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Abundance and conservation status of *Rosa gallica* in Strzyżów Foothills (SE Poland)

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Abstract. *Rosa gallica* is a rare, threatened, and legally protected species; hence, research on this species is important for identification of threats and development of protection strategies. The aim of the study was to characterise plant communities with *Rosa gallica* and to determine the habitat conditions, abundance, and diversity of selected population traits. The study was conducted in 2016-2020 in two localities (Bukowa, Kołaczyce) in Strzyżów Foothills. Twenty phytosociological relevés were made using the Braun-Blanquet method. The habitat conditions were assessed using Ellenberg indicator values. The following parameters were used to evaluate the diversity and quantitative relationships between the species in the analysed communities: Shannon-Wiener diversity (H'), Evenness (J'), and Simpson dominance (SIMP) indices. The size of the analysed populations was estimated based on the number of vegetative and generative shoots. Height was measured in 100 randomly selected shoots, and the number of flowers per generative shoot was additionally determined. *Rosa gallica* was part of the community with *Brachypodium pinnatum* in the Bukowa locality and occurred in the association *Arrhenatheretum elatioris* in Kołaczyce. The diversity indices had higher values in Kołaczyce. The population in Bukowa covered an area of 500 m^2 and comprised 911 (578 generative and 333 vegetative) shoots. From 1 to 10 flowers per shoot were noted. The population from Kołaczyce occupied a twofold smaller area and was less numerous, i.e. 465 (168 generative and 297 vegetative) shoots were recorded. It was also characterised by less abundant flowering (1-5 flowers per shoot). There were differences in the height of the generative and vegetative shoots. The parameter exhibited higher values in Bukowa (55.17 and 36.95 cm, respectively) than in Kołaczyce (33.79 and 26.79 cm, respectively). All the habitat indices (except for K and R) and the biodiversity indices had higher values in Kołaczyce. The present results show that *Rosa gallica* occurs in a wide range of habitats varying in light, moisture, and fertility requirements. It grows in different-sized clusters or sometimes produces single shoots. Advanced succession has a negative impact on the conservation status of the population, which is particularly evident in the Kołaczyce locality. Therefore, the conservation of this species will depend on active protection measures.

Keywords: *Rosa gallica*, threatened species, xerothermic grassland, Western Carpathians.

1. Introduction

Rosa gallica is a small shrub producing numerous underground stolons and typically reaching 0.5-1 m in height. It has delicate shoots covered with various thorns: from straight, slightly bent to hook-shaped, as well as numerous small needle-like prickles and glandular bristles. A characteristic feature of the species is its large (7-9 cm in diameter), dark pink, fragrant flowers placed on fairly long, densely glandular pedicels (Zieliński, 1987). The occurrence

range of the species mainly covers central, southern, and south-eastern Europe. In addition to the European continent, *Rosa gallica* occurs in northern Turkey and the western regions of the Caucasus (Meusel et al., 1965; Zieliński, 2014). In Poland, it reaches the northern limit of its range, and its occurrence is concentrated in Silesia Lowland, Małopolska Upland, and Lublin Upland (Zając & Zając, 2001). In the Carpathians, it is a rare species known for its lower mountain locations: Wieliczka Foothills (Bartoszek, 1997; Ociepa, 2001; Pacyna, 2004), Rożnów Foothills (Piątek, 1999), Ciężkowice Foothills (Kornaś et al., 1996), Dynów Foothills (Gutkowska & Niedźwiecka, 2014), Przemyśl Foothills (Wolanin, 2014), Jasło-Krosno Basin (Oklejewicz 1993), Beskid Niski Mts. (Deptuch & Oklejewicz, 1998), and Strzyżów Foothills, where it has been reported from three sites in the Wisłoka River Valley (Towpasz, 1987).

In Poland, *Rosa gallica* is under strict species protection (Regulation, 2014). It is recognised as a valuable element of native flora, as evidenced by its presence in the *Polish Red Book of Plants* (Zieliński, 2014) and the *Polish Red List of Ferns and Flowering Plants* (Kaźmierczakowa et al., 2016) with the VU (vulnerable) category. It is also included in many local red lists with the following categories: critically endangered (CR) – Sudety Mts. (Fabiszewski & Kwiatkowski, 2002), endangered (EN) – Silesia Province (Parusel & Urbisz, 2012), Opole Province (Nowak et al., 2008), and vulnerable (VU) – Podkarpacie Province (Oklejewicz et al., 2015), Lublin Province (Cwener et al., 2016), Lower Silesia (Kącki et al., 2003), Małopolska Upland (Bróż & Przemyski, 2009), and Wielkopolska (Jackowiak et al., 2007).

