VASCULAR FLORA OF OLD CEMETERIES TRANSFORMED INTO PARKS IN POZNAŃ

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ABSTRACT. In 2011–2012, the vascular flora of all the eight park-like old cemeteries in Poznań was studied. They are former Protestant cemeteries, transformed into parks after the World War 2. Each of them was investigated in both spring and summer. In total, 334 species of vascular plants were found there, including 62 in the tree layer, 91 in the shrub layer, and 181 in the herb layer. Their vascular flora includes 173 taxa (51.8% of the total) introduced into cultivation, most of them in the shrub layer (70 species, i.e. 20.9%). Among plants with symbolic meanings, 52 species are in the tree and shrub layer, and 34 in the herb layer. Currently the symbolism of cemetery plants is of little significance, and they are planted mostly for ornament. Funeral plants in the investigated cemeteries are represented by 74 species. These include 15 species of geophytes, which are indicator plants (phytoindicators) of former cemeteries: Gagea arvensis, G. lutea, Galanthus nivalis, Hemerocallis fulva, Muscari botryoides, Narcissus poeticus, Ornithogalum boucheanum, O. nutans, O. umbellatum, Puschkinia scilloides, Saponaria officinalis, Scilla sibirica, Tulipa gesneriana, and T. sylvestris.

KEY WORDS: Poznań, old cemeteries, vascular plants, funeral plants, ergasiophytes

INTRODUCTION

The aesthetic role of cemeteries increased in the 19th century, when the concepts of cemetery parks, cemetery gardens or rural cemeteries were created. Plants started to play a major role in the cemetery space. Cemetery planning involved gardeners, landscape architects. Tall vegetation, shrubs, lawns, and flowers appeared in cemeteries (TANAS 2008). Because of the landscape cemetery concept, they are ideal for strolls and contemplation.

In Poland, old cemeteries can be transformed into parks 40 years after the last burial (NIEMIRSKI 1973). Thanks to the existence of parks at the sites of former cemeteries, they are cared for and maintained, and thus are easy to distinguish in the landscape. They are of both historical and environmental value.

The cemeteries where the proportion of tall vegetation is high are an important link in the system of urban green areas. Their extensive green spaces undoubtedly affect the microclimate of urban districts, and can also play an important visual role in urban landscape (NIEMIRSKI 1973). According to BORCZ (2002), cemeteries can be classified as urban green areas because they include groups of trees, alleys, vegetation planted at cemetery edges, solitary trees, and continuously intensively flowering plants.

SIEWNIAK & MITKOWSKA (1998) report that irrespective of the epoch and geographic region, cemeteries fulfilling their major function (as burial sites) nearly always became also green areas. Their boundaries are well-defined, so they are like gardens of special type, always with emphasis on the atmosphere of silence, reflection, and meditation, usually with many sacral objects.

Municipal cemeteries, as wooded habitats, are classified also as urban green areas (SIEWNIAK & MITKOWSKA 1998, DĄBSKI & OLEŚ 2006). The oldest cemeteries are habitat islands in urban and suburban districts, often with old, valuable trees, a well-developed shrub layer, and interesting funeral plants in the herb layer. Before the World War 2, HEMPELMANN (1927) noted that individual lanes in cemeteries, to improve orientation, should be planted with contrasting tree species. Then the visitors would easily find their way even at large cemeteries.

Cemeteries are some of the most valuable forms of our cultural heritage. Now they also reflect the
level of tolerance and sensitivity of the current generations in relation to other cultures or nationalities. This applies e.g. to abandoned German cemeteries (Rydzewska et al. 2011).

In Poznań, the flora of several cemeteries has already been studied: historical cemeteries in Świerczewo (Czarna 2005) and the Citadel (Czarna 2016), and currently used ones: Górczyn Cemetery, Nowina Cemetery in Jeżyce, Corpus Christi Cemetery in Bluszczowa St., and John Vianney Parish Cemetery in Lutycka St. (Czarna et al. 2011).

Before the World War 2, cemeteries were used for burial but in the course of years they acquired the form of specific gardens. The plants were selected carefully, in a planned way, to create a complete composition. This is reflected in the current tree layer of vegetation in these cemeteries (transformed into parks), as the trees have reached maturity.

This study was aimed to analyse the taxonomic composition of vascular plants in park-like old cemeteries in Poznań and to verify the hypothesis that in park-like cemeteries the majority of funeral plants (cemetery phytoindicators) are geophytes.

**MATERIAL AND METHODS**

In 2011–2012, floristic investigations were conducted in eight park-like cemeteries. They are former Protestant cemeteries, transformed into parks after the World War 2. Each of them was investigated in both spring and summer (Table 1).

Names of spontaneously occurring species follow (Mirek et al. 2002), while names of cultivated species follow (Gawryś 2008).

To determine the ground cover of species, a 7-degree scale of frequency was used: R = negligible (1–2 plants); + = several plants; 1 = very rare (covering 1–5% of cemetery area excluding graves); 2 = rare (5–25%); 3 = moderately frequent (25–50%); 4 = frequent (50–75%); 5 = common (75–100%).

| No. | Polish name | Street        | Denomination | Graves | Use         | Date of research |
|-----|-------------|---------------|--------------|--------|-------------|-----------------|
| I   | Malta       | Świętojańska  | Catholic     | none   | mown        | 24.04.2012      |
|     |             |               |              |        |             | 24.07.2012      |
| II  | Park Górczyński | Ostrobramska | Protestant   | none   | mown        | 20.04.2012      |
|     |             |               |              |        |             | 26.07.2012      |
| III | Park K. Marcinkowskiego | Towarowa | Protestant   | none   | mown        | 04.04.2011      |
|     |             |               |              |        |             | 23.07.2012      |
| IV  | Park Lubuski | Królowej Jadwigi | Protestant | none   | mown        | 22.04.2012      |
|     |             |               |              |        |             | 23.07.2012      |
| V   | Park G. Manitiusa | Grunwaldzka | Protestant   | none   | mown        | 02.04.2011      |
|     |             |               |              |        |             | 30.08.2011      |
| VI  | Park. im. Gen. J. H. Dąbrowskiego | Ogrodowa | Protestant   | none   | mown        | 22.04.2012      |
|     |             |               |              |        |             | 23.07.2012      |
| VII | Plac Kosynierów | Słowiańska | Protestant   | 1 grave | mown        | 22.04.2012      |
|     |             |               |              |        |             | 30.07.2012      |
| VIII| Park near Hotel Vivaldi | Winogрадy | Protestant   | none   | no management | 22.04.2012    |
|     |             |               |              |        |             | 24.07.2012      |
The species that occurred in 2–3 layers of vegetation in the studied cemeteries, were counted twice or thrice in the classification of life-forms and geographical-historical groups, i.e. as they occurred.

