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'HOT' AND 'WHITE' SPOTS OF LICHEN DIVERSITY OF THE UKRAINIAN PLAINS (AFTER GEOBOTANICAL SUBPROVINCES AND ADMINISTRATIVE OBLASTS)

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Abstract: Podolian-Middle-Dnieper geobotanical subprovince of Forest-Steppe zone and the belts of *Artemisia*-Gramineae Steppes and grass-*Stipeta-Festuca* Steppes of Priazov Black Sea Steppe subprovince of Steppe zone are the most well studied among twelve geobotanical subprovinces of the Ukrainian plains, while the lack of information on lichen species diversity found to be in Middle Russian subprovince of Forest zone and belt of grass-*Stipeta-Festuca* Steppes of Middle-Don Steppe subprovince of Steppe zone of this territory. Among twenty three administrative oblasts of the Ukrainian plains situated in twelve geobotanic subprovinces of three zones the highest lichen species diversity is found in Kherson oblast of the belt of *Artemisia*-Gramineae Steppes (464 species), Mykolaiv oblasts of the belt of grass-*Stipeta-Festuca* Steppes of Priazov Black Sea Steppe subprovince (389 species) of Steppe zone, as well as in Kharkiv oblast of Middle Russian subprovince (332 species) of Forest-Steppe zone of the Ukrainian plains on the basis of the Fourth checklist of lichen-forming and lichenicolous fungi including 2,106 of the total Ukrainian lichens. The lower lichen diversity is hitherto recorded from Rightbank Polessian subprovince (the highest species diversity 296 species in Zhytomyr oblast) and Baltic Forest subprovince (281 species in Lviv oblast) in Forest zone of the Ukrainian plains as well as Podolian-Middle-Dnieper subprovince (287 species in Khmelnytsk oblast) of the Forest-Steppe zone of territory mentioned. Insufficient level of data on lichen diversity is recorded for Middle Russian and Podolian-Bessarabian Forest subprovinces of the Forest zone, as well as the belt of grass-*Stipeta-Festuca* Steppes of Middle-Don Steppe subprovince and the belt of *Stipeta-Festuca* Steppes of Priazov Black Sea Steppe subprovince of Steppe zone. The same rather lower level of data on lichen diversity is found in Ivano-Frankivsk, Chernivtsi, Chernihiv, Vinnytsia and Sumy of Forest and Forest-Steppe zones; in Poltava and Kharkiv, as well as Cherkasy, Kirovograd, Mykolaiv and Donetsk oblasts in Forest-Steppe and Steppe zones; in Odessa, Kherson and Dnipropetrovsk oblasts of Steppe zone, as well as Zhytomyr oblasts in Podolian-Middle-Dnieper subprovince of Forest-Steppe zone. List of the rarest taxa of the regionally unique group (hitherto known from single or a few localities) proposed as candidates for including to Red Regional lists of 22 oblasts of the Ukrainian plains as far the whole nature protection activity in Ukraine is provided.

Key words: administrative oblast, Forest, Forest-Steppe, Kharkiv, Kherson, Mykolaiv, nature protection, Steppe zone, Ukraine, Zhytomyr oblast

INTRODUCTION

The first attempt to carry out special analysis of lichens species diversity of various geobotanic subprovinces and administrative oblasts of the Ukrainian plains was done in the middle of 1990s, when the first Checklist of Ukrainian lichens (Kondratyuk *et al.* 1996) was in preparation. However, these results were published only as preliminary data (Kondratyuk 1996).

The first data on species diversity of lichens of geobotanical subprovinces and administrative oblasts of the whole Ukrainian territory were published in 1998 for the first time in the Second checklist of lichens of Ukraine including 1,322 species (Kondratyuk *et al.* 1998). Geobotanical subprovinces and administrative oblasts are listed in distribution of each taxon. The Fourth checklist of lichen-forming and lichenicolous fungi of Ukraine including 2,106 species (Kondratyuk *et al.* 2021*a*, *b*) is prepared in the same style as the second checklist. Comparative analysis of data on species diversity of subprovinces and administrative oblasts known by 1996, 1998 and 2021 is still in preparation and will be discussed elsewhere. Furthermore, Ukrainian edition of the Fourth checklist of lichen-forming and lichenicolous fungi of Ukraine, published as '*Prodromus of sporen plants of Ukraine: Lichens*' (Kondratyuk *et al.* 2021*b*) for the first time included unified data on all published localities of each taxon, as widely distributed as rare, and it has allowed to carry out analysis of Ukrainian lichens distribution within five macroregions, as well as to recognise importance of regionally unique species at recent stage*. Detailed analysis of lichen species diversity of the Carpathian Mts including 1,395 species of 2,106 of the total Ukrainian lichens and their regionally unique taxa as well as perspectives of their protection were provided by us previously (Kondratyuk *et al.* 2022). However, similar data on lichen diversity of the Ukrainian plains have neither been analysed nor discussed so far.

The aim of this contribution is to provide results of analysis of lichen species diversity in twenty three administrative oblasts of the Ukrainian plains situated in twelve geobotanic subprovinces of three zones on the basis of the Fourth checklist of lichen-forming and lichenicolous fungi including 2,106 of the total Ukrainian lichens as well as to identify 'hot' and 'white' spots of lichen diversity of this region and to propose list of rare and regionally unique species for local protection and for further monitoring.

* Detailed data mostly on distribution of rare species was included in fundamental taxonomic treatment 'Flora of the lichens of Ukraine' (Oxner 1956, 1968, 1993, 2010), while data on more or less widely distributed species were usually omitted (to safe space of editions mentioned).

MATERIALS AND METHODS

Species diversity of the Ukrainian lichens discussed here is based on data of the Fourth checklist of lichen-forming and lichenicolous fungi of Ukraine (Kondratyuk *et al.* 2021*a*, *b*) and on our current knowledge on species diversity of the Ukrainian lichens and their distribution up to 2021.

Lichens hereafter includes both lichen-forming and lichenicolous fungi traditionally investigated by lichenologists.

Geobotanical subprovinces of the Ukrainian plains (i.e. Baltic, Polessian, Middle Russian, Western Ukrainian and Podolian-Bessarabian subprovinces of Forest zone, Podolian-Middle-Dnieper, Leftbank Priednieper and Middle Russian subprovinces of Forest-Steppe zone as well as the belts of grass-*Stipeta-Festuca* Steppes, *Stipeta-Festuca* Steppes and *Artemisia*-Gramineae Steppes of Priazov Black Sea Steppe subprovince, and the belt of grass-*Stipeta-Festuca* Steppes of Middle-Don Steppe subprovince of the Steppe zone are provided after the 2nd and the 4th checklist of Ukrainian lichens (Kondratyuk *et al.* 1998, 2021*a*, *b*).

Nomenclature of lichens is given after Kondratyuk *et al.* (2021*a*) with a few additions of recent taxonomy of the Physciaceae (Kondratyuk *et al.* 2021*c*).

