

Review

In Situ and Ex Situ Conservation of Ornamental Geophytes in Poland

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Abstract: The protection of biological diversity in nature and in agriculture, including the production of ornamental crops, has become increasingly important in Poland as well as worldwide. The Convention on Biological Diversity, signed in 1992 at the Earth Summit of the UN in Rio de Janeiro and ratified by the Polish government in 1995, imposed new regulations related to the protection of nature and the genetic resources of cultivated crops in Poland. The conservation of the genera, varieties and cultivars of ornamental geophytes—a group of plants of great interest from a botanical and physiological, but also a horticultural point of view—takes place in situ (both in nature and in the places of cultivation) and through the establishment of ex situ gene banks and collections. The natural genetic resources of ornamental geophytes include species from the genera *Allium*, *Fritillaria*, *Gladiolus*, *Iris*, *Leucojum*, *Lilium* and *Muscari*, among others, and more than a dozen species are protected by law due to varying degrees of threats. Botanical gardens play an essential role in the conservation of endangered species. Their activities focus on genus monitoring, managing ex situ gene banks (including National Collections), developing propagation methods and carrying out their reintroduction. In order to protect the national genetic resources of cultivated plants, the National Centre for Plant Genetic Resources at the Plant Breeding and Acclimatisation Institute—National Research Institute, under the auspices of the Ministry of Agriculture and Rural Development, was established. Concerning ornamental geophytes, the National Centre coordinates two field collections of cultivars of the genera *Gladiolus*, *Lilium*, *Narcissus* and *Tulipa*, which are of great economic importance and have a long tradition of breeding in Poland. The first one is located at the National Institute of Horticultural Research in Skierniewice (central Poland), and the second one is at the Experimental Substation of Variety Testing in Lisewo (northern Poland). The history of tulip collections in Poland dates back to the 1960s. At that time, the first breeding work for this species began. The collection of bulbous crops in Skierniewice is currently one of the largest in Poland, with a total of 934 accessions. Most of them are tulips (522) and lilies (222). Other plants in the collection in Skierniewice are gladiolus and narcissus. The most valuable accessions are grown under special protection (tunnels with dense nets) to guard against insects and maintain a mild climate inside. The genetic resources of the ornamental bulb plant collection in Lisewo currently consist of 611 accessions, mainly tulips (358), daffodils (121) and gladioli (132). All bulbous crops in both collections (Skierniewice and Lisewo) are grown in accordance with all principles of agrotechnics (negative field selection, fertilisation, soil maintenance). A particularly important task of botanical gardens, universities, research institutes and the National Centre is leading research on the methods of storage for survival organs, in vitro cultures and cryopreservation. We have discovered that the various activities for the species conservation of ornamental geophytes require a great deal of constantly deepening knowledge and extraordinary measures, including frequent monitoring of the effects of the applied measures.

Keywords: biological diversity; botanical garden; collection; extinction; protection; red list; reintroduction



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1. Introduction

The protection of biological diversity in nature and in agriculture, including the production of ornamental crops, has become increasingly important in Poland as well as worldwide. The Convention on Biological Diversity [1], signed in 1992 at the Earth Summit of the UN in Rio de Janeiro and ratified by the Polish government in 1995, imposed new regulations related to the protection of nature and the genetic resources of cultivated crops in Poland. A very important legal act is the Act of 16 April 2004 on nature protection [2], which concerns, among other things, the protection of taxa at risk of total or partial extinction. In 2014, the Ministry of the Environment issued a regulation on plant species protection [3], defining its types, i.e., strict protection and partial protection, and listing species requiring the definition of their protection zones. The regulation introduced rules and prohibitions on deliberately picking, damaging or destroying not only the protected species themselves but also their entire habitats; harvesting or collecting; possessing or keeping specimens of species; and, in particular, selling, offering for sale, exchange, donation or transport; and deliberately moving or introducing them into the natural environment. The regulation further specifies ways to protect species, including: inventorying, assessing the conservation status, monitoring plant sites, habitats, sanctuaries and populations; maintaining and providing access to databases on their sites and sanctuaries; carrying out conservation measures that maintain the habitat of plants in good condition; safeguarding a representative part of the population through ex situ conservation; reinforcing or reconstructing their populations; promoting biodiversity conservation; and educating the public.

We devoted our review article to an economically important group of ornamental plants—ornamental geophytes, i.e., bulbous, tuberous and rhizomatous plants—whose global production value was estimated at the beginning of the twenty-first century at more than USD 1 billion [4]. The world acreage occupied for the reproduction of bulbs and tubers of the seven economically most important botanical genera (*Tulipa*, *Lilium*, *Narcissus*, *Gladiolus*, *Hyacinthus*, *Crocus* and *Iris*) was determined to be close to 18,000 ha [5], and in the Netherlands alone—the world leader in bulb production—this area increased to 21,000 ha in the 2023–2024 season [6,7]. In Poland, estimates for 2017 [8] identify a total area of 1230 ha dedicated to the cultivation of ornamental geophytes, of which 749 ha are dedicated to the reproduction of bulbs, tubers and rhizomes and 481 ha to the cultivation of cut flowers in the field. Nearly 25% of the total acreage is devoted to the production of tulip bulbs and more than 10% is devoted to the production of narcissus bulbs. The remaining area is occupied successively for the cultivation of lilies, gladioli, ornamental alliums, hyacinths, dahlias and others. On the other hand, however, ornamental geophytes are a physiologically and botanically very interesting and rich group of plants comprising more than 800 botanical genera spread worldwide in nature as well as in cultivation [9].

