

# A taxonomic study of *Melampsora* (Uredinales) on *Populus* in Bulgaria

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**Abstract.** A taxonomic revision of *Melampsora* on *Populus* in Bulgaria was carried out. The study yielded distributions of *M. allii-populina*, *M. populnea* (f. sp. *laricis*, f. sp. *magnusiana*, f. sp. *pinitorqua*, and f. sp. *rostrupii*), and *M. larici-populina* on 20 host species of *Allium*, *Mercurialis*, *Pinus*, and *Populus*, representing a total of 28 rust/host combinations. Three species of *Populus* are recorded as new hosts for Bulgaria. The morphological characteristics and distribution of these rust fungi are reported.

**Key words:** Bulgaria, fungal diversity, *Melampsora*, *Populus*, rust fungi, taxonomy, Uredinales

## Introduction

Poplar rusts, caused by *Melampsora* spp., are important tree diseases in Bulgaria where three species of *Melampsora* on *Populus* are known so far, viz. *M. allii-populina*, *M. larici-populina*, and *M. populnea* (Denchev 1995). Information about these species has been previously reported by Malkoff (1906, 1908), Dimitrov (1923, 1926), Savov (1923), Ivanov (1928), Atanasov *et al.* (1932), Radoslavov (1943), Kovatshevski (1955), Markov (1959, 1961), Zashev & Tsanova (1960, 1969), Krousheva (1964), Hinkova (1959a, b, 1960, 1968, 1978, 1981), Tsanova (1966, 1967), Rosnev (1976), Naydenov (1984, 1996), Naydenov & Bencheva (1992), etc. These articles focus on phytopathological investigations or contain data only on rust-host combinations and their localities.

During 2004–2006, a taxonomic revision of the available Bulgarian specimens of *Melampsora* on *Populus* was made.

## Materials and Methods

In the course of this investigation, 51 specimens of *Melampsora* from Bulgaria were studied. All the specimens are kept in the Mycological Collection of the Institute of Botany, Bulgarian Academy of Sciences (SOMF).

Aeciospores, urediniospores, and teliospores from dried specimens were examined under a light microscope after mounting in lactophenol solution, gently heating to the boiling point, and then cooling. The measurements of spores are given in the form: min-max (mean  $\pm$  1 standard deviation). In the species descriptions, a symbol 'n(x) =' is used to indicate the total number of measured spores (n) from all collections (x).

Identification of the rusts and clarification of their nomenclature and distribution were made with the aid of classical and modern works by Sydow & Sydow (1912–1915), Arthur (1934), Săvulescu (1953), Kuprevich & Tranzschel (1957), Gäumann (1959), Wilson & Henderson

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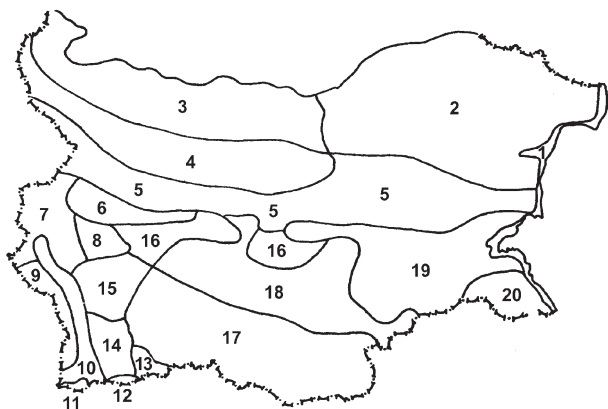


Fig. 1. Map of the floristic regions of Bulgaria

(1966), Boerema & Verhoeven (1972), Gjaerum (1974), Kuprevich & Ulyanishchev (1975), Majewski (1977), Hiratsuka *et al.* (1992), Bagyanarayana (1998), Poelt & Zwetko (1997), Cellerino (1999), Zwetko (2000), Tian *et al.* (2004), Azbukina (2005), Pei & Shang (2005), and Tian & Kakishima (2005).