General floristic similarity of the studied cemeteries was visualized using cluster analysis. The dendrogram was generated by Statistica software on the basis of Euclidean distances and the unweighted pair-group average. The dendrogram (Fig. 1) was generated on the basis of species occurrence assessed using the Braun-Blanquet scale. The scale was transformed into a numerical scale as follows: r into 1, + into 2, 1 into 3, 2 into 4, 3 into 5, 4 into 6, and 5 into 7. Each species was used in the analysis only once, even if it occurred in many layers.

RESULTS

In all the eight park-like old cemeteries in Poznań, 334 species of vascular plants were found. The tree layer consisted of 62 species, the shrub layer of 91, and the herb layer of 181 (Table 2). Numbers of recorded species were the highest in cemeteries III (155 species), I (119), and VIII (108), whereas the lowest in cemeteries VI (58) and V (66) (Table 3).

In general, the highest number of species represented frequency class “+” (341 records), followed by classes “1” (226) and “R” (121) (Table 3). Only one species (Aesculus hippocastanum) in one cemetery (VI) was included in the highest frequency class “5”. Also frequency class “4” was represented by only one species (Lolium multiflorum) in the same cemetery (VI). Plants of frequency class “3” were found in cemeteries III (1 species), IV (5), V (6), VII (1), and VIII (3). The lowest frequency class, “R”, was represented by the largest numbers of species in cemeteries I, III, IV, and VI. Frequency classes “2” and “3” included the largest numbers of species in cemetery III.

Raunkiaer’s life-forms are adaptations to survival in unfavourable periods, such as winter and droughts. Vascular plants of park-like cemeteries in Poznań represent six life-forms: megaphanerophytes, nanophanerophytes, chamaephytes, geophytes, therophytes, and hemicyrpyphytes. Among

Table 2. Occurrence of vascular plants in park-like cemeteries in Poznań and their classification into life-forms (LF), geographical-historical groups (GH), symbolic plants (S), and funeral plants (F)

| Species                                               | Cemetery | LF | GH | S | F |
|-------------------------------------------------------|----------|----|----|---|---|
| Abies concolor (Gordon & Glend.) Lindl. ex Hildebr.   | I        | 2  | 1  | 1 | F1 |
| Aesculus carnea Hayne                                  | II       | 1  | 1  |   | Ap2 |
| Aesculus hippocastanum                                | III      | 3  | 1  | 1 | Sp2 |
| Alnus incana (L.) Swingle                              | IV       | 4  | 1  | 1 | ErW |
| Betula pendula Roth                                    | V        | 2  | 1  | 1 | 1 |
| Carpinus betulus L.                                    | VI       | 1  | 1  | 1 | 1 |
| Catalpa bignonioides Walter                           | VII      | 1  | 1  | 1 | ErW |
| Cerasus mahaleb (L.) Mill.                             | VIII     | 1  | 1  | 1 | 1 |
| Crataegus × media Bechst.                              |          |    |    |   |    |
| Crataegus monogyna Jacq.                               |          |    |    | S |    |
| Fagus sylvatica L.                                     |          |    |    | F1 |    |
| Fagus sylvatica L. ‘Pendula’                           |          |    |    |    |    |
| Fraxinus excelsior L.                                  |          |    |    |    |    |
| Fraxinus excelsior L. ‘Diversifolia’                   |          |    |    |    |    |
| Fraxinus excelsior L. ‘Pendula’                        |          |    |    |    |    |
| Fraxinus pennsylvanica Marshall                       |          |    |    |    |    |
| Hedera helix L.                                        |          |    |    |    |    |
| Juglans regia L.                                       |          |    |    |    |    |
| Malus domestica Borkh.                                 |          |    |    |    |    |
| Malus × oxyepala Czarna & Nowińska                     |          |    |    |    |    |
| Malus × purpurea Rehder                                |          |    |    |    |    |
| Morus alba L.                                          |          |    |    |    |    |
| Morus nigra L.                                         |          |    |    |    |    |
| Picea abies (L.) H. Karst.                             |          |    |    |    |    |
| Picea pungens Engel.                                   |          |    |    |    |    |

Vascular flora of old cemeteries transformed into parks in Poznań 117
| Species | Cemetery | LF | GH | Symbolic (S) and funeral (F) plants |
|---------|----------|----|----|-----------------------------------|
| *Pinus strobus* L. | - 1 cul - - - - - F1 Kn S |
| *Platanus × hispanica* Mill. ex Mâñchh. | - 3 cul 1 cul 1 cul 1 cul F1 ErW |
| *Populus alba* L. | 1 cul 1 cul - - - 1 cul 1 cul F1 Ap2 S |
| *Populus × canadensis* Moench | - - 1 cul - - - 1 cul F1 ErW S |
| *Populus nigra* L. | - - 1 cul 1 cul - - - F1 Ap2/Sp2 S |
| *Populus tremula* L. | - - 1 cul 1 cul - 1 cul 1 cul F1 Ap2 S |
| *Prunus cerasifera* Ehrh. | 1 cul - 1 cul 2 cul - - - F1 Kn S |
| *Prunus cerasifera* Ehrh. ‘Atropurpurea’ | - - 1 cul 1 cul - - - F1 Kn S |
| *Prunus domestica* L. | - 1 - - - - - F1 ErW S |
| *Pseudotsuga menziesii* (Mirb.) Franco | 1 cul - 1 cul 1 cul - - - F1 Kn |
| *Pyrus pyraster* (L.) Burgsd. | - - 1 cul 1 cul - - - 1 cul F1 Kn S |
| *Quercus robur* L. | - 2 cul 1 cul 2 cul 2 cul 2 cul - F1 Ap2/Sp2 S, F |
| *Quercus rubra* L. | - - - - 1 cul - - - F1 Kn S, F |
| *Quercus robur × Q. petrea* | - - - - 1 cul - - - F1 Ap2/Sp2 S |
| *Rhamnus cathartica* L. | - - 1 1 - - - F1 Ap2/Sp2 |
| *Robinia pseudoacacia* L. | 1 cul 1 cul 2 cul 1 cul - 1 cul 1 cul 1 cul F1 Kn S, F |
| *Salix alba* L. | - - 1 cul - - - - F1 Ap2 S |
| *Salix alba* L. ‘Tritis’ | - - 1 cul - - - - F1 ErW S, F |
| *Sophora japonica* L. | - - 1 cul - - - - F1 ErW F |
| *Sorbus aucuparia* L. emend. Hedl. | - - 1 cul - - - - F1 Ap2/Sp2 S |
| *Sorbus intermedia* (Ehrh.) Pers. | - - 1 cul - - - - F1 ErG S, F |
| *Thuja plicata* Donn ex D. Don | - 1 cul - - 1 cul - - - F1 ErW S, F |
| *Tilia americana* | - - 1 cul - - - - F1 ErW S, |
| *Tilia cordata* Mill. | - 2 cul 1 cul 1 cul 3 cul 1 cul 1 cul 1 cul F1 Ap2 S, F |
| *Tilia ‘Euchlora’* | 2 cul 1 cul 1 cul 3 cul - - - F1 ErW S, F |
| *Tilia platanoides* Scop. | - 3 cul 1 cul 1 cul 1 cul 1 cul - 2 cul F1 ErG S, F |
| *Ulmus glabra* Huds. | - - - - 1 cul - - - F1 Ap2 S |
| *Ulmus laevis* Pall. | 1 cul 1 cul 1 cul 2 cul 1 cul 1 cul 1 cul - F1 Ap2/Sp2 S |
| *Viscum album* L. | + + 1 1 + + 1 + C Ap1 S |