Data on distribution of each taxon within the subprovinces and administrative oblasts of Ukraine are based mostly on Ukrainian version of the 4th checklist (Kondratyuk *et al.* 2021*b*) with some minor corrections.

RESULTS

Geobotanical subprovinces of three zones

The Polessian subprovince of the five subprovinces of Forest zone of the Ukrainian plains is characterised by the highest lichen species diversity, i.e. 464 species. It is the same species diversity as in Zakarpattia portion of the Chornohora Mts or Zakarpattia portion of the Volcanic Carpathians or Maramorosh Mts (452, 464 and 431 species, respectively) (Kondratyuk *et al.* 2022). The Baltic, Western Ukrainian and Podolian-Bessarabian Forest subprovinces are characterised by lower diversity, i.e. 281, 247 and 184 species, respectively. The lowest lichen species diversity (i.e. 22 species) has been recorded so far from the Middle Russian subprovince of Forest zone.

Three subprovinces of Forest-Steppe zone are more or less well studied from lichenological point of view among 12 geobotanical subprovinces of the Ukrainian plains. 584 lichen species found to be hitherto recorded from Podolian-Middle-Dnieper subprovince of Forest-Steppe zone which is also the highest species diversity considering all subprovinces of the Ukrainian plains.

Lichen species diversity of Middle Russian and Leftbank Priednieper subprovinces is somewhat lower, i.e. 358 and 248 lichen species.

The belts of *Artemisia*-Gramineae Steppes and grass-*Stipeta-Festuca* Steppes both of Priazov Black Sea Steppe subprovince of Steppe zone of the Ukrainian plains found to be characterised by the highest species diversity in this zone. There are 573 and 563 lichen species recorded so far from each belt, respectively. Much lower lichen diversity has been recorded so far from the belt of grass-*Stipeta-Festuca* Steppes of Middle-Don Steppe subprovince and the belt of grass-*Stipeta-Festuca* Steppes of Priazov Black Sea Steppe subprovinces (only 84 and 155 species, respectively).

Thus, among twelve geobotanical subprovinces of the Ukrainian plains the Podolian-Middle-Dnieper subprovince of Forest-Steppe zone and the belts of *Artemisia*-Gramineae and grass-*Stipeta-Festuca* Steppes of Priazov Black Sea Steppe subprovince of Steppe zone are the most well studied, while lack of information on lichen species diversity found to be in the Middle Russian subprovince of Forest zone and belt of grass-*Stipeta-Festuca* Steppes of the Middle-Don Steppe subprovince of Steppe zone of this territory.

Administrative oblasts per geobotanical subprovinces

a) Forest zone

The Zhytomyr oblast of the Polessian subprovince of the administrative oblasts of the Forest zone of the Ukrainian plains has been found so far to hold the highest number of lichen species (i.e. 296), while it is only a half of total species diversity (of 638 species) of the whole Forest zone of the Ukrainian plains** (Table 1, Fig. 1). This lichen species diversity is similar to lichen diversity of Ivano-Frankivsk part of the Gorgany Mts or Chernivtsi part of the Chyvchyn Mts (i.e. 253 and 277 species, respectively) (KONDRATYUK *et al.* 2022).

Lviv administrative oblast has been found to have the highest lichen species diversity in two subprovinces of Forest zone of the Ukrainian plains, i.e. in the subprovinces Baltic Forest subprovince and Western Ukrainian Forest subprovince.

Slightly lower species diversity is hitherto recorded from Kyiv and Sumy oblasts within the Forest zone of the Ukrainian plains.

Insufficient level of data on lichen diversity is so far registered in Chernivtsi, Ivano-Frankivsk, and Chernihiv oblasts of Forest zone. It should be emphasised that Chernivtsi and Ivano-Frankivsk oblasts are mostly situated in the Carpathian Mts, while their portion in plain Forest zone is rather small. However, Chernihiv oblasts is mostly situated in Forest zone.

** Species diversity and regionally unique lichens of the Carpathian lichens of the Forest zone of Ukraine was analysed in our previous paper (KONDRATYUK *et al.* 2022).

b) Forest-Steppe zone

The highest species diversity is hitherto known from Kharkiv oblast (332 species) of the Middle Russian Forest-Steppe subprovince, and Khmelnytsk oblast (287 species) within the Podolian-Middle-Dnieper subprovince as well as Poltava oblast (206 species) within the Leftbank Priednieper subprovince of Forest-Steppe zone of the Ukrainian plains. The species diversity of Kharkiv oblast is somewhat similar to lichen species diversity of Zakarpattia portion of the Svydovets Mts or Ivano-Frankivsk part of the Chyvchyn Mts (i.e. 312 and 344 lichen species) (Kondratyuk *et al.* 2022).

Lower lichen species diversity has been found in Kyiv, Ternopil and Cherkasy oblasts (261, 257 and 250 species, respectively) of Forest-Steppe zone of the Ukrainian plains.

Level of investigation of Zhytomyr, Chernihiv, Sumy, Ivano-Frankivsk, Chernivtsi, Vinnytsia, Kirovograd, Mykolaiv oblast portions in some subprovinces of Forest-Steppe zone of the Ukrainian plains cannot be accepted as sufficient (Table 2).

c) Steppe zone

The highest species diversity is hitherto recorded from Kherson oblast (464 species) of the belt of *Artemisia*-Gramineae Steppes of Priazov Black Sea Steppe subprovince, Mykolaiv oblast (389 species) in belt of grass-*Stipeta-Festuca* Steppes of the same subprovince, and Luhansk oblast (132 species) in belt of

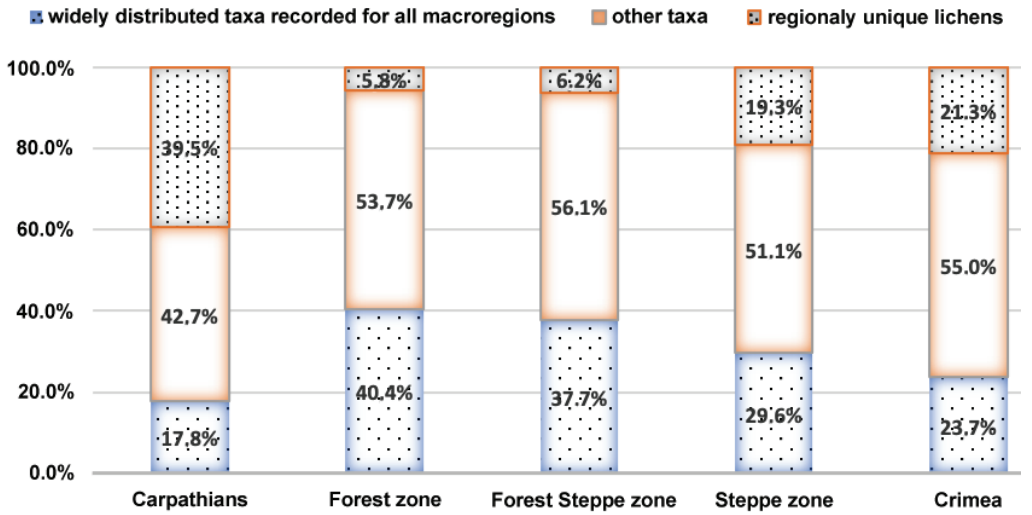

Fig. 1. Species diversity of distributional groups in lichen flora of Ukraine (with % of the total Ukrainian lichens) and florae of main macroregions of Ukraine (with % of total taxa of each macroregion) (after Kondratyuk *et al.* 2022).