The botanical investigations carried out in recent years have contributed to the discovery of a number of new *Rosa gallica* localities in Poland, e.g. in Małopolska Upland (Towpasz & Cwener, 2002; Piwowarczyk, 2006; Łazarski, 2016), Sandomierz Basin and San River Valley (Klichowska, 2013; Nobis et al., 2015; Jaźwa & Stadnicka-Futoma, 2017; Wójcik et al., 2021), and the Odra River valley near Wrocław (Wójcik et al., 2014). Many studies of this species are focused on investigations of generative organs, e.g. pollination biology (Żuraw, 2015), pollen grain morphology (Wrońska-Pilarek & Boratyńska, 2005; Wrońska-Pilarek & Jagodziński, 2009; Wrońska-Pilarek, 2011), and the importance of the morphology of achenes for taxonomy (Jagodziński et al., 2016). It is also worth mentioning that *Rosa gallica* is highly popular as an ornamental plant and has a number of derived cultivars (Monder, 2014). However, this taxon has poorly differentiated morphology in its natural geographical range and rarely hybridises with other rose species (Fedorova et al., 2010). Although several studies have presented the characteristics of phytocoenoses comprising *Rosa gallica* (Towpasz & Cwener, 2002; Valachovič, 2004; Brzeg, 2005; Sărățeanu et al., 2011; Wójcik et al., 2014) and some features of the species (Wójcik et al., 2014), its habitat requirements are still not fully known. Additionally, there are no precise data on the abundance and diversity of the population characteristics in different habitat conditions. Hence, there is a need to conduct further ecological research to determine the conservation status of the population and to take effective protection measures.

The aim of the study was to characterise plant communities with *Rosa gallica* in Strzyżów Foothills to determine the habitat conditions as well as the abundance and diversity of selected characteristics of the population.

2. Study area

The study was conducted in Strzyżów Foothills, i.e. a region of the Outer Western Carpathians (Solon et al., 2018). In 2016-2020, *Rosa gallica* localities presented by Towpasz (1987) were monitored. Two localities in Bukowa (Fig. 1) and Kołaczyce (Fig. 2) were confirmed, whereas plants from the Krajowice locality were considered probably extinct. The analysed species occurs on steep slopes with S, SW, and SE exposure in the Wisłoka River Valley. This area is known in the botanical literature for the island occurrence of patches of xerothermic vegetation, which is rare in this part of the Western Carpathians. The presence of xerothermic species in this area, away from their compact range, is determined by the geological structure, the calcium carbonate-rich substrate, and the favourable orography of the area, i.e. slopes with southern or similar exposure. The development and persistence of xerothermic grasslands in this region is also strongly associated with extensive human activity, especially animal grazing. Unfortunately, these areas have been excluded from agricultural activities for at least 20 years and are gradually being overgrown (Towpasz, 1990; Wójcik, 2018; Wójcik & Towpasz, 2019).

3. Material and Methods

In 2016-2019, 20 phytosociological relevés (10 in Bukowa and 10 in Kołaczyce) were made using the Braun-Blanquet (1964) method. The relevés were compiled in two tables separately for each locality, and the constancy and cover coefficients were calculated for each species. The syntaxonomic affiliation of the species was determined as in Matuszkiewicz (2001). The species names were adopted from Mirek et al. (2020), and protected species were distinguished in accordance with the Regulation of the Minister of Environment (Regulation, 2014). In 2020, the size of the populations was estimated based on the number of vegetative and generative shoots. Next, the height of 100 randomly selected vegetative and

Figure 1. Occurrence of *Rosa gallica* in Bukowa (photo T. Wójcik 21.06.2016)

Figure 2. Occurrence of *Rosa gallica* in Kołaczyce (photo T. Wójcik 2.07.2021)

generative shoots was measured, and the number of flowers per generative shoot was additionally determined.

The habitat conditions were assessed using Ellenberg indicator values (Ellenberg & Leuschner, 2010). The following indicators were used to evaluate the species diversity and quantitative relationships in the analysed plant communities: Shannon-Wiener diversity (H'), Evenness (J'), and Simpson (SIMP) indices. The JUICE program (Tichy, 2002) was applied to calculate the mean values of the following indicators: light conditions (L), thermal conditions (T), continentality (K), soil moisture (F), soil reaction (R), soil fertility (N), and diversity indices (H', J', SIMP) for each phytosociological relevé. Next, the mean values of the indicators were calculated for the plant communities.

The Student t-test was used to compare the differences in the height of vegetative and generative shoots and the number of flowers between the localities. The non-parametric Mann-Whitney U test was used to check the statistical significance of the differences in the Ellenberg indicator values between the localities and to compare the diversity indices.

