

## Distribution and ecology of the lichen *Fellhanera gyrophorica* in the Pojezierze Olsztyńskie Lakeland and its status in Poland

Dariusz Kubiak\*

Department of Mycology, Warmia and Mazury University in Olsztyn, Oczapowskiego 1a, 10-957 Olsztyn, Poland

### Abstract

The study presents recent data on the distribution of *Fellhanera gyrophorica* (Pilocarpaceae, Ascomycota) in Poland, a rare lichen with a crustose, usually sterile thallus. Both previous and new localities of the species are presented with data on its ecology and general distribution. Furthermore, this paper provides detailed results on floristic investigations of the species in the forest areas of the Pojezierze Olsztyńskie Lakeland (northern Poland). Fertile specimens of *F. gyrophorica* have been observed in Poland for the second time and in the world – for the third time. Also, a new substrate for this species has been found: *Acer platanoides*. In addition, *Carpinus betulus* and *Populus tremula* were also found to be the species' substrates in Poland. Based on this study and previous reports, *F. gyrophorica* seems to be a relatively common species in north-eastern Poland.

**Keywords:** inconspicuous crustose lichens, new localities, old-growth forest

### Introduction

Crustose lichens constitute the majority of lichens in the world and are usually dominant component of the local lichen biota. However, it is a very poorly studied group. During the last few years, the degree of knowledge on the crustose lichens and their habitats has increased significantly in Poland. Penetration of areas and habitats, previously neglected by lichenologists, as well as better methods of taxa identification, e.g., more common usage of thin layer chromatography (TLC), allowed to discover many species previously unknown in Poland [1-10] and new localities for taxa already known to exist in Poland [11-20]. However, current knowledge about the majority of species, especially those in which the ascospores are formed sporadically or not at all, is still insufficient. Besides their distribution, the ecology of these lichens and their sensitivity to anthropopressure are very poorly studied. Insufficient knowledge about the species hinders proper determination of the extent of the threat to the species. Therefore, it is necessary to conduct further research to recognize the exact status and ecology of crustose lichens. This article presents information on *Fellhanera gyrophorica* Sérus. Coppins, Diederich & Scheidegger, a species occurring in several localities in the central and north-eastern parts of Poland. The main objective of this

study was to determine the prevalence and habitat preferences of this lichen in a selected mesoregion in which this species had not been found before.

### Material and methods

Results presented in this paper summarize a research into the species diversity of lichens conducted in the years 2006-2011 on the area of selected forest complexes of the Pojezierze Olsztyńskie Lakeland (3817 km<sup>2</sup>), covering the best preserved (the oldest) fragments of meso- and eutrophic deciduous forests – lowland beech forests *Galio-Fagetum*, sub-Atlantic oak-hornbeam forests *Stellario-Carpinetum* and subcontinental oak-linden-hornbeam forests *Tilio-Carpinetum*. The study encompassed both areas of nature reserves as well as managed forests. A detailed list of explored areas and applied methods of inventory was provided in Tab. 1. In the case of most of the research areas, the field investigation was conducted with the line transects method. On the area of Las Warmiński Nature Reserve, the survey were conducted at 60 research sites with a constant area of 0.04 ha, each time determined in the central part of the analyzed forest community. All potentially suitable substrata were searched for lichens, however, particular attention was paid to epiphytes. A detailed list of recognized taxa on each study site was prepared. In the case of trees colonized by *F. gyrophorica*, quantitative proportions (the cover) of species on a tree trunk were determined as well. Species difficult to identify in the field were collected for further routine examinations in the laboratory. The TLC method, following Orange et al. [21], was applied for identification of the most sterile taxa (solvent C). Comparative studies were conducted in the Puszcza Białowieska Forest within the framework of a project in order to fill in the gaps on the diversity of lichens and lichenicolous

\* Email: [darkub@uwm.edu.pl](mailto:darkub@uwm.edu.pl)

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**Tab. 1** Description of the study areas.

Area	Size (ha)	Dominated forest community	Data collection methods	
Kamienna Góra Nature Reserve	95.14	lowland beech forest <i>Galio odorati-Fagetum</i> with a broad ecological amplitude, acidiphilous beech forest <i>Luzulo pilosae-Fagetum</i> and sub-Atlantic oak-hornbeam forest <i>Stellario holosteeae-Carpinetum</i>	line transects method	
Las Warmiński Nature Reserve	1803.15	oak-linden-hornbeam forest <i>Tilio-Carpinetum</i> (52.6%), continental oak-pine forest <i>Quercus roboris-Pinetum</i> (22.3%), fresh pine-spruce forest <i>Peucedano-Pinetum</i> (10%)	floristic relevés method	
Dęby Napiwodzkie Nature Reserve	37.11	sub-Atlantic oak-hornbeam forest, degenerated forms of streamside alder-ash forest and oak-pine forest	line transects method	
Koniuszanka II Nature Reserve	64.55	oak-linden-hornbeam forest, streamside alder and alder-ash forest,	line transects method	
Źródła rzeki Łyny Nature Reserve	120.5	spring communities, streamside alder forests, degenerative forms of oak-linden-hornbeam forest	line transects method	
Kudypy FD	forest arboretum	15.69 <sup>1</sup> (0.5 <sup>2</sup> )	oak-linden-hornbeam forest with broad ecological amplitude, pine and oak old-growth stands	line transects method
	fs No. 259	28.2		
Olsztyn FD	fs No. 290	25.66		line transects method
	fs No. 243	38.48		
Wichrowo FD	fs No. 402	38.14		line transects method
	fs No. 403	25.55		
Wipsowo	fs No. 36	19.03		line transects method
FD	fs No. 37	21.12		

