The Northeast Chinese species of *Psathyrella* (Agaricales, Psathyrellaceae)

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Abstract
Twenty seven species of *Psathyrella* have been found in Northeast China. Amongst them, *P. conica*, *P. jilinensis*, *P. mycenoides* and *P. subsingeri* are described as new species, based on studying morphological characteristics and phylogenetic analyses. Detailed morphological descriptions, line drawings and photographs of the new species are presented. Phylogenetic analysis of the nuclear ribosomal internal transcribed spacer (ITS) region and an identification key to the 27 *Psathyrella* species occurring in Northeast China are provided.

Keywords
Basidiomycete, new taxon, phylogenetic analysis, taxonomy

Introduction

*Psathyrella* (Fr.) Quél. is one of the large genera of Agaricales Underw. which consists of 1,030 records in Index Fungorum (http://www.indexfungorum.org), comprising approximately 500 species (Smith 1972; Kits van Waveren 1985; Örstadius and Kundsen 2012;). It is characteristic of fragile basidiomata, hygrophanous pileus, brown to
black brown spore print, always present cheilocystidia and basidiospores smooth or rarely granulose or with myxosporium, fading to greyish in concentrated sulphuric acid ($H_2SO_4$).

The studies of this genus mainly focused on Europe and North America in recent years (Romagnesi 1952; Smith 1972; Kits van Waveren 1985; Nagy et al. 2011; Örstadus and Kundersen 2012; Örstadus et al. 2015). In China, 51 names (Psathyrella s.l.) were reported, including four new species (Chiu 1973; Bi et al. 1985; Bi et al. 1987; Bi 1991; Wang and Bau 2014). Amongst them, 21 species can be found in Northeast China which includes Heilongjiang Province, Jilin Province, Liaoning Province and the northeast of Inner Mongolia Autonomous Region (Wang 2014).

Due to the morphological plasticity of the Psathyrella, some species cannot be distinguished clearly and many names have been combined (Örstadus and Kundersen 2012). Therefore, the aim of this study is to clarify the diversity of Psathyrella in Northeast China by traditional taxonomy and molecular phylogenetic analysis. The examined specimens (from 1997 to 2017) are deposited in the Herbarium of Mycology, Jilin Agricultural University (HMJAU). As a result of morphological and molecular observations, 27 species of Psathyrella were identified, and of which P. conica, P. jilinensis, P. mycenoides and P. subsingeri were reported as new species. Molecular phylogenetic affinities of the 27 species based on the nuclear ribosomal internal transcribed spacer (ITS) region and an identification key to them are provided.

**Materials and methods**

**Morphological studies**

Specimens are deposited in the Herbarium of Mycology, Jilin Agricultural University (HMJAU). Macroscopic characteristics were recorded from fresh specimens. Colour codes are from Kornerup and Wanscher (1978). Samples for microscopic examination were mounted in water and 5% aqueous KOH. Amyloid reactions were diagnosed in Melzer’s reagent. Thirty basidiospores, cystidia and basidia were measured for each collection. The basidiospores quotient ($Q=L/B$) was calculated from measurements of basidiospores.

**DNA extraction and sequencing**

The NuClean Plant Genomic DNA kit (CWBIO) was employed for DNA extraction and PCR amplification from dried specimens. PCR was performed using a touchdown programme (Yan and Bau 2017) and the ITS region was amplified with the primer pair ITS1 and ITS4 (White et al. 1990). The details of sequenced specimens are given in Table 1. The DNA sequencing was done by Comate Bioscience Co., Ltd., Changcun City, China.
## Table 1. Sequenced specimens used in phylogenetic analysis.