In Poland, the natural genetic resources of ornamental geophytes are severely limited, and their existence is often threatened. The most recent lists of endangered species are the Polish Red Book of Plants published in 2014 [10] and the Polish Red List of Pteridophytes and Flowering Plants [11].

The conservation of the genera, varieties and cultivars of ornamental geophytes takes place in situ and through the establishment of ex situ gene banks and collections. The natural genetic resources of ornamental geophytes in Poland include species from the genera *Allium*, *Fritillaria*, *Gladiolus*, *Iris*, *Leucojum*, *Lilium* and *Muscari*, among others, and more than a dozen species are protected by law due to varying degrees of threats. The group of ornamental geophytes includes strictly protected species such as *Lilium martagon* L., partially protected species such as *Galanthus nivalis* L., or extinct and endangered species listed in the Polish Red Book of Plants such as *Allium strictum* Schrad.

In order to protect the national genetic resources of cultivated plants, the National Centre for Plant Genetic Resources at the Plant Breeding and Acclimatisation Institute—National Research Institute, under the auspices of the Ministry of Agriculture and Rural Development, was established. Concerning ornamental geophytes, the National Centre

coordinates field collections of cultivars of the genera *Gladiolus*, *Lilium*, *Narcissus* and *Tulipa*, which are of great economic importance and have a long tradition of breeding in Poland.

Therefore, we undertook a review of the various forms of conservation of ornamental geophytes in Poland for the preservation of biodiversity, as well as a description of the conservation of genetic resources of cultivated geophytes, which is of great importance for contemporary and future breeding. The aim of our review was to present all the most important species of ornamental geophytes occurring naturally in Poland and examples of different forms of their protection—legal, passive and active—and to present the involvement of various scientific institutions and botanical gardens in the protection of ornamental geophytes in situ and ex situ.

2. The Occurrence and Characteristics of Protected Ornamental Geophytes in Poland

2.1. *Allium*

A large group of species under various forms of protection includes the genus *Allium*. The species most at risk of extinction in Poland is *Allium sibiricum* L., which is why this species is under strict protection. Its natural localities are mainly in the areas of two mountain ranges: Karkonosze and the Pilsko massif in the Żywiec Beskid (southern Poland). The plant reaches a maximum height of 60 cm, and the violet-pink flowers are gathered in a very dense and ball-shaped umbel, which can turn red or purple. Flowering occurs from late June to mid-September, but most of the naturally occurring individuals do not flower. Currently, the population of this species is over 10,000 individuals in the Polish part of the Karkonosze and several thousand individuals in the Pilsko Mountains (southern Poland) [12].

Alliums included in the 2016 Polish Red List are: *A. carinatum* L., *A. strictum*, *A. rotundum* L., *A. scorodoprasum* L. and *A. victorialis* L. *Allium carinatum* is considered to be an extinct species in natural sites throughout Poland. Previously, it could be found in two localities—in Bielinek on the Oder River and in the Orlickie Foothills in the Central Sudety Mountains [13]. Reports from 2017 [14] state that it is currently only found in the Botanical Garden of Warsaw University and the Botanical Garden of Maria Curie-Skłodowska University in Lublin. However, in 2023, there were reports of *A. carinatum* being found at two sites in the Komańcza municipality (Figure 1) in the Bieszczady Mountains (southeastern Poland) [15], so the status of the species should be changed. The second extinct *Allium* species is *A. strictum*, which, according to the Polish Red Book (2014), only occurred in the Kaczawskie Foothills (southwestern Poland). Harvesting the last naturally occurring specimens by collectors is considered to be the cause of extinction [16]. *A. rotundum* is very rare in Poland and has the status of a critically endangered species. Its natural localities are in the southern part of Poland, in the Nida Basin, the southern part of the Lublin and Małopolska Uplands, but also in the southern part of the Krajeńskie Lake District or north of Nakło. In addition, localities along the disused Jarocin–Śrem railway route have also been recorded [17,18]. The other two species, namely *A. scorodoprasum* and *A. victorialis*, have vulnerable and near threatened status. *A. scorodoprasum* has a strong tendency to produce aerial (inflorescence) bulbs, but through the exploitation of wasteland, intensification of cultivation in parks, squares, cemeteries, roadsides and dikes, it is unable to spread rapidly [19]. Natural sites for *A. victorialis* are stony slopes, pastures or mountain meadows [20]. In Poland, it occurs in a single locality in the Lublin region [21], in the Bieszczady National Park [22], but also in areas of the Suchedniów Plateau and eastern Roztocze [23].

In addition, there are two garlics in Poland under partial species protection by the Ministry of Environment: *A. ursinum* L. (Figure 2A) and *A. angulosum* L. The former was highly vulnerable due to its widespread use in herbal medicine and the culinary industry. Due to extensive usage, its natural habitats were heavily exploited. However, thanks to its inclusion in the protection programme, it can now be found in the southern part of the country, in moist deciduous forests, beech forests, oak-hornbeam forests, near springs and by streams [24,25]. The latter occurs mainly in western Poland near the Oder, Warta and Noteć rivers [26] and in the north-eastern and eastern parts of the country as the bank vegetation of the Bug, Niemen, Narew and Vistula rivers [27].