**Shrub layer**

| Abies concolor (Gordon & Glend.) Lindl. ex Hildebr. | - - + cul - - - - - F1 ErW S |
| *Acer campestre* L. | - 1 - - - - - F1 Ap2/Sp2 S |
| *Acer platanoides* L. | + + + + - - - + 1 F1 Ap1 S |
| *Acer pseudoplatanus* L. | - - + - - - - + F1 Ap1 S |
| *Aesculus hippocastanum* L. | - - - - - - - 2 F1 Kn S |
| *Amelanchier spicata* Lam. | - + cul - - - - - 1 cul F2 Kn |
| *Berberis thunbergii* DC. | - - + cul - - - + cul - F2 ErW S |
| *Berberis vulgaris* L. | + cul - + cul 1 cul - - - F2 ErW Sp2 S |
| *Betula pendula* Roth | + cul - - - - - - F1 ErW |
| *Carex groenlandica* Lam. | - + cul - - - - - F2 ErG F |
| *Carpinus betulus* L. | - + cul - - - - - F1 Sp2 |
| *Catalpa bignonioides* Walter | - - + cul - - - - - F1 ErW |
| *Castanea sativa* Mill. | + cul - - - - - - F1 ErW S |
| *Cerasus avium* (L.) Moench | + + - - - - - F1 Kn S, F |
| *Cerasus mahaleb* (L.) Mill. | - - - - - - - + cul F1 Kn F |
| *Clematis vitalba* L. | - - - - - - cul - + cul + cul C Kn F |
| *Cornus alba* L. | - - - - - - + cul - - F2 ErW |
| *Cornus mas* L. | - - + cul + cul - - - - F1 ErW |
| *Corylus avellana* L. | 1 cul - - - - - - F2 Sp2 S |
| *Cotinus coggyria* Scop. | - - - - - - + cul - F2 ErW |
| *Crataegus monogyna* Jacq. | - - + cul - - - - - F1 Ap2/Sp2 S |
| *Euonymus europaeus* L. | - - + + - - - + F2 Ap1/Sp1 |
| *Euonymus fortunei* (Turcz.) Hand.-Mazz. | - - + cul - - - - - F2 ErW |
| *Fagus sylvatica* L. | - + cul + - - - + cul - - F1 Ap1/Sp1 S |
| *Fagus sylvatica* L. ‘Atropurpurea’ | - - - - - cul + cul - + cul - F2 ErW |
| *Fraxinus excelsior* L. | - + + 1 - - - - + F1 Ap1 S |
| *Ginkgo biloba* L. | - + + cul - - - - - F1 ErW |
| *Hedera helix* L. | - - - - - - - 1 cul C Kn S, F |
| *Juglans regia* L. | - - - - - - + + F1 Kn S |
| *Juniperus horizontalis* Moench | - + 1 cul - - - - - F2 ErW Sp2 S, F |
| *Larix polonica* Raib. | + cul - - - - - - F1 Sp2 S |
| *Laurocerasus officinalis* Roem. | - - + cul - - - - - F2 ErW |
| Species | Cemetery | LF | GH | Symbolic (S) and funeral (F) plants |
|---------|----------|----|----|----------------------------------|
| *Ligustrum vulgare* L. | + cul + cul + cul + cul – – – + cul | F2 | ErW | F |
| *Lonicera × bella* Zabel | – + cul + cul – – – – | F2 | ErW | – |
| *Lonicera maackii* (Rupr.) Herder | – + cul + cul – – – – | F2 | ErW | – |
| *Lonicera tatarica* L. | – + cul + cul + cul – – – – | F2 | ErW | – |
| *Lonicera xylosteum* L. | – – + cul + cul – – – – | F2 | ErW | – |
| *Lycium barbatum* L. | – – + cul 1 cul – – – – | F2 | Kn | – |
| *Mahonia aquifolium* (Pursh) Nutt. | – – + cul + cul – – – – | F2 | ErW | S, F |
| *Malus baccata* (L.) Borkh. | – – 1 cul – – – – | F1 | ErW | S |
| *Malus × purpurea* Rehder | – – 1 cul – – – – | F1 | ErW | S |
| *Morus alba* L. | – – – – – – + cul | F1 | ErW | S |
| *Padus avium* Mill. | – – + cul – – – – | F2 | Sp1 | S, F |
| *Padus serotina* (Ehrh.) Borkh. | – – – – – – + | F2 | Kn | S, F |
| *Parthenocissus quinquefolia* (L.) Planch. in A. & C. DC. | + cul – – – – – – | C | ErW | F |
| *Persica vulgaris* Mill. | + – – – – – – | F2 | ErG | – |
| *Phyllostachys nigra* L. | – 1 cul 1 cul – + cul | – – | F2 | ErW | F |
| *Physocarpus opulifolius* (L.) Maxim. | – – – + cul + cul – – | F2 | ErW | – |
| *Picea abies* (L.) H. Karst. | + cul – – – – – | F1 | Kn | S |
| *Picea pungens* Engelm. | + cul – + cul – – – | F1 | ErW | S |
| *Pinus sylvestris* L. | + cul – – – – – | F1 | Ap1 | S |
| *Platanus × hispanica* Münchh | – – 1 cul + cul + cul – – | F1 | ErW | – |
| *Populus alba* L. | – – – – – – + cul | F1 | Ap1 | S |
| *Potentilla fruticosa* L. | – – 1 cul – – – | F2 | ErW | – |
| *Prunus cerasifera* Ehrh. | + – + – | F1 | Kn | S |
| *Prunus spinosa* L. | – – + cul | F2 | Ap1 | S |
| *Pseudotsuga menziesii* (Mirb.) Franco | + cul – – – – – | F1 | Kn | – |
| *Pyracantha coccinea* M. Roem. | – – + cul + cul – – | F2 | ErW | – |
| *Quercus robur* L. | – + cul + cul – – – + cul | F1 | Ap2/Sp2 | S, F |
| *Rhamnus cathartica* L. | – – + cul – – – – | F2 | Ap1/Sp1 | – |
| *Rhododendron catawbiense* Michx. | – + cul – – – – | F2 | ErW | – |
| *Ribes alpinum* L. | – 1 cul – – - – + cul | – F2 | ErW | – |
| *Ribes sanguineum* Pursh | – – – – + cul – – | F2 | ErW | – |
| *Robinia pseudoacacia* L. | – + 1 – – – – | F1 | Kn | S |
| *Rosa balsamita* Aiton | – 1 cul – – – – | F2 | ErW | S, F |
| *Rosa canina* | – 1 – + – – – + | F2 | Ap1 | S |
| *Rosa damaliscus Bechst., emend. Boulenger | – – + – – – – | F2 | Ap1 | S |
| *Rosa multiflora* Thumb. | – 1 cul – – – – | F2 | Kn | S |
| *Rosa ‘Poznań’* | – – 1 cul – – – – | F2 | ErW | – |
| *Rosa majalis* × *R. rugosa* | – – – 1 cul – – – | F2 | ErW | S, F |
| *Rosa × rugotida* Belder & Wijnands | – – 1 cul – – – | F2 | ErW | S, F |
| *Sambucus nigra* L. | – + 1 – + + + | F2 | Ap1 | S |
| *Sorbus aucuparia* L. emend. Hedl. | – – + + + + + | F1 | Ap1/Sp1 | S |
| *Sorbus intermedia* (Ehrh.) Pers. | – – + cul – – – | F1 | ErG | S |
| *Spiraea ‘Arguta’* | – + cul – + cul – – | F2 | ErW | – |
| *Spiraea chamaedrifolia* L. emend. Jacq. | – – – + cul | F2 | ErW | F |
| *Spiraea × vanhouttei* (Briot) Zabel | – 2 cul 1 cul + cul + cul – – | F2 | ErW | F |
| *Symphoricarpos albus* (L.) S.F. Blanke | – 2 cul 2 cul 1 cul 1 cul – – | F2 | ErW | F |
| *Symphoricarpos × chenaultii* Rehder | – 1 cul 1 cul – – – | F2 | ErW | – |
| *Symphoricarpos occidentalis* Moench | – 1 cul – – – – | F2 | ErW | – |
| *Syringa vulgaris* L. | + cul – + cul + cul + cul – – + cul | F2 | ErW | S, F |
| *Taxus baccata* L. | – – + cul 1 cul + cul – – | F2 | ErG | S |
| *Thuja orientalis* L. | + cul – – – – – | F1 | ErW | S, F |
| *Tilia ‘Euclea’* | – – – – + cul – – | F1 | ErW | S, F |
| *Tilia cordata* Mill. | – + + + – – | F1 | Ap2 | S, F |
| *Tilia platyphyllos* Scop. | + cul – – – – – | F1 | ErG | S |
| *Ulmus laevis* Pall. | – + – – – – | F1 | Ap2 | S |
| *Viburnum lantana* L. | – – + cul – – – | F2 | ErW | S |
| *Viburnum rhytidophyllum* Hemsli. | – – – + cul | F2 | ErW | S |
| *Weigela floryda* (Bunge) A. DC. | – – – + cul – – | F2 | ErW | – |