Stipeta-Festuca Steppes of the same subprovince (as well as Kherson oblast – 84 species in the belt of grass-*Stipeta-Festuca* Steppes of Middle-Don Steppe subprovince subprovince) of the Steppe zone of the Ukrainian plains.

Lower lichen species diversity has been recorded from Donetsk, Luhansk and Kirovograd oblasts (276, 193 and 171 species, respectively) of the belt of

Table 1. Species diversity of distributional groups in main macroregions of Ukraine (with % of total Ukrainian lichens) (after KONDRATYUK *et al.* 2022).

Distributional groups / Macroregions	Ca	Fo	Fo-S	S	Cr	% of total Ukrainian lichens
Ca	551					26.2
Fo		36				1.7
Ca + Fo	46	46				2.2
Fo-S			41			1.9
Fo+ Fo-S		11	11			0.5
Ca + Fo-S	35		35			1.7
Ca + Fo + Fo-S	41	41	41			1.9
S				162		7.7
Fo-S + S			21	21		1.0
Fo + S		13		13		0.6
Fo + Fo-S + S		9	9	9		0.4
Ca + S	29			29		1.4
Ca + Fo-S +S	17		17	17		0.8
Ca + Fo + S	14	14		14		0.7
Ca + Fo + Fo-S + S	29	29	29	29		1.4
Cr					224	10.6
S + Cr				96	96	4.6
Fo-S + Cr			13		13	0.6
Fo-S + S + Cr			36	36	36	1.7
Fo + Cr		11			11	0.5
Fo + S + Cr		12		12	12	0.6
Fo + Fo-S +S + Cr		26	26	26	26	1.2
Ca + Cr	134				134	6.4
Ca + S + Cr	47			47	47	2.2
Ca + Fo-S + Cr	30		30		30	1.4
Ca + Fo-S + S + Cr	54		54	54	54	2.6
Ca + F + Fo-S + Cr	48	48	48		48	2.3
Ca + F + Cr	44	44			44	2.1
Ca + Fo + S +Cr	27	27		27	27	1.3
Ca + Fo +Fo-S + S +Cr	249	249	249	249	249	11.8
Total	1,395	616	660	841	1,051	100

Abbreviation of macroregions: Ca = Carpathians, Fo = Forest zone, Fo/S = Forest Steppe zone, S = Steppe zone, Cr = Crimea (mountainous and Mediterranean portions).

grass-*Stipeta-Festuca* Steppes of Priazov Black Sea Steppe subprovince, as well as Mykolaiv, Odessa and Zaporizhzhia oblasts (220, 185 and 162 species, respectively) in the belt of *Artemisia*-Gramineae Steppes of Priazov Black Sea Steppe subprovince of Steppe zone.

Level of data on lichen species diversity is probably still not sufficient for the belt of *Stipeta-Festuca* Steppes of Priazov Black Sea Steppe subprovince and belt of grass-*Stipeta-Festuca* Steppes of Middle-Don Steppe subprovince, as well as for Poltava, Kharkiv, Dnipropetrovsk and some other oblasts mentioned above within Steppe zone of the Ukrainian plains.

Thus, two administrative oblasts Zhytomyr and Lviv have been found to have the highest lichen species diversity in various subprovinces of Forest zone; Kharkiv, Khmelnytsk and Poltava oblasts – in various subprovinces of Forest-Steppe zone, as well as Kherson, Mykolaiv, and Luhansk oblasts – in various provinces of Steppe zone of the Ukrainian plains. These proposed oblasts here are to consider as 'hot' spots of the Ukrainian plains lichen species diversity.

Slightly lower species diversity of lichens is hitherto recorded from Kyiv, Sumy oblasts in Forest zone, Ternopil and Cherkasy oblasts of Forest-Steppe zone, as well as Donetsk, Luhansk and Kirovograd oblasts in various subprovinces of Steppe zone.

Unfortunately, very insufficient level of data on lichen species diversity has been found registered in Chernivtsi, Ivano-Frankivsk and Chernihiv oblasts of Forest zone, Vinnytsia, Kirovograd and Mykolaiv oblasts in Forest-Steppe zone, as well as Poltava, Kharkiv, Dnipropetrovsk oblasts of Steppe zone. The portions mentioned of latter oblasts are proposed here to consider as 'while' spots of lichen species diversity of the Ukrainian plains, which are in urgent need of special inventory.

Regionally unique lichens of the Ukrainian plains

Term 'regionally unique' lichens was proposed by us based on analysis of distribution of 30 distributional groups in five macroregions of Ukraine (Kondratyuk *et al.* 2022). Due to the number of regionally unique lichen taxa the Steppe zone is the most diverse in the Ukrainian plains (Table 1). There are 162 regionally unique taxa of lichens in Steppe zone (i.e. 19.35 of Steppe diversity), while only 41 (i.e. 6.2% of Forest-Steppe lichens) and 36 species (i.e. 5.8% of Forest lichens) of regionally unique lichens in Forest-Steppe and Forest zones, respectively. It should be emphasised that portion of regionally unique lichens in different zones of the Ukrainian plains is much lower than in mountainous macroregions of the Carpathians and the Crimea (551 species (i.e. 39.5% of the Carpathian lichens) and 224 species (i.e. 21.3% of Crimean lichens), respectively) (Kondratyuk *et al.* 2022).

a) Geobotanical subprovinces

Within the Ukrainian plains the highest number of regionally unique taxa are hitherto recorded from the belts of *Artemisia*-Gramineae Steppes and grass-*Stipeta-Festuca* Steppes of Priazov Black Sea Steppe subprovince of Steppe zone, i.e. 107 and 57 species, respectively. These data are distinctly correlating with the total lichen species diversity of subprovinces analysed in this paper.

The highest number of regionally unique species in subprovinces of Forest-Steppe and Forest zones is much lower: 26 species in Podolian-Middle-Dnieper Forest-Steppe and 24 species in Polessian Forest subprovinces (Table 3, Fig. 2).

Very low number of regionally unique lichen species are so far known from Baltic Forest subprovince and Podolian-Bessarabian Forest subprovince of Forest zone, Leftbank Priednieper and Middle Russian Forest-Steppe subprovinces as well as the belt of *Stipeta-Festuca* Steppes of Priazov Black Sea Steppe subprovince and belt of grass-*Stipeta-Festuca* Steppes of Middle-Don Steppe subprovince of Steppe zone.

