus*	AMLIV*		0	0	833	12	48	3	881	0	0
Anethum graveolens L.	ANGRA		0	0	0	0	1	1	1	0	0
Atropa belladonna L.	ATBEL		1	1	0	0	0	0	1	0	0
Avena sativa L.	AVSAT	AVSAT	0	0	8	4	22	3	8	22	0
Avena sp.	AVEN	AVSAT	1	1	28	17	136	15	10	155	0
Brassica napus L.	BRNAP	BRRAP	0	0	2	1	13	8	15	0	0
Brassica napus/rapa L./L.	BRRAP	BRRAP	9	5	30	12	89	24	128	0	0
Brassica nigra (L.) W. D. J. Koch	BRNIG		0	0	3	3	163	27	166	0	0
Brassica oleracea L.	BROLE		0	0	2	1	0	0	2	0	0
Brassica sp.	BRAS		1	1	25	7	40	16	64	0	2
Camelina sativa (L.) Crantz	CAMSA		0	0	0	0	1	1	1	0	0
Cannabis sativa L.	CANSA		1	1	20	14	42	24	60	0	3
Carum carvi L.	CACAR		0	0	2	1	1	1	1	0	2
Cerasus sp.	PRAVC*	PRUN	0	0	5	2	39	15	44	0	0
Cerealia indet.	CEREA	CEREA	33	4	473	24	288	30	232	560	2
Daucus carota L. (L.) Scop.	DACAR		2	1	16	8	143	23	159	1	1
Digitaria sanguinalis	DISAN		1	1	7	4	1	1	8	1	0
Ficus carica L.	FICAR		0	0	2	2	46	18	48	0	0
Foeniculum vulgare Mill.	FOVUL		0	0	0	0	2	2	2	0	0
Hordeum sp.	HORD	HORD	0	0	5	4	2	1	3	4	0
Hordeum vulgare L. (hulled)	HOVUL	HORD	0	0	3	3	904	11	3	904	0
Hordeum/Secale	HOSE	CEREA	0	0	0	0	96	6	96	0	0
Humulus lupulus L.	HULUP		10	5	91	25	134	36	234	0	1
Iris sibirica L.	IRSIB		0	0	1	1	38	4	39	0	0
Juglans regia L.	JUREG		0	0	0	0	22	14	21	1	0
Lens culinaris Medik.	LECUL		1	1	3	2	0	0	0	4	0
Linum usitatissimum L.	LIUSI		14	2	26	9	68	30	108	0	0
Malus sylvestris/domestica Mill./ Borbás	MASYD		1	1	18	12	19	10	37	0	1
Malus/Pyrus	MALPY		0	0	2	2	6	4	8	0	0
Malva alcea/moschata L./L.	MAALC*	MALV	0	0	1	1	0	0	0	1	0
Malva cf. *crispa* L.	MAVER*	MALV	0	0	0	0	1	1	1	0	0
Malva cf. *pusilla* Sm.	MAPUS	MALV	0	0	0	0	14	1	14	0	0
Malva cf. *sylvestris* L.	MASIL	MALV	2	2	9	4	8	2	18	1	0
Malva sp.	MALV	MALV	1	1	9	3	4	3	2	12	0
Origanum vulgare L.	ORVUL		0	0	15	8	147	32	162	0	0
Panicum miliaceum L.	PAMIL		428	13	2238	60	247	57	2464	439	10
Papaver somniferum L.	PASOM		0	0	1	1	40	19	35	2	0
Pastinaca sativa L.	PASAT		1	1	0	0	1	1	2	0	0
Pisum sativum L.	PISAT		2	2	8	7	4	3	3	11	0
Pisum sativum/Vicia faba L./L.	PIVIC		0	0	1	1	0	0	1	0	0
Portulaca oleracea L. subsp. *oleracea*	POOLE*		0	0	0	0	6	4	6	0	0
Prunus domestica L.	PRDOM	PRUN	0	0	2	2	2	1	4	0	0
Prunus/Cerasus	PRUN*	PRUN	2	2	12	10	75	19	86	3	0
Pyrus communis L.	PYCOM		1	1	22	7	14	6	37	0	0
Secale cereale L.	SECER		163	6	591	27	235	24	259	730	0
Secale/Triticum	SETRI	CEREA	0	0	91	3	1	1	0	92	0
Setaria italica (L.) P. Beauv.	SEITA		0	0	0	0	6	1	6	0	0
Triticum aestivum L. type	TRAES	TRAES	47	4	157	35	21	6	16	209	0
Triticum monococcum L.	TRMOC		0	0	0	0	2	2	1	1	0
Triticum sp.	TRIT	TRAES	2	1	57	7	5	2	3	60	1
Vicia sativa L.	VISAT		0	0	0	0	5	1	5	0	0
Vitis sp.	VITI	VITI	0	0	0	0	1	1	0	0	1
Vitis vinifera L.	VIVIN	VITI	1	1	0	0	5	3	6	0	0

the probably-cultivated plants, remains of hop (*Humulus lupulus* L.), black mustard (*Brassica nigra* L.), wild marjoram (*Origanum vulgare* L.), and carrot (*Daucus carota* L.) were almost as abundant as those of oat and wheat, but their type of preservation usually differed (Tab. 2). The number and frequency of probably-cultivated plants increased in time, with the exception of hop and mallow (*Malva* spp.), which were more frequent in the samples from the tribal period. Hop fruits were most frequent in samples dated to the tribal period, and their number and frequency became significant again in the late medieval samples (Fig. 2 B, C).