| Taxa                                      | Voucher   | Locality                                           | GenBank accession no. (ITS) |
|-------------------------------------------|-----------|----------------------------------------------------|-----------------------------|
| *P. amaura* (Berk. & Broome) Pegler       | HMJAU 37810 | Jilin: Qiupi Village, Tonghua City                | MG734724                    |
| *P. bipellis* (Quél.) A.H. Sm.            | HMJAU 25349 | Jilin: Jilin Agricultural University               | MG734722                    |
| *P. borealis*                             | HMJAU 37924 | Inner Mongolia Autonomous Region: Mangui Town      | MG734743                    |
| *P. borealis* A.H. Sm.                    | HMJAU 37911 | Jilin: Changbai Mountain National Nature Reserve  | MG734746                    |
| *P. boreifasciculata* Kytöv. & Liimat.    | HMJAU 27556 | Heilongjiang: Nanwenghe National Nature Reserve   | KX901850                    |
| *P. candolleana*                          | HMJAU 37994 | Jilin: Dayangcha, Erdaobaihe Town                 | MG734719                    |
| *P. candolleana* (Fr.) Maire              | HMJAU 37994 | Liaoning: Wulong Mountain                          | MG734720                    |
| *P. conica*                               | HMJAU 22096 | Jilin: Lushuihe Town, Baishan City                | MG734713                    |
| *P. conica* Type                          | HMJAU 37846 | Jilin: Changbai Mountain National Nature Reserve | MG734739                    |
| *P. conica*                               | HMJAU 37905 | Jilin: Changbai Mountain National Nature Reserve | MG734745                    |
| *P. effikulata* Örstad. & E. Ludw.        | HMJAU 37832 | Jilin: Jininguetan National Scenic Area            | MG734727                    |
| *P. fennoscandica* Örstad. & E. Larss.    | HMJAU 37918 | Heilongjiang: Shuanghe National Nature Reserve    | MG734723                    |
| *P. gordonii*                             | HMJAU 35984 | Jilin: Jilin Agricultural University              | KY901852                    |
| *P. gordonii* (Berk. & Broome) A. Pearson & Dennis | HMJAU 35983 | Jilin: Jilin Agricultural University              | KY120974                    |
| *P. jilinensis* Type                      | HMJAU 37822 | Jilin: Changbai Mountain National Nature Reserve | MG734717                    |
| *P. jilinensis*                            | HMJAU 37824 | Jilin: Changbai Mountain National Nature Reserve | MG734721                    |
| *P. lutensis* (Romagn.) M.M. Moser         | HMJAU 37840 | Inner Mongolia Autonomous Region: Huihe National Nature Reserve | MG734748          |
| *P. luteapallida* A.H. Sm.                | HMJAU 5148  | Jilin: Zuojia Town, Jilin City                    | MG734736                    |
| *P. mammifera*                            | HMJAU 21098 | Jilin: Mahutou Mountain, Changchun City           | MG734734                    |
| *P. mammifera* (Romagn.) Courtec.         | HMJAU 37882 | Jilin: Changbai Mountain National Nature Reserve | MG734740                    |
| *P. mycenoides*                           | HMJAU 37888 | Jilin: Jilin Agricultural University              | MG734730                    |
| *P. mycenoides*                            | HMJAU 37993 | Jilin: Jilin Agricultural University              | MG734731                    |
| *P. obtusata*                             | HMJAU 37307 | Jilin: Changbai Mountain National Nature Reserve | KY224080                    |
| *P. obtusata* (Pers.) A.H. Sm.            | HMJAU 37310 | Jilin: Changbai Mountain National Nature Reserve | KY224081                    |
| *P. paraeoloides* (Maire) Arnolds          | HMJAU 23696 | Jilin: Lushuihe Town, Baishan City                | MG734733                    |
| *P. pertinax* (Fr.) Örstad.               | HMJAU 6830  | Jilin: Changbai Mountain National Nature Reserve | MG734735                    |
| *P. phlegophila*                           | HMJAU 37848 | Jilin: Songjiang Town                             | MG734738                    |
| *P. phlegophila*                           | HMJAU 37804 | Heilongjiang: Shengshan National Nature Reserve   | MG734726                    |
| *P. phlegophila* Romagn.                  | HMJAU 28267 | Inner Mongolia Autonomous Region: Baiyin'aobao National Nature Reserve | MG734728          |
| *P. piluliformis* (Bull.) P.D. Orton       | HMJAU 37922 | Heilongjiang: Shuanghe National Nature Reserve   | MG734716                    |
| *P. pygmaea* (Bull.) Singer                | HMJAU 37850 | Jilin: Changbai Mountain National Nature Reserve | MG734744                    |
| *P. senex* (Peck) A.H. Sm.                | HMJAU 4450  | Inner Mongolia Autonomous Region: Hulunbeier City | MG734732                    |
| Taxa                        | Voucher       | Locality                                           | GenBank accession no. (ITS) |
|-----------------------------|---------------|----------------------------------------------------|-----------------------------|
| *P. singeri* A.H. Sm.       | HMJUA 37867   | Jilin: Changbai Mountain National Nature Reserve  | MG734718                   |
| *P. spintrigeroides*        | HMJAU 37820   | Jilin: Changbai Mountain National Nature Reserve  | MG367203                   |
| *P. spintrigeroides* P.D. Orton | HMJAU 37901   | Jilin: Changbai Mountain National Nature Reserve  | MG734737                   |
| *P. squamosa*               | HMJAU 37816   | Heilongjiang: Nanwenghe National Nature Reserve    | MG367206                   |
| *P. squamosa* (P. Karst.) A.H. Sm. | HMJAU 35923   | Jilin: Lushuihe Town, Baishan City                | MG374729                   |
| *P. subsingeri*             | HMJAU 37814   | Yunnan: Yeya Lake                                  | MG734714                   |
| *P. subsingeri*             | HMJAU 37811   | Jilin: Jilin Agricultural University               | MG734715                   |
| *P. subsingeri*             | HMJAU 37913   | Jilin: ingyuetan National Scenic Area              | MG734725                   |
| *P. subsingeri*             | HMJAU 37915   | Henan: Boerdeng National Forest Park               | MG734742                   |
| *P. subspadiceogrisea* Type | HMJAU 35992   | Jilin: Changbai Mountain National Nature Reserve  | KY678465                   |
| *P. subspadiceogrisea* T. Bau & J.Q. Yan | HMJAU 35996   | Jilin: Changbai Mountain National Nature Reserve  | KY678466                   |
| *P. subterrestris* A.H. Sm. | HMJAU 37885   | Jilin: Changbai Mountain National Nature Reserve  | MG734747                   |
| *P. subterrestris*          | HMJAU 37887   | Jilin: Songjiang Town                               | MG734741                   |

Data analyses

ITS1+5.8S+ITS2 sequences of 27 species were tested with BLAST in GenBank. Fifty five sequences were downloaded from GenBank, including 21 type species of *Psathyrella*, based on BLAST results and referred to the recent studies (Nagy et al. 2013; von Bonsdorff et al. 2014; Örstadius et al. 2015; Yan and Bau 2017). A total of 103 ITS sequences were aligned using MAFFT 7.205 (Katoh and Standley 2013). The aligned ITS dataset consisted of 643 nucleotide sites (including gaps). The best model (GTR+I+G) was selected by AIC in MRMODELTEST 2.3 (Nylander 2004). Bayesian Inference (BI) was performed with MRBAYES 3.2.6 and four Markov Chains (MCMC) were run for three million generations, sampling every 300th generation. The first 25% trees were discarded (Ronquist and Huelsenbeck 2003). Maximum likelihood analysis was performed with IQTREE 1.5.6 (Nguyen et al. 2014).