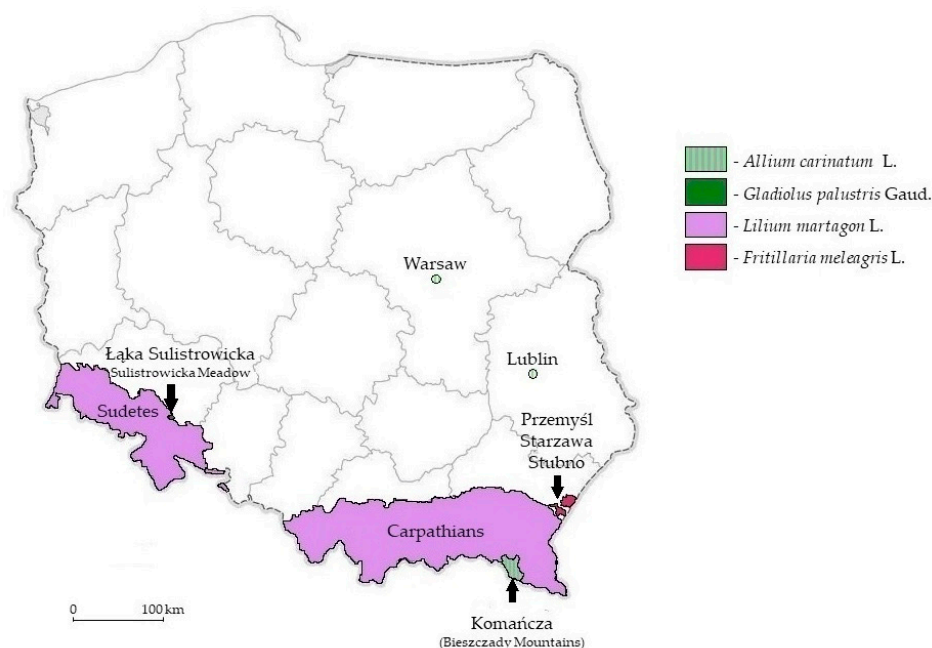


Figure 1. Location of selected rare ornamental geophyte species in natural sites in Poland: *Allium carinatum* L. previously considered regionally extinct in Poland (RE) and growing only in botanical gardens in Warsaw and Lublin but found in natural sites in 2023 in the Bieszczady Mountains; *Gladiolus palustris* Gaud. (critically endangered; CR) occurring in the only known natural site in Poland in the reserve Łąka Sulistrowicka; *Lilium martagon* L. (under strict species protection on Ministry list) relatively more widespread species found in mountainous areas (Sudetes and Carpathians) and also in lowlands, most often in moist mixed forests; *Fritillaria meleagris* L. (critically endangered; CR) is only found in the vicinity of Przemysł, Starzawa and Stubno, S-E of Poland, close to Ukrainian border.



Figure 2. Protected species of ornamental geophytes in Poland and cultivated varieties of *Lilium martagon* and *Hemerocallis*: (A) *Allium ursinum* with the expansive competitive species *Aegopodium podagraria* in an old park in Kamieniec, southwest of Poznań, Poland; (B) *Leucojum vernum*; (C) One of the cultivars in the National Collection of genus *Hemerocallis* in Arboretum Wojsławice, northwest of Wrocław, Poland; (D) *Galanthus nivalis*; (E) Cultivar 'Fairy Morning' of *Lilium martagon*.

2.2. *Galanthus*, *Leucojum*, *Gladiolus* and *Iris*

In addition to the above-mentioned garlics, the *Amaryllidaceae* family also includes *Galanthus nivalis* (Figure 2D) and *Leucojum vernum* L. (Figure 2B). Both species, except for their medicinal values, have high ornamental qualities. For this reason, their natural habitats began to be heavily devastated and had to be placed under partial species protection. *G. nivalis* in Poland occurs mainly in the southern and central parts of the country, but it can also be found in the Lublin region. It is a species characteristic of deciduous forests [28]. *L. vernum* occurs naturally in the Lower Silesian Voivodeship—Trzebnickie Hills and Oleśnicka Plain [29], as well as the Carpathian Mountains [30].

In Poland, 4 species of geophytes belonging to the *Iridaceae* family are under strict species protection: *Gladiolus imbricatus* L., *Gladiolus palustris* Gaud. (= *G. paluster* Gaud.), *Iris aphylla* L. and *Iris sibirica* L. Additionally, one of the species from this family, *Iris graminea* L., was included in the 2016 Polish Red List as an extinct species. *G. imbricatus* occurs mainly in the lower mountains and southern uplands of Poland, but in recent years there has been a drastic reduction in the population and a decrease in the number of natural sites [31,32]. *G. palustris*, which is recognised in Poland as the rarest naturally occurring species of the genus *Gladiolus*, inhabits only the areas of the Łąka Sulistrowicka reserve in Lower Silesia [33] (Figure 1). It was identified as a critically endangered species in the 2014 Polish Red Book. The main causes of the extinction of *G. palustris* are the draining of wet meadows and their ploughing, the plucking of flowering shoots or the digging up of whole plants. However, the greatest threat to the species is the progressive succession of rush and forest communities [34]. Paradoxically, the inclusion of the *G. palustris* site in a nature reserve, the abandonment of grazing animals and the mowing of meadows had the opposite effect to what was intended—a reduction in the population of this geophyte as a result of rapid forest succession. It is only in recent years that this mistake has been understood, and the removal of trees competing with the photophilous meadow species is being carried out [35]. A programme of introduction of this species to new sites was initiated in 2009, four of which were monitored in 2014, finding the populations to be small (the most numerous with 23 flowering individuals) and poorly flowering [36].

