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Research Article

State of the Population of *Gladiolus imbricatus* L. in a *Molinia* Meadow after Extensive Management and Abandonment

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The abandonment of seminatural *Molinia* meadows observed in Central and Eastern Europe during the 20th century started the secondary succession and threatened the state and persistence of populations of numerous meadow species. Considering this, the aims of the presented investigations were to study the abundance and selected traits of individuals of *Gladiolus imbricatus* L. in extensively used (EM) and unmanaged for at least 15 years (UM) *Molinia* meadows (Southern Poland, Central Europe). Altogether, 125 juvenile individuals, 21 vegetative individuals, and 119 generative individuals of *Gladiolus imbricatus* were investigated. The field studies showed positive correlation among the height of shoots and other traits of generative individuals in both study patches. Moreover, the greater abundance of population of *Gladiolus imbricatus* (especially the greater number of juveniles), as well as the greater dimensions of leaf blades, shoots, inflorescence, and number of capsules in the patch UM, indicates the appropriate state of the population. These data indicate a positive influence of abandonment and evolving secondary succession on the *Gladiolus imbricatus* population within the *Molinia* meadows.

1. Introduction

The meadows representing alliance *Molinion caeruleae* Koch 1926 mainly present in Eastern and Central Europe [1–9] develop in intermittently wet habitats where the groundwater table fluctuates considerably during the growing season, e.g., [4]. They occupy muck, muck gley, and gleysolic soils with alkaline, neutral, or slightly acidic reaction [7, 8]. They are characterised by a specific development phenology, broad ecological amplitude, and multispecies structure, especially the presence of many rare and protected plant species, such as *Epipactis palustris* (L.) Crantz, *Gentiana pneumonanthe* L., *Gladiolus imbricatus* L., *Iris sibirica* L., and *Trollius europaeus* L. [10].

Due to substantial biodiversity, they have been included in the list of habitat areas protected under the European ecological network Natura 2000 under Directive 92/43 EEC as a habitat 6410-"*Molinia* meadows on calcareous, peaty, or clayey-silt-laden soils" [11] with the requirement for regular monitoring, whose assumptions and methodology were specified in numerous countries, e.g., [12, 13]. *Molinia* meadows represent seminatural communities associated with human activity, suitable traditional practices of management. The conservation of these meadows in the cultural landscape depends on natural habitat factors (changeable ground water levels) and suitable traditional practices of management. The proper development of *Molinia* meadows requires late mowing (in late August or early September) at least every second year [14]. During the 20th century in

Central and Eastern Europe, traditional agricultural management was either heavily intensified or abandoned due to socioeconomic reasons [15]; in effect, *Molinia* meadows represent the most endangered habitats in many regions [14, 16]. The land abandonment leading to subsequent secondary succession reverted many *Molinia* meadows into *Phragmites* swamps, *Salix* or *Alnus* thickets, as well as woodlands [17–21].

One of aforementioned species affiliated to *Molinia* meadows is *Gladiolus imbricatus*, which represents the Euro-Siberian subelement and occurs particularly in Eastern and Central Europe [22]; in Poland, it occurs mainly in the southern highlands and lower mountains [23]. Populations of the investigated species particularly inhabit wet meadows, especially representing the alliance *Molinion caeruleae* W. Koch 1926. Moreover, they might occur in marshes, meadows springs, as well as open-canopy forests. Individuals of *G. imbricatus* may occasionally grow also as a weed in corn, clover, oats, and barley fields [24]. The number of populations of *G. imbricatus* is decreasing gradually; therefore, they are considered as rare and threatened in numerous European regions. They are included in numerous regional, e.g., [25–27] Red Lists and Books.

G. imbricatus represents long-lived herbaceous clonal plants. The individuals create underground tubers performing the role of storage and regenerative organs of shoot origin. However, the vegetative spread is limited, and the production of more than one daughter corm within one season is rare. The leaves are obtuse and subulate. The generative individuals form leaved shoots, bearing one-sided inflorescence containing usually from several to a dozen or so purple flowers [28–30]. Pollination is realised as melittophily (by bees *Apis mellifera*) at the beginning of anthesis, and mostly as autophily at the end of anthesis. The fruit is a slightly inflated capsule containing numerous wind-dispersed seeds with a characteristic sculptured surface [31]. One plant can produce 200–400 seeds, and a chilling period of several months is needed for the seeds to germinate when temperatures increase in late spring [32–34].