Results

The phylogenetic tree (Figure 1) shows that all studied materials fall into *Psathyrella*, with a high statistical support value (BPP=1). It is divided into 14 clades. Most of them have a high statistical support value (BPP≥0.95, Bootstrap≥75), except /fibrillosa I and /fibrillosa II.

Four new species are separated into individual lineages (BPP=1, Bootstrap=100) and are independent from the close taxa. *Psathyrella conica* forms a distinct lineage in /fibrillosa II; *P. jilinensis* belongs to /fibrillosa II and groups together with *P. borealis*; *P. mycenoides* belongs to /prona and is closely related to *P. lilliptutana* Örstadius & E. Larss.; and *P. subsingeri* forms a distinct lineage in /candolleana.
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**Figure 1.** Bayesian and Maximum Likelihood tree inferred from partial ITS sequence data (BPP≥0.95, Bootstrap≥75 are indicated). The tree is rooted with *Coprinellus sclerocystidiosus* (M. Lange & A.H. Sm.) Vīgalys, Hopple & Jacq. Johnson. Newly generated sequences appear in bold. ● indicates newly described species.

The positions of some species are firstly supplemented: *P. amaura* belongs to /pygmaea and is very close to *P. olympiana* A.H. Sm.; *P. borealis* belongs to /fibrillosa II. *P. mammifera* belongs to /spadiceogrisea; *P. singeri* A.H. Sm. belongs to /candelleana; and *P. subterrestris* belongs to /noli-tangere.
Taxonomy

Psathyrella conica T. Bau & J. Q. Yan, sp. nov.
MycoBank: MB823858
Figs 2a–b, 3

Diagnosis. Pileus campanulate to conical, with a subacute to obtuse umbo in early stage. Lamellae 3.0–5.0 mm broad, close. Basidiospores 7.8–8.8 × 4.0–4.5(–5.0) μm, germ pore indistinct or absent. Pleurocystidia numerous, narrowly utriform, with obtuse to broad obtuse or slightly subcapitate at apex. Cheilocystidia scattered.

Holotype. CHINA. Jilin Province, Yanbian Korean Autonomous Prefecture, Antu County, Changbai Mountain, 30 Jun 2017, HMJAU 37846.

Etymology. Name refers to the conical pileus.

Description. Pileus 12–45 mm, campanulate to conical, with a subacute to obtuse umbo in early stage, hygrophanous, chestnut (7D4–7D6), becoming dirty white with slightly yellowish-brown (6C5–6C6) as drying, striate indistinctly. Veil with a thin coating of white to dirty white (6A1–6B1) fibrils, evanescent. Context dirty white with slightly pink (6B4–6B5), about 3.0 mm thick at stipe centre. Lamellae 3.0–5.0 mm broad, close, adnate to slightly adnexed, coffee-cream (6C4–6C6); edges white (6A1), saw-toothed under 20× magnifier. Stipe 34–85 × 2.0–7.0 mm, cylindrical, slightly

Figure 2. Basidiomata of Psathyrella species. a–b Psathyrella conica c–e Psathyrella jilinensis f Psathyrella mycenoides g–i Psathyrella subsingeri; Bars: 10 mm (a, c, d, f–h). Photographs a–e, g–i by Jun-Qing Yan; Photograph f by Tolgor Bau.
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**Figure 3.** Microscopic features of *Psathyrella conica* (HMJAU 37846). a Basidiomata b Basidiospores c Basidia d Pileipellis e Pleurocystidia f Cheilocystidia. Bars: 10 mm (a); 10 μm (b–f). Drawing by Jun-Qing Yan.

expanded or not at base, white, with slightly brown at base, hollow, equal, surface covered with white (6A1) fibrils in early stage, evanescent. Odour and taste indistinctive.

Basidiospores 7.8–8.8 × 4.0–4.5(–5.0) μm, Q=1.8–2.1(–2.3), oblong-ellipsoid to oblong, in profile slightly flattened on one side, pale yellowish-brown in water, yellowish-brown to brown in 5% potassium hydroxide (KOH), inamyloid, smooth, with 1–2 guttulate, germ pore indistinct or absent. Basidia 20–25 × 7.3–9.8 μm, clavate, hyaline, 4- or 2-spored. Pleurocystidia 43–61 × (8.5–)9.8–12 μm, numerous, narrowly utriform, thin-walled, hyaline, with obtuse to broad obtuse or slightly subcapitate, sometimes adhering subhyaline deposits. Cheilocystidia scattered, similar to pleurocystidia, 24–39 × 8.5–12 μm; spheropedunculate or clavate cells abundant, 20–29 ×
12–18 μm. Trama of gills irregular, up to 20 μm broad. Pileipellis consisting of 2–3 cells deep layer of subglobose cell, 25–37 μm broad. Clamps present.

**Habit and habitat.** Solitary to scattered on rotten wood or humus in mixed forests.

**Other specimens examined.** Jilin Province, Baishan City, Fusong County, Lushuihe town, 7 Jul 2004, HMJAU 4969; 29 Jun 2005, HMJAU 4923; 25 Jun 2009, HMJAU 22096; Yanbian Korean Autonomous Prefecture, Antu County, Changbai Mountain, 23 Jun 2012, HMJAU 25342; 4 Jul 2015, HMJAU 37826; 29 Jun 2017, HMJAU 37847, HMJAU 37904; 6 Aug 2017, HMJAU 37905.

