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MOSS VEGETATION OF CLASS *CERATODONTO PURPUREI-POLYTRICHETEA PILIFERI* MOHAN 1978 IN NATURAL AND URBAN ECOSYSTEMS OF THE FOREST-STEPPE OF UKRAINE

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Background. Bryophyte vegetation and its classification are increasingly attracting the attention of both bryologists and geobotanists. Due to their morphological and biological organization, as well as their ecological-biological and ecological-coenotic features, bryophytes manifest their coenotic role in ecosystems in various ways. They may either constitute part of the general herbaceous cover as synusiae, or they form distinct bryocoenoses with different substrate specificities-epigeic, epiphytic, and epixylic-which are classified separately from vascular plant communities using the eco-floristic classification approach to Braun-Blanquet.

At present, detailed studies of individual syntaxa of moss vegetation at the class level are becoming increasingly important. Therefore, the aim of this study was to characterize the class *Ceratodonto purpurei-Polytrichetea piliferi* in natural and urban ecosystems of the Forest-Steppe zone of Ukraine.

Materials and Methods. The material for this study consisted of geobotanical relevés of bryocoenoses belonging to this class of moss vegetation, identified within natural ecosystems of the Forest-Steppe zone of Ukraine and urban ecosystems of several regional cities in the Left-Bank Dnipro Region. Bryophyte communities were classified according to the eco-floristic classification based on the Braun-Blanquet approach, following standard methodological guidelines.

Data processing and analysis were carried out using JUICE.NET software and the updated version of the TWINSPAN algorithm. The classification scheme of moss

vegetation was developed using leading classification systems proposed in Central and Western Europe, taking into account the results of our own research. The nomenclature of bryophytes follows “Prodromus of Spore Plants of Ukraine: Bryophytes” (Virchenko *et al*, 2022), while lichens’ nomenclature follows “Prodromus of Spore Plants: Lichens” (Kondratiuk *et al*, 2021).

Results. Moss vegetation of the class *Ceratodonto purpurei-Polytrichetea piliferi* in natural and urban ecosystems of the Forest-Steppe zone of Ukraine was characterized, and its classification scheme was developed. The studied class of moss vegetation is represented by one order, two alliances, six associations, and five subassociations. The alliance *Ceratodonto purpurei-Polytrichion piliferi* Waldh. ex v. Hübschm. 1967 is represented by the associations *Racomitrio-Polytrichetum piliferi*, *Brachythecietum albicantis*, *Polytrichetum juniperini*, *Buxbaumietum aphyllae*, and *Syntrichietum ruraliformis*. The first association is also represented by four subassociations. The alliance *Campylopodion polytrichoidis* Giacomini 1951 is represented by the association *Polytricho-formosi-Campylopodetum polytrichoides*. For each identified syntaxon, ecological and eco-coenotic characteristics, as well as localities within the region, are presented. The association *Polytricho-formosi-Campylopodetum polytrichoides* is reported for the first time in Ukraine.

Conclusions. Unlike in Western Europe, within the studied region, class *Ceratodonto purpurei-Polytrichetea piliferi* is represented by a small number of syntaxa, which are primarily confined to pine forests, sand arenas, and occasionally steppe areas. The moss vegetation of the studied territory within the class includes one order, two alliances, six associations, and five subassociations. All identified associations and subassociations were documented within natural ecosystems. Of these, two associations and four subassociations were also recorded in urban ecosystems. Therefore, further research on the bryocoenoses of this class in Ukraine is promising and requires a detailed study.

Keywords: bryophytes, bryocoenoses, bryophyte communities, bryosyntaxa, eco-floristic classification, Forest-Steppe zone of Ukraine, pine and mixed forests, Latoritsa River basin, beech forests

INTRODUCTION

Bryophyte vegetation and its classification are increasingly attracting the attention of both bryologists and geobotanists. Due to their morphological and biological organization, as well as their ecological-biological and ecological-coenotic features, bryophytes manifest their coenotic role in ecosystems in various ways: they either form part of the general herbaceous cover as synusiae, or they form distinct bryocoenoses with different substrate specificities – epigeic, epiphytic, and epixylic – which are classified separately from vascular plant communities using the eco-floristic classification according to the Braun-Blanquet approach.

The study of bryophyte vegetation and its classification is a highly relevant task in bryosyntaxonomy. Generalized results regarding the moss vegetation of Western Europe and adjacent regions, as well as Europe as a whole, are available in the monographic summaries by R. Marstaller (2006) and L. Mucina *et al*. (2016).

A number of works are dedicated to the study of moss communities in specific territories. For instance, epiphytic bryophyte communities in certain regions of Turkey were

investigated by M. Alataş *et al.* (2017, 2021, 2023), N. Batan *et al.* (2025), and M. Can Güzcü *et al.* (2018). Specific data regarding the study of moss communities relate to Saudi Arabia (Hugonnot *et al.*, 2026), Italy (Hugonnot *et al.*, 2025; Puglisi *et al.*, 2022), and New Zealand (Marino *et al.*, 2025).