4. Results

During the study, two *Rosa gallica* localities reported previously from Strzyżów Foothills, i.e. in Bukowa and Kołaczyce, were confirmed. In Bukowa, *Rosa gallica* was found in the upper part of the slope (271-314 m a.s.l.) with varied inclination (5-25°) and southern or similar exposure (Table 1). The species was present in patches of overgrown xerothermic grasslands and was accompanied by a substantial proportion of shrubs whose cover ranged from 1 to 20% (mean 8.4%). The herb layer reached full coverage in each relevé. From 24 to 34 species (mean 28) were recorded in the phytosociological relevés, and in total 70 species were found in the entire community. *Rosa gallica* formed several large and compact patches (relevés 4, 5, 7, 8, 10) or single shoots (relevés 1-3, 6, 9). Species characteristic for the class *Festuco-Brometea* (14 species) were characterised by the highest cover degree, with dominance of *Brachypodium pinnatum* reaching the highest abundance in all relevés. Hence, the analysed phytocoenoses were described as the community with *Brachypodium pinnatum* within the class *Festuco-Brometea*. Species from the class *Trifolio-Geranietea* (9 species) represented a high proportion of the community structure with *Origanum vulgare*, *Galium verum*, *Agrimonia eupatoria*, and *Coronilla varia* achieving high coverage and stability degrees. In turn, meadow plants were represented by the greatest number of species (20 species from the class *Molinio-Arrhenatheretea*), but they exhibited low abundance and low coverage (except for *Galium mollugo*). There were also 8 shrub species from the class *Rhamno-Prunetea*, with the greatest coverage of *Prunus spinosa*. Species that were not affiliated to any of the distinguished syntaxonomic units occurred sporadically and did not play an important role in the structure of the community. Two protected species (*Gentiana cruciata* and *Rosa gallica*) were identified in the community.

In Kołaczyce, *Rosa gallica* patches were found in the upper part of the slope (262-270 m a.s.l.) with a slight inclination towards the south and on the plateau (Table 2). *Rosa gallica* was present on the border of overgrown *Molinio-Arrhenatheretea* meadows and cultivated orchards. The shrub layer reached 1-20% coverage (mean 10.1%), while the herb layer reached a full compactness degree. From 24 to 32 species were recorded per relevé (mean 29), while 55 species in total were identified in the entire community. *Rosa gallica* produced single shoots and formed small assemblages, whereas larger clusters were rarely found. The greatest cover was determined in the case of *Arrhenatherum elatius*. It was accompanied by numerous species characteristic for fresh meadows from the alliance *Arrhenatherion elatioris* (4 species) and order *Arrhenatheretalia elatioris* (7 species) as well as 14 species from the class *Molinio-Arrhenatheretea*. Therefore, the community was classified as part of the association *Arrhenatheretum elatioris*. Among these syntaxonomic units, the degree of constancy V and high coverage were achieved by *Galium mollugo*, *Knautia arvensis*, *Achillea millefolium*, *Dactylis glomerata*, *Daucus carota*, *Festuca rubra*, *Pimpinella saxifraga*, and *Veronica chamaedrys*. The class *Festuco-Brometea* was represented by 7 species with *Centaurea scabiosa* and *Plantago media* playing a major role in the community structure. Similarly, there were 7 taxa from the class *Trifolio-Geranietea*, but only two of these species (*Agrimonia eupatoria* and *Origanum vulgare*) exhibited high stability. There were also 4 shrub species (class *Rhamno-Prunetea*), with a considerable cover degree exhibited by *Prunus spinosa*. Ten other species were

Table 1. Occurrence of *Rosa gallica* in the community with *Brachypodium pinnatum* in Bukowa

Relevé number	1	2	3	4	5	6	7	8	9	10	Constancy	Cover coefficient
Date (Day, month, year)	21.06.2016						17.08.2019					
Area of relevé [m^2]	25											
Altitude [m.a.s.l.]	314	312	307	306	307	300	308	321	271	268		
Exposure	SW	S	SE	SW	SW	SW	S	S	SW	SW		
Inclination [°]	20	20	20	20	15	25	5	5	5	5		
Cover of the shrub layer [%]	2	1	5	3	3	15	10	20	20	5		
Cover of the herb layer [%]	100	100	100	100	100	100	100	100	100	100		
Number of species	32	34	32	26	27	30	24	26	30	21		
Rosa gallica	+	+	+	2.2	2.2	+	4.5	3.5	+	2.3	V	1550
Ch.Cl. *Festuco-Brometea*												
Brachypodium pinnatum	5.4	5.4	4.3	5.4	5.4	4.3	3.5	4.4	4.5	4.5	V	7000
Centaurea scabiosa	+	1.2	+	+	+	1.2	+	+	+	1.2	V	185
Hypericum perforatum	+	+	+	+	+	.	+	+	+	.	IV	40
Carlina vulgaris	+	+	1.1	.	+	+	+	+	.	.	IV	80