In the rubric 'Specimens examined', the floristic regions of Bulgaria are put between parentheses and numbered as follows: [1] Black Sea Coast, [2] Northeast Bulgaria, [3] Danubian Plain, [4] Forebalkan, [5] Balkan Range, [6] Sofia region, [7] Znepole region, [8] Vitosha region, [9] West Frontier Mts, [10] Valley of River Strouma, [11] Mt Belasitsa, [12] Mt Slavyanka, [13] Valley of River Mesta, [14] Pirin Mts, [15] Rila Mts, [16] Mt Sredna Gora, [17] the Rhodopes, [18] Thracian Lowland, [19] Toundzha Hilly Country, and [20] Mt Strandzha (Fig. 1). The following abbreviations of collectors' names are used: [MM] – M. Markov, [CH] – Ts.H. Hinkova. The abbreviation 'specim. n.v.' is used for records without a herbarium voucher.

## Taxonomy

*Melampsora populnea* gr. includes various races usually distinguished as species, which do not differ essentially in morphological characters but possess different aecidial hosts (Wilson & Henderson 1966; Boerema & Verhoeven 1972; Bagyanarayana 1998). In the present article, we follow mainly the concept of Bagyanarayana (1998) in accordance to which *M. populnea* consists of 5 *formae speciales* but we prefer to treat *M. allii-populina* as a good taxon at species level.

1. *Melampsora allii-populina* Kleb., Z. Pflanzenkrankh. 12: 25, 1902. — *Melampsora populnea* (Pers. : Pers.) P. Karst. f. sp. *allii-populina* Bagyan., Proc. First IUFRO Rusts of forest trees W.P. Conference, Finnish Forest Res. Inst., Res. Papers 712: 47, 1998. — *Caecoma allii-ursini* G. Winter in Rabenhorst, Kryptog.-Fl. Deutschl. 1(1): 255, 1881, p.p. — *Uredo allii-populina* Arthur, Rés. Sci. Congr. Int. Bot. Vienne 1905, p. 338, 1906.

**Spermogonia** amphigenous, scattered or grouped, minute, rounded, 0.1-0.2 mm diam, sometimes confluent and inducing appearance of dark spots in the center of each aecial group, reddish brown, compact, glossy. **Aecia** amphigenous, *Caecoma*-type, scattered, rounded 0.5-1 mm diam, elongated 1.2-2 mm or confluent in ring-shaped or elliptical groups, 3-8 mm large, around the spermogonia, rupturing the epidermis, pulverulent, yellow-orange; **aeciospores** globose, subglobose or broadly ellipsoid,  $20-27.5 \times 17.5-25$  ( $23.8 \pm 2.0 \times 21.2 \pm 1.8$ )  $\mu\text{m}$  [ $n_{(8)} = 240$ ], wall  $2.5-3 \mu\text{m}$  thick, thickened laterally to  $3.5-4 \mu\text{m}$ , verruculose; **paraphyses** lacking; **Uredinia** amphigenous, mostly hypophyllous, scattered, rounded 0.2-0.8 mm diam, sometimes elongated 0.8-1 mm, often confluent in small groups, yellow-orange, pulverulent; **urediniospores** obovoid, broadly ellipsoid or ellipsoid,  $24.5-36 \times 15.5-22.5$  ( $29.9 \pm 2.8 \times 18.6 \pm 1.8$ )  $\mu\text{m}$  [ $n_{(16)} = 460$ ], wall uniformly thickened,  $2-4 \mu\text{m}$ , almost colourless, content pale yellow, echinulate, but smooth at the apex, spines *ca*  $1 \mu\text{m}$  high; **paraphyses** numerous, clavate, seldom capitate,  $39-80.5 \times 14.5-23 \mu\text{m}$ . **Telia** amphigenous, subepidermal, scattered, rounded 0.3-1.5 mm diam, elongated or confluent in large and irregularly shaped crusts, chestnut-brown to reddish brown; **teliospores** cylindrical, rounded at both ends, prismatic, clavate or ellipsoid,  $32.5-55.5 \times 8-14$  ( $44.1 \pm 5.8 \times 10.8 \pm 1.6$ )  $\mu\text{m}$  [ $n_{(12)} = 340$ ], wall *ca*  $1.5 \mu\text{m}$ , not thickened at the apex, pale yellow, smooth, with indistinct pores; **paraphyses** lacking.

**Life cycle, hosts, and distribution:** 0, I – II, III (Hetero-eu form): 0, I on *Allium*, *Arum*, and *Muscari* spp.; II, III on *Populus* spp. (Sect. *Aigeiros* and *Tacamahaca*) – Europe, Asia, and Africa.