The ecological features of individual bryophyte species within communities, as well as the ecology of moss communities as a whole, are studied separately in a number of countries: Brazil (Tássia *et al.*, 2020), Indonesia (Putrika *et al.*, 2026; Kentjens *et al*., 2025), China (Su *et al.*, 2025), and Germany (Möller et al., 2026).

Syntaxonomic syntheses of the bryophyte vegetation of France (Bardat, 2002) and Turkey (Alataş, 2018) are well-known.

To date, moss vegetation of Ukraine has been insufficiently studied. There are preliminary generalizations regarding the results of its classification for the Forest-Steppe of Ukraine (Hapon *et al*., 2018) and isolated data concerning other territories where moss vegetation is underexplored (Karpinets *et al.*, 2017; Rahulina *et al.*, 2021; Didukh *et al.*, 2023; Pleskach *et al.*, 2024). For example, the epiphytic moss vegetation of the Oleksandriya arboretum was described by L. Pleskach *et al*. (2024); shaded chasmophytic communities, including moss communities, were investigated by Ya. Didukh *et al.* (2023). Information on the moss vegetation of the rocky outcrops in the Chortova Skelya Landscape Reserve and cryptogam communities on the walls of the defensive monastery in Pidkamin was presented in the works of M. Rahulina *et al.* (2021 a,b). Moss communities functioning as synusiae and their characteristic features were studied by L. Karpinets *et al.* (2017). O. Khodosovtsev *et al*. (2011) investigated lichen and moss communities of the Lower Dnipro sand arenas (the Steppe zone of Ukraine) and lichen and moss communities of the Black Sea Biosphere Reserve (Khodosovtsev *et al*., 2012).

Currently, detailed research of specific syntaxa of moss vegetation at the class level is highly relevant. Therefore, the aim of our work is to characterize the class *Ceratodonto purpurei-Polytrichetea piliferi* in natural vegetation types and urban ecosystems of the Forest-Steppe zone of Ukraine. For Western Europe and adjacent territories, according to R. Marstaller (2006), moss communities within this class belong to 1 order, 3 alliances, 12 associations, and 24 subassociations.

MATERIALS AND METHODS

The material for this work consisted of geobotanical relevés of bryocoenoses belonging to this class of moss vegetation, identified within natural vegetation types of the Forest-Steppe zone of Ukraine and urban ecosystems of regionally subordinated cities in the Left-Bank Dnipro region (Lubny, Myrhorod, Poltava (Poltava region)), Romny (Sumy region), Pryluky (Chernihiv region), as well as one association identified as a result of processing geobotanical relevés performed by L. M. Felbaba-Klushyna and A. Bizilya in the vicinity of Uzhhorod (the Latoritsa River basin). Bryophyte communities were classified by us according to the eco-floristic classification based on the Braun-Blanquet approach, using appropriate methodological guidelines (Marstaller, 2017). Geobotanical relevés of bryocoenoses were performed within sample plots (from 1 dm^2 to 4 dm^2) established on regularly repeating, ecologically homogeneous areas of well-developed moss cover. A total of 139 geobotanical relevés were processed. Data processing and analysis were carried out using the JUICE.NET software package, as well as the updated implementation of the TWINSPAN algorithm (Petr Šmilauer). The compilation of the moss vegetation classification scheme was conducted using leading

classification schemes developed in Central and Western Europe (Marstaller, 2006; Mucina, Bültmann, Dierßen *et al*., 2016). The nomenclature of bryophytes follows the ”Prodromus of Spore Plants of Ukraine: Bryophytes” (Virchenko *et al*., 2022), and for lichens, the “Prodromus of Spore Plants: Lichens” (Kondratyuk *et al*., 2021).

The following abbreviations are adopted in this work: D.s. – diagnostic species (singular or plural); abbreviations of region (oblast) names: Vinnytsia – Vin.; Kyiv – Kv.; Zakarpattia – Zk., Kirovohrad – Krv., Odesa – Od., Poltava – Pl., Sumy – Sm., Kharkiv – Khrk., Khmelnytskyi – Khm., Cherkasy – Chrk., Chernihiv – Chrn.

RESULTS AND DISCUSSION

The results of the present study confirm that out of the 13 classes of bryophyte vegetation known for Western Europe in the monograph by R. Marstaller (2006), in the summary by L. Mucina *et al*. (2016) for Europe as a whole, and the bryophyte communities identified by us for the Forest-Steppe of Ukraine belong to 10 classes: *Ceratodonto purpurei-Polytrichetea piliferi* Mohan 1978, *Racomitrietea heterostichi* Neumayr 1971, *Schistidietea apocarpii* Jezek et Vondracek 1962, *Cladonio digitatae-Lepidozietea reptantis* Jez. & Vondr. 1962, *Grimmietea anodontis* Had. & Vondr. In Jez. & Vondr. 1962, *Psoretea decipientis* Marst. 1985, *Neckeretea complanatae* Marst. 1986, *Frullanio dilatatae-Leucodontetea sciuroidis* Mohan 1978, *Pleurochaeto squarrosae-Abietinelletea abietinae* Marst. 2002, and *Hylocomietea splendentis* Marst. 1992 (Hapon *et al*., 2018).

