Tuexenia 46: xxx–xxx. Göttingen 2026.
doi: 10.14471/2026.46.001, available online at www.tuexenia.de

SHORT COMMUNICATION

Extremely high fine-scale plant species richness in an Armenian grassland

Extrem hohe Artenvielfalt auf kleiner räumlicher Skala in einem armenischen Grasland

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Abstract

The Caucasus biodiversity hotspot is renowned for its exceptionally rich biota and considerable endemism. However, some aspects of local biodiversity remain understudied. Here we report the results of our pilot vegetation sampling of a species-rich grassland in Armenia. We present data from two nested square plots located in semi-dry grassland with species richness reaching 90 and 104 rooted vascular plant species per 10 and 25 m^2, respectively. Within Eurasia, these represent the most species-rich plots of these sizes recorded so far, except for the Carpathians, where global maxima have been found, and some old records from the steppes in western European Russia. These grasslands correspond to meadow steppe (phytosociological class *Festuco-Brometea*, order *Brachypodietalia pinnati*), in which dicots predominate over graminoids. We hypothesize that the high species diversity results from the interplay of several factors, including the preservation of traditional, low-intensity farming that combines hay-making and grazing by free-ranging cattle. Additionally, local species richness is likely enhanced by a large species pool, a rich regional flora, and moderate (non-extreme) water availability and soil reaction. We conclude that the species richness of Caucasian grasslands, its origin and conservation implications are still understudied and warrant further research, especially as these grasslands face ongoing degradation. We anticipate that grasslands with similar or even higher species richness reported here could still be found elsewhere in the Caucasus region.

Keywords: Armenia, Caucasus, extreme species richness, *Festuco-Brometea*, meadow steppe, plant diversity, traditional farming, vascular plants, vegetation plot

Erweiterte deutsche Zusammenfassung am Ende des Artikels

Manuscript received 15 September 2025, accepted 28 Januar 2026
Published online 23 August 2026
Co-ordinating Editor: Péter Török

1. Introduction

Understanding the ecological and geographical patterns of extremely species-rich plant communities is important for both basic ecological research and nature conservation. Meso-xeric temperate grasslands of the Palaearctic biogeographic realm stand out for their high plant species richness (Biurrun et al. 2021). They include Carpathian meadows in Czechia, Slovakia, Ukraine and Romania (Roleček et al. 2014, 2021, 2025, Chytrý et al. 2015) or Fennoscandian wooded meadows in Estonia (Kull & Zobel 1991, Sammul & Kukk 2013). In contrast, extremely species-rich grassland communities in other regions with diverse flora and well-preserved low-intensity farming have received little attention (Török & Dengler 2018). One such region is the Caucasus, a mountainous area spanning Europe and Asia and lying between the Black and Caspian Seas (Mittermeier et al. 2004). This study describes a species-rich grassland community sampled in the northern part of the Armenian Highlands in Armenia, a landlocked country in the Southern Caucasus. Its flora comprises approximately 3800 vascular plant species and is characterized by significant endemism and high taxonomic diversity (Fayvush 2023). The grassland habitats of the Caucasus and the adjacent parts of the Middle East are particularly diverse. They have a large species pool mainly determined by a long regional history of dry and semi-dry open habitats, complex environmental conditions, and the location at a crossroads of four floristic regions (Ambarlı et al. 2020). Many well-preserved grasslands have survived in the region to the present day, which contrasts the rapid decline of grasslands across Western Eurasia. However, grasslands in the region are seriously threatened, primarily by ongoing land-use changes such as afforestation, overgrazing, or abandonment of traditional pastoral systems (Ambarlı et al. 2020). The phytosociology of Armenian dry grasslands and thorn-cushion communities was investigated by a field expedition of the Eurasian Dry Grassland Group in 2019 (Vynokurov et al. 2024). They reported the highest vascular plant species richness of 74 species of vascular plants on 10 m^2 in a xero-mesic polydominant grassland near the northern shore of Lake Sevan, northern Armenia, at an altitude of 2100 m. In this short contribution, we show that Armenia contains much richer grassland plant communities, which are among the richest globally.