**Herb layer**

| *Acer campestre* L. | – – – – – | F1 | Ap2/Sp2 | S |
| *Acer negundo* L. | – – – – – | F1 | Kn | S |
| *Acer platanoides* L. | – – – – – | F1 | Ap1 | S |
| Species                                              | Cemetery | LF | GH | Symbolic (S) and funeral (F) plants |
|------------------------------------------------------|----------|----|----|------------------------------------|
| Acer pseudoplatanus L.                               |          | F1 | Ap1 | S                                  |
| Achillea millefolium L. s.s.                         |          | H  | Ap1 | S                                  |
| Aegopodium podagraria L.                             | + cul    |   |    | S, F                               |
| Anthemis cotula L.                                   |          | H  | Ap1 | S                                  |
| Allium oleraceum L.                                  |          | G  | Ap1 | S                                  |
| Allium scorodoprasum L.                              | 2 cul    |   |    | S                                  |
| Allium vineale L.                                    | + 1.1    |   |    | S                                  |
| Anchusa officinalis L.                               |          |   |    | T1                                 |
| Anemone nemorosa L.                                  |          |   |    | T1                                 |
| Anemone ranunculoides L.                             |          |   |    | S                                  |
| Anthemis ruthenica L.                                |          |   |    | T1                                 |
| Alfalfa (L. Presl)                                   |          |   |    | T1                                 |
| Armeria serpyllifolia L.                             |          |   |    | T1                                 |
| Arrhenatherum elatius (L.) P. Beauv. ex J. Presl & C.|          |   |    | T1                                 |
| Artemisia vulgaris L.                                | R + R    |   |    | T1                                 |
| Aster novi-belgii L.                                 |          |   |    | T1                                 |
| Atriplex patula L.                                   |          |   |    | T1                                 |
| Ballota nigra L.                                     |          |   |    | T1                                 |
| Bellis perennis L.                                   | 1.1      |   |    | T1                                 |
| Berteroa incana (L.) DC.                             |          |   |    | T1                                 |
| Bidens frondosa L.                                   |          |   |    | T1                                 |
| Brassica napus L.                                    |          |   |    | T1                                 |
| Bromus carinatus Hook. & Arn.                        |          |   |    | T1                                 |
| Bromus inermis Leys.                                 |          |   |    | T1                                 |
| Bromus sterilis L.                                   |          |   |    | T1                                 |
| Calluna vulgaris (L.) Hull                           |          |   |    | T1                                 |
| Campanula rapunculoides L.                           |          |   |    | T1                                 |
| Capella bursa-pastoris (L.) Medik.                   | R + R    |   |    | T1                                 |
| Cardamine hirsuta L.                                 |          |   |    | T1                                 |
| Carex hirta L.                                       |          |   |    | T1                                 |
| Carex spicata Huds.                                  |          |   |    | T1                                 |
| Cerastium glomeratum Thuill.                         |          |   |    | T1                                 |
| Cerastium holostoides Fr. emend. Hyl.                |          |   |    | T1                                 |
| Cerastium semidecandrum L.                           |          |   |    | T1                                 |
| Chaerophyllum temulum L.                             |          |   |    | T1                                 |
| Chelidonium majus L.                                 | + R R    |   |    | T1                                 |
| Chenopodium album L.                                 |          |   |    | T1                                 |
| Chenopodium hybridum L.                              |          |   |    | T1                                 |
| Cichorium intybus L.                                 |          |   |    | T1                                 |
| Cirsium arvense (Savi) Scop.                         |          |   |    | T1                                 |
| Cirsium vulgare (Savi) Ten.                          |          |   |    | T1                                 |
| Convolvulus arvensis L.                              |          |   |    | T1                                 |
| Coriaria canadensis (L.) Cronquist                   |          |   |    | T1                                 |
| Corenia varia L.                                     |          |   |    | T1                                 |