To date, the current state of knowledge on *Gladiolus imbricatus* shows the several investigations concentrated on two main streams of interest: (i) the diversity of individual traits, e.g., [35–38], and (ii) the spatial and/or temporal variability of abundance and structure of populations, e.g., [39–46]. The majority of aforementioned investigations were conducted in new localities. Based on performed observations, the authors described the state and perspectives of persistence of populations in occupied sites. A much less number of researchers focused on the effects of management on the number of individuals [47–49].

Despite the growing number of publications, the knowledge on the cause of disappearance of populations of *G. imbricatus* especially in changing landscape remains insufficient. The individual features as well as the number and structure of the population of *G. imbricatus* depend on the type of habitat and activities such as mowing, cattle grazing, and sheep grazing, but these usually covered only a few consecutive years (after disturbance) and did not provide an unambiguous answer as to what would be the future direction of changes. As such, there is clearly no comparative study of habitats with different degrees of use and abandonment. As regards the fact related to the inadequate state of knowledge, we might state that the performed investigations contribute to bridging this "research gap."

Basing on suggested by the majority of the aforementioned authors positive impact of meadow management on the state and maintenance of *Gladiolus imbricatus* populations, we adopted the hypothesis that the population of *Gladiolus imbricatus* will be in better condition in the extensively used moist *Molinia* meadow than in the unmanaged one.

According to working hypothesis, the specific goals of the field studies aimed for the assessment of comparison between extensively used and unmanaged *Molinia* meadows in respect of:

(i) the abundance of juvenile, vegetative, and generative individuals of *Gladiolus imbricatus,*

(ii) the number and dimensions of shoots, leaves, inflorescences, and capsules of *G. imbricatus,*

(iii) the relationship among height of shoots and other selected individual traits of *G. imbricatus.*

2. Materials and Methods

2.1. Field Sampling. The research studies were conducted in 2021 in the Gielniów Hummock, a region situated in the northern foreland of the Świętokrzyskie Mountains (Southern Poland, Central Europe), in two moist *Molinia* meadows where *G. imbricatus* occurs:

(i) Extensively used as the Natura 2000 protected area "Dolina Czarnej"-SAC PLH260015 (51°13′26″N, 20°41′35″E). This patch was labeled EM (Figure 1 EM);

(ii) Unmanaged from at least 15 years, where secondary succession was observed (51°9′46″N, 20°43′7″E). This patch was labeled UM (Figure 1UM).

At the beginning of the twenty-first century, the extensively used meadow was used for the short-lived cultivation of *Zea mays* L. for wild animals. Within a period of up to five years of this disturbance, the meadow is under protection (and it is extensively used). This meadow as well as the unmanaged one has never been fertilised.

To show the floristic composition and the structure of the patches where the populations of *G. imbricatus* occur in EM and UM meadows, a phytosociological relevé (square plot 25 m^2) using the Braun–Blanquet method [50] was made in each meadow. Both relevés were made in the central part of the populations of *G. imbricatus*. In addition, in both study patches the mean height of neighbouring plants was evaluated on the basis of the measurements of 10 lowest and 10 highest stems.

Figure 1: Two patches of moist *Molinia* meadows: extensively used (EM) and unmanaged from at least 15 years (UM), where secondary succession was observed (photo. M. Podgórska).

Taxonomic nomenclature was adopted after Mirek et al. [51]. Syntaxonomic nomenclature was adopted after Matuszkiewicz [24].

In each meadow, in the central part of the population of *G. imbricatus* (covering *ca* 900 m^2), 15 study plots (measured 1 m^2) were randomly established. The locality of each study plot was marked with a wooden labeled peg. Every plot was visited once in July (16 and 18 July plots on EM and 19 and 20 July plots on UM). In each plot, the number of juvenile individuals (individuals forming one leaf), as well as vegetative (individuals creating at least two leaves) and generative (individuals creating a flowering shoot or shoot with capsules), was investigated.