<sup>1</sup> Total area. <sup>2</sup> Excluded part of natural forest communities.

fungi of this forest complex (see [22]).

Distribution of localities of *F. gyrophorica* in Poland (Fig. 1) was presented in the ATPOL grid square ([23]; modified by Cieśliński and Fałtynowicz [24]). The nomenclature of lichens follows Fałtynowicz [25] and Diederich et al. [26], except for *Bacidia hemipolia* f. *pallida* [5] and *Rinodina degeliana* [27]. Names of plant communities were accepted after Matuszkiewicz [28] and names of physical-geographical mesoregions after Kondracki [29]. The collected material (34 specimens of *F. gyrophorica* and several hundred specimens of other species) was deposited in the Herbarium of the Department of Mycology, the University of Warmia and Mazury in Olsztyn (OLTC-L). The following abbreviations are used: FD – forest district, fs – forest section, NP – national park, NR – nature reserve, ! – specimen with apothecia.

## Results

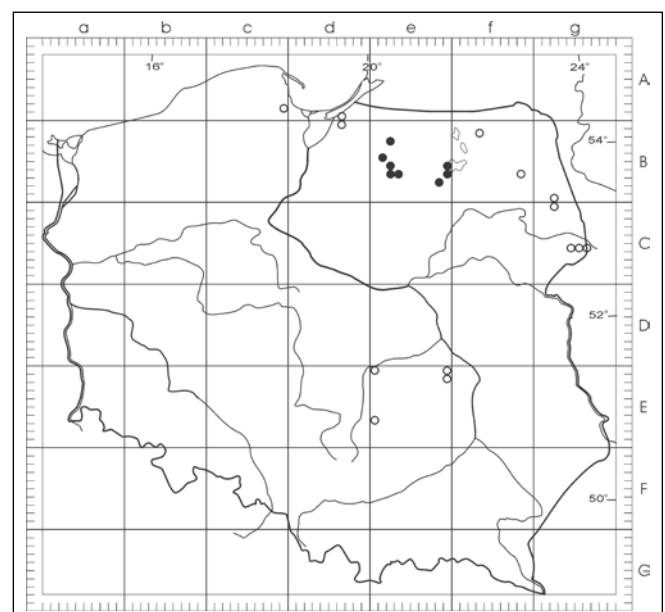
*Fellhanera gyrophorica* Sérus., Coppins, Diederich & Scheidegger [30].

*Fellhanera gyrophorica* (Pilocarpaceae, Ascomycota) was recently described by Sérusiaux et al. [30], based on the collection originating from several countries of Central Europe. Specimens of this lichen were previously reported in several publications as “*Fellhanera* sp.” (see [31]). Probably the oldest known specimen of *F. gyrophorica* comes from Poland, from the 1950s. This specimen was discovered during the revision of the herbarium of Professor T. Sulma, which comes from the Wysoczyzna Elbląska High Plain [32]. *F. gyrophorica* was described as a species new to science, based only on sterile specimens with pycnidia [30]. A year later, fertile thalli with apothecia were discovered in the Puszcza Białowieska Forest in Poland [33]. This discovery proved the accuracy of the former