Iris aphylla, which is characterised by its low height (reaching a maximum of 30 cm) and showy violet-coloured flowers, in Poland, in addition to being placed under strict species protection by the Ministry, was also included in the Polish Red Book as a species at risk of extinction [37]. In 2003, there were only 8 populations in natural sites in Poland, 4 of which were reintroduced [38]. The most recent reports state that there are 10 such sites, mainly located in the Małopolska Upland, Lublin Upland and Biebrza National Park [39]. Natural succession, consisting of heavy overgrowth by trees and shrubs, is cited as the cause of its habitat destruction [38].

The second of the irises under strict protection in Poland is *Iris sibirica*. It is most abundant in Lower Silesia, Roztocze and the Lublin Upland, where it can be found in a variety of habitats. These include riparian forests, oak-hornbeam forests and pine forests, although the most common of its natural communities is also found in moor-grass meadows. The smallest populations of this species are present in the Baltic coastal zone, but also throughout Western Pomerania [40]. According to researchers, the reason for the species' declining habitat is the change of grassland into arable land or land for development, the lowering of groundwater levels, flower picking, but also the complete uprooting of plants [41]. *Iris graminea* is an extinct species in present-day Poland. It was found in the lower mountains, where the habitats were characterised by a warmer climate and the substrate was rich in calcium carbonate. Natural succession and, in addition, strong afforestation of mid-forest clearings contributed mainly to its extinction [42].

2.3. *Lilium*

In the *Liliaceae* family, representatives of the genera *Lilium* and *Fritillaria* are under strict protection. The former includes two species: *Lilium martagon* and *Lilium bulbiferum* L.; the second one also appears on the Polish Red List of Pteridophytes and Flowering Plants

and has the status of an endangered species [43–45]. *L. martagon* has a wide distribution range, covering Europe and the temperate zone of Asia. In Poland, it occurs not only in mountainous areas (Sudetes and Carpathians), but also in lowlands, most often in moist mixed forests [43,46] (Figure 1). This geophyte has characteristic elongated bulbs with sharply pointed yellow scales. Longitudinally ovate leaves that are arranged and twisted in whorls. The flowers, 3 to as many as 20 in number, fragrant and pendulous, are gathered in a pinnate umbel on a shoot reaching up to 150 cm tall and are strongly upwardly bent and dirty purple in colour. The flowering season is June and July [43,45–48]. Cultivated varieties of *Lilium martagon* are very popular in gardens. The cultivar ‘Fairy Morning’ (Figure 2E) is an example, and the introduction of cultivated varieties of protected species is one very effective way of protecting their species growing in the wild.

Lilium bulbiferum is found in central Europe, mainly in mountainous areas in the Alps, Rudawy Mountains, Sudetes and Western Carpathians, as well as in the Apennines and Corsica. In Poland, it has localities only in the Sudetes and the Carpathians and is threatened with extinction. A similar problem has also been reported in Germany, Slovakia and the Czech Republic [45]. This geophyte is mainly found in subalpine meadows. It can grow up to 130 cm tall, but in most natural sites, it only reaches 50 cm. Its name comes from the bulbs that form at the angles of the leaves on the stem and are often called aerial bulbs or tubers. The stem itself is spotted and hairy in the lower part [43,45]. *L. bulbiferum* is particularly ornamental because of its odourless, orange-spotted flowers [45].

2.4. *Fritillaria*

The genus *Fritillaria* is represented in Poland by the critically endangered species *Fritillaria meleagris* L. The situation is similar in Slovakia or Germany, where it is highly threatened, while in Ukraine it has endangered status. It is found in Central Europe, ranging from central England, the southern part of the Scandinavian Peninsula and central Russia in the north to the southern Alps and the central part of the Balkan Peninsula in the south. It occurs in scattered localities throughout its range. The natural habitat of this species is wet meadows, river valleys or places with high groundwater levels, which may be periodically waterlogged. In Poland, *F. meleagris* is only found in the vicinity of Przemyśl, Starzawa and Stubno (Southern Poland) [44,49] (Figure 1). This plant reaches a height of up to 60 cm. It has grey-green leaves that appear in numbers from 4 to 5 at the top of the stem. The flower is single, hanging characteristically downwards with purplish-brown petals, but can also be white. The plant takes its name from the checkerboard-like pattern on the flower petals. The geophyte, whose storage organ is an uncovered bulb, blooms about five years after sowing in late April/early May. It is pollinated mainly by hymenoptera, and the seeds are dispersed in mid-June [44,49].

2.5. *Muscari and Ornithogalum*

The *Asparagaceae* family is represented by two species: *Muscari comosum* (L.) Parl. and *Ornithogalum collinum* Guss., both under strict species protection in Poland. *M. comosum* has a bulb that rarely exceeds 3 cm in diameter. In late April/early May, 50 cm long and 2.5 cm wide leaves with a characteristic blue coating emerge from the bulb. The inflorescence stem is long and can reach up to 70 cm. At the top of the stem, there are blazing, intense blue flowers, whose stalks are longer than the flowers. These act as attractants. The fertile flowers are inconspicuous, small and brown in colour. The species has reached the end of its distribution range due to the fact that it is heat- and light-hardy. At the turn of the 20th and 21st centuries, only 13 of its localities were recorded, mainly in Lower Silesia and the Lublin region. Currently, the number of sites considered to exist has increased to 38 [50,51]. All possible measures related to the preservation of its natural habitat have been established as protection for *Ornithogalum collinum* [52]. In Poland, it is found, among others, in the Gipsowa Mountain Nature Reserve [53,54] or throughout the Lublin region, where it has been included on the local Red List of Plants as a critically endangered species [55].