2. Methods

2.1 Study site

We conducted a pilot vegetation sampling of a species-rich meso-xeric grassland near the village of Akner (Alaverdi Community, Lori Province) in the forest zone of northernmost Armenia (Fig. 1). These grasslands have developed on a plateau of Cenozoic andesite-dacite lavas (Fayvush 2023), which is slightly inclined to the northeast. The site is located between the canyons of the Debed River and its right tributary, Acher, 200–300 m above the Debed riverbed, at an altitude of 930–1000 m. The mean annual temperature in the area is ~9 °C. The warmest months are July and August, with a mean temperature of 21 °C, while the coldest month is January, with a mean temperature of -2 °C. Annual precipitation reaches 700 mm, with monthly maxima in May and June and a dry period in August and September (Karger et al. 2017). According to our observations, traditional grassland management, still practiced in this part of the country, often combines hay making and extensive grazing by freely roaming herds of cows. This is likely also the case of the sampled grassland, as we found traces of ongoing cow grazing. We assume this grassland is of secondary origin, having developed on land deforested by humans. This assumption is partly based on climatic characteristics of the region, which

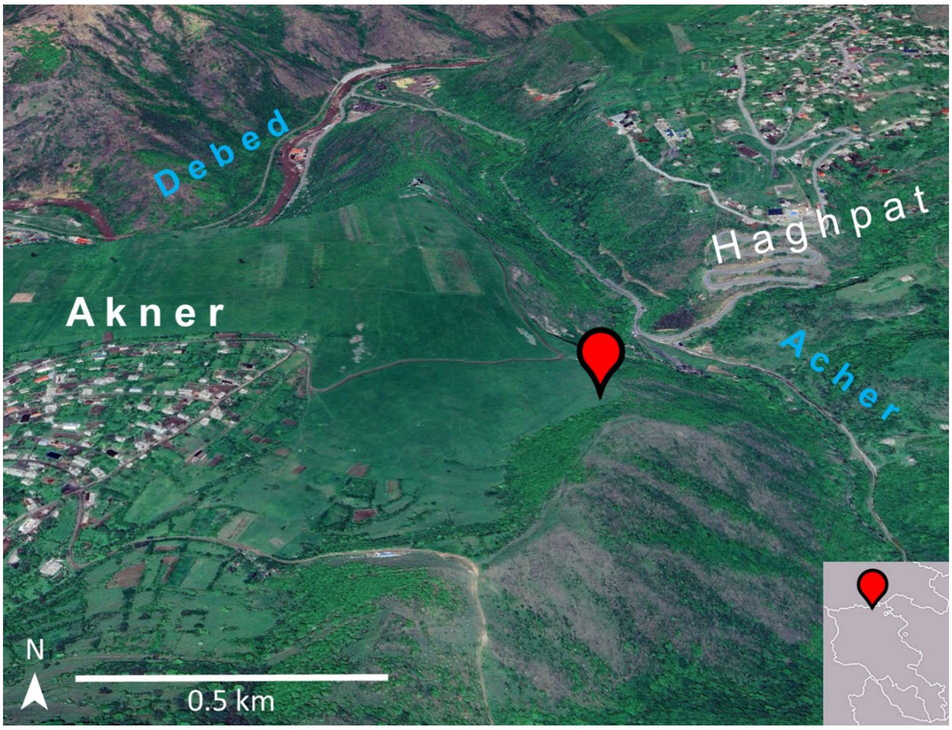

Fig. 1. Location of the sampled grassland (red point) on a plateau above the confluence of the Debed and Acher Rivers near the village of Akner (Image © 2025 Maxar Technologies) and on the map of Armenia (bottom right inset).

Abb. 1. Lage der beprobten Grasfläche (roter Punkt) auf einem Plateau oberhalb des Zusammenflusses der Flüsse Debed und Acher in der Nähe des Dorfes Akner (Bild © 2025 Maxar Technologies) und auf der Karte von Armenien (Ausschnitt unten rechts).

support closed-canopy deciduous forests as the dominant natural habitat (cf. Ambarlı et al. 2020). Meso-xeric Caucasian forests (*Carpinus betulus*, *C. orientalis*, *Fagus orientalis* and *Quercus petraea* subsp. *iberica*), substituted by arid forests and tragacanth formations at the lowest elevations, are considered the potential natural zonal vegetation in the region (Fayvush 2023). At its upper edge, the grassland borders a relatively shady deciduous forest of *Carpinus orientalis*, which is managed as coppice-with-standards, and shrubland with *Cornus mas* and *Crataegus monogyna*. The vigorous growth of trees and shrubs at the unmown edge of this grassland also indicates the site's potential for the development of dense woody vegetation.