It should be emphasised that there are no regionally unique taxa in two subprovinces: Middle Russian and Western Ukrainian Forest subprovince of Forest zone of the Ukrainian plains. And it is also additional illustration that these territories are still waiting for the first special step of inventory of lichen species diversity.

b) Oblasts per subprovinces

As it was stressed above, the level of inventory of species diversity of the half of administrative oblasts (i.e. 11 of 23) within the Ukrainian plains can only be accepted as rather sufficient. The oblasts included 'hot' spots of lichen species diversity of the Ukrainian plains are shown in Tables 2 and 3 in bold. Consequent analysis of data on regionally unique lichen taxa is the most reliable for these oblasts. However, we have included data on regionally unique lichen taxa of all oblasts, where we hitherto have such data.

The highest number of regionally unique records are so far present in Kherson (89 species totally), Mykolaiv (53 species), and Zaporizhzhia oblast (28 species) in Steppe zone of the Ukrainian plains. Regionally unique lichen taxa of Kherson oblasts have been recorded so far from two subprovinces, i.e. belt of *Artemisia*-Gramineae Steppes of Priazov Black Sea Steppe subprovince and belt of grass-*Stipeta-Festuca* Steppes of Middle-Don Steppe subprovince (84 and 5 species, respectively).

Similarly to this group of lichens of Kherson oblast, Mykolaiv and Zaporizhzhia oblasts also have regionally unique taxa in the belts of grass-*Stipeta-Festuca* Steppes and *Artemisia*-Gramineae Steppes of Priazov Black Sea Steppe subprovince of Steppe zone (34 and 19 species in Mykolaiv and 11 and 17 species in Zaporizhzhia oblasts, respectively).

Kharkiv oblast including both Forest-Steppe and Steppe zones hitherto supports totally 19 regionally unique lichens, while 14 species of them are known from Middle Russian subprovince of Forest-Steppe zone. That is the highest number of regionally unique taxa within Forest-Steppe zone of the Ukrainian plains. 5 species of regionally unique lichens of Kharkiv oblasts have been known so far from belt of grass-*Stipeta-Festuca* Steppes of Priazov Black Sea Steppe subprovince of Steppe zone.

Number of regionally unique taxa in Forest and Forest-Steppe zones is much lower than in Steppe zone (see above). So the highest species diversity of regionally unique taxa is so far known from Khmelnytsk oblast (totally 15 species), of which 13 species are hitherto recorded from Podolian-Middle-Dnieper subprov-

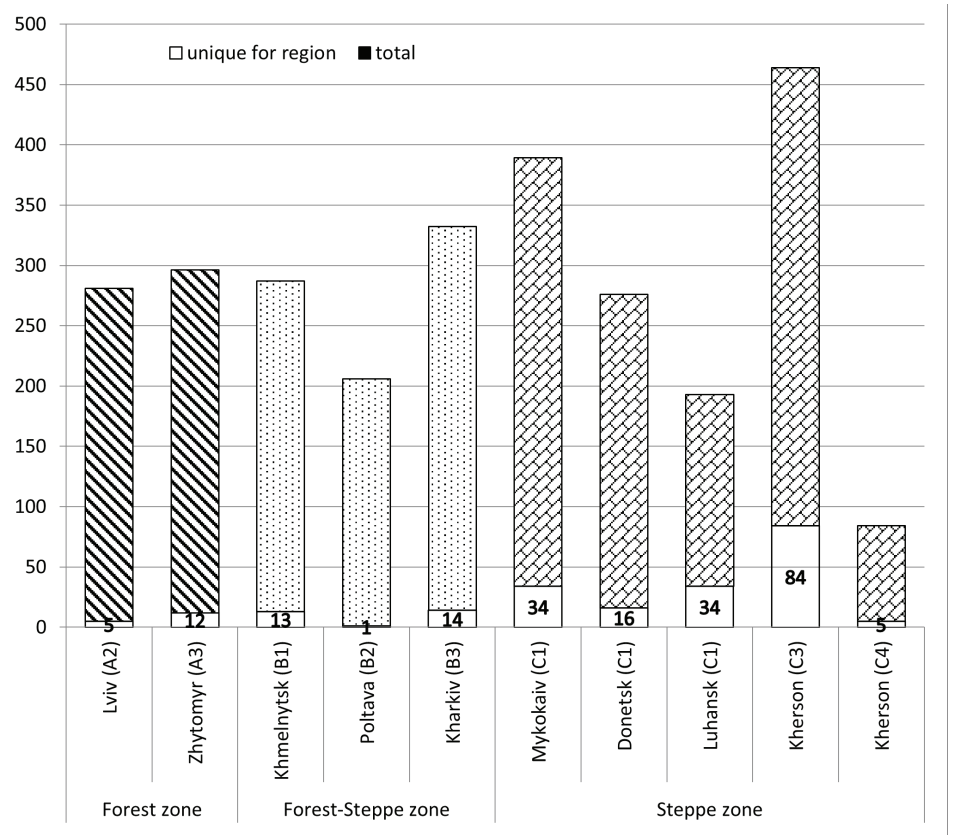

Fig. 2. Species diversity and number of regionally unique lichen species in administrative oblasts after geobotanical subprovinces of Forest (1–2), Forest-Steppe (3–5) and Steppe (6–10) zones of Ukrainian Plains, where 1 = Lviv (A2), 2 = Zhytomyr (A3); 3 = Khmelnytsk (B1), 4 = Poltava (B2), 5 = Kharkiv (B3); 6 = Mykolaiv (C1), 7 = Donetsk (C1), 8 = Luhansk (C1), 9 = Kherson (C3), 10 = Kherson (C4) oblasts. Abbreviation of geobotanical subprovinces of the Ukrainian plains as in Tables 2 and 3.

ince of Forest-Steppe zone, and single species are also recorded from Polessian and Podolian-Bessarabian Forest subprovinces of Forest zones (Table 3).

Kyiv oblast, similarly to Khmelnytsk oblast, includes regionally unique taxa from both Forest and Forest-Steppe zones characterised by bigger number of such species from Forest zone. Kyiv oblast includes 9 regionally unique species of

Table 2. Lichen species diversity of the Ukrainian plains after administrative oblasts and geobotanical subprovinces.