2.6. *Helleborus* and *Anemone*

The decree issued by the Ministry of the Environment also includes a species belonging to the *Ranunculaceae* family—*Helleborus purpurascens* Waldst. & Kit. It is a rhizomatous geophyte growing up to 25 cm in height with flowers 5 cm in diameter, brownish-red in colour. It is strictly protected throughout the country; however, in the Polish Carpathians, it is considered a species threatened with extinction, while in other locations, it is considered a lower-risk or vulnerable species. In Poland, it occurs mainly in the Western Bieszczady Mountains, where it was first found in 1959 [56,57].

The second species belonging to the *Ranunculaceae* family is *Anemone sylvestris* L., which in Poland is recognised as a species in need of active protection through various measures related to the preservation of its natural habitats [52]. In the South Podlasie Lowlands, it is considered critically endangered. According to the authors, the population of this species in 2001 was several dozen; however, in 2009 and 2013, the species was represented by only a dozen individuals [58]. Additionally, three populations of *A. sylvestris* were located in the Lublin Uplands [59]. Also, an important natural site is a xerothermic grassland in the Przemyskie Foothills, as it occurs there in great numbers. Its stand is located exclusively in the southern part of the grassland, on an area of approximately 0.15 ha. According to analyses, it was determined that the population numbered 950 individuals [60].

3. Botanical Garden Activities

Botanical gardens play an essential role in the conservation of endangered species. Their activities focus on genus monitoring, managing ex situ gene banks, developing propagation methods and carrying out their reintroduction.

An example of botanical gardens' activities is the FlorIntegral project called the Integrated in situ and ex situ conservation of rare, threatened and priority species of flora in Poland, led by the Botanical Garden—Centre for the Preservation of Biodiversity of the Polish Academy of Sciences in Warsaw—Powsin (BG-PAS) (2018–2021). The FlorIntegral project covers 31 rare and endangered national vascular plant species, including two from the geophyte's group: *Allium victorialis* Stephan ex Willd. (*Amaryllidaceae*) and *Anemone sylvestris* (*Ranunculaceae*). Seed samples of all species are secured doubly: in the seed bank at the BG-PAS and, as duplicates, in the seed bank of the Silesian Botanic Garden (SBG) under cryogenic conditions and in the DNA bank (in ultra-freezers at -80°C). The second species—omitted from the Polish Red Book of Plants and the Red List of Plants and Fungi of Poland and partially protected since 2014, was subject to restoration, i.e., the strengthening of existing wild populations in three sites in the Ojców National Park close to Kraków [61]. As part of the earlier project “Ex situ conservation of wild, endangered and protected plants in eastern Poland—FlorNaturOB” (2010–2013), seeds of 61 vascular plant species, protected, rare or threatened with extinction, were collected from 161 natural sites from across the country to permanently preserve their seeds in a cryobank at the Powsin Botanical Garden. Among the species whose seeds were collected for the cryobank are four geophytes: *Allium rotundum* (= *A. scorodoprasmum* var. *rotundum*), *Allium victorialis*, *Iris aphylla* (= *I. polonica*) and *Fritillaria meleagris* [62].

In the Botanical Garden of Warsaw University, a very interesting project about the evolution of flower characteristics in the genus *Fritillaria* (*Liliaceae*) in response to pollinator change was conducted from 2014 to 2017. The study covered 38 species of *Fritillaria* and also included *Fritillaria meleagris*, which is native to Poland but is already rare. The obtained results showed that the flowers of fritillaries produced nectar with a varying composition and concentration of amino acids. These differences were mostly associated with the pollinator type. The nectar of passerine bird-pollinated species was rich in amino acids, whereas hummingbird-pollinated species produced low-amino acid nectar. Contrary to previous reports, the nectar of the insect-pollinated species did not contain a higher amount of proline. Two non-protein amino acids, sarcosine and norvaline, were detected in the floral nectar for the first time [63].

A regional seed bank has been in operation at the Silesian Botanic Garden since 2011. Its main purpose is to store seeds of rare and endangered species important to the Upper Silesian area. The collected seeds will be used for species reintroduction, habitat restoration and population enhancement. Seeds collected on the premises of the Katowice airport, where the project entitled Translocation of protected plant species and fragments of communities from the area of Katowice Airport was implemented, are stored in the Botanic Garden. The seeds collected included *Gentiana pneumonanthe* L. and *Iris sibirica* [64]. In the Botanical Garden in Łódź (central Poland) two species of geophytes (*Anemone sylvestris* and *Iris sibirica*) are protected ex situ [65].

4. National Plant Collections

The national plant collections are very important for the conservation of species and cultivated varieties. The programme is a certification scheme for the best maintained and most complete collections, which was initiated by the UK, USA, France, the Netherlands and Germany in the 1980s and 90s. In Poland, first works began in 2002 in the Polish Society of Botanical Gardens [66]. Until now, 36 National Collections were established, and the programme is now managed by the Polish Dendrological Society. Among these collections are three botanical genera from the ornamental geophyte group: *Hemerocallis*, *Paeonia* and *Colchicum*. Noteworthy is the collection of the genus *Hemerocallis* at the arboretum in Wojsławice (Lower Silesia) with the status of a National Collection from 2011 (Figure 2C), comprising more than 3900 objects, mainly hybrid cultivars. This collection includes 1185 Polish-origin taxa (30% of the total number of accessions) from 23 names of breeders, with the leading number of cultivars bred by Tadeusz Nowak, Jerzy Byczyński and Grażyna Świątkiewicz [67]. This collection is one of the largest in Europe. In some Arboretum, the field collection of the genera *Paeonia* was established in 2021 as a National Collection, which consists of 778 cultivars, but only 10 of them were bred in Poland in the 1960s and 1970s [68]. The National Collection of *Colchicum*, located in a private botanical garden in Niegoszcz (Baltic Sea coast), was established in 2014 with 84 taxa, now expanded to 113 taxa and 174 accessions because some taxa have different origins [69].