Our results also demonstrate that bryocoenoses of different classes of moss vegetation play a diverse role within the vegetation cover of the Forest-Steppe of Ukraine. They form different types of bryophyte vegetation: epigeic, epiphytic, epixylic, and epilithic, both in natural vegetation types and in urban ecosystems (Hapon *et al*., 2018). The class *Ceratodonto purpurei-Polytrichetea piliferi* unites only epigeic bryocoenoses, which, within the Forest-Steppe of Ukraine, are confined to various types of pine forests; one association is recorded in a beech forest (Uzhhorod, Latorytsia River basin).

Based on our findings, the following syntaxonomic scheme of the studied class has been compiled:

Cl. *Ceratodonto purpurei-Polytrich*e*tea piliferi*
Ord. *Polytrichetalia piliferi* v. Hübschm. 1975
All. *Ceratodonto purpurei-Polytrichion piliferi* Waldh. ex v. Hübschm. 1967
Ass. *Racomitrio-Polytrichetum piliferi* v. Hübschm. 1967
- typicum
- *syntrichietosum ruralis* v. d. Dunk 1972
- *brachythecietosum albicantis* v. d. Dunk 1972
- *ceratodontetosum purpurei* v. d. Dunk 1972
- cladonietosum v. d. Dunk 1972
Ass. *Brachythecietum albicantis* Gams ex Neum. 1971
Ass. *Polytrichetum juniperini* v. Krus. 1945
- *dicranetosum scoparii* v. Krus 1945
Ass. *Buxbaumietum aphyllae* Stef. 1947
Ass. *Syntrichietum ruraliformis* Boiko et Khodosovtsev in Khodosovsev *et al*., 2011
All. *Campylopodion polytrichoidis* Glacomini 1951
Ass. *Polytricho-formosi-Campylopodetum polytrichoides* Guerra & all. 1981
(*Campylopodetum polytrichoides*)

Thus, the class *Ceratodonto purpurei-Polytrichetea piliferi* is represented within the studied region by one order, two alliances, six associations, and four subassociations (Hapon *et al*., 2018). It unites epigeic bryophyte communities confined to pine and mixed forests both in natural vegetation types of the region and in pine plantations on the outskirts of urban ecosystems within the Left-Bank, Right-Bank, and Western Forest-Steppe of Ukraine. The association *Polytricho-formosi-Campylopodetum polytrichoides* has been reported for a beech forest in the vicinity of Uzhhorod, while the association *Syntrichietum ruraliformis* has been identified within the sand arenas in the Left-Bank Steppe (cited from Khodosovtsev *et al*., 2011, 2012).

A characteristic feature of the class is the significant participation of lichens. Diagnostic species (D.s.) of the class are lichens of the genus *Cladonia* (*C. arbuscula*, *C. ciliata*, *C. foliacea*, *C. rangiferina*, *C. subulata*), *Cetraria islandica*, *Peltigera malacea*, the moss *Polytrichum piliferum*, etc. The bryocoenoses of this class within the studied territories are confined to arid conditions characteristic of various types of pine, and less often mixed forests, as well as open sandy areas, illuminated forest edges, and rarely steppe slopes.

The order *Polytrichetalia piliferi* unites epigeic acidophytic bryophyte communities under conditions of moderate to insufficient moisture. D.s. of the class and order are: *Ceratodon purpureus* (Hedw.) Brid., *Niphotrichum canescens* (Hedw.) Bedn.-Ochyra & Ochyra., *Polytrichum juniperinum* Hedw.

The alliance *Ceratodonto purpurei-Polytrichion piliferi* includes epigeic acidophytic, heliophilous, and heliosciophilous bryophyte communities of pine and oak-pine forests, as well as sand arenas. D.s. of the alliance are: *Cephaloziella divaricata* (Sm.) Schiffn, *Ceratodon purpureus*, *Polytrichum juniperinum*.

The association *Racomitrio-Polytrichetum piliferi* (D.s. *Polytrichum piliferum* Hedw.) (**Table 1**, relevés 1–13) is represented within the studied region by typical bryocoenoses and four subassociations. The typical association unites terrestrial acidophytic, light-demanding, xerophytic communities, which most often occur in open, illuminated glades. They are confined to lichen pine forests, are widely distributed within natural vegetation types, and have also been found on the outskirts of the cities of Lubny, Myrhorod, Poltava, and Pryluky. It is recorded for the Vin., Kv., Krv., Od., Pl., Sm., Chrk., Khm., and Khrk. regions (**Tables 1; 4**).

The subassociation ***ceratodontetosum purpurei*** (**Table 1**, relevés 14–29) (D.s.: *Ceratodon purpureus*) includes epigeic, acidophytic, xerophytic bryocoenoses ranging from light-demanding to indifferent to light conditions, characteristic of lichen pine forests. They were found throughout the entire region in young and middle-aged pine and mixed forests. In the vicinity of urban ecosystems (the cities of Lubny, Myrhorod, and Poltava), they are confined to pine plantations and occur more frequently than typical bryocoenoses. This subassociation has been recorded for the Kv., Krv., Pl., Sm., Chrk., Khm., and Khrk. regions (**Tables 1; 4**).

