

## EXPANSION OF THE LIVERWORT *TETRALOPHOZIA SETIFORMIS* IN THE POLISH TATRA MTS (WESTERN CARPATHIANS)

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### ABSTRACT

The article presents the spread of the liverwort *Tetralophozia setiformis* in the Polish Tatra Mts (Western Carpathians). In the years 1814-1957 only four localities of this plant have been found in High Tatra Mts. Since the 90-ties, an increase in recording of *T. setiformis* has been noticed, including the first locality in Western Tatra Mts. Currently, there are 17 localities of *T. setiformis* in the Polish Tatra Mts. In many of them, the plant occurs abundantly; it also remains in the places of its first records. The species has a narrow ecological scale. It is attached to rock blocks, mostly of north exposition. It creates small, single-species turfs plaited in mossy pillows of alpine grasslands of *Oreochloa distichae*-*Juncetum trifidi racomitriosum lanuginosi* hung among rocks.

KEY WORDS: *Tetralophozia setiformis*, liverworts, rare species, species expansion, Tatra Mts.

### INTRODUCTION

*Tetralophozia setiformis* (Ehrh.) Schljakov [=*Chandonanthus setiformis* (Ehrh.) Lindb.] is a subarctic-alpine species (Duell 1983). It has been recorded in Svalbard, Iceland, Norway, Sweden, Finland, Britain, Belgium, Germany, Austria, Czech Republic, Slovakia, Novaya Zemlya, Franz Josef Land, North, Northwest and East Russia, Siberia, Russian Far East, Mongolia, Subarctic America, Western and Eastern Canada, North-Central and North-Eastern USA (Söderström et al. 2002). In Europe, *T. setiformis* is common in Nordic countries; in the remaining area it occurs in relict localities in higher mountain places (Damsholt 2002). It is considered a highly endangered species in Belgium, Germany and Czech Republic (De Zuttere and Schumacker 1984; Ludwig et al. 1996; Kučera and Váňa 2003), and a rare species in Slovakia (Kubinska et al. 1996).

In Poland, *Tetralophozia setiformis* is found only in the mountains. Ten localities have been recorded in the Sudety Mts (nine in Karkonosze and one in Izerskie Mountains; Szweykowski 1956). In Polish Carpathians, this liverwort is limited to the Tatra Mountains.

The first localities of *Tetralophozia setiformis* in Tatra Mountains have been documented in the Slovakian Tatra from Kiezmarska Valley (1536 m a.s.l.) already in the 19th century (Wahlenberg 1814 after Szweykowski 1956). Other localities in Slovakian Tatra have been found under the peak of Lomnický štít (Szyszyłowicz 1885), Velká Svišťovka (Szweykowski 1960; Šmarda 1961; Boros et al.

1960), and from Velká Studená Dolina (Duda and Váňa 1982).

In 2006, I confirmed the localities under the peak of Velká Svišťovka (rock cracks on northern slope, 2000 m a.s.l., POZNB 523) and on slopes east to the Lomnický štít (1970 m a.s.l., POZNB 524).

On the Polish side of the border, the species have been recorded by Szweykowski (1956, 1957, 1960) and Wojterski (1957; see the list of localities below). At the same time, Szweykowski (1956) has pointed out that *T. setiformis* is a very rare plant and sparse information on it could not be explained by unsatisfactory level on knowledge on Tatra liverwort flora. So, in 1814-1957 only four localities were known in the Polish Tatra Mountains. There was no information on the species in geobotanical papers published thereafter. However, it should be kept in mind that there were not many hepaticological investigations in that time. In the 80-ties and 90-ies, the research staff of Professor J. Szweykowski from A. Mickiewicz University in Poznań continued gathering data for the flora of Tatra Mountains liverworts. These materials have been deposited in the POZW herbarium and have not been published yet. Since the 90-ties, an increase in records of the species has occurred, including the first locality in Western Tatra. In 2005, I found 10 new localities of *Tetralophozia setiformis* in High Tatra Mts. The abundance of the plant in new localities, and its localization in high mountain valleys other than those already recorded, indicate that the species starts to spread in the area, or at least the number of its localities increases.

The aim of this paper is to present the current distribution of *Tetralophozia setiformis* in Polish Tatra Mts and the characteristics of its localities in habitat-phytocoenosis context.

## MATERIAL AND METHODS

In order to find localities of *Tetralophozia setiformis* I investigated the whole area of Polish Tatra Mts (High and Western Tatra Mts). The Tatra is the highest mountain range in the whole Carpathians (with Gerlach elevated at 2663 m a.s.l. in Slovakia and Rysy 2499 m a.s.l. in Poland). It is a borderline mountain chain situated between Poland and Slovakia, with the greater part belonging to the latter country.