Table 1. cd

Carex caryophyllea	.	1.2	2.2	1.2	1.2	+	.	.	.	.	III	330
Thymus pulegioides	+	+	.	.	+	.	.	.	2.3	1.3	III	240
Allium oleraceum	.	+	.	.	.	+	+	.	+	.	II	20
Ranunculus polyanthemos	+	+	+	.	.	.	.	.	.	+	II	20
Euphorbia cyparissias	.	.	.	.	.	.	.	.	+	1.2	I	55
Melampyrum arvense	.	.	.	.	.	.	.	.	+	1.1	I	55
Sanguisorba minor	+	.	1.1	.	.	.	.	.	.	.	I	55
Ch.Cl. *Trifolio-Geranietea*												
Origanum vulgare	3.2	2.2	3.2	2.1	2.2	3.2	1.2	2.2	2.2	2.2	V	2225
Galium verum	2.1	2.2	2.1	+	2.2	1.1	1.1	2.1	1.1	1.1	V	1080
Agrimonia eupatoria	.	1.1	1.1	1.1	+	1.1	+	1.1	1.1	1.1	V	360
Coronilla varia	1.2	1.1	2.2	2.2	.	2.2	+	.	+	.	IV	635
Clinopodium vulgare	1.2	+	1.2	.	.	+	+	1.2	.	.	III	165
Viola hirta	.	+	.	.	+	.	.	+	+	+	III	25
Fragaria viridis	+	.	+	.	.	.	+	.	.	+	II	20
Ch.Cl. *Molinio-Arrhenatheretea*												
Galium mollugo	1.2	1.2	2.2	2.2	1.2	2.2	.	+	+	+	V	690
Achillea millefolium	1.2	+	+	+	1.1	1.1	1.1	1.1	1.1	.	V	315
Pimpinella saxifraga	1.1	+	+	1.1	1.1	1.1	1.1	1.1	.	.	IV	310
Centaurea jacea	+	+	.	+	+	+	1.2	1.1	+	.	IV	130
Arrhenatherum elatius	1.2	1.1	1.1	1.1	2.2	1.1	.	+	.	.	IV	430
Festuca rubra	1.2	1.2	1.2	+	+	2.2	.	.	.	.	III	335
Leucanthemum vulgare	+	1.1	+	+	+	+	.	.	.	.	III	75
Knautia arvensis	+	+	+	.	.	+	.	.	+	+	III	30
Linum catharticum	+	+	+	+	+	+	.	.	.	.	III	30
Briza media	+	+	.	.	+	+	1.1	.	.	.	III	70
Dactylis glomerata	+	+	.	.	.	.	.	+	+	.	II	20
Vicia cracca	.	.	.	.	.	.	+	+	+	+	II	20
Lathyrus pratensis	1.2	+	+	.	.	.	.	.	.	.	II	60
Daucus carota	.	.	.	.	.	.	+	+	+	.	II	15
Lotus corniculatus	.	.	.	.	.	.	.	+	+	+	II	15
Anthoxanthum odoratum	+	+	.	.	.	.	.	.	.	.	I	10
Ch.Cl. *Rhamno-Prunetea*												
Prunus spinosa b	.	.	+	.	+	+	1.1	2.1	2.2	1.2	IV	465
Cornus sanguinea b	+	.	+	.	.	+	.	1.1	1.1	.	III	115
Rosa canina b	.	+	.	+	.	.	1.1	1.1	.	.	II	110
Acer campestre b	+	.	.	+	+	.	.	1.1	.	.	II	65
Rhamnus catharticus b	.	.	+	+	.	2.1	.	.	.	.	II	185
Pyrus pyraster b	.	.	+	.	.	.	1.1	.	.	.	I	55
Other species												
Solidago virgaurea	+	+	+	+	+	+	1.1	1.1	.	+	V	135
Hieracium umbellatum	.	.	.	.	+	+	+	.	.	.	II	15
Medicago lupulina	.	.	.	.	.	+	.	.	+	+	II	15
Myosotis arvensis	.	+	.	+	+	.	.	.	.	.	II	15
Quercus robur b	.	.	+	.	+	.	+	.	.	.	II	15
Euphorbia esula	+	.	.	+	.	.	.	.	.	.	I	10
Lathyrus tuberosus	+	+	.	.	.	.	.	.	.	.	I	10
Polygala vulgaris	.	.	.	.	.	.	.	.	+	+	I	10

Sporadic species: Ch.Cl. *Festuco-Brometea* – *Gentiana cruciata* 9(+, 5), *Plantago media* 9(+, 5), *Senecio jacobaea* 8(+, 5); **Ch.Cl. *Trifolio-Geranietea*** – *Agrostis capillaris* 8(+, 5), *Campanula rapunculoides* 4(+, 5); **Ch.Cl. *Molinio-Arrhenatheretea*** – *Cerastium holosteoides* 1(+, 5), *Leontodon hispidus* 9(+, 5), *Prunella vulgaris* 9(+, 5), *Rumex acetosa* 5(+, 5); **Ch.Cl. *Rhamno-Prunetea*** – *Crataegus monogyna* b 3(+, 5), *Ulmus campestre* b 9(+, 5); **Other species** – *Carex spicata* 4(1.2, 50), *Melilotus officinalis* 6(1.1, 50), *Carduus acanthoides* 6(+, 5), *Cichorium intybus* 10(+, 5), *Consolida regalis* 2(+, 5), *Convolvulus arvensis* 6(+, 5), *Erigeron acris* 2(+, 5), *Fallopia convolvulus* 4(+, 5), *Rubus caesis* 3(+, 5), *Vicia hirsuta* 3(+, 5).

