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## ON TAXONOMIC POSITION OF TWO LITTLE-KNOWN WARM-TEMPERATE TRAMETOID FUNGI

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*Key words:* higher basidiomycetes, thermophilic polypores, scenidioid morphotype, trametoid morphotype

### Introduction

Little-investigated polypores, *Trametes ljubarskyi* Pilát and *T. cervina* (Schwein.) Bres., are distributed over the arid flange of temperate Eurasia, including forest-steppe and steppe zones of Ukraine and South Russia. Their position in the genus *Trametes* Fr. is rather conventional. The former species deviates from the current *Trametes* concept by having slightly thick-walled lacrymoid spores and faintly cyanophilous irregularly inflated skeletal. The latter differs by prominently cyanophilous skeleto-binding hyphae devoid of denroid appendages and bearing ampullate swellings.

Respectively, *T. ljubarskyi* was merged into *Haploporus* [1] and *Perenniporia* [10], whereas *T. cervina* was placed within *Antrodia* [6], *Funalia* [2], *Diplomitoporus* [8], and *Trametopsis* [9]. All these rather pre-arranged replacements are a subject of controversy with the concept. Particularly, a bristle character of *T. ljubarskyi* for its placement in *Haploporus* is an even exosporium, whereas for combination in *Perenniporia* an indextrinoid structure is rather critical aspect. Concerning the listed above positions of *T. cervina*, the genus *Antrodia* P. Karst. is inappropriate due to its brown rot characteristics; *Funalia* is ambiguously distinguished from *Trametes*; the genus *Diplomitoporus* differs by shorter basidia and basidiospores in core representatives. Position of *T. cervina* within a monotypic genus *Trametopsis* Tomšovský requires a separate comment. The author [9] described this genus exclusively on the basis of a molecular cladogram representing relationships between *T. cervina*, *Trametes suaveolens* Fr., *Antrodia albida* (Fr.) Donk, *Ceriporiopsis aneirina* (Sommerf.) Domański, and *C. resinascens* (Romell) Domański. At the same time, conclusion on the generic affiliation within the assemblage of trametoid fungi should be made on the basis of comparison of many representatives from all artificial units of the generic rank, at least *Funalia*, *Irpex*, *Pycnoporus*, *Antrodiella* in the temperate zone, and some

in tropics. Molecular approach [5] has not been used so far to study tropical trametoids. However, it confirms the position of *Diplomitoporus* representatives in various domains of Meruliaceae-cluster (nevertheless, distant from *Ceriporiopsis*). Within this cluster, the *Irpex* species are also included. All branches of the current molecular trees are a subject of certain rotation; therefore, the modern taxonomic concept requires parallel arrangement based on morphological patterns.

The purpose of the present investigation is to generalize the characters' patterns of trametoid genera of the temperate zone and tropics and to clarify the taxonomic position of two warm-temperate taxa, *T. ljubarskyi* and *T. cervina*.

## Material and methods

The studied material of *Trametes* consists of the author's collections in some regions of Russia (mainly Rostov Region) as well as temperate and tropical specimens of trametoid fungi from the Mycological Herbarium of the Komarov Botanical Institute, LE (St. Petersburg).

All specimens were studied and preserved using standard methods. Macroscopic description was based on examination of the fresh and exsiccated material.

The dried material was studied using light microscopic techniques. Microscopic study of basidiocarps was carried out as described by Gilbertson & Ryvarden [4]. Freehand sections and squash mounts of basidiocarps were examined in 5 % KOH and 2 % Cotton Blue. Structures measurements contained 30 items per specimen. The terms devoted to dextrinoidity degree are accepted after Spirin et al. [7]. The following abbreviations were used: L — length, W — width, Q — quotient of the mean length and mean width (L/W ratio). Specimens are deposited in the Herbarium of the Komarov Botanical Institute (LE).

## Results and discussion

The results of our comparative morphological studies are summarized in the Table.