| Crepis biennis L.                                    |          |   |    | T1                                 |
| Crocus chrysanthus (Herb) Herb.                      | R cul    |   |    | T2                                 |
| Crocus vernus (L.) Hill                              |          |   |    | T2                                 |
| Dactylis glomerata L.                                |          |   |    | T2                                 |
| Dactylis glomerata L.                                |          |   |    | T2                                 |
| Daucus carota L.                                     |          |   |    | T2                                 |
| Diplolaxis muralis (L.) DC.                          |          |   |    | T2                                 |
| Echinochloa crus-galli (L.) P. Beauv.                |          |   |    | T2                                 |
| Elymus caninus (L.)                                  |          |   |    | T2                                 |
| Elymus repens (L.) Gould                             |          |   |    | T2                                 |
| Equisetum arvense L.                                 |          |   |    | T2                                 |
| Eregeron annuus (L.) Pers.                           |          |   |    | T2                                 |
| Species | Cemetery | LF | GH | Symbolic (S) and funeral (F) plants |
|---------|----------|----|----|-----------------------------------|
| *Erigeron ramosus* (Walters) Britton, Sterns & Poggem. | R cul | – | – | T2 Kn F |
| *Erodium cicutarium* (L.) L’Hér. | – | – | + R | T1 Ap1 |
| *Erophila verna* (L.) Chev. | – | – | – | T1 Ap1 |
| *Euphorbia helioscopia* L. | – | – | R | T1 Ar |
| *Euphorbia peplus* L. | – | – | R | T1 Ar |
| *Falcaria vulgaris* Bernh. | – | – | – | + cul 1 cul H Ap1 |
| *Fallopia dametorum* (L.) Holub | R | – | – | T1 Ap1 Sp1 |
| *Festuca rubra* L. s.s. | 1.1 | – | – | – | H Ap1 |
| *Ficaria verna* Huds. | 1 cul 1 cul 2 cul 3 cul 3 cul 1 cul + cul 3 cul G | Ap2/Sp2 |
| *Gagea arvensis* (Pers.) Dumort. | 1 cul + cul – 1 cul 2 cul – + cul + cul G | Ar F |
| *Gagea lutea* (L.) Ker Gawl. | 1 cul – 1 cul 3 cul 3 cul 1 cul + cul 2 cul G | Sp2 F |
| *Gagea pratensis* (Pers.) Dumort. | 2 3 3 3 3 1 2 1 G | Ap2 |
| *Galanthus nivalis* L. | + cul – – 1 cul R cul – – + cul B | Ap2/Sp1 S, F |
| *Galinsoga pubescens* Besser | + – – – – – – + cul T1 Ap1 Sp1 |
| *Galinsoga ciliata* (Raft.) S.F. Blake | + – R – – – – | T1 Kn |
| *Galinsoga parviflora* Cav. | + + + R – – – | – T1 Kn |
| *Galium mollugo* L. s.s. | + – – – – – – | – H Ap1 |
| *Geranium molle* L. | – – – – – – – | T1 Kn |
| *Geranium psilium* Burm. F. ex L. | R – R R R R – – T1 Ar |
| *Geranium pratense* L. | – – R – – – + H | Ap1 |
| *Geum urbanum* L. | – – – – – – – + H | Ap1 |
| *Glechoma hederacea* L. | + + + + + + + | – H Ap1 |
| *Heder a helix* L. | – – + cul – – – – – 1 cul | C Kn S, F |
| *Helichrysum arenarium* (L.) Moench | – – – – – – R – H | Ap1 |
| *Hemerocallis citrina* Baroni | – – 1 cul – – – – | H ErW |
| *Hemerocallis fulva* L. | – – + cul – – – – + H | ErW F |
| *Hieracium pilosella* L. | + – – – – – – – | H Ap1 – |
| *Holothea umbellatum* L. | – – – – – – + – | T1 Ap1 |
| *Hordeum marinum* L. | – – R R – – R | T2 Ar |
| *Hyoscyamus niger* L. | – – R – – – – – T1 Ar |
| *Impatiens parviflora* DC. | R – – – – – – + T1 Kn |
| *Juglans regia* L. | R – – – – – – – F1 Kn |
| *Lactuca serriola* L. | – R – – – – – – R | T2 Ar |
| *Lamium album* L. | + cul + cul + cul R cul R cul 1 cul – 1 cul H | Ar F |
| *Lamium purpureum* L. | + – – – – – – – R + + | T1 Ar |
| *Lapsana communis* L. s.s. | – – – – – – – – – + | T1 Ap1 Sp1 |
| *Lavandula angustifolia* Mill. | – – + cul – – – – – | C ErW S |
| *Leonotis autumnalis* L. | R – R R – – – | H Ap1 |
| *Lobelia erinus* L. | – – + cul – – – – | T1 ErW |
| *Lolium multiflorum* Lam. | – – R R – – R | T1 ErW |
| *Lumienus perenne* L. | 1 2 2 2 3 1 2 1 + H | Ap1 |
| *Malva neglecta* Wallr. | R – R + – R + – T2 Ar |
| *Malva pusilla* Sm. | – – – – – – – R | – T2 Ar |
| *Malva sylvestris* L. | – – – – – – – R | – T2 Ar |
| *Medicago falcata* L. | – – – – – – – – – + | H Ap1 |
| *Medicago album* (Mill.) Garcke | – – – – – – – – – R | H Ap1 |
| *Mentha longifolia* (L.) L. | + cul – – – – – – – H | Ap2 |
| *Moehringia trinervia* (L.) Clairv. | + – – – – – – – | H Ap1 Sp1 |
| *Muscaria botryoides* (L.) Mill. | + cul R cul + cul – – – – – | G ErW F |
| *Myosotis sylvatica* Ehrh. ex Hoffm. | + cul – – – – – – – | T1 ErG S, F |
| *Narcissus poeticus* L. | – – R cul – – – – | G ErW S, F |
| *Narcissus pseudonarcissus* L. | – – R cul – – – – | G ErW S, F |
| *Onopordon acanthium* L. | – – R – – – – – | – T2 Ar |
| *Ornithogalum boccheanum* Asch. | 2 cul – – – – – – – | G ErG F |
| *Ornithogalum nutans* L. | – – – – – – – 1 cul – | G ErG F |
| *Ornithogalum umbellatum* L. | 1 cul 1 cul 2 cul + cul 1 cul + cul + cul 1 cul | G ErG F |
| *Oxalis dillenii* Jacq. | – – – – – – – – – | T1 Kn |
| *Oxalis corniculata* L. ×O. dillenii Jacq. | + – – – – – – – – – | T1 Kn×Kn |
| *Pachysandra terminalis* Siebold & Zucc. | – – + cul – – – – – | C ErW |
| *Papaver rhoeas* L. | – – R – – – – – | T1 Ar S |
| *Papaver somniferum* L. | R – – – – – – – | T1 Ef S |
| *Phalaris arundinacea* L. | – – – – – – – – | R H Ap1 |
### Species and Cemetery Distribution