Table 2. Occurrence of *Rosa gallica* in the association *Arrhenatheretum elatioris* in Kołaczyce

Relevé number	1	2	3	4	5	6	7	8	9	10	Constancy	Cover coefficient
Date (Day, month, year)	27.07.2018											
Area of relevé [m^2]	25											
Altitude [m.a.s.l.]	270	270	270	270	270	269	268	265	265	262		
Exposure	-	-	-	-	S	S	S	S	S	S		
Inclination [°]	-	-	-	-	1	1	2	2	2	2		
Cover of the shrub layer [%]	15	10	5	20	15	1	5	20	5	5		
Cover of the herb layer [%]	100	100	100	100	100	100	100	100	100	100		
Number of species	24	27	30	29	30	30	27	32	30	29		
Rosa gallica	+	1.2	1.2	3.2	2.2	3.2	2.2	+	+	+	V	1220
Ch.Ass. *Arrhnenatheretum elatioris*												
Arrhenatherum elatius	3.2	2.2	3.2	3.2	3.2	3.2	3.2	3.2	2.2	2.2	V	3150
Ch.All. *Arrhenathereterion elatioris*												
Galium mollugo	1.2	1.2	1.2	1.2	+	1.2	1.2	1.2	+	2.2	V	535
Knautia arvensis	+	+	+	+	1.1	+	+	1.1	+	1.1	V	185
Crepis biennis	.	+	.	.	+	+	.	.	.	.	II	15
Tragopogon pratensis	.	.	.	.	+	+	.	+	.	.	II	15
Ch.O. *Arrhenatheretalia elatioris*												
Achillea millefolium	2.2	2.2	1.2	1.2	1.2	1.2	1.2	2.2	1.2	1.2	V	875
Dactylis glomerata	2.2	1.2	2.2	2.2	2.2	2.2	1.2	+	2.2	1.2	V	1205
Daucus carota	1.1	1.1	+	+	+	1.1	1.1	1.1	2.1	1.1	V	490
Heracleum sphondylium	+	+	+	.	.	.	.	+	+	.	III	25
Lotus corniculatus	.	.	.	+	.	.	.	+	+	+	II	20
Trisetum flavescens	.	+	.	+	.	.	+	.	.	.	II	15
Leucanthemum vulgare	.	.	.	.	.	.	.	.	+	+	I	10
Ch.Cl. *Molinio-Arrhenatheretea*												
Festuca rubra	1.2	1.2	1.2	2.2	2.2	2.2	2.2	2.2	3.2	1.2	V	1450
Pimpinella saxifraga	1.1	+	1.1	1.1	1.1	1.1	1.1	1.1	1.1	+	V	410
Veronica chamaedrys	1.1	+	1.1	1.1	1.1	+	1.1	1.1	1.1	1.1	V	410
Plantago lanceolata	+	+	+	+	+	+	+	+	+	+	V	50
Lathyrus pratensis	+	.	+	+	.	+	+	+	.	.	III	30
Potentilla reptans	+	+	+	+	+	.	.	+	.	.	III	30
Leontodon hispidus	1.1	.	.	+	+	+	1.2	.	.	.	III	115
Festuca pratensis	1.2	2.2	1.2	.	+	.	.	.	.	.	II	280
Phleum pratense	.	1.2	+	.	.	.	+	.	.	+	II	65
Poa pratensis	.	.	.	.	.	.	.	+	+	+	II	15
Rumex acetosa	+	.	+	+	.	.	.	.	.	.	II	15
Vicia cracca	.	.	.	.	+	.	.	.	.	+	I	10
Ch.Cl. *Festuco-Brometea*												
Centaurea scabiosa	+	2.2	1.2	2.2	+	+	+	+	2.2	2.2	V	775
Plantago media	+	+	+	+	1.1	+	1.1	1.1	1.1	+	V	230
Ranunculus polyanthemos	+	+	+	.	+	1.1	+	.	+	+	IV	85
Allium oleraceum	.	+	.	+	+	+	+	+	+	+	IV	40
Hypericum perforatum	.	.	.	+	1.2	+	.	+	+	.	III	70
Gentiana cruciata	.	.	.	+	+	.	.	.	.	.	I	10
Melampyrum arvense	.	.	.	.	.	+	+	.	.	.	I	10
Ch.Cl. *Trifolio-Geranietea*												
Agrimonia eupatoria	+	1.1	1.1	1.1	1.1	1.2	1.1	1.1	1.1	1.1	V	455
Origanum vulgare	.	.	.	1.2	+	+	1.2	1.2	1.2	2.2	IV	385
Clinopodium vulgare	.	.	.	+	1.2	1.2	.	.	1.2	2.2	III	330
Galium verum	.	.	+	+	.	.	+	+	1.2	.	III	70
Fragaria viridis	.	.	.	.	.	+	+	+	.	.	II	15

Table 1. cd

Medicago falcata	.	.	+	.	.	.	.	+	.	+	II	15
Trifolium medium	+	.	.	.	.	.	.	.	.	+	I	10
Ch.Cl. *Rhamno-Prunetea*												
Prunus spinosa b	2.3	2.3	1.2	2.3	2.3	+	1.3	2.2	.	.	IV	975
Rosa canina b	.	+	+	.	.	.	.	+	1.2	1.1	III	115
Other species												
Picris hieracioides	+	2.1	+	+	.	+	.	.	+	.	III	200
Carex spicata	.	.	+	.	.	+	+	+	.	.	II	20
Equisetum arvense	.	+	.	.	+	+	.	.	.	+	II	20
Solidago gigantea	.	.	.	.	+	.	.	+	+	+	II	20
Cuscuta epithymum	.	.	+	.	.	+	.	+	.	.	II	15
Erigeron annuus	.	.	.	.	.	.	.	+	+	+	II	15

