

Comparison of European Archaeophyte lists in the light of distribution data

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Abstract

Currently is not available a complex archaeophyte definition based on the same criteria in Europe, and it cause significant anomalies between neighbouring countries. The main aim of our work was to provide the criteria which based on the available lists and chorological information. For this purpose, the archaeophyte flora of 15 European countries was compared in our research. The list of available resources has been revised and completed, taking into account the distribution data of the species. The lists were merged to contain 560 species. The majority of the plants in the merged list belong to the Asteraceae and Poaceae families with 74 and 55 species, respectively. The *Chenopodium* genus is characterized by the most frequent occurrence (14 species). More than half of the plants are annual and 151 species belong to Eurasian geoelements. The greatest numbers of species were observed in Crete (461 species) and Greece (460 species) and the smallest numbers were observed in Ireland (240 species) and England (241 species). In case of individual countries, plants with composite flowers, annual life form and Eurasian elements represent the highest volume, but the number of southern geoelements is also significant. All lists included anaecophytes archaeophytes. Comparison of revised lists showed 83-99% similarity. Using with this method can be formed an international archaeophyte database, which based on phytogeographical distribution and helps future researchers.

Keywords: archaeobotany; chorology; phytogeography; segetal plants; taxonomy

Introduction

Archaeophytes are species that were originally non-native to the area and were introduced and established in the specific area before the year 1500 (or 1492) (Terpó *et al.*, 1999; Pysek *et al.*, 2012; Maslo and Abadžić, 2015). In European flora research, they are also called “oldcomer plants” (Balogh, 2003), old anthropophytes, distinguished from neophytes (Zajac *et al.*, 2009) which came into the European flora after the discovery of the American continent. They are also interpreted as ‘almost native’ species, or in recent publications (together with neophytes) as allophytes, aliens, or non-native species. In many cases, they are regarded as cultural relics indicating a nomadic, migrant lifestyle of people (Comin and Poldini, 2009). Most species in Slovakia are naturalized and have a relatively stable population (Medvecká *et al.*, 2012). At the same

time, Belgium does not distinguish between native species and archaeophytes due to uncertain data and missing sources (Verloove, 2006).

There are five criteria for their identification including:

- There is evidence of their presence based on archaeological excavations, and current habitat and distribution in Europe and beyond (Preston *et al.*, 2004).
- There are no fossils of the taxon from ages before the Neolithic. This is the period (from about 5700 BC) when the first cultivated cereal fields were formed, with the first archaeophyte weed species (Hajnalová *et al.*, 1993).
- The individuals and populations of the taxon are mainly found in artificial habitats, especially in agricultural areas (Celesti-Grapow *et al.*, 2010), while neophytes dominate the ruderal areas of settlements (Lososová *et al.*, 2006).
- Archaeophytes are not capable of invasion; they do not spread suddenly in the habitat (Preston *et al.*, 2004).
- In addition, the uncertain native status in Europe, historical data from 1700, and spreading in 'New Europe' (e.g. North America) is a prerequisite (Preston *et al.*, 2004). These criteria vary slightly from country to country due to differences in the historical and geographical background (Williamson *et al.*, 2008). In northern European areas, the border line is slightly later: originally non-native species are considered to belong to this group that reached Norway, Iceland and Estonia before 1650, before 1770 and the middle of the 18th century, respectively (Ööpik *et al.*, 2008; Wąsowicz 2018). This anomaly would have made it difficult to compile a uniform list, and the lack of detailed archaeophytic flora in the Scandinavian literature, we do not analyse this area.

Although it is not a criterion, Lososová *et al.* (2006) state that species belonging to this group are the most common annual species that are insect or self-pollinated, R-strategists, reproducing by seeds, and have a permanent seed bank.

Well-known archaeophytes research works analyse the flora of individual countries. However, it is important to note that a taxon does not necessarily have the same judgment in different countries in terms of whether it can be considered an archaeophyte. It is explained by the definition itself: a given plant endemism in the area or the time of its introduction should be examined to determine whether the taxon in question can be considered to be an archaeophyte in that area. Obviously, it may vary from country to country, so that a taxon is considered an archaeophyte in a country is, while it might be native or neophyte in another country. It adds complexity to the judgment of this category. Example the *Artemisia* and *Brassica* genera have several species of archaeophytes in the Czech Republic (Pysek *et al.*, 2012), but they are not listed in Poland (Zajac *et al.*, 2009; Tokarska-Guzik *et al.*, 2010) since they are distributed to this area (Anastasiu and Negrean, 2005). In the Czech Republic, more *Allium* species are also referred to as "oldcomer plants" but none of them listed in Slovakia (Medvecká *et al.*, 2012). Therefore, based on our results, we aimed to propose a supplement to the available definition of archaeophytes.