### Distribution of morphological markers within white-rot smooth-spored trametoid genera

As it follows from the material presented, the trametoid genera are characterized by diverse fine morphological features. The basidiome morphotype varies from typically trametoid (sessile with thickened context layer) to corioid (sessile with context comparable to tube layer) and scendiioid (with very thin parchment-like context and strong decurrent tendency); some corioid fungi can develop a stipe (polyporoid morphotype), or can grow as totally resupinate patches (fibroporioid morphotype). The flesh color varies from white to tan-brownish via obscure cream, pale and woody colorations. The spore wall width varies from thin-walled in the most of genera to faintly thick-walled or thick-walled in some taxa.

The morphotype characteristics and color of the context demonstrate certain range of parallel variability not correlating with generic limits. For example, *Ganoderma lucidum*-complex shows a wide range of flesh colorations from white to coffee brown.

**Distribution of morphological markers within white-rot smooth-spored trametoid genera**

Genus	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
Morphotype	I	II, V	II	I, II	IV	II, V	IV	I, V	IV, V	I	II, V	II, V	I	III	III	I	II, V	I, II	I	
Context coloration	b	w	w	b	w	w	w	c	c	c	w, c	w	b	w	w, b	b	c	c	o	w
Pore size (pores per mm)	2<	3<	1<	2<	1<	3<	1<	3<	1<	1<	1<	2<	2<	4<	3<	3<	3<	3<	1<	
Branching pattern of sclerotia	d	d/a	d	d/a	d	d, f	d, f	d	d	d/a	d, d/a	d	d, d/a	d/a	d/a	d/a	d, f	d	d/a	
Hypal cyanophily*	CB+	CB—	CB—	CB—	CB—	CB—	CB—	CB—	CB—	CB+CB—	CB—	CB—	CB—	CB—	CB—	CB—	CB+	CB+	CB+	CB—
Clamps presence	+	+	+	+	+	+	+	—/+	—/+	+	+	—	+	+	+	+	+	+	+	
Basial length (µm)	<20	<20	>20	>20	>20	>20	>20	<20	>20	>20	>20	>20	>20	<20	<20	<20	<20	<20	<20	>20
Basidiospore length (µm)	<10	<10	<10	>10	>10	<10	>10	<10	<10	>10	>10	<10	<10	<10	<10	<10	<10	<10	<10	
Basidiospore shape	e	e, c	e	fc	fc	c	fc	e, c	c	fc	fc	c	e	e, c	s	e	e	c	c, fc	
Spore wall width	tk	t	t	t	t	t	t	t	t	t	t	t	ft	t	ft	ft	tk	t	t	
Melzer's reaction of a spore wall	d	id	id	id	id	id	id	id	id	id	id	id	wd	id	wd	id	d	id	id	

The scenidioid morphotype, besides the *Trametes* generic complex, is characteristic for many tropical representatives of *Daedalea* Pers., and *Trichaptum* Murrill.

The spores develop in more stable conditions, therefore their structure can be more informative as markers of deeper divergence. Particularly, the thick-walled or ornamented spores in polypores can indicate independent lineages in the development within certain polyporoid grades. The Melzer's positive spores have as a rule a huge glucane matrix, which can be interpreted as a remnant of more complicated wall structure (e.g., ganodermoid).

The branching pattern of sclerohyphae possess an intermediate position in its taxonomic value. On the one hand, this character is highly dependent on convergence due to some common regularities of hyphal branching. On the other hand, it can mark at least two morphogenetic lines: (1) monotonous branching with regularly dichotomous skeletoid elements as a result and (2) active branching with arboriform skeletoid elements as a result.

Having considered the fine morphological features, we propose the following taxonomic position for the two studied species.

'*Trametes*' *ljubarskyi* has important distinctive characters, faintly thick-walled and weakly dextrinoid basidiospores. The sclerified hyphae are arboriform and anisodiametric, like those in *Perenniporia* Murrill. However, spores in *Perenniporia* are strongly thick-walled and dextrinoid, and the morphotype is never truly pileate. Due to the mentioned features of '*T.*' *ljubarskyi*, including its trametoid habit and woody-colored to tan context, this species is transferred to the thermophilous genus having combination of all these fine distinguishing characters, *Loweporus*.