The subassociation ***syntrichietosum ruralis*** (D.s.: *Syntrichia ruralis* (Hedw.) F. Weber & Mohr.) unites epigeic xerophytic bryocoenoses under excessively illuminated conditions; it occurs on the edges of pine forests and clearings. It has been identified both in natural ecosystems and in the vicinity of urban ecosystems. We recorded it for the Vin., Kv., Pl., Sm., Chrk., Khm., and Khrk. regions (**Table 4**).

The subassociation ***brachythecietosum albicantis*** (D.s.: *Brachythecium albicans* (Hedw.) Schimp.) unites epigeic xeromesophytic communities of open areas in pine and mixed forests, on forest edges, as well as on steppe slopes in places free from dense

Table 1. The association ***Racomitrio-Polytrichetum piliferi* v. Hübschm. 1967**

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	CONST
Plot area, dm^2	16	16	9	9	4	4	10	4	6	6	9	24	4	25	9	16	16	9	10	8	8	6	4	4	8	10	16	9	10	
TPC, %	75	80	100	100	90	80	80	90	90	90	100	95	100	95	75	90	90	95	100	100	100	100	95	95	80	85	75	75	80	
Substrate	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
No. of species	3	2	2	2	4	3	2	4	4	5	2	4	3	4	3	5	4	4	4	3	3	4	4	4	3	4	4	3	4	
D.s. ass. *Racomitrio-Polytrichetum piliferi*																														
Polytrichum piliferum	+	5	2	3	4	2	2	3	2	4	3	2	4	4	4	4	4	4	2	4	3	4	3	4	4	4	4	4	5	V
D.s. all. *Ceratodonto purpurei-Polytrichion piliferi*, ord. *Polytrichetalia piliferi*																														
Polytrichum juniperinum	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	I
Niphotrichum canescens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	I
D.s. cl. *Ceratodonto purpurei-Polytrichetea piliferi*																														
Cetraria islandica	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Cladonia foliaceae	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	I
D.s. subass. *ceratodontetosum purpurei*																														
Ceratodon purpureus															2	2	+	1	4	2	2	2	3	2	2	2	2	2	2	V
Other mosses																														
Lophocolea minor	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	I
Brachythecium salebrosum	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	2	.	.	.	.	.	.	.	.	.	I
Ptyhostomum capillare	.	.	.	.	.	.	.	.	+	.	.	.	.	.	2	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Brachythecium albicans	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	2	.	.	I
Dicranum scoparium	.	.	.	.	.	.	.	.	.	2	.	.	3	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	+	I
Plagiothecium nemorale	.	.	.	.	.	.	.	.	.	.	.	3	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Sciuro-hypnum curtum	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	I
Hypnum cupressiforme	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	+	.	.	2	.	.	.	.	I
Pohlia nutans	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	2	.	.	.	3	.	.	.	.	2	.	I
Polytrichum formosum	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	I
Ptychostomum moravicum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	I
Other lichens																														
Cladonia fimbricata	.	.	.	.	+	+	+	2	.	.	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	II
Cladonia arbuscula ssp. *arbuscula*	.	.	.	.	+	+	.	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Cladonia furcata	.	.	.	.	.	.	.	2	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Cladina mitis	.	3	.	.	+	.	.	.	.	.	.	1	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	I

Relevés were made: 1, 3, 4, 8, 11, 12, plantations. 2, 17 – 20.10.09. Poltava region, Zinkiv district, vicinity of Zinkiv city, lichen pine forest. 5–7, 9, 10, 13 – 26 – 22.07.08. Odesa region, Savran district, vicinity of Savran city, young pine forests. 06. Poltava region, Hadiach district, projected RLP "Hadiatskyi", Sary village, lichen pine forest. 15 – 17.08.03. Kharkiv region, Kharkiv district, Borshchova village, pine forest. 18–20 – 19.08.06. Poltava region, Kotelevskyi district, vicinity of Kotelva urban-type settlement, Kotelva forestry, lichen pine forest. 21–25 – 26.11.10. Kharkiv region, Zmiiv district, NNP "Homilshanski Lisy", Zadonetske village, pine forest. 26–29 – 26.07.10. Cherkasy region, Cherkasy district, vicinity of Cherkasy city, tract "Cherkaskyi Bir", pine forest

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herbaceous cover. It has been identified both in natural ecosystems and in the vicinity of urban ecosystems (the cities of Lubny, Myrhorod, and Poltava). It is recorded for the Vin., Pl., Sm., Chrk., Khm., and Khrk. regions (**Table 1**).

The subassociation ***cladonietosum*** (D.s.: *Cladonia furcata*, *Cladonia chlorophaea*) includes acidophytic, xerophytic communities in dry lichen pine forests within the region. It is recorded for the Vin., Kv., Krv., Od., Pl., Sm., Chrk., Khm., and Khrk. regions (**Table 4**).