**Psathyrella jilinensis** T. Bau & J.Q. Yan, sp. nov.
MycoBank: MB823856
Figs 2c–e, 4

**Diagnosis.** Pileus paraboloid to convex, margin at first appendiculate with adhering patches of white evanescent inner veil. Lamellae 2.0–5.0 mm broad, moderately close. Basidiospores (5.8–)6.3–7.3(–7.8) × (2.9–)3.4–4.4 μm, germ pore absent or indistinct. Pleurocystidia fusiform to narrowly fusiform. Cheilocystidia similar to pleurocystidia. Cheilocystidia and pleurocystidia covered by hyaline, hemispherical amorphous incrustation at apex.

**Holotype.** CHINA. Jilin Province: Changbai Mountain, Antu County, Yanbian Korean Autonomous Prefecture, 42°23’51”N, 126°05’47”E, 760 m alt., 7 Jul 2015, HMJAU 37822.

**Etymology.** Name refers to the type locality where the new species was collected.

**Description.** Pileus 17–45 mm, paraboloid to convex, hygrophanous, reddish-brown (8E5–8E6) at centre, pale yellowish-brown (7C6–7D7) at margin in early stage, yellowish-brown (6B5–6C5), striate up to 1/2 from margin at maturity, becoming slightly brown (7C5–7D6) as pileus dries. Veil white (6A1), thin, fibrillose, at first as appendiculate inner veil or adhering patches at pileus margin, evanescent. Context white (6A1), thin, very fragile, about 2.0 mm thick at centre. Lamellae 2.0–5.0 mm broad, moderately close, adnate, greyish to greyish-brown (7C1–7C3); edges saw-toothed under 20× magnification. Stipe 40–50 × 3.0–7.0 mm, white (6A1), cylindrical, hollow, surface covered with slight white (6A1) evanescent fibrils. Odour and taste indistinctive.

Basidiospores (5.8–)6.3–7.3(–7.8) × (2.9–)3.4–4.4 μm, Q= (1.4–)1.8–2.0(–2.3), oblong-ellipsoid, in profile flattened on one side, pale brown in water, brown in 5% KOH, gradually becoming greyish-brown, inamyloid, smooth, germ pore absent or indistinct, about 0.9 μm wide (if it can be observed). Basidia 15–17 × 6.0–7.0 μm, clavate, hyaline, 4 or 2-spored. Pleurocystidia fusiform, narrowly fusiform, rarely narrowly utriform, thin-walled or slightly thick-walled, apex obtuse to subacute, hyaline, covered by hyaline, hemispherical amorphous incrustation, which can dissolve in 5% KOH. Cheilocystidia 37–51 × 8.5–12 μm, similar to pleurocystidia, hyaline, covered
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Figure 4. Microscopic features of *Psathyrella jilinensis* (HMJAU 37822). a Basidiomata b Basidiospores c Basidia d Pileipellis e Pleurocystidia f Cheilocystidia. Bars: 10mm (a); 10μm (b–f). Drawing by Jun-Qing Yan.

with amorphous incrustation at apex. Trama of gills parallel to hyphae, up to 15 μm broad. Pileipellis consisting of 2–3 cells deep layer of subglobose cell, 20–30 μm broad. Veil composed of cylindrical hyphae, 8.5–10 μm broad. Clamps present.

**Habit and habitat.** Solitary to scattered on rotten wood or humus in mixed forests.

**Other specimens examined.** Jilin Province, Baishan City, Fusong County, Lushuihe town, 27 Jun 2009, HMJAU 22099; 9 Jul 2015, HMJAU 37823; Yanbian Korean Autonomous Prefecture, Antu County, Changbai Mountain, 23 Jun 2012, HMJAU 25351; 31 Aug 2012, HMJAU 25351; Dayangcha, 6 Jul 2015, HMJAU 37824.
**Psathyrella mycenoides** T. Bau, sp. nov.
MycoBank: MB823857
Figs 2f, 5

**Diagnosis.** Pileus 4.0–5.0 mm, hemispherical to convex. Stipe slender. Basidiospores 8.8–9.2(–9.7) × 4.9–5.4 μm, germ pore distinct, but small. Pleurocystidia scattered, fusiform to lageniform with an obtuse apex. Cheilocystidia lageniform, with an obtuse apex or clavate to spheropedunculate with a long or short mucronate apex.

**Holotype.** CHINA. Jilin Province, Changchun City, Jilin Agricultural University, 43°48’36”N, 125°24’25”E, 220 m alt., 10 Sep 2016, HMJAU 37888.

**Etymology.** Name refers to its macroscopic characteristics similar to *Mycena*.

**Description.** Pileus 4.0–5.0 mm, hemispherical to convex, dirty white with pinkish (7A4–7B5), hygrophanous, striate up to centre from margin. Veil not observed. Context very thin and very fragile, about 0.5 mm thick at stipe centre. Lamellae 1.5–2.0 mm broad, adnate to slightly adnexed, pale brown (7C3–7C4), edges saw-toothed under 20× magnification. Stipe slender, 25–30 × 0.5–1.0 mm, hygrophanous, subhyaline, cylindrical, hollow, equal, fragile, evanescently pruinose at apex.