### Host range and distribution in Bulgaria:

On *Allium carinatum* L. subsp. *pulchellum* Bonn. & Lay.: Pirin Mts (Hinkova 1959b, as *Caecoma alliorum* Link – specim. n.v.). On *A. cepa* L.: widespread. On *A. guttatum* Stev. subsp. *sardorum* (Moris) Stearn: Black Sea Coast. On *A. porum* L.: Danubian Plain. On *A. sativum* L.: Northeast Bulgaria, Danubian Plain. On *Arum maculatum* L.: Sofia region (Krousheva 1964 – specim. n.v.).

On *Populus ×berolinensis* (C. Koch) Dipp.: widespread (Zashev & Tsanova 1960). On *P. ×canadensis* Moench: Black Sea Coast, Northeast Bulgaria, Danubian Plain, Sofia region. On *P. ×canadensis* cv. 'marylandica': widespread (Zashev & Tsanova 1960, 1969). On *P. ×canadensis* cv. 'regenerata': widespread (Zashev & Tsanova 1960, 1969). On *P. ×canadensis* cv. 'robusta' (*P. ×bachelieri*): widespread (Tsanova 1966; Zashev & Tsanova 1969). On *P. ×canadensis* cv. 'serotina': widespread (Tsanova 1966; Zashev & Tsanova 1960). On *P. nigra* L.: widespread (Markov 1961; Zashev & Tsanova 1960). On *P. nigra* cv. 'italica': Northeast Bulgaria, Danubian Plain.

### Specimens examined:

On *Allium cepa* L.: [2]: distr. Ruse, prope pagum Marten, 20.V.1960, MM (7466); distr. Targovishte, in pago Zараеvo, 25.V.1960, MM (25 520); distr. Silistra, in oppido Silistra, 12.V.1960, MM (25 522); [3]: distr. Pleven, in oppido Pavlikeni, 1956, MM (25 519); ditto, 20.V.1960, MM (25 521).

On *A. guttatum* Stev. subsp. *sardorum* (Moris) Stearn: [1]: distr. Varna, l. d. 'Pobitite Kamani', prope oppid. Beloslav, 20.V.1958, CH (8972).

On *A. porum* L.: [3]: distr. Pleven, in oppido Pavlikeni, 6.V.1960, MM (25 523); ditto, 8.V.1960, MM (25 524); ditto, 10.V.1960, MM (8499).

On *A. sativum* L.: [2]: distr. Silistra, in oppido Silistra, 12.V.1960, MM (25 516); [3]: distr. Pleven, in oppido Pavlikeni, 27.IV.1960, MM (25 517); ditto, 4.V.1960, MM (25 518).

On *Populus ×canadensis* Moench: [1]: distr. Burgas, prope pagum Obzor, 2.IX.1959, CH (12 532); [2]: distr. Silistra, prope oppidum Silistra, 8.X.1958, MM (7468); distr. Silistra, prope oppidum Tutrakan, 14.X.1959, MM (8150); distr. Varna, in pago Staro Orjahovo, 20.VIII.1962, MM (25 512); [3]: distr. Pleven, in oppido Pavlikeni, 26.IX.1960, MM (25 511); ditto, 15.IX.1959, MM (7467); ditto, 6.X.1959, MM (8149); [6]: distr. Sofia, supra pagum Lokorsko, 3.XI.1961, CH (12 566).

On *P. nigra* L.: [1]: distr. Varna, prope pagum Galata, 13.VIII.1958, CH (764); distr. Burgas, Slantshev Brjag, 24.VIII.1963, MM (sub *M. allii-populina* on *P. canadensis*) (25 513); [2]: distr. Targovishte, prope pagum Zahari Stojanovo, 8.X.1959, MM (10 395); distr. Varna, l. d. 'Pobiti Kamani', prope pagum Beloslav, 11.IV.1958, CH (8843); distr. Razgrad, prope pagum Balkanski, 16.X.1960, MM (sub *M. allii-populina* on *P. canadensis*) (7538); [3]: distr. Veliko Tarnovo, prope oppid. Svishtov, 13.VII.1960, MM (sub *M. allii-populina* on *P. canadensis*) (7537); [4]: distr. Veliko Tarnovo, prope pagum Stambolovo, 30.V.1960, MM (sub *M. allii-populina* on *P. canadensis*) (7536); [10]: distr. Blagoevgrad, prope pagum Kulata, 8.VII.1959, CH (2284); [19]: distr. Haskovo, prope oppid. Svilengrad, 3.XI.1959, CH (12 637); [20]: distr. Burgas, loco dicto 'Urgarski Dol', prope pagum Kosti, 24.VIII.1959, CH (8856).