For the majority of new localities I made phytosociological documentation according to the Braun-Blanquet method, with the use of Londo scale for determination of quantitative participation of species (cfr. Dierschke 1994). Location of the studied patches and all geographical names in this paper are given according to the map Tatra Polskie (1992). The names of liverworts are in accordance with the list of Grolle and Long (2000), Ochyra et al. (2003) for mosses, Mirek et al. (2002) for vascular plants, and Fałtynowicz (2003) for lichens.

Herbarium materials were deposited in the herbarium of the Department of Botany, August Cieszkowski Agricultural University in Poznań, Poland (POZNB). Moreover, I studied materials deposited in the Liverworts Laboratory and Herbarium of Adam Mickiewicz University, Poznań (POZW).

## RESULTS

### *Distribution of Tetralophozia setiformis in Tatra Mts*

Previous localities of *T. setiformis* have been grouped near Żółta Turnia and comprised the northern part of Dolina Gąsienicowa Valley and Dolina Pańszczyca Valley in High Tatra. Complementation of the distribution picture of *T. setiformis* shows a clear concentration of localities in Dolina Gąsienicowa Valley (Fig. 1). The liverwort also occurs in the southern part of the valley (under Orla Perć) and in the cauldron under Świnica. Moreover, I found it in high-located valleys where it has not been recorded so far, i.e. Dolina Waksmundzka Valley and Dolina Pięciu Stawów Polskich Valley. It is clear that the species spreads to the south from the places where it has been recorded first.

I confirmed that *T. setiformis* has stayed in some localities (e.g. in Dolina Pańszczyca Valley) and found new localities near the older ones, especially in sub-peak part of Żółta Turnia, where previously the plant has been recorded on rock shelves at 1660 m a.s.l., and now it is common in the sub-peak localizations from 1970 m a.s.l. to the peak (2087 m a.s.l.).

I did not find *Tetralophozia setiformis* in the southernmost valleys of the High Tatra – Dolina Rybiego Potoku Valley and Dolina za Mnichem Valley. Despite search I did not confirm the existence of the plant in rubble of Ornak and the mountain range of Liptowska Grań (the Western Tatra).

### *List of localities*

#### *Literature and herbarium data*

#### THE HIGH TATRA MTS, DOLINA GĄSIENICOWA VALLEY:

1. Dubrawiska, on humus among rock boulders, 1550 m, mass (Szweykowski 1956).
2. North-western precipices of Żółta Turnia, on rock shelves, 1660 m, sparse (Szweykowski 1956).
3. Near western shore of Czarny Staw Gąsienicowy Lake, below Przełęcz Karb Pass, on humus among granite boulders, 1625 m (Wojterski 1957).
4. Near northern shore of Długi Staw Gąsienicowy Lake, in a tuft with *Juncus trifidus* (POZW, leg. K. Buczkowska, J. Szweykowski, 22.09.1992).
5. Kocioł Kościelcowy (POZW, leg. J. Szweykowski, 21.08.1959).

#### THE HIGH TATRA MTS,

#### DOLINA PAŃSZCZYCA VALLEY:

6. Above Czerwony Stawek, on humus among rock boulders, ca 1700 m (Szweykowski 1956); locality confirmed in 2005, close to the pond and tourist path, 1660 m, POZNB 521, leg. P. Górski.

#### THE WESTERN TATRA MTS,

#### DOLINA GORYCZKOWA VALLEY:

7. Below Przełęcz Goryczkowa nad Zakosy Pass, ca 1800 m, rock rubble (POZW, leg. K. Buczkowska, A. Bączkiewicz, 11.08.2002).

### *New localities*

#### THE HIGH TATRA MTS, DOLINA GĄSIENICOWA VALLEY:

8. In sub-peak part of Żółta Turnia, many localities in altitude range from 1970 m to the peak (2087 m); on rock shelves, mass (POZNB 511 and 512, leg. P. Górski, see Table 1, rel. A and B).
9. Above southern shore of Czarny Staw Gąsienicowy Lake, below Kościelec, rock blocks, 1685 m (POZNB 510 and 520, leg. P. Górski, see Table 1, rel. G).
10. Above Zmarzły Staw Gąsienicowy Lake, below Kozia Przełęcz Pass, 1845 m, in two small tufts (POZNB 513, leg. P. Górski, see Table 1, rel. F).
11. Above Czerwone Stawki below Skrajna Turnia, among rock blocks, 1750 m (POZNB 514, leg. P. Górski, see Table 1, rel. C).
12. Above southern shore of Zadni Staw Gąsienicowy, below Świnica, among rock blocks, 1885 m (POZNB 515, leg. P. Górski, see Table 1, rel. D).
13. Above north-eastern shore of Zadni Staw Gąsienicowy, below Kościelec, among rock blocks, 1850 m (POZNB 516, leg. P. Górski, see Table 1, rel. E).