The national collections programme in Poland is still developing, and new collections are being proposed. It is to be expected that these will also include collections dedicated to further genera in the ornamental geophyte group.

5. Medicinal and Spice Geophyte Plants

Some species of ornamental geophytes are important as medicinal and/or spice plants, so their natural sites are particularly vulnerable to exploitation. Hence, there is a need for their continuous inventory and monitoring, but also for analyses of conservation possibilities, research into their propagation methods, cultivation possibilities and the extraction of valuable herbal material. The studies that were carried out in 2004 included 17 species of medicinal and aromatic plants at 212 sites of their natural occurrence. Only two of the cases were the ornamental geophytes *Colchicum autumnale* and *Convallaria majalis*, each on 14 natural sites [70]. Twenty-four and twenty-six accessions were collected for the ex situ collection, and 13 and 15 were donated to the Polish Gene Bank, *C. autumnale* L. and *C. majalis* L., respectively.

Examples include bear's garlic (*Allium ursinum*) or *Convallaria majalis*. The authors of a study [71] conducted their research on a dense patch of *A. ursinum* with an area of 750 m² in a palace park in Korytów (in the Kłodzko Basin, southern Poland). The results showed that the major threats to the species are negative anthropogenic changes within the park area, such as excessive cutting of trees and soil eutrophication leading to the development of herbaceous plant species competing with garlic. One way to protect this species is through manual removal of competing species, *Impatiens parviflora* DC. and *Urtica dioica* L., as well as, as suggested by the authors, the popularisation of bear's garlic planting as a ground cover plant in projects in urban green spaces. A rare garlic species—*A. ursinum* and *A. scorodoprasmum*—were described as having unique populations in the Poznań region

in a historic landscape park in Kamieniec [25]. Fortunately for both garlic populations, no green maintenance work has been carried out in this park for years, including no tree felling, allowing shading to remain at 50–60% over *A. ursinum* patches and 65–70% over *A. scorodoprasum* patches.

6. Ex Situ Collections of Ornamental Geophytes in the National Centre for Plant Genetic Resources

In order to protect the national genetic resources of cultivated plants, the National Centre for Plant Genetic Resources at the Plant Breeding and Acclimatisation Institute—National Research Institute, under the auspices of the Ministry of Agriculture and Rural Development, was established. Concerning ornamental geophytes, the National Centre coordinates two field collections of cultivars of the genera *Gladiolus*, *Lilium*, *Narcissus* and *Tulipa*, which are of great economic importance and have a long tradition of breeding in Poland. The first one is located at the National Institute of Horticultural Research in Skierniewice (central Poland), and the second one is at the Experimental Substation of Variety Testing in Lisewo (northern Poland). The collection in Lisewo currently holds 611 accessions, including 132 cultivars of gladiolus, 358 cultivars of tulips and 121 cultivars of narcissus [72]. The collection in Skierniewice currently holds 934 objects; details are provided below for each botanical genus.

Collections of ornamental bulb plants have been kept at the National Institute of Horticultural Research in Skierniewice since the early 1970s [73–76]. The collections include four main species: gladioli (*Gladiolus*), lilies (*Lilium*), narcissus (*Narcissus*) and tulips (*Tulipa*) [77–79] (Figure 3A–E). The tulip collection, gathered currently at the National Institute in Skierniewice, was started in the 1950s on the basis of the collection in the IHAR Ornamental Plants Laboratory in Puławy (later in the structures of the Institute of Cultivation, Fertilisation and Soil Science), then moved in 1968 to the Orchard Experimental Station of the Research Institute of Pomology in Miłobądz, near Tczew [73]. From 1971 to 1992, the tulip collection was partially maintained in Miłobądz (near the Baltic Sea) and partially in Skierniewice, which allowed us to compare the influence of climate on tulip growth.



Figure 3. Field collections of ornamental geophytes at the National Institute of Horticultural Research in Skierniewice, Poland: (A) tulip collection in an insect-proof tunnel; (B) lily collection in the open field; (C) tulip collection in the open field; (D) field collection of *Gladiolus*; and (E) *Narcissus* in an insect-proof tunnel.

The aim of the collection in Skierniewice is primarily to collect, maintain, evaluate and make available the genetic resources of the ornamental geophytes. The plant material and data enable maintaining biodiversity and preserving particularly valuable old cultivars of Polish breeding. The ornamental bulbous crops collected in Skierniewice are also used for educational purposes, comparative and cultivar experiments, basic research and further breeding work as a source of diverse and interesting genotypes [80,81]. The bulb collections are usually maintained as field collections, and some of the most valuable genotypes of tulips and narcissus are grown in insect-proof tunnels covered by nets [79,82–84].

Numerous cultivars in the Institute's collection are commonly known in cultivation as cut flower plants, but many of them are unique and rare. Breeding work carried out in recent years allowed us to obtain several interesting narcissus clones that are currently being evaluated and have a chance of becoming cultivars.

Maintaining a collection of bulb plants is quite time-consuming due to the need to conduct annual selection for diseases, especially viral ones, genetic identity, agrotechnical treatments and systematic descriptions, photographic documentation and collecting passport data according to the EURISCO system (the European Search Catalogue for Plant Genetic Resources). Each season, observations are made regarding flowering dates and descriptions of morphological features using the developed descriptors. This information is successively transferred to the central database on genetic resources of useful plants, EGISET, run by the National Centre for Plant Genetic Resources. During the flowering season, the collection is frequently visited by people interested in this group of plants, including students, scientists and collectors.