On *P. nigra* L. cv. 'italica': [2]: distr. Targovishte, in oppido Popovo, 6.VIII.1960, MM (sub *M. allii-populina* on *P. pyramidalis*) (25 514); [3]: distr. Pleven, in oppido Pavlikeni, 3.X.1959, MM (10 396); ditto, 1.X.1959, MM (sub *M. allii-populina* on *P. pyramidalis*) (25 474).

Note: Hinkova (1978, 1981) reported *M. allii-populina* on *Allium ursinum* L. (SOMF 8862) but during the taxonomical revision, no aecia were found on that specimen. Thus the latter is omitted here.

2. *Melampsora populnea* (Pers. : Pers.) P. Karst., Bidrag Kännedom Finlands Natur Folk 31: 53, 1879. — *Sclerotium populneum* Pers., Observ. Mycol. 2: 25, 1800[1779]. — *S. populneum* Pers. : Pers., Syn. Meth. Fungorum, p. 125, 1801. — *Uredo aecioides* DC., Fl. Franç. 2: 236, 1805 (II). — *Melampsora aecioides* ["DC."] J. Schröt. in Cohn, Kryptog.-Fl. Schles. 3(1): 362, 1887. — *M. tremulae* Tul., Ann. Sci. Nat. Bot., Sér. 4, 2: 95, 1854. — *Melampsora populina* auct., p.p.

**Life cycle, hosts, and distribution:** 0, I – II, III (Hetero-eu form): 0, I on *Chelidonium*, *Corydalis*, *Fumaria*, *Larix*, *Mercurialis*, *Papaver*, and *Pinus* spp.; II, III on *Populus* spp. – cosmopolitan.

2(1). f. sp. *laricis* Boerema & Verh., Netherlands J. Pl. Pathol. 78(Suppl. 1): 25, 1972. — *M. laricis* R. Hartig, Allg. Forst- und Jagd-Zeitung 61: 326, 1885. — *M. tremulae* f. *laricis* R.

Hartig, Lehrbuch Baumkrankh., 2<sup>nd</sup> edn, p. 14, 1889. — *M. larici-tremulae* Kleb., Forstl.-Naturwiss. Z. 6: 470, 1897.

**Spermogonia and aecia** on *Larix* ssp. but not seen in the Bulgarian materials. **Uredinia** hypophyllous, scattered, minute, rounded, 0.2-0.5 mm diam, sometimes in groups, pulverulent, yellow; **urediniospores** subglobose, broadly ellipsoid to obovate, 19-25.5 × 14-18 (22.5 ± 1.9 × 15.8 ± 0.1) µm [ $n_{(1)} = 30$ ], content yellow, wall 1.5-2 µm thick, laterally thickened up to 3-3.5 µm, pale yellow to colourless, echinate, spines 1.5 µm high, pores indistinct; **paraphyses** capitate, 41-70 × 11.5-15 µm, wall ca 3.5 µm thick. **Telia** hypophyllous, subepidermal, scattered, rounded or irregular in shape, often confluent, chestnut-brown to dark brown; **teliospores** cylindrical and rounded at both ends, clavate or obovate, 35.5-52.5 × 6.5-13 (45.5 ± 5.2 × 10.4 ± 1.5) µm [ $n_{(1)} = 30$ ], wall ca 1.5 µm smooth, sometimes thickened at the apex, with indistinct pores; **paraphyses** lacking.

**Life cycle, hosts, and distribution:** 0, I – II, III (Hetero-eu form): 0, I on *Larix* spp.; II, III on *Populus* spp. [Sect. *Populus* (*Leuce*)] – Europe, Asia, North Africa, and North America (USA).