Moreover, in every individual occurring within the plots, the following traits were measured or counted:

(i) the number of leaves and length of the longest leaf blade of vegetative individuals,

(ii) the number of leaves, length of the longest stem leaf blade, and height of shoot of generative individuals,

(iii) the length of inflorescence and length of the labellum of the largest flower in the inflorescence,

(iv) the number of capsules per infructescence, the length of the largest capsule, and the length of the smallest capsule,

(vii) the width of the largest capsule, as well as the width of the smallest capsule in the infructescence.

These traits were previously investigated in several studies [36–38].

2.2. Data Analysis. The arithmetic mean (x) and standard deviation (SD) of (i) the number of juvenile, vegetative, and generative individuals per study plot, as well as (ii) the individual traits were calculated for each population of *G. imbricatus* separately. The normal distribution of untransformed data was checked using the Kolmogorov–Smirnov test, while homogeneity of variance was tested using the Levene test at the significance level of $p < 0.05$. As the values in some groups were not consistent with normal distribution and the variance was not homogeneous, the analysis was based on nonparametric Mann–Whitney U test, which was applied to test the significance of differences among individuals of *G. imbricatus* occurring in used meadow (EM) and unmanaged meadow (UM) in:

(i) the number of juvenile, vegetative, and generative individuals per plot,

(ii) the number of leaves and length of the longest leaf blade of vegetative individuals,

(iii) the number of leaves, length of the longest stem leaf blade, and height of shoot of generative individuals,

(iv) the length of inflorescence and length of the labellum of the largest flower in the inflorescence,

(v) the number of capsules per infructescence, the length of the largest capsule, the length of the smallest capsule, the width of the largest capsule, as well as the width of the smallest capsule in the infructescence.

The Spearman correlation coefficient ($p < 0.05$), which indicates whether it is amonotonic positive or negative relationship among the variables, was used to test the relation among the height of shoots of generative individuals and (i) number of stem leaves, (ii) length of the longest stem leaf blade, (iii) length of the inflorescence, (iv) length of the labellum of the largest flower in the inflorescence, (v) number of capsules per infructescence, (vi) length of the largest capsule in the infructescence, (vii) length of the smallest capsule in the infructescence, (viii) width of the largest capsule in the infructescence, and (ix) width of the smallest capsule in the infructescence.

All statistical analyses were performed using STATISTICA 13 software (StatSoft).

3. Results

3.1. The Floristic Composition and the Structure of the Patches Where the Populations of G. imbricatus Occur. As the phytosociological relevés showed (Table 1), both patches have species characteristic for *Molinietum caeruleae* W. Koch 1926 association (*Selino-Molinietum* Kuhn 1937) and *Molinion* alliance (Table 1), but their structure is different.

In patch of the extensively used meadow (Figure 1EM), 25 species were noted; all of them were herbs which built a single-layer phytocoenosis. In this community, there was no one dominant species, the highest degree of the Braun–Blanquet scale (2 abundance-cover degree) contains six species, and four of these species were characteristic for *Molinietum caeruleae* association (Table 1, relevé 1).

Table 1: Floristic composition of the two studied meadows: extensively used meadow (relevé 1) and unmanaged meadow (relevé 2).