The origin of the hop specimens is ambiguous, as this plant, probably cultivated in medieval times, certainly also grew on natural and anthropogenic sites (e.g. Kluk 1787, Latałowa 1992, Behre 1999). Beer brewing became important after the chartering of the late medieval town. In that period there were ca 25 breweries inside the town walls (Kutrzeba 1898). Nowadays only unpollinated hops are used in brewing (Kaznowski 1951), and the high frequency and number of hop fruits in the archaeological samples can be interpreted as due to gathering of the plant from nature, or the growth of male plants next to hop plantations. The origin of the fruit can be explained by disposal of spoilt hops (cf. Behre 1999: 39), but we cannot rule out the possibility that in medieval times it was mainly pollinated hops that were used for brewing. Other condiments such as wild marjoram or fruits of carrot may have been used in medieval brewing as well (Kluk 1786, 1787, Behre 1999, Łuczaj & Szymański 2007).

Diaspores of black mustard and wild marjoram were absent in the samples from the tribal period, appeared in the early medieval period, and became numerous in late medieval samples (Fig. 2B, C). This may be connected with the type of samples or with increasing use of the plants. Black mustard probably was placed under cultivation as a secondary crop in the Mediterranean during ancient times (Hanelt 2001), and in Western Europe its use become more common in medieval times, associated mainly with rural sites (Livarda & van der Veen 2008). Remains of edible fruits of the genera *Cerasus*, *Prunus*, *Malus*, and *Pyrus* were quite abundant overall, although samples from coarse sieving, which contained mainly fruit stones, were not included in the comparison; samples studied in other institutions were also omitted (Tab. 2, Mueller-Bieniek 2012). In the omitted samples there were also single remains of peach (*Prunus persica* Mill., Klichowska 1964), cucumber (*Cucumis sativus* L., Klichowska 1964), and sorghum (*Sorghum bicolor* (L.) Moench subsp. *bicolor*, Giżbert & Żaki 1954, Wasylikowa et al. 2006).

The abundance of plant diaspores is not always related to the utility of the plant. Among the more or less cultivated plants only millet was very frequent, and millet, rye, barley, and amaranth were very numerous in the studied samples. Peas and other pulses were conspicuously scarce, especially in the light of information from written sources indicating that peas were one of the most important foods (e.g. Piekosiński 1896, Dembińska 1963, Wajs 1993, Samsonowicz 2001). Pea (*Pisum sativum*) remains are also very rare in material from other medieval town sites from this region of Europe (e.g. Wieserowa 1967, 1979, Wasylikowa 1978, Beneš et al. 2002, Pokorný et al. 2002, Badura et al. 2005, Stančikaitë et al. 2008, Kirleis 2009, Badura 2011).

Correspondence analysis (CA) of cultivated and probably-cultivated plants (Figs 3, 4, Mueller-Bieniek & Walanus 2012) revealed a distinct difference in occurrence between millet, large-grained crops, and the group of probably-cultivated plants (carrot, wild marjoram, *Brassica* sp., together with probably imported figs); this difference was found both for all remains and for waterlogged remains. Millet finds were dominated by waterlogged remains of lemmas and paleas (florets, chaff) and were found mostly in early medieval samples from Wawel Hill. The samples connected with the group of probably-cultivated plants came mainly from the eastern part of the Main Square (Mueller-Bieniek 2012, Mueller-Bieniek & Walanus 2012). Wheat remains are also prominent in the early medieval samples but not as much as millet (Fig. 5). Remains of large-grained crops were found mainly in single, visibly charred samples (sample RGXIV_6 and samples from pit E1, Mueller-Bieniek & Walanus 2012); these affected the composition of the remains very significantly. In the waterlogged remains, rye and undetermined cereals (represented mainly by rachis internodes) are associated with late medieval samples from the north-western part of the Main Square, where vestiges of wooden houses