#### Host range and distribution in Bulgaria:

On *Populus alba* L.: widespread (Naydenov 1984, 1996; Naydenov & Bencheva 1992 – as *M. larici-tremulae*). On *P. ×canescens* (Ait.) Sm. (*P. alba* × *tremula*): widespread (Naydenov & Bencheva 1992, as *M. larici-tremulae*). On *P. tremula* L.: widespread (Radoslavov 1943; Naydenov 1984, 1996; Naydenov & Bencheva 1992 – as *M. larici-tremulae*).

#### Specimen examined:

On *Populus tremula*: [8]: Mons Ljulin, distr. Sofia, supra pagum Gorna Banja, 7.X.1975, CH (as *M. larici-tremulae*) (9089).

2(2). f. sp. *magnusiana* Bagyan.\*\*, Proc. First IUFRO Rusts of forest trees W.P. Conference, Finnish Forest Res. Inst., Res. Papers 712: 48, 1998. — *M. magnusiana* Wagner, Oesterr. Bot. Z. 46: 273, 1896 (*nom. nud.*). — *M. magnusiana* Wagner ex Kleb., Z. Pflanzenkrankh. 7: 340, 1897. — *Caeoma fumariae* Link., Sp. Pl., 6<sup>th</sup> edn, 2: 24, 1825. — *C. chelidonii* Magnus, Hedwigia 14: 20, 1875.

[**Spermogonia and aecia** unknown in Bulgaria]. **Uredinia** hypophyllous, scattered, rounded, 0.2-0.8 mm diam or elliptical, sometimes confluent, orange-yellow, pulverulent; **urediniospores** subglobose, obovate to broadly ellipsoid, 20-27 × 15-21 (23.3 ± 1.6 × 19.2 ± 1.4) µm [ $n_{(2)} = 60$ ], wall 2-3 µm thick, laterally thickened up to 3.5 µm, echinate, spines 1-1.5 µm high, pores indistinct; **paraphyses** capitate, 42.5-68.5 × 13-22.5 µm. **Telia** hypophyllous, subepidermal, scattered, rounded, 0.3-0.8 mm diam or elongated, 0.5-1.2 mm, often confluent into small dark brown crusts; **teliospores** prismatic, cylindrical and rounded at both ends or clavate, 31-53 × 7-15.5 (42.9 ± 5.4 × 10.2 ± 2.0) µm [ $n_{(3)} = 90$ ], wall ca 1.5 µm thick, smooth, yellow-brown with indistinct pores; **paraphyses** lacking.

\*\* *Forma specialis magnusiana* has been proposed by Bagyanarayana (l.c.) as a new combination [as (Wagn.) Bagyanarayana comb. nov.] based on *M. magnusiana* Wagner (*nom. nud.*). Because the category *forma specialis* is not sanctioned by ICBN, a validation of this name is not necessary.

**Life cycle, hosts, and distribution:** 0, I – II, III (Hetero-eu form): 0, I on *Chelidonium*, *Corydalis*, *Fumaria*, and *Papaver* ssp.; II, III on *Populus* spp. [Sect. *Populus* (*Leuce*) and *Tacamahaca*] – Europe, Asia, and North America (USA).

**Host range and distribution in Bulgaria:**

On *Populus candicans* Aiton: Sofia region. On *P. tremula* L.: Sofia region, Rila Mts (Hinkova 1959a, 1960, as *M. magnusiana* – specim. n.v.).

**Specimens examined:**

On *Populus candicans*: [6]: Sofia, IX.1927, A. Vulkanov (sub *M. magnusiana* on *Populus tremula*) (10 422).

On *P. tremula*: [6]: distr. Sofia, supra pagum Dolna Banja, alt. 1100 m, CH, 5.X.1953 (813) & 1956 (9519) (both as *M. magnusiana*).

2(3). f. sp. *pinitorqua* Boerema & Verh., Netherlands J. Pl. Pathol. 78(1): 25, 1972. — *M. tremulae* f. *pinitorquum* R. Hartig, Lehrbuch Baumkrankh., 2<sup>nd</sup> edn, p. 140, 1889. — *Caecoma pinitorquum* de Bary, Monatsber. Königl. Preuss. Akad. Wiss. Berlin, 1863: 624, 1863 (I). — *Melampsora pinitorqua* [de Bary] Rostr., De Farligste Snyltesvampe i Danmarks Skove (Copenhagen), p. 10, 1889. — *Uredo pinitorqua* Arthur, Rés. Sci. Congr. Int. Bot. Vienne 1905, p. 338, 1906. — *Melampsora pruinosa* Tranzschel in Serebriankow, Mycotheca Rossica, no. 265, 1912.