| Species | Cemetery | LF | GH |
|---------|----------|----|----|
| Picris hieraciodes L. | R – – – – – – H | Ap1 |
| Plantago lanceolata L. | + + + + + 1 I H | Ap1 |
| Plantago major L. s.s. | + 1 + 1 – – – H | Ap1 |
| Poa annua L. | + 1 1 1 + T2 Ap1 |
| Poa nemoralis L. | – 1 – – – I H | Ap1/Sp1 |
| Poa pratensis L. s.s. | + – 2 1 2 + H | Ap1 |
| Polygonum aviculare L. | 1 + 1 2 – + T1 Ap1 |
| Polygonum persicaria L. | R – – – – – T1 Ap1 |
| Populus alba L. | – – + – – F1 Ap1 |
| Potentilla argentea L. s.s. | – – + – – + + H | Ap1 |
| Potentilla reptans L. | R – – + – – H | Ap1 |
| Puschkinia scilloides Adams | – – 1 cul – – – – – G | ErG F |
| Ranunculus repens L. | + – – – – – H | Ap1 |
| Rubia pseudoacaul L. | + – + – – – F1 Kn |
| Rubus caesius L. | – – – – – – + cul 1 cul | Ap1/Sp1 |
| Rumex crispus L. | – – – – – – R H | Ap1 |
| Rumex obtusifolius L. | – + – – – R R – H | Ap1 |
| Rumex thyrsiflorus Fingerh. | + – – – – – H | Ap1 |
| Sambucus nigra L. | R R – – – – – F2 Ap1 |
| Saponaria officinalis L. | – – – – – + cul 1 cul | G Ap1 |
| Scilla sibirica Haw. | – – 1 cul R cul R cul – – + cul G | ErG S, F |
| Selenthras perennis L. | – – – – – – R – H | Ap1 |
| Sedum acre L. | – – – – – – + – H | Ap1 |
| Sedum reflexum L. | – – + cul – – – – H | Sp2 |
| Setaria viridis (L.) P. Beauv. | – – + – – – – – – – – – – – – T1 Ar |
| Silene vulgaris (Moench) Garcke | – – – – – – + – – – – H | Ap1 |
| Solanum nigrum L. emend. Mill. | + – R – – – – – T1 Ar |
| Solidago canadensis L. | – – – – + cul – – R cul | G Kn |
| Solidago gigantea Aiton | R cul – – – – – R cul | G Kn |
| Sonchus oleraceus L. | + – R R – R – – T1 Ar |
| Stellaria media (L.) Vill. | + – 1 + + + + + T1 Ap1 |
| Stellaria palifera (Dumort.) Piré | 1 – 1 + + + + 1 T2 Ap1 |
| Tanacetum vulgare L. | – – – – – – – – + H | Ap1 |
| Taraxacum officinale Web. | 1 1 1 1 1 2 + H | Ap1 |
| Tilia cordata Mill. | + – – – – – – + – F1 Ap1 |
| Torilis japonica (Houtt.) DC. | – – – – – – – – – – – – – T2 Ap1 |
| Trifolium campestre Schreb. | R – – – – – – – – – – T1 Ap1 |
| Trifolium pretense L. | R + – – – – – – – – H | Ap1 |
| Trifolium repens L. | + + 1 + + + 2 – H | Ap1 |
| Tulipa gesneriana L. | – – + cul – – – – + cul G | ErW F |
| Tulipa sylvestris L. | 1 cul – 2 cul – – 1 cul – – – G | ErG F |
| Ulmus laevis Pall. | – – R R – – – – F1 Ap1/Sp1 |
| Urtica dioica L. | + + + + + + T2 Ap1 |
| Urtica urens L. | R – – – – – – + 1 H | Ap1/Sp1 |
| Verbascum lychnites L. | – – – – – – – – – – – – T1 Ar |
| Veronica arvensis L. | R – – – – – – + T2 Ap1 |
| Veronica chamaedrys L. s.s. | + – + – R R – – + H | Ap1 |
| Veronica persica Poir. | – – – – – – – – – – – – – T1 Kn |
| Veronica polita Fr. | – – – – – – R – – T1 Ar |
| Veronica subhollowa M.A. Fisch. | 1 1 2 1 1 1 1 1 T1 Ap1 |
| Veronica triphylla L. | – – – – – – – – – – – – T1 Ar |
| Vinca major L. | – – 1 cul – – – – – H | ErW |
| Vinca minor L. | – – – – – – – – – 1 cul C | ErW S, F |
| Viola cyanea Čelak. | – – + cul – – – – 1 cul H | Kn S, F |
| Viola odorata L. | 1 cul 1 cul 1 cul + cul R cul + cul 1 cul H | Kn S, F |