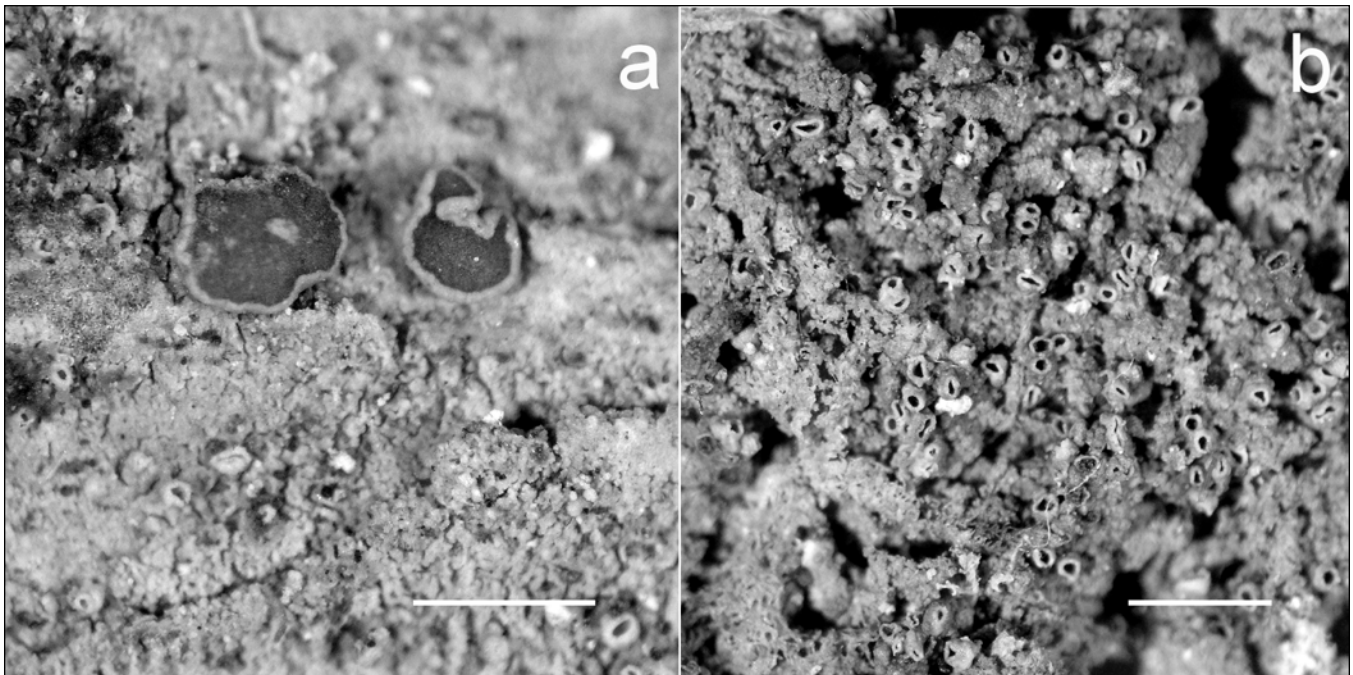
diagnosis. *F. gyrophorica* usually lacks ascomata but is well characterized by the thallus, which is rather thick and produces numerous and distinct pycnidia (Fig. 2). The detailed description of *F. gyrophorica* can be found in studies by Sérusiaux et al. [30] and Sparrius [33].

### Ecology

In Poland, according to the previous study, *F. gyrophorica* was reported from the bark of *Alnus glutinosa*, *Fagus*



**Fig. 1** Distribution of *Fellhanera gyrophorica* in Poland, in the ATPOL grid square system. White circles – known localities; black circles – new localities.



**Fig. 2** *Fellhanera gyrophorica*. **a** Thallus with apothecia and pycnidia (OLTC-L 3123). **b** Thallus with pycnidia (OLTC-L 3182). Scale bars: 1 mm.

*sylvatica*, *Fraxinus excelsior*, *Quercus robur* and *Tilia cordata* [11,20,32,34-36]. The only known data on the occurrence of this taxa on wood comes also from Poland [35]. At newly discovered localities in the Pojezierze Olsztyńskie Lakeland, the species has been recorded on *Acer platanoides*, *Carpinus betulus*, *Populus tremula*, *Quercus robur* and *Tilia cordata*. The author observed it on *Carpinus betulus* and *Quercus robur* in the Puszcza Białowieska Forest, where previously it was reported only from *Alnus glutinosa* and *Fraxinus excelsior* [37].

*F. gyrophorica* grows in Poland mostly in humid, meso- and eutrophic broadleaved forests; in oak-linden-hornbeam and alder swamp forests – in the north-eastern and central part of the country and in beech forests – in northern parts. In the Las Warmiński Nature Reserve, *Fellhanera gyrophorica* occurs in mature forest stands, at least 129 years old (Tab. 2). The average age of these forest stands was more than 182 years. Although *F. gyrophorica* preferred the oldest tree stands, the age of trees, on which it was observed, was highly differentiated (Tab. 3). The lichen grew on barks of young trees, for example 50 years old hornbeams; however, it was also observed on 250 years old oaks. From the phytosociological perspective, *Fellhanera gyrophorica* grows in the best preserved patches of subcontinental oak-linden-hornbeam forests, representing the fresh (*Tilio-Carpinetum typicum*) and dry (*T.-C. calamagrostietosum*) communities. In the reserve, the species forms moderately differentiated epiphytic communities, which include several lichen species (Tab. 3). Nine to twenty two accompanying species were observed on a single tree. However, considering the diverse age and kind of settled phorophytes, the total number of accompanying species is relatively high and amounts to 68. The most differentiated communities were recorded on old hornbeams. Among accompanying species, a large number of rare and threatened lichens was observed (Tab. 3).

Outside Poland, *Fellhanera gyrophorica* was recorded on the bark of several phorophytes, both deciduous (*Alnus glutinosa*, *Carpinus betulus*, *Fagus sylvatica*, *Fraxinus excelsior*, *Populus tremula*, *Quercus robur*) and coniferous (*Abies alba*, *Picea abies*) [30,35,38-41]. The species mostly forms epiphytic

communities, which are rich in species; however, only a few accompanying species were recorded on younger trees and trees overgrown by bryophytes [30]. Within the distribution range, the lichen grows in well preserved, rather shady and humid deciduous and mixed forests, at low elevations [30,42].