Oblast / subprovince	Forest zone					Forest-Steppe zone			Steppe zone			
	A2	A3	A4	A5	A6	B1	B2	B3	C1	C2	C3	C4
Volynska		101										
Rivne		94										
Zhytomyr		**296**				**3**						
Kyiv		226				261	122					
Chernihiv		100					41					
Sumy		**179**	**21**				**26**					
Lviv	**281**	**29**		**149**								
Ivano-Frankivsk				81		9						
Chernivtsi				25	53	55						
Ternopil		3		74	1	257						
Khmelnytsk		**90**			**59**	**287**						
Vinnytsia					**106**	**69**						
Cherkasy						250	72	2				
Kirovograd						122			171		1	
Poltava							**206**	**2**	**21**	**1**		
Kharkiv							**19**	**332**	**40**	**13**		
Luhansk									**193**	**132**		**1**
Odessa									10	3	185	
Mykolaiv									**389**	**1**	**220**	
Kherson						**77**			**4**	**5**	**464**	**84**
Dnipropetrovsk									150	2	17	
Zaporizhzhia									137		162	
Donetsk								1	276	35		
Total per subprovince	281	464	22	247	184	584	248	358	563	155	573	84
Total	638					687			873			

Abbreviations of subprovinces: A2 = Baltic Forest, A3 = Polessian Forest, A4 = Middle-Russian, A5 = Western Ukrainian, A6 = Podolian-Bessarabian Forest, B1 = Podolian-Middle-Dnieper Forest-Steppe, B2 = Leftbank Priednieper Forest-Steppe, B3 = Middle Russian Forest-Steppe subprovinces, C1 = the belt of grass-*Stipeta-Festuca* Steppes, C2 = the belt of *Stipeta-Festuca* Steppes, C3 = the belt of *Artemisia*-Gramineae Steppes of Priazov Black Sea Steppe subprovince, and C4 = the belt of grass-*Stipeta-Festuca* Steppes of Middle-Don Steppe subprovince (the same as in KONDRATYUK *et al.* 1996, 2021*a*, *b*, 2022).

which 6 species are known only from Polessian subprovince of Forest zone, while two and one species are hitherto recorded only from Podolian-Middle-Dnieper and Leftbank Priednieper Forest-Steppe subprovinces, respectively.

Among administrative oblasts situated in Forest zone, Zhytomyr oblast is characterised by the highest species diversity of regionally unique lichens (12 species in Polessian Forest subprovince). However, that is the lowest diversity of regionally unique species in the Ukrainian plains (as in the whole Ukraine see Kondratyuk *et al.* 2022).

Table 3. Number of regionally unique lichen species in administrative oblasts after geobotanical subprovinces of the Ukrainian plains.

Oblast / subprovince	A2	A3	A6	B1	B2	B3	C1	C2	C3	C4	Total
Volyn		2									2
Rivn		3									3
Zhyt		**12**									**12**
Kyiv		6		2	1						9
Chern		1									1
Sumy		2									2
Lviv	5										5
Ter			3	9							12
Khmel		1	1	**13**							**15**
Cherk											2
Kiro							3				3
Polt					1						1
Khar						**14**	5				**19**
Luh							6	2			8
Odes								2	9		11
Myk							**34**		**19**		**53**
Kher									**84**	5	**89**
Dnipr							8				8
Zapo							11		17		**28**
Done							16	1			17
Total	5	24	4	26	2	14	57	5	107	5	

Abbreviations of subprovinces: A2 = Baltic Forest, A3 = Polessian Forest, A6 = Podolian-Bessarabian Forest, B1 = Podolian-Middle-Dnieper Forest-Steppe, B2 = Leftbank Priednieper Forest-Steppe, B3 = Middle Russian Forest-Steppe subprovinces, C1 = the belt of grass-*Stipeta-Festuca* Steppes, C2 = the belt of *Stipeta-Festuca* Steppes, C3 = the belt of *Artemisia*-Gramineae Steppes of Priazov Black Sea Steppe subprovince, and C4 = the belt of grass-*Stipeta-Festuca* Steppes of Middle-Don Steppe subprovince (the same as in Kondratyuk *et al.* 1996, 2021*a*, *b*, 2022). – Abbreviation of oblasts: Volyn = Volynska, Rivn = Rivne, Zhyt = Zhytomyr, Chern = Chernihiv, Ter = Ternopil, Cherk = Cherkasy, Kiro = Kirovograd, Polt = Poltava, Khar = Kharkiv, Luh = Luhansk, Odes = Odessa, Myk = Mykolaiv, Kher = Kherson, Dnip = Dnipropetrovsk, Zapo = Zaporizhzhia, Don = Donetsk.

Extremely low number of species of regionally unique lichen species are found in such oblasts as Volynska, Rivne, Chernihiv, Cherkasy, Kirovograd and Poltava, which is also illustration of the level of inventory of lichen diversity in these oblasts and they are rather insufficient (see also above under total species diversity of subprovinces and oblasts).

The lack of data on regionally unique lichen taxa in Ivano-Frankivsk, Chernivtsi, Vinnytsia oblasts in Forest zone, and Zhytomyr, Chernihiv, Sumy, Kirovograd oblasts in Forest-Steppe zone, as well as Poltava oblast in Steppe zone illustrates that these territories are in urgent need of the first special inventory of lichen diversity. It is also a confirmation that they can be included to 'white' spots of the Ukrainian plains species diversity.

Among regionally unique taxa there are sixteen species recently described from Ukraine, and data on their distribution is still waiting on confirmation from other localities. Four newly described species are so far known from Polessian Forest subprovince, i.e. *Melaspilea oxneri* – from Kyiv oblast, as well as *Caloplaca orloviana*, *Lecanora orlovii*, and *Rusavskia drevlyanica* from Zhytomyr oblast. Furthermore, six species of newly described Ukrainian taxa, i.e. *Norrlinia medoborensis* and *Pyrenula boberskiana* are so far known only from Ternopil oblast of Podolian-Middle-Dnieper Forest-Steppe subprovince, *Collemopsidium kostikovii* is recorded only from Poltava oblast of Leftbank Priednieper subprovince, and three species: *Agrestia zerovii*, *Involucropyrenium breussii* and *Pronectria gromakovae* are so far known only from Kharkiv oblast of Middle Russian subprovince of Forest-Steppe zone.

Totally six newly described taxa from Ukraine are recorded from Steppe zone, where two species, i.e. *Epibryon kondratyukii* and *Lecanora panticapensis* are recorded from Mykolaiv and Dnipropetrovsk oblasts of the belt of grass-*Stipeta-Festuca* Steppes of Priazov Black Sea Steppe subprovince, respectively, and four taxa, i.e. *Candelariella boikoi*, *Didymocyrtis trassii, Pyrenodesmia syvashica* and *Zwackhiomyces khodosovtsevii* are recorded from Kherson oblast of the belt of *Artemisia*-Gramineae Steppes of Priazov Black Sea Steppe subprovince. In the latter group, *Pyrenodesmia syvashica* is so far known as from Kherson and from Mykolaiv oblasts. Hopefully all recently described taxa mentioned above will be confirmed from additional localities of the Ukrainian plains and other regions of Europe in future inventorial investigations.

c) Proposals to the red lists of administrative oblasts of Ukraine

As it was stressed by us before (KONDRATYUK *et al.* 2022), all kinds of nature protection activities within Ukraine are done at level of administrative oblasts. It is why analysis of distribution of regionally unique lichens within the

separate administrative oblast of the Carpathian mesoregion: Zakarpattia, Lviv, Ivano-Frankivsk and Chernivtsi oblasts was provided in the previous paper (Kondratyuk *et al.* 2022).

d) Representativeness of regionally unique lichens in the Red data book of Ukraine

Proportion of regionally unique and scarcely distributed lichens of main macroregions of Ukraine in the Red data book of Ukraine (Didukh 2009) is analysed in our previous paper (Kondratyuk *et al.* 2022). It was stressed earlier that the Red data book of Ukraine includes 57.7% (or 30 species) belonging to the group of regionally unique, and 42.3% (or 22 species) of scarcely distributed taxa. It was emphasised, that Red data book of Ukraine does not include any widely distributed taxa. However, the Red data book of Ukraine includes only 2.4% of total species diversity of Ukraine.