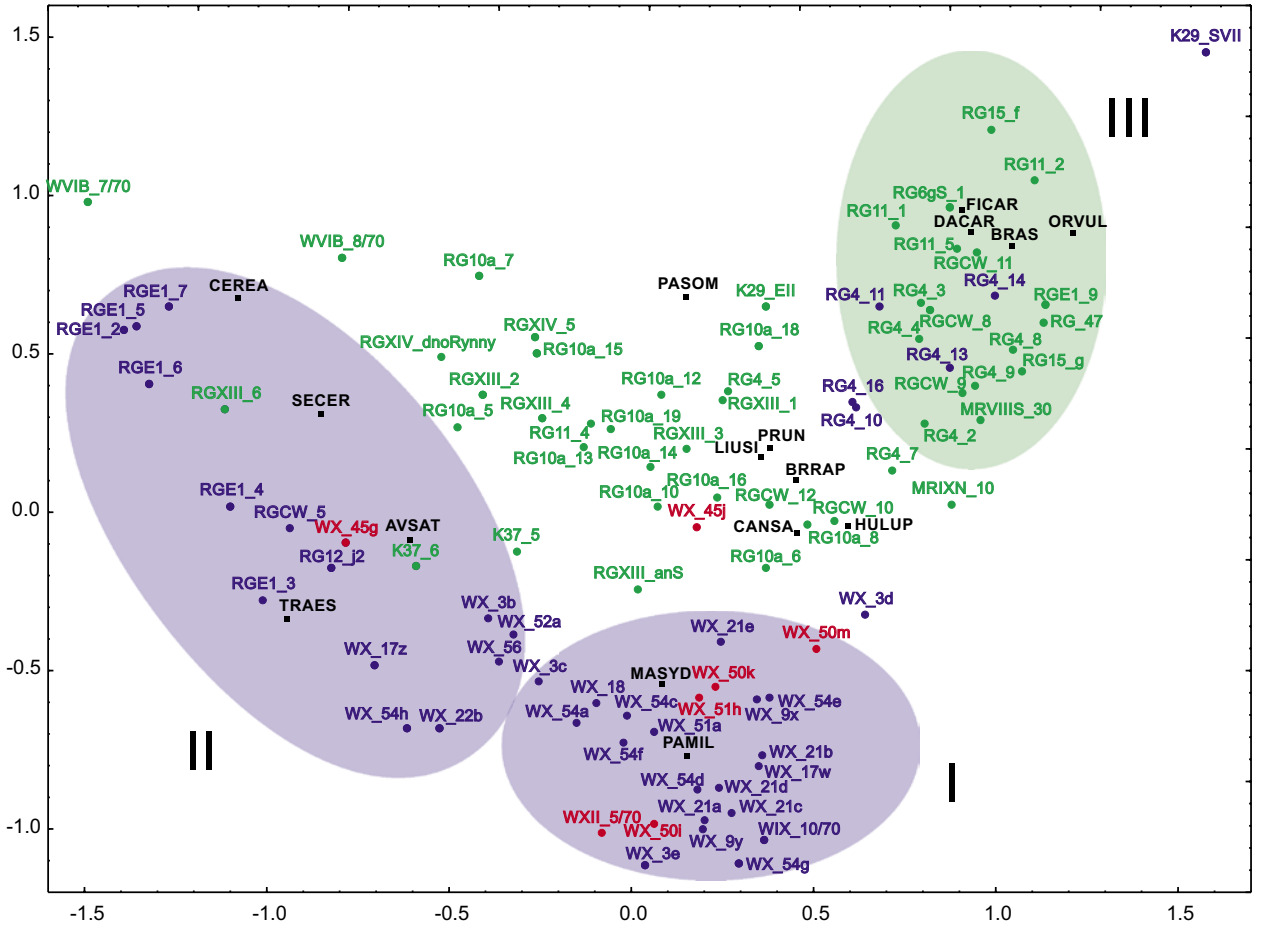

Fig. 3. Correspondence analysis results for cultivated and probably-cultivated plants found in at least 20 samples containing at least 50 macroremains each. The analyses included carbonised (charred) as well as uncarbonised (waterlogged, mineralised) plant macroremains. Horizontal axis – first dimension (21% of variance), vertical axis – second dimension (15%). Plant and sample codes as in Tables 1 and 2: Plant codes – **black**, Sample codes: **red** – tribal period (MA1), **blue** – early medieval period (MA2), **green** – late medieval period (MA3). **I** – group of *Malus* sp. and *Panicum miliaceum*, tribal and early medieval samples mainly from Wawel Hill, **II** – group of large-grained crops (*Triticum aestivum*, *Avena sativa*, *Secale cereale*; *Cerealia* indet.; barley not frequent and not included, Table 2) and mostly early medieval samples; that part of the graph is strongly influenced by charred samples, **III** – group of probably-cultivated plants and fig (*Brassica* sp., *Daucus carota*, *Ficus carica*, *Origanum vulgare*) and late medieval samples from eastern part of Main Square

were discovered, and with late medieval samples from Wawel Hill (area VIB) (Fig. 4). The decrease of wheat and millet over time, and their association with early medieval samples, may reflect economic changes occurring at the time the town was chartered, when most of the trade and processing of crops were restricted to areas outside the city walls (Kutrzeba 1898: 41, Wyrozumski 1992: 391). Probably only finished products, flour and groats were sold inside the town (Mueller-Bieniek 2012, Mueller-Bieniek & Walanus 2012). Different rules most likely applied to barley, prepared for beer production in town breweries, and oat, used as horse fodder. Rye straw (waterlogged rachis internodes) found in the late medieval area of wooden houses in the Main Square probably originated from thatch and other types of insulation. Those samples are accompanied by field weeds (Mueller-Bieniek & Walanus 2012, de Moulins 2007). Millet and large-grained crops differ in their occurrence, partly due to the way they were prepared for consumption. The frequency of millet (mostly waterlogged chaff) is linked statistically to the frequency of apples (parts of cores), suggesting that their remains are mainly household waste (Mueller-Bieniek & Walanus 2012). In late medieval times, millet was no longer a raw material, probably having been processed outside the city walls or in special areas, while the distribution and use of apples (discarded cores) seen in the early and late medieval samples was much the same during the whole medieval period.

Statistical analysis placed fig remains in a clearly separated cluster of probably-cultivated plants (together with carrot, wild