#### Distribution in Poland

In Poland *Fellhanera gyrophorica* was recorded for the first time by Sérusiaux et al. [30], based on specimens from the Puszcza Borecka Forest provided by Dr. A. Zalewska (see also [34]). Its localities were later discovered by Czyżewska et al. [11,37,43], Sparrus [33,35] and Czarnota [44], also in the north-eastern part of the country. In Gdańsk Pomerania, the lichen was found by Kukwa [45], as well as Szymczyk and Kukwa [32]. Recently *F. gyrophorica* was also reported from central Poland by Cieśliński [46], Motiejūnaitė and Czyżewska [36] and Łubek [20]. In the Pojezierze Olsztyńskie Lakeland, as many as 25 new localities of this species were discovered (Fig. 1), 20 of which were located in the Las Warmiński Nature Reserve, two in the Wichrowo Forest Division and one in the Kamienna Góra Nature Reserve, the Olsztyn Forest Division and the Kudypy Forest Division (the forest Arboretum). The conducted studies also confirmed the previous reports regarding the fact that this is a frequently occurring lichen in the Puszcza Białowieska Forest, especially in the Białowieża National Park.

#### World distribution

*Fellhanera gyrophorica* occurs only in Central Europe, where it has a subcontinental distribution. The species is known from Austria, Belarus, Estonia, Lithuania, Luxembourg, Poland, Slovakia, Switzerland and Ukraine [30,40,42,47].

#### Specimens examined

[Be22] – Pojezierze Olsztyńskie Lakeland, Wichrowo FD, fs. No. 239, 54°02'04.2"N/20°23'36.3"E, oak-hornbeam forest, on oak, 2010.05.22, leg. D. Kubiak (OLTC L-3414), *ibid.*, fs. No. 218, oak-hornbeam forest, 54°02'23.9"N/20°23'50.3"E,

**Tab. 2** Lichenological value of forest stands (each with an area of 0.04 ha) with *Fellhanera gyrophorica* in the Las Warمیński Nature Reserve.

No. of locality*	Forest community	Age of dominated stand	No. of lichen species	No. of red listed species	No. of protected species	No. of species – indicators of lowland old-growth forests
8 (707b)	<i>T.-C. typicum</i>	155	42	12	5	4
10 (708c)	<i>T.-C. typicum</i>	155	36	11	1	4
18 (329i)	<i>T.-C. typicum</i>	131	38	12	4	3
28 (705d)	<i>T.-C. typicum</i>	221	54	20	11	7
29 (705a)	<i>T.-C. typicum</i>	221	63	20	11	8
47 (297c)	<i>T.-C. typicum</i>	191	68	23	9	10
58 (656b)	<i>T.-C. typicum</i>	215	50	21	8	9
61 (688c)	<i>T.-C. typicum</i>	205	48	17	6	6
37 (729c)	<i>T.-C. mercurialetosum</i>	220	55	22	4	8
7 (707b)	<i>T.-C. calamagrostietosum</i>	155	61	20	9	6
9 (706c)	<i>T.-C. calamagrostietosum</i>	155	41	10	5	5
11 (708c)	<i>T.-C. calamagrostietosum</i>	155	53	13	8	4
15 (461a)	<i>T.-C. calamagrostietosum</i>	191	39	13	8	3
31 (177g)	<i>T.-C. calamagrostietosum</i>	231	67	21	9	6
33 (496b)	<i>T.-C. calamagrostietosum</i>	181	50	21	7	5
48 (296c)	<i>T.-C. calamagrostietosum</i>	185	51	18	9	8
57 (640b)	<i>T.-C. calamagrostietosum</i>	129	38	13	6	6
59 (657f)	<i>T.-C. calamagrostietosum</i>	215	56	21	10	8
60 (689b)	<i>Quercu roboris-Pinetum</i>	205	49	14	6	5
2 (103a)	<i>Peucedano-Pinetum</i>	135	44	13	8	2

*T.-C.* – *Tilio-Carpinetum*. \* The number of forest section was given in brackets.