**Spermogonia** and **aecia** on *Pinus* ssp. but not seen on Bulgarian materials. **Uredinia** hypophyllous, scattered, minute, rounded, 0.3-1 mm diam or elongated up to 1 mm, often grouped or confluent, yellow, pulverulent, inducing occurrence of yellow spots on the upper leaf surface; **urediniospores** subglobose, obovate to broadly ellipsoid, 20-27 × 15.5-20 (22.8 ± 1.6 × 17.9 ± 1.3) μm [ $n_{(4)} = 120$ ], wall 1.5-2 μm, laterally thickened to 3 μm, echinate, spines 1-1.5 μm high; pores indistinct; **paraphyses** 36.5-70 × 15.5-23 μm, wall 2-3 (-4) μm. **Telia** hypophyllous, subepidermal, scattered, rounded, 0.2-0.5 mm diam or elliptical, often confluent in large and irregularly shaped crusts, chestnut-brown to dark brown; **teliospores** prismatic, cylindrical and rounded at both ends or clavate, 28-46 × 6.5-12.5 (36.4 ± 4.8 × 9.6 ± 1.5) μm [ $n_{(2)} = 60$ ], wall ca 1.5 μm thick, not thickened at the apex, yellow-brown, smooth, with indistinct pores; **paraphyses** lacking.

**Life cycle, hosts, and distribution:** 0, I – II, III (Hetero-eu form): 0, I on *Pinus* spp.; II, III on *Populus* spp. [Sect. *Populus* (*Leuce*) and *Tacamahaca*] – Europe, Asia.

**Host range and distribution in Bulgaria:**

On *Pinus nigra* L. (cult.): Pirin Mts (Rosnev 1976, as *M. pinitorqua* – specim. n.v.). On *P. sylvestris* L. (cult.): Forebalkan, Balkan Range, Sofia region (Dimitrov 1923, as *Caecoma pinitorquum* – specim. n.v.), Vitosha region, Pirin Mts (Rosnev 1976, as *M. pinitorqua* – specim. n.v.), Rhodopi Mts, Thracian Lowland (Tsanova 1960, 1967, as *M. pinitorqua* – specim. n.v.).

On *Populus candicans* Aiton: Rila Mts, Mt Sredna Gora. On *P. ×canescens* (Ait.) Sm. (*P. alba* × *tremula*): Balkan Range (Tsanova 1967, as *M. pinitorqua* – specim. n.v.). On *P.*

*tremula* L.: widespread. On *P. trichocarpa* Torrey & A. Gray ex Hooker: Mt Strandzha.

**Specimens examined:**

On *Populus candicans*: [15]: distr. Kjustendil, prope Monasterium Riloense, l. d. 'Tschereschovo', 26.VI.1965, B. Zheljazova & CH (sub *M. pinitorqua* on *P. tremula*) (11 586); [16]: Mons Lozenska Planina, distr. Sofia, prope pagum Kokaljane, alt. 700 m, 4.X.1970, CH (sub *M. pinitorqua* on *Populus tremula*) (11 840).

On *P. tremula*: [8]: Mons Vitoscha, 25.IX.1960, CH (sub *M. pinitorqua*) (2312).

On *P. trichocarpa*: [20]: distr. Burgas, l. d. 'Odereto', supra pagum Kosti, 24.VIII.1959, CH (sub *M. pinitorqua* on *P. tremula*) (9511).

2(4). f. sp. *rostrupii* Boerema & Verh., Netherlands J. Pl. Pathol. 78(1): 25, 1972. — *Melampsora rostrupii* Wagner, Oesterr. Bot. Z. 46: 274, 1896 (*nom. nud.*). — *M. rostrupii* Wagner ex Kleb., Z. Pflanzenkrankh. 7: 342, 1897 (*nom. provis.*). — *M. rostrupii* Kleb., Die Wirtwechselnden Rostpilze, p. 407, 1904[903]. — *Uredo mercurialis* H. Mart., Prodr. Fl. Mosq., 2: 229, 1817. — *Caecoma mercurialis* Link., Sp. Pl., 6<sup>th</sup> edn, 2: 35, 1825. — *Melampsora pulcherrima* Maire, Mycotheca Bor.-Afric., fasc. 5: 108, 1914.