The association ***Brachythecietum albicantis*** (D.s.: *Brachythecium albicans*) unites epigeic, acidophytic, heliophilous, xerophytic bryophyte communities on sandy loam soils of pine forests: gramineous-forb pine forests, lichen pine forests, and less often green-moss pine forests. They have been recorded on the edges of pine forests and less frequently occur in steppe phytocoenoses with sparse herbaceous cover. They have been found in pine forests and steppe areas of the studied region, as well as in all the studied cities (the cities of Lubny, Myrhorod, Poltava, Pryluky, and Romny). This subassociation has been recorded for the Vin., Kv., Krv., Od., Pl., Sm., Chrk., Khm., and Khrk. regions (**Table 2; Fig. 1**).

Fig. 1. The association *Brachythecietum albicantis.* Photo by Yu. Hapon

The association ***Polytrichetum juniperini*** (**Table 3**, relevés 1–21; 4) (D.s.: *Polytrichum juniperinum*) unites epigeic, acidophytic, heliophilous, xerophytic, and xeromesophytic communities growing on sandy loam soils. They are typical of pine forests (middle-aged 50–60-year-old plantations): predominantly gramineous-forb pine forests and dead-cover pine forests, and less frequently – lichen pine forests, green-moss pine forests, and oak-pine forests. It has not been recorded in urban ecosystems. It is recorded for the Kv., Pl., Sm., Chrk., Khm., and Khrk. regions.

Table 2. **The association *Brachythecietum albicantis* Gams ex Neum. 1971**

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	CONST
Plot area, dm^2	16	8	4	8	9	8	4	4	8	25	8	12	8	9	8	9	4	2	2	4	8	
TPC, %	75	70	90	95	100	70	95	70	80	85	85	90	90	100	95	85	100	100	100	95	85	
Substrate	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
No. of species	4	4	3	4	4	4	3	4	5	4	3	4	4	4	4	4	4	4	3	4	4	
D.s. ass. *Brachythecietum albicantis*																						
Brachythecium albicans	4	4	4	4	5	4	3	4	4	4	4	4	4	4	5	4	4	4	3	4	4	V
D.s. all. *Ceratodonto purpurei-Polytrichenion piliferi*																						
Ceratodon purpureus	3	.	.	3	.	.	2	2	2	.	.	.	.	2	.	.	.	.	2	.	.	II
D.s. ord. *Polytrichetalia piliferi*, cl. *Ceratodonto purpurei-Polytrichetea piliferi*																						
Polytrichum piliferum	.	+	2	2	2	2	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II
Polytrichum juniperinum	.	.	.	.	.	+	.	.	.	.	.	.	.	.	2	2	2	.	.	.	.	I
Cladonia foliaceae	.	2	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	I
Cetraria islandica	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	I
Cladonia furcata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	+	.	.	I
Racomitrium canescens	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Other mosses																						
Sciuro-hypnum curtum	+	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.	+	.	.	.	I
Hypnum cupressiforme	.	.	+	.	.	.	.	.	.	3	.	.	.	.	.	+	.	.	.	.	.	I
Brachythecium salebrosum	.	.	.	+	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.	I
Atricum undulatum	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	2	.	I
Polytrichum formosum	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	2	.	.	.	I
Dicranum scoparium	.	.	.	.	1	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	2	I
Tortula ruralis	.	.	.	.	.	.	.	.	2	.	.	2	.	.	.	.	.	.	.	.	.	I
Ptychostomum imbricatulum	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	I
Ptychostomum moravicum	.	.	.	.	.	.	.	.	.	.	.	.	2	.	+	.	.	.	.	.	.	I
Ptychostomum capillare	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	+	.	I
Other lichens																						
Cladonia fimbriata	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	I
Cladonia chlorophea	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	I

Only in one relevé: *Cladonia* sp. (1: +), *Lophocolea minor* (5: +), *Thuidium assimile* (10: +), *Barbula unguiculata* (12: +), *Cladonia macilenta* (8: +), *Dicranum polysetum* (18: +), *Pohlia nutans* (21: 2)

Relevés were made: 1, 8–10 – 22.07.08. Odesa region, Savran district, vicinity of Savran city, pine forest. 2-4, 12, 13 – 21.08.08. Vinnytsia region, Bershad district, Obodivka village, pine forest. 5–7, 14 – 16.08.06. Poltava region, Hadiach district, projected RLP “Hadiatskyi”, gramineous-forb pine forest. 11 – 21.08.08. Vinnytsia region, Bershad district, Balanivka village, pine forest. 15, 17, 18 – 2.11.08. Sumy region, Konotop district, Novomutyn village, Novomutyn forestry, tract “Mutynskyi Bir”, pine forest. 19–21 – 26.07.08. Cherkasy region, Chyhyryn district, Medvedivka village, pine forest

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Table 3. **The association *Polytrichetum juniperini* v. Krus 1945**