2.2 Data sampling and processing

We sampled two nested square plots of 10 m^2 and 25 m^2, delineated with string. We first sampled the smaller plot and then expanded it by extending its sides in directions that maintained the same slope inclination and aspect in the larger plot. Consequently, the plots shared their southwestern corner. Vegetation sampling was carried out on 17 May 2025. We estimated the total percentage cover of the herb and moss layers. Then, we recorded species rooted in each plot and estimated their covers using the Braun-Blanquet nine-degree cover-abundance scale (Dengler et al. 2008). To characterize basic soil properties, we took four subsamples of 15 cm of topsoil from four locations in the 10 m^2 plot and mixed them. After drying, the sample was sieved through a 2 mm mesh. Then, we measured its pH and conductivity in a suspension with deionized water (soil:water ~2:5) using the portable instrument Hach

HQ40D. We recorded the geographic position (WGS84) using a GPS and took several photographs of the plots from various angles. Sampling was conducted at the phenological optimum for most species, with vernal annuals and geophytes still detectable. The work took three and a half hours of intensive effort by four field botanists skilled in grassland vegetation sampling. The plot records were stored in the Transcaucasian Vegetation Database (Novák et al. 2023). The compendium Flora of the USSR (Kirpicznikov 1969) served as the primary source of data on species distribution, biology and ecology. Taxonomic nomenclature was harmonized according to Euro+Med (2025). Syntaxon names are accompanied by author citations to avoid misinterpretations.

3. Results

We found a grassland with very high fine-scale species richness of vascular plants. This grassland adjoins the village of Akner to the east (Fig. 1), while open habitats to the south and west of the village are poorer in species, likely due to higher grazing intensity. The records from two nested plots in this grassland are presented in Table 1 (see also Fig. 2).

Both plots lacked distinct dominant species, while dicot herbs predominated. The most abundant species did not exceed a cover grade of 2a (5–15%) and were identical in both nested plots. These included the perennials *Cruciata laevipes*, *Pedicularis sibthorpii* and *Primula veris* subsp. *macrocalyx*. Common grassland generalists included *Plantago lanceolata*, *P. media*, *Schedonorus pratensis*, *Trifolium pratense* and *Trisetum flavescens*. The presence of root holoparasites and hemiparasites was conspicuous. Besides *Pedicularis sibthorpii*, *Melampyrum* sp., *Orobanche lutea*, *Rhinanthus subulatus* and *Thesium ramosum* also occurred in the plots. Numerous recorded species were therophytes and winter annuals (e.g. *Holosteum umbellatum*, *Noccaea perfoliata*, *Veronica arvensis*). Regarding moisture requirements, the species composition consisted mainly of xero-mesophytes (e.g. *Fragaria viridis*, *Geranium sanguineum*, *Salvia verticillata*) and mesophytes (e.g. *Campanula rapunculoides*, *Cruciata laevipes*, *Schedonorus pratensis*), while true xerophytes (e.g. *Ranunculus illyricus*) were scarce. The site was on a gentle northeast-facing slope, which was less dry than the nearby steeper, southeast-facing slopes. However, the arid summer period probably supports drought-tolerant species. From a biogeographic perspective, Caucasian endemics and species with a core range in the Caucasus included the herbs, such as *Campanula alliariifolia*, *C. oblongifolia*, *Pedicularis sibthorpii*, *Trifolium canescens*, *T. tumens* and *Veronica multifida*. We did not find any non-native species (according to the Euro+Med 2025 data for Armenia) in the plots or their immediate vicinity, indicating a relatively well-preserved environment.

To place the sampled grassland within the context of the Eurasian dry grassland vegetation classification scheme, we propose its phytosociological assignment to the class *Festuco-Brometea* Br.-Bl. et Tx. ex Soó 1947 and the order *Brachypodietalia pinnati* Korneck 1974. As the vegetation contains numerous characteristic Euro-Siberian species, whereas members of the Caucasian floristic element are less abundant, we prefer this classification over assignment to the ecologically similar order *Plantagini atratae-Bromopsietalia variegatae* Vynokurov et al. 2024, which includes high-mountain meso-xeric grasslands of the Caucasus (Vynokurov et al. 2024). Regarding the alliance, the grassland presumably falls within the variability of *Cirsio-Brachypodion pinnati* Hadač et Klika in Klika et Hadač 1944.

Table 1. Two nested vegetation plots recorded in Armenia.

Tabelle 1. Zwei ineinander verschachtelte Vegetationsaufnahmen in Armenien.

Akner (Lori Province): grassland in a complex of pastures and meadows between the SE edge of the village and the Acher River gorge, 1.4 km SW of the Haghpat Monastery. 41.08325° N, 44.70253° E, GPS location uncertainty ± 2 m, altitude: 960 m a.s.l., slope inclination: 14°, slope aspect: 350°, soil pH: 7.83, soil conductivity: 432 µS.cm^{-1}, date: 17/05/2025, authors: Pavel Novák, Milan Chytrý, Pavel Dřevojan, Daniel Szokala. Transcaucasian Vegetation Database plot IDs: 13726 (10 m^2) and 13747 (25 m^2).

*Caucasian endemics and taxa with a core range in the Caucasus (not indicated for species with uncertain identification: "cf.")

Beyond the boundaries of the larger plot, but still within the sampled vegetation type, we also observed *Carex humilis*, *Nepeta betonicifolia*, *Veronica gentianoides*, *Vicia abbreviata* and *Vinca herbacea*.