The other problem arises from the fact that the distribution of plants not linked to the administrative boundaries of the countries, it is primarily determined by climatic and edaphic factors and by the phytogeographical features. Currently is not available a complex archaeophytes list based on the same criteria in Europe, so the main aim of our work was to provide the criteria which based on the available lists. Use of these criteria the synthesized merged European archaeophytes list can be compiled. Based on these results, we have also prepared a merged list, but in this study, we do not aim at simply notification of the list, but analysing it and presenting the relationships. We examined the list for taxonomy (families, genera), life forms and geoelements, with the aim of presenting significant and less significant archaeophyte groups and emphasizing proportions. It is also important to compare the lists of neighbouring countries, especially in the case of nations with close geographical and historical relationship.

Materials and Methods

Data source

The basis for our analysis was the archaeophyte list of 15 European countries including:

- Bosnia and Herzegovina (Maslo, 2014a; Maslo, 2014b; Maslo and Abadžić, 2015; Sarajlic and Jogan, 2017),
- Crete (Cin D'Agata *et al.*, 2009) (We examined the Crete list separately from Greece because of its unique geographical features),
- Croatia (Nikolić, 2018),
- Czech Republic (Pysek *et al.*, 2012),
- England (Preston *et al.*, 2004),
- France (Brun, 2009),
- Germany (Hofmeister and Garve, 2006),
- Greece (Arianoutsou *et al.*, 2010),
- Hungary (Terpó *et al.*, 1999),
- Ireland (Williamson *et al.*, 2008),
- Italy (Celesti-Grapow *et al.*, 2009; Comin and Poldini, 2009),
- Poland (Zajac *et al.*, 2009, Tokarska-Guzik *et al.*, 2010),
- Slovakia (Medvecká *et al.*, 2012),
- Slovenia (Jogan *et al.*, 2012),
- Switzerland (Richner, 2014) and
- Ukraine (Protopopova and Shevera, 2014).

Countries with available literature on archaeophytes were included in the study. Where more sources were available, the lists were merged (the taxon was included in the common list if at least one of the sources mentioned it).

Prior to analysing the data, the names of the plants were checked for the common nomenclature and the current names were improved (The International Plant Names Index, 2012; The Plant List, 2013). The cladistic system APG IV was used to determine the taxonomy of plants (Stevens, 2017). To determine the lifestyle of taxa, the handbook of plants (Simon, 2000; Király, 2009) and the lists published for the countries were used. The gene centres of the species are shown on the basis of the lists and the Euro-Mediterranean plant diversity database (Euro+Med PlantBase, 2006) was used. Erhardt *et al.* (2002), Erhardt *et al.* (2008) were used as a source of distribution data. For which taxon no data were found in these papers, or the data reported were not clear (e.g. cultivated plant, hybrid or anaecophyte), the original national lists were used as the basis for determining the distribution. If the taxon had been non-native to Europe according to the above sources, it was omitted from the list (e.g. *Citrus limon* and *Cucumis sativus*). To determine the geoelements, Soó (1964-1985), Meusel *et al.* (1965), Simon (2000) were used. For which taxon no data were found in these papers, was used to distribution data and georeferenced from Global Biodiversity Information Facility database (GBIF.org, 2019) to determine the geoelements category. In the case of hybrid species, a cross-section of the parent species area types was taken.

One-way analysis of variance (ANOVA) was carried out and significant differences were calculated according to Tukey test, with $P \leq 0.05$ being considered significant in all analyses. Statistical analyses were carried out using the SPSS 20 software (IBM, New York, US).

Results

Analysis of the merged European list

The following considerations have been taken into account in the establishment of the united European archaeophyte list:

- the taxon should meet the specific criteria for the definition of archaeophytes according to Hajnalová, 1993; Preston *et al.*, 2004; Celesti-Grappo *et al.*, 2010;
- plants listed under different (synonym) names in national lists should be listed only once, under a name approved by the International Nomenclature Committee;
- the current natural distribution of taxon should be classified as native in Europe and we recommend adding this phylogeographic criterion to the definition, that is, plants that are exclusively cultivated and not found in natural or seminatural populations in Europe (e.g. *Arundo donax*, *Cucumis melo*, *Cyperus papyrus*, etc.) we do not recommend to be called archaeophyte species.