#### THE HIGH TATRA MTS, DOLINA PAŃSZCZYCA VALLEY:

14. North to Wielka Kopka, near tourist trail to Przełęcz Krzyżne Pass, rock rubble, 1735 m (POZNB 517, leg. P. Górski).

#### THE HIGH TATRA MTS, DOLINA WAKSMUNDZKA VALLEY:

15. Above Waksmundzki Potok, on the slope going down from Wołoszyn, below Skrajny Wołoszyn, 1805 m, rock rubble (POZNB 519, leg. P. Górski see Table 1, rel. H).

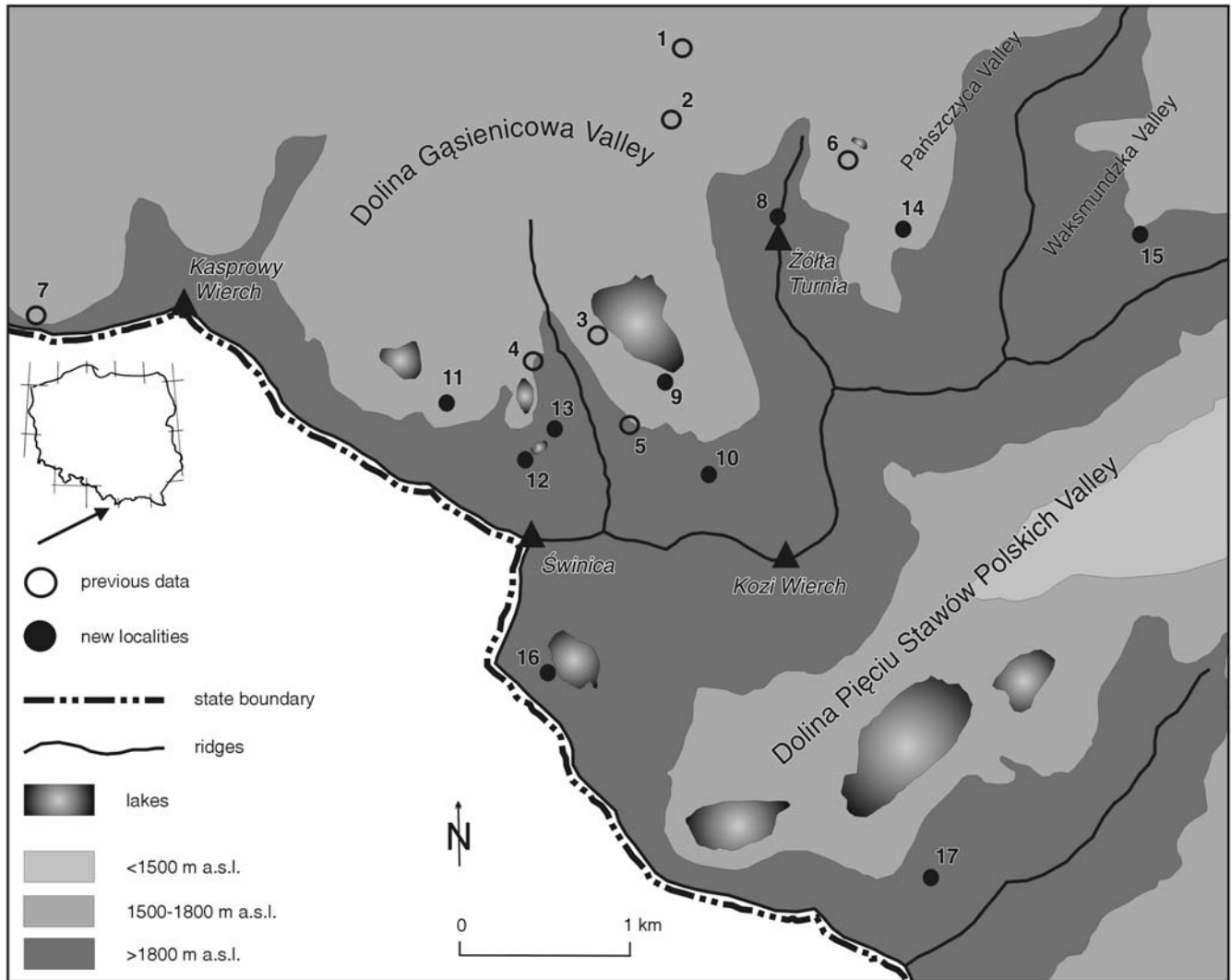


Fig. 1. Distribution of *Tetralophozia setiformis* (Ehrh.) Schljakov in the Polish part of the Tatra Mts (for details of the sites represented by numbers 1-17 see list of localities).

#### THE HIGH TATRA MTS, DOLINA PIĘCIU STAWÓW POLSKICH VALLEY:

16. Zadni Piarg, rock rubble going down to southern shore of Zadni Staw, below Walentkowy Wierch, 1880 m (POZNB 518, leg. P. Górski).

17. Brzuchaty Piarg, above southern shore of Wielki Staw, below Miedziane range, 1910 m, mass (POZNB 522, leg. P. Górski).

#### Ecology of *Tetralophozia setiformis* in the Tatra Mts

*Tetralophozia setiformis* is an alpine plant connected with acid ground formed in places with granitoid rocks in Tatra Mts. It grows only in the area of rock blocks, on slopes of colder exposure (northern, north-western, and western), in shady places. Exceptionally I noted *T. setiformis* on coarse scree. *T. setiformis* sprouts flat surface of rock blocks and shelves on which a thin layer of humus develops. Usually the plants form mono-species turfs braided into mossy pillows of alpine grasslands suspended among rocks. In phytosociological depiction, these phytocoenoses represent forms of *Oreochloa distichae*-*Juncetum trifidi* Szaf., Pawł. et Kulcz. (1923) 1927 *racomitrietosum lanuginosi* (Table 1). They are characterized by domination of