	Plot area (m^2)		10	25
	Cover of the herb layer (%)		90	90
	Cover of the moss layer (%)		5	5
	Number of vascular plant species		90	104
1	*Cruciata laevipes*	Hemicryptophyte	2a	2a
2	*Pedicularis sibthorpii*	perennial root hemiparasite	2a	2a
3	*Primula veris* subsp. *macrocalyx*	rosette perennial herb	2a	2a
4	*Poa angustifolia*/*pratensis*	perennial graminoid	2m	2m
5	*Achillea millefolium* aggr.	perennial herb	1	1
6	*Fragaria viridis*	perennial herb	1	1
7	*Medicago sativa*/×*varia*	perennial herb	1	1
8	*Plantago media*	rosette perennial herb	1	1
9	*Rhinanthus subulatus**	annual root hemiparasite	1	1
10	*Salvia verticillata*	perennial herb	1	1
11	*Campanula rapunculoides*	perennial herb	1	+
12	*Schedonorus pratensis*	perennial graminoid	1	+
13	*Cerinthe glabra*	perennial herb	r	1
14	*Agrimonia eupatoria*	perennial herb	+	+
15	*Ajuga genevensis*	rosette perennial herb	+	+
16	*Alyssum alyssoides*	therophyte	+	+
17	*Arabis auriculata*	therophyte	+	+
18	*Arenaria serpyllifolia*	therophyte	+	+
19	*Briza media* subsp. *elatior*	perennial graminoid	+	+
20	*Buglossoides incrassata* subsp. *splitgerberi*	therophyte	+	+
21	*Campanula oblongifolia**	perennial herb	+	+
22	*Carex caryophyllea*	perennial graminoid	+	+
23	*Carex flacca* subsp. *serrulata*	perennial graminoid	+	+
24	*Carex michelii*	perennial graminoid	+	+
25	*Carex tomentosa*	perennial graminoid	+	+
26	*Cerastium purpurascens**	hemicryptophyte	+	+
27	*Cichorium intybus*	rosette perennial herb	+	+
28	*Convolvulus arvensis*	hemicryptophyte	+	+
29	*Crepis marschallii**	biennial herb	+	+
30	*Crepis sancta*	therophyte	+	+
31	*Dactylis glomerata*	perennial graminoid	+	+
32	*Draba nemorosa*	therophyte	+	+
33	*Elytrigia repens*	stoloniferous graminoid	+	+

34	*Falcaria vulgaris*	perennial herb	+	+
35	*Gagea* sp.	bulbous perennial	+	+
36	*Galium album*	hemicryptophyte	+	+
37	*Geranium columbinum*	therophyte	+	+
38	*Geranium sanguineum*	hemicryptophyte	+	+
39	*Gladiolus* cf. *caucasicus*	tuberous perennial	+	+
40	*Holosteum umbellatum*	therophyte	+	+
41	*Inula aspera*	hemicryptophyte	+	+
42	*Koeleria albovii* subsp. *caucasica**	perennial graminoid	+	+
43	*Leontodon hispidus*	hemicryptophyte	+	+
44	*Leucanthemum vulgare*	hemicryptophyte	+	+
45	*Lotus corniculatus*	perennial herb	+	+
46	*Muscari armeniacum*	geophyte	+	+
47	*Myosotis* cf. *ramosissima*	therophyte	+	+
48	*Neslia paniculata*	therophyte	+	+
49	*Noccaea perfoliata*	therophyte	+	+
50	*Onobrychis* sp.	perennial herb	+	+
51	*Orobanche lutea*	parasite	+	+
52	*Physospermum cornubiense*	perennial herb	+	+
53	*Picris hieracioides*	hemicryptophyte	+	+
54	*Plantago lanceolata*	hemicryptophyte	+	+
55	*Poaceae* sp.	graminoid	+	+
56	*Potentilla divaricata*	perennial herb	+	+
57	*Ranunculus illyricus*	hemicryptophyte	+	+
58	*Ranunculus polyanthemos*	hemicryptophyte	+	+
59	*Rosa* sp.	juvenile shrub	+	+
60	*Rubus* subgen. *Rubus*	perennial herb	+	+
61	*Rumex tuberosus*	bulbous herb	+	+
62	*Salvia nemorosa*	rosette perennial herb	+	+
63	*Sanguisorba minor*	rosette perennial herb	+	+
64	*Scabiosa bipinnata**	rosette perennial herb	+	+
65	*Securigera varia*	hemicryptophyte	+	+
66	*Seseli peucedanoides*	perennial herb	+	+
67	*Stachys atherocalyx/iberica*	hemicryptophyte	+	+
68	*Taraxacum* sp.	rosette perennial herb	+	+
69	*Teucrium chamaedrys*	dwarf shrub	+	+
70	*Thesium ramosum*	perennial root hemiparasite	+	+
71	*Tragopogon* sp.	perennial herb	+	+
72	*Trifolium canescens**	perennial herb	+	+
73	*Trifolium medium*	perennial herb	+	+
74	*Trifolium pratense*	perennial herb	+	+
75	*Trifolium repens*	perennial herb	+	+
76	*Trifolium tumens*	perennial herb	+	+
77	*Trisetum flavescens*	perennial graminoid	+	+
78	*Verbascum* sp.	biennial rosette herb	+	+
79	*Veronica arvensis*	therophyte	+	+
80	*Veronica chamaedrys*	hemicryptophyte	+	+
81	*Veronica multifida*	hemicryptophyte	+	+
82	*Carpinus orientalis*	juvenile tree	r	+
83	*Cirsium* cf. *ciliatum*	hemicryptophyte	r	+

