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PLAGIOMNIUM DRUMMONDII (BRUCH ET SCHIMP.) T. J. KOP. – A NEW SPECIES OF MOSS FOR THE FLORA OF UKRAINE

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Background. *Plagiomnium drummondii* (Bruch et Schimp.) T. J. Kop. belongs to *Mniaceae* Schwägr.: section *Plagiomnium* T. J. Kop. This Holarctic hemiboreal species has a wide range but is rare in most regions. It is widespread in North America and is very rare in Europe (south-eastern Finland, southern Latvia, Serbia, northern and central parts of European Russia). The main limiting factors of distribution are the low competitiveness, the reduction of areas of ancient forests and the general climate change.

Materials and Methods. The moss sample was found on the territory of the “Roztochchya” Nature Reserve, on the site of a 40-year-old felling of the Stradch Educational and Production Forestry Plant (Yavorivskyi District, Lviv Region). The species of moss was identified using appropriate descriptions and keys. Morphometric analysis of plants (length of shoots and setae, sizes of leaves and capsules) was performed on the stereo binocular “Stemi 2000-C” (Carl Zeiss). The size of leaf cells and spores was determined using the Motorized Fluorescence Microscope Axio Imager M1 (Carl Zeiss).

Results. The first record of a new moss species, *Plagiomnium drummondii* (Bruch et Schimp.) T. J. Kop. has been reported for the flora of Ukraine. Short morphological characteristics, differences from similar typical forest moss species *Plagiomnium cuspidatum* (Hedw.) T. J. Kop., ecological peculiarities, geographical distribution, and original illustrations of moss gametophyte and sporophyte from the Ukrainian sample are provided. Important morphological traits by which the moss *P. drummondii* was identified were based on the following features of the gametophyte: leaf shape and size, presence of teeth on the leaf margin, the shape of the mid-leaf cells and thickening of their walls, as well as on the features of the sporophyte such as the orientation of seta, the shape of the capsule and availability of papillae on spores.



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Conclusions. *P. drummondii* cannot be unequivocally removed from the bryoflora of continental Europe; further studies of the identified moss specimens and the search for new localities are necessary. The identified moss samples are stored in the bryological herbarium of the Institute of Ecology of the Carpathians, NAS of Ukraine (LWKS).

Keywords: bryophytes, new record, *Plagiomnium drummondii*, “Roztochchya” Nature Reserve

INTRODUCTION

During the collection of bryophytes (July 13, 2023) on the territory of the “Roztochchya” Nature reserve, namely on the site of a 40-year-old felling of the Stradch Educational and Production Forestry Plant, our attention was drawn to turf mosses, habitually similar to *Plagiomnium* T. J. Kop., but with bright yellow-green color and thickened gametangia at the top of numerous fertile shoots. Loose moss turfs grew on rotten wood among other mosses: mesoeutrophic mesophyte *Brachythecium rutabulum* (Hedw.) Schimp. and a slight admixture of the mesotrophic mesophyte *B. velutinum* (Hedw.) Ignatov & Huttunen., under the canopy of *Pinus sylvestris* L. on the forest meadow. On the surface of the *Plagiomnium drummondii* (Bruch et Schimp.) T. J. Kop. moss turf were many separate setae of sporogonium with or without capsules. The capsules were ripe, without lids, open, with a peristome and spores, often with germinated spores, or empty without a peristome.

According to T. Koponen (Koponen, 1968, 2017; Koponen & Sun, 2016), the moss family Mniaceae includes 74 species + *Cinclidium minutifolium* Broth. worldwide, thus being one of the largest families of mosses and one of the most studied families regarding chromosome numbers, the cytotaxonomic study of haploid-diploid species pairs, and structural features (Koponen, 2019). Moreover, this number will likely increase as new species continue to be recognized (Koponen & Sun, 2016; Wyatt, 2021; Wyatt *et al.*, 2021; Müller & Koponen, 2022). Plants of this acrocarpous family are generally large compared to most other mosses and have broad leaves whose margins may be entire or toothed and whose laminal cells are short-elongate or isodiametric, frequently hexagonal and angular (McIntosh & Newmaster, 2014).