Regarding macroregions, the Red data book of Ukraine includes the biggest number of species i.e. 17 species (32.7%) of Crimean regionally unique lichens, while there are only 11 species (21.2%) of Carpathian, and only 2 species (3.8%) of Steppe lichens. It should also be emphasised that among scarcely distributed taxa (totally 22 species or 42.3%) hitherto included in the Red data book of Ukraine there are also 8 species known from both the Carpathian and Crimean macroregions, as well as 3 species recorded from Steppe zone and Crimean mesoregion. Thus, from the Ukrainian plains only lichens of Steppe zone are included in the Red data book of Ukraine. However, in general the representativeness of regionally unique taxa in the Red data book of Ukraine cannot be accepted as sufficient, and a new proposal to be prepared on widening of this list of lichens in mentioned edition.

Thus, in general, we have to confirm the previous conclusion that the Red data book of Ukraine cannot provide prevention of regionally unique taxa of lichen flora of Ukraine (Kondratyuk *et al.* 2022). Consequently, we have to find other ways of monitoring and preservation of rare species of Ukraine and region of the Ukrainian plains in particular.

On the one hand, we propose to include all rare regionally unique taxa to the local red lists, which can provide the further monitoring of their number of localities as well as situation in each administrative oblast, but on the other hand we should carry out special analysis which portion of regionally unique lichens are currently confirmed on protected territories of the Ukrainian plains.

Thus, the rarest taxa of the group of regionally unique lichens are proposed here to consider as candidates to the red lists of separate oblasts to be the object of future monitoring. They are listed in Appendix 1.

The number of taxa is much lower of similar lists for the Carpathian mesoregions, where the highest number of rare lichen taxa (83 species) are hitherto recorded from the Gorgany Mts portion of Zakarpattia oblast, while number of such taxa in the Eastern Beskydy and the Chornohora Mts portions of this oblast is much lower (63 and 41 species, respectively) (Tables 4, 6 in KONDRATYUK *et al.* 2022).

The number of rare lichen species so far known only from Ivano-Frankivsk oblast is rather lower, than in Zakarpattia oblast, namely 23 species from the Chyvchyn Mts portion of this oblast, while 12 and 7 species recorded from the Gorgany Mts and the Chornohora portions of this oblast.

Analysis of regionally unique taxa as well as distribution of rare lichen species after administrative oblasts within the territory of the Ukrainian plains is provided here for the first time, and these data can be compared only with data on various geomorphological districts of the Eastern Carpathians or the whole Carpathian Mts. However, we do hope that data on regionally unique taxa of the Ukrainian Carpathians provided in previous paper can be used in future for comparison of similar regionally unique portion of lichen flora for other regions of the Eastern Carpathians in Poland, Slovakia, and Romania, as well as in the whole Carpathians in the frame of future planning nature protection activity in the Carpathian region. Data on regionally unique taxa of the Ukrainian plains will also be compared with data on regionally lichen species of other territories of Eastern European Plain in future.

CONCLUSIONS

Podolian-Middle-Dnieper geobotanical subprovince of Forest-Steppe zone and the belts of *Artemisia*-Gramineae Steppes and grass-*Stipeta-Festuca* Steppes of Priazov Black Sea Steppe subprovince of Steppe zone among twelve geobotanical subprovinces of the Ukrainian plains, as well as Kherson oblast of belt of *Artemisia*-Gramineae Steppes of Priazov Black Sea Steppe subprovince (464 species), Mykolaiv oblasts of belt of grass-*Stipeta-Festuca* Steppes of Priazov Black Sea Steppe subprovince (389 species) of Steppe zone as well as in Kharkiv oblast of Middle Russian subprovince (332 species) of Forest-Steppe zone of the Ukrainian plains are the most well studied among twenty-three administrative oblasts of the Ukrainian plains. These data found to correlate with number of regionally unique taxa found in regions mentioned. Subprovinces and administrative oblasts within zones all mentioned above are proposed to be considered as hot spots of lichen diversity of the Ukrainian plains.

On the other hand, the lack of information on lichen species diversity in Middle Russian and Podolian-Bessarabian subprovinces of Forest zone and the belt of grass-*Stipeta-Festuca* Steppes of Middle-Don Steppe subprovince and the belt of *Stipeta-*

Festuca Steppes of Priazov Black Sea Steppe subprovince of Steppe zone of this territory, as well as rather lower level of data on lichen diversity in Ivano-Frankivsk, Chernivtsi, Chernihiv, Vinnytsia and Sumy of Forest and Forest-Steppe zones; in Poltava and Kharkiv, as well as Cherkasy, Kirovograd, Mykolaiv and Donetsk oblasts in Forest-Steppe and Steppe zones; in Odessa, Kherson and Dnipropetrovsk oblasts of Steppe zone, as well as Zhytomyr oblast in Podolian-Middle-Dnieper subprovince of Forest-Steppe zone is found. This group of subprovinces and oblasts within the studied zones considered to be 'white' spots of the Ukrainian plains, and lichen species diversity of them is in urgent need of special inventory.

* * *

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Appendix 1. List of rarest regionally unique lichens and lichenicolous fungi proposed for Red Regional lists of administrative oblasts of the Ukrainian plains.