84	*Allium* sp.	bulbous herb	r	r
85	*Lamium purpureum*	therophyte	r	r
86	*Melampyrum* sp.	root hemiparasite	r	r
87	*Papaver commutatum*	therophyte	r	r
88	*Quercus petraea* subsp. *iberica*	juvenile tree	r	r
89	*Ranunculus breyninus*	hemicryptophyte	r	r
90	*Valeriana officinalis*	hemicryptophyte	r	r
91	*Brachypodium pinnatum*	graminoid	.	+
92	*Campanula alliariifolia**	hemicryptophyte	.	+
93	*Carduus* cf. *hamulosus*	hemicryptophyte	.	+
94	*Crataegus monogyna*	juvenile shrub	.	+
95	*Filipendula vulgaris*	hemicryptophyte	.	+
96	*Pimpinella* cf. *saxifraga*	hemicryptophyte	.	+
97	*Polygala anatolica*	hemicryptophyte	.	+
98	*Potentilla recta*	hemicryptophyte	.	+
99	*Valerianella dentata*/*rimosa*	therophyte	.	+
100	*Viola odorata*	hemicryptophyte	.	+
101	*Cornus mas*	juvenile shrub	.	r
102	*Erigeron acris*	hemicryptophyte	.	r
103	*Pyrus communis* subsp. *caucasica**	juvenile tree	.	r
104	*Thalictrum minus*	hemicryptophyte	.	r
1	*Abietinella abietina*	bryophyte	1	1
2	*Plagiomnium cuspidatum*	bryophyte	1	1
3	*Brachythecium rutabulum*	bryophyte	+	+
4	*Bryum* sp.	bryophyte	+	+

Fig. 2. a) The species-rich grassland recorded in our nested plots in the foreground, and relatively intensively managed meadows and pastures, with yellow patches of blooming *Bunias orientalis* in the background, near the village of Akner (Photo: P. Novák, 17/05/2025). **b)** Close-up of the sampled grassland with flowering *Ajuga genevensis*, *Pedicularis sibthorpii*, *Polygala anatolica* and *Veronica chamaedrys* (Photo: M. Chytrý, 17/05/2025).

Abb. 2. a) Im Vordergrund die artenreiche Graslandschaft unserer verschachtelten Probeflächen, im Hintergrund relativ intensiv bewirtschaftete Wiesen und Weiden mit gelben Blütenständen von *Bunias orientalis*) nahe des Dorfes Akner (Foto: P. Novák, 17.05.2025). **b)** Nahaufnahme der beprobten Graslandschaft mit blühendem *Ajuga genevensis*, *Pedicularis sibthorpii*, *Polygala anatolica* und *Veronica chamaedrys* (Foto: M. Chytrý, 17.05.2025).