Plagiomnium drummondii (Bruch et Schimp.) T. J. Kop. [*Mnium drummondii* Bruch & Schimp., 1843; *Astrophyllum Drummondii* Lindb., 1879; *Orthomnion drummondii* (Bruch & Schimp.) T. J. Kop. & Yu Sun, 2017] belongs to Mniaceae Schwägr.: *Plagiomnium* T. J. Kop. [*Orthomnion* Wils.] section *Plagiomnium*). This moss species most resembles *P. japonicum* (Lindb.) T. J. Kop., both being larger and having larger teeth on leaf margin than three other species of the section: *P. acutum* (Lindb.) T. J. Kop., *P. floridanum* R. E. Wyatt & Odrzyk. and *P. cuspidatum* (Hedw.) T. J. Kop. (Koponen, 2019). Based on the number of chromosomes, they are likely not a dioicous – monoicous species pair. According to R. Wyatt and I. J. Odrzykoski (1998) “*P. japonicum* is genetically most similar to *P. drummondii*, but these species are highly genetically distinctive from all other species”.

This study aims to report on the first find of *P. drummondii* in Ukraine, indicating the characteristic peculiarities of the Ukrainian material and similar and distinctive features that make it possible to identify moss species and distinguish them from related species.

MATERIALS AND METHODS

Determination of bryophyte samples was carried out according to literary sources (Nyholm, 1954; Koponen, 1968). The names of moss species are presented following the latest sources (Virchenko & Nyporko, 2022).

Morphological examinations were carried out using a light microscope “Primo Star” (Carl Zeiss), stereo binocular “Stemi 2000-C” (Carl Zeiss) with a photo attachment, and a “Nikon Coolpix” digital camera.

Morphometric analysis of plants. Measuring of the shoots' length, the size of the leaves and their cells was performed on the Motorized Fluorescence Microscope Axio Imager M1 (Carl Zeiss) using the Carl Zeiss AxioVision 4.6 software and UTHSCSA Image Tool 3.0i and the stereo binocular Stemi 2000-C. Important morphological traits by which the moss *P. drummondii* was identified, were based on the following gametophytic features such as leaf shape and size, presence of teeth on the leaf margin, the shape of the mid-leaf cells and thickening of their walls, and sporophytic features such as orientation of seta of the sporogonium, capsule form and availability of papillae on spores.

Field water capacity in samples was calculated as the fresh weight of the sample minus dry weight divided by dry weight and expressed as a percentage. Temperatures of air, moss turf, and the substrate's 0–3 cm top layer were measured with mercury thermometers. The habitat's light intensity was fixed with a lux meter U116. Forest canopy cover was defined as the proportion of the forest covered by the vertical projection of the tree crowns.

RESULTS AND DISCUSSION

On the territory of the felled beech-oak forest with a plantation of *Pinus sylvestris* and *Red oak* (*Quercus rubra* L.) self-seeding, the following indicators of microclimatic conditions for the habitat of moss *P. drummondii* were determined: air temperature above the moss turf – +36.0 °C to +39.0 °C, turf temperature – +30.0 °C to +33.0 °C, air humidity above the turf – 22 %, field humidity of shoots – 3.4 %, soil moisture capacity under moss turf – 3.9 %, crown density – 0.4–0.5, light intensity – 80–100 thousand lux. Coordinates of location: 49°40'N; 82°14'E.

The results of the study of the anatomical and morphological features of the moss showed that although their leaves are toothed from the middle to the tip, like those of *P. cuspidatum*, which is common throughout Ukraine, they differ from it in a number of features, notably, by the shiny, light green color of loose turf with upright shoots, while the turf of *P. cuspidatum* is dark green and matte (**Table, Fig. 1A**).

The round-ovate leaves of *P. drummondii* are slightly wavy in the dry state, almost flat when wet (**Fig. 1A–E**). Only the larger leaves are rosette-shaped at the top of the fertile shoots; the cells are uniformly thickened and hexagonal (**Figs 1E, 2C–D**). In *P. cuspidatum*, the leaves are inverted-ovate, almost elliptic to spatulate, dry, and strongly wavy. The leaves of fertile shoots are only slightly larger than the sterile leaves, and their cells are round-hexagonal, thickened at the corners, and much smaller. *P. drummondii* is a monoecious species, synecium or heteroecium bisexual type – the perigonium forms at the top of a lateral branch of a synecial plant (**Fig. 1C–F**).