No. of relevé		1	2
Date (d/m/y)	—	16.07.2021	18.07.2021
Area of relevé	(m^2)	25	25
Coverage of shrub layer *b*	(%)	—	35
Coverage of herb layer *c*	(%)	90	90
No. of species in relevé	—	25	25
	Layer		
Trees and shrubs:			
Accompanying species:			
Frangula alnus Mill.	*b*	—	2
Rubus sp.	*b*	—	2
Quercus robur L.	*b*	—	+
Herbs:			
ChAss. *Molinietum caeruleae* W. Koch 1926/ChAll. *Molinion caeruleae* W. Koch 1926:			
Gladiolus imbricatus L.	c	2	2
Iris sibirica L.	*c*	2	3
Betonica officinalis L.	*c*	2	2
Selinum carvifolia (L.) L.	*c*	2	1
Molinia caerulea (L.) Moench	*c*	1	1
Succisa pratensis Moench.	*c*	1	+
Gentiana pneumonanthe L.	*c*	—	+
ChO. *Molinietalia caeruleae* W. Koch 1926:			
Serratula tinctoria L.	*c*	2	1
Lysimachia vulgaris L.	*c*	2	1
Filipendula ulmaria (L.) Maxim.	*c*	1	1
Lychnis flos-cuculi L.	*c*	1	1
Angelica sylvestris L.	*c*	+	1
Juncus effusus L.	*c*	+	1
Scirpus sylvaticus L.	*c*	+	1
Deschampsia caespitosa (L.) P.Beauv.	*c*	+	+
Lotus uliginosus Schkuhr	*c*	+	—
ChCl. *Molinio-Arrhenetheretea* R. Tx. 1937:			
Ranunculus acris L.	*c*	1	1
Alopecurus pratensis L.	*c*	+	1
Ranunculus repens L.	*c*	+	+
Vicia cracca L.	*c*	—	+
Accompanying species:			
Agrostis canina L.	*c*	1	—
Potentilla erecta (L.) Raeusch	*c*	1	—
Carex ovalis Gooden.	*c*	+	—
Carex pallescens L.	*c*	+	+
Holcus mollis L.	*c*	+	+
Nardus stricta L.	*c*	+	+
Ranunculus flammula L.	*c*	+	—

In order to show the percentage cover of the species, the Braun–Blanquet scale is used (+ <5%, 1 = 5%, 2 = 5–25%, 3 = 25–50%, 4 = 50–75%, 5 = 75–100%); Ch-species characteristic for respective syntaxa: All.-alliance, Ass.-association, Cl.-class, and O.-order (Braun-Blanquet, 1964).

G. imbricatus was quite evenly distributed, and it did not create agglomerates (Figure 1EM).

A different structure was noted in the patch of meadow which was unmanaged for at least 15 years (Figure 1UM). The relevé 2 confirms the process of secondary succession, in this case involving a two-layer community. A shrub layer covered about 35% of the meadow and was built by *Frangula alnus* Mill., *Quercus robur* L., and *Rubus* sp. In the herb layer, which covered 100%, 22 species were noted. In this meadow, *I. sibirica* has the higher, 3-abundance-cover degree of the Braun–Blanquet scale. Two species characteristic of *Molinietum caeruleae* association achieved 2 abundance-cover degree (*G. imbricatus* and *Betonica officinalis* L.). In total, 7 species were characteristic for the association (Table 1, relevé 2). *G. imbricatus* formed agglomerates and occurred between clusters of *I. sibirica* and aggregations of *Rubus* sp.

In addition, the secondary succession was also reflected in the height of the neighbouring plants in both meadows. The mean height (range) of stems of the highest herbaceous plants on the extensively used meadow was 73.9 cm (range 55–94) and on the unmanaged meadow was over two times higher (161.9 cm, range 110–197). The mean height of stems of the lowest herbaceous plants was as follows: 27.4 cm (range 15–35), extensively used meadow and 68.9 cm (range 54–90), unmanaged meadow. Both kinds of stems differed significantly between the two meadows (the tallest plant

Table 2: Total and mean (±SD) number of individuals of *Gladiolus imbricatus* growing in 15 plots established within extensively used meadow (EM) and 15 plots established in unmanaged meadow (UM).

	Patch EM		Patch UM		Mann-Whitney U test value
	Total number	Mean (±SD)	Total number	Mean (±SD)	
Juvenile individuals	31	2.07 (±1.53)	94	6.27 (±4.56)	$U = 50.5^{**}$
Vegetative individuals	7	0.47 (±0.64)	14	0.93 (±1.28)	$U = 95.5^{ns}$
Generative individuals	37	2.47 (±1.25)	82	5.47 (±4.81)	$U = 80.5^{ns}$
All individuals	75	5.00 (±2.67)	190	12.67 (±9.26)	$U = 59.0^{*}$

Asterisks denote the statistical significance level: ns–not significant; $p \leq 0.05$, $p < 0.01$, and $p < 0.001$.