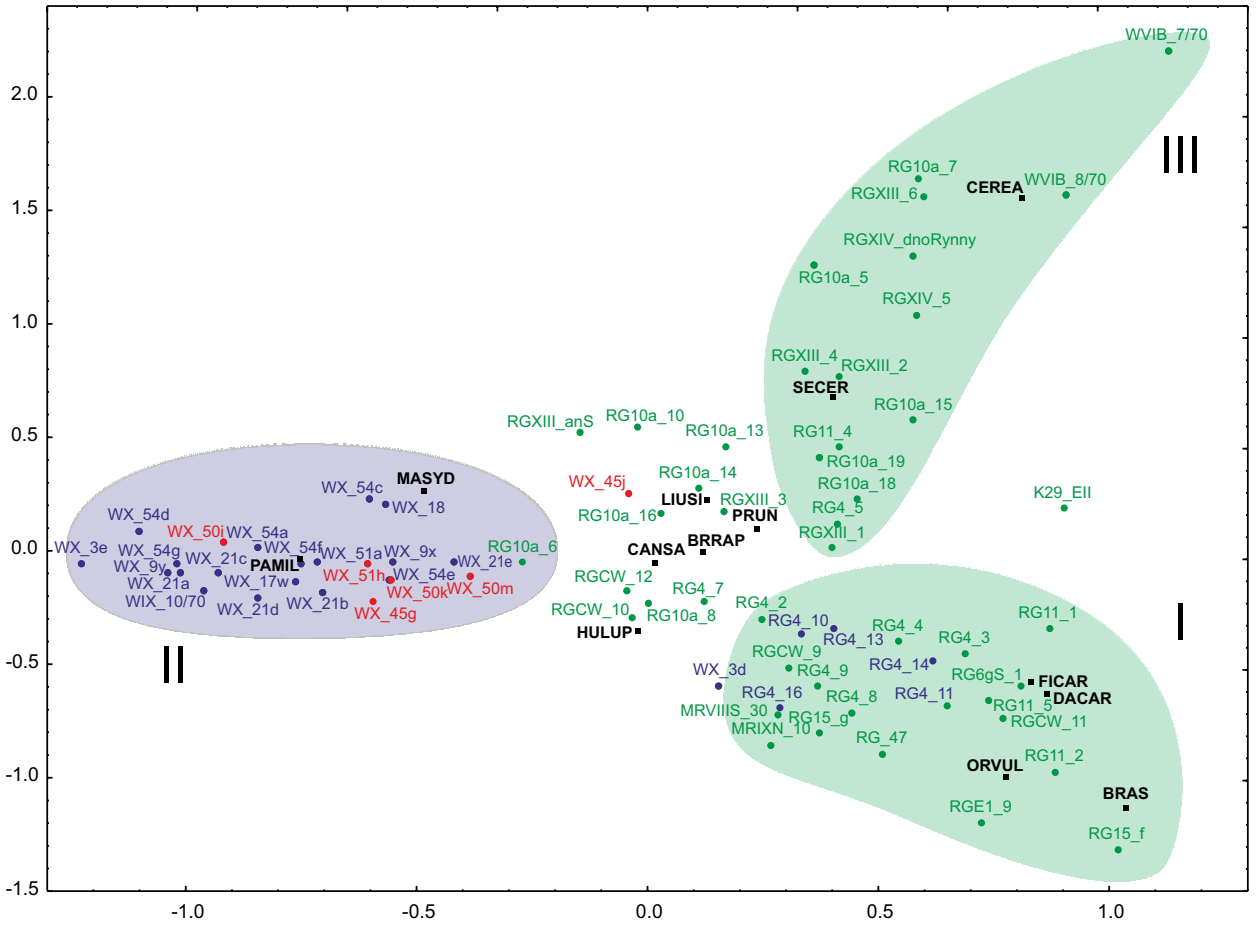

Fig. 4. Correspondence analysis results for cultivated and probably-cultivated plants found in at least 20 samples containing at least 50 macroremains each. Only waterlogged plant macroremains were analysed. Horizontal axis – first dimension (20% of variance), vertical axis – second dimension (18%). Other descriptions as in Figure 3. In group **III**, *Triticum aestivum* and *Avena sativa* are excluded because most of their remains were charred

marjoram, *Brassica* spp.), although it probably was cultivated elsewhere and imported to the town. The samples containing this group of plants came mainly from the eastern part of the Main Square (Figs 3, 4). They apparently represent remnants of fodder and are consequently associated with accumulations of animal dung, and human excrement in the case of fig remains (Greig 1996, Alsleben 2007, van der Veen 2007, Mueller-Bieniek & Walanus 2012). Most of the carrot fruits evidently originate from fodder and dung, with the exception of one large concentration of processed carrot fruits in a late medieval sample from the Main Square, which most likely were being prepared for sowing by removal of their spines (Młodzianowska 1981, Mueller-Bieniek 2010). The statistical analysis also showed some connection of oil-rich plants (flax, hemp, *Brassica napus/rapa*), condiments (hop *Humulus lupulus* L.), and drupes (*Prunus* spp.) with late medieval wooden buildings located in the north-western part of the Main Square.

Remains of amaranth (AMLIV) occupy a unique position among the cultivated and probably-cultivated taxa (Fig. 5). In some samples, amaranth heavily loads the first principal component (horizontal axis, 20% of inertia); in fact the result is governed by that single taxon. In the second component its loading is moderate (13%). The extreme samples containing massive finds of amaranth date mainly to early medieval times and are located close to the interior side of the defence walls of the Okół suburb (Kanonicza St. 17 site, trench XXIX – mainly samples K29_EVIII, K29_EIII, K29_EIX, K29_SVI) (Tab. 3).

AMARANTH
***(Amaranthus lividus* L. cf. var. *lividus*)**

Amaranth seeds were most abundant in the early medieval samples, preserved mostly in profile XXIX from the Kanonicza St. 17 site (Tab. 3, Figs 6–8), and generally were not frequent (Tab. 2, Fig. 2C, Mueller-Bieniek 2012).