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Note. **Genera:** 1 — *Abundisporus* Ryvarden, 2 — *Antrodiella* Ryvarden et I. Johans., 3 — *Cerrena* Gray, 4 — *Corioloipsis* Murrill, 5 — *Datronia* Donk, 6 — *Diplomitoporus* Domański, 7 — *Earliella* Murrill, 8 — *Flaviporus* Murrill, 9 — *Flavodon* Ryvarden, 10 — *Funalia* Pat., 11 — *Hexagonia* Fr., 12 — *Irpex* Fr., 13 — *Loweporus* J.E. Wright, 14 — *Microporus* P. Beauv., 15 — *Microporellus* Murrill, 16 — *Nigroporus* Murrill, 17 — *Perenniporia* Murrill, 18 — *Pycnoporus* P. Karst., 19 — *Trametes* Fr. **Morphotype:** I — trametoid, II — coriolooid, III — polyporoid, IV — scenidioid, V — fibroporoid. **Context coloration:** w — white, c — cream to woody, b — tan to ochre-brown; o — orange. **Branching pattern of sclerohyphae:** f — fibroid, d — dichotomously branching without dendroid appendages, d/a — dichotomously branching with dendroid appendages and terminations. **Hyphal cyanophily:** CB+ — clearly cyanophilous, CB— — acyanophilous or obscurely cyanophilous. **Basidiospore shape:** e — ellipsoid to lacrymoid, s — subglobose to globose, c — cylindrical, fc — fusoid-cylindrical or long cylindrical. **Spore wall width:** t — thin wall, ft — faintly thickened wall, tk — thickened wall. **Melzer's reaction of a spore wall:** id — indextrinoid, wd — weakly dextrinoid, d — dextrinoid.

The generic columns corresponding to the character's patterns of '*Trametes*' *cervina* (left) and '*Trametes*' *ljubarskyi* (right) are allocated.

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\* The taxonomically valuable variability of this character can be obtained from inner contextual sclerohyphae only. Abhymenial sclerohyphae as a rule are distinctly cyanophilic.

'*Trametes*' *cervina* has an intermediate habitus between scenidioid to coriolioid and in many aspects corresponds to tropical species *Flavodon flavus*. The basidiospores are cylindrical, thin-walled, but weakly cyanophilous. Skeleto-binding hyphae of '*Trametes*' *cervina* do not have dendroid appendages and are clearly cyanophilous and comparable with regularly dichotomous pseudoskeletal of *Flavodon flavus*. The basidiocarps are strikingly parchment-like, with radially-ridged thin pilei and large pores. The sufficient difference between two species can be reduced to clampless condition in *F. flavus*; however, they are regarded as congeneric taxa.

### Taxa description

*FLAVODON* Ryvarden

Norw. J. Bot. 20: 3, 1973.

Basidiocarps seasonal to persisting, scenidioid to coriolioid, with widely effused base and thin parchment-like pilei. Pores large, 1—3 per mm, hexagonioid to irpicoid. Context floccose-felt, pseudodimitic to dimitic with dichotomous skeleto-binding hyphae without appendages. Hyphae fibulate or efibulate. Pseudocystidia present or not. Basidia clavate, 4-spored. Spores cylindrical, thin-walled, Melzer's negative. Saprotrophic on wood. Causes a white rot.

**Type:** *Flavodon flavus* (Klotzsch) Ryvarden

Thermophilic genus, rather distant from *Trametes*, but closely related to some members of *Meruliaceae* currently poorly resolved in molecular cladograms. In warm-temperate climate one species is distributed.