4. Discussion

4.1 Determinants of the extraordinary species richness

We hypothesize that the high fine-scale species richness in the studied grassland is determined by a specific combination of mutually interconnected factors, as in Carpathian species-rich grasslands (Merunková et al. 2012, Roleček et al. 2014, 2021, Fajmonová et al. 2020). Regional factors include the unusually species-rich flora of the southern part of the Caucasus biodiversity hotspot (Fayvush 2023), which is associated with a large pool of species of dry and semi-dry open habitats (Ambarlı et al. 2020). Steppes have been identified as the most species-rich of all Armenian habitats and have the highest level of vascular plant endemism (Fayvush & Ghukasyan 2023). The regional climate in northeastern Armenia is relatively mild and favourable for closed-canopy forests, as the area receives more than 500 mm of annual precipitation (cf. Ambarlı et al. 2020). Landscape factors include a relatively fine-grained mosaic of various habitats such as forests, pastures, ruderal habitats and scrub patches near the studied grassland. Such fine-grained heterogeneity generally enhances the coexistence of metapopulations of numerous species with contrasting ecological requirements, and individual habitat patches may serve as sources of propagules to enrich nearby grasslands (Merunková et al. 2012). A combination of different low-intensity agricultural activities at one site (here cattle grazing and probably also hay-making) supports plant species diversity (Janišová et al. 2025). The abiotic site factors were found to be moderate (non-extreme), enhancing the co-existence of species from multiple ecological groups. The adverse effects of summer drought are probably mitigated by the position of the grassland on the northeast-facing slope. A positive correlation between soil humidity and species richness of semi-dry grasslands was demonstrated by Fajmonová et al. (2020), who explained that higher soil moisture in such grasslands facilitates the coexistence of species with various water requirements. Soil pH in the sampled plots was slightly alkaline, but the measured value is non-extreme in open vegetation, i.e., not causing serious macronutrient deficiency to plants, although soil phosphorus availability might be limiting in such conditions (Läuchli & Grattan 2012). Nevertheless, the European species pool of plants tolerant to base-rich soils is larger than that of plants tolerant to acidic soils (Tichý et al. 2023). The presence of several species of root parasites in the plots could also be pivotal, as species with this trophic mode are often considered keystone species in species-rich grasslands due to their ability to suppress dominants and thus promote the local co-existence of multiple species (Těšitel et al. 2021). Numerous recorded annuals presumably benefit from low-intensity grazing, which disturbs the topsoil and exposes the mineral soil necessary for their establishment (Janišová et al. 2025).

4.2 Species richness of the Akner grassland in the Palaearctic context

The Akner grassland is among the most species-rich grassland plant communities in the entire Palaearctic (Fig. 3). Higher species richness of vascular plants in Palaearctic grasslands has so far only been recorded in the steppes near Kursk in the western part of European Russia and in the Carpathian region. However, the extremely high species counts in the Streletskaya Steppe near Kursk were last recorded in the early 1960s (Golubev 1962, Redulesku-Ivan 1965), whereas more recent vegetation survey (Zolotukhina & Zolotukhin 2012) from the same area report far fewer species than in the Akner grassland.

Currently, the richest known Palaearctic grasslands are the meso-xeric *Brachypodio pinnati-Molinietum arundinaceae* Klika 1939 meadows in the peri-Carpathian forest-steppe, specifically in the White Carpathians in the Czech Republic, in western Ukraine and in the Transylvanian Basin in Romania (Roleček et al. 2025). Another site with a higher richness than the Akner grassland is the Kopanecké meadows in the Slovak Paradise in the Western Carpathians (Chytrý et al. 2015). Possibly higher richness may occur in Estonian wooded meadows, such as at the Laelatu site. However, high counts of vascular plants in Estonia have only been recorded in areas of 1 m^2 or smaller (Kull & Zobel 1991, Sammul & Kukk 2013), while larger plots have rarely been sampled there. All other Palaearctic grasslands with reliable records of species richness are poorer than the Akner grassland. The highest recorded values from Ukraine (Buzhdygan et al. 2025) are close to the species counts from Akner, but the richest grasslands in the Ukrainian steppe zone (Borovyk et al. 2024) are significantly poorer. The highest values found in an extensive review for the Czech Republic and Slovakia outside the exceptionally rich sites in the White Carpathians and Kopanecké meadows are also much poorer (Chytrý et al. 2015).