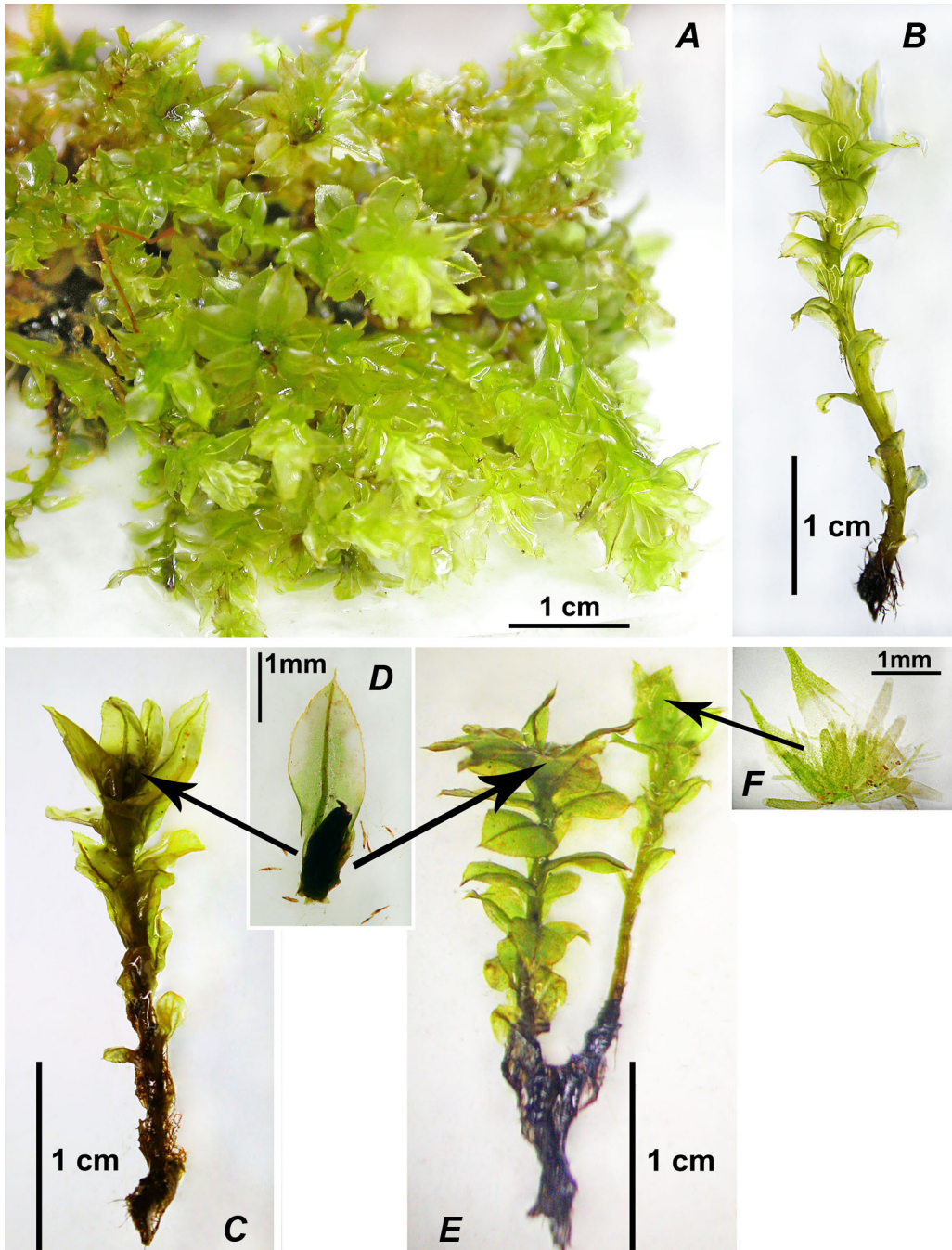


Fig. 1. Turf, sterile and fertile shoots of moss *Plagiomnium drummondii*: **A** – shiny, yellow-pale-green turf; **B** – orthotropic sterile shoot with macronema at stem base; **C** – an erect fertile plant with synoicous gametangium; **D** – gametangium including mixed archegonia and antheridia; **E** – a fertile plant with gynoecious type of monoicy – syneocium and perigonium on the same shoot; **F** – perigonium with antheridia