The merged list of 15 countries contains 617 taxa. Considering distribution data as described above, we found that 57 taxa are not native in the European countries we investigated. Within the remaining 560 archaeophytes, 533 species, 12 under species taxonomic units (subspecies, variety or form) and 15 hybrids were determined.

The taxa included in the complex list belong to 62 different plant families. Two of those families are gymnosperms, six are monocotyledonous and 54 families are dicotyledonous. The number of species per family ranges between one and 71. For 24 of all families, only one species was listed. There are 25 families with two to ten species, and 13 families with more than ten taxa in the list. The Brassicaceae, Fabaceae, Poaceae and Asteraceae families comprise 45, 42, 55 and 71 species, respectively. The last accounts for 13% of the number of species in the merged list.

Examining the 281 genera included in the list, most of them (168 genera) are represented by only one taxon, and there are at least two species in the merged list for 113 genera. 22 genera have five or more species; eight genera contain eight or more species. Those include *Arctium*, *Bromus*, *Carduus*, *Chenopodium*, *Lamium*, *Lathyrus*, *Veronica* and *Vicia*. Of these, most taxa (14 species) can be observed in the *Chenopodium* genus. The success of the four largest genera with the highest taxon numbers (*Bromus*, *Chenopodium*, *Lathyrus* and *Vicia*) might be due to their intensive agricultural utilization.

Studying plant life forms, ten different categories (or overlaps among them) were observed with nine double categories. The number of species in each lifestyle category ranged from one to 296 in the list. The latter value represents the number of annual plants, the therophytes (Th) group, which takes 52.9% of the total list. In addition, there is also a significant number of perennials - hemicryptophytes (H) - (76) and annual-biennials - therophytes-hemitherophytes (Th-TH) - (63). Woody species (including chamaephytes) are represented by a total of 55 plants. This is only 9.8% of the total list, while the herbaceous species took 90.2% (505).

Among the archaeophytes included in the merged list can be found the members of 11 geoelements (the first taxon-specific flora element reported in the literature was considered). These are: Eurasian (151 taxa, of which 88 taxa have Mediterranean effect), Mediterranean (103 taxa), European (62 taxa), sub-Mediterranean (58 taxa), South Eurasian (51 taxa), cosmopolitan (50 taxa), Atlantic (24 taxa, almost all have Mediterranean influence), Central European (19 taxa), Eastern Mediterranean-sub-Mediterranean (16 taxa, these are the archaeophytes found in south-eastern Europe), Pontic (14 taxa), circumpolar (12 taxa). Based on these results, the number of "global" (comprising at least two continents) geoelements in the merged list is 264, while the number of "local" archaeophytes with a smaller area is 296. The widespread distribution of the "global" archaeophytes group can also be observed in the areas examined by us: 132 of the 264 taxa can be found in all examined lists, while the number of "global" archaeophytes in the single list is 13. On average, one of these plants is found in 12.84 of the 16 European lists examined.

Among the "local", regional distributed archaeophytes there can be found only 66 taxa in all examined lists, at the same time 34 plants were present in only one area. These can be found averagely in 9.18 lists. The

number of southern flora elements is 228, not including significant Mediterranean impacts in the Eurasian category and other categories. In the literature, in 353 of the 560 taxa used the word “Mediterranean” in chorological characterisation.

The comparison of country lists

The size of the lists

Observing the size of the corrected lists, it can be stated that Crete has the largest archaeophyte list (comprising 461 species, more than 82.1% of the merged list). In addition, Greece (460 species), Croatia (451 taxa), Italy (450 taxa), Bosnia and Herzegovina (446 taxa), Slovenia (438 taxa) and France (402 taxa) are also very important countries. The smallest number of archaeophyte plants is registered in the Irish (240) and in English (241) floras. The other countries surveyed (Ukraine, Switzerland, Hungary, Slovakia, Poland, Czech Republic and Germany) have values between 300 and 400 species. In addition, we have data from the Romanian archaeophyte list, which contains 51 species (Anastasiu and Negrean, 2005), and the size of the Finnish list is also mentioned in several publications: according to Suominen and Hämet-Ahti (1993), 192 species and 228 taxonomic units, while Pykälä (1998) reported on 100-140 species and 120-170 taxonomic units. The latter seems probable; while the number of Romanian archaeophytes is likely to be higher in terms of distribution data (at least 317 species might be included in the list of this country from the merged list). Possible list of Icelandic archaeophytes contain 19 species (Wąsowicz, 2018).