**FC** (frequency classes): R – 1–2 specimens, + – several specimens, 1 – very rare (covering 1–5% of cemetery area excluding graves), 2 – rare (5–25%), 3 – moderately frequent (25–50%), 4 – frequent (50–75%), 5 – very frequent (75–100%); cul – cultivated, introduced in the past or presently introduced to cultivation.

**LF** (life-forms): F1 – megaphanerophytes, F2 – nanophanerophytes, C – chamaephytes, G – geophytes, H – hemicryptophytes, T1 – annual therophytes, T2 – biennial therophytes, T0 – non-wintering therophytes; li – climber, pp – parasite, ppe – semi-parasite.

**GH** (geographical-historical status): spontaneously occurring therophytes (Sp1), planted therophytes (Sp2), semi-syndanthropic therophytes (Ap/Sp), autophytes (Ap1) – species that penetrated spontaneously from natural localities to localities changed by human activity, hemerophytes (Ap2) – cultivated native species, archaeophytes (Ar), chamaephytes (Kn), ephemerophytes (Ed), vegetatively spreading ergasiophytes (ErW), generatively spreading ergasiophytes (ErG), non-wintering ergasiophytes (Er0).
them, in general the most diverse were megaphanerophytes (101 species) and hemicyryptophytes (67). Also in individual cemeteries megaphanerophytes were the most numerous, except for cemeteries VII and VIII, where hemicyryptophytes dominated. In contrast, many annual therophytes were recorded in cemeteries I (26) and III (26) (Table 4).

Interestingly, also the proportion of geophytes was relatively high (31 species). Those plants can survive in unfavourable conditions thanks to deeply hidden buds, protected against drought and low temperature, which increases their chance to survive in: cemeteries. This group includes primarily bulb plants flowering in spring, e.g. Gagea arvensis, G. lutea, Galanthus nivalis, Muscari botryoides, Narcissus poeticus, N. pseudonarcissus, Ornithogalum bouc hanum, O. nutans, O. umbellatum, Puschkinia scilloides, Scilla sibirica, Tidipa gesnerana, and T. sylvestris.

Out of the 315 taxa recorded in this study, native species (apophytes and spontaneophytes) accounted for more than 50%. However, in individual cemeteries their proportion varied from 33% (cemetary VI) to 67% (cemetary III). In all cemeteries, apophytes were represented by Acer platanoides, Bellis perennis, Ficaria verna, Praxinus excelsior, Gagea pratenis, Loli um perenne, Tanacetum vulgare, Taraxacum officinale, Ulmus laevis, and Veronica sublobata. Among alien plants, the largest number of species belonged to the group of ergasiophytes (71 species), followed by kenophytes (56) (Table 5). In all cemeteries, kenophytes were represented by Conyza canadensis, Ornithogalum umbellatum and Viola odorata. The smallest numbers of species of ergasiophytes were recorded in cemeteries VII (5) and VI (6), because their herbaceous layer was completely transformed by destruction of the former ground cover and sowing of new lawns.

Funeral plants are represented in the studied cemeteries by 74 species. The best indicator plants of cemeteries (including geophytes, distinguished by underlining) are Aster novi-belgii, Aesculus carnea, A. hippocastanum, Campanula rapunculoides, Caragana arborescens, Erigeron annuus, E. ramosus, Fagus sylvatica 'Atropurpurea', F. sylvatica 'Pendula', Fraxinus excelsior 'Pendula', Gagea arvensis, G. lutea, Galanthus nivalis, Hedera helix, Hemerocallis fulva, Lamium album, Ligustrum vulgare, Lonicera tatarica, Mahonia aquifolium, Muscari botryoides, Myosotis sylvatica, Narcissus poeticus, N. pseudonarcissus, Ornithogalum bouc hanum, O. nutans, O. umbellatum, Parthenocissus quinquefolia, Philadelphus coronarius, Plat anus ×hispanicana, Ribes alpinum, Salix alba 'Tristis', Saponaria officinalis, Scilla sibirica, Sedum reflexum, Spiraea chamaedrifolia, Symphoricarpos albus, Syringa vulgaris, Thuja plicata, Tidipa gesnerana, T. sylvestris, Vinca minor, Viola cyan eae, and V. odorata.

Description of the process of synanthropization by means of indices allows to determine its rate and various aspects of anthropogenic transformations of flora. The following indices were analysed in this study according to Chmiel (2006).

a) indices of flora synanthropization: WSc = 168%, WSt = 212% (WSc = total synanthropization index, WSt = permanent synanthropization index)

b) indices of apophytization: WAPc = 75.6%, WAPt = 87.7% (WAPc = total apophytization index, WAPt = permanent apophytization index)

c) indices of flora anthropophytization: WANC = 92.5%, WANT = 87.7% (WANC = total anthropophytization index, WANT = permanent anthropophytization index)

d) indices of flora archaeophytization: WARc = 19.5%, WARt = 31.8% (WARc = total archaeo-

### Table 3. Numbers of species included in frequency classes in park-like old cemeteries in Poznań

| Frequency class | I  | II | III | IV | V  | VI | VII | VIII | Total |
|----------------|----|----|-----|----|----|----|-----|------|-------|
| R              | 26 | 7  | 23  | 18 | 9  | 20 | 6   | 12   | 121   |
| +              | 59 | 41 | 56  | 36 | 27 | 16 | 45  | 61   | 341   |
| 1              | 28 | 25 | 64  | 32 | 20 | 18 | 14  | 26   | 227   |
| 2              | 6  | 10 | 11  | 5  | 4  | 2  | 7   | 6    | 51    |
| 3              | 1  | 5  | 6   | 1  | 3  |    |     |      | 16    |
| 4              |    |    |     |    |    |    |    | 1    | 1     |
| 5              |    |    |     |    |    |    | 1   |      | 1     |
| Total          | 119| 83 | 155 | 96 | 66 | 58 | 73  | 108  | 758   |