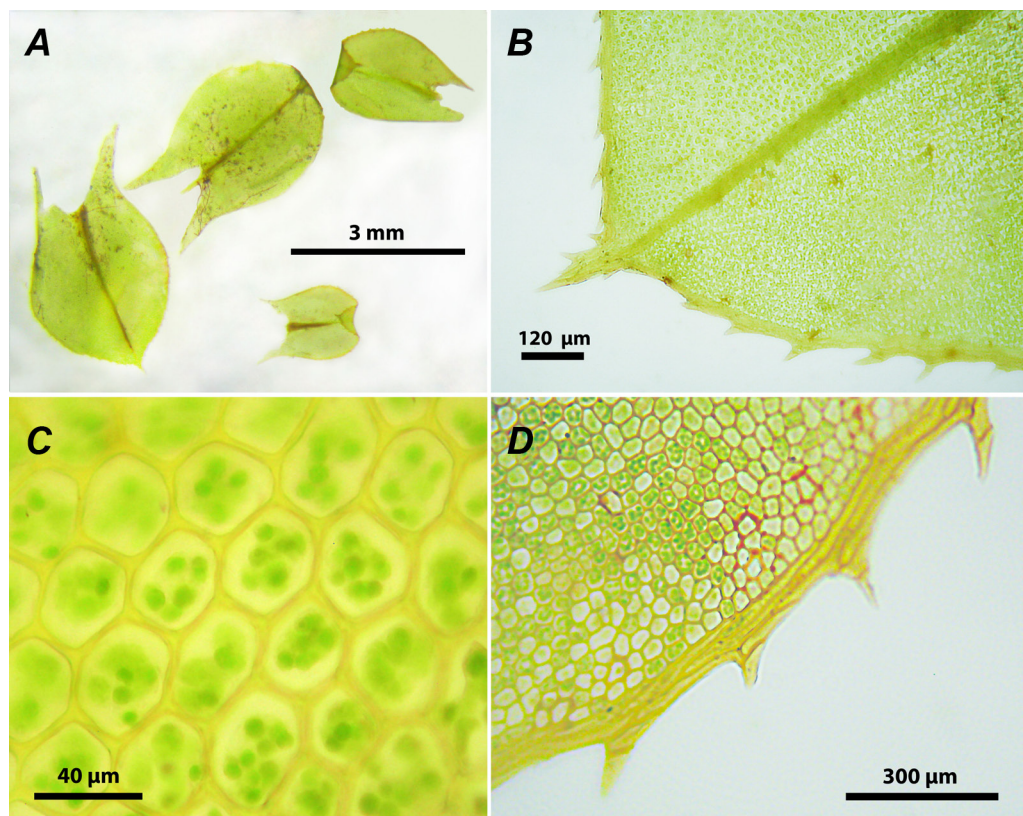


Fig. 2. Morphological features of leaves of *Plagiomnium drummondii*: **A** – leaves from the middle and lower parts of the stem with a long decurrent base; **B** – a nerve ending in the apex of the upper leaf; **C** – hexagonal mid-leaf cells; **D** – leaf margin with unistratose, yellowish border, sharply denticulate