Considering the size of each country (Kovács and Szigeti, 2007) in relation to the national lists, it can be stated that in average most archaeophytes are found in Crete. The number of species in Slovenia is also high. The smallest number of plants related to the area occurred in Poland, Great Britain, Germany, France and Ukraine. Each of these countries has an area exceeding 100,000 km².

Pairwise comparison after the analysis of variances has separated six groups based on the size of the lists. The number of species was significantly lowest in two western European islands (Ireland and Great Britain), while the group with the highest values comprises Greece and Crete, the Balkan Peninsula and Italy. Germany, Ukraine, Switzerland and Poland also have smaller species numbers. The other East-Central European and Central European countries as well as France have lists of intermediate sizes (Figure 1).



Figure 1. Taxon number of corrected archaeophytes lists in Europe

Note: letters after numbers represent significantly homogeneous groups (Tukey test for SL = 0.05)

Comparison of the lists of neighbouring countries or territories

1. Great Britain and Ireland (the ratio of identical taxa compared to the merged list of both countries: 99.59%)

For both islands, the length of the modified archaeophyte list is very short, with 241 and 240 species. The difference between the two areas is coming from a single taxon (*Artemisia pontica*). It follows that the Irish list is a perfect subset of English.

2. Greece and Crete (the ratio of identical taxa compared to the merged list of both countries: 95.54%)

There are 450 species in each of these areas. Comparing the 10 and 11 species contributing to the difference between the two areas, it can be stated that in case of the island, six of them are woody species; while among the archaeophytes in Greece only one (*Salvia officinalis*) belongs to the woody plants.

3. Croatia and Bosnia and Herzegovina (the ratio of identical taxa compared to the merged list of both countries: 95.00%)

The relationship of the two neighbouring states according to the composition of the archaeophyte flora has been statistically confirmed with pairwise comparison, so we can also make a more detailed comparison. The taxon number is high in both countries (451 and 446), and we found 437 identical species. Number of different plants is 14 in Croatia and nine in Bosnia and Herzegovina. The difference between the two countries is mainly due to the six *Triticum* species in Croatia, which are not or only rarely found in the other countries examined.

4. Czech Republic and Slovakia (the ratio of identical taxa compared to the merged list of both countries: 90.93%)

A similar list size (393 and 386 species) or a geographical location justified comparing these two neighbouring states. There are 371 species in both lists. There are only 15 species that can find only in Slovakia, and 22 species occurring only in Czech Republic, with a high proportion of hybrids. Most of the differences are the species of *Allium*, *Arctium*, *Carduus* and *Chenopodium*.

5. Germany and Poland (the ratio of identical taxa compared to the merged list of both countries: 85.95%)

The two countries also have a similar geographical location, they share close historical relationships with each other, and their lists are also similar in size (342 and 346 taxa). The number of identical species is 318. Only in Germany can find 24 species and 28 species occurring just in Poland.

6. Italy and Slovenia (the ratio of identical taxa compared to the merged list of both countries: 85.00%)

The archaeophyte lists of the two neighbouring areas are very similar in size (450 and 438 species). The number of identical plants is 408. There are only 42 species that can find only in Italy and 30 species occurring only in Slovenia.

7. Hungary and Ukraine (the ratio of identical taxa compared to the merged list of both countries: 83.64%)

The modified archaeophyte list of Hungary contains 364 plants, while Ukraine has 343 plants. The number of identical species in this case is 322. There are only 21 species that can be found only in Ukraine and another 42 species occurring only in Hungary.

Distribution of individual lists based on the frequency of plant families

From the 62 families present in the merged list, 60 families are represented in at least three of the 15 countries. However, 36 families are listed in all the 15 areas studied. Examining the percentage distribution of families having more than ten species in the merged list (Table 1), *Asteraceae* is the most frequent family with species all of the countries. This is probably due to the diversified seed dispersal strategy (anemochory/zoochory/anthropochory) (Comin and Poldini, 2009).