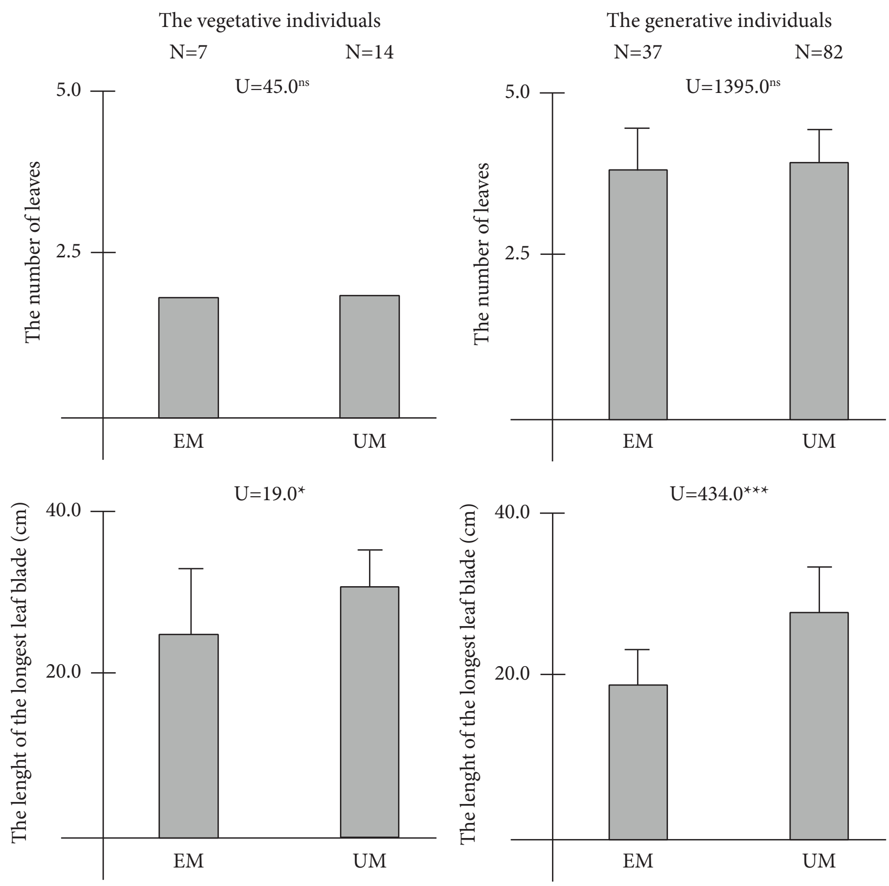

Figure 2: The mean (±SD) of number of leaves and the length of the longest stem leaf blade (cm) of vegetative and generative individuals *Gladiolus imbricatus* occurring within the extensively used meadow (EM) and unmanaged meadow (UM). Asterisks denote the statistical significance level: ns-not significant, $^{*}p \leq 0.05$, $^{**}p < 0.01$, and $^{***}p < 0.001$.

Table 3: Mean (±SD) values of *G. imbricatus* traits measured in 37 individuals growing within extensively used (EM) and 82 individuals growing within unmanaged (UM) meadows.

G. imbricatus traits	Patch EM	Patch UM	Mann-Whitney U test value
The height of shoot (cm)	59.84 (±11.03)	78.21 (±15.96)	$U = 521^{***}$
The length of inflorescence (cm)	8.21 (±2.48)	11.53 (±11.07)	$U = 898.0^{***}$
The length of labellum of the biggest flower (cm)	2.94 (±0.39)	2.72 (±0.32)	$U = 898.0^{***}$
The number of capsules in infructescence	5.70 (±1.71)	7.59 (±2.44)	$U = 790.0^{***}$
The length of the smallest capsule (cm)	0.33 (±0.26)	0.50 (±0.33)	$U = 213.0^{ns}$
The width of the smallest capsule (cm)	0.27 (±0.27)	0.34 (±0.30)	$U = 21.0^{ns}$
The length of the greatest capsule (cm)	1.07 (±0.45)	1.44 (±0.41)	$U = 164.0^{*}$
The width of the greatest capsule (cm)	0.70 (±0.29)	0.86 (±0.23)	$U = 238.0^{ns}$

Asterisks denote the statistical significance level: ns–not significant; $p \leq 0.05$, $p < 0.01$, and $p < 0.001$.

species: $U = 0.00$; $p < 0.001$ and the lowest plant species $U = 0.00$; $p < 0.001$).