Moss turfs of *P. drummondii* are loose, shiny, bright green and yellow-green, felt at the base. Sterile shoots are mostly erect, 2.5–6.0 cm long; fertile shoots are straight and 2–4 cm long (**Fig. 1B–C, E**). Leaves are round-ovate, 2.5–4 – 1.8–2.5 mm long, slightly wavy when dry, almost flat when wet, and densely placed on fertile shoots. Only at the apex of the stem the larger leaves are rosette-like and crowded, predominantly broadly decurrent and long-decurrent (**Fig. 2A**). The leaf plate is pointed, sometimes rounded; along the margin with a clear, single-layered yellowish border with 2–3 rows of longitudinally rectangular cells, strongly toothed from the apex to the middle; the teeth are sharp, shiny, of 1–2(3) cells (**Fig. 2B, D**). The nerve is powerful, brown-green, and ends at the tip of the leaf or before it (**Figs 1D, 2A–B**). The leaf cells are hexagonal, isodiametric or short-elongated, uniformly thickened, approximately 40–43 μm, much smaller towards the margin (**Fig. 2C–D**). The seta of the sporogonium is about 1.5–2.5 cm long, yellow or yellowish (**Fig. 3A**). The capsule is pendulous, yellow, ovate, about 3 mm long (**Fig. 3B**). The peristome is double: the lanceolate teeth of the outer pinnate are green-yellow; the teeth of the inner pinnate are red-yellow with suddenly apical-like narrowed outgrowths and nodular cilia (**Fig. 3C**). Spores are green, papillose, 20–22 μm, often germinated even in the capsule (**Fig. 3D–E**).

**Comparison of morphological traits of the species in the genus *Plagiomnium* T. J. Kop.,
Mniaceae Schwägr. (E. Nyholm (1954, 1993); T. Koponen (1968); A. Stebel (1987);
WFO (2025): <http://www.worldfloraonline.org/taxon/wfo-0001186530>)**

<i>Plagiomnium drummondii</i>	<i>Plagiomnium cuspidatum</i>
The turf is denser, light green, and shiny.	The turf is loose, dark green, and matte.
The leaves are round-ovate, dry, almost flat.	The leaves are obovate, dry, strongly wavy-twisted, from almost elliptical to elongated-lanceolate spatula-shaped.
Fertile shoots with larger upper leaves that are rosette-shaped and crowded at the top.	Only leaves of fertile shoots are slightly larger than sterile ones.
The margin of the leaf has a single-layer yellowish border of linear cells lined up in 2–3 rows.	The margin of the leaf has a multi-row, single-layer border.
Leaf cells are hexagonal, uniformly thickened, approximately 40–43 µm.	Leaf cells are round-hexagonal, thickened in the corners, and much smaller.
The teeth are sharp, shiny, with 1–2 cells, from the tip to the middle of the leaf blade.	The teeth are shorter.
The seta of the sporogonium is yellow or yellowish.	The seta of the sporogonium is red or reddish.
The capsule is pendulous, yellow, ovoid, and about 3 mm long.	The capsule is ovoid or cylindrical, horizontal to pendulous, about 3.5 mm long, and has a short neck.
The teeth of the exostome are green-yellow, and the teeth of the endostome are red-yellow with lanceolate, suddenly apical-like narrowed outgrowths and nodular cilia.	The teeth of the exostome are yellowish-green, and the teeth of the endostome are with a high main membrane.
Spores are papillose.	Spores are weakly papillose.
Synoi-cous + heteroi-cous.	Synoi-cous.

The species is monoecious; gametangium is thickened; type of bisexuality: synoi-cous – archegonia and antheridia mixed in the same gametangium (**Fig. 1C–D**) or heteroi-cous – perigonium is formed at the top of the lateral branch of the synecial plant (**Fig. 1E–F**).

The results of the study of the moss sample *P. drummondii* found in Ukraine indicate that the Ukrainian material generally does not differ from the known literary descriptions in terms of anatomical and morphological characteristics. However, features have been established that have not been mentioned in the descriptions of the species so far. This is primarily the presence of fertile plants with different types of monoeciousness (synoi-cous or heteroi-cous) and germination of spores in capsules. It should be noted that the number of sporophytes formed from one perichaetium has not been finally clarified. Only plants with one sporophyte were found in the sample. There were undoubtedly many sporophytes, as indicated by the numerous setae on the surface of the turf, and the presence of a thickened perichaetium, as if formed from several, gives rise to the hope that there could have been more than one.