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	CONST
Plot area, dm^2	16	100	100	16	100	8	16	8	24	8	6,25	8	16	8	100	22,5	16	16	8	100	8	9	9	16	100	8	
TPC, %	75	80	90	90	90	95	70	75	75	85	90	95	95	95	100	100	100	100	95	85	80	90	95	100	100	100	
Substrate	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
No. of species	4	3	4	4	5	4	4	3	4	3	5	4	3	4	4	4	3	3	4	4	4	5	4	3	6	3	
D.s. ass. *Polytrichetum juniperini*																											
Polytrichum juniperinum	4	4	4	4	4	4	3	4	4	3	4	4	4	5	4	4	4	4	4	5	5	4	4	4	4	4	V
D.s. all. *Ceratodonto purpurei-Polytrichenion piliferi*																											
Ceratodon purpureus	.	.	.	2	.	.	.	.	.	.	.	.	.	1	.	.	3	.	.	.	.	.	.	.	.	.	I
D.s. ord. *Polytrichetalia piliferi*, cl. *Ceratodonto purpurei-Polytrichetea piliferi*																											
Polytrichum piliferum	.	.	.	.	.	.	.	.	.	.	.	1	.	+	.	.	.	2	.	.	.	.	.	.	.	.	I
Niphotrichum canescens	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	I
Cladonia furcata	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
D.s. subass. *Dicranetosum scoparii*																											
Pleurozium schreberi	.	2	.	.	2	2	+	2	2	+	+	2	2	.	.	.	.	.	.	1	.	1	.	.	.	.	III
Dicranum scoparium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3	2	+	2	I
Polytrichum formosum	.	3	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Other mosses																											
Brachythecium albicans	.	.	.	.	.	+	+	+	.	.	.	.	.	2	.	+	.	.	.	.	.	.	+	.	1	.	II
Sciuro-hypnum curtum	.	.	+	.	+	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	2	.	.	2	.	.	II
Dicranum polysetum	.	.	2	.	.	2	3	.	.	.	.	.	3	.	.	.	.	.	.	.	.	2	.	.	3	.	II
Brachythecium salebrosum	.	.	.	.	2	.	.	.	.	.	.	.	.	.	3	2	.	.	+	2	.	.	.	.	.	.	I
Hypnum cupressiforme	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.	.	I
Ptychostomum capillare	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	I
Pohlia nutans	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	I
Plagiomnium affine	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	I

Other lichens																															
Cladonia fimbriata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	2	.	.	.	.	.	+	.	.	.	.	I
Cladina mitis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	+	.	I
Cladonia macelenta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	I
Cladonia chlorophaea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	+	.	I

Only in one relevé: *Atrichum undulatum* (1: 2), *Brachytheciastrum velutinum* (1: +), *Polytrichum commune* (3: +), *Lophocolea minor* (8: +), *Thuidium assimile* (15: 3)

Relevés were made: 1 – 2.11.08. Sumy region, Konotop district, Novomutyn village, Novomutyn forestry, tract “Mutynskyi Bir”, pine forest. 2–4, 8 – 10.05.05. Poltava region, Lokhvytsia district, reserve “Chervonoberezhzhia”, oak-pine forest. 5, 6, 12 – 26.07.06. Poltava region, Hadiach district, Sary village, projected RLP “Hadiatskyi”, dead-cover pine forest. 7, 14, 16, 18 – 15.08.06. Poltava region, Hadiach district, Liutenka village, projected RLP “Hadiatskyi”, dead-cover pine forest. 9, 17 – 26.07.08. Cherkasy region, Chyhyryn district, Medvedivka village, pine forest. 10 – 22.07.08. Odesa region, Savran district, Savran city, pine forest. 11 – 26.07.06. Poltava region, Hadiach district, Krasna Luka village, projected RLP “Hadiatskyi”, dead-cover pine forest. 13 – 26.07.06. Poltava region, Hadiach district, Maksymivka village, projected RLP “Hadiatskyi”, dead-cover pine forest. 15 – 9.06.09. Poltava region, Kotelevskyi district, Myloradove village, Borivske forestry, oak-pine-bracken forests. 19 – 17.08.03. Kharkiv region, Borshchova [village], pine forest. 20, 21 – 16.08.03. Kharkiv region, Zmiiv district, Lyman village, Lake Borove, pine forest. 22, 23 – 24.07.09. Chernihiv region, Ichnia district, Ichnia city, NNP “Ichnianskyi”, gramineous-forb pine forest

Table 4. **Description of the syntaxa of the class *Ceratodonto purpurei-Polytrichetea piliferi* Mohan 1978**