on oak, 2010.05.22, leg. D. Kubiak (OLTC L-3415); [Be41] – Pojezierze Olsztyńskie Lakeland, Kamienna Góra NR, beech forest, on oak, 2005.08.01, leg. D. Kubiak (OLTC L-2036); [Be52] – Pojezierze Olsztyńskie Lakeland, Kudypy, forest arboretum, oak-linden-hornbeam forest, on maple, 2006.07.03, leg. D. Kubiak (OLTC L-2154); [Be59] – Kraina Wielkich Jezior Mazurskich Lakeland, Maskulińskie FD, 53°45'47.4"N/21°30'53.8"E, fresh oak-linden-hornbeam forest, on oak, 2010.06.30, leg. D. Kubiak (OLTC L-3469); [Be62] – Pojezierze Olsztyńskie Lakeland, Las Warمیński NR, fs No. 705d, 53°38'59.7"N/20°30'03.1"E, oak-linden-hornbeam forest, on oak, 2008.05.01, leg. D. Kubiak (OLTC L-3028); *ibid.*, fs No. 496b; 53°36'59.4"N/20°29'58.3"E, dry oak-linden-hornbeam forest, on oak, 2008.05.01, leg. D. Kubiak (OLTC L-3029); *ibid.*, fs No. 496b; 53°36'59.4"N/20°29'58.3"E, dry oak-linden-hornbeam forest, on hornbeam, 2008.09.12, leg. D. Kubiak (OLTC L-3030); *ibid.*, fs No. 705d; 53°38'59.7"N/20°30'03.1"E, fresh oak-linden-hornbeam forest, on linden, 2008.07.08, leg. D. Kubiak (OLTC L-3031); *ibid.*, fs No. 705a; 53°38'54.5"N/20°30'24.7"E, fresh oak-linden-hornbeam forest, on oak, 2008.07.09, leg. D. Kubiak (OLTC L-3032, -3033); *ibid.*, 53°38'53.9"N/20°30'05.7"E, fresh oak-linden-hornbeam forest, on oak, 2010.04.12, leg. D. Kubiak (OLTC L-3410); *ibid.*, fs No. 297c; 53°38'37.3"N/20°30'22.6"E, fresh oak-linden-hornbeam forest, on hornbeam, 2009.09.16, leg. D. Kubiak (OLTC L-3115); *ibid.*, fs No. 296c; 53°38'49.5"N/20°30'32.1"E, dry oak-linden-hornbeam forest, on oak, 2009.09.16, leg. D. Kubiak (OLTC L-3116); *ibid.*, fs No. 656b; 53°40'23.6"N/20°30'09.6"E, fresh oak-linden-hornbeam forest, on maple, 2009.09.22, leg. D. Kubiak (OLTC L-3117); *ibid.*, fs No. 656b, 53°40'23.6"N/20°30'09.6"E, fresh oak-linden-hornbeam forest,

on hornbeam, 2009.09.22, leg. D. Kubiak (OLTC L-3118); *ibid.*, fs No. 657f, 53°40'14.2"N/20°29'55.1"E, dry oak-linden-hornbeam forest, on oak, 2009.09.22, leg. D. Kubiak (OLTC L-3119); *ibid.*, fs No. 657f, 53°40'14.2"N/20°29'55.1"E, dry oak-linden-hornbeam forest, on aspen, 2009.09.22, leg. D. Kubiak (OLTC L-3120); *ibid.*, fs No. 657f, 53°40'16.1"N/20°29'50.2"E, dry oak-linden-hornbeam forest, on oak, 2010.04.17, leg. D. Kubiak (OLTC L-3411!); *ibid.*, fs No. 689b, 53°39'29.4"N/20°29'35.9"E, oak-pine forest, on oak, 2009.09.22, leg. D. Kubiak (OLTC L-3121); *ibid.*, fs No. 688c; 53°79'19.5"N/20°30'18.4"E, fresh oak-linden-hornbeam forest, on oak, 2009.09.22, leg. D. Kubiak (OLTC L-3122); *ibid.*, fs No. 103a, 53°40'42.9"N/20°30'43.0"E, pine-spruce forest, 2009.08.22, leg. D. Kubiak (OLTC L-3178, KRAM); *ibid.*, fs No. 461a; 53°37'31.1"N/20°30'02.7"E, dry oak-linden-hornbeam forest, on oak, 2009.08.24, leg. D. Kubiak (OLTC L-3183); *ibid.*, fs No. 708c, 53°38'52.3"N/20°28'58.1"E, fresh oak-linden-hornbeam forest, on oak, 2009.08.23, leg. D. Kubiak (OLTC L-3184); *ibid.*, fs No. 708c, 53°38'44.2"N/20°29'13.1"E, dry oak-linden-hornbeam forest, on oak, 2009.08.23, leg. D. Kubiak (OLTC L-3185); *ibid.*, fs No. 706c, 53°38'53.9"N/20°29'44.1"E, dry oak-linden-hornbeam forest, on oak, 2009.08.23, leg. D. Kubiak (OLTC-L 3186); *ibid.*, fs No. 707b, 53°38'44.9"N/20°29'32.7"E, fresh oak-linden-hornbeam forest, on linden, 2009.08.23, leg. D. Kubiak (OLTC L-3187); *ibid.*, fs No. 707b, 53°38'44.9"N/20°29'32.7"E, fresh oak-linden-hornbeam forest, on linden, 2010.04.17, leg. D. Kubiak (OLTC L-3408); *ibid.*, fs No. 707b, 53°38'59.9"N/20°29'27.9"E, dry oak-linden-hornbeam forest, on oak, 2009.08.23, leg. D. Kubiak (OLTC L-3188); *ibid.*, fs No. 707b, 53°38'59.9"N/20°29'27.9"E, dry oak-linden-hornbeam forest, on oak, 2010.04.17, leg. D. Kubiak (OLTC L-3409);

**Tab. 3** The floristic comparison of selected epiphytic communities with *F. gyrophorica* occurring in the Las Warmiński Nature Reserve.