moss layer including *Racomitrium lanuginosum*, *Polytrichum alpinum*, *Cetraria islandica*, and sporadically, with higher participation, a lichen *Alectoria ochroleuca*. The herbaceous plant cover is low. Permanent components of this layer are *Huperzia selago* and *Juncus trifidus*. The affinity of phytocoenoses with *Tetralophozia setiformis* to the mentioned type of alpine grassland is without a question. The patches are characterized by small but permanent dash of alpine grassland species of the class *Caricetea curvulae* Br.-Bl. 1948. The community has been previously recorded in High Tatra, Dolina Pięciu Stawów Polskich Valley (Balcerkiewicz 1984), and – as *Racomitrietum lanuginosi* – in Dolina Temnosmrečinova Valley (Hadač 1956). It is yet widespread in both High and Western Tatra. In the investigated patches I found eight species of liverworts, with the most frequent being *Tritomaria quinqueidentata*, *Anastrophyllum minutum*, *Diplophyllum taxifolium*, and *Lophozia wenzelii*. Among lichens, *Cetraria islandica* and *Cladonia bellidiflora* have a high participation in the cover.

*Tetralophozia setiformis* is a plant attached to habitat conditions of little variety. This causes that the ecology of this species is legible in both habitat and phytocoenotic context.

TABLE 1. *Oreochloa-Juncetum trifidi racomitrietosum lanuginosi* with *Tetralophozia setiformis* from the Polish part of the High Tatra Mts.