6.1. Tulipa

The largest part of the ornamental bulbous crop collection in Skierniewice is the tulip collection, with as many as 522 objects (Table 1). Observations of *Tulipa* accessions are performed using developed descriptors [85–88]. Actually, the majority of the tulip cultivars in the collection belong to the Triumph Group (17.9%), followed by cultivars from the Fosteriana Group (12.9%), the Greigii Group (11%) and the Kaufmanniana Group (9%). Very interesting tulip cultivars and species belong to the 15th (Miscellaneous) Group (Table 1). In this group are the most famous botanical tulip species, such as *T. acuminata* L., *T. aucheriana* L., *T. bakeri* L., *T. batalini* L., *T. clusiana* L., *T. eichlerii* L., *T. praestans* L., *T. tarda* L., *T. turkiestanica* L., *T. urumiensis* L., *T. whittalli* L. and *T. sylvestris* L. The latter is the only species that can be found in the wild in Poland—it has small, uniformly yellow flowers. Some characteristics of botanical tulip cultivars and species were described by Jadwiga Treder [89].

Table 1. Percentage of tulips from individual horticultural classification groups in the tulip collection at the National Institute of Horticultural Research in Skierniewice, consisting of 522 objects in the 2023/2024 season.

Group Number	Tulip Classification Group	Percentage in the Cultivar Collection (%)
1	Single Early	1
2	Double Early	2
3	Triumph	17.9
4	Darwin Hybrids	9
5	Single Late	6.2
6	Lily-flowering	4.3
7	Fringed	2.2
8	Viridiflora	2.9
9	Rembrandt	-
10	Parrot	4
11	Double Late	7
12	Kaufmanniana	9
13	Fosteriana	12.9
14	Greigii	11
15	Miscellaneous	10

The tulip collection in Skierniewice includes numerous cultivars bred in Poland, e.g., ‘Agalia’, ‘Fringed Black’, ‘Giewont’ (Figure 4H), ‘Joanna’, ‘Moniuszko’, ‘Janosik’, ‘Ognik’, ‘Krakus’, ‘Karłowicz’, ‘Polka’, ‘Mazowsze’, ‘Neptun’, ‘Profesor Wójcicki’, ‘Victor’, ‘Sambor’ and ‘Rewizor’ (Figure 4E). Some tulip cultivars bred in the Netherlands during the last few years bear the names of famous Polish persons: ‘Jan Paweł II’, ‘Maria Kaczyńska’, ‘Mikołaj Kopernik’, ‘Lech Kaczyński’ (Figure 4G), ‘Anna Komorowska’, ‘Jolanta Kwaśniewska’, ‘Irena Sendler’, ‘Jerzy Buzek’, ‘Generał Stanisław Sosabowski’, ‘Generał Stanisław Maczek’ and ‘Preludium Chopina’ (Figure 4F).



Figure 4. Interesting Polish cultivars and Dutch cultivars with Polish names in the collections of ornamental geophytes at the National Institute of Horticultural Research in Skierniewice, Poland: (A) ‘Bursztynek’—Polish cultivar of large-cupped *Narcissus*; (B) ‘Posejdon’—Polish large-cupped cultivar of *Narcissus*; (C) Polish lily cultivar—‘Pantera’; (D) ‘Pomarańczowa Pantera’—Polish cultivar of Asiatic Lily; (E) One of the oldest Polish cultivars of Tulipa—‘Rewizor’, registered in 1972; (F) Dutch tulip cultivar ‘Preludium Chopina’ named after famous Polish composer and pianist—Frederic Chopin; (G) Dutch cultivar named after President of Poland ‘Lech Kaczyński’; (H) ‘Giewont’—Polish cultivar of tulip; and (I) ‘Kaprys’—Polish-bred cultivar of *Gladiolus*.

Interesting data that are recorded are the blooming times of each accession. In 2023, the earliest blooming tulip cultivars are: ‘Primose’ (7 April), ‘Berlioz’ (12 April) and ‘Daylight’ (18 April) belonging to Group 12 (Kaufmanniana Group), and ‘Red Revival’ (16 April) and ‘Brilliant Star’ (21 April) belonging to the Single Early Group. The flowering period of tulips from these groups ranged from 15 to 20 days. Cultivars such as ‘Monsella’ (21 April), ‘Yellowa’ (21 April), ‘First Price’ (21 April) and ‘Double Price’ (24 April) belong to the 2nd classification group (Double Early). The flowering period of tulips in this group ranged from 17 to 21 days. The latest to bloom were the tulip cultivars from the Viridiflora Group, e.g., ‘Virichic’ (4 May), ‘Green Wave’ (5 May), ‘Nightrider’ (5 May) and ‘Violet Bird’ (7 May). The flowering period of tulips from this group ranged from 10 to 13 days. However, the cultivars of tulips from the Lily-Flowered Group started flowering the latest, e.g., the ‘Mrs. Moon’ (10 May) or ‘Elegant Lady’ (10 May), but also cultivars from the Double Late Group, e.g., ‘Mount Tacoma’ (11 May) or ‘Blue Diamond’ (11 May). The flowering period of tulips from these groups ranged from 9 to 12 days (own data, not published).