Species	No. of locality															
	7	8	28	29	33						37	57	58	59		
	Substrate – phorophyte (DBH)															
	Qr (57)	Tc (33)	Tc (16)	Qr (45)	Qr (64)	Cb (12)	Cb (15)	Cb (23)	Cb (44)	Qr (43)	Qr (35)	Qr (72)	Ap (50)	Qr (45)	Qr (50)	
1	2	3	4	5	6	8	9	7	10	11	12	13	14	15	16	
<i>Fellhanera gyrophorica</i>	1	2	1	2	2	3	1	1	1!	1	1	1	1	1	1!	
<i>Lepraria</i> spp.	2	3	5	5	5	4	3	4	4	5	5	5	3	4	4	
<i>Lecanora expallens</i>	2	1	1	1	2	.	.	3	3	1	2	2	1	1	1	
<i>Hypogymnia physodes</i>	1	2	1	1	1	.	1	2	1	.	1	1	.	1	1	
<i>Micarea prasina</i> s.l.	1	1	2	1	1	1	.	1	.	1	.	1	.	.	.	
<i>Phlyctis argena</i>	1	.	.	.	1	1	.	.	2	1	1	1	2	.	2	
<i>Chrysothrix candelaris</i>	2	.	.	1	1	.	.	.	1	.	1	.	1	1	1	
<i>Pertusaria amara</i>	3	2	.	.	.	.	4	1	.	.	.	2	2	1	2	
<i>Arthonia spadicea</i>	.	.	.	.	1	.	.	1	1	1	.	1	1	1	.	
<i>Chaenotheca chrysocephala</i>	1	.	.	1	1	.	.	.	1	.	1	.	.	.	1	
<i>Ch. ferruginea</i>	1	.	1	2	3	.	.	.	.	1	1	.	.	.	.	
<i>Parmelia sulcata</i>	.	1	.	.	.	1	1	1	.	.	.	1	1	.	.	
<i>Ramalina farinacea</i>	1	.	.	.	.	.	.	1	1	.	.	1	1	1	.	
<i>Arthonia mediella</i>	2	.	.	.	.	.	.	.	1	.	.	.	1	1	1	
<i>Biatora efflorescens</i>	.	1	1	.	1	1	.	.	.	.	.	.	1	.	.	
<i>Evernia prunastri</i>	1	.	.	1	1	.	.	.	1	.	1	.	.	.	.	
<i>Anisomeridium polypori</i>	.	.	.	.	.	.	.	.	.	.	.	1	1	1	1	
<i>Coenogonium pineti</i>	.	.	.	.	1	1	.	1	.	1	.	.	.	.	.	
<i>Graphis scripta</i>	.	.	1	.	.	2	1	1	.	.	.	.	.	.	.	
<i>Lecanora thysanophora</i>	.	.	.	.	.	.	.	.	.	.	1	1	.	1	1	
<i>Melanelixia fuliginosa</i>	.	.	1	.	.	.	1	.	1	.	1	.	.	.	.	
<i>Opegrapha viridis</i>	1	1	.	.	.	.	.	.	.	.	.	.	.	1	1	
<i>Rinodina degeliana</i>	.	.	1	1	.	.	.	.	.	1	.	.	1	.	.	
<i>Ropalospora viridis</i>	.	1	.	.	.	.	2	2	1	.	.	.	.	.	.	
<i>Buellia griseovirens</i>	.	.	.	.	.	.	.	1	.	.	.	.	1	.	.	
<i>Calicium salicinum</i>	+	.	.	1	.	.	.	.	1	.	.	.	.	.	.	
<i>Cladonia coniocraea</i>	.	1	.	1	.	.	.	1	.	.	.	.	.	.	.	
<i>C. fimbriata</i>	1	.	.	.	.	.	.	.	.	.	.	.	.	1	1	
<i>Fuscidea pusilla</i>	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Hypcenyomyce scalaris</i>	.	.	1	.	.	.	.	.	1	.	1	.	.	.	.	
<i>Acrocordia gemmata</i>	1	.	.	.	.	.	.	.	3	.	.	.	.	.	.	
<i>Arthonia byssacea</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	
<i>Bacidia biatorina</i>	2	.	.	.	.	.	.	.	.	.	.	.	.	.	1	
<i>B. rubella</i>	.	.	.	.	.	.	.	.	1	.	.	.	1	.	.	
<i>Chaenotheca furfuracea</i>	.	.	.	1	.	.	.	.	.	.	.	.	.	1	.	
<i>Ch. stemonea</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	
<i>Ch. trichialis</i>	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	
<i>Fuscidea arboricola</i>	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.	
<i>Lecanora chlarotera</i>	.	.	.	.	.	.	.	1	.	.	.	1	.	.	.	
<i>Microcalicium disseminatum</i>	.	.	.	.	1	.	.	.	.	.	2	.	.	.	.	
<i>Mycoblastus fucatus</i>	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.	
<i>Opegrapha varia</i>	.	.	.	.	.	.	.	.	.	1	.	.	.	1	.	
<i>Parmeliopsis ambigua</i>	.	.	.	1	.	.	.	1	.	.	.	.	.	.	.	
<i>Amandinea punctata</i>	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	
<i>Arthonia muscigena</i>	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	
<i>A. radiata</i>	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	
<i>A. vinosa</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	
<i>Bacidia arceutina</i>	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	
<i>B. hemipolia f. pallida</i>	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	
<i>Bacidina sulphurella</i>	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	
<i>Biatora vernalis</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	
<i>Calicium adpersum</i>	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	
<i>C. viride</i>	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	
<i>Lecanora argentata</i>	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	
<i>L. conizaeoides</i>	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	