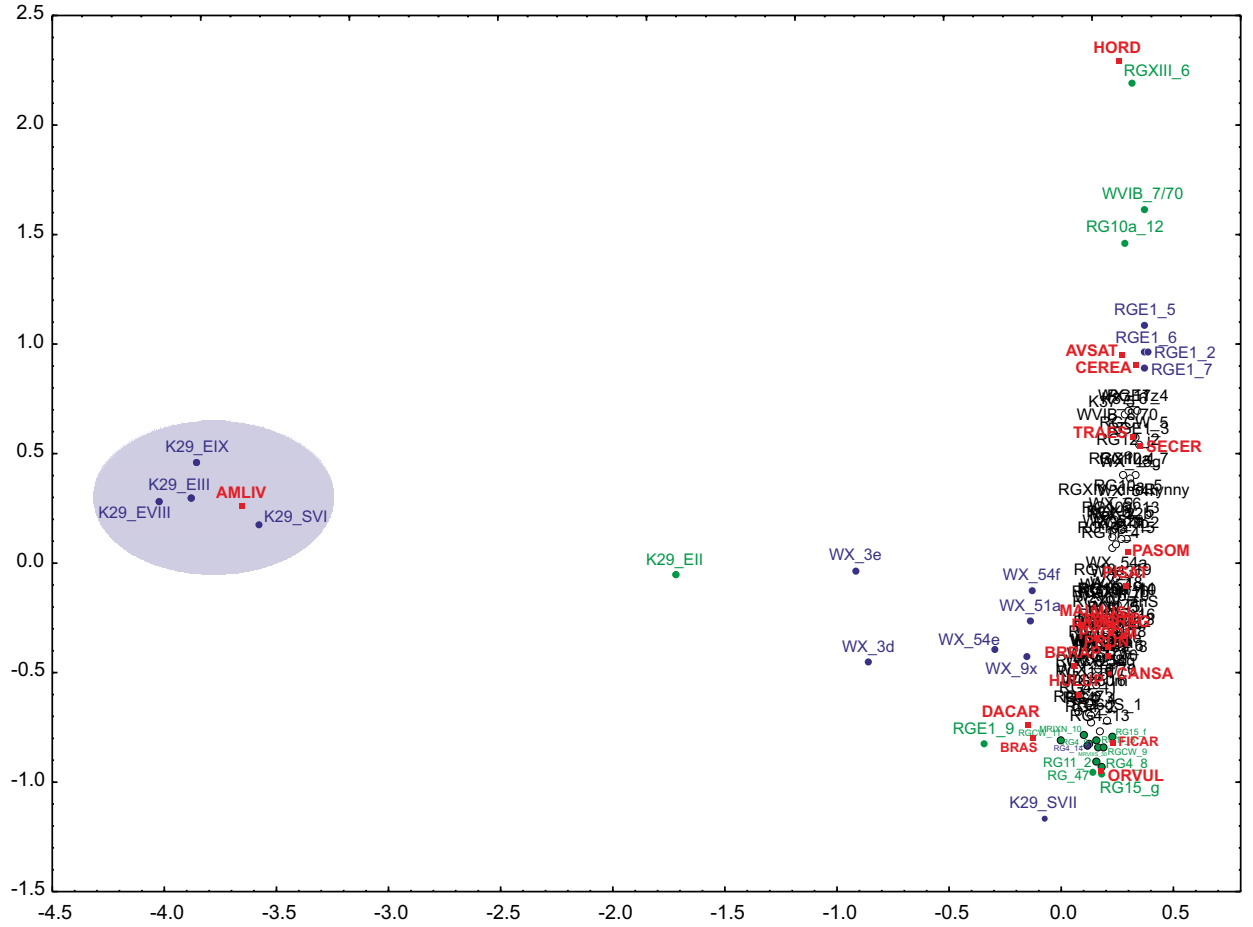

Fig. 5. Correspondence analysis results for cultivated and probably-cultivated plants found in at least 11 samples containing at least 50 macroremains each. The analysis included carbonised as well as uncarbonised (waterlogged, mineralised) plant macroremains. Horizontal axis – first dimension (21% of variance), vertical axis – second dimension (14%). Plants and sample codes as in Tables 1 and 2 and Figure 3. Shaded group shows *Amaranthus lividus* var. *lividus* and associated early medieval samples from Kanonicza St. 17, trench 29. Several sample codes on the other side of the graph are omitted because of crowding of points; only the chronology colours of those samples are shown

The identification criteria were discussed in a monograph on the Wawel Hill remains (Wasylikowa 1978: 130–131). The seeds from the Wawel and Kanonicza St. sites are similar in size (Wawel: diameter 1.25–1.7 mm, average 1.54 mm; Kanonicza St.: diameter 1.3–1.8 mm, average 1.5 mm) and are significantly bigger than the wild-growing variety *Amaranthus lividus* L. var. *ascendens* Thell., which has seeds smaller than 1.4 mm (Kowal 1954, Frey 1974), as well as other species of *Amaranthus*. The plant was cultivated as a leafy vegetable in Central Europe in the early Middle Ages and was sown until the 16th and 17th centuries. The place of its domestication, possibly the Mediterranean or India, is uncertain (Hanelt 1968, Hanelt 2001). The taxonomy of the genus is controversial, but Rostafiński (1900: 157) reports that under the name *Amaranthus blitum* L., considered by later researchers to be *Amaranthus lividus* var. *lividus* (Frey 1974 and literature cited there), the plant was known as a cultivar in the Polish literature from the 16th century. In the recent Polish flora, *Amaranthus lividus* L. is given as a nitrophilous invasive species which in protected areas can be controlled mainly by eliminating ruderal sites (waste ground) (http://www.iop.krakow.pl/ias/Gatunek.aspx?spID=30). *Amaranthus lividus* seeds are commonly found at continental European sites, especially in Germany, from the 11th to 15th centuries (Greig 1996 and literature cited there). In Europe it was found several times starting from late Bronze Age sites and more commonly from medieval and early modern sites (http://www.archaeobotany.de).

Amaranthus species (e.g. *A. lividus*, *A. retroflexus*) are still widely gathered in parts of the Balkans (Łuczaj et al. 2013, Dolina & Łuczaj 2014), where they are one of the most commonly used wild foods, especially in Albania, Macedonia, Bulgaria, and Bosnia-Herzegovina

(e.g. Redzic 2006, Pieroni 2008, Nedelcheva 2013). They are still widely used as food in China (e.g. Kang et al. 2013).

The botanical context of the samples containing amaranth seeds (Fig. 6, Tab. 3, and Mueller-Bieniek & Walanus 2012) shows that it probably was cultivated on the early medieval Wawel Hill (accompanied by large numbers of remains of other cultivated plants and weeds), but that in the samples from the early medieval Okół suburb it was a ruderal plant (together with large numbers of remains of typical ruderal plants like *Urtica dioica* and *Chenopodium* spp. and small numbers of cultivated plants other than amaranth). These suggestions are supported by the CA results, which separate the early medieval samples containing amaranth seeds (from Kanonicza St. 17 site) from the others (Fig. 5). Those samples also show ruderal character in another CA analysis of the same dataset for frequent plants and for ecological groups that also included rare plants dominating in the material (Mueller-Bieniek & Walanus 2012). The late medieval findings of amaranth are not significant, but paradoxically the small number of amaranth remains may indicate their use as a cultivated plant consumed as a leaf vegetable before fruiting.