6.2. *Narcissus*

The narcissus collection (*Narcissus*) at the National Institute of Horticultural Research in Skierniewice is currently the largest in Poland and contains 139 objects belonging to particular classification groups. Belonging to a particular group depends on many phenotypic features, e.g., botanical origin, number of flowers on the shoot, size and shape of the crown, arrangement of perianth tepals and the fullness of the flowers. One of the most numerous groups represented in the collection in Skierniewice are Trumpet daffodil cultivars, e.g., ‘Dutch Master’, ‘Mount Hood’, ‘Carlton’, ‘Moneymaker’, ‘Ice Follies’ and ‘John Evelyn’. Interesting Polish-bred cultivars ‘Bryza’, ‘Lajkonik’, ‘Bursztynek’ (Figure 4A), ‘Passat’, ‘Posejdon’ (Figure 4B) and ‘Heweliusz’ as well as some interesting breeding clones (as numbers) are also kept in the collection. The collection also includes numerous representatives of other classification groups of narcissus, e.g.: Small-cupped, Double, Triandrus, Cyclamineus, Jonquilla, Tazetta and Poeticus daffodil cultivars, and Split-corona daffodil cultivars [84,90]. The observations in the narcissi collection are performed using the UPOV descriptor [91].

6.3. *Lilium*

The number of lily taxa in the collection is currently 222. The most numerous cultivars are lilies from the Asiatic group (A), Longiflorum $\times$ Asiatic (LA), followed by Trumpet lily (T), Oriental lilies (O), Oriental $\times$ Trumpet (OT) and some wild species, e.g., *L. davidii* L., *L. candidum* L., and *L. martagon* L. There are no representatives from lily groups such as American hybrids and Longiflorum. Some interesting Polish cultivars of Asiatic hybrids are present in the collection, such as ‘Prima’—the earliest flowering cultivar, ‘Rumba’, ‘Pantera’ (Figure 4C), ‘Pomarańczowa Pantera’ (Figure 4D), ‘Pajak’ and ‘Polaris’ as well as lilies from Trumpet group: ‘Aldona’, ‘Bahama’, ‘Bora’, ‘Borneo’, ‘Tobago’, ‘Jamajka’, ‘Jawa’, ‘Samoa’ and ‘Sumatra’. The growth characteristics of some lily cultivars present in the lily collection in Skierniewice are described by Jadwiga Treder [92]. The observations in *Lilium* collection are doing using the UPOV descriptor [93].

6.4. *Gladiolus*

The gladiolus collection is kept at the National Institute of Horticulture in Skierniewice as field collection, with 51 cultivars. As for other bulbous collections, regular agrotechnical treatments and selection for viruses are performed every season. Also, growth characteristics such as flowering time, plant height, flower size and flower number in spikes are evaluated for systematic descriptions, photographic documentation and collecting passport data, according to the EURISCO system. Between other gladiolus cultivars, some interesting cultivars bred in Poland, such as ‘Srebrnik’, ‘Dukat’, ‘Talar’, ‘Kaprys’ (Figure 4I), ‘Karmazyn’, ‘Kopernik’, ‘Polonez’, ‘Wars’ and ‘Sawa’ are present in the collection in Skierniewice.

7. Propagation Procedures

Botanic gardens, research institutes and universities in Poland developed propagation techniques and procedures, both by seed and vegetatively. Within clonal reproduction, micropropagation is of great importance. This makes it possible to regenerate plants from a small part of the mother plant, even a single valuable specimen, and to control the health of the plantlets obtained. Regarding endangered national plant species, in vitro techniques are used in Poland as both micropropagation methods and a long-term storage methods. Plants obtained in vitro can be of great value for research, living collections, and plant reintroduction programmes [94]. In the case of Polish-protected geophytes, Ptak [30] developed a protocol for indirect somatic embryogenesis of *Leucojum vernum*, and a few research groups developed protocols for organogenesis and indirect somatic embryogenesis of *Lilium martagon* [95–97]. Also, for other ornamental geophyte species maintained in field collections and at risk of virus infection, procedures are being used to micropropagate and even release old, heavily infected cultivars from viruses. Such work was carried out at the National Institute of Horticultural Research in Skierniewice in relation to tulips and narcissi [98–100].

8. Conclusions

Our overview article shows the current status of the genetic resources of ornamental geophytes in Poland, both in their natural state and ex situ. National regulations are designed to ensure the survival and preservation of Poland's wild, rare, endemic, vulnerable and endangered plant species and their habitats and refugia. Species protection also aims to preserve species and genetic diversity. A number of state institutions, botanical gardens, universities, scientific research institutes, associations and private individuals are involved in plant species protection in Poland. We have provided numerous examples of such activities. However, practical species protection is not easy, as it requires identification and effective reduction of the negative impact of human activity. We are discovering that the various activities for the species conservation of ornamental geophytes require a great deal of constantly deepening knowledge and extraordinary activity, with frequent monitoring of the effects of the measures applied. Sometimes, however, nature shows its strength on its own, as in the case of *Allium carinatum*, considered to be an extinct species but found in natural sites in recent years. In another case—*Gladiolus palustris*—the abandonment of all activities after the establishment of the nature reserve Łąka Sulistrowicka (Sulistrowicka Meadow) led to the meadow becoming overgrown with forest, which proved to be one of the greatest threats to the only natural population of this species in Poland. Cultivated varieties of ornamental geophytes are also protected in Poland under a circular programme—here, the most important thing is to preserve the genetic material for breeding, to preserve old native cultivars and to maintain biodiversity. Just maintaining the genetic resources of cultivated varieties of ornamental geophytes is not an easy task because of their type of vegetative propagation and maintenance, mainly in field collections. We show, using the example of the tulip and narcissus collections in Skierniewice, the possibility of growing them in insect-proof tunnels, which protect the plants from viral reinfection.

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