Basidiospores 8.8–9.2(–9.7) × 4.9–5.4 μm, Q=1.6–2.0, ellipsoid to oblong-ellipsoid, in profile flattened on one side, pale yellowish-brown in water, becoming dark grey to dark brown in 5% KOH, germ pore distinct, but small, about 0.9 μm broad. Basidia 15–17 × 8.8–10 μm, clavate, hyaline, 4- or 2-spored. Pleurocystidia 37–56 × 12–17 μm, scattered, fusiform to lageniform with an obtuse apex, thin-walled and hyaline. Cheilocystidia numerous, 29–44 × 9.8–17 μm, hyaline, lageniform with an obtuse apex or clavate to spheropedunculate, with long or short mucronate apex, rarely spheropedunculate. Trama of gills irregular, hyphae up to 10 μm broad. Pileipellis hymeniderm, cells 20–30 μm broad. Clamps present.

**Habit and habitat.** Solitary to scattered on humus in mixed forests.

**Other specimens examined.** CHINA. Jilin Province, Changchun City, Jilin Agricultural University, 12 Sep 2016, HMJAU 37993.

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**Psathyrella subsingeri** T. Bau & J.Q. Yan, sp. nov.
MycoBank: MB823855
Figs 2g–i, 6

**Diagnosis.** Pileus 15–40 mm, paraboloid to conical. Lamellae 2.0–4.0 mm broad, close. Basidiospores 5.8–7.8(–8.8) × 3.9–4.4(–5.0) μm, very pale, nearly hyaline or slightly yellow in water and 5% KOH. Germ pore absent. Pleurocystidia absent. Cheilocystidia utriform to predominantly spheropedunculate.

**Holotype.** CHINA. Jilin Province, Changchun City, Jingyuetan National Scenic Area, 43°47’38”N, 125°26’55”E, 200 m alt., 25 Jun 2017, HMJAU 37913.

**Etymology.** Name refers to its microscopic characteristics similar to *P. singeri*. 

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**Psathyrella mycenoides** T. Bau, sp. nov. 
MycoBank: MB823857
Figs 2f, 5

**Diagnosis.** Pileus 4.0–5.0 mm, hemispherical to convex. Stipe slender. Basidiospores 8.8–9.2(–9.7) × 4.9–5.4 μm, germ pore distinct, but small. Pleurocystidia scattered, fusiform to lageniform with an obtuse apex. Cheilocystidia lageniform, with an obtuse apex or clavate to spheropedunculate with a long or short mucronate apex.

**Holotype.** CHINA. Jilin Province, Changchun City, Jilin Agricultural University, 43°48’36”N, 125°24’25”E, 220 m alt., 10 Sep 2016, HMJAU 37888.

**Etymology.** Name refers to its macroscopic characteristics similar to *Mycena*.

**Description.** Pileus 4.0–5.0 mm, hemispherical to convex, dirty white with pinkish (7A4–7B5), hygrophanous, striate up to centre from margin. Veil not observed. Context very thin and very fragile, about 0.5 mm thick at stipe centre. Lamellae 1.5–2.0 mm broad, adnate to slightly adnexed, pale brown (7C3–7C4), edges saw-toothed under 20× magnification. Stipe slender, 25–30 × 0.5–1.0 mm, hygrophanous, subhyaline, cylindrical, hollow, equal, fragile, evanescently pruinose at apex.

Basidiospores 8.8–9.2(–9.7) × 4.9–5.4 μm, Q=1.6–2.0, ellipsoid to oblong-ellipsoid, in profile flattened on one side, pale yellowish-brown in water, becoming dark grey to dark brown in 5% KOH, germ pore distinct, but small, about 0.9 μm broad. Basidia 15–17 × 8.8–10 μm, clavate, hyaline, 4- or 2-spored. Pleurocystidia 37–56 × 12–17 μm, scattered, fusiform to lageniform with an obtuse apex, thin-walled and hyaline. Cheilocystidia numerous, 29–44 × 9.8–17 μm, hyaline, lageniform with an obtuse apex or clavate to spheropedunculate, with long or short mucronate apex, rarely spheropedunculate. Trama of gills irregular, hyphae up to 10 μm broad. Pileipellis hymeniderm, cells 20–30 μm broad. Clamps present.

**Habit and habitat.** Solitary to scattered on humus in mixed forests.

**Other specimens examined.** CHINA. Jilin Province, Changchun City, Jilin Agricultural University, 12 Sep 2016, HMJAU 37993.
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Figure 5. Microscopic features of *Psathyrella mycenoides* (HMJAU 37888). a Basidiomata b Basidiospores c Basidia d Pileipellis e Pleurocystidia f Cheilocystidia. Bars: 10 mm (a); 10 μm (d-f). Drawing by Jun-Qing Yan.

**Description.** Pileus 15–40 mm, paraboloid to conical, obtuse or slightly umbo-nate at disc, hygrophanous, dark reddish-brown (8E7–8F8) or faint yellowish-brown (5C5–5C4), becoming yellowish-brown (6D5–6D6) as pileus dries, striate indistinct. Veil present in early stage, thin, white (6A1), fibrillose, evanescent. Context white (6A1), thin and very fragile, about 2.5 mm thick at stipe centre. Lamellae 2.0–4.0 mm broad, close, adnate, pale brown (6C4–6C5), edges white (6A1), saw-toothed under
Figure 6. Microscopic features of *Psathyrella subsingeri* (HMJAU 37913). a Basidiomata b Basidiospores c Basidia d Pileipellis e Cheilocystidia f Caulocystidia. Bar: 10 mm (a); 10 μm (b–f). Drawing by Jun-Qing Yan.

20× magnifier. Stipe 35–50 × 3.0–4.5 mm, cylindrical, hollow, equal, fragile, covered with slight white (6A1) fibrils, which fall off easily. Spore print chocolate (7E7–7E8). Odour and taste indistinctive.