Taxon name	Forest	Forest-Steppe	Steppe
Abrothallus suecicus			Myk – C1
Acaroconium punctiforme			Zap – C3
Acarospora versicolor	Riv – A3		
Acremonium caloplacae			Kher – C3
Acremonium lichenicola			Kher – C3
Adelococcus interlatens			Kher – C3
Agrestia zerovii		Khar – B3	
Anema decipiens		Khml – B1	
Arctoparmelia centrifuga			Don – C1
Arthonia cretacea			C3
Arthonia patellulata	Kyiv - A3		
Arthopyrenia grisea		Cherk – B1, Kyiv – B2	
Arthopyrenia saxicola		Khml – B1	
Ascohyta candelariellicola			Myk – C3, Kher – C4
Aspicilia epiglypta			Don – C1
Athallia alnetorum			Myk – C3, Kher – C3
Athelium imperceptum			Kher – C3, Ode – C3, Zap – C3
Bacidia viridescens			Kher – C3
Biatorella germanica		Ter – B1	
Brackelia lunkei			Kher – C3
Calogaya ferrugineoides			Kher – C4
Caloplaca cupreobrunnea			Dni – C1
Caloplaca emilii			Kher – C3
Caloplaca orloviana	Zhyt – A3		
Candelaria pacifica			Kher – C3
Candelariella antennaria			Zap – C3

Appendix 1. (continued)

Taxon name	Forest	Forest-Steppe	Steppe
Candelariella boikoi			Kher – C3, Kher – C4
Candelariella xanthostigmoides			Kher – C3
Ceratobasidium bulbillifaciens			Kher – C3
Cercidospora crozalsiana	Zhyt - A3		
Cercidospora lobothalliae			Kher – C3
Cercidospora solearispora			Zap – C3
Cerothallia luteoalba		Ter – B1, Khar – B3	
Cetraria ramulosa		Ky – B1	
Circinaria cupreogrisea			Don – C1
Circinaria gyrosa			C2
Circinaria hoffmanniana			Myk – C1
Cladonia bacilliformis	Kyiv – A3		
Cladonia diversa			Don – C1, Myk – C1
Cladonia magyarica			Myk – C1, Don – C1, Luh – C1, Kher – C3
Cladonia peziziformis			Khar – C1, Kher – C3, Myk – C3
Cladophialophora parmeliae			Myk – C1
Codonmyces lecanorae			Don – C1, Kher – C1, Kir – C1, Khar – C1, Myk – C1, Myk – C3
Collema substellatum			Kher – C4
Collemopsidium iocarpum	Kyiv – A3		
Collemopsidium kostikovii		Polt – B2	
Collemopsidium subarenisedum			Kher – C3
Cornutispora ciliata			Kher – C3
Cornutispora pyramidalis	Sum – A3		
Cyrtidula hippocastani		Khar – B3	
Cyrtidula quercus		Khar – B3	
Dacampia cladoniicola			Myk – C1, Kher – C3

Appendix 1. (continued)

Taxon name	Forest	Forest-Steppe	Steppe
Dermatocarpon borysthenicum			Zap – C1
Didymellopsis perigena			Khar – C1, Zap – C3, Kher – C3, Myk – C3
Didymocyrtis trassii			Kher – C3
Diploschistes scruposus var. *arenarius*		Khar – B3	
Enchylium bachmanianum			Kher – C3
Enchylium coccophorum			Kher – C3
Endocarpon latzelianum		Khml – B1	
Endocarpon obscuratum			Luh – C2
Endocarpon psorodeum			Myk – C1, Dni – C1, Kir – C1, Zap – C1, Zap – C3
Endococcus fusiger			Myk – C1, Zap – C3
Eonema pyriforme			Kher – C3
Epibryon kondratyukii			Myk – C1
Epicladonia simplex			Kher – C3
Epicladonia stenospora	Sum – A3		
Epithamnolia rangiferinae			Kher – C3
Evernia elenkiniana		Khar – B3	
Flavoplaca marina			C3
Fulgensia desertorum			Kher – C3
Haematomma nemetzii			Myk – C1
Heppia lutosa			C2
Hertelidea botryosa	Zhyt – A3		
Heteroplacidium phaeocarpoides			Kher – C3
Hymenostilbe lecaniicola	A3		
Hyphodiscus ucrainicus	Chern – A3		
Hysterium pulicare			Kher – C3
Involucropyrenium breussii		Khar – B3	
Knufia peltigerae		Ter – B1	
Lawalreea lecanorae			Kher – C3, Zap – C3
Lazarenkoella polycarpoides			Kher – C3

Appendix 1. (continued)

Taxon name	Forest	Forest-Steppe	Steppe
Lecania ephedrae			Kher – C3, Myk – C3
Lecania leprosa			Myk – C3
Lecania spadicea			Myk – C3
Lecania triseptata			Kher – C3
Lecaniella sylvestris			Kher – C3
Lecanora alpigena	Zhyt – A3		
Lecanora atrosulphurea			Don – C1
Lecanora caesiosora			Zap – C3
Lecanora crenulatissima			C2
Lecanora leopoliensis	Lv – A2		
Lecanora orlovii	Zhyt – A3		
Lecanora orosthea			Myk – C1, Zap – C1
Lecanora panticapensis			Dni – C1
Lecanora wasmuthii			Kher – C3
Lecidea aff. *fuscoatrata*			Zap – C3
Lecidea exilis		Khar – B3	
Lecidea grisea			Don – C1
Lecidea sarcogynoides			Myk – C1, Dni – C1, Zap – C1
Lecidea umbonata	Khml – A6		
Lepraria caesioalba			Myk – C1
Leproplaca proteus		Khml – B1	
Leptorhaphis lucida	Vol – A3		
Leptorhaphis parameca	Kyiv – A3		
Leptorhaphis pyri		B3	
Licea parasitica			Kher – C3
Lichenochora caloplacae			Kher – C3, Myk – C3
Lichenochora wasseri			Kher – C3
Lichenoconium aeruginosum			Zap – C3
Lichenohendersonia squamarinae			Kher – C3, Myk – C3
Lichenohendersonia varians			Zap – C3
Lichenopeltella coppinsii			Kher – C3
Lichenostigma dimelaenae			Myk – C1

Appendix 1. (continued)

Taxon name	Forest	Forest-Steppe	Steppe
Lichenostigma epipolinum	Zhyt – A3		
Lichenostigma rugosa			Kher – C3
Lichenothelia tenuissima	Zhyt – A3		
Llimoniella adnata			Kher – C3
Llimoniella caloplacae			Kher – C3
Megaspora rimisorediata		Khar – B3	
Melaspilea oxneri	Kyiv – A3		
Micarea nitschkeana		Khar – B3	
Micarea subnigrata			Luh – C1, Don – C1
Microsphaeropsis caloplacae			Kher – C3
Mycomicrothelia melanospora			Ode – C3
Nectria lichenicola	Lv – A2		
Nectriopsis lecanodes	Lv – A2		
Norrlinia medoborensis		Ter – B1	
Opegrapha demutata			Ode – C2
Opegrapha opaca			Kher – C3
Opegrapha verrucariae			Myk – C1
Orcularia insperata			Don – C2
Parmelia farinosa	Vol – A3, Riv – A3, Zhyt – A3		
Parmelia neglecta		Cherk – B1	
Peltigera extenuata	Lv – A2		
Phaeophyscia hispidula		Ter – B1	
Phaeophyscia hispidula		Ter – B1	
Phoma candelariellae			Myk – C1, Kher – C3, Myk – C3
Physarium didermiodes			Kher – C3
Physcia tenella subsp. *marina*			Ode – C2
Placidiopsis cinerascens			Kher – C3, Ode – C3
Pleospora xanthoriae			Kher – C3
Polyblastia sepulta		Khml – B1	
Polycoccum microsticticum	Zhyt – A3		
Polyozosia bandolensis			Myk – C3
Pronectria caloplacae			Kher – C4