**Spermogonia** indistinct. **Aecia** hypophyllous, forming ring-shaped groups, 3-4 mm diam around the spermogonia, often on the petioles, inducing occurrence of yellow spots on the upper leaf surface, scattered, rounded, 0.5-1 mm diam or irregularly elongated up to 1-1.5 mm, rupturing the epidermis, pulverulent, orange-yellow; **aeciospores** subglobose, obovate to ellipsoid, 18-23 × 15-20 (20.5 ± 1.4 × 17.1 ± 1.3) μm [ $n_{(3)} = 90$ ], wall 2-2.5 μm thick, sometimes laterally thickened to 3 μm, pale yellow to colourless, verruculose, with indistinct pores; **paraphyses** lacking. **Uredinia** amphigenous, scattered, rounded, 0.2-1 mm diam or elliptical, sometimes confluent, orange-yellow, pulverulent; **urediniospores** globose, subglobose to obovate, 19-26 × 15-19 (21.8 ± 1.7 × 17.1 ± 1.1) μm [ $n_{(1)} = 30$ ], wall 2-2.5 (-3) μm, sometimes laterally thickened up to 3.5 μm, echinate. **Telia** amphigenous, subepidermal, scattered or confluent in large and irregular crusts, chestnut-brown to dark reddish brown; **teliospores** 39.5-65.5 × 6.5-11.5 (51.7 ± 6.1 × 8.8 ± 1.3) μm [ $n_{(1)} = 30$ ], wall ca 1.5 μm.

**Life cycle, hosts, and distribution:** 0, I – II, III (Hetero-eu form): 0, I on *Mercurialis* spp.; II, III on *Populus* spp. [Sect. *Aigeiros* and *Populus* (*Leuce*)]. – Europe, Asia (China, India), North Africa, North America (USA).

**Host range and distribution in Bulgaria:**

On *Mercurialis annua* L.: Balkan Range (Hinkova 1981, as *M. pulcherrima* Maire – specim. n.v.). On *M. ovata* Sternb. & Hoppe.: Black Sea Coast. On *M. perennis* L.: Forebalkan, Vitosha region, Mt Strandzha.

On *Populus alba* L.: Pirin Mts, Rhodopi Mts (Hinkova 1981, as *M. pulcherrima* – specim. n.v.). On *Populus ×canadensis* Moench – Rila Mts (Dimitrov 1926, as *M. mercuriali-tremulae* Kleb. = *M. rostrupii* – specim. n.v.). On *P. tremula* L.: Vitosha region.

**Specimens examined:**

On *Mercurialis ovata*: [1]: distr. Burgas, in valle rivi Silistarsko Dere, l. d. 'Djadovijat Stankov Drenak', prope pagum Sinemorec, 26.IV.1964, CH (sub *M. rostrupii*) (5310).

On *M. perennis*: [4]: Mons Vratschanska, in declivibus cac. Petrovski Vrah, alt. 1200 m, 17.V.1966, CH (sub *M. rostrupii*) (8627); [8]: Mons Vitoscha, supra Knjazhevo, 31.V.1967, CH (sub *M. rostrupii*) (10 208); Mons Vitoscha, 6.V.1930, leg. A. Vulkanov (2313); [20]: distr. Burgas, l. d. Uzunbudzhak, alt. 100 m, 13.V.1965, CH (sub *M. rostrupii*) (5534).

On *Populus alba*: [14]: Distr. Blagoevgrad, prope pagum Katuntsi, alt. 340 m, 27.X.1964, CH (sub *M. rostrupii*) (4668).

On *P. tremula*: [8]: Mons Ljuljin, 6.X.1940, A. Radoslavov & CH (sub *M. rostrupii*) (12 590).

Note. Savov (1923) reports establishing of the telial stage of *Caeoma mercurialis* on *P. nigra* cv. 'italica' (*P. pyramidalis* Rozan.) but there is no deposited voucher thus a *forma specialis* can not be determined.

### *Melampsora populnea* s. lat.

In three examined specimens only uredinia were found. Urediniospores subglobose to broadly ellipsoid, 18.5-26 × 15-19.5 (21.7 ± 1.8 × 17.5 ± 1.2) µm [ $n_{(3)} = 90$ ], wall 2-2.5 µm thick. The rusts on these studied specimens were not confidently determined as some of the *formae speciales* of *M. populnea*.