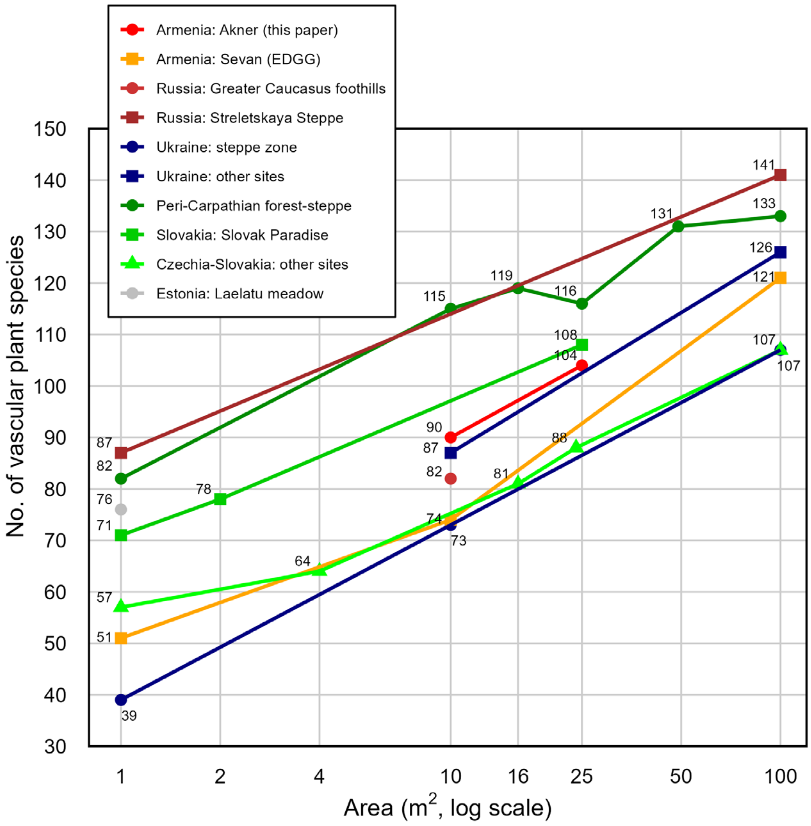

Fig. 3. Highest regional numbers of vascular plant species recorded in the Western Palaearctic in plots of 1 to 100 m^2 (see Section 4.2 for details) compared with the values for the Akner grassland.

Abb. 3. Die höchsten regionalen Anzahlen von Gefäßpflanzenarten in der Westpaläarktis auf Probeflächen von 1 bis 100 m² (siehe Abschnitt 4.2 für Details) im Vergleich zu den Werten für das Akner-Grasland.

High species richness has also previously been reported from Armenian grasslands, particularly in the Lake Sevan area, based on data from a field workshop of the Eurasian Dry Grassland Group (EDGG) (Aleksanyan et al. 2020). These data were also published in the synthetic overview of Palaearctic grassland species richness by Biurrun et al. (2021), where an alleged Palaearctic record of 144 vascular plant species in 100 m^2 and a record for the "Dry Midlatitudes" region of 80 vascular plant species in 10 m^2 were published (Tables 2 and S5.1 in Biurrun et al. 2021). However, these records were incorrect, as the counts included several species recorded under more than one provisional name (I. Biurrun and D. Vynokurov, pers. commun. 2025). After data cleaning, the actual number of vascular plant species decreased to 121 per 100 m^2 and 74 per 10 m^2 (the latter figure was published by Vynokurov et al. 2024). Although these values are significantly lower than the species counts from the Akner grassland, they still fall within the uppermost quantiles of species numbers observed in Palaearctic grasslands (Biurrun et al. 2021), suggesting that extremely species-rich grasslands can also be found at other sites in northern Armenia or the neighbouring part of Georgia. Another report of very high fine-scale species richness from the Caucasus region was published by Vynokurov et al. (2021), who recorded 82 species of vascular plants in a 10 m^2 plot in the northern foothills of the Greater Caucasus in Russia.

5. Concluding remarks

Extremely species-rich grasslands managed at low intensity are among high nature value grasslands and are identified as biodiversity hotspots (Veen et al. 2009). Their comprehensive ecological research is therefore crucial for effective nature conservation. We point out that such plant communities also occur in the Caucasus region, where they can be considered "a hotspot within a hotspot". Among the international community of ecologists, the region is renowned for its alpine and subalpine biodiversity (Mittermeier et al. 2004, Fayvush 2023), while ecosystems at lower elevations remain relatively understudied. Especially in view of the ongoing deterioration of habitat quality, these grasslands require urgent and comprehensive study and conservation. Otherwise, their astonishing biodiversity might soon vanish without being adequately explored. Like other temperate Palaearctic grasslands (Török & Dengler 2018), potential threats include land-use changes such as abandonment and the subsequent spread of highly competitive generalists, overgrazing, or ploughing and conversion to arable land (Fayvush 2023).

Erweiterte deutsche Zusammenfassung

Einleitung – Das Verständnis der ökologischen und geographischen Muster extrem artenreicher Pflanzengemeinschaften, wie etwa paläarktischer meso-xerischer Graslandschaften, ist sowohl für die ökologische Grundlagenforschung als auch für den Naturschutz von zentraler Bedeutung (Biurrun et al. 2021). Der Biodiversitäts-Hotspot Kaukasus (Westeurasien) ist bekannt für seine außergewöhnlich artenreiche Flora und Fauna (Fayvush 2023). Einige Aspekte der lokalen Biodiversität, darunter die Artenvielfalt der dortigen Graslandschaften, sind jedoch noch unzureichend erforscht. Ziel dieser Studie ist es, die extrem hohe Artenvielfalt von Gefäßpflanzen in einer Graslandschaft im nördlichen Armenien (Südkaukasus) zu dokumentieren und deren Ursprung sowie Stellung im paläarktischen Kontext zu diskutieren.