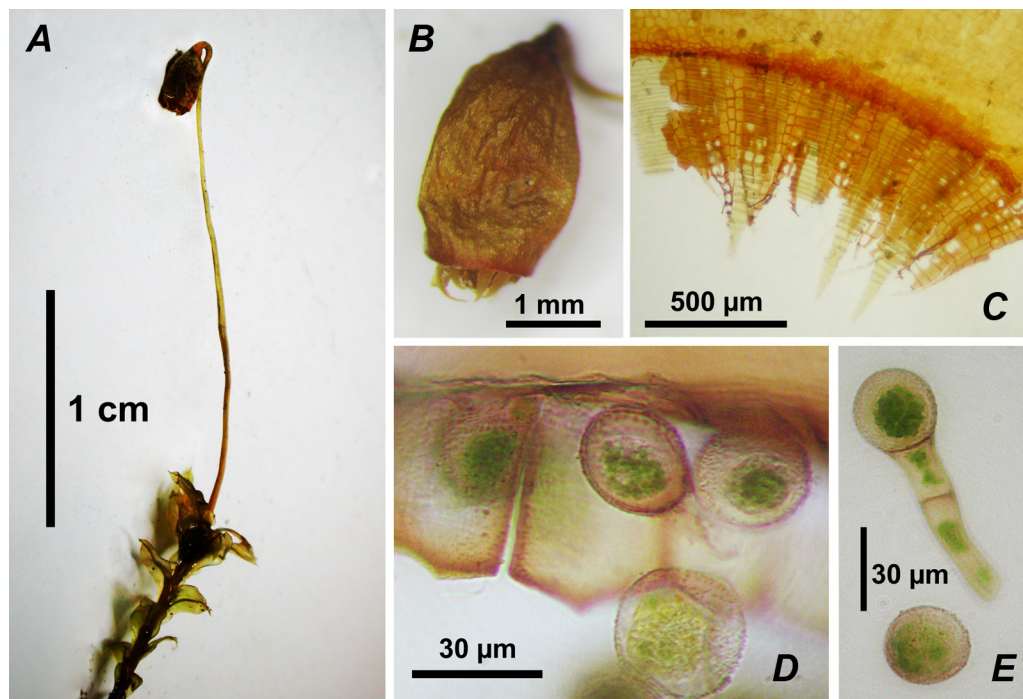


Fig. 3. Characteristic features of the sporophyte and spores *Plagiomnium drummondii*: **A** – leaf plant with sporogonium; **B** – an open capsule with yellowish-green exostome teeth; **C** – the apical part of the capsule with peristome teeth; **D** – spores on the cells of the annulus; **E** – the sporeling and matured spores

The identified samples are stored in the bryological herbarium of the Carpathian Ecology Institute of the National Academy of Sciences of Ukraine (LWKS).

General distribution. Holarctic hemiboreal species has a wide range but is rare in most regions (Nyholm, 1954; 1993). It is widespread in North America, ranging across the continent from British Columbia to Nova Scotia (Crum & Anderson, 1981), whereas in Northeast, East, and Central Asia – in China, Mongolia, Eastern and Central Siberia, and the south of the Russian Far East (Koponen, 2017). *P. drummondii* was recorded in the northeastern side of India, Sikkim State (Yadav *et al.*, 2022). In Europe, it is locally frequent in south-eastern Finland (Fagerstén, 1999), southern Latvia (Abolin', 1968), Serbia (Sabovljević *et al.*, 2024) as well as northern and central parts of European Russia. It extends eastward to the southern Ural Mountains and from the Republic of Karelia and the south of the Republic of Komi to Tver, northern Tambov and Nizhny Novgorod regions and the Republic of Mari El.

Ecological features. *P. drummondii* is a hemicryptophyte. Ecological index values: light, temperature, and substrate response according to Ellenberg (Ellenberg *et al.*, 1992): L = 4, T = 4, R = 5.

It is a neutrophilic species that grows in forests, on damp, highly decomposed wood, and on raw soil in shady or semi-shady forests, especially in fir groves with well-developed undergrowth, on limestone soils (Nyholm, 1993). It reproduces by spores that ripen in summer and vegetatively.

A reduction in the number of species was noted in Fennoscandia (Stebel, 2004; Stebel & Ochyra, 2004). It is quite rare in Finland (species status VU – Vulnerable). To preserve the population of *P. drummondii*, the city of Kuopio changed its plan to expand the city limits.