3.2. The Characteristics of Traits of Gladiolus imbricatus Individuals. Altogether, within the study plots in the extensively used meadow (EM), 75 individuals of *G. imbricatus* were observed, while in the unmanaged meadow (UM), 190 individuals were recorded. The total number of individuals and juvenile individuals per plot was significantly greater within patch UM, while the number of vegetative and generative individuals did not differ (Table 2). The ratio of flowering to nonflowering individuals in extensively used meadow (EM) reached 1 : 1.03, while in unmanaged meadow (UM), it achieved 1 : 1.30. The share of flowering individuals in patch EM amounted 49.33%, whereas in patch UM, it reached 43.15%.

The length of the leaf blade in juvenile individuals differed significantly among the investigated populations ($U = 294$; $p < 0.001$) and reached 26.19 cm (±9.20) in patch EM, whereas in patch UM, it reached 46.60 cm (±14.31). In case of vegetative and generative individuals, the number of leaves did not differ among the populations, while the length of the longest leaf blade was remarkably greater in patch UM (Figure 2). The height of shoot, length of inflorescence, number of capsules per infructescence, and the length of the longest capsule were substantially greater in patch UM, while the length of labellum of the largest flower was greater in patch EM (Table 3).

Taking into consideration the combined data from both populations, it may be stated that the height of the shoot of generative individuals is positively correlated with the number of leaves ($r_s = 0.28$), length of the longest leaf blade ($r_s = 0.75$), length of inflorescence ($r_s = 0.28$), and number of capsules ($r_s = 0.70$), while it is negatively correlated with the length of labellum ($r_s = -0.23$). A similar trend showed individuals from particular populations treated separately. The statistically significant values of the Spearman coefficient between height of generative shoot and number of leaves ($r_s = 0.42$), length of the longest leaf blade ($r_s = 0.59$), length of inflorescence ($r_s = 0.68$), and number of capsules in infructescence ($r_s = 0.56$) were recorded in individuals growing in patch EM. Also, the significant values of the correlation coefficient between height of generative shoot and number of leaves ($r_s = 0.38$), length of the longest leaf blade ($r_s = 0.68$), length of inflorescence ($r_s = 0.34$), and number of capsules in infructescence ($r_s = 0.66$) were recorded in individuals occurring in patch UM. The insignificant negative correlation was observed between the height of generative shoot and the length of labellum of the largest flower in individuals occurring in patch EM ($r_s = -0.07$) and patch UM ($r_s = -0.08$).

4. Discussion

Performed observations clearly indicate that more than double the number of individuals of *Gladiolus imbricatus* were observed in the unmanaged meadow than in the extensively used one. This substantially greater number of individuals in the unmanaged meadow was caused by an increase of juvenile individuals. This is a surprising phenomenon because much of the research to date shows that better habitats for seedling recruitment of *Gladiolus imbricatus* are used meadows than unmanaged ones [47, 49, 52]. Moreover, numerous authors observed the appearance of seedlings in small-sized openings in continuous plant cover originating as a result of artificial removal of the aboveground parts of plants, e.g., [47, 48, 53]. On the other hand, Kubíková and Zeidler [38] noted only a slightly greater number of juvenile individuals of *G. imbricatus* in abandoned meadows than in regularly or accidentally mown ones.

The unexpected fact of a greater appearance of *G. imbricatus* juveniles in the abandoned meadow might be the effect of the clustered occurrence of the species, *G. imbricatus* formed almost single-species agglomerates in the 1 m^2 study plots, so the number of seeds is many times higher in the vicinity of them, than in the extensively used meadow, where the distribution is quite evenly and *G. imbricatus* grows accompanied by another meadow species. Moreover, the low seedling recruitment and therefore the smaller number of juvenile individuals of *G. imbricatus* observed in the extensively used meadow might be connected to its history; this is a meadow in an advanced stage of regeneration after cultivation of *Zea mays*, so it is possible that *Gladiolus imbricatus* is in the regeneration too. Kostrakiewicz-Gierałt and Podgórska [54] have indicated the regeneration of the rare meadow species *Iris sibirica* on a postcultural land. The performed investigations evidenced the population of *I. sibirica* presumably regenerates mainly in previously occupied locations, thanks to subsequent vegetative growth of juvenile individuals. The juvenile individuals of *G. imbricatus* regenerates mainly thanks to considerable seedling recruitment and that the regeneration process can be slower than in the case of *I. sibirica* which uses vegetative reproduction to spread.