Sporadic species: Ch.Cl. *Molinio-Arrhenatheretea* – *Cerastium holosteoides* 4(+, 5), *Symphytum officinale* 3(+, 5); **Ch.Cl. *Rhamno-Prunetea*** – *Cornus sanguinea* b 2(+, 5), *Ligustrum vulgare* b 9(+, 5); **Other species** – *Artemisia vulgaris* 3(+, 5), *Cichorium intybus* 7(+, 5), *Medicago lupulina* 9(+, 5), *Solidago virgaurea* 5(+, 5).

recorded as well, but their share in the community was marginal. Protected species were represented by *Gentiana cruciata* and *Rosa gallica*.

The analysis of Ellenberg indicator values showed statistically significant differences in five of these parameters: L, K, F, R, and N (Table 3). The L, F, and N values were higher in the association *Arrhenatheretum elatioris*, whereas higher values of K and R were obtained in the community with *Brachypodium pinnatum*. The mean number of species per phytosociological relevé and the T value were similar in both analysed communities. Significant statistical differences were noted for all the diversity indices (H', J', SIMP). Their values were higher in the association *Arrhenatheretum elatioris*.

In the studied populations, the greatest differences were found in the abundance and occupied area. In Bukowa, in total 911 shoots were recorded, including 578 generative and 333 vegetative shoots, in an area of approx. 500 m^2, and the size of the individual patches varied from 0.5 to 20 m^2. The Kołaczyce population was nearly twofold smaller, as there were 465 (168 generative and 297 vegetative) shoots, and covered an area of 250 m^2; the patches with *Rosa gallica* were usually small (0.2-2 m^2). There were also differences in the

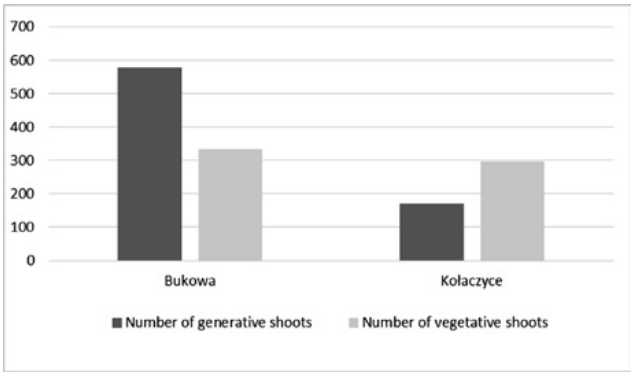

Figure 3. Number of *Rosa gallica* shoots

Table 3. Mean values of the characteristics of the analysed plant communities

	A	B	*p*
Light availability (L)	6.74 (6.66–6.84)	7.25 (7.11–7.37)	U=0.0 (***)
Temperature (T)	5.53 (5.37–6.01)	5.66 (5.38–5.97)	U=26.5 (ns)
Climatic continentality (K)	4.25 (4.07–4.34)	3.85 (3.61–4.04)	U=0.0 (***)
Moisture (F)	3.94 (3.87–3.99)	4.35 (4.04–4.56)	U=0.0 (***)
Reaction (R)	7.21 (7.05–7.41)	7.08 (6.94–7.32)	U=22.5 (*)
Nitrogen (N)	3.69 (3.50–3.91)	4.92 (4.27–5.45)	U=0.0 (***)
Shannon-Wiener index (H´)	2.30 (2.05–2.54)	2.78 (2.56–3.01)	U=0.0 (***)
Evenness index (J´)	0.69 (0.65–0.74)	0.83 (0.77–0.89)	U=0.0 (***)
Simpson index (SIMP)	0.78 (0.72–0.84)	0.89 (0.86–0.93)	U=0.0 (***)
Mean number of vascular plant species	27.8 (21–33)	28.7 (24–32)	U=44.5 (ns)

A – community with *Brachypodium pinnatum* in Bukowa; B – association *Arrhenatheretum elatioris* in Kołaczyce; *p* – probabilities based on the Mann-Whitney U test; *P<0.05; ***P<0.001.

Table 4. Analysis of individual traits of *Rosa gallica*

	A	B	*p*
Shoot length of a generative individual [cm]	55.17 (32–99)	33.79 (20–63)	7.43***
Number of flowers per shoot	3.22 (1–10)	1.53 (1–5)	12.0***
Shoot length of a vegetative individual [cm]	36.95 (13–74)	26.79 (9–50)	7.73***

A – community with *Brachypodium pinnatum* in Bukowa; B – association *Arrhenatheretum elatioris* in Kołaczyce; *p* – probabilities based on the Student *t*-test; ***P<0.001.

numbers of generative and vegetative shoots in the entire population. A greater number of generative shoots was found in Bukowa, whereas vegetative shoots were more numerous in Kołaczyce (Fig. 3). The analysis of the individual features of *Rosa gallica* showed substantially higher values for plants growing in the community with *Brachypodium pinnatum* (Table 4). The height of the generative shoots was in the range of 32-99 cm (mean 55.17 cm) in Bukowa and 20-63 cm (mean 33.79 cm) in Kołaczyce. Similarly, the vegetative shoots in Bukowa were higher (13-74 cm, mean 36.95 cm) than in Kołaczyce (9-50 cm, mean 26.79 cm). The greatest differences were observed in the number of flowers per shoot. From 1 to 5 flowers per shoot (mean 1.53) were observed in the fresh meadow association *Arrhenatheretum elatioris*, and a twofold higher number, i.e. from 1 to 10 (mean 3.22), was recorded in the community with *Brachypodium pinnatum*.