Successive number in table	1	2	3	4	5	6	7	8	c
Number of relevé in the field	D	F	C	H	B	A	E	G	o
Cover of moss layer d [%]	90	60	95	100	95	90	75	70	n
Cover of herb layer c [%]	5	15	30	80	50	5	5	10	s
Exposure	N		N		NW	NW	W		t
Inclination [°]	3		–		–	3	–		a
Area of relevé [m <sup>2</sup> ]	0.1	0.7	0.3	0.5	0.4	0.3	0.5	0.5	n
Altitude [m]	1885	1845	1750	1805	1975	1970	1850	1685	c
Number of species	8	14	11	13	13	11	11	8	y
<b><i>Tetralophozia setiformis</i></b>	1	1	2	1	2	<b>8</b>	<b>6</b>	<b>4</b>	V
<b>Ch. <i>Caricetea curvulae</i></b>									
<i>Huperzia selago</i>	.4	.4	.1	.	.2	.2	.2	.	IV
<i>Juncus trifidus</i>	.	1	3	7	5	.	.	1	IV
<i>Alectoria ochroleuca</i>	.	.	.	.4	6	7	.	.	II
<i>Thamnia vermicularis</i>	.	.2	.	.	.2	2	.2	.	III
<i>Festuca airoides</i>	.	.	.	.2	.	.2	.	.	II
<i>Oreochloa disticha</i>	.	.	.	.2	.	.	.1	.	II
<b>Others</b>									
<i>Racomitrium lanuginosum</i>	.2	<b>4</b>	3	.1	.2	.2	<b>6</b>	<b>3</b>	V
<i>Polytrichastrum alpinum</i>	1	.4	1	.2	2	.4	1	1	V
<i>Cetraria islandica</i>	.	.2	.2	2	.2	.	.1	.2	IV
<i>Cladonia bellidiflora</i>	.	.1	.1	.1	.2	.	.	.2	IV
<i>Tritomania quinqueidentata</i>	.	2	.	.	.2	.	.1	.1	III
<i>Anastrophyllum minutum</i>	.2	.	.1	.2	.	.1	.	.	III
<i>Lophozia sudetica</i>	.2	.	.	.	.	.1	.	.	II
<i>Diplophyllum taxifolium</i>	.	.1	.	.	.1	.1	.	.	II
<i>Lophozia wenzelii</i>	.	.2	.	1	.	.2	.	.	II
<i>Anastrepta orcadensis</i>	.	.	.	1	.1	.	.	.	II
<i>Gymnocolea inflata</i>	.2	.	.	.	.	.	.	.	I
<i>Bazzania tricrenata</i>	.1	.	.	.	.	.	.	.	I
<i>Cladonia gracilis</i>	.	.2	.	.	.	.	.	.	I
<i>Cetraria ericetorum</i>	.	.1	.	.	.	.	.	.	I
<i>Dryptodon contortus</i>	.	.1	.	.	.	.	.	.	I
<i>Cladonia coccifera</i>	.	.	.1	.	.	.	.	.	I
<i>Cladonia furcata</i>	.	.	.1	.	.	.	.	.	I
<i>Stereocaulon vesuvianum</i>	.	.	.1	.	.	.	.	.	I
<i>Dicranum scoparium</i>	.	.	.	.2	.	.	.	.	I
<i>Cladonia pleurota</i>	.	.	.	.	.1	.	.	.	I
<i>Cladonia coniocrea</i>	.	.	.	.	.	.	.2	.	I
<i>Pohlia nutans</i>	.	.	.	.	.	.	.1	.	I
<i>Cladonia fimbriata</i>	.	.	.	.	.	.	.1	.	I
<i>Poa laxa</i>	.	.	.	.	.	.	.	.1	I

## DISCUSSION

What are the reasons of the increase in the number of localities of *Tetralophozia setiformis* in the investigated area? Insufficient level of examination of Tatra hepaticoflora has to be excluded, because Szweykowski (1956) focused his studies on revealing all localities of this plant in the Tatra Mts. At present – like earlier (Szweykowski 1956) – *T. setiformis* in Tatra does not create sporophytes and does not proliferate by gemmae. A possible way of propagation is fragmentation of gametophores and transmission of their parts by the wind or animals. The gametophores may crush, which is favored by leaves divided into lobes and frequent parching of turfs suspended among rock blocks, a highly drained ground that does not retain water. This, however, does not explain why the increase in the number of localities in Tatra happens now and has not caused the spread of the species earlier. However, on a local scale, regarding a single alpine valley, this actually may be the reason of increment in the number of localities (e.g. in Dolina Gašienicowa Valley). Climatologic data from recent deca-

des show that after a warm period (1927-1959) there was a cold one in years 1960-1990 (Niedźwiedź 2004). Since the 90-ties, the Tatra climate has been getting warmer, probably due to higher frequency of advection of the air from the Atlantic Ocean (Niedźwiedź 1996). So, records of *Tetralophozia setiformis* from the 50-ties (Szweykowski 1956, 1957; Wojterski 1957) and the present ones fall on a period of local climate warming. These data should be interpreted carefully; they still do not explain the issue completely.

On the other hand, one can advance a hypothesis on long-distance transmission of spores from the North of Europe, where the sporophytes, although rare, are present (Damsholt 2002). This, however, should have induced an increase in the number of localities of *Tetralophozia setiformis* in the Sudety and other mountains of Central Europe. A question about factors inducing sporulation in places of compact occurrence of *Tetralophozia setiformis* still remains, though. Investigation of genetic variability of the Tatra population of *T. setiformis* should allow better explaining the reasons of its spread in the mountains.



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