Basidiospores 5.8–7.8(–8.8) × 3.9–4.4(–5.0) μm, Q=1.4–2.0, ellipsoid to oblong-ellipsoid, in profile flattened on one side, very pale, nearly hyaline or slightly yellow in water and 5% KOH, inamyloid, smooth. Germ pore absent. Basidia 15–22 × 7.3–9.8 μm, 4- or 2-spored, clavate, hyaline. Pleurocystidia absent. Cheilocystidia utriform to spheropedunculate, rarely clavate to fusiform with an obtuse to broadly obtuse apex, thin-walled, hyaline. Caulocystidia 26–37 × 9.8–15 μm, rarely, various, clavate, utriform, thin-walled, hyaline. Trama of gills irregular, up to 15 μm broad. Pileipellis consisting of 1–2 cells, deep layer of subglobose cell, 20–32 μm broad. Clamps present.

**Habit and habitat.** Solitary to scattered on terrestrial or humus in mixed forests.

**Other specimens examined.** Henan Province, Xinyang City, Boer Deng National Forest Park, 16 Jul 2017, HMJAU 37915; Xian Mountain, 15 Jul 2017, HMJAU
The Northeast Chinese species of *Psathyrella* (Agaricales, Psathyrellaceae) 37931; Jilin Province, Changchun City, Jilin Agricultural University, 21 Jun 2016. HMJAU 37811; Jingyuetai National Scenic Area, 25 Jun 2017, HMJAU 37914; 7 Jul 2017, HMJAU 37849; Tonghua City, Qiupi Village, 6 Aug 2015, HMJAU 37812, HMJAU 37813; Yunnan Province, Yeya Lake, 7 Aug 2016, HMJAU 37814; 6 Aug 2017, HMJAU 37852; 23 Aug 2017, HMJAU 37962.

**Discussion**

These phylogenetic results are very much in congruence with the study of Larsson and Örstadius (2008) and Örstadius et al. (2015), except /fibrillosa/, which separates to two lineages (/fibrillosa I and /fibrillosa II). As only ITS sequences were analysed in this study, this accounts for the difference and the very low support value (BPP<0.3). Four new species are separated into individual lineages (BPP=1) and distinct from other closely related taxa.

*Psathyrella conica* is a distinct lineage in fibrillosa II, which is independent from any other related taxa. Morphologically, it can be classified in subsection *Spadiceogriseae* (Kits van Waveren 1985). Only *P. clivensis* (Berk. & Broome) P. D. Orton does not have a germ pore in this subsection, but basidiospores of *P. clivensis* are obviously broader, 8–10 × 5.5–6.5 μm and ellipsoid to ovoid (Kits van Waveren 1985). It can also be classified in section Fattucae (Smith 1972), some species having sturdy stipe and utriform cystidia, but they can be clearly distinguished from *P. conica* by other micromorphology. *Psathyrella acadiensis* A.H. Sm. has smaller basidiospores, which are only up to 6.0 μm long; *P. albocinerascens* A.H. Sm. has an obvious germ pore and white pileus in the early stage; *P. amarella* A.H. Sm. and *P. spadiceogrisea* (Schaeff.) Maire have an obvious germ pore; *P. vesiculocystis* A.H. Sm. has pedicellate-pleurocystidia (Smith 1972). Furthermore, *P. terrestris* Natarajan has aspects of *P. conica*, whose pileus is umbonate, but it has broadly utriform pleurocystidia and its basidiospores are dark brown, subglobose and up to 8.5 μm broad (Natarajan 1978).

*Psathyrella jilinensis* grouped together with *P. borealis* in /fibrillosa II. However, *P. borealis* has an obvious germ pore. Morphologically, it can be classified in section Hydrophilae by basidiospores rarely exceeding 7.5 μm and the presence of pleurocystidia. There are hardly any other species in the section that match the characteristics of *P. jilinensis*. The pleurocystidia of *P. atomatoideas* (Peck) A.H. Sm. do not have amorphous incrustation. Basidiospores of *P. cortinarioides* P.D. Orton and *P. pertinax* have a clearly truncated base. Cystidia of *P. umbrina* Kits van Wav. have subacute apex and their basidiospores are broader, up to 4.5–5.5 μm (Kits van Waveren 1985; Örstadius and Kundsen 2012). Furthermore, *P. cokeri* (Murrill) A.H. Sm., *P. pennata* and *P. sub similissima* A.H. Sm. have some similar aspects of *P. jilinensis*, but *P. cokeri* (Murrill) A.H. Sm. and *P. sub similissima* A.H. Sm. do not have amorphous incrustation (Smith 1972) and *P. pennata* grows on burnt soil, its basidiospores being larger and narrowly amygdaloid (Örstadius and Kundsen 2012).
Psathyrella mycenoides belongs to /prona and is placed close to *P. lilliputana*. However, *P. lilliputana* has larger (9.5–11 × 5.0–6.0 μm) and snout-like basidiospores (Örstad & Huhtinen 1996; Delannoy et al. 2002); the coprophilous fungi of *P. granulose* have utriform cystidia (Arnolds 2003); basidiospores of *P. liciosae* are partly phaseoliform in side view and ochraceous-brown in 5% KOH (Contu and Pacioni 1998); *P. minima* has very distant lamellae (Peck 1878); and basidiospores of *P. psilocyboidea* are truncated at the base (Smith 1972).