5. Discussion and conclusion

Rosa gallica is a characteristic species of the class *Trifolio-Geranietea*, in which a separate association *Rosetum gallicae* was distinguished by Valachovič (2004) and Brzeg (2005). Additionally, it is regarded as a characteristic species of the order *Quercetalia pubescentis* in the class *Querco-Fagetea* and as a typical species of the subassociation *Potentillo albae-Quercetum rosetosum gallicae* (Matuszkiewicz, 2001). Numerous studies have demonstrated that the occurrence of *Rosa gallica* is associated with warm calcareous habitats offering the species appropriate conditions for growth and development. Many authors highlight its occurrence in xerothermic grasslands, especially in patches with an advanced stage of succession (Towpasz & Cwener, 2002; Wójcik et al., 2014; Łazarski, 2016; Bede & Csathó, 2019), as in the case of the community with *Brachypodium pinnatum* in Bukowa, where *Rosa gallica* exhibited higher abundance, greater height, and more abundant flowering. The species also occurs in unused thermophilic meadow communities (Czarna, 1992; Bartoszek, 1997; Sărățeanu et al., 2011; Klichowska, 2013; Wójcik et al., 2014; Wójcik et al., 2021), as confirmed by the present results from the Kołaczyce locality. Additionally, it occurs in thermophilic shrub communities with a high proportion of species characteristic of the class *Rhamno-Prunetea* (especially accompanied by *Prunus spinosa* and *Rosa canina*) (Towpasz & Cwener, 2002; Łazarski, 2016). It is also recorded in communities with undetermined syntaxonomic affiliation composed of species from different units (*Molinio-Arrhenatheretea*, *Trifolio-Geranietea*, *Festuco-Brometea*, *Rhamno-Prunetea*) and frequently ruderal species (Piwowarczyk, 2006; Klichowska, 2013, Wójcik et al., 2014). The wide phytosociological scale of *Rosa gallica* and its high adaptation abilities is evidenced by its occurrence in phytocoenoses with a large proportion of meadow and synanthropic species, as those recorded near Wrocław (Wójcik et al., 2014).

Rosa gallica prefers highly insolated places and is clearly associated with thermophilic communities (Towpasz & Cwener, 2002; Brzeg, 2005; Zieliński, 2014; Łazarski, 2016). This was partially confirmed by the present study, where the light index reached high values and the thermal index did not coincide with that reported in the literature (Zarzycki et al., 2002). The analysis of the K index has shown that *Rosa gallica* is neutral to continentality, which was confirmed by Wójcik et al. (2014) in a study conducted near Wrocław. There were slight differences in the soil moisture index between the examined patches, which indicated that they had fresh soils. Although the current data indicate a relationship of this species with thermophilic communities, usually with dry soils, *Rosa gallica* was also found on wet soils in the valleys of streams and rivers (Klichowska, 2013; Wójcik et al., 2021). This proves its wide tolerance to moisture conditions. The soil acidity index in both localities was high, which was associated with the presence of calcium carbonates in the substrate. This is consistent with results reported by other authors who classify *Rosa gallica* as a xerothermic species associated with calcium carbonate-rich habitats (loess, rendzinas) (Bartoszek, 1997; Towpasz & Cwener, 2002; Zieliński, 2014). The analysis of the trophism index showed significant differences between the analysed communities. It indicated poor soils in the community with *Brachypodium pinnatum*, whereas the higher value of the index in the association *Arrhenatheretum elatioris* in Kołaczyce was probably related to the large amount of biomass accumulated in this unused land. The literature provides information about high diversity

in the richness of habitats, even in patches of fresh, variably wet, and moist communities (Brzeg 2005; Sărățeanu et al., 2011; Klichowska, 2013; Wójcik et al., 2014).