Syntaxon number	1	2	3	4	5	6
Number of relevés in syntaxon	29	21	26	15	12	16
Total number of species	25	29	24	10	4	7
D.s. ass.						
Polytrichum piliferum Hedw.	**V**	II	I	I		
Ceratodon purpureus (Hedw.) Brid.	**V**	II	II		V	
Brachythecium albicans (Hedw.) Schimp.	**IV**	**V**	II			
Polytrichum juniperinum Hedw.	I	I	**V**			
Buxbaumia aphylla Hedw.				**V**		
Syntrichia ruraliformis (Besch.) Mans.					**V**	
Polytrichum formosum Hedw.	I	I	I	I		**V**
D.s. subass.						
Syntrichia ruralis (Hedw.) F. Weber & D. Mohr	**IV**	I				
Cladonia chlorophea (Flörke ex Sommerf.) Spreng.	**IV**	I	I			
Dicranum scoparium Hedw.	I	I	**IV**			II
D.s. *Ceratodonto piliferi-Polytrichetea piliferi* Mohan 1978, *Polytrichetalia piliferi* v. Hübschm. 1975, *Ceratodonto purpurei-Polytrichion piliferi* Waldh. ex v. Hübschm. 1967						
Cephalosiella divaricata (Sm.) Schiffn.				I	III	
Niphotrichum canescens (Hedw.) Bedn.-Ochyra & Ochyra	II	I	I			
Cladonia furcata (Huds.) Schrad.	I	I	I			
Cetraria islandica (L.) Ach.	I	I				
Cladonia foliaceae (Huds.) Willd.	I	I				
Cladonia arbuscula ssp. *arbuscula*(Wallr.) Hale & W. L. Culb. (Wallr.) Hale & W. L. Culb.	I					
D.s. *Campilopodion polytrichoidis*						
Campilopus fragilis (Brid.) Bruch & Schimp.						**III**
Other mosses						
Lophocolea minor Nees	I	I	I	II		
Atrichum undulatum (Hedw.) P. Beauv.		I	II	II		
Dicranella varia (Hedw.) Schimp.				I		II
Dicranum polysetum Sw. ex Anon.		I	II			I
Barbula unguiculata Hedw.		I				
Ptychostomum capillare (Hedw.) Holyoak & N. Pedersen	I	I	I			I
Ptychostomum moravicum (Podp.) Ros & Mazimpaka	I	I		I		
Ptychostomum imbricatulum (Müll. Hal.) Holyoak & N. Pedersen		I			I	
Pohlia nutans (Hedw.) Lindb.	I	I	I			
Plagiomnium affine (Blandow ex Funck) T. J. Kop.			I			
Plagiothecium nemorale (Mitt.) A. Jaeger	I					

Oxyrrinchium hians (Hoffm. ex F. Weber & D. Mohr) Schimp.	I				
Brachythecium salebrosum (Hoffm. ex F. Weber & D. Mohr) Schimp.	I	I	I		
Sciuro-hypnum curtum (Lindb.) Ignatov	I	I	II	I	I
Brachytheciastrum velutinum (Hedw.) Ignatov & Huttun	I		I	III	
Hypnum cupressiforme Hedw.	I	I	I		
Thuidium asimille (Mitt.) A. Jaeger		I	I		
Pleurosium schreberi (Willd. ex Brid.) Mitt.			III		
Other lichens					
Cladonia mitis Sandst.	I		I		
Cladonia fimbriata (L.) Fr.	I	I	I		
Cladonia macilenta Hoffm.		I	I		

Names of syntaxa: 1 – *Racomitrio-Polytrichetum piliferi*; 2 – *Brachythecietum albicantis*; 3 – *Polytrichetum juniperini*; 4 – *Buxbaumietum aphyllae*; 5 – *Syntrichietum ruraliformis*; 6 – *Polytricho-formosi-Campylopodetum polytrichoides*

The subassociation ***dicranetetosum scoparii*** (D.s.: *Dicranum scoparium* Hedw.) ecotopically, unlike typical bryophyte communities, occurs in more humid conditions on sandy loam soils. It is recorded for the Kv., Krv., Pl., Sm., Chrk., and Khrk. regions (**Table 3**, relevés 22–26; 4).

The epigeic, acidophytic, heliosciophilous, xerophytic association ***Buxbaumietum aphyllae*** (D.s.: *Buxbaumia aphylla* Hedw.) is confined within the Forest-Steppe of Ukraine to middle-aged pine forests that undergo the least degradation. It occurs rarely. It has not been found in urban ecosystems. It is recorded for the Kv., Pl., and Khrk. regions (**Table 4**).

The association ***Syntrichietum ruraliformis*** (D.s.: *Ceratodon purpureus*, *Syntrichia ruraliformis* (Besch.) Mans.) unites „xeromesophytic, acidophytic communities of sandy massifs of the Lower Dnipro arenas on naturally or anthropogenically disturbed, more or less flat forms of microrelief. Fully developed phytocoenoses of the association are confined to the edges of field roads, old sand ejections from the activity of *Spalax arenarius*, areas after fires, etc." (Khodosovtsev *et al*., 2011, p. 63). It is recorded for the Kherson region (**Table 4**).

The epigeic, heliosciophilous, xeromesophytic association ***Polytricho-formosi-Campylopodetum polytrichoides*** (D.s.: *Campylopus fragilis* (Brid.) Bruch & Schimp., *Polytrichum formosum*) was discovered by L. Felbaba-Klushyna and A. Bizilya in the vicinity of Uzhhorod in a rocky oak forest massif. It is recorded for the Zakarpattia region (**Table 4; Fig. 2**) and is reported for the first time for Ukraine.

CONCLUSIONS

Thus, unlike in Western Europe, within the studied region, class Ce*ratodonto purpurei-Polytrichetea piliferi* is represented by a small number of syntaxa, and they are predominantly confined to pine forests, sand arenas, and occasionally steppe areas. The studied moss vegetation within the class comprises one order, two alliances, six associations, and five subassociations. All identified associations and subassociations were documented within natural ecosystems. Among these, two associations and four subassociations were also recorded in urban ecosystems. Therefore, further research on the bryocoenoses of this class within Ukraine is promising and requires a detailed study.