***Flavodon cervinus*** (Schwein.) Zmitr. comb. nov. — Basionym: *Boletus cervinus* Schwein., Schr. naturf. Ges. Leipzig 1: 96, 1822. — *Trametes cervina* (Schwein.) Bres., 1903. — *Coriolus cervinus* (Schwein.) Bondartsev, 1953. — *Coriolellus cervinus* (Schwein.) Kotl. et Pouzar, 1957. — *Antrodia cervina* (Schwein.) Kotl. et Pouzar, 1983. — *Funalia cervina* (Schwein.) Y.C. Dai, 1996. — *Diplomitoporus cervinus* (Schwein.) Spirin et Zmitr., 2008. — *Trametopsis cervina* (Schwein.) Tomšovský, 2008; *Polyporus carolinensis* Berk. et M.A. Curtis, 1849; *P. scarrosus* Berk. et M.A. Curtis, 1872; *P. squarrosus* Berk. et M.A. Curtis, 1872; *Trametes populina* Bres., 1896; *Coriolus orizabensis* Murrill, 1912; *Polyporus mali* Velen., 1922. — Fig. 1.

Basidiocarps annual or persisting, of scenidioid-coriolioid appearance, sessile or effused-reflexed, 0.5—4.0 cm long, 3—6 cm wide and 0.2—0.8(1.5) cm thick, parchment-like, usually clustered and confluent. Upper surface squalid to naked, radially ridged and scrupose, whitish cream, then unevenly tan to cervino-gilvus with more intensive rusty-ochraceous ridges. Margin sharp and often sinuose (like *Hexagonia* and tropical *Daedalea* species), sterile, initially white, then cream to ochraceous, up to 1 mm wide. Pore surface uneven, often decurrent, white to cream-ochre, the pores splitted in irpicoid manner, firstly round, later elongated and angular, 0.5—2.0 per mm. Section: context woody-colored, floccose-felt; tubes woody-grayish, densely coriaceous. No distinct odour, taste mild.

Hyphal system dimitic with dichotomously branching skeleto-binding hyphae. Generative hyphae 2—4 µm wide, thin-walled, hyaline, clamped. Skeleto-binding hyphae

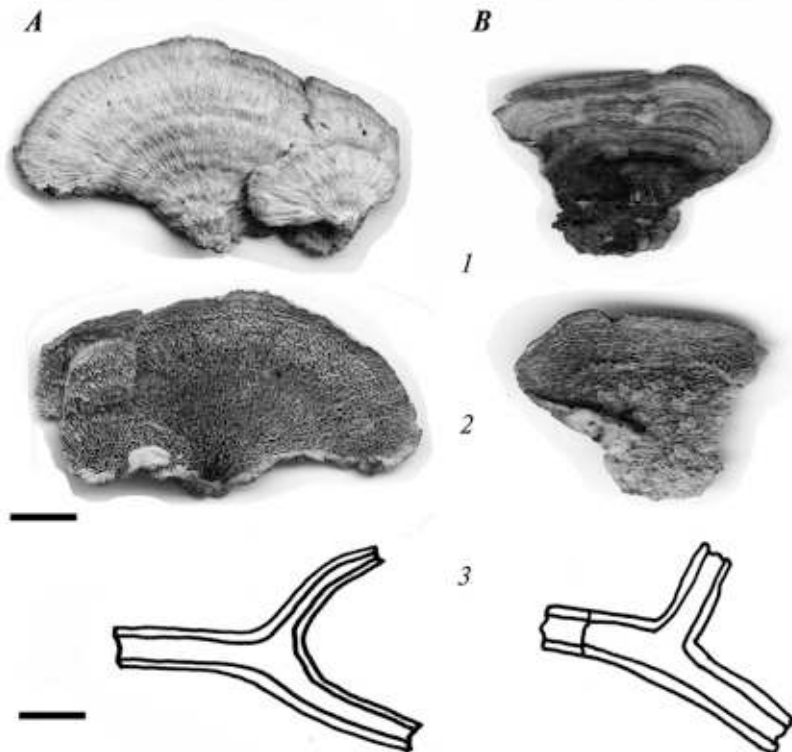


Fig. 1. Sufficient basidiocarp aspects of *Flavodon cervinus* (A) and *F. flavus* (B):  
 1 — Pilei from abhymenial side, 2 — hymenophore, 3 — modal elements of sclerohyphae.  
 Scale bar 1 cm (1, 2) and 10  $\mu$ m (3)

without dendroid appendages, dichotomously branching, present in both context and tubes, 3—6(7)  $\mu$ m wide, with wide lumina. Leptocystidia fusoid, 15—20  $\times$  4.0—5.5  $\mu$ m, rather rare. Pseudocystidia 20—25  $\mu$ m in observable part, 5—6  $\mu$ m wide, extremely rare. Basidia clavate, 20—25  $\times$  5—7  $\mu$ m, fibulate at the base. Basidiospores cylindrical, slightly curved, 7—9(10)  $\times$  2.5—3.0  $\mu$ m, hyaline, thin-walled, Melzer's negative, weakly cyanophilous.