Table 1. Percentage (%) of plant families with high taxon numbers compared to the total number of archaeophytes, in the 15 national archaeophyte lists and the merged European archaeophyte list

Country	As (%)	Po (%)	Br (%)	Fa (%)	Ap (%)	La (%)	Am (%)	Ca (%)	Pl (%)	Pa (%)	Ro (%)	Bo (%)	Ra (%)
Bosnia and Herzegovina	12.13	9.89	8.76	6.97	5.39	4.72	5.39	4.72	4.04	3.60	1.80	2.47	2.47
Crete	11.74	9.35	8.26	7.83	5.65	4.57	5.43	4.57	3.91	3.70	2.83	2.39	2.39
Croatia	12.44	11.11	8.22	6.89	5.33	4.89	5.33	4.67	4.00	3.56	1.56	2.44	2.67
Czech Republic	11.99	8.16	9.69	6.12	6.38	5.10	6.12	4.85	4.34	3.32	3.57	3.06	1.79
France	11.94	9.95	8.21	6.97	5.97	4.98	4.73	4.73	4.48	3.73	1.49	2.49	2.49
Germany	12.32	6.74	9.38	5.87	5.87	5.87	6.16	5.57	5.28	3.52	2.05	2.64	2.05
Great Britain	13.33	7.50	8.75	4.58	6.25	7.08	4.58	6.67	5.83	4.17	2.92	2.50	1.25
Greece	11.55	10.02	8.50	7.41	5.88	4.79	5.23	4.58	3.92	3.70	1.74	2.40	2.40
Hungary	11.02	8.26	10.19	6.06	6.34	4.68	5.79	5.51	4.68	3.31	1.65	2.75	2.48
Ireland	12.97	7.53	8.79	4.60	6.28	7.11	4.60	6.69	5.86	4.18	2.93	2.51	1.26
Italy	10.91	9.80	8.46	8.02	6.24	4.45	5.12	4.45	4.23	3.34	2.23	2.45	2.45
Poland	11.30	7.83	10.14	6.09	6.38	4.93	6.09	5.51	4.64	3.19	1.74	2.90	2.32
Slovakia	12.21	8.31	9.35	6.49	6.49	4.94	6.23	5.19	4.42	3.12	3.38	2.60	2.08
Slovenia	12.36	9.38	8.47	6.64	5.4	5.26	5.49	4.81	4.12	3.66	1.60	2.52	2.52
Switzerland	11.92	6.69	10.17	6.10	5.81	4.94	6.40	5.52	5.23	3.49	1.74	2.62	2.33
Ukraine	11.70	9.06	10.23	6.14	4.97	4.97	6.14	5.85	4.68	2.92	1.46	2.63	2.34
Merged list	12.68	9.82	8.04	7.50	5.89	5.54	5.18	3.93	3.75	3.21	3.21	2.32	2.32

Legends: Am – *Amaranthaceae*, Ap – *Apiaceae*, As – *Asteraceae*, Bo – *Boraginaceae*, Br – *Brassicaceae*, Ca – *Caryophyllaceae*, Fa – *Fabaceae*, La – *Lamiaceae*, Pa – *Papaveraceae*, Pl – *Plantaginaceae*, Po – *Poaceae*, Ra – *Ranunculaceae*, Ro – *Rosaceae*.

It is followed by the Brassicaceae and Poaceae families. The proportion of grasses is extremely high in Croatia, while in the Swiss and German lists those values are significantly lower compared to those of the merged list. In addition to the Asteraceae in the British Isles, the number of archaeophytes belonging to the Caprifoliaceae, Caryophyllaceae, Geraniaceae, Lamiaceae and Papaveraceae families is outstanding. At the same time, the Great Britain and Ireland have the fewest species in the Fabaceae family. In western European countries (British Isles and France), the proportion of Amaranthaceae species is low, and the lowest number of Rosaceae family can be observed in France. In contrast, Slovakia and the Czech Republic are characterized by high proportion of Rosaceae species compared to other examined areas. The percentage of Fabaceae species is the highest in the Southern European states (Italy, Greece and Crete). Plantaginaceae species predominantly occur in central and western European states (Switzerland, Ireland, Germany and Great Britain).