Tab. 3 (continued)

	1	2	3	4	5	6	8	9	7	10	11	12	13	14	15	16
<i>L. pulcaris</i>	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
<i>Lobaria pulmonaria</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
<i>Ochrolechia microstictoides</i>	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>O. turneri</i>	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
<i>Peltigra praetextata</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
<i>Pertusaria coccodes</i>	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
<i>P. leioplaca</i>	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
<i>P. pupillaris</i>	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
<i>Phaeophyscia endophoenicea</i>	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
<i>Porina aenea</i>	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
<i>Ramalina pollinaria</i>	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
<i>Reichlingia leopoldii</i>	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.
<i>Rinodina efflorescens</i>	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
No. of species		18	16	13	14	15	9	12	22	19	10	16	17	16	19	18

Cover-abundance scale: 1 – species cover up to 5% of sample on the three-trunk; 2 – from 5.1% to 12.5%; 3 – from 12.6% to 25.0%; 4 – from 25.1% to 50.0%; 5 – above 50%. Ap – *Acer platanoides*; Cb – *Carpinus betulus*; DBH – diameter at breast height (cm); Qr – *Quercus robur*; Tc – *Tilia cordata*; ! – specimens with apothecia.

ibid., fs No. 496b, 53°36'59.4"N/20°29'58.3"E, dry oak-linden-hornbeam forest, on hornbeam, 2008.09.12, leg. D. Kubiak (OLTC L-3189!); [Be63] – Pojezierze Olsztyńskie Lakeland, Las Warمیński NR, fs No. 177h, 53°39'47.5"N/20°31'15.5"E, dry oak-linden-hornbeam forest, on hornbeam, 2008.08.14, leg. D. Kubiak (OLTC L-3039); ibid., fs No. 256g, 53°38'53.0"N/20°30'48.4"E, oak-pine forest, on oak, 2009.08.24, leg. D. Kubiak (OLTC L-3180); ibid., fs No. 329i, 53°38'04.2"N/20°31'28.8"E, fresh oak-linden-hornbeam forest, on linden, 2009.08.24, leg. D. Kubiak (OLTC-L 3181), ibid., fs No. 329i, on mosses growing on hornbeam, 2009.08.24, leg. D. Kubiak (OLTC L-3182); Pojezierze Olsztyńskie Lakeland, Olsztyn FD, fs No. 133, 53°41'27.2"N/20°38'25.8"E, oak-linden-hornbeam forest, on oak, 2010.06.03, leg. D. Kubiak (OLTC L-3418); [Be69] – Pojezierze Mrągowskie Lakeland, Krutyński Piecек village, 1 km on W, 53°40'35.2"N/21°26'18.0"E, oak-linden-hornbeam forest, on oak, 2010.06.23, leg. D. Kubiak (OLTC L-3470); [Be78] – Równina Mazurska Plain, Pupy NR, fs No. 211, 53°34'02.0"N/21°21'10.0"E, fresh oak-linden-hornbeam forest with old beeches, on oak, 2011.06.04, leg. D. Kubiak (OLTC L-3473); [Cg55] – Równina Bielska Plain, Białowieża NP, Mogiłki, fs No. 399, 52°43'22.7"N/23°51'50.6"E, fresh oak-linden-hornbeam forest, on oak, 2006.05.10, leg. D. Kubiak (OLTC L-3110!); ibid., on linden, 2006.05.10, leg. D. Kubiak (OLTC L-3123!); ibid., fs No. 370, 52°43'22.6"N/23°51'22.0"E, fresh oak-linden-hornbeam forest, on hornbeam, 2006.05.10, leg. D. Kubiak (OLTC L-3124!); ibid., fs No. 340c, on oak, 2006.05.12, leg. D. Kubiak (OLTC L-3125).

## Discussion and conclusions

The inventory revealed 25 new localities of *Fellhanera gyrophorica*. This is the highest density of the known localities of the species within its occurrence range, documented by collected specimens. Thus, north-eastern Poland and Lithuania are the most important centres of this species' distribution (see [39]).