### Table 4. Numbers of species included in plant life-form categories in park-like old cemeteries in Poznań

| Life-form | I  | II | III | IV | V  | VI | VII | VIII | Total |
|-----------|----|----|-----|----|----|----|-----|------|-------|
| F1        | 31 | 25 | 53  | 34 | 19 | 14 | 14  | 27   | 217   |
| F2        | 6  | 12 | 26  | 15 | 11 | 4  | 3   | 6    | 83    |
| C         | 3  | 2  | 4   | 1  | 2  | 1  | 1   | 4    | 18    |
| G         | 13 | 11 | 15  | 11 | 13 | 8  | 8   | 19   | 98    |
| H         | 34 | 23 | 26  | 17 | 13 | 12 | 29  | 34   | 189   |
| T1        | 26 | 6  | 25  | 14 | 6  | 11 | 14  | 8    | 110   |
| T2        | 7  | 3  | 5   | 4  | 2  | 7  | 4   | 10   | 42    |
| T0        |    |    |     |    |    | 1  |     |      | 1     |
| Total     | 120| 82 | 155 | 96 | 66 | 58 | 73  | 108  | 758   |

### Table 5. Numbers of species included in geographical-historical groups in park-like old cemeteries in Poznań

| Group     | I  | II | III | IV | V  | VI | VII | VIII | Total |
|-----------|----|----|-----|----|----|----|-----|------|-------|
| Sp1       | 1  | 1  | 1   | 0  | 0  | 0  | 1   | 5    |       |
| Sp2       |    | 4  | 4   | 3   | 2  | 1  | 1   | 3    | 23    |
| Sp1/Sp2   | 5  | 3  | 4   | 3   | 1  | 2  | 2   | 7    | 27    |
| Sp2/Sp2   | 5  | 8  | 14  | 7   | 6  | 3  | 3   | 49   |       |
| Ap1       | 39 | 23 | 31  | 27 | 17 | 26 | 33  | 46   | 232   |
| Ap2       | 8  | 8  | 9   | 5   | 6  | 6  | 6   | 7    | 55    |
| Ar        | 14 | 5  | 17  | 11 | 6  | 9  | 10  | 9    | 81    |
| Kn        | 20 | 12 | 25  | 16 | 9  | 6  | 5   | 20   | 113   |
| Kn×Kn     | 1  | 0  | 0   | 0  | 0  | 0  | 0   | 0    | 1     |
| Ef        | 1  | 0  | 0   | 0  | 0  | 0  | 0   | 0    | 1     |
| ErW       | 13 | 17 | 36  | 18 | 13 | 4  | 11  | 8    | 120   |
| ErG       | 8  | 2  | 11  | 5  | 6  | 1  | 2   | 5    | 39    |
| ErG×Ap1   | 0  | 0  | 1   | 0  | 0  | 0  | 0   | 0    | 1     |
| ErO       | 0  | 0  | 1   | 0  | 0  | 0  | 0   | 0    | 1     |
| Total     | 119| 83 | 155 | 96 | 66 | 58 | 73  | 108  | 758   |
phytization index, WARt = permanent archaeophytization index)
e) indices of flora kenophytization: WKNc = 36.7%, WKNt = 55.5% (WKNc = total kenophytization index, WKNt = permanent kenophytization index)
f) flora modernization index: WM = 6.3%
g) index of floristic fluctuations: WF = 0.25%.

On the basis of the diagram of cemetery similarity, three groups of cemeteries were distinguished (Fig. 1). One group is composed of cemeteries I (near Świętojańska St.), VII (near Kosynierów Square), and VIII (near Winogrady St.), the similar second group consists of cemeteries IV (near Królowej Jadwigi St.), V (near Grunwaldzka St.), and VI (near Ogrodowa St.), and the third, least similar group comprises cemeteries II (near Ostrobamska St.) and III (near Towarowa St.).

DISCUSSION

The dendroflora of cemeteries and parks has been studied by many researchers. In comparison to other habitats explored floristically, cemeteries and parks that were formerly cemeteries have a rich dendroflora, characteristic of cemeteries.

Parks that were formerly cemeteries, because of the species richness and age of the dendroflora, are valuable because of their nature and history. The most common species of woody plants, found in all the investigated cemeteries, are Acer platanoides and Fraxinus excelsior. Floristic species richness is the highest in cemetery III (155 species), and the lowest in cemetery VI (58 species).

Konon et al. (2005), who studied the dendroflora of six cemeteries in Lednica Landscape Park, recorded 23 species of trees and shrubs: 19 broad-leaved and four coniferous. In comparison, the dendroflora of eight parks that were formerly cemeteries includes 61 species of trees and 91 species in the shrub layer. In research on four active cemeteries in Poznań (Czarna et al. 2011), 89 species of trees and shrubs were found. It is noteworthy that in the urban cemeteries the number of species of trees and shrubs is much higher than in the village cemeteries. Similar disproportions were reported by Karczmarz & Trzaskowska (2013).

The flora of old cemeteries in Poznań is clearly distinguished from the flora of medieval fortified settlements (Celka 1999), flora of Poznań (Jackowski 1990), and flora of the eastern part of Gniezno Lakeland (Chmiel 2006) by its high indices of synanthropization, apophytization, anthropophytization, kenophytization, and archaeophytization, whereas indices of floristic fluctuations and flora modernization are very low.

A taxon new to the Polish flora is Rosa ‘Poznan’. Roses as a genus were frequently used for planting in old cemeteries (Czarna 1999).

It is noteworthy that a native species recorded in six cemeteries – Aegopodium podagraria – had a symbolic meaning: it symbolized faith because of the shape of its leaves It was certainly planted in cemeteries as an ornamental groundcover plant (Kossak 2017).

Results of this study confirm the hypothesis that many funeral plants are geophytes (17 species). The most interesting among them is Tulipa sylvestris. Besides, funeral plants include 26 species of trees (7.8% of the total), 31 species of shrubs (9.3%), and 33 herbaceous species (9.9%).

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