The three minor families (they are present in the list of only one, two, or three countries) include the Araliaceae, Cupressaceae and Vitaceae. At the same time, most of the 'one-species' families in the merged list are listed in 5-8 countries (Cyperaceae, Juglandaceae, Lauraceae, Linaceae, Moraceae, Myrtaceae, Paeoniaceae, Pinaceae, Platanaceae and Sapindaceae). Convolvulaceae, Lythraceae, Montiaceae and Verbenaceae, all of which contain a single taxon, have extensive distribution, because the species of these families can be found in all 15 examined areas.

Distribution of plant life-forms in national lists

Similarly, to the merged list, the annual species also represent the majority of archaeophytes in each of the 15 European countries. Their proportions exceed 50% in all countries. The ratio of therophytes is extremely high in the Polish list (57.2%). The ratios of annual-biennial (Th-TH) and biennial (TH) species are remarkable in Great Britain (14.5%; 5%) and Ireland (14.6%; 5%).

The proportion of perennials is also significant in the merged list (13.6%). The highest percentage (14.8%) of hemicryptophytes occurred in the Slovak list. This life form is present in Switzerland and Germany in more than 14% of the archaeophytes. Geophytes have a significant number of taxa in the Hungarian, Swiss, French and Italian lists, considering the proportions (over 4%). The proportion of large trees (MM) is considerable in the Cretan list (1.5%), but large tree species are not found in Ukraine, Switzerland and Germany. The proportion of woody archaeophytes is also outstanding in the Balkan Peninsula and Italy. The majority of these plants have Mediterranean or Eurasian origin, so the consequences of the ancient trading networks and Turkish mediators might be observed in such distribution patterns.

Comparing the proportions of herbaceous and woody species in all national lists, herbaceous plants represent over 90% of species, a value similar to the merged list. The lowest number of herbaceous species can be found in Crete (90.7%). Such a value is very high in Ukraine, Switzerland, Hungary, Ireland, Poland, Germany and Great Britain (over 94%). According to Lososová *et al.* (2006) the proportion of perennials and woody plants is more prominent among neophytes.

Distribution of national lists by geoelements categories

Of all the national lists, Eurasian taxa have the highest rates (28-35% of the lists). Cosmopolitan archaeophytes are present in 10-14% of each area, with the largest amount occurring in the British Isles. Also, worth mentioning is the number of archaeophytes of southern origin (southern Eurasia, Mediterranean, sub-Mediterranean, eastern Mediterranean). These four categories together constitute 24-40% of the list of some areas. The lowest number of southern geoelements can be observed on the Irish, British and German lists. The major differences are mainly due to different proportion of the Mediterranean area type plants. The least Mediterranean archaeophytes are in the Polish and German list (3.2-3.5%). The number of Atlantic species - in addition to Great Britain, Ireland and France in this flora region - can be considered high even in the German and Swiss national lists. The proportion of Central European archaeophytes reaches the highest percentage in Slovakia, while the Hungarian and Polish lists contain the highest number of Pontic geoelements. The

proportion of circumpolar taxa in the sub-Mediterranean-Mediterranean states (Croatia, Italy, Bosnia-Herzegovina, Greece) nearly half that in Ireland and United Kingdom (Table 2).

Table 2. Percentage of geoelements with high taxon numbers compared to the total number of archaeophytes, in the 15 national archaeophyte lists and the merged European archaeophyte list