A relatively high number of newly discovered localities of *F. gyrophorica* in the Pojezierze Olsztyńskie Lakeland probably results from the choice of the inventory method. The study revealed that the method of floristic relevés – a detailed comprehensive study on a relatively small area, is the most effective in the conservation assessment of inconspicuous lichens with relatively well known ecological requirements (see [48]).

*F. gyrophorica* has been found in almost all analyzed objects but its frequent occurrence in the Las Warمیński Nature Reserve is worth mentioning. The study has revealed that *F. gyrophorica* is a relatively common lichen there. The Las Warمیński Nature Reserve protects the largest and best-preserved patches of natural forests occurring in the Pojezierze Olsztyńskie Lakeland. Nearly all the forest communities occurring at the border of north-eastern and central Poland are protected there. The largest area of the reserve is covered by oak-linden-hornbeam forests with a different age structure and high average age of tree stands, which is rarely observed in Poland in forests with such a large area [49]. It should be mentioned that the Las Warمیński Nature Reserve is one of the largest among all analyzed areas and, in contrast to the others, is located within the dense forest complex of Puszcza Nidzicka Forest, which is one of the largest forest complexes in Poland [50].

The presented results seem to confirm the correct rank of the lichen *F. gyrophorica* recognized as an indicator of lowland old-growth forest in Poland [51]. The species has a similar status in Lithuania, where it was observed only in forests with a long ecological continuity [38,52]. One of the features of old-growth forests, beside their age and location in vast and dense complexes, is high diversity of cryptogamic plants and fungi [51]. It seems that the majority of newly discovered localities of *F. gyrophorica* in the Pojezierze Olsztyńskie Lakeland, especially in the Las Warمیński Nature Reserve, fulfill the criterion. Although the lichen biota of the reserve is not fully known yet, it could be considered as rich and diversified [49]. It includes at least 218 taxa that have been discovered thus far. It allows to classify this object within the biocentre group of lichen diversity, not only in the Puszcza Nidzicka Forest, but

also in the whole country [43,51]. Moreover, the lichen biota of the reserve is characterized by a significant number of other species, which demonstrate a particular relationship with old-growth forests [49,51]. Against this background, patches of forest communities with *F. gyrophorica* in the reserve constituted the richest lichen habitats in this area (Tab. 2). As many as 144 lichen species were recorded on 20 analysed sites (with the total area of 0.8 ha). Thirty six to sixty eight taxa were observed in particular patches – on average over 50. The biota includes a significant number of threatened (62 species) and protected lichens (19 species) in Poland. At particular sites, 11 to 23 red-listed, and 1 to 11 protected species were recorded. At each site, the presence of lichens – indicators of lowland old-growth forests was also observed in the quantity of 2 to 10 (24 taxa in total). Thus, *F. gyrophorica* can be accepted as the indicator species, distinguishing the areas with the highest diversity and richness of lichens and probably other organisms.

The study has shown that in the Pojezierze Olsztyńskie Lakeland, the age of the youngest tree stands with *F. gyrophorica* is usually higher than the clear-cutting age accepted by the national methodology for forest cultivation. This situation creates very unfavorable conditions for the growth of this species in managed forests. Probably for this reason, the main sites of this lichen's occurrence are now national parks, nature reserves and other protected areas, which preserve deciduous old-growth forests of natural character.

The occurrence of *F. gyrophorica* thalli with apothecia, rarely observed within the species range, is noteworthy. Besides the Polish part of the Puszcza Białowieska Forest [33], the fertile material of this species is known only in Lithuania [38].

It is difficult to assess why the species was previously so rarely reported, particularly within the well explored areas, such as the Puszcza Białowieska Forest (see [53]). One of the reasons could be the fact that the species was spreading rapidly during the last two decades, but most likely it was overlooked in the field or confused with other lichens. *B. sulphurella* (Samp.) Hauck et Wirth (syn. *Bacidia sulphurella* Samp., *Bacidina arnoldiana* auct.) is a similar species which very often occurs with pycnidia only [54,55]. *B. sulphurella* can be found in habitats and substrates similar to those of *F. gyrophorica*, but presumably it has a wider ecological range. In the Las Warمیński Nature Reserve, *B. sulphurella* occurs more rarely than *F. gyrophorica* and it was documented only at 16 sites. In seven cases both species were observed at one site only, and only in one case they occurred on the same tree (Tab. 3).

Based on the obtained data, it could be assumed that further research will result in a discovery of new localities of *F. gyrophorica*, especially in north-eastern Poland. New localities of this lichen could be discovered in large forest complexes, e.g., the Puszcza Augustowska Forest and the Puszcza Romincka Forest, where the species has not been found yet [34].

Although regionally *F. gyrophorica* is a relatively common species, since permanent anthropogenic transformations of natural forest environments (also those in protected areas), however it seems relevant to continue with this species' rank as near threatened (NT) in Poland [56].

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