On arid flange of broadleaf forest zone of Eurasia and North America. Associated with fallen logs and stumps of *Acer*, *Betula*, *Carpinus*, *Celtis*, *Cerasus*, *Corylus*, *Fraxinus*, *Ilex*, *Juglans*, *Malus*, *Morus*, *Myrica*, *Populus*, *Pyrus*, *Quercus*, *Salix*, and *Ulmus*. Distributed occasionally in Lithuania, Belarus and Poland, more frequent in Spain, France, Germany, Switzerland, Romania, Ukraine, Georgia, and Russia (Rostov, Samara and Voronezh Regions, more scattered in Nizhegorod, Tatarstan; Siberian findings are mainly ambiguous). In Asia known from China (LE).

*LOWEPORUS* J.E. Wright  
 Mem. N.Y. bot. Gdn 28: 225, 1976.

Basidiocarps seasonal to persisting, distinctly trametoid, sessile to effuso-reflecting. Pores medium-sized, 3—7 per mm, of normal trametoid appearance. Context floccose-coriaceous, wood-colored to brownish, dimitic with dendroid skeleto-binding hyphae. Generative hyphae fibulate. No pseudocystidia. Basidia clavate, 4-spored. Spores ellipsoid or lacrymoid, faintly thick-walled, weakly dextrinoid. Saprotrophic on wood. Causes a white rot.

Type: *Loweoporus tephrophorus* (Mont.) Ryvarden

Thermophilic genus, differs from *Perenniporia* by pileate basidiocarps with intensely colored context and finer thickened, weakly dextrinoid walls. *Nigroporus* is similar, but distinguished by indextrinoid spores, deeper context and smaller pores. In warm-temperate climate one species is distributed.

*Loweoporus ljubarskyi* (Pilát) Zmitr. comb. nov. — Basionym: *Trametes ljubarskyi* Pilát, Bull. Soc. Mycol. France 52: 309, 1936. — *Haploporus ljubarskyi* (Pilát) Bondartsev et Singer ex Bondartsev, 1953. — *Perenniporia ljubarskyi* (Pilát) Spirin, Zmitr. et V. Malysheva in Wasser et al., 2006. — Fig. 2.

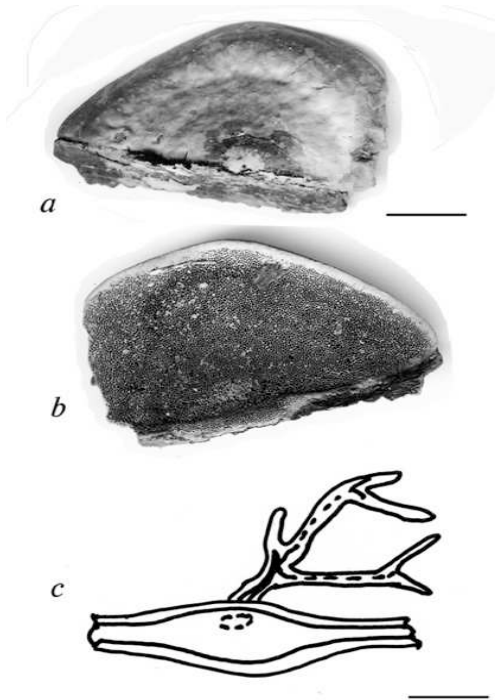


Fig. 2. *Loweoporus ljubarskyi*: *a* — basidiocarp upperside, *b* — hymenophore, *c* — skeletobinding hypha. Scale bar 1 cm (*a*, *b*) and 10  $\mu$ m (*c*)