Fig. 2. The association *Polytricho-formosi-Campylopodetum polytrichoides.* Photo by L. Felbaba-Klushyna

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of Interest: the authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Animal Rights: this article does not include animal studies.

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

AUTHOR CONTRIBUTIONS

Conceptualization, [S.H.; L.F-K.]; methodology [S.G.; Y.G.; L.F.-K.]; formal analysis [S.G.; Y.G.; L.F.-K.]; investigation [S.G.; Y.G.; L.F.-K.; A.B.]; resources [S.G.; Y.G.; L.F.-K.; A.B.]; data curation [S.G.; Y.G.; L.F.-K.] writing – original draft preparation [S.G.; L.F.-K.]; writing review and editing [S.G.; Y.G.]; visualization [S.G.; Y.G.; L.F.-K.; A.B.]; supervision [S.G.; L.F.-K.]; project administration [S.G.; Y.G.; L.F.-K.; A.B.].

All authors have read and agreed to the published version of the manuscript.

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МОХОВА РОСЛИННІСТЬ КЛАСУ *CERATODONTO PURPUREI-POLYTRICHETEA PILIFERI* MOHAN 1978 У ПРИРОДНИХ ТА УРБОЕКОСИСТЕМАХ ЛІСОСТЕПУ УКРАЇНИ

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Обґрунтування. Бріофітна рослинність і її класифікація дедалі більше привертають увагу як бріологів, так і геоботаніків. Мохоподібні, з огляду на морфолого-біологічну організацію, еколого-біологічні й еколого-ценотичні особливості проявляють свою ценотичну роль в екосистемах по-різному: або входять до складу загального трав'янистого покриву у вигляді синузій, або формують окремі, різні за субстратною приуроченістю бріоценози: епігейні, епіфітні, епіксильні, які класифікуються окремо від угруповань судинних рослин за еколого-флористичною класифікацією, згідно з методом Браун-Бланке. На часі є детальне дослідження окремих синтаксонів мохової рослинності на рівні класів. Тому метою нашої роботи і є характеристика класу *Ceratodonto purpurei-Polytrichetea piliferi* у природних екосистемах і урбоекосистемах Лісостепу України.

Матеріали та методи. Матеріалом для написання роботи слугували геоботанічні описи бріоценозів цього класу мохової рослинності, виявлені в межах природних екосистем Лісостепу України й урбоекосистем низки міст обласного підпорядкування Лівобережного Придніпров'я. Бріоугруповання ми класифікували за еколого-флористичною класифікацією на основі методу Браун-Бланке з використанням відповідних методичних підходів. Обробку й аналіз даних проводили з використанням програмного пакета JUICE.NET, а також оновленої реалізації алгоритму TWINSPAN. Укладення класифікаційної схеми мохової рослинності здійснено з використанням провідних класифікаційних схем, створених у Центральній і Західній Європі та з урахуванням результатів власних досліджень. Назви мохоподібних наведено за "Продромусом спорових рослин України: мохоподібні", лишайників за "Продромусом спорових рослин: лишайники".

Результати. Охарактеризовано мохову рослинність класу C*eratodonto purpurei-Polytrichetea piliferi* у природних типах рослинності й урбоекосистемах Лісостепу України, наведено її класифікаційну схему. Досліджуваний клас мохової рослинності представляють 1 порядок, 2 союзи, 6 асоціацій, 5 субасоціацій. Союз *Ceratodonto*

purpurei-Polytrichion piliferi Waldh. ex v. Hübschm. 1967 репрезентований асоціаціями *Racomitrio-Polytrichetum piliferi*, *Brachythecietum albicantis*, *Polytrichetum juniperini*, *Buxbaumietum aphyllae*, *Syntrichietum ruraliformis.* Перша асоціація представлена ще 4 субасоціаціями. Союз *Campilopodion polytrichoidis* Clacom 1951 репрезентований аоціацією *Polytricho-formosi-Campylopodetum polytrichoides.* Для кожного виявленого синтаксону наведено екологічні, еколого-ценотичні особливості й місцезнаходження в межах регіону. Асоціацію *Polytricho-formosi-Campylopodetum polytrichoides* наведено вперше для України.

Висновки. На відміну від Західної Європи, в межах досліджуваного регіону даний клас представлений невеликою кількістю синтаксонів, і приурочені вони переважно до соснових лісів, піщаних арен, зрідка степових ділянок. Мохова рослинність досліджуваної території в межах класу налічує 1 порядок, 2 союзи, 6 асоціацій, 5 субасоціацій. Усі ідентифіковані асоціації та субасоціації було зафіксовано в межах природних екосистем. Серед них 2 асоціації та 4 субасоціації також відзначено в урбоекосистемах. Тому подальші дослідження бріоценозів цього класу в межах України є перспективними і потребують детального вивчення.

Ключові слова: мохоподібні, бріоценози, бріоугруповання, бріосинтаксони, еколого-флористична класифікація, Лісостеп України, соснові та мішані ліси, басейн р. Латориці, букові ліси

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