*Psathyrella subsingeri* belongs to /candollena. Only *P. luteopallida* and *P. singeri* have nearly hyaline basidiospores in this clade. However, the basidiospores of *P. luteopallida* are longer than 8.0 μm. The basidiospores of *P. singeri* are broader, up to 5.5 μm (Smith 1972). Morphologically, *P. subsingeri* belongs to section Spintrigerae with basidiospores less than 9.0 μm and absent pleurocystidia (Kits van Waveren 1985). Its cheilocystidium is similar to *P. submicrospora* Heykoop & Moreno [= *Coprinopsis submicrospora* (Heykoop & Moreno) Örstad & E. Larss.], but basidiospores of *P. submicrospora* are predominantly amygdaliform (Heykoop and Moreno 2002). It also can be classified in series Africastaneae (Smith 1972). There are only three species in the series that match the characteristic of subhyaline to hyaline basidiospores in water or 5% KOH. However, they can be separated as follows: the basidiospores of *P. atricastanea* (Murrill) A.H. Sm are truncate; *P. albipes* A.H. Sm. and *P. subhyalinispora* (Murrill) A.H. Sm. differ in having an obvious germ pore (Smith 1972). Furthermore, *P. aequatoriae* Singer has subhyaline to hyaline basidiospores, but differs by smaller and sometimes papillate pileus. *Psathyrella olympiana* and *P. bipellis* [= *P. odorata* (Peck) Sacc.] have aspects of *P. subsingeri* in macroscopic characteristics, whose pileus are reddish-brown, but have pleurocystidia (Örstad & Kundsen 2012).

**Key to species of Psathyrella in Northeast China**

1  Pleurocystidia absent ..............................................................................................................2
   – Pleurocystidia present ...........................................................................................................5

2  Basidiospores brown in 5% KOH .................................................................................. *P. candolleana*
   – Basidiospores very pale, subhyaline in 5% KOH .........................................................3

3  Basidiospores predominantly longer than 8.0 μm ........................................ *P. luteopallida*
   – Basidiospores shorter ......................................................................................................4

4  Basidiospores up to 5.5 μm broad ...................................................................................... *P. singeri*
   – Basidiospores up to 4.5 μm broad .................................................................................... *P. subsingeri*
The Northeast Chinese species of *Psathyrella* (Agaricales, Psathyrellaceae)

| Step | Description | Outcome |
|------|-------------|---------|
| 5    | Basidiospores longer than 10 μm, pleurocystidia utriform to clavate, sometimes with yellowish-brown inclusions | *P. bipellis* |
| 6    | Germ pore always or predominantly distinctly visible | 6 |
| 7    | Germ pore absent or predominantly indistinctly visible | 19 |
| 8    | Pleurocystidia rarely, lageniform, shorter than 40 μm, clamps absent | *P. effibulata* |
| 9    | Basidiospores longer | 10 |
| 10   | Basidiospores up to 35 μm long, mostly with distinct crystals | *P. pygmaea* |
| 11   | Basidiomata densely caespitose, cheilocystidia fusiform or mucronat, basidiospores 8.5–9.8 × 4.6–5.1 μm | *P. boreifasciculata* |
| 12   | Basidiospores up to 7.0 μm long | 9 |
| 13   | Basidiomata up to 5.0 mm, cheilocystidia with long or short mucronate | *P. mycenoides* |
| 14   | Basidiospores up to 5.0 μm broad | 18 |
| 15   | Basidiospores scattered | *P. phegophila* |
| 16   | Basidiomata with a thin coating of fibrils, pleurocystidia narrowly utriform | *P. senex* |
| 17   | Basidiospores up to 6.0 μm broad | 18 |
| 18   | Basidiomata with distinct crystals, basidiospores up to 9 μm long | *P. jilinensis* |
| 19   | Basidiomata with distinct crystals, basidiospores up to 9 μm long | 20 |
| 20   | Basidiomata with distinct crystals, basidiospores up to 9 μm long | 21 |
| 21   | Basidiomata with obtuse or subacute apex | *P. piluliformis* |
| 22   | Basidiomata with obtuse or subacute apex | 22 |
| 23   | Basidiomata with obtuse or subacute apex | 25 |
100

22 Cheilocystidia mucronate, basidiospores ellipsoid, pale brown in 5% KOH.......................... P. obtusata
– Not as above ......................................................................................................................23
23 Basidiospores (6.8–)7.3–7.8(–8.8) × 3.4–4.9 μm, base often broadly truncate, in profile often phaseoliform.......................... P. pertinax
– Not as above ......................................................................................................................24
24 Basidiospores oblong to oblong-ellipsoid, pleurocystidia thin-walled ....................
.......................................................................................................................... P. squamosa
– Basidiospores ellipsoid, pleurocystidia slightly thick-walled.... P. spintrigeroides
25 Basidiospores reddish-brown in water ........................................ P. mammifera
– Basidiospores yellowish-brown or pale yellowish-brown in water ..............
26 Pileus often with subacute or obtuse umbo, basidiospores 7.8–8.8 × 4.0–4.5(–5.0) μm, oblong to oblong-ellipsoid ..................... P. conica
– Pileus without umbo, basidiospores 6.8–7.8 × 3.9–4.9 μm, ellipsoid, rarely oval................................................................. P. subspadiceogrisea