Country	Eua	Smed	Cosm	S-eua	Med	Eur	Atl	C-eu	Circ	Pont	E-med-smed
Bosnia and Herzegovina	28.70	11.66	10.54	10.76	15.47	9.19	3.59	2.47	2.24	2.69	2.69
Crete	28.42	11.06	10.20	10.63	17.14	9.33	3.47	2.39	2.17	2.60	2.60
Croatia	28.82	11.75	10.20	10.42	15.96	8.87	3.77	2.66	2.22	2.66	2.66
Czech Republic	33.08	12.72	10.69	9.67	8.40	9.92	3.82	3.56	2.80	2.80	2.54
France	29.10	11.94	11.19	10.45	14.18	9.95	5.22	2.49	2.49	2.24	0.75
Germany	35.67	13.45	11.11	10.82	3.51	10.23	5.26	2.92	2.92	2.92	1.17
Great Britain	34.85	9.13	14.11	7.47	7.47	10.79	7.88	3.32	4.15	0.41	0.41
Greece	28.04	11.30	10.22	10.65	16.96	9.35	3.70	2.39	2.17	2.61	2.61
Hungary	34.07	13.74	11.54	11.26	4.12	8.24	4.12	3.30	3.02	3.30	3.30
Ireland	34.58	9.17	14.17	7.50	7.50	10.83	7.92	3.33	4.17	0.42	0.42
Italy	28.44	11.11	10.22	9.78	17.11	9.78	4.44	2.22	2.22	2.44	2.22
Poland	34.97	14.16	11.56	10.69	3.18	8.96	4.34	3.18	3.18	3.18	2.60
Slovakia	34.20	12.69	10.36	10.36	6.48	9.59	3.89	4.15	2.85	2.85	2.59
Slovenia	28.54	11.87	10.50	10.73	14.16	9.13	4.57	2.51	2.51	2.74	2.74
Switzerland	34.20	13.91	11.59	10.72	5.22	9.57	5.22	2.90	2.90	2.61	1.16
Ukraine	34.69	12.83	12.54	10.50	5.25	9.04	4.96	2.62	2.92	2.33	2.33
Merged list	31.90	12.03	11.30	10.15	10.13	9.55	4.76	2.90	2.81	2.43	2.05

Legends: Eua – Eurasian, Smed – sub-Mediterranean, Cosm – cosmopolitan, S-eua – south Eurasian, Med – Mediterranean, Eur – European, Atl – Atlantic, C-eu – Central-European, Circ – circumpolar, Pont- Pontic, E-med-smed – East-Mediterranean-sub Mediterranean

Discussion

There were significant differences in the sizes of the original lists, both in terms of the length of the lists (the Ukrainian list contains nine archaeophytes while that of the Czech Republic possess 312 species). This difference can be also stated in case of the comparison of neighbouring countries to some genera. These significant imbalances have disappeared in the case of revised or supplemented lists (198 of all the 560 species are included in the list of each area, with the shortest list containing 240 archaeophytes). As a tendency it can be observed that the length of the modified national lists is gradually decreasing northward from the Balkan Peninsula and from East to the West. It follows that we found the shortest archaeophyte list in the British Isles, which is explained by the historical-geographical processes (migration, Mongol invasion, Turkish conquest). By observing the gene centres the presence of anaecophyte archaeophytes is notable in the average of the studied areas (7.3%). This value also expresses the uncertain phytogeographical status of archaeophytes. Because the original habitat of these hemerophytes species has already been destroyed and found only in anthropogenic environment (Pinke and Pál, 2005). Among these homeless species, for example *Agrostemma githago*, *Sinapis arvensis* and *Tripleurospermum inodorum* can be found in all lists. All three species can be used to indicate archaeophyte associations: corncockle can be considered a pH neutral plant (Andreasen and Skovgaard, 2009; Fried *et al.*, 2010), charlock can be found in both northern and southern countries (Glemnitz *et al.*, 2004), and scentless mayweed is also used as a signalling species because it is easy to identify and serves as an indicator of agro-biodiversity through the number of trophic connections (Hyvönen and Huusela-Veistola, 2008). When examining geoelements, it is evident that the proportion of Mediterranean and sub-Mediterranean taxa

increases significantly in southern European areas. The same effect can be observed in the Atlantic countries: the presence of archaeophytes, which can be considered as Atlantic, is significantly higher in these countries than the others. However, the same effect cannot be observed in the lists of Central European or Pontic countries: we do not find a significant proportion of Central European or Pontic geoelements by examination. The explanation is that the proportion of Mediterranean (10.13%) and sub-Mediterranean (12.03%) geoelements is much higher among archaeophytes compared to Central European (2.90%) or Pontic (2.43%) geoelements.

Conclusions

In our study we compared archaeophytes of 15 European countries. By using distribution data, we have proposed to reduce anomalies between the lists published by each archaeophyte research, which may be particularly useful for the archaeophyte lists of neighbouring countries. We hope that our results will also help to judge disputed taxa. For future European lists, we recommend that, in addition to the definition of Preston *et al.* (2004), the authors should also take into account the available lists of neighbouring countries, geoelements and current distribution area of each taxon. Applying this approach will make it possible to establish a Europe-wide database which not only useful for the botanist.

Acknowledgements

This work was supported by EFOP-3.6.1-16-2016-00006 “The development and enhancement of the research potential at John von Neumann University” project. The Project is supported by the Hungarian Government and co-financed by the European Social Fund.

Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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