The samples containing amaranth seeds are adjacent in the excavation profiles. At the Kanonicza St. 17 site, most of them come from one archaeological layer (IIId) dated to the 11th–12th centuries AD, but the presence of amaranth also extends to a sample bordering the late medieval (K29_EII, layer IIj, dated to 13th–14th cent., Zaitz 2005). Most of the amaranth samples from Wawel Hill also are from one layer (VIe) dated to the 11th–12th centuries AD, described as 'brown earth with manure, often strong-smelling', characterised by ruderal communities (Wasylikowa 1978: 120, 183). The earliest appearance of amaranth is in a sample from Wawel Hill dated to the 11th–12th centuries (Tab. 3). The late medieval finds from the Main Square are from its eastern part, where mostly small-scale trade was practiced, and the other samples from that area contain abundant plant remains from grassland and wet sites, indicating the increased movement (and presence) of animals there (Mueller-Bieniek & Walanus 2012).

TRACING THE DEVELOPMENT OF RUDERAL PLANTS INSIDE THE TOWN WALLS: CASE STUDY OF KANONICZA ST. SITE

A comparison of the data from two profiles from trench 29 at the Kanonicza St. 17 site (Fig. 7) suggests the probable development of plant cover and/or human activity at that locality. In profile E the number of taxa increases in time, especially in the late medieval sample. In the oldest sample, taken from the bottom of a pit dated to the tribal period (10th cent.), the

Table 3. List of samples containing seeds of amaranth (*Amaranthus lividus*), and selected archaeological and botanical data. AMLIV – *Amaranthus lividus* L. var. *lividus*, URDIO – *Urtica dioica* L., Chen – *Chenopodium* spp. including mainly *Chenopodium album* L. type and *Chenopodium hybridum* L., **MA2**, **MA3**, **w**, **ch**, **mi** as in Table 1, * – depth given in metres above sea level, not comparable with other data (208.56-208.51)

Sample location		Sample	Depth (cm)		Age	Chronology	Number of specimens						
							AMLIV	URDIO	Chen	Total	w	ch	mi
Kanonicza 17 trench XXIX	profile E	K29_EIII	458	463	11-12th c.	MA2	100	418	37	729	726	3	0
		K29_EIX	445	453	11-12th c.	MA2	380	700	77	1395	1384	11	0
		K29_EVIII	439	445	11-12th c.	MA2	224	335	67	962	954	8	0
		K29_EII	427	433	13-14th c.	MA3	45	140	28	524	521	3	0
	profile S	K29_SI	433	441	11-12th c.	MA2	4	62	11	99	95	4	0
		K29_SV	425	433	11-12th c.	MA2	4	12	7	36	34	2	0
		K29_SVI	418	425	11-12th c.	MA2	102	400	35	642	640	2	0
Wawel Hill	area X	WX_51a	533	543	10-11th c.	MA2	1	23	93	241	231	10	0
		WX_54f	635	645	11-12th c.	MA2	1	3	90	307	295	9	3
		WX_54e	620	635	11-12th c.	MA2	6	4	452	887	882	1	4
		WX_3e	520	530	11-12th c.	MA2	4	4	85	477	469	8	0
		WX_3d	510	515	11-12th c.	MA2	4	2	192	443	428	13	1
		WX_9x	515	523	11-12th c.	MA2	3	3	132	665	664	1	0
Rynek Główny	pit E1	RGE1_9	*	*	late medieval	MA3	2	1	55	230	226	3	1
	trench SII	RG14_a	450	470	late medieval	MA3	1	1	0	25	25	0	0