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References

Arnolds E (2003) Rare and interesting species of Psathyrella. Fungi non delineati 26: 1–76.
Bi ZS (1991) Two new species of Pasthyrella and Gymnopilus from Guangdong Province. Guihaia 11: 373–382.
Bi ZS, Li TH, Zheng GY (1987) A preliminary study on the genus Pasthyrella from Guangdong Province of China. Guihaia 7: 23–27.
Bi ZS, Li TH, Zheng GY, Zhong L (1985) Four new species of Agaricales. Acta Microbiologica Sinica 4: 155–161. https://doi.org/10.13346/j.mycosystema.1985.03.005
Chiu WF (1973) The new species of Agaricales from Yunnan, China. Acta Microbiologica Sinica 13: 129–135. https://doi.org/10.13343/j.cnki.wxsb.1973.02.004
Contu M, Pacioni G (1998) Amanita cistetorum and Psathyrella liciosa, two new Mediterranean species. Mycotaxon 69: 437–446.
Delannoy A, Chiaffi M, Courtecuisse R, Eyssartier G (2002) Psathyrella coprinoides sp. nov. une nouvelle Psathyrelle de la section Cystopsathyra. Bulletin trimestriel de la Société mycologique de France 118: 1–9.
Heykoop M, Moreno G (2002) Studies in the genus Psathyrella in Spain. IV. Psathyrella submicrospora sp. nov. and P. microsporoides nom. nov. Mycotaxon 83: 425–433
The Northeast Chinese species of *Psathyrella* (Agaricales, Psathyrellaceae)

Katoh K, Standley DM (2013) MAFFT multiple sequence alignment software version 7: improvements in performance and usability. Molecular Biology & Evolution 30: 772. https://doi.org/10.1093/molbev/mst010

Kits van Waveren E (1985) The Dutch, French and British species of *Psathyrella*. Persoonia Suppl 2: 1–284.

Kornerup A, Wanscher JHK (1978) The Methuen Handbook of Colour (3rd edn). Eyre Methuen Ltd., London, 252 pp.

Larsson E, Örstadius L (2008) Fourteen coprophilous species of *Psathyrella* identified in the Nordic countries using morphology and nuclear rDNA sequence data. Mycological Research 112: 1165–1185. https://doi.org/10.1016/j.mycres.2008.04.003

Nagy LG, Vágvölgyi C, Papp T (2013) Morphological characterization of clades of the Psathyrellaceae (Agaricales) inferred from a multigene phylogeny. Mycological Progress 12: 505–517. https://doi.org/10.1007/s11557-012-0857-3

Nagy LG, Walther G, Házi J, Vágvölgyi C, Papp T (2011) Understanding the evolutionary processes of fungal fruiting bodies: Correlated Evolution and Divergence Times in the Psathyrellaceae. Systematic Biology 60: 303–317. https://doi.org/10.1093/sysbio/syr005

Natarajan K (1978) South Indian Agaricales IV. A new species of *Psathyrella*. Mycologia 70: 1259–1261. https://doi.org/10.2307/3759328

Nguyen LT, Schmidt HA, von Haeseler A, Minh BQ (2014) IQ-TREE: a fast and effective stochastic algorithm for estimating maximum-likelihood phylogenies. Molecular biology and evolution 32(1): 268–274. https://doi.org/10.1093/molbev/msu300

Nylander J (2004) MrModeltest 2.3. Computer program and documentation distributed by the author. Evolutionary Biology Centre, Uppsala University, Uppsala.

Örstadius L, Huhtinen S (1996) The psathyrellloid taxa described by PA Karsten. Österr Z Pilzk 5: 131–148.

Örstadius L, Kundsen H (2012) *Psathyrella* (Fr.) Quél. In: Knudsen H, Vesterholt J (Eds) Funga Nordica Agaricoid, boletoid, cyphelloid and gasteroid genera. Nordsvamp, Copenhagen, 586–623.

Örstadius L, Ryberg M, Larsson E (2015) Molecular phylogenetics and taxonomy in Psathyrellaceae (Agaricales) with focus on psathyrellloid species: introduction of three new genera and 18 new species. Mycological Progress 14: 1–42. https://doi.org/10.1007/s11557-015-1047-x

Peck CH (1878) Report of the Botanist. Annual Report on the New York State Museum of Natural History 41: 51–122.

Romagnesi H (1952) Species et formae ex genere *Drosophila* Quél. Bulletin mensuel de la Société linnéenne de Lyon 21: 151–156. https://doi.org/10.3406/linly.1952.7506

Ronquist F, Huelsenbeck JP (2003) MrBayes 3: Bayesian phylogenetic inference under mixed models. Bioinformatics 19: 1572–1574. https://doi.org/10.1093/bioinformatics/btg180

Smith AH (1972) The North America species of *Psathyrella*. The New York Botanical Garden 24: 1–633.

von Bonsdorff T, Kytövuori I, Vauras J, Huhtinen S, Halme P, Rämä T, Kosonen L, Jakobsson S (2014) Sienet ja metsien luontoarvot. Luonnonontieteilinen keskussmuseo 27: 1–272.

Wang Y (2014) Studies on taxonomy of genus *Psathyrella* from the Northeast of China. Jilin Agricultural University.
Wang Y, Bau T (2014) Well-known Chinese species of *Psathyrella* and their distribution. Journal of Fungal Research 12: 133–141. https://doi.org/10.1016/j.mycres.2008.04.005

White TJ, Bruns TD, Lee SB, Taylor JW, Innis MA, Gelfand DH, Sninsky JJ (1990) Amplification and direct sequencing of Fungal Ribosomal RNA Genes for phylogenetics. In: Innis MA, Gelfand DH, Sninsky JJ, White TJ (Eds) PCR Protocols: A Guide to Methods and Applications. Academic Press, San Diego, 315–322. https://doi.org/10.1016/B978-0-12-372180-8.50042-1

Yan JQ, Bau T (2017) New and newly recorded species of *Psathyrella* (Psathyrellaceae, Agaricales) from Northeast China. Phytotaxa 321: 139–150. https://doi.org/10.11646/phytotaxa.321.1.7