Methoden – Am 17. Mai 2025 führten wir eine Pilot-Vegetationserhebung auf einem meso-xerischen Grasland in der Nähe des Dorfes Akner (Provinz Lori) in der Waldzone im nördlichsten Armenien durch. Der Untersuchungsstandort (960 m ü. NN) zeichnete sich durch eine mittlere Jahrestemperatur von ca. 9 °C und eine jährliche Niederschlagsmenge von 700 mm aus. Die Bewirtschaftung umfasste extensive Rinderweide und Heugewinnung. Wir erfassten zwei quadratische, ineinander verschachtelte Probeflächen (10 m² und 25 m²) nach der Braun-Blanquet-Methode. Die Deckung der Pflanzenarten, sowohl Gefäßpflanzen als auch Moose, wurde anhand der neunstufigen Deckungs-Abundanz-Skala (Dengler et al. 2008) bestimmt. Zusätzlich wurde eine Bodenprobe zur Messung von pH-Wert und Leitfähigkeit entnommen. Die Probeflächen wurden in der Transkaukasischen Vegetationsdatenbank (Novák et al. 2023) gespeichert.

Ergebnisse und Diskussion – In den untersuchten Probeflächen wurden 90 (10 m²) bzw. 104 (25 m²) Gefäßpflanzenarten erfasst. Keine Art dominierte eindeutig, und zweikeimblättrige Pflanzen überwogen. Die Arten mit den höchsten Deckungsgraden (2a, d. h. 5–15 %) waren in beiden Flächen identisch: *Cruciata laevipes*, *Pedicularis sibthorpii* und *Primula veris* subsp. *macrocalyx*. Weitere Artengruppen umfassten Grasland-Generalisten (z. B. *Plantago lanceolata*, *Trifolium pratense*), Xero-Mesophyten (*Fragaria viridis*, *Salvia verticillata*), Wurzelparasiten (z. B. *Orobanche lutea*, *Rhinanthus subulatus*) und Therophyten (z. B. *Holosteum umbellatum*, *Noccaea perfoliata*). Es wurden keine Neophyten gefunden, was auf ein relativ gut erhaltenes Ökosystem hindeutet. Der pH-Wert (7,83) und die Leitfähigkeit (432 $\mu S \cdot cm^{-1}$) des Bodens wiesen auf nicht extreme Bedingungen hin; dasselbe galt für die Kombination aus Hangneigung (14°) und Exposition (350°). Wir schlagen eine pflanzensoziologische Zuordnung zur Klasse *Festuco-Brometea* Br.-Bl. et Tx. ex Soó 1947 (Ordnung *Brachypodietalia pinnati* Korneck 1974) vor.

Wir vermuten, dass die hohe Artenvielfalt im untersuchten Grasland auf einer spezifischen Kombination sich gegenseitig beeinflussender Faktoren beruht. Zu den regionalen Faktoren zählt die ungewöhnlich artenreiche Flora des südlichen Teils des Biodiversitäts-Hotspots Kaukasus, wobei Grasland an erster Stelle steht (Fayvush 2023). Landschaftliche Faktoren umfassen ein relativ feinmaschiges Mosaik verschiedener Lebensräume in der Nähe des untersuchten Graslands sowie eine extensive, traditionelle Bewirtschaftung. Beide wurden als Merkmale identifiziert, die die Artenvielfalt einer Pflanzengemeinschaft fördern (Merunková et al. 2012). Die abiotischen Standortfaktoren erwiesen sich als moderat und begünstigten Arten aus verschiedenen ökologischen Gruppen. Die nachgewiesenen Wurzelparasitenarten könnten die lokale Koexistenz mehrerer Arten zusätzlich fördern (Těšitel et al. 2021). Das Akner-Grasland gehört zu den artenreichsten Grasland-Pflanzengemeinschaften der gesamten Paläarktis. Eine höhere Artenvielfalt an Gefäßpflanzen in paläarktischen Graslandschaften wurde bisher nur im westlichen Teil des europäischen Russlands und in der Karpatenregion nachgewiesen (Roleček et al. 2025). Wir schließen daraus, dass vergleichbar artenreiche Pflanzengesellschaften auch im Kaukasus vorkommen, wo sie als „Hotspot innerhalb eines Hotspots“ betrachtet werden können und weiterer umfassender Forschung bedürfen.

Acknowledgements

We thank Denys Vynokurov, Idoia Biurrun and Dariia Borovyk for providing details on species-rich grassland plots recorded in Armenia by the Eurasian Dry Grassland Group, Marcela Růžičková for measuring soil properties, and Jiří Danihelka, Eva Mikulášková and Renata Piwowarczyk for plant identification. The research was supported by the Czech Science Foundation project no. GA25-15235S.

Author contributions

PN and MC conceived the research idea, PN led the writing, MC prepared the overview of the most species-rich Palaearctic grassland plots, PN, MC, DS and PD participated in the field sampling, and GF provided the regional background for the research. All authors critically revised the manuscript.

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