Plant communities with *Rosa gallica* are usually floristically poor compared to other xerothermic communities. Brzeg (2005) found on average 26 species per phytosociological relevé. Similar results (27 species) were reported by Towpasz and Cwener (2002), which is consistent with the results obtained in Bukowa and Kołaczyce. The species richness and relationships between species are reflected by the Shannon-Wiener diversity index. Its value was higher (H´=2.78) in the association *Arrhenatheretum elatioris*, which was related to the higher total species richness and the uniformity of cover of most species. The lower index (H´=2.30) in the community with *Brachypodium pinnatum* may result from the dominance of one or several species (mainly *Brachypodium pinnatum*). Its value is similar (H´=2.21) to that obtained in a previous study conducted in Bukowa (Wójcik, 2018). In turn, Wójcik and Towpasz (2019) reported a higher Shannon-Wiener index (H´=3.24) in the typical patches of xerothermic grasslands in Kołaczyce in comparison with the communities analysed in the present study. This relationship can also be seen in studies of xerothermic grasslands from other regions of Poland, e.g. Wyżyna Małopolska Upland, where the H´ index in various periods ranged from 2.99 to 3.57. A similar relationship can be noticed in the case of the Evenness index, which was lower in Bukowa and Kołaczyce than in the better developed xerothermic communities in Wyżyna Małopolska Upland (Towpasz & Stachurska-Swakoń, 2012).

Numerous studies show that plant patches with *Rosa gallica* cover different-sized areas. Near Wrocław, they range from 0.12 to 1833 m^2; however, most of these areas are in the range of 10-100 m^2. The total surface area occupied by this species is estimated at approx. 22 312 m^2 (Wójcik et al. 2014). The patches from Bukowa and Kołaczyce occupy a small area in comparison to that reported by the aforementioned authors. In terms of the number of individuals, it is difficult to determine the size of the population precisely, as *Rosa gallica* produces numerous underground stolons and often reproduces in a vegetative way. Therefore, its population size is determined based on the number of shoots. A *Rosa gallica* population in Wielickie Foothills was found to consist of over a dozen of generative shoots (Bartoszek, 1997). In turn, 50 generative shoots were reported from the Lower Wisłoka River Valley (Wójcik et al., 2021), and approximately 150 generative shoots were found in the Dunajec River Valley (Klichowska, 2013). The populations in Wyżyna Małopolska Upland exhibited a wide range from 1 to 300 shoots (Piwowarczyk, 2006; Łazarski, 2016). This indicates that the populations from Bukowa (911 shoots) and Kołaczyce (465 shoots) should be considered numerous.

According to Zieliński (2014) *Rosa gallica* is a shrub plant with the shoot height rarely exceeding 30-50 cm. In the study area, the height of the generative shoots was in the range of 32-99 cm in the community with *Brachypodium pinnatum* and 20-63 cm in the association *Arrhenatheretum elatioris*, whereas the vegetative shoots were shorter. A similar height range (45-75 cm) was recorded in Wielkopolska (Czarna, 1992). The largest differences in the length of generative shoots were noted in the population near Wrocław, where the tallest shoots were up to 130 cm high, while the height of the lowest shoots was only 14 cm (Wójcik et al., 2014). The populations analysed in the present study also differed significantly in the number of flowers. From 1 to 10 flowers per generative shoot were recorded in Bukowa, and from 1 to 5 flowers were noted in the more shaded locality in Kołaczyce. Increased shading associated with the spread of shrub species blocking access to light limits flowering, which was also observed by Łazarski (2016).

Rosa gallica grows in a wide range of habitats differing in moisture, fertility, light, and thermal requirements. Multiyear research conducted in Romania has proved that fertilisation and biomass harvesting did not affect the occurrence of the species (Sărățeanu et al., 2011). In its habitats near Wrocław, various management treatments and random events (mowing, flooding, or burning) did not cause disappearance of the species (Wójcik et al., 2014) but only limited its flowering. As suggested by Klichowska (2013) and Łazarski (2016), abandonment of management for several years has a beneficial effect on the abundance and conservation status of *Rosa gallica*. The shoots are not damaged and the species can freely increase its cover. However, continued abandonment results in the spread of shrubs (mainly *Prunus spinosa*) that pose a threat to the *Rosa gallica* population and limit the availability of open habitats for this low shrub. Hence, many authors indicate succession as one of the main threats not only to this species (Piwowarczyk, 2006; Wójcik et al., 2014; Łazarski, 2016) but also to xerothermic habitats (Towpasz & Stachurska-Swakoń, 2012; Podgórska & Łazarski, 2021). In this respect, *Rosa gallica* is an exceptionally persistent species; although it can be found in various types of habitats, the margins of thermophilic scrubs and xerothermic grasslands ensure its optimum development. Therefore, the most numerous and best-preserved populations can be found in patches that were abandoned several years before, as in the case of the Bukowa locality. The progressing succession does not eliminate the species immediately but causes its gradual disappearance (Wójcik et al., 2014; Łazarski, 2016). On the other hand, *Rosa gallica* has specific habitat preferences, i.e. it is associated with marginal habitats that are now disappearing from the landscape, such as small patches of grasslands and fringes, field margins, steep slopes, and margins of thermophilic shrubs and forests.

Therefore, the preservation of its population will depend largely on the maintenance of a heterogeneous landscape with a mosaic of habitats. The necessity of protection of the most valuable landscape elements comprising *Rosa gallica* has been repeatedly postulated (Facsar, 2005; Bede & Csathó, 2019). The patches of thermophilic grasslands and shrubs in Bukowa and Kołaczyce, which are rich in xerothermic species and thus play the role of a specific refuge of biological diversity, should definitely be protected.

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