Appendix 1. (continued)

Taxon name	Forest	Forest-Steppe	Steppe
Pronectria casaresii			Kher – C3
Pronectria cf. *dillmaniae*			Kher – C3
Pronectria gromakovae		Khar – B3	
Pronectria robergei	Lv – A2		
Pronectria xanthoriae			Myk – C3
Protoblastenia terricola		Khml – B1	
Protoparmeliopsis acharianum			Don – C1
Protoparmeliopsis admontensis		Khml – B1	
Protoparmeliopsis laatokkensis			Myk – C1, Khar – C1, Don – C1, Zap – C1, Luh – C1, Dni – C1, Zap – C3
Psora saviczii			Ode – C3
Psorotichia montinii			Myk – C1, Khar – C1
Psorotichia moravica			Myk – C1, Don – C1, Luh – C1, Kher – C3
Pyrenocollema strontianense			Kir – C1, Zap – C1, Dni – C1, Kher – C3
Pyrenodesmia erodens			Myk – C1
Pyrenodesmia molariformis			Luh – C1
Pyrenodesmia syvashica			Kher – C3, Myk – C3
Pyrenopsis cf. *grumulifera*	Vinn		
Pyrenula boberskiana		Ter – B1	
Ramalina lacera			C3
Rebentischia unicaudata			Kher – C3
Refractohilum achromaticum			Kher – C3
Rhizodiscina lignyota			Kher – C3
Rimularia gibbosa			Luh – C1, Zap – C1, Don – C1
Rinodina aspera			Don – C1

Appendix 1. (continued)

Taxon name	Forest	Forest-Steppe	Steppe
Rinodina luridata			Don – C1
Rinodina mucronatula			Kher – C3
Rinodina terrestris		Khar – B3	
Roccella fucoides			C2
Roselliniella cladoniae		Khml – B1	
Roselliniella frustulosa			Myk – C1
Roselliniella lecideae			Dni – C1
Rusavskia drevlyanica	Zhyt – A3		
Sarcogyne latericola	Riv – A3		
Sarcogyne praetermissa			Kher – C3
Sclerococcum sphaerale	Zhyt – A3		
Scutula miliaris		Ter – B1	
Scutula tuberculosa		Ter – B1	
Scytinium callopismum			Kher – C3
Seirophora lacunosa			Myk – C3, Kher – C3, Zap – C3, Kher – C4
Sistotrema brinkmannii			Kher – C3
Sphaerellothecium aculeatae			Myk – C1, Kher – C3
Sphaerellothecium cf. *atryneae*			Myk – C1
Squamarina lamarckii			C2
Stagonospora exasperatulae	Ter – A6		
Staurothele columellaris			Zap – C1
Staurothele elenkinii	Khml – A3		
Staurothele epigea			Kher – C3
Staurothele geoica			Kher – C3
Stigmidium bellemerei			Kher – C3
Stigmidium clauzadei			Myk – C1, Kher – C3, Zap – C3
Stigmidium glebarum			Myk – C1, Ode – C3
Stigmidium lichenum	A3		
Stigmidium mycobilimbiae			Ode – C3
Stigmidium ramalinae			Kher – C3
Stigmidium rivulorum		Ter – B1	

Appendix 1. (continued)

Taxon name	Forest	Forest-Steppe	Steppe
Stigmidium stygnospilum			Myk – C1
Strikeria anomala		Khar – B3	
Taeniolella rolfii			Kher – C3
Teniolella beschiana	Zhyt – A3		
Thalloidima massatum			Kher – C3
Thelenella pertusariella		Ky – B1	
Toninia diffracta	Ter – A6		
Toninia physaroides			Myk – C1
Toninia subfuscae			Ode – C3
Toninia talparum		Khml – B1	
Tremella everniae	Ter – A6		
Trichothecium roseum			Myk – C1, Kher – C3
Trimmatothelopsis scabrida			Zap – C1, Zap – C3
Tuckermannopsis ciliaris	Kyiv – A3		
Umbilicaria subpolyphylla			Don – C1
Unguiculariopsis groenlandiae			Kher – C3
Unguiculariopsis thallophila			Don – C1
Variospora sororicida			Kher – C3
Verrucaria aphanes		Khar – B3	
Verrucaria bernaicensis			C3
Verrucaria ditmarsica			C2
Verrucaria fuscoatroides		Khml – B1	
Verrucaria fusconigrescens			Zap – C1
Verrucaria obfuscans		Khml – B1	
Verrucaria papillosa			Myk – C1
Verrucaria schindleri			Myk – C1, Kher – C3, Myk – C3, Zap – C3
Weddellomyces heterochrous			Luh – C2
Weddelomyces epicallopisma			Kher – C3
Xanthocarpia borysthenica			Kher – C3, Ode – C3
Xanthocarpia diffusa			Myk – C1
Xanthocarpia tominii			Kher – C3, Ode – C3, Myk – C3

Appendix 1. (continued)

Taxon name	Forest	Forest-Steppe	Steppe
Xanthoria ectaneoides			Kher – C3
Xanthoria monofoliosa			Kher – C3 Myk – C3
Zwackhiomyces calcariae			Myk – C1, Kher – C3
Zwackhiomyces calcisedus			Kher – C3
Zwackhiomyces diederichii			Kher – C3
Zwackhiomyces inconspicuus			Kher – C3
Zwackhiomyces khodosovtsevii			Kher – C3
Zwackhiomyces lithoiceae			Zap – C1, Dni – C1, Myk – C1, Kher – C3, Myk – C3

Abbreviations of subprovinces: A2 = Baltic Forest, A3 = Polessian Forest, A4 = Middle-Russian, A5 = Western Ukrainian, A6 = Podolian-Bessarabian Forest, B1 = Podolian-Middle-Dnieper Forest-Steppe, B2 = Leftbank Priednieper Forest-Steppe, B3 = Middle Russian Forest-Steppe subprovinces, C1 = the belt of grass-*Stipeta-Festuca* Steppes, C2 = the belt of *Stipeta-Festuca* Steppes, C3 = the belt of *Artemisia*-Gramineae Steppes of Priazov Black Sea Steppe subprovince, and C4 = the belt of grass-*Stipeta-Festuca* Steppes of Middle-Don Steppe subprovince (the same as in KONDRATYUK *et al.* 1996, 2021*a*, *b*, 2022).
Abbreviation of oblasts: Volyn = Volynska, Rivn = Rivne, Zhyt = Zhytomyr, Chern = Chernihiv, Ter = Ternopil, Cherk = Cherkasy, Kiro = Kirovograd, Polt = Poltava, Khar = Kharkiv, Luh = Luhansk, Odes = Odessa, Myk = Mykolaiv, Kher = Kherson, Dnip = Dnipropetrovsk, Zapo = Zaporizhzhia, Don = Donetsk.