Limiting factors. Low competitiveness. The reduction of areas of ancient forests and rapid environmental and climate changes. Recreational load.

Storage recommendations. Searching for new populations and limiting anthropogenic influence on the territory where the species grows is necessary.

CONCLUSIONS

The appearance of *P. drummondii* in Central Europe is considered doubtful since the collections from Poland, the Czech Republic and Slovakia were recognized as erroneous (Stebel, Ochyra, 2004), and therefore, the species was removed from the bryoflora of continental Europe. This species is considered to be limited only to the northern part of Europe. However, it is known to spread in the territory of south-eastern Finland (Fagerstén, 1999), in the south of Latvia (Abolin', 1968), Serbia (Sabovljević *et al.*, 2024) as well as in the northern and central parts of European Russia, to the east and south of the Ural Mountains. Several new moss localities have been reported from south-eastern Europe, from the eastern Carpathians of Romania (Mohan, 1998). The location of *P. drummondii* is known for the Bryansk Polissia – the south-eastern part of the Bryansk region of Russia. Therefore, *P. drummondii* cannot be unequivocally removed from the bryoflora of continental Europe; further studies of the identified moss specimens and the search for new localities are necessary.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of Interest: the author declares the absence of any conflict of interest.

Human Rights: this article does not contain any studies with human subjects performed the author.

Animal Studies: all international, national and institutional guidelines for the care and use of laboratory animals were followed.

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PLAGIOMNIUM DRUMMONDII (BRUCH ET SCHIMP.) T. J. KOR. – НОВИЙ ВИД МОХУ ДЛЯ ФЛОРИ УКРАЇНИ

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Вступ. *Plagiomnium drummondii* (Bruch et Schimp.) T. J. Kor. належить до родини *Mniaceae* Schwägr.: секція *Plagiomnium* T. J. Kor. Голарктичний гемібореальний вид має широкий ареал, але дуже рідко трапляється у більшості регіонів. Він поширений у Північній Америці та дуже рідкісний у Європі (південно-східна Фінляндія, південна Латвія, Сербія, північна і центральна територія європейської частини Росії). Основними обмежувальними чинниками поширення є низька конкурентоспроможність, скорочення площ старовікових лісів і загальна зміна клімату.

Матеріали і методи. Зразок моху виявлено на території Природного заповідника “Розточчя”, на ділянці 40-річної вирубки Страдцівського навчально-виробничого лісокомбінату (Яворівський район, Львівська область). Вид моху визначили за допомогою відповідних описів і ключів. Морфометричний аналіз рослин (довжини пагонів і ніжки спорогонів, розмірів листків і коробочок) проводили на стереобінокулярі “Stemi 2000-C” (Carl Zeiss) та на моторизованому флуоресцентному мікроскопі Axio Imager M1 (Carl Zeiss) (визначали розмір клітин листків і спор).

Результати. Повідомлено про першу знахідку нового виду *Plagiomnium drummondii* (Bruch et Schimp.) T. J. Kor. для флори України. Подано коротку морфологічну характеристику, відмінності від подібного типового лісового моху *Plagiomnium cuspidatum* (Hedw.) T. J. Kor., екологічні особливості, географічне поширення, а також оригінальні ілюстрації гаметофіту і спорофіту моху з українського зразка. Важливі морфологічні ознаки, за якими ідентифіковано мох *P. drummondii*, ґрунтувалися на таких особливостях гаметофіту: форма і розмір листків, наявність зубців на краю листків, форма клітин середини листка та потовщення їхніх стінок, а також на ознаках спорофіту: орієнтація ніжки спорогона, форма коробочки та наявність папілу на спорах.

Висновки. *P. drummondii* не можна однозначно вилучити з бріофлори континентальної Європи, потрібні подальші дослідження виявлених зразків і пошук його нових місцевиростань. Ідентифіковані зразки моху зберігаються у бріологічному гербарії Інституту екології Карпат НАН України (LWKS).

Ключові слова: мохоподібні, нова знахідка, *Plagiomnium drummondii*, Природний заповідник “Розточчя”