We observed the secondary succession on the unmanaged meadow in terms of the appearance of trees, shrubs, and the expansive grasses. Similar phenomenon was also found by other authors on the different unmanaged meadows, e.g., [17, 20, 21]. In addition, we found that the secondary succession on the unmanaged meadow was also reflected in the height of neighbouring plants (more than double the height of herbaceous plants than in extensively used meadow). It could have an impact on traits of *G. imbricatus* individuals. We found that the length of the longest leaf blade and the height of the shoot, as well as the length of inflorescence, number of capsules in infructescence, and the length of the greatest capsule are greater in the unmanaged meadow. The larger dimensions of leaves allow *G. imbricatus* to effectively compete with neighbouring plants for light interception [36–38]. A similar phenomenon was also presented by other species occurring in meadows subjected to secondary succession, e.g., *Iris sibirica* [54, 55] and *Trollius europaeus* [56]. The greater height of shoot and length of inflorescence of *Gladiolus imbricatus* in unmanaged meadow is consistent with the findings of Kostrakiewicz-Gierałt [37] and might help enlarge the visibility of flowers and augment the chance for successful pollination from the order *Hymenoptera*, which are attracted particularly by blue, pink, purple, and mauve colours in the vicinity of tall plants [57–59]. Moreover, the results of the research of Chelariu and Draghia [35], showing a greater height of shoots and flower number in inflorescence in natural habitat than in cultivated, seem to correspond with the results found in the present study considering the fact that the unmanaged meadow (UM) has a more natural character than the extensively used meadow (EM) [54].

The observed positive correlations between shoot height and the number of leaves, length of the longest leaf blade, length of inflorescence, and number of capsules support the observations of Rameau and Gouyon [60], who determined the positive relationship between shoot height and leaf width, number of flowers, and length of inflorescence in cultivars of *G. imbricatus*.

Kose et al. [47], as well as Kose and Moora [52], found that the long-term, late-season mowing was the most favourable management type for *G. imbricatus*. On the other hand, Gryzielec [61] noticed a lack of influence of mowing conducted in *Molinia* meadows on abundance of populations of *G. imbricatus*. Our results correspond with the Gryzielec [61] findings.

5. Conclusions

The results of the presented field studies of populations of *Gladiolus imbricatus* occurring in extensively used and unmanaged *Molinia* meadows, which show the considerably greater number of individuals (especially juveniles), as well as the greater dimensions of leaf blades, shoots, inflorescence, and number of capsules in the unmanaged patch.

The obtained results may indicate a positive impact of several years of secondary succession on the *G. imbricatus* population within the *Molinia* meadows and inspires further observations of the performance of individuals of this species in changing landscape. The moist *Molinia* meadows do not require as frequent mowing as it is commonly believed, and the succession in such habitats can be stopped on a more advanced stage.

The more advanced stage of succession has not as negative impact on populations of rare and characteristic species for the *Molinietum* association (e.g. *Gladiolus imbricatus*) as we usually expected. Future investigations on the systematic long-term monitoring of abundance and traits of *G. imbricatus* individuals occurring in different extensively used and unmanaged *Molinia* meadows could contribute to completing the still insufficient state of knowledge.

Such investigations are particularly important for solving the scientific problem of the role of natural and artificial disturbances in the persistence of *G. imbricatus* populations within the extensively used meadows and abandoned sites and for evaluation of opportunities for the maintenance of populations in sites subjected to secondary succession.

Data Availability

All datasets generated and analyzed during the current study and used to support the findings of this study (including figures and images) are the researchers' own work and are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

All authors contributed to the study conception and design. Material preparation and data collection were performed by Monika Podgórska and Stanisław Kłosowski. Data analysis was performed by Kinga Kostrakiewicz-Gierałt and Monika Podgórska. The first draft of the manuscript was written by Kinga Kostrakiewicz-Gierałt, Monika Podgórska, and Stanisław Kłosowski. All authors commented on previous versions of the manuscript. All authors have read and approved the final manuscript.

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