#### *Specimens examined:*

On *Populus alba* L.: [1]: distr. Varna, prope urbem Varna, 30.XI.1958, CH (sub *Melampsora* sp.) (9674); [17]: distr. Plovdiv, ad pagum Batschkovo, IX.1956, CH (sub *Melampsora* sp.) (12 871).

On *P. ×canescens* (Ait.) Sm. (*P. alba* × *P. tremula*): [2], distr. Dobritsch, in pago Batovo, 43°24' N, 27°57' E, 24.IX.1998, C.M. Denchev (98 308).

3. *Melampsora larici-populina* Kleb., Z. Pflanzenkrankh. 12: 43, 1902. — *Caeoma laricis* (Westend.) R. Hartig, Wichtige Krankheiten der Waldbäume, p. 93, 1874. — *Uredo larici-populina* Arthur, Rés. Sci. Congr. Int. Bot. Vienne 1905, p. 338, 1906. — *Melampsora populina* auct., p.p.

This species has been reported from Bulgaria (cfr Denchev 1995) but there are no deposited vouchers in the Bulgarian collections. *Melampsora larici-populina* is similar to *M. allii-populina* but has epiphyllous telia, urediniospores with distinct laterally thickened walls, and paraphyses with

apical walls thickened up to 25 µm (Tian & Kakishima 2005).

**Life cycle, hosts, and distribution:** 0, I – II, III (Hetero-eu form): 0, I on *Larix* spp.; II, III on *Populus* spp. – Europe, Asia, North and South America, Australia, and New Zealand.

#### **Host range and distribution in Bulgaria:**

On *Populus balsamifera* L. (cult.), *P. nigra* cv. 'italica' (*P. pyramidalis* Rozan.) (Denchev 1995).

## Conclusions

The present taxonomic revision of *Melampsora* on *Populus* in Bulgaria resulted in the recognition distribution of three species, *M. allii-populina*, *M. populnea* (with four *formae speciales*: *laricis*, *magnusiana*, *pinitorqua*, and *rostrupii*), and *M. larici-populina*. These rust fungi infect 20 host species of *Allium*, *Mercurialis*, *Pinus*, and *Populus* and, thus, represent 28 rust/host combinations. Three species or hybrids of *Populus* are recorded as new hosts, viz. *P. ×canescens* for *M. populnea* s. lat., *P. trichocarpa* and *P. candicans* for *M. populnea* f. sp. *pinitorqua*. One host species, *Allium ursinum*, of the acedial stage of *M. allii-populina* could not be confirmed for Bulgaria.

Based on some morphological differences (relatively larger urediniospores, presence of a smooth surface at the apex of the urediniospores, and amphigenous telia), we regard *Melampsora allii-populina* as a distinct species but not as a *forma specialis*, as it was proposed by Bagyanarayana (1998). There are no morphological differences separating *M. laricis*, *M. magnusiana*, *M. pinitorqua*, and *M. rostrupii* and, therefore, we consider these taxa as *formae speciales* of *M. populnea*.

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## Key to the species of *Melampsora* on *Populus* in Bulgaria

- |      |  |                           |
|------|--|---------------------------|
| 1    | Urediniospores with distinct laterally thickened walls . . . . .                                       | <i>M. larici-populina</i> |
| 1*   | Urediniospores with uniformly thickened walls . . . . .  | 2                         |
| 2    | Urediniospores with a smooth apex. Aecia on <i>Allium</i> , <i>Arum</i> , and <i>Muscari</i> . . . . . | <i>M. allii-populina</i>  |
| 2*   | Urediniospore apex not smooth . . . . .  | <i>M. populnea</i> 3      |
| 3    | Aecia on <i>Larix</i> . . . . .  | f. sp. <i>laricis</i>     |
| 3*   | Aecia on <i>Chelidonium</i> , <i>Corydalis</i> , <i>Fumaria</i> , and <i>Papaver</i> . . . . .         | f. sp. <i>magnusiana</i>  |
| 3**  | Aecia on <i>Pinus</i> . . . . .  | sp. <i>pinitorqua</i>     |
| 3*** | Aecia on <i>Mercurialis</i> . . . . .  | f. sp. <i>rostrupii</i>   |

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