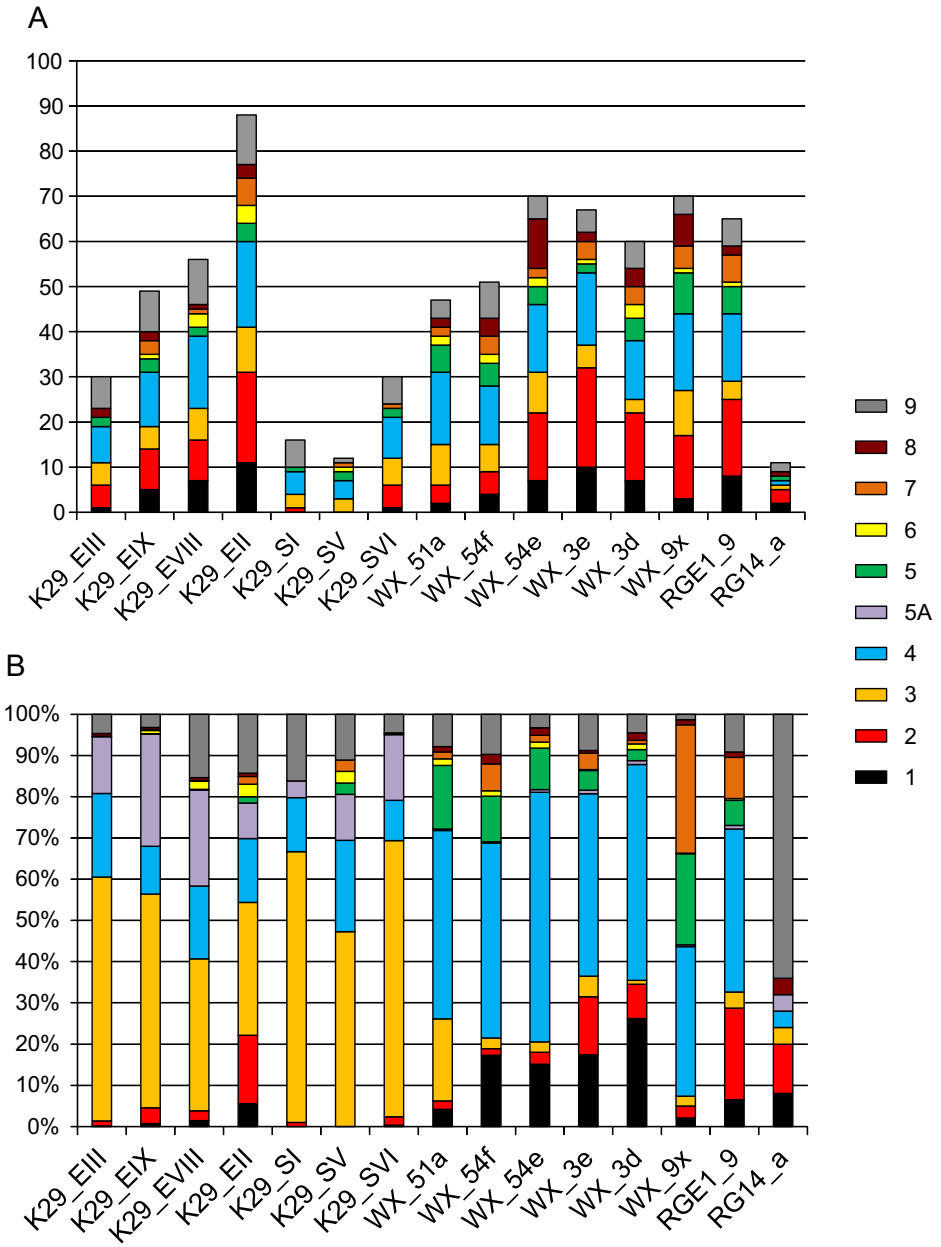

Fig. 6. Samples with remains of amaranth (*Amaranthus lividus* L.), and the botanical context of the finds. Ecological groups: **1** – water, water margins, boggy places, **2** – grassland, meadow, pasture, **3** – ruderals, **4** – unspecified ruderals/segetals, **5A** – *Amaranthus lividus*, **5** – cultivated, **6** – weeds of root-crop plants and gardens (spring weeds), **7** – weeds of autumn-sown field crops (winter weeds), **8** – forest, **9** – various and unspecified. **A** – number of taxa in the groups, **B** – percentage shares of remains of the plants in the groups. Amaranth specimens shown separately

plant composition is typical for plant husbandry (cultivated and synanthropic plants as well as edible forest fruits). The next 7 samples belong to layer IIId, dated to the 11th–12th centuries, but their plant composition differs slightly. The lowest sample (K29_E5) contains useful cultivated plants (millet *Panicum miliaceum*), wild plants (raspberry *Rubus idaeus*), and some forest plants (silver fir *Abies alba*, *Moehringia trinervia*), while typical ruderal plants including nettle (*Urtica dioica*) are not significant. In the upper samples, diaspores of ruderal plants became very numerous, represented mostly by nettle (*Urtica dioica*) seeds, also known as an important useful plant (Lityńska-Zając 2012). Unusually, seeds of nipplewort (*Chelidonium majus*) were noted in sample K29_E6. Nowadays the plant is known as a useful ruderal plant, mostly of pharmaceutical application but also used as a pesticide (Hanelt 2001). In sample K29_EIII, amaranth seeds appear (in Fig. 7 included in the group of cultivated plants, but separated in Fig. 6). It can be seen that ruderal plants appeared earlier in that area, and the presence of taxa belonging to other ecological groups suggests that the area

may have been used as a waste dump or that the area was abandoned and that natural accumulation of organic detritus took place there, close to the suburb walls. The samples from profile S from the same trench generally were not rich in plant remains (Tab. 3). The lowest sample presented here (K29_S3) was dated to the tribal period (9th–10th cent.). It contained mostly remains of useful plants or typical weeds (*Atropa belladonna*, *Sambucus nigra*, *Rubus idaeus*, *Avena* sp., *Panicum miliaceum*, *Secale cereale*, *Pisum sativum*, *Agrostemma githago*, *Typha* sp.). Deadly nightshade (*Atropa belladonna* L.) seeds are practically absent in Polish archaeobotanical data (Lityńska-Zając unpublished and pers. comm., Mueller-Bieniek 2012); this is connected mostly with the plant's geographical range (Piękoś-Mirkowa & Mirek 2003). In Poland it grows only in southern parts, in mountains up to 1100 m a.s.l., in forests and forest clearings. Archaeobotanical finds of deadly nightshade come mainly from southern regions of Europe and from England, dating from the Neolithic onwards (Brombacher 2010a, b, Kohler-Schneider & Canepelle 2009: 69, Kenward & Hall 1995, Hall & Kenward 1999). In Northern Europe some remains of deadly nightshade were found in north-eastern Germany in material from the 16th–17th centuries AD (Alsleben 2007: 27). Deadly nightshade was known as a medicinal plant in medieval times (Rostafiński 1900) and