Fig. 3. *Loweoporus ljubarskyi*: basidiospores with thickened wall and small adherent granules outside. Scale bar 5  $\mu$ m

Basidiocarps annual or short-living perennial, sessile, pileate, 5—15 cm long, 3—8 cm wide and 0.8—3.0 cm thick, densely coriaceous to corky, solitary or in small groups. Upper surface firstly velutinate, pale ochraceous with grayish tints, later becoming glabrous and partly agglutinated, tan to reddish brown in old or persistent basidiocarps. Margin sharp or terminally blunt, firstly grayish, then clay to ochraceous, up to 1 mm wide, sterile. Pore surface even, mostly ochraceous; pores firstly round, later more or less elongated, 3—4 per mm, with thin opaque entire dissepiments. Section: context pale ochraceous to clay, 0.3—0.8 cm thick, tough; tubes pale ochraceous, 1—2 cm thick, densely coriaceous.

Hyphal system dimitic with dendroid skeletobinding hyphae (trimitic in a current sense). Generative hyphae rare, present mostly in tubes, 1.5—2.5  $\mu\text{m}$  wide, thin-walled, hyaline, clamped. Pileus surface consisting of brownish skeletal hyphae 4—6  $\mu\text{m}$  wide, glued together by amorphous matter easily dissolving in KOH. Skeleto-binding hyphae hyaline to pale ochraceous in KOH, 3—5  $\mu\text{m}$  wide, irregularly arranged in all parts of basidiocarp, with large lumina, sometimes inflated and then up to 8  $\mu\text{m}$  wide, unchanging in IKI, cyanophilous. Binding hyphae present in both context and tubes, 1.5—3.0  $\mu\text{m}$  wide, almost solid, strongly branched. Cystidioles conical, 15—25  $\times$  5—6  $\mu\text{m}$ , relatively rare. Basidia broadly clavate, 15—28  $\times$  6—10  $\mu\text{m}$ , fibulate at the base. Spores broadly ellipsoid, lacrymoid or indistinctly truncate, (4.2)4.5—6.8(7.0)  $\times$  (3.5)3.6—4.5(4.7)  $\mu\text{m}$ , hyaline, with distinct walls, faintly dextrinoid or not, cyanophilous [7].

On arid flange of broadleaf forest zone of Eurasia. Associated with fallen logs and stumps of *Acacia*, *Carpinus*, *Populus*, *Prunus*, *Quercus*, occasionally on *Pinus*. Distributed in Portugal, Spain, France, Italy, Croatia, Ukraine, and Russia (Rostov and Samara regions, South of Russian Far East). In Asia also known from China (LE, [3]).

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#### ПРО ТАКСОНОМІЧНЕ ПОЛОЖЕННЯ ДВОХ МАЛОВІДОМИХ ПОМІРНО-ТЕРМОФІЛЬНИХ ТРАМЕТОЇДНИХ ГРИБІВ

У результаті здійснених порівняльно-морфологічних досліджень визначено таксономічну позицію двох рідкісних термофільних видів траметоїдних грибів — *Trametes cervina* і *T. ljubarskyi*. Перший за сукупністю ознак був перенесений до роду *Flavodon*, а другий — до роду *Loweoporus*.

*К л ю ч о в і с л о в а*: вищі базидіомицети, термофільні поліпорові гриби, сценідіоїдний морфотип, траметоїдний морфотип.

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#### О ТАКСОНОМИЧЕСКОМ ПОЛОЖЕНИИ ДВУХ МАЛОИЗВЕСТНЫХ УМЕРЕННО-ТЕРМОФИЛЬНЫХ ТРАМЕТОИДНЫХ ГРИБОВ

В результате проведенных сравнительно-морфологических исследований определена таксономическая позиция двух редких термофильных видов траметоидных грибов — *Trametes cervina* и *T. ljubarskyi*. Первый по совокупности признаков был перенесен в род *Flavodon*, а второй — в род *Loweoporus*.

*К л ю ч е в ы е с л о в а*: высшие базидиомицеты, термофильные полипоровые грибы, сценидиоидный морфотип, траметоидный морфотип.