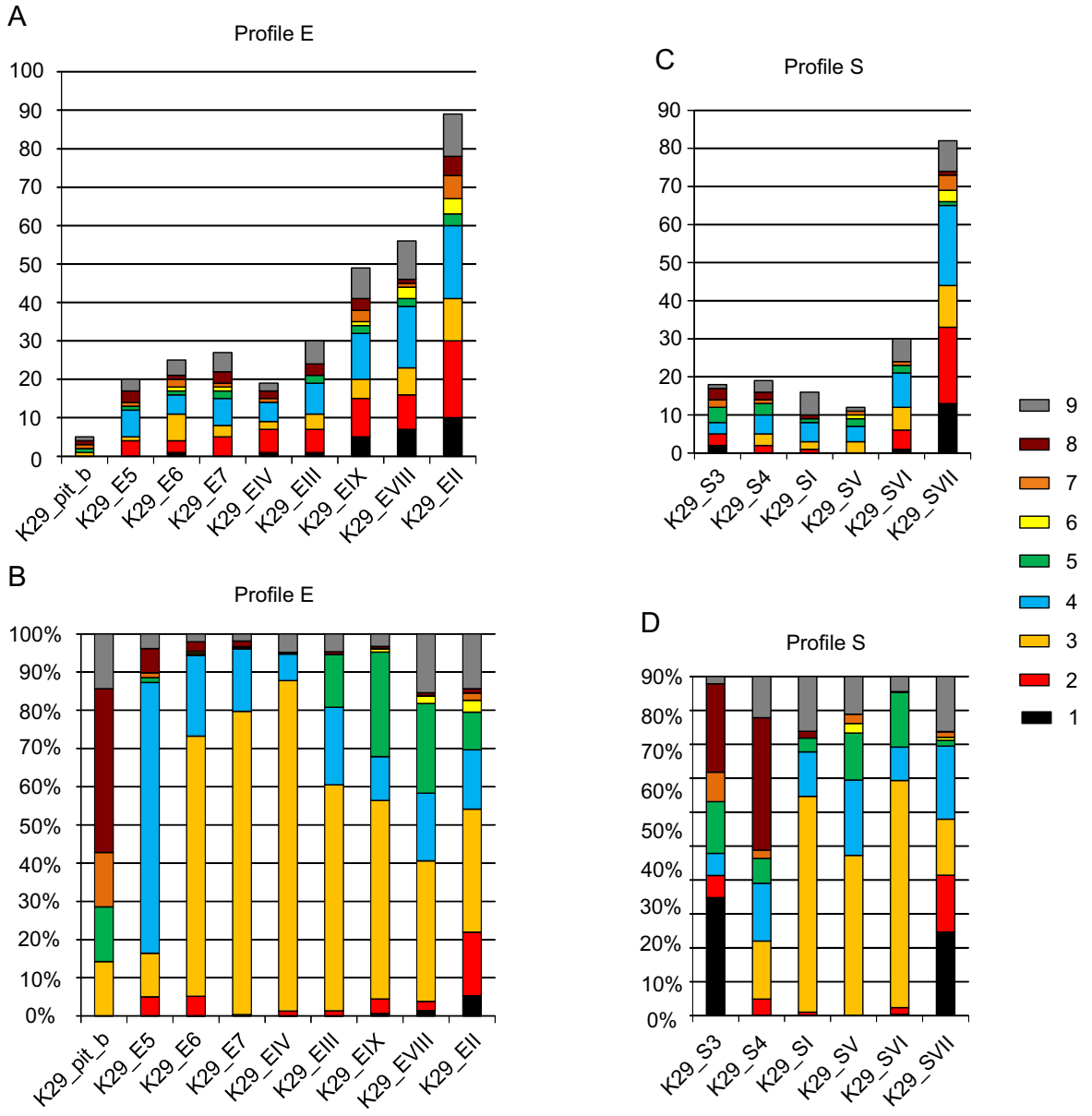

Fig 7. Samples from trench 29 at Kanonicza St. 17 site, ecological groups of the plants as in Figure 6. **A**, **C** – number of taxa; **B**, **D** – proportions of remains

Fig. 8. Location of trench 29 (arrow) at Kanonicza St. 17 site on model of Kraków before its chartering in 1257 (after Firlet 2006, model developed by Z. Pianowski, consulted with M. Niezabitowski and E. Zaitz, made by R. Gaweł)

its leaves are used now (Hanelt 2001, Broda & Mowszowicz 2002). The context of the find suggests that it was a useful plant, and its cultivation in that time (tribal period) cannot be ruled out. A neighbouring sample dated to the early medieval period (early medieval layer IIId, 11th–12th cent.) also contained remains of useful plants, mostly edible wild fruits, and the first diaspores of ruderals (*Urtica dioica*) appeared. The next three samples are ruderal in character but the plant remains usually are sparse (Tab. 3). The upper sample from the same archaeological layer IIId is similar to the upper early medieval sample from profile E (Fig. 7).

The data suggest that in early medieval Kraków, amaranth (*Amaranthus lividus* var. *lividus*) escaped from gardens, growing on ruderal sites rich in nitrogen (at least in the area of Kanonicza St. 17). In general, ruderal plants were much less significant in the late medieval samples from Kraków than in the early medieval samples. This is probably connected with the hygiene rules imposed by Magdeburg Law through the charter (Kutrzeba 1900: 115–116, Wyrozumski 1992: 463, Mueller-Bieniek & Walanus 2012: 142).

CONCLUSIONS

Among the cultivated and probably-cultivated plants, millet remains dominated the analysed samples, and large-grained crops were abundant; the latter were preserved mainly by charring. Other plants were preserved mostly by waterlogging, among them amaranth, the seeds of which were present mainly in early medieval samples from Wawel Hill and from the Okół suburb. Amaranth remains were very numerous in the samples from the Kanonicza St. 17 suburb site.

The changes in plant numbers and frequency mainly reflect the town's chartering in 1257, which led to changes in the distribution of food plants. Millet and wheat are rarer in the late medieval samples, a finding probably connected with relocation of the town mills outside the city walls and to a lesser extent with changes in the food preferences and wealth of the residents. The number of cultivated plants generally increased in the late medieval samples, but hop and mallow were more frequent in the tribal period than later.

The amaranth from the Kanonicza St. 17 site differs from cultivated plants in (1) the

number of remains and type of preservation (numerous seeds preserved by waterlogging); (2) the botanical context of the samples (domination of ruderal plants and scarcity of cultivated plants); (3) the association with sample proximity in the profile (adjacent samples contained smaller amounts of amaranth seeds); and (4) plant remains associated with domestic activity were gradually replaced by ruderal plants that already grew at the site before amaranth appeared.

The special character of finds of amaranth (*Amaranthus lividus* var. *lividus*) in the early medieval Okół suburb can be explained by the expansion of this garden plant in ruderal places. The samples containing numerous amaranth seeds are ruderal in character; this is seen in the composition of plant macroremains and was supported by correspondence analysis.

Statistical analysis of the plant assemblages indicated the character of certain areas of medieval Kraków in specific periods. The presence of ruderal plants was most conspicuous, probably connected with the autochthonous origin of their remains, in contrast to the origin of useful plants and those connected with animal fodder and transport.

The archaeobotanical assemblages are fragmentary. When available, information from written sources and data from other scientific fields should also be used. Pea remains are evidently underrepresented